July 4 – 7

Stamford Grand Adelaide, Glenelg, South Australia

The Australian Society of Animal Production and the New Zealand Society of Animal Production have joined together to bring Animal Production 2016 to Adelaide, South Australia.

Over the past few decades we have witnessed a proliferation of societies dedicated to single disciplines such as genetics, nutrition, physiology, molecular biology, ruminant nutrition and the like.

While this has allowed the development of discipline-specific technologies, it is becoming increasingly clear that animal industries need to develop ‘whole-of-chain’ approaches to the application of these technologies. As consumers become more aware of, and involved in, the origins of their food and fibre, it is critical that technological solutions to animal production are developed with consumers in mind.

To this end, Animal Production 2016 brings together scientists, educators, social scientists, extension experts, consultants, consumer advocates, processors and producers to share the latest information on all aspects of animal production. We have invited national and international leaders in animal production and are thrilled to have Professor Temple Grandin, the world leader in animal behaviour and welfare, as our keynote speaker. We have also made students a focus of the conference with a dedicated session for them to present their research in a three-minute ‘Student Snapshot’.

On behalf of the Australian and New Zealand Societies of Animal Production, we hope you have a tremendous conference, make new contacts, reconnect with old friends and leave feeling re-energised and enthusiastic about your role in animal production!

Prof Phil Hynd
President
Australian Society of Animal Production

Dr Chris Logan
President
New Zealand Society of Animal Production
AgCommunicators specialises in communication, education, executive support and events for primary production, science and natural resources.

We tailor conferences, workshops and forums to suit your target audience. Events are key opportunities to communicate your message, teach and inspire delegates or provide industry leadership and collaboration.

Our team can assist with all areas of event management such as program planning, online registrations, event marketing, media liaison, seeking sponsorship, budget and finance coordination and post-event evaluation and reporting. We can work with you from the outset, taking your idea from the concept stage through to execution, or we can help with specific event elements, such as media, marketing or logistics. We aim to bring a clever and creative approach to your event, while ensuring we manage every minute detail that will guarantee success.

If you have an event, workshop or conference on the horizon, we look forward to considering how we can add spark to your program and delivery.

Contact AgCommunicators Event Manager Rebecca Jeisman, 0438 683 436 and rebecca.jeisman@agcommunicators.com.au
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ORGANISING COMMITTEE

Phil Hynd, President, Australian Society of Animal Production
Wayne Pitchford, Vice President, Australian Society of Animal Production
Mariana Caetano, Secretary, Australian Society of Animal Production
Michael Wilkes, Treasurer, Australian Society of Animal Production
Bruce Hancock, Rural Solutions SA: PIRSA and Sheep CRC - Lamb Supply Chain Group
Emily Buddle, PhD Student, University of Adelaide
Chris Logan, President, New Zealand Society of Animal Production

REVIEWER

Forbes Brien, Associate Professor, University of Adelaide

VOLUNTEERS

Conference Volunteer Coordinator
Cynthia Bottema, Associate Professor, University of Adelaide

Conference Volunteers
Jackson Adams – Student, University of Adelaide
Bianca Agenbag – Student, University of Adelaide
Jo Aldersey – Student, University of Adelaide
Jena Alexopoulos – Student, University of Adelaide
Amy Bates – Student, University of Adelaide
Alex Boileau – Student, University of Adelaide
Rudi McEwin – Student, University of Adelaide
The University of Adelaide was established in 1874 and began teaching in 1876. The first official lecture was in Latin and the Bachelor of Arts the first degree offered. The University was the first in Australia to grant degrees in science starting in 1882. The University constitutes over 25,000 students and 3500 staff and is consistently ranked in the top 1% of Universities worldwide.

Australia’s first Agricultural College was established in 1883 at Roseworthy, approximately 50km north of the city. The College joined the University in 1991 and is now home of the School of Animal and Veterinary Sciences. The degrees taught are Veterinary Medicine, Animal Science and Agricultural Science which is in collaboration with the School of Agriculture, Food and Wine located on the Waite Research Institute, 7km SE of the city. The South Australian Research and Development Institute is a strong research partner. Research activity at Roseworthy is rapidly growing and just this month three centres have been established. The Davies Research Centre which is focussed on the red meat industries; The Animal Welfare Science Centre; and The Centre for Anti-Microbial Resistance in Animals.

We are delighted the University is a Platinum sponsor, we welcome you to Adelaide and hope you enjoy a stimulating conference which will lead to increased profitability of our primary industries.

Meat & Livestock Australia Limited (MLA) delivers research, development and marketing services to Australia’s cattle, sheep and goat producers. MLA has approximately 50,000 livestock producer members who have stakeholder entitlements in the company.

MLA’s vision is to be the recognised leader in delivering world-class research, development and marketing outcomes that benefit Australian cattle, sheep and goat producers.

Working in collaboration with the Australian Government and wider red meat industry, MLA’s mission is to deliver value to levy payers by investing in initiatives that contribute to producer profitability, sustainability and global competitiveness.
PIRSA is a key economic development agency of the Government of South Australia. PIRSA assists primary industries to grow, innovate and maximise their economic growth potential.

PIRSA works with industry to manage resources sustainably and enhance value chains, and fosters environmentally sustainable and internationally competitive industries.

PIRSA leads the delivery of the State Government’s Premium food and wine produced in our clean environment and exported to the world economic priority.

PIRSA leads and coordinates the state’s regional development agenda to improve economic and social outcomes for regional South Australia through the Government’s Charter for Stronger Regional Policy.

Baiada Poultry Pty Ltd is a privately-owned Australian company which provides premium quality poultry products throughout Australia.

Our business operations include broiler and breeder farms, hatcheries, processing plants, feedmilling and protein recovery. Our products include sales of live poultry including breeding stock, poultry feed, fertile eggs, day-old chickens, primary processed chicken (raw) and further processed chicken products, and pet food.

At Baiada Poultry, our aim is simple – to provide our customers with quality products and an excellent service.
SPONSORS

NETWORKING HOUR & BRONZE

ALLTECH
www.alltech.com
Founded in 1980 by Irish entrepreneur and scientist Dr. Pearse Lyons, Alltech improves the health and performance of people, animals and plants through nutrition and scientific innovation, particularly yeast-based technology, nutrigenomics and algae.

Alltech has three major bioscience centers, complemented by 20 formal research alliances with leading universities and research institutions around the world, from Uruguay to China.

BRONZE

AUSTRALIAN PORK LIMITED
www.australianpork.com.au
APL is a unique rural industry service body for the Australian pork industry. It is a producer-owned company delivering integrated services that enhance the viability of Australia’s pig producers. The organisation aims to enhance opportunities for the sustainable growth of the Australian pork industry by delivering integrated marketing, innovation and policy services along the pork industry supply chain.

AUSTRALIAN WOOL INNOVATION
www.wool.com
Australian Wool Innovation Limited is a not-for-profit company that invests in R&D and marketing to increase the long-term profitability of Australian woolgrowers. Based in Sydney, AWI has offices in key markets around the world to help us increase the global demand and market access for Australian wool.

DAIRY AUSTRALIA
www.dairyaustralia.com.au
Dairy Australia is the national services body for the $13 billion Australian dairy industry. We act as the ‘investment arm’ of the industry, investing in projects that can’t be done efficiently by individual farmers or companies to help them adapt to the changing operating environment, and achieve a profitable, sustainable dairy industry.
ELANCO ANIMAL HEALTH
www.elanco.com.au
Elanco is a global leader in the discovery and development of products that improve animal health, performance and well-being. In doing so, our products play a direct role in maximising the health and efficiency of livestock animals; ensuring consumers have access to an abundant, affordable and safe source of food and fibre. Likewise, our expanding range of innovative companion animal products enables veterinarians to help pets live longer, healthier and higher-quality lives.

GRIFFLES PATHOLOGY
www.gribblesvets.com.au
Gribbles Veterinary Pathology is the longest-established veterinary pathology provider in Australia, and has had a long standing relationship with PIRSA in South Australia. Our focus is to provide expert pathology services and excellent customer service, by partnering with our clients to develop innovative solutions that meet their needs. We have nine pathologists (including four registered specialists) operating in Melbourne and Adelaide.

STEGGLES
www.steggles.com.au
With a heritage that dates back to 1919, Steggles is an iconic Australian brand and one of the most progressive in the poultry industry. Steggles is renowned for quality and innovation. The Steggles brand is highly recognised by Australian consumers and has a proud reputation for upholding traditional, family oriented values.
### Monday, July 4, 2016

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<tr>
<th>Time</th>
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| 3:45pm – 5:00pm | Ballroom 5   | **Careers Master Class for students**  
Session chair: Phil Hynd and Emily Buddle |
|                |              | Prof Mike Looper  
University of Arkansas USA  
Building your brand: turning opportunities into a career |
|                |              | Prof James Sartin  
Journal Of Animal Science  
Scientific publications: Surviving the editorial process |
|                |              | Geoff Lucas and Felicity Davies  
Lucas Group  
Getting your resume into shape |
| 4:30pm – 5:30pm |              | Poster collection and mounting |
| 5:00pm – 5:30pm |              | Speakers’ Briefing |
| 6pm – 8pm      | Ballroom 2 and 3 | **Animal Production 2016 Welcome Reception**  
Business Attire |

### Tuesday, July 5, 2016

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<tr>
<th>Time</th>
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<th>Session</th>
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| 8:30am – 10:30am | Plenary Room | **Animal welfare – what is it? How do we measure it? How can we make animals’ lives better?**  
Session chairs: Phil Hynd and Chris Logan |
|                |              | Prof Temple Grandin - 1433  
University of Colorado USA  
Animal handling and welfare |
|                |              | Alan Tilbrook - 1288  
SARDI  
Hormones, Stress and Animal Welfare  
(BARNETT MEMORIAL LECTURE) |
|                |              | Tina Widowski - 1422  
University of Guelph  
Translating animal welfare science into animal care standards |
| 11:00 – 12:30   |              | **Major welfare issues facing the animal industries in Australia.**  
Session chairs: David Scobie and Kate Collins |
|                |              | Jojo Jackson - 1493  
AECL  
Poultry eggs: Australian animal welfare priorities |
|                |              | Jim Rothwell - 1400  
Meat and Livestock Australia  
Red meat: Australian animal welfare priorities |
|                |              | Andrew Spencer - 1432  
Australian Pork Limited  
Pork: Australian animal welfare priorities |
|                |              | Kathryn Davis - 1147  
Dairy Australia  
Dairy: Australian animal welfare priorities |
|                |              | Kylie Hewson - 1287  
RIRDC  
Chicken meat: Australian animal welfare priorities |
|                |              | Geoff Lindon  
AWI  
Wool: Australian animal welfare priorities |
|                |              | Cameron Hall  
Elders  
Commercial live export: Australian animal welfare priorities |
|                |              | Cross-species facilitated discussion |
|                |              | **Morning Tea** |

**Sponsored by:**

- [Australian Pork](#)
- [Dairy Australia](#)
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<tr>
<th>Time</th>
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<td><strong>Lunch</strong></td>
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<tr>
<td>1:30pm – 3:00pm</td>
<td>Plenary Room</td>
<td><strong>Consumers and animal welfare: consumer attitudes to, and influence on, animal welfare.</strong></td>
<td>Wayne Pitchford and Juan-Felipe M Rocha</td>
<td>Grahame Coleman - 1202 University of Melbourne</td>
<td>Relevance of public attitudes to animal welfare for the pork industry</td>
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<td>Heather Bray - 1421 University of Adelaide</td>
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<td>Not all Australian families find it easy to talk about where meat comes from</td>
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<td>Emily Buddle - 1420 University of Adelaide</td>
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<td>Consumers link ‘better’ farm animal welfare with better quality products</td>
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<td>Lenka Malek - 1419 University of Adelaide</td>
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<td>Consumer valuation of and attitudes towards farm animal welfare claims</td>
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<tr>
<td><strong>Afternoon Tea</strong></td>
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<tr>
<td>3:30pm – 5:00pm</td>
<td>Plenary Room</td>
<td><strong>Animal health, survival and resilience.</strong></td>
<td>Geoff Hinch and Lydia Farrell</td>
<td>Joanne Conington - 1495 Scotland’s Rural College</td>
<td>Breeding better health and welfare in sheep – what is compromised if we do?</td>
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<td></td>
<td>Jason Trompf - 1498 JT Agri-Source</td>
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<td>Survive and Thrive ‘You can have your cake and eat it too’</td>
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<td>Kate Plush - 1415 SARDI</td>
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<td>Preparing the neonate for the transition from intra- to extra-uterine life</td>
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<td><strong>5:00pm – 6:00pm</strong></td>
<td><strong>Plenary Room</strong></td>
<td><strong>Alltech Networking Hour</strong></td>
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<td>Opportunity to engage presenters on their poster topic with a glass of wine and cheese.</td>
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<td><strong>6:00pm – 7:00pm</strong></td>
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<td><strong>Society General Meetings (for members and prospective members)</strong></td>
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<td>ASAP BGM – Plenary Room NZSAP AGM – Ballroom 5</td>
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<td>7:00pm</td>
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<td>Explore Glenelg’s local dining options</td>
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Wednesday, July 6, 2016

8:30am – 10:00am | Plenary Room
Grazing systems: integrating crops and animals; animals and the environment.
Session chairs: Michael Friend and Carolina Gallardo

Hugh Dove - 1431
CSIRO

Systems impacts of introducing crop grazing into pasture-based systems
(MCCLYMONT MEMORIAL LECTURE)

Antonio de Vega - 1179
University of Zaragoza, Spain

Grazing systems: integrating crops and animals
(STOBBS MEMORIAL LECTURE)

Richard Eckard - 1270
Primary Industries Climate Challenges Centre

Climate challenges for pastoral agriculture in Australia

Morning Tea

10:30am – 12:15pm | Plenary Room
ASAP Student Snapshot – Concurrent Session 1 of 2
Session chairs: Cindy Bottema
Judges: Temple Grandin, Geoff Lucas and Hamish Dickson

1303 Victoire De Raphelis-Soissan
Feeding frequency and rate of nitrate ingestion affect nitrite toxicity in sheep supplemented with dietary nitrate

1172 Cassius Coombs
Sponsor: ASAP NSW
Effect of eight weeks chilled or frozen storage on consumer-defined sensory quality traits of lamb

1255 Lea Labeur
Effect of combined cold, transport and handling stress in mid- and late-pregnancy on morphometric measures in lambs

1210 Joshua Philp
Withholding lucerne in summer to feed in subsequent winter feed deficits modestly increases feed efficiency of small mixed farms in western China

1220 Alannah Mackay
Testing a model to initiate feather pecking in free-range laying hens

1290 Jaime Manning
Sponsor: ASAP NSW
The impact of forage availability on livestock behaviour in Australian heterogeneous paddocks

1323 Laura Villar
Nitrate and canola oil are synergistic in reducing methanogenesis in cattle

1014 Muhammad Shoailb Tufail
Development of village-based forage seed enterprises through farmer participatory research approach by varietal selection and evaluation

1262 Peta Taylor
Productivity, leg health and range use of individual broiler chickens on a free-range commercial farm

1215 Carolina Munoz
Reliability and feasibility of animal-based indicators to assess the welfare of extensively managed ewes.

1222 Emma Pettigrew
Can farmers select good rams based on phenotype?

1239 Emily Grant
Qualitative behavioural assessment (QBA) of remotely captured video footage can identify positive and negative welfare states in sheep

1052 Paula Alejandra Gonzalez-Rivas
Reducing rumen starch fermentation of wheat with 3% NaOH has the potential to ameliorate the effect of heat stress in grain-fed sheep.

1265 Lucy Watt
Lamb growth and in vivo organic matter digestibility of arrowleaf clover and bladder clover hay

1230 Maddison Corlett
Including biserrula chaff in the diet of sheep reduced methane yield on the basis of energy intake

1249 Dr Kate Loudon
On farm factors increasing dark cutting in beef cattle

1307 Lauren Staveley
Sponsor: Pork CRC
The effect of maternal parity and birth weight on ovarian follicle population of female pigs (gilts).

1200 Mandy Bowling
Sponsor: Pork CRC
Heart rate variability as an indicator of pig welfare

1243 Patricia Condous
Sponsor: Pork CRC
Use of strategic sow confinement with farrowing induction can achieve similar stillborn mortality and reduce overlay caused piglet mortality compared to loose housed sows

1199 Jamee Seccafien
Sponsor: Pork CRC
The effects of heat stress on porcine oocyte maturation, Fertilisation and embryo development and methods of alleviation
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<th>Session</th>
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<th>Abstract</th>
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<tr>
<td>1201</td>
<td>Farrah Preston Sponsor: SASAG</td>
<td>Pre-slaughter washing increases dark cutting incidence in beef</td>
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<tr>
<td>1205</td>
<td>Octavia Kelly Sponsor: SASAG</td>
<td>Lamb survival should be considered separate genetic traits across different birth types</td>
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<tr>
<td>1273</td>
<td>Hussein Al-Moadhen Sponsor: SASAG</td>
<td>Implementing the Australian Funded ‘On-The-Ground’ Aid Program at the Holy Karbala Sheep Research Station in Iraq</td>
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<td>1286</td>
<td>Emily Buddle Sponsor: SASAG</td>
<td>Meat Consumers Ignore Online Animal Welfare Activism</td>
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<td>1310</td>
<td>Haylee Clifford Sponsor: SASAG</td>
<td>Grape marc inclusion in ruminant diets reduces protein absorption</td>
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<td>1254</td>
<td>Risa Antari Sponsor: ASAP QLD</td>
<td>Metabolisable energy intake but not crude protein intake or bovine somatotropin hormone (bST) increased hip height in Bos indicus cross steers</td>
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<td>1268</td>
<td>Jarud Miller Sponsor: ASAP QLD</td>
<td>Are neonatal beef calves getting enough to drink in northern Australia?</td>
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<td>1260</td>
<td>Andrea Wallage Sponsor: ASAP QLD</td>
<td>Exposure of bulls to high heat load decreases efficacy of scrotal thermoregulation</td>
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<tr>
<td>1251</td>
<td>Tanya Nowland Sponsor: Pork CRC</td>
<td>Caffeine increases an neonatal piglets body temperature and negatively effects survival at 24 hours of age</td>
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10:30am – 12:15pm    | Ballroom 5
**NZSAP Presidential Address & NZ Young Scientists** – Concurrent Session 2 of 2
Session chairs: Chris Logan

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<tr>
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<tr>
<td>NZSAP 26</td>
<td>Rhiannon Handcock</td>
<td>More dairy heifers are achieving liveweight targets</td>
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<td>NZSAP 2</td>
<td>Gabriella Gronqvist</td>
<td>Does ewe nutrition during pregnancy affect the neonatal behaviour of twin-born lambs?</td>
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<td>NZSAP 6</td>
<td>Catherine O’Connell</td>
<td>Sustained diuretic effect of plantain when ingested by sheep</td>
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<tr>
<td>NZSAP 12</td>
<td>Lisa Box</td>
<td>Milk production and urinary nitrogen excretion of dairy cows grazing perennial ryegrass-white clover and pure plantain pastures</td>
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<tr>
<td>NZSAP 7</td>
<td>Lydia Jane Farrell</td>
<td>Urine excretion of non-lactating dairy cows in late gestation fed fodder beet and kale based diets in winter</td>
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<tr>
<td>NZSAP 48</td>
<td>Irene Lingjun Zhang</td>
<td>Using genomic information to predict sex in dairy cattle</td>
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Lunch
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<tr>
<th>Time</th>
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<th>Session Chairman(s)</th>
<th>Title</th>
<th>Authors</th>
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<tr>
<td>1:15pm – 3:15pm</td>
<td>Colley</td>
<td>Forbes Brien and Kate Loudon</td>
<td><strong>Breeding</strong> – Concurrent Sessions 1 of 3</td>
<td>Days to calving and inter-calving interval in beef and dairy-beef crossbred cows</td>
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<td></td>
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<td><strong>NZSAP 31 ST Morris</strong></td>
<td><strong>Breeding</strong> – Concurrent Sessions 1 of 3</td>
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<td><strong>Preliminary Investigations into the Genetics of Residual Feed Intake in Sheep</strong></td>
<td><strong>NZSAP 45 Patricia Johnson</strong></td>
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<td>Relationships among methane traits in cattle fed ad libitum roughage diet</td>
<td><strong>NZSAP 19 Alan M Hurley</strong></td>
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<td>Genetics of alternative definitions of feed efficiency in grazing lactating dairy cows</td>
<td><strong>NZSAP 19 Alan M Hurley</strong></td>
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<td>Feed intake for sheep can be measured precisely in less than 35 days</td>
<td><strong>NZSAP 1252 Claire MacLeay</strong></td>
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<td>An update on genetic parameters for facial eczema tolerance in sheep</td>
<td><strong>NZSAP 42 Kathryn McRae</strong></td>
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<td>NZ Corriedale Performance Recording</td>
<td><strong>NZSAP 30 John Booker</strong></td>
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<td>The impact of divergent selection for methane yield on age at puberty</td>
<td><strong>1219 Dr Kath Donoghue</strong></td>
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<td>Estimation of genetic parameters for milk yield traits at different herd production level in cows milked once- or twice-daily</td>
<td><strong>NZSAP 32 Felipe Lembeye</strong></td>
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<td>DEERSelect – review of the first decade</td>
<td><strong>NZSAP 40 Jamie Ward</strong></td>
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<td>Genetic parameters of female reproductive traits measured by ultrasound in beef cattle</td>
<td><strong>1238 Nicholas Corbet</strong></td>
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<td>Impact of date of birth recording in genetic evaluation in sheep</td>
<td><strong>NZSAP 51 Sharon McIntyre</strong></td>
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<tr>
<td>1:15pm – 3:15pm</td>
<td>Plenary Room</td>
<td></td>
<td><strong>Grazing / Pastures / Supplements</strong> – Concurrent Sessions 2 of 3</td>
<td>Days to calving and inter-calving interval in beef and dairy-beef crossbred cows</td>
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<td></td>
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<td>Session chairs: Paul Kenyon and Andrea Wallage</td>
<td>Days to calving and inter-calving interval in beef and dairy-beef crossbred cows</td>
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<td><strong>1138 Dr Di Mayberry</strong></td>
<td>Quantifying the scale of livestock yield gaps in India and identifying opportunities for investment</td>
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<td><strong>1148 Dr Cesar Pinares</strong></td>
<td>Influence of integration of dual-purpose wheat and canola crops in a pasture system on liveweight of Merino sheep</td>
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<td><strong>1272 Ian McFarland</strong></td>
<td>Pastures from Space - a practical application</td>
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<td><strong>1283 Renelle Jeffrey</strong></td>
<td>It’s Ewe Time - a national productivity stimulation campaign</td>
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<td><strong>1118 Dr Lindsay Bell</strong></td>
<td>Feed-base strategies that reduce risk of feed-gaps in livestock systems across Australia’s mixed farming zone</td>
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<td><strong>1136 Dr Maree Bowen</strong></td>
<td>The profitability of forage options for beef production in the subtropics of northern Australia</td>
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<td><strong>1203 Dr Robin Dobos</strong></td>
<td>Inferring rumination behaviour from a tri-axial accelerometer</td>
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<td><strong>NZSAP 63 David Pacheco</strong></td>
<td>Plasma amino acid profiles of lactating dairy cows feed fodder beet and ryegrass diets</td>
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<td><strong>NZSAP 14 Lydia Cranston</strong></td>
<td>Effect of early weaning onto a plantain-clover mix on ewe and lamb performance</td>
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<td><strong>NZSAP 24 Aimi Nabilah Hussein</strong></td>
<td>Social dominance and milk production of grazing dairy cows in New Zealand.</td>
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<td><strong>NZSAP 20 Racheal Bryant</strong></td>
<td>Does mowing before grazing increase dry matter intake and milk yield of late lactation dairy cows?</td>
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<td><strong>NZSAP 61 Rene Corner-Thomas</strong></td>
<td>The use of Farm management tools by New Zealand sheep farmers: changes over time</td>
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### Welfare Issues / Measurement – Concurrent Sessions 3 of 3

**Session chairs:** Kate Plush and Patricia Condous

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<thead>
<tr>
<th>NZSAP 34 Mhairi Sutherland</th>
<th>An investigation of automated measures for assessing pain-induced distress in dairy calves</th>
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<tr>
<td>NZSAP 18 Melissa Hempstead</td>
<td>A physiological evaluation of the efficacy of pain-mitigation strategies for cauterized and disbudded goat kids</td>
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<tr>
<td>NZSAP 5 Jamie Ward</td>
<td>Development and evaluation of a temperament scoring system for farmed deer - genetic and environmental components</td>
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<td>NZSAP 9 C. Trotter</td>
<td>Liver Abscessation in Pasture Based Beef Bulls in the South Island of New Zealand - The Incidence and Effect on Carcass Weight.</td>
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<tr>
<td>1261 Brett Wilson</td>
<td>Wild dog predation and flock productivity - field methods to quantify stress and behavioural responses of sheep in the line of fire</td>
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<td>1197 Dr Amanda Doughty</td>
<td>Remote monitoring for wellbeing in grazing sheep: are social behaviours useful?</td>
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<td>1266 Tellisa Kearton</td>
<td>Positioning of sensing microchips for detecting core temperature changes in sheep</td>
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<tr>
<td>1037 Dr Edward Narayan</td>
<td>Optimising non-invasive cortisol measurement in sheep (Ovis aries)</td>
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<td>1180 Dr Cathy Burnard</td>
<td>Longer distances are better for measuring flight speed in sheep</td>
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<tr>
<td>1174 Joanna Blunden</td>
<td>Beyond consumer defined welfare - paddock based egg production</td>
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<td>1156 Dr Greg Cronin</td>
<td>The impact of a feather-pecking outbreak in an experimental free-range layer flock on growth, egg production, plumage damage and mortality</td>
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<tr>
<td>1181 Dr Brian Horton</td>
<td>Mortality in adult ewes associated with cold conditions despite moderate length wool</td>
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**Afternoon tea**

### Meat Science – Concurrent Sessions 1 of 3

**Session chairs:** David Rutley and Jena Alexopoulus

<table>
<thead>
<tr>
<th>NZSAP 43 PJ Back</th>
<th>Do different grazing strategies affect pre-weaning calf growth rates?</th>
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<tr>
<td>NZSAP 47 Wendy Bain</td>
<td>Variation in total body fatness, and fat distribution in maternal sheep estimated using computed tomography scanning</td>
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<td>1193 Dr Shawn McGrath</td>
<td>Turning dual-purpose wheat into meat: comparison of Merino and White Dorper maternal systems on a mixed-farming feedbase</td>
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<tr>
<td>1454 Dr Robert Banks</td>
<td>Balancing efficiency of production and product quality with new tools – the example of lamb</td>
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<tr>
<td>1221 Bruce Hancock</td>
<td>The Lamb Supply Chain Group provides a model for engaging value chains</td>
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<td>1313 Stephanie Fowler</td>
<td>Prediction of beef eating quality using Raman spectroscopy</td>
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<td>1195 Dr Janelle Hocking Edwards</td>
<td>Genomic breeding values for Lean Meat Yield, Intramuscular Fat and Shear Force do not affect live lamb production traits</td>
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<tr>
<td>NZSAP 56 PJ Back</td>
<td>Calf grazing behaviour and preference</td>
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<tr>
<td>NZSAP 4 Bryan Thompson</td>
<td>The impact of lamb pre and post weaning growth rate on farm profitability</td>
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<tr>
<td>NZSAP 38 Laura Deeming</td>
<td>Variability in growth rates of goat kids on 16 New Zealand dairy goat farms</td>
</tr>
<tr>
<td>NZSAP 17 Nicholas W Sneddon</td>
<td>Lactation curves for yields of dairy products from Holstein Friesian, Jersey and Holstein Friesian-Jersey crossbred cows.</td>
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### Grazing / Pastures / Supplements – Concurrent Sessions 2 of 3

**Session chairs:** Dennis Poppi and Jaime Manning

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<thead>
<tr>
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<tr>
<td>1247</td>
<td>Tim Hillier: Demonstrating a successful premium pasture-fed beef value chain</td>
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<td>1159</td>
<td>Dr Ferrier: Phenotypes to meet pasture-fed market requirements</td>
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### Repro – Concurrent Sessions 2 of 3

**Session chairs:** Rebecca Hickson and Jose Webb

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<tbody>
<tr>
<td>1:30pm – 3:10pm</td>
<td>Plenary Room</td>
<td><strong>Changing the sex ratio of lambs may alter gross margins in sheep flocks</strong></td>
<td>Prof Michael Friend</td>
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<td><strong>Development of a remote sensing device to detect duration of parturition in ewes</strong></td>
<td>Dr Sabine Schmoelzl</td>
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<tr>
<td>1145</td>
<td></td>
<td><strong>The effect of weight and age on pregnancy rates in maiden Brahman heifers in northern Australia.</strong></td>
<td>Tim Schatz</td>
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<tr>
<td>NZSAP 27</td>
<td></td>
<td><strong>Reproductive production constraints within the New Zealand racing industry</strong></td>
<td>Chris Rogers</td>
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<tr>
<td>NZSAP 3</td>
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<td><strong>The impact of dam age on ewe reproductive performance at two years of age</strong></td>
<td>Paul Kenyon</td>
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<td>NZSAP 8</td>
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<td><strong>The influence of previous lactation on subsequent fertility in multiparous ewes?</strong></td>
<td>David Scobie</td>
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<tr>
<td>NZSAP 29</td>
<td></td>
<td><strong>Which traits best predict ewe performance and survival the following year on a UK hill farm?</strong></td>
<td>Harriet Wishart</td>
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### Grazing / Pastures / Supplements – Concurrent Sessions 3 of 3

**Session chairs:** Janelle Hocking Edwards and Melissa Hempstead

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<tr>
<td>1:30pm – 3:10pm</td>
<td>Ballroom 5</td>
<td><strong>No production response of injectable trace minerals in young cattle grazing pasture based systems in the Northern Territory</strong></td>
<td>Kieren McCosker</td>
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<tr>
<td>1139 Prof Nagalakshmi Devanaboyina</td>
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<td><strong>Supplementation of zinc-proteinate on serum biochemical parameters, antioxidant status, immune response and ovarian follicles in buffalo heifers</strong></td>
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<td>834 Prof David Cottle</td>
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<td><strong>Novel livestock supplementation: reducing shy feeders</strong></td>
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<td>1229 Dr Mariana Caetano</td>
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<td><strong>Effect of ensiled crimped grape marc on growth performance and methane emissions of Angus steers</strong></td>
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<tr>
<td>1290 Dr Rob Dixon</td>
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<td><strong>Productivity and phosphorus content of rib and tail bones in reproducing cows ingesting diets deficient or adequate in phosphorus</strong></td>
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<td>1143 Dr Helen Golder</td>
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<td><strong>Metabolome and microbiome associations after a grain and sugar challenge</strong></td>
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<td>1296 Michael Wilkes</td>
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<td><strong>Pasture quality and pre-slaughter mob movements increase the incidence of dark cutting beef</strong></td>
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<td>1278 Dr Dean Thomas</td>
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<td><strong>The case for livestock monitoring in the mixed farming region - is it possible to reduce management complexity without adding to it?</strong></td>
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<td>NZSAP 1 J Kleinman</td>
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<td><strong>Feed value of maize silage in New Zealand</strong></td>
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### Afternoon Tea

### Forward Thinking – Where to from here?

**Session chairs:** Phil Hynd and Chris Logan

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<td>3:30pm – 4:30pm</td>
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<td>793 Dr Mary-Jane Rogers</td>
<td>Are pre- and post-grazing measurements of nutritive characteristics appropriate for defining what a cow actually consumes?</td>
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<td>841 Dr Simon Quigley</td>
<td>Liveweight gain, dry matter intake, hip height change, cortical bone thickness and phosphorus in the plasma and faeces of Bos indicus crossbred steers all increase in response to increasing phosphorus intake</td>
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<td>1194 Dr Mary Fletcher</td>
<td>Thermo-alkaline Degradation of Hepatotoxic Indospicine in Camel Meat</td>
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<td>Does melatonin enhance reproductive performance of Border Leicester rams mated to Merino ewes in spring?</td>
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<td>1207 Jane Court</td>
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<td>1209 Dr Rachelle Hergenhan</td>
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<td>1211 Mario Lema</td>
<td>Can nutritional level and parental EPD for rib eye area influence feed conversion efficiency and carcass yield in steers?</td>
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<td>1212 Dr Georgett Banchero</td>
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<td>Forage quantity and quality of dual-purpose wheat: changes during grazing and implications for livestock production</td>
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<td>Providing pasture choice to sheep reduced intensity of methane emissions and increased growth compared with annual ryegrass</td>
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<td>Dr Michelle Hebart</td>
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<td>4-Nonylphenol induced Genotoxicity assessment in blood cells of fish Channa punctatus using Comet Assay</td>
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KEYNOTE SPEAKERS

TEMPLE GRANDIN, UNITED STATES

Professor Temple Grandin is known for her award-winning work on the design of animal handling facilities. She was born in Boston, Massachusetts, and at age two had no speech and showed signs of severe autism. Many hours of speech therapy and intensive teaching enabled Prof Grandin to learn to speak. Mentoring by her high school science teacher and her aunt, who lived on a ranch in Arizona motivated her to study and pursue a career as a scientist and livestock equipment designer. Prof Grandin obtained her BA at Franklin Pierce College in 1970. In 1975 she earned her MS in Animal Science at Arizona State University for her work on the behaviour of cattle in different squeeze chutes. Prof Grandin was awarded a PhD in Animal Science from the University of Illinois in 1989 and is currently a Professor at Colorado State University.

JOHN BLACK, AUSTRALIA

Eric Underwood Memorial Lecture
Dr John Black describes himself as a reductionist scientist with a strong desire to understand underlying mechanisms, but then to integrate the pieces, quantitatively, back into a whole system – the essentials of modelling. He runs a research management company, John L Black Consulting, where as a Research Management Consultant he manages research programs for a wide range of rural research and development organisations and private companies. His activities include working for the beef, dairy, pig, poultry, grains, fodder and honeybee industries. He previously worked as a Chief Research Scientist at CSIRO, was Officer-in-Charge of the Prospect laboratory in Sydney and an Adjunct Professor in veterinary science at the University of Sydney.

KRISTEN BRENnan, UNITED STATES

Dr Kristen M Brennan is a research project manager at Alltech’s Center for Animal Nutrigenomics and Applied Animal Nutrition in Nicholasville, Kentucky. She received her Bachelor and Master degrees in animal science from the University of Massachusetts Amherst. In 2008, she completed a PhD in Animal Science at Washington State University. Upon completion of her PhD, she joined Alltech as a post-doctoral research fellow. Currently, she manages the animal nutrigenomics and equine nutrition research programs. She is especially interested in establishing a link between nutritional genomics approaches and applied nutrition research in a variety of agricultural animal models. Dr Brennan also serves as the Institutional Animal Care and Use Committee chairperson and is an adjunct assistant professor in the College of Ag at the University of Kentucky.

JOANNE CONINGTON, UNITED KINGDOM

Dr Joanne Conington is a Reader in Applied Livestock Genetics in the Animal and Veterinary Sciences research group, Scotland’s Rural College (SRUC, previously known as SAC). Her research focuses on the development of new, broader breeding goals for multi-trait breeding programs incorporating aspects of disease resistance and maternal efficiency. Her present research is mostly undertaken in collaboration with industry partners investigating genetic and genomic approaches to breed for resistance to mastitis in sheep and goats, footrot and internal parasites in sheep, lamb survival and ewe longevity. She lectures to undergraduate and postgraduate students at SRUC and the University of Edinburgh and also advises the UK Government on animal breeding issues relating to animal welfare.
ANTONIO DE VEGA, SPAIN 1179

Harry Stobbs Memorial Lecture

Dr Antonio de Vega is currently an Associate Professor at the University of Zaragoza in Spain, and is Head of the Department of Animal Production and Food Sciences. He completed a B Vet Med degree at Zaragoza, and was awarded a PhD in rumen kinetics in sheep. After completing his PhD, Dr de Vega moved to the University of Queensland to work as a postdoctoral fellow for two years, during which he gained experience on the understanding of digesta particle kinetics in ruminants. Dr de Vega is concerned about viable ruminant production in semi-arid and arid environments, where pasture availability is scarce. He has been working for more than 15 years on the use of cereal crops and their by-products as feed for grazing ruminants.

HUGH DOVE, AUSTRALIA 1431

Hugh Dove was an Honorary Research Fellow at CSIRO Agriculture, Canberra, but recently retired after a 40-plus year career with the organisation. After completing an agricultural science degree, a diploma in education and then a PhD at the University of Melbourne, he joined CSIRO Plant Industry in 1975 and since then, has been involved in studies on the nutrition of grazing animals, principally sheep and cattle. Much of his work has been directed toward obtaining data with which to relate animal performance to pasture conditions, and data on the interaction between pastures and supplements. His work has been mainly with sown pastures but in the past decade, he has also worked extensively on the role of dual-purpose winter crops in grazing systems. In 2007, he was awarded the Research Medal of the Nutrition Society of Australia for services to animal nutrition research.

TAD SONSTEGARD, UNITED STATES 1418

Dr Tad Sonstegard is an internationally recognised leader in livestock genetics with more than 25 years of experience in the field. He has made seminal contributions to the sequencing of livestock genomes, been involved in the development of industry-standard genetic diagnostic platforms and elucidation of the genetic basis for traits impacting food animal health, production and well-being. Prior to joining the Recombinetics team, Dr Sonstegard developed and led federally funded projects in applied genomics for ruminant genetic improvement at the United States Department of Agriculture Agricultural Research Service’s Animal Genomics & Improvement Laboratory. He holds a BS in Agricultural Biochemistry from Iowa State University and a PhD in Molecular, Cellular, Developmental Biology and Genetics from the University of Minnesota.

TINA WIDOWSKI, CANADA 1422

Tina Widowski is a Professor of Animal Biosciences and Director of the Campbell Centre for the Study of Animal Welfare at the University of Guelph, Ontario, Canada, and holds BS, MS and PhD degrees from the University of Illinois-Urbana. With training in animal behaviour and physiology, she uses a variety of measures to determine how the housing and management of farm animals affects their welfare. Prof Widowski has studied diverse topics such as the endocrinology of nest building in sows, the behavioural responses of hens to different lighting systems, the ontogeny of feeding and drinking in piglets and motivation for dust bathing and nesting in laying hens. Her research group has tackled some difficult issues including transport and handling of market pigs and methods for euthanasia for piglets and poultry. In 2011, Prof Widowski was appointed the Egg Farmers of Canada Research Chair in Poultry Welfare.
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The impact of forage availability on livestock behaviour in Australian heterogeneous paddocks

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Summary

Cattle are selective grazers that actively search their landscape (forage) and selectively graze certain pasture species, especially in heterogeneous (non-uniform) paddocks commonly found in Australian extensive production systems. A variety of pasture (sugar, protein, fibre content etc.) and paddock (elevation, distance to water, temperature etc.) variables influence where cattle select and graze. By understanding the drivers of livestock foraging and fodder preferences, we have the potential to improve the way we monitor and manage livestock, such as through better paddock rotation. Further, with increasing concerns from consumer groups over the welfare of livestock in extensive systems, the ability to monitor livestock remotely using Global Navigation Satellite System (GNSS) technology will enable us to increase the level of monitoring and animal welfare, whilst coincidently gaining information at a paddock level about pasture availability and quality, which should contribute to increased efficiency of livestock production.

Introduction

Cattle forage preferences are impacted by numerous pasture attributes, with the most important being the quantity and quality of pasture (Senft et al. 1985; Bailey and Brown 2011). The grazing preferences of cattle, and the underlying drivers of foraging behaviour and fodder ingestion (grazing) will substantially determine the production potential of grazing systems and enterprise profitability. Key to these outcomes is improved knowledge for decision-making by farm managers (Trotter et al. 2008). Relevant management strategies include improved utilisation of pastures by timely paddock rotation, for example to ensure that a minimum ground cover is maintained. Traditionally, gaining information on cattle behaviour required direct observation in the paddock and was time consuming (Agouridis et al. 2004). However, with the incorporation of Global Navigation Satellite System (GNSS) technology in collars worn by livestock, we are able to remotely determine the location of livestock in real-time, while coincidently generating extensive data sets of the spatial behaviour of livestock over extended periods of time. Similarly, pasture biomass and quality analyses were subjective, time-consuming tasks. Due to the delay in receiving the findings, data were considered historical and consequently less likely to be undertaken by producers. However, the potential to apply remote sensing technologies to measure pasture quality and quantity (biomass) in real time, coupled with real-time information on grazing behaviour offer a practical means to help producers manage their pastures and livestock more precisely.

The majority of Australian paddocks are heterogeneous, meaning they are not uniform in terms of pasture species, altitude, slope or other paddock attributes such as the quality and quantity of pasture. Little research has been reported investigating the foraging behaviour and grazing preferences of livestock in these environments. It would seem that such information is important for the sustainability of profitable livestock production, especially with most Australian beef originating on pasture-based systems. Australian research is lacking on the range of pasture quality attributes such as protein, sugar and fibre content. Therefore, by better understanding what motivates foraging and grazing behaviour of beef cattle in these environments, improved management of paddocks should be achieved. Further, through the potential for remote monitoring of livestock within their environment, improved animal welfare outcomes should be achieved. The objectives of the trial described here were to evaluate the practicality of using remote sensing technologies to monitor pasture biomass, pasture quality attributes and cattle behaviour in the paddock. The effect on animal behaviour of cattle wearing a collar containing a GNSS unit was also evaluated.

Materials and Methods

A trial with 20 Charolais cows was conducted at The University of Sydney’s John Bruce Pye farm in Greendale NSW (33°56’19.18”S, 150°40’33.32”E). Ten randomly selected cows received a UNETracker II GNSS collar (Trotter et al. 2010). These GNSS collars were the same as previously used by Manning et al. (2014) on sheep, but following modification to include a larger box to fit a D-cell battery enabling a longer deployment. This 15-day trial was divided into three time periods: before, during and after GNSS collars to determine if cattle behaviour was affected by the presence of a GNSS collar. This information is crucial prior to conducting further studies to ensure that wearing a GNSS collar does not change the “normal” behaviour of cattle and thus impact the trial outcome. A catalogue of 12 behaviours was prepared and the behaviour of all 20 cows was recorded by direct observation from a distance of about 100-200 m assisted by binoculars. Behaviour was recorded at 5 minute intervals using a scan sampling technique in Noldus Pocket Observer (Noldus Information Technology, Wageningen, The Netherlands). Observation sessions occurred daily at 06:00-08:00 h, 09:00-10:00 h, 11:00-12:00 h, 14:00-15:00 h, 16:00-17:00 h, and 18:00-20:00 h. Statistical analysis compared behavioural differences (proportion of time) between collared (CD) and non-collared (NC) cows before, during and
after GNSS collar attachment using a Reduced Maximum Likelihood model (REML) in R. Additionally NDVI (Normalised Difference Vegetation Index) mapping using a CropCircle® system was conducted, providing an estimate of pasture biomass every 4-6 days.

**Results and Discussion**

There was no effect of wearing GNSS collars on cattle behaviour within the different time periods (before, during and after). Additionally, there was no difference between cow treatment group (CD or NC) and time period. Thus we are confident that future trials involving the attachment of GNSS collars to cattle will not change animal behaviour. The GNSS unit plus collar weighed 0.61 kg or about 0.1% of live weight (based on an average 607 kg). Whilst there was no difference in livestock behaviour when wearing UNEtracker II GNSS collars, it cannot be assumed that collars weighing significantly more than 0.1% of live weight will have the same affect.

The ability to collate the behaviour of cattle using direct observation provides us with qualitative information regarding activity in the paddock or at a pasture level. Over the period of the trial pasture biomass and NDVI declined linearly ($R^2 = 0.99$). However, the proportion of the cows’ time budget allocated to grazing increased. We assume the increase in grazing reflects the motivation of the animal to seek and consume feed in the situation of declining availability of fodder to meet nutritional requirements (Figure 1). If livestock producers were able to detect this change early on, or measure grazing behaviour in real-time, they could implement management decisions such as rotating cattle onto a new paddock before pasture was depleted, leading to a potential increase in production efficiency, pasture preservation and animal welfare.

Future research is currently underway into the pasture quality drivers of livestock preference, specifically the sugar, protein and fibre content in conjunction with various macro and micronutrients. By knowing the underlying quality of the pasture, animal movement and preference can be established for beef cattle in pasture-based grazing systems.

**Conclusions**

The results from this study demonstrated that GNSS collars weighing 0.1% of live weight did not have an effect on the behaviour of cattle managed extensively. It also highlights one use of GNSS technology to provide us with information about what is happening at a paddock level (the quantity and quality of pasture). This has the potential to change the way we manage and monitor livestock in extensive systems, whilst providing farmers with timely information, enabling them to increase the level of livestock monitoring whilst better managing their pastures.

Figure 1. The proportion of time spent grazing by Charolais beef cows versus average NDVI across the paddock (●) over the duration of the trial (15d). No difference in the proportion of time spent grazing was found between collared (■) and non-collared (▲) cows.

**Acknowledgements**

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**References**


Are pre- and post-grazing measurements of nutritive characteristics appropriate for defining what a cow actually consumes?

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Summary

The pasture mass and nutritive characteristics data from a three-year grazing management experiment on tall fescue in northern Victoria was used to estimate the nutritive characteristics of the pasture that was actually consumed by the dairy cows, rather than what was on offer by the pasture. Analysis of the estimated metabolisable energy and crude protein concentrations of the consumed pasture revealed that there were many unrealistic values, even when treatment means, rather than individual plots values, were used. When the data was divided into categories based upon the amount of consumed pasture at individual grazings, it was found that most of the occasions with unrealistically high values were associated with grazings in which <0.5 t DM/ha was consumed. This suggests the methodology is not appropriate for determining the nutritive characteristics of consumed pasture in situations when the amount of pasture consumed at any individual grazing is low.

Introduction

Tall fescue (\textit{Festuca arundinacea} (Schreb) Darbysh.) is a species that is well-suited to the high temperatures observed over summer in the irrigation region of northern Victoria. However, the species is not widely grown in the region because its grazing management is perceived to be more difficult than that of perennial ryegrass (Lawson et al 2016).

A large field experiment was conducted in northern Victoria to determine the effect of a range of grazing management regimes on the DM accumulation, forage removal, species composition, nutritive value and persistence of tall fescue-based pastures (Lawson et al 2016). The component of this research that is reported here relates to the methodology for determining the nutritive characteristics of the plant material that was actually consumed by the grazing dairy cow, rather than that which was on offer.

Materials and Methods

The experiment was conducted on a commercial dairy farm near Tatura in northern Victoria. A tall fescue / white clover pasture was sown in October 2010. The experimental was a randomized complete block design with six grazing treatments and four blocks (24 plots in total). The plots were 375 m\textsuperscript{2} (15 by 25 m) in area. The experimental site was managed under border-check irrigation.

Six grazing management treatments were imposed from September 2011 for 3 years, they were:

- **1-leaf** – grazed at the 1-leaf stage throughout the year.
- **2-leaf** – grazed at the 2-leaf stage throughout the year and at the 1.5 leaf stage during spring.
- **3-leaf** – grazed at the 3-leaf stage throughout the year and at the 2.0 leaf stage during spring.
- **Best Bet** – used the best grazing management practices for tall fescue as outlined in Milne \textit{et al}. (1998). Grazing frequencies were: Winter ~ 60 days, August/September ~ 25 days, October–December ~ 15 days, January–April ~ 21 days. Grazing residuals were 4–5 cm throughout the year except in October–November when pastures were grazed to ~ 3–4 cm.
- **Lax Spring** – as per Best Bet except that in October–December the pasture was grazed as per the January–April period, ie. every 21 days to a residual of 4–5 cm.
- **(Rye Freq)** – used the grazing frequencies that would be applicable for a perennial ryegrass pasture grazed using the 3-leaf stage approach (Lawson and Hildebrand (2003). (Grazing of perennial ryegrass throughout the year at the 2.5–3 leaf stage except during spring when it is grazed at the 2–2.5 leaf stage). All of the treatments were grazed to a residual height of 4.5 cm unless otherwise specified.

Lactating dairy cows were placed in the plots at the target grazing criteria and removed from the plots when the target residual was reached. Maximum time on any given plot was typically for 2–4 hours. The plots were topped to a height of 5–6 cm when required (but not more often than every second grazing).

Measurements made on the plots included pre- and post-grazing pasture mass and pre- and post-grazing nutritive characteristics (see Lawson \textit{et al}. 2016). A rising plate meter (Earle and McGowan 1979) was used to estimate pre- and post-grazing herbage masses, by collecting 50 height estimates in each plot. Forage nutritive characteristics were measured prior to each grazing by cutting ten toe cut samples (100 mm by 100 mm) from each plot to ground level. In Year 3, post-grazing samples were also taken using the same methodology.

The samples were dried at 60°C for 72 hrs, and then ground through a 0.5 mm sieve, prior to analysis for nutritive value using the DEDJTR laboratory at Horsham, Victoria which used the same techniques as previously used by FEEDTEST at Hamilton, Victoria. Analyses included crude protein (CP) and
in vitro dry matter digestibility (IVDMD). Metabolisable energy (ME) was calculated from IVDMD using:

\[ ME = 0.17 \times DMD - 2.0 \]  

(SCA 1990).

The nutritive characteristics of the consumed pasture \( (NV_{\text{con}}) \) were estimated using the formula:

\[ NV_{\text{con}} = (DM_{\text{pre}} \times NV_{\text{pre}} - DM_{\text{post}} \times NV_{\text{post}}) / (DM_{\text{pre}} - DM_{\text{post}}), \]  

(Wales et al. 1998)

where \( (DM_{\text{pre}}) \) and \( (DM_{\text{post}}) \) are pre- and post-grazing pasture masses, respectively, and \( (NV_{\text{pre}}) \) and \( (NV_{\text{post}}) \) are pre- and post-grazing nutritive characteristics, respectively.

All samples that had pasture consumption <0.1 t DM/ha or had an ash content >14 %DM were removed (18% of samples). Data was plotted using either individual plot data \( (n=255) \) or treatment averages \( (n=65) \). Treatment averages were only calculated if there were three or more valid samples for that grazing; the calculation involved averaging the \( DM_{\text{pre}}, DM_{\text{post}}, NV_{\text{pre}} \) and \( NV_{\text{post}} \) data for each treatment at each grazing, prior to calculating \( NV_{\text{con}} \). (Thereby mimicking a situation in which there was three or four times as many height estimates or toe cuts taken per sample).

**Results and Discussion**

There was a large amount of variation in the estimated ME and CP concentrations of the consumed pasture with many values being unrealistically high, particularly for ME (Fig 1). Using treatment means rather than individual plots had minimal effect upon the proportion of unrealistically high values.

When the ME and CP data was divided into categories based upon the amount of consumed pasture at any individual grazing (Fig 2), it revealed that most of the samples with unrealistically high values were associated with grazings in which <0.5 t DM/ha was consumed. When >0.5 t DM/ha was consumed, there were relatively few samples with unrealistic ME or CP values.

Over the entire three years of the experiment, 21% of the individual grazings had <0.5 t DM consumed (Table 1). These samples were concentrated in the most frequently-grazed treatments, particularly the 1-leaf and to a lesser extent the Best Bet and Lax Spring treatments. However, removal of these samples would make it difficult to compare the treatments in a systematic way.

In conclusion, the suitability of the methodology by Wales et al (1998) to determine the nutritive characteristics of consumed pasture appears to be very dependent upon the amount of pasture consumed at an individual grazing. We found that when pasture consumption was >0.5 t DM/ha, the majority of calculated nutritive characteristic values were realistic. However, when pasture consumption was <0.5 t DM/ha, there were many unrealistic values suggesting that the technique is not suitable in these situations.

**Acknowledgement**

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Teat sealant lowers milk somatic cell count

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Summary
A total of 2200 dairy cows had all 4 quarters treated with antibiotic dry cow therapy (ADCT) alone or in combination with internal teat sealant (ADCT + TS) at dry-off. Individual milk yield, fat and protein percentage, and individual cow cell count (ICCC) were measured at 14 ± 3 day intervals after calving for the first 60 days in milk (DIM). Clinical mastitis and health events were recorded from dry-off to 60 DIM. The combination of ADCT + TS decreased ICCC, compared to ADCT alone. The odds of at least 1 case of subclinical mastitis (ICCC ≥ 250,000 cells/mL) were 1.9 times higher [95% confidence interval (CI): 1.4 to 2.6] with ADCT alone in the first 60 DIM, compared to ADCT + TS. The combination of ADCT and TS provides benefits over ADCT alone through improved prevention of subclinical mastitis and reduced ICCC in the first 60 DIM.

Introduction
A recent meta-analysis by Rabiee and Lean (2013) showed bismuth subnitrate based internal teat sealant (TS) in the presence of ADCT reduced the risk of clinical mastitis after calving in lactating cows by 48% [risk ratio (RR) = 0.52; 95% CI 0.37 to 0.75]. Studies on the effects of the combination of ADCT and TS on milk ICCC and subclinical mastitis are limited but Godden et al. (2003) and Runciman et al. (2010) showed benefits in ICCC. Runciman et al. (2010) and Baillargeon and LeBlanc (2010) showed benefits for subclinical mastitis. The ADCT is designed to cure existing intra-mammary infections (IMI) and prevent the establishment of new IMI during the dry period (Smith et al. 1966). The TS mimics the protective effects of the keratin plug during the entire dry period by forming a physical barrier against mastitis-causing organisms entering the teat. The objective of this study was to determine the efficacy of a TS product when used in combination with ADCT, administered at dry-off, on milk ICCC, milk production and components, and the incidence of clinical and subclinical mastitis in multiparous dairy cows up to 60 DIM, compared to ADCT only.

Materials and Methods
Multiparous cows from 8 commercial pasture-based dairy herds in Southern and Eastern Australia were enrolled in this multicentre, randomised controlled trial with blocking between May 2014 and June 2015. All experimental procedures were approved by the Scibus Animal Ethics Committee (Scibus 0414-1215).

Herds were selected on (1) location, (2) willingness to comply with the study protocol, (3) number of cows, (4) good biographical records of cows, (5) absence of Mycoplasma bovis on a bulk vat PCR test (RtMastitis major-4, Dairy Technical Services Ltd., Kensington, Vic, Australia), and (6) eligibility of cows. Herds were not selected on the basis of previous mastitis incidence or ICCC. The target enrolment was 1000 cows per treatment group.

Cows were eligible for enrolment if they (1) had no clinical signs of disease, (2) had a predicted dry period between 40 to 80 days, (3) were entering at least their second lactation, (4) had 4 functioning quarters free from teat abnormalities with teat-end scores of ≤ 3 on a 1 to 5 scale (Britt and Farnsworth Unknown Year), (5) lameness score ≤ 2 on a 1 to 5 scale (Sprecher et al. 1997) (6) had not received antibiotic or anti-inflammatory treatment during the previous 30 days, (7) had a body condition score of 2 to 4 on a 5 point scale (Edmondson et al. 1989), and (8) had unique identification.

Cows were assigned to 1 of the 2 following treatment groups: ADCT or ADCT + TS based on the following blocking factors: anticipated calving date, and milk production and ICCC from previous herd test using statistical software (SAS for Windows Version 9.3, Cary, NC, USA). Randomisation was performed for each herd and cohort within each herd. The ADCT (Orbenin Enduro Dry Cow, Zoetis Australia, Silverwater, NSW, Australia) contained Dynomilled cloxacillin at 600 mg/syringe (syringe weight = 3.6 g) and the TS (Teatseal, Zoetis Australia) contained bismuth subnitrate at 650 mg/g (syringe weight = 4 g). Study personnel that administered the treatments were not masked to treatments. All other study, farm, and laboratory personnel were masked to treatment allocation.

All dry-off treatments were administered by trained personnel wearing plastic gloves. Before treatment cows were milked out and teat-end scored (Britt and Farnsworth Unknown Year). Each teat-end was scrubbed with teatwipes that contained 70% isopropanol (Prepare Teatwipes, Zoetis Australia) until no manure or mud was visible on the wipe. Each quarter from every cow was infused with 1 syringe of ADCT in the teat canal and ADCT was massaged up the teat ends. Tyloses were manually sprayed with diluted iodine.

In all 8 herds, enrolled cows were kept with the main herd throughout the study and were subjected to the routine management practices of the respective farm, including treatment protocols for clinical mastitis.

Milk yield, fat and protein percentage, and ICCC were measured at 14 ± 3 day intervals after calving for the first 60 DIM. The first measurement occurred between 10 to 24 DIM. Clinical mastitis and health events were recorded from dry-off to 60 DIM.
Statistical analysis was performed in SAS and not conducted by a person masked from the treatment allocation. Data were included in this analysis if: (1) A cow calved within a post dry-off interval of 40 to 100-days, (2) A cow had her first herd test on or between d 10 to 24 postpartum, and (3) A cow had at least one subsequent herd test, either 11 to 17 days after the first herd test (second herd test) or 22 to 34 days after her first herd test (analysed as data for third herd test). Data from individual herd tests were excluded if initiation of antibiotic treatment occurred within 7 days of a herd test or if the data was not a composite of both morning and afternoon sample measurements for all of the following variables: milk yield, fat and protein percentage, and ICCC.

Log-transformed ICCC, ICCC weighted by milk yield, milk yield, and fat and protein percentage were analysed using a general linear mixed model for repeated measures, with the fixed effects of treatment group, time point, and the interaction of these effects, the random effects of farm, block, and animal, and the interaction terms for treatment group and farm, and treatment group, time point, and farm. The time to clinical mastitis (days post-calving) was analysed using survival analysis methods for censored data, with non-mastitis cases censored at the time of the last herd test up to 60 DIM. The presence or absence of subclinical mastitis post-calving (at least one ICCC of ≥ 250,000 cells/mL between 10 to 60 DIM) was analysed using a generalized linear mixed model with the fixed effect of treatment group, the random effects of farm and block, and the interaction term for treatment group and farm.

Results

A total of 2200 cows were allocated to treatment groups and 2080 of these cows met the enrollment criteria. Of the enrolled cows, 1044 received ADCT and 1036 received ADCT + TS. In total, 1488 cows (71.5% of enrolled cows) met the inclusion criteria for analysis of herd test data: 739 from the ADCT group and 749 from the ADCT + TS group.

Milk yield, ICCC weighted by milk yield, and fat and protein percentage were not affected by the interaction of treatment and time or treatment. Treatment with ADCT + TS decreased geometric mean ICCC (P = 0.021), compared to treatment with ADCT alone. Geometric mean ICCC (x1000 cells/mL) was 32.0 (95% CI: 26.8 to 38.3) and 43.5 (95% CI: 36.2 to 52.1), respectively. The odds of at least one subclinical mastitis (ICCC ≥ 250,000 cells/mL) were 1.9 times higher (95% CI: 1.4 to 2.6%) with ADCT alone in the first 60 DIM, compared to ADCT + TS. Only 4 cows that calved 40 to 100 days after dry-off had a first case of clinical mastitis in the dry period. Five percent of cows that calved 40 to 100 days after dry-off had a first case of clinical mastitis between 0 and 60 DIM. Forty-three cases (5.7%) occurred in the ADCT group and 33 (4.3%) for the ADCT + TS group out of 1528 cows included in this analysis (P = 0.194). Proportional hazards estimates of survival showed there was no difference in the number of days post-calving to detection of first cases of clinical mastitis between the ADCT and ADCT + TS groups over the first 60 DIM (P = 0.153). The estimated hazard ratio for clinical mastitis over this period in the ADCT + TS cows was 0.70 (95% CI: 0.43 to 1.14%)

Discussion

The decrease in ICCC in early lactation in cows treated with the combination of ADCT and TS, compared to ADCT alone is likely to be the result of a combination of good hygiene at dry-off, the positive effects of the long acting antibiotics of the ADCT, and the TS mimicking the physical barrier of the keratin plug during the dry period.

Similar to our study, Godden et al. (2003) and Runciman et al. (2010) demonstrated benefits to ICCC in cows or quarters treated with ADCT and TS in combination, compared to ADCT. Baillargeon and LeBlanc (2010) observed only a trend (P = 0.07) toward decreased ICCC in ADCT + TS cows, compared to the ADCT cows at their second herd test. Mütze et al. (2012) found that the ICCC over the first 3 months of lactation was not different between ADCT and ADCT + TS treated cows (P = 0.37).

Runciman et al. (2010) showed that the RR of subclinical mastitis, defined as ICCC ≥ 250,000 cells/mL at their first herd test (conducted 7 to 50 DIM), in ADCT + TS treated cows, compared to ADCT only was 0.80 (95% CI: 0.65 to 0.98; P = 0.035). Our odds of reduction of subclinical mastitis in ADCT + TS cows were greater.

The lack of a significant effect of ADCT + TS on the incidence of clinical mastitis in this study is not consistent with results from a meta-analysis by Rabiee and Lean (2013) that showed the combination of ADCT and TS reduced the risk of clinical mastitis after calving in lactating cows by 48% (RR = 0.52; 95% CI: 0.37 to 0.75). However, the reduction in risk of 30% over the first 60 DIM is broadly consistent with many of the studies included in the meta-analysis by Rabiee and Lean (2013) and highlights the need for large numbers of cattle to provide adequate study power in health studies. Godden et al. (2003) produced a survival analysis using the Cox proportional hazards regression model with a very similar estimate for the reduction in risk of failure in treated quarters by 60 DIM (Hazard ratio = 0.67; P < 0.05) as observed in our study.

In conclusion, the combination of ADCT and TS provides benefits over ADCT use alone through improved prevention of the incidence of subclinical mastitis and reduced ICCC in the first 60 days of lactation.

Acknowledgements

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References

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Mobile feed bin trailers that enable control and monitoring of the maximum daily supplement intake by individual grazing cattle have been developed. Data from four trailers can be integrated via wireless to manage larger mobs within a paddock. Compared to using conventional feed bins and multiple recorded live weights, shy feeders can be removed to different management regimes quickly after supplement introduction. Animals cannot gorge on supplement, so deaths are less likely. Management groups can be fed differently without the need for drafting. Animals’ live weights can be used to remotely adjust individual maximum daily intakes to achieve targeted growth paths and faster finishing. Twice as many grazing heifers at 'Te Mania', with access to 2 Sapien trailers and 2 Greenfeed bins, ate supplement from the trailers. Of those heifers accessing both bin types, the proportion of their maximum daily allowance consumed was 3 times higher via the trailers.

**Introduction**

Prior research into smart feed bunks has produced the following list of key design criteria: animal throughput to suit mob size, feed holding capacity to optimise feed loading schedule, animal training and behaviour patterns to make the equipment as animal friendly as possible, transportation and logistics to ensure practical application, setup and commissioning fit for purpose in the paddock, reliability, low cost by clever choice and use of components to meet expected price points and a feed ration system to provide accuracy and flexibility.

Challenges to achieving this are: different animals feed at different rates, drafting shy feeders based on their short term liveweight (LW) change can be inaccurate, animal personalities result in different approaches to the feed bunk resulting in animals gaining weight at different rates with a wider LW spread at market time.

Using individual animal measurement at the feed bin and metering feed to each animal can control the amount any animal receives in any given time. We propose that one can profile animal personalities to allow mob creation based on similar feeding traits. We also propose that metering feed to individual animals provides much greater control over reducing feed waste by preventing overeating by an aggressive animal and giving all animals a chance to eat the prescribed amount for their current weight. Coupling the smart feed bunk to a Walk-Over-Weigh system would provide even greater accuracy for feeding to manage weight gain of the individual animal and to drive the weight gain of the individual animal, and therefore the entire mob, to a target market LW with greater accuracy.

Previous work, e.g. Bowman and Sowell (1997), Cockwill et al. (2000), Dixon et al. (2003), Eggington et al. (1990) and Kahn (1994), has shown that the supplement intake of individual animals varies widely within a herd or flock. This leads to a wider range of LWs at the end of the finishing period. It is well accepted that higher prices are received for more even mobs of cattle with some major domestic buyers, such as Coles and Woolworths, having well defined, tight ranges for the LW and condition of cattle that they purchase.

A study of reducing methane production by selecting on pasture intake generated data that allowed comparison of the distributions of stock access to supplement fed from Greenfeed (GEM) feed stations versus multi-feed station trailers (Sapien Technology).

**Materials and Methods**

At Te Mania Angus stud, Mortlake, Victoria, 122 heifers grazed a silver grass (40%), perennial ryegrass (30%), bent grass (25%) pasture with Yorkshire fog (5%) and were given access to two Sapien mobile trailers (Figure 1) that fed controlled amounts of maize supplement (1.5kg/hd/d maximum), each with four of six feed stations (2/3 per side) operating, starting on 14 September 2015.

**Figure 1. Two mobile feed trailers at Te Mania**

Regular daily maize intakes, from November 23rd to December 3rd, required for pasture feed intake estimates from pasture and faecal samples (Cottle 2016) were achieved in 57 of the 120 heifers. The heifers also had access between November 12th and December 12th to two GEM bins (units 26 and 53) to measure methane production (Cottle et al. 2015) during the trial period. There were 360 minutes between each feeding session (4 sessions/day); each feeding session comprised 5 feed drops spaced 40 seconds apart. Therefore the maximum number of feed drops offered was 20 drops (~0.69kg/day) across the 2 GEMs. The heifers were pre-trained onto the GEMs by
gradually pulling in the side panel wings to form the race leading into the GEM. The GEMs’ main purpose is methane measurement, not the supplementation of animals.

The same (attractant) maize supplement was used in the Sapien mobile trailers and the GEM bins. The total daily intake of maize supplement by individual animals was therefore calculated by adding the amount each heifer ate from both the Sapien and GEM bins.

The crushed maize supplement contained 92.99% lightly rolled maize, 3% bentonite, 3% lime, 1% molasses (Molafos Gold) and 0.01% Agolin.

The distributions of individual heifer daily maize supplement intakes from the Sapien trailers and Greenfeed bins were studied by calculating the relative daily intakes of each heifer as a proportion of the set daily maximum (Sapien: 1.50kg, GEM: 0.69kg). A linear model (JMP, 2016) with feed bin type as a fixed effect and a random animal effect (multiple days of data) was run using all non-zero, relative intake data and a subset of data from heifers that fed from both types of bin. Only 1 heifer can eat at a time at a GEM, whereas 2 heifers could feed side by side on each side of a Sapien trailer.

Results
The average LW of the 122 heifers on the 8 September was 363 ± 21.7 kg. The maize supplement was 89% dry matter (DM) and 82% digestible organic matter (as %DM).

The distributions of heifer numbers versus their average daily maize intakes for 16 days from November 17 to December 2 are shown in Figure 2. Half of the heifer mob did not visit either of the 2 GEMs, while only 13% (16/122) of heifers did not visit either of the 2 Sapien trailers. All heifers that ate at the GEMs also ate at the Sapien trailers, but not all heifers that ate from the Sapien trailers ate at the GEMs.

Discussion
Significantly more heifers accessed the feed stations on the 2 Sapien trailers than the 2 GEMs during the 16 trial days and those heifers eating at the trailers had higher proportional maize intakes. Waghorn et al. (2016) suggested a single GEM may handle up to 100 dairy cows as each cow averaged less than 2 visits per day, but they noted that the reasons for low and intermittent GEM visits were unknown. Cottle et al. (2015) also found an average of only 2 visits per day to GEMs which are designed for methane measurement.

The maximum daily intakes settings for the bins were influenced by the need to have not much pasture substitution caused by the supplement intake, as pasture intake estimation was the main aim of the project. Ideally the maximum set would have been the same for both types of bins but rescaling the average daily supplement intakes to the proportion of maximum allowed daily intake would reduce any unknown bias.

It can be postulated that having animals able to feed side by side makes them feel more comfortable and secure and enables ‘bullies’ and/or animals that gorge on the supplement to be more easily avoided or dislodged by other animals. A new controlled supplement device (SmartFeed Pro) that has a single bin design appears to have been modified from the GEMs (C-Lock 2016). Mobile Sapien trailers hold 2.5 tonne of supplement so only need topping up weekly. A large SmartFeed bin volume is 0.78m³ (~ 0.59 tonne maize), so five SmartFeed bins would be needed to feed as much supplement as one Sapien trailer.

A trial to compare the abilities of mobile Sapien trailers and SmartFeed bins (where there was a similar investment cost in the number of units deployed) to service the controlled supplementation of a typical herd size would be worthwhile.

Acknowledgement
This research was funded by the Department of Agriculture and Water Resources, through the Action on the Ground program. We thank Tom Gubbins, Rob Herry and Mark Troeth of Te Mania, Russell Cranston, Sapien and Graeme Bremner, UNE for their assistance with the heifers and trial.

References
Liveweight gain, dry matter intake, hip height change, cortical bone thickness and phosphorus in the plasma and faeces of Bos indicus crossbred steers all increase in response to increasing phosphorus intake

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Summary

Thirty Bos indicus crossbred steers were fed a diet representative of early wet season pastures in northern Australia [110 g crude protein (CP), 9.3 MJ metabolisable energy (ME)/kg DM] with increasing phosphorus (P) content (0.9, 1.3, 1.8, 2.0 and 2.4 g P/kg DM) for 172 days. All steers were then offered a diet containing 110 g CP, 9.3 MJ ME and 2.4 g P/kg DM for an additional 84 days after which they were slaughtered. Liveweight (LW) gain (LWG), dry matter intake (DMI), hip height (HH) change, cortical bone thickness (CBT) and the concentration of P in the plasma (PiP) and faeces (FecP) all increased in a linear fashion with increasing P intake (P<0.001). Steers that were deficient in P responded to a high P diet with increased LWG and HH change but their carcasses were lighter and leaner at slaughter than steers that received adequate P throughout the experiment.

Introduction

Phosphorus is the second most abundant mineral in the body of cattle and is required for skeletal growth (and strength), energy metabolism, DNA and protein synthesis, lactation and microbe function in the rumen. Soils and forages across approximately 70% of northern Australia are estimated to be acutely P deficient (<5 ppm P in soil; McCosker and Winks, 1994). Forage P content increases during the wet season but a P deficiency occurs as insufficient P is available to meet the increased requirements for growth of young cattle during the wet season when CP and ME intake are adequate to support high LWG. Young cattle grazing these areas have low LWG, and show a positive LWG response to wet season P supplementation (Winter et al. 1994). As such, wet season P supplementation of growing cattle is recommended in areas of northern Australia where acute P deficiencies occur. The objective of this experiment was to determine the response in LWG, DMI, CBT, PiP and FaecP of growing Bos indicus steers to increasing dietary P content when adequate dietary ME and CP are available (i.e. typical of the early wet season in northern Australia).

Materials and Methods

The experiment was conducted at the Queensland Animal Science Precinct, The University of Queensland, Gatton, QLD. The procedures were approved by The University of Queensland Animal Ethics Committee.

Thirty Bos indicus crossbred steers were fed a diet of pangola grass (Digitaria eriantha)/lucerne (Medicago sativa) hay [2.8 g P, 118 g CP/kg DM] at approximately 20 g DM/kg LW.day in individual pens for approximately 90 days prior to the commencement of the experiment. At the commencement of the experiment the steers (228 ± 2 kg LW; mean ± s.e.m) were blocked on LW and randomly allocated to pens and one of five dietary P treatments (n=6/treatment) in a completely randomized block design. During the experiment, steers were fed pelleted diets (Johnson's Stockfeed, Kapunda, SA) that provided 0.9, 1.3, 1.9, 2.0 and 2.4 g P/kg DM and were formulated to provide 100 to 110 g CP/kg DM and 60 to 65% dry matter digestibility (DMD) when fed ad libitum. The pellets contained (as-fed basis) 59% barley straw, 23% sugar, 8% gluten, 8% wheat starch, 0.8% urea, 0.5% KCl, 0.4% Ca(OH)\textsubscript{2} with 0.2% MgO and 0.1% premix containing monensin (TMV mono 20) with Biofos (Rumevite, Ridley Agri-products) added to meet the requisite P content of the pellets. No Biofos was added to the pellets of lowest P content (0.9 g P/kg DM). The chop length of the barley straw was approximately 15 mm and the pellets were 20 mm in diameter and 40 mm in length. All steers were offered 0.5 kg/day of chopped Mitchell grass (Astrebla spp.) hay and had access to drinking water at all times. The final P content of the diets (pellets and hay) was calculated to provide 0.9 (0.9P), 1.3 (1.3P), 1.8 (1.8P), 2.0 (2.0P) and 2.4 (2.4P) g P/kg DM. Steers were fed the treatment diets for 172 days (Depletion phase) and were then offered the pelleted diet containing 0.9 g P, 110 g CP and 9.3 MJ ME/kg DM plus monosodium phosphate at 6 g/kg pellet for 84 days (Repletion phase) after which they were slaughtered in a commercial abattoir.

Liveweight and DMI was measured every week during the experiment. Hip height change was measured every three weeks and blood and faecal samples were collected every three weeks during the experiment; blood samples were collected from the jugular vein into lithium heparin tubes that were centrifuged at 1300 g for 10 min with plasma stored at -80°C prior to analysis. Bone biopsies (16 mm cores) were collected from alternate 12\textsuperscript{th} ribs prior to the commencement of and at the end of the Depletion phase, while the entire 12\textsuperscript{th} rib was collected at slaughter after the Repletion phase.

One steer from the 1.3P treatment group was not included in the statistical analysis as it spent significantly less time ruminating than the other steers. Liveweight gain, HH
change, DMI, PiP, FecP and CBT were analysed within each phase (Depletion and Repletion) as repeated measures using the MIXED procedure in SAS (SAS Inst. Inc., Cary, NC). Linear and quadratic effects of dietary P intake (mg P/kg W.day) during the Depletion phase were analysed using the GLM procedure in SAS for linear and quadratic effects. Interaction terms and quadratic relationships that were not significant (P>0.05) were removed from the various statistical models.

Results

Phosphorus intake ranged from 4 to 21 g/day (14 to 61 mg P/kg W.day) providing a wide range of P intakes upon which variable responses could be determined. Steers fed the 0.9P diet were significantly lighter than steers fed the 2.4P diet approximately 5 weeks after the commencement of treatments and gained 130 kg less liveweight than those fed the 2.4P diet over the 172 day Depletion phase. During the Depletion phase LWG, DMI, HH change, CBT at the end of the feeding period, PiP and FecP all increased in a linear fashion with increasing P intake [mg P/kg W.day (Table 1) and on a g P/day basis (not presented)]. The LWG response was due to a dietary P mediated regulation of ME intake. The PiP responded more immediately to a change in P intake and was more stable throughout the current experiment than FecP. Steers that consumed a P deficient diet (0.9P or 1.3P) had thinner 12th rib CBT at the end of the Depletion phase than steers fed the 2.0P and 2.4P diets.

Table 1. Responses in (Y) liveweight gain (LWG, kg/day), dry matter intake (DMI, g/kg LW.day), hip height change (HH, mm/100 day), cortical bone thickness (CBT, mm) and the concentration of phosphorus in plasma (PiP, mmol/L) and faeces (FecP, mg/kg DM) of steers fed diets with increasing P intake (X; mg P/kg LW.day)

| Variable | Equation | R² | RMSE | P
<table>
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<tr>
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<tbody>
<tr>
<td>LWG</td>
<td>Y = 0.02x + 0.123</td>
<td>0.92</td>
<td>0.08</td>
<td>&lt;0.001</td>
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<td>DMI</td>
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<tr>
<td>CBT</td>
<td>Y = 0.023x + 2.23</td>
<td>0.42</td>
<td>0.48</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PiP</td>
<td>Y = 0.03x + 0.64</td>
<td>0.88</td>
<td>0.20</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>FecP</td>
<td>Y = 22.4x + 2980.2</td>
<td>0.69</td>
<td>267.4</td>
<td>&lt;0.001</td>
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</tbody>
</table>

Values are least-square means with pooled standard error of the mean. Different superscripts across a row indicate significant differences due to previous P treatment (P<0.05).

Discussion

These results demonstrate the importance of P in the diet of steers consuming pastures in northern Australia when CP and ME are not limiting for LWG. An additional 130 kg of LW was produced in steers that consumed 21 g P/day compared to those that consumed 4 g P/day over 172 days. A P mediated reduction in LWG took between 4 to 6 weeks to manifest itself in steers that were of an adequate P status, while production responses in P deficient steers occurred within 7 days of consumption of a P supplement. These results provide valuable information for producers as to when P supplements should be provided to steers. After the Repletion phase, steers previously offered the low P diets (0.9P and 1.3P) never fully compensated to the LW of their counterparts that consumed diets with greater than 2 g P/kg DM throughout the experiment; due to the shorter duration of the Repletion phase. As a consequence steers fed the 0.9P and 1.3P diets during the Depletion phase had lighter and leaner carcasses at slaughter but these were not different to the other steers when adjusted to a common LW.

PiP was a more stable and immediate indicator of P intake of steers consuming different amounts of P during the Depletion phase. The PiP response was no carry-over effects of previous diets apparent.

Acknowledgements

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References


Development of village-based forage seed enterprises through farmer participatory research approach by varietal selection and evaluation

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Summary

An extensive field study was conducted on Berseem clover (Trifolium alexandrinum L.) crop at smallholder farmer’s fields in Pakistan during 2012-13 and 2013-14. The research was initiated with the objective; to evaluate the performance of research-station improved variety (RS) against conventionally used farmer own-saved (FS) and market seed (MS) sources of Berseem clover through farmer participatory research approach (FPRA). Significant differences (P < 0.05) among seed sources and cutting treatments were recorded for forage and seed yields, and forage quality parameters across all the research sites. The RS proved to be the best seed source amongst tested, produced highest green forage yield (GFY) of 89.65 t/ha and dry matter yield (DMY) of 13.37 t/ha, however, maximum predicted seed yield (PSY) of 580 kg/ha was also produced by RS when taken three forage cuts prior to seed harvest. The three forage cuts (65, 110 and 150 days after sowing) prior to seed harvest (T2) cutting treatment was found the best harvesting regimen; produced maximum forage and seed yields of better quality of all seed sources across all research sites.

Introduction

Livestock production in mixed farming systems typically suffer from limited availability of green forage due to unavailability of seed. In Pakistan, the demand for Berseem clover seed cannot be fulfilled through the formal seed supply system, as in many situations, formal seed supply has been unable to meet farmers’ complex needs (David, 2004). Thus there is need of an alternative forage seed supply system, which not only increase fodder production but also supplies quality seed to farmers. Therefore, the development of village-based forage seed enterprises (VBFSEs) can develops an alternative and secure Berseem clover seed supply system at the local level (Phaikaew and Stur, 1998), it increases seed supply of improved Berseem clover varieties resulting in increased fodder and seed production at village level. In addition, it is a means of educating and increasing awareness of farmers on improved varieties and agronomic production technology (Nakamanee et al., 2008).

Materials and Methods

On-farm experimental trials were conducted in the two successive growing seasons of 2012-13 and 2013-14 to establish the most appropriate seed source of Berseem clover and harvesting regimen through FPRA in order to achieve maximum forage and seed production. Five smallholder farmers were randomly selected from Kasur and Okara districts of Pakistan. A randomised complete block design with a factorial arrangement (3 seed sources x 4 cutting regimens) and five replicates was used, where each research site was considered as replication. At each site 12 plots (3 m x 7 m; 21 m²) were established. The three sources of Berseem clover seed were FS, MS and RS. The four cutting frequencies were tested as two forage cuts (T1), three cuts (T2), four cuts (T3) and five cuts prior to seed harvest (T4).

Seeds were inoculated with Rhizobium trifolii prior to sowing, which was undertaken during the 2nd week of October in both years using a seed rate of 20 kg/ha. Following germination, the forage cuts were taken according to the predetermined harvesting regimen and data was recorded on GFY and DMY (t/ha) and PSY (kg/ha). Additionally, the major indicators of fodder nutritive value metabolisable energy (ME), crude protein (CP), Neutral-detergent fibre (NDF), water soluble carbohydrates (WSC) and dry matter digestibility (DMD) were measured through near-infrared reflectance (NIR) to access the forage nutrition. The data were analysed with linear mixed model (REML) by using GenStat® (17th edition) at 5% level of significance to compare treatment means.

Results

The different cutting treatments and seed sources significantly (P < 0.05) affected the forage and seed yields and forage quality parameters of Berseem clover across all the research sites. Further, the analysis revealed that the DMY, GFY and PSY were significantly (P < 0.05) affected by farms (replicates) in both the districts of Kasur and Okara. Mean total DMY (8.39 t/ha) and GFY of 74.93 t/ha were achieved using RS and T4. However, mean PSY of 508 kg/ha was produced at T2 cutting treatment. The overall pattern of the DMY, GFY and PSY comparing different cutting treatments are presented in Figure 1.

Figure 1. The effect of different cutting regimens on dry matter, green forage and seed yields of Berseem clover.
Both seed source and cutting treatment had significant effects \( (P < 0.001) \) on GFY. The maximum GFY of 89.65 t/ha was achieved using RS and T4, while the minimum GFY of 20.58 t/ha was recorded by using FS and T1. Consistent with GFY, both seed source and cutting treatment had significant effects \( (P < 0.001) \) on DMY. The maximum DMY of 13.37 t/ha was achieved using RS and T4, while the minimum DMY of 2.2 t/ha was recorded by using FS and T1.

In comparing cutting treatments, the PSY were highest \( (P < 0.001) \) for T2 and T3 yielded 508 and 368 kg/ha, respectively, although did not differ \( (P > 0.05) \) between T3 and T1 (368 and 334 kg/ha, respectively). For all seed sources, PSY was significantly lower \( (P < 0.001) \) for T4 (84 kg/ha) compared to other cutting treatments. Based on seed source, PSY was significantly higher \( (P < 0.001) \) for forage grown from RS (580 kg/ha) than that grown from FS (186 kg/ha) or MS (204 kg/ha). The overall performance of the three seed sources of Berseem clover are presented in Figure 2.

![Figure 2. Mean dry matter, green forage and predicted seed yields of Farmer, Market and Research-station seed.](image)

The average nutritive value of the forage significantly affected by both seed source \( (P < 0.05) \) and cutting days \( (P < 0.001) \). However, WSC did not vary \( (P > 0.05) \) between the different seed sources and cutting days. Based on the seed sources, RS produced better quality forage of Berseem clover compared to FS and MS seeds. RS seed also produced maximum mean nutrition of CP (26.77%), DMD (68.31%), and ME (10.128%) from 1st to 3rd forage cuttings over FS and MS.

### Discussion

Cutting management in Berseem clover is the most crucial agronomic factor which directly affects crop yields through plant growth and development, and indirectly influences the nutritive value of the forage (De Santis et al., 2004). However, the forage and seed yields of Berseem clover and its quality primarily depends on the phenological stage of growth when plants are cut and frequent cuttings increases the regeneration and growth rate of Berseem plants and therefore enhances DMY and GFY (Iannucci, 2001). Seed production in Berseem clover represents a strong inverse source-sink relationship between vegetative and reproductive plant organs. Photosynthates from leaves and stems translocated to the seed during the reproductive growth for seed growth and development resulted in increased seed yield (SY) (Iannucci, 2001). The frequency of cutting can be used to manipulate the distribution of DM, subsequently impacting on DMY and SY of Berseem clover (Amato et al., 2013). The timing of the last forage cut not only influences both DMY and GFY and also SY of Berseem clover (Sardana and Narwal, 2000) which was in agreement to the results reported in the present study. The nutritive value of Berseem clover forage is influenced by growing season, growth stage and time of cutting, and leaves are of higher nutritive value than stems (De Santis et al., 2004) and thus later cuttings are of lower nutritive value due to an increase in the proportion of stem material.

Farmers responded positively in the present study to the improved RS variety which they have evaluated and the local varieties (FS and MS) showed poor performance (Figure 2). Varietal selection and evaluation through FPRA and introducing the idea of village-based seed production would be of great importance and sustainable way to solve the forage shortage problem. Therefore, the introduction of improved varieties of forages in smallholder farming systems has been found to not only significantly increase forage production but also to result in the establishment of new markets for both the surplus forage and seed (David, 2004).

In conclusion, the RS produced the highest weight of green forage, DM and seed yields of better quality across all farm sites when taken three forage cuts at 65, 110 and 150 DAS prior to seed harvest. Moreover, the great potential and opportunity of VBFSE application to Pakistani dairy farmers as a future approach to strengthen the current forage seed production and supply system.

**Acknowledgement**

We are greatly thankful to Australian Centre for International Agricultural Research (ACIAR) for providing funds to undertake this research project.

**References**


Faecal glucocorticoid metabolite analysis provides a robust non-invasive tool for assessing baseline and acute stress responses of livestock in relation to environmental stressors. In this research project, we quantified faecal cortisol metabolites (FCMs) in sheep using a broad-spectrum polyclonal antibody enzyme-immunoassay. We quantified the underlying variation in FCMs levels in sheep grazing a ‘toxic pasture’ (*Biserrula pelecinus*) known to cause primary photosensitization (PS)-skin inflammation. Sheep ingesting *B. pelecinus* had significantly higher FCM levels than controls suggesting a physiological stress response. In conclusion, non-invasive FCM EIA can be applied to assess physiological stress in sheep on farms to assist in addressing health and welfare concerns.

**Introduction**

Animal welfare is an issue of growing concern in today’s society. One method that is used to assess welfare is stress endocrinology; assessing stress hormones in the body in response to physical (e.g. manual capture) and/or psychological stress (e.g emotional stress). When an animal is subjected to a stress event, the central nervous system signals the hypothalamus to release corticotrophin-releasing hormone. Corticotrophin-releasing hormone travels to the anterior pituitary causing it to release adrenocorticotropic hormone (ACTH), this travels to the adrenal cortex, which then produces stress hormone - glucocorticoids (mainly cortisol and/or corticosterone) (Bayazit, 2009). Glucocorticoid production is a vital part of an animal’s stress normal response as they help it to cope with the stress event and return its body to a state of homeostasis (back to an unstressed state).

In the past, we have used levels of cortisol in blood plasma as an indicator of stress in livestock; however, this requires taking multiple blood samples via a jugular catheter (Fulkerson and Jamieson, 1982), which is obviously an invasive technique which, ironically, causes the animal more stress. For these reasons, we are starting to look more at non-invasive methods to evaluate stress in livestock, looking at the same stress hormones but without using invasive techniques to measure them.

The primary aim of this research was to validate the R4866 EIA for measuring FCMs in sheep faecal extracts. In Australian farming systems, photosensitisation (PS) is a common problem in sheep production systems due to exposure to toxic plant species that cause either primary or secondary PS (Kessell, Ladmore, & Quinn, 2015). Our study provides an opportunity to apply this innovative non-invasive technique for sheep health and management.

**Materials and Methods**

All research was undertaken with approval from Charles Sturt University (CSU) Animal Care and Ethics Committee (protocol numbers 15/044, 13/033 and 13/018).

**Animals and field study site**

All sheep were merino ewes sourced from the CSU flock (n = 100). Sheep were already acclimatised to their paddock when field work began, comprised of naturalized ryegrass pasture containing ryegrass and native grass species with some common pasture weeds. Animals had access to water *ad libitum* and were intermittently supplemented with oaten hay delivered by pickup truck. Apart from occasional hay drops the sheep were left largely undisturbed in the paddock until sampling began in May 2015. Faecal sampling was restricted to one randomly selected section of the paddock, approximately 100 m x 150 m, due to the wide geographical area.

**Photosensitivity study - animals and study design**

Female crossbred lambs (n = 230) of 7 months of age and mean live weight of 33 kg were sourced from a single local producer. Sheep arrived at CSU farm holding yards by commercial transport on Wednesday 8th July, 2015 and were herded from the transport by dogs as per commercial practice before yarding for allocation to trial plots. Animals were weighed, ear tagged, and had a faecal sample removed directly from the rectum for FCM analysis (day 0). Animals were then allocated to plots and their plot number identified on their dorsal fleece using non-irritant sheep spray paint. All animals were then left overnight in the holding yards, with ample access to fresh feed and water *ad libitum*. The following day they were yarded again and moved with a small trailer to their treatment pastures, either a non-photosensitising pasture comprising lucerne (*Medicago sativa*) and subterranean clover (*Trifolium subterraneum*) dominant or a photosensitising pasture containing a monoculture of *Biserrula pelecinus* var. ‘Casbah’. Each treatment pasture was a minimum of 0.3 ha in size and contained sufficient biomass of each pasture for feed not to be limiting. Water was provided *ad libitum* throughout the trial. After 14 d on pasture all animals were again run through the race, weighed, faecal sampled and scored for clinical signs of photosensitivity with a scoring system ranging from 0 (no effect), to 5 (severe).
Faecal cortisol metabolite enzyme immunoassay

Faecal cortisol metabolites were extracted from sheep faecal samples using previously published methods (Möstl et al., 2002). To quantify concentration of FCM in each sample, plates were read at 450 nm (reference 630 nm) on an ELx800 (BioTekTM) microplate reader. The lower limit of detection of the assay was 0.28 ± 0.03 pg/well⁻¹ (n = 7). Intra-assay coefficients of variation were 1.8% and 5.3% for low- and high-percentage bound controls respectively, and inter-assay coefficients of variation were 5.8% and 1.8%, respectively.

Statistical analysis

All FCM data was log transformed to meet the assumptions of homogeneity of variances (Levene’s test) and test for normality. In all studies, ANOVA revealed an overall significant difference in mean FCM concentrations (P < 0.05), therefore post hoc testing was used to determine levels of significant difference between sample groups. Analysis was done in SYSTAT software version 13.0 for all ANOVA and post hoc comparisons. Faecal cortisol metabolite data for all experiments is expressed as ng/g (mean ± S.E.M.) of dry faecal mass.

Post hoc comparisons using Fisher’s Least Significant-Difference-Test was utilised to make pairwise comparisons of mean FCM values between the animals on photosensitising or non-photosensitising pastures.

Results and Discussion

Analysis of variance showed a significant difference in mean FCM concentrations of animals grazing the two pasture species on days 0 and 14 (F₃,₅₂ = 4.974, p < 0.005). Post hoc testing using Fisher’s Least-Significant-Difference Test shows the increase in mean FCM concentrations from day 0 to day 14 in sheep grazing biserrula to be highly significant (P < 0.005). There was no comparative increase in sheep grazing lucerne pasture (P > 0.05). Furthermore, comparisons between mean FCM concentrations of sheep grazing biserrula and those grazing lucerne on day 0 were not significantly different (P > 0.05), but on day 14 were (P < 0.05).

In conclusion, development of standard field sample collection devices based on power analysis for number and size of faecal samples required per animal/treatment could also help to minimise error and drive the future of non-invasive field based endocrinology research in livestock (Morgan, et al., 2005).

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References

Effects of diet containing raw, full-fat soybean meal and supplemented with high-impact protease for broilers on relative weight of pancreas

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Summary

A 3 x 3 factorial study was used, with 3 levels of raw soybean meal (RSBM) (0, 10 or 20 %, replacing commercial SBM) and 3 levels of protease (0.0, 0.2 or 0.3 g/kg). Each treatment was replicated six times, with nine birds per replicate. The birds were housed in cages in an environmentally controlled room, and fed on starter, grower and finisher diets. The concentration of trypsin inhibitor (TI) was 13,098.0 TIU/g in RSBM and ranged from 1,730.5 to 9,913.2 TIU/g in diets. Although body weight (BW) was reduced at early age of birds, neither RSBM nor protease supplementation affected (P>0.05) the BW at 35 d of age. Increasing the level of RSBM increased the weight of the pancreas at 10 d (p<0.001), 24 d (p<0.001) and 35 d (p<0.05) of age. This increase in pancreatic weight appeared not to have any negative effect on gross performance, possibly due to supplementation with the protease.

Introduction

Although SBM is considered to be the best protein source for poultry feeding (Banaszkiewicz, 2011), the nutritive value of raw full-fat soybean meal (RSBM) is poor due to the presence of anti-nutritional factors (ANF), especially trypsin inhibitors (TI) (Liu, 1997; Newkirk, 2010; Erdaw et al., 2014)). The TI negatively affects the functions of the pancreas, in terms of synthesis and secretion of digestive enzymes, including proteases. The pancreas often tries to compensate by increasing in size (Liener, 1995). However, Pettersson and Pontoppidan (2013) reported that supplementation with microbial protease could reduce the negative impacts of TI in non-ruminant animal diets. The aim of this study was to evaluate the effects of exogenous protease in broiler diets containing RSBM on growth and function of the pancreas.

Materials and Methods

A 3 x 3 factorial study with 3 levels of RSBM, replacing commercial soybean meal at 0 10 or 20 % and 3 levels of mono-component protease (Ronozyme® ProAct) (DSM Nutritional Products, Australia Pty. Ltd) at 0.1, 0.2 or 0.3 g/kg was conducted. The recommended level of microbial phytase (1000 FYT/kg, DSM Nutritional Products, Australia Pty. Ltd) was uniformly added to each diet. Each treatment was replicated six times, with nine male birds per replicate. Birds were housed in cages, in climate-controlled rooms and offered starter (1-10 d), grower (11-24 d) and finisher (25-35 d) corn-soybean-based diets, which were formulated to Aviagen standards for Ross 308 broiler. Representative samples of the formulated diets were chemically analysed for ANF, including concentration of TI. In addition to evaluation of feed consumption and body growth, one bird per cage was killed by cervical dislocation at 10, 24 and 35d. The pancreas was collected, weighed, snap-frozen in liquid nitrogen and then stored at -20 °C until it was used for further analysis.

Results and Discussion

The concentration of TI in RSBM was 13,098.0 TIU/g while they ranged from 1,730.5 to 9,913.2 TIU/g in the test diets. As shown in Table 1, there was a reduction (p<0.001) in BW at 10d of age in response to increasing level of RSBM but this effect was no longer significant at 24 or 35d. The exogenous protease supplement also improved BW at 10d (p<0.01), 24d (p<0.05) and 35 d (p<0.06). Pettersson and Pontoppidan (2013) had reported such response of non-ruminant animals to exogenous protease on diets when fed diets containing TI. Increasing the level of RSBM increased the weight of the pancreas at 10 and 24 d (p<0.001) and 35 d (p<0.05) of age. This result is in agreement with those of Mirghelenj et al., (2013) who reported that when protease (trypsin) inhibitors prevent the pancreas from producing enough endogenous trypsin or other proteases, the animal tries to compensate by increasing the size of the pancreas and this may be through cellular hyperplasia and/or hypertrophy (Liener, 1995). Supplemental protease had no effect on the weight of the pancreas. However, the activities of the pancreatic digestive enzymes, including trypsin (p<0.05), chymotrypsin (p<0.01) and general proteolytic activity (p<0.05) were increased. The activity of lipase tended (p<0.06) to be improved as a result of exogenous protease supplement. The results suggest that although the weight of the pancreas was increased, it had no negative effect on the functionality of the organ. The increase in weight of the organ rather appears to be of some benefit, and supported optimum growth of the birds. The supplemental protease also tended to have a positive effective on pancreatic function and body growth.

Worth noting is that the negative effect of RSBM waned with time, as the birds became older. This may be due to adaptation to the TI but it is also possible that the effect of the supplemental protease began to be felt. Similar responses have been reported by previous researchers (Loeffler (2012; Erdaw et al., 2015). Mirghelenj et al. (2013) observed an effect of dietary TI on weight of pancreas of chickens at 21 d, but this effect had disappeared by 42 d of age.

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Table 1: Effects of graded levels of raw soybean meal in diets and protease supplementation on hypertrophy (change) of pancreas weight (g/100 g of the body weight) in relation to the live body weight of broilers (g/b).

<table>
<thead>
<tr>
<th>RSBM (%)</th>
<th>Protease Body weight (days)</th>
<th>Weight of pancreas (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-10</td>
<td>1-24</td>
</tr>
</tbody>
</table>
| 0        | 278.3
d       | 1451 | 2494 | 0.51\(^a\) | 0.23\(^b\) | 0.17\(^c\) |
| 0.1      | 283.0\(^a\) | 1455 | 2515 | 0.51\(^bc\) | 0.22\(^a\) | 0.15\(^b\) |
| 0.2      | 283.0\(^a\) | 1482 | 2603 | 0.61\(^bc\) | 0.25\(^cd\) | 0.15\(^b\) |
| 10       | 271.9\(^a\) | 1423 | 2389 | 0.65\(^bc\) | 0.30\(^bcd\) | 0.19\(^b\) |
| 0.2      | 282.0\(^a\) | 1390 | 2391 | 0.59\(^bc\) | 0.32\(^a\) | 0.20\(^b\) |
| 0.3      | 283.0\(^a\) | 1448 | 2515 | 0.61\(^bc\) | 0.31\(^bc\) | 0.20\(^b\) |
| 20       | 259.9\(^a\) | 1397 | 2389 | 0.69\(^bc\) | 0.36\(^a\) | 0.22\(^a\) |
| 0.2      | 260.3\(^a\) | 1402 | 2477 | 0.73\(^a\) | 0.34\(^a\) | 0.21\(^a\) |
| 0.3      | 276.1\(^a\) | 1459 | 2525 | 0.71\(^ab\) | 0.33\(^a\) | 0.20\(^b\) |
| Pooled SEM | 1.64 | 8.63 | 21.4 | 0.02 | 0.01 | 0.01 |

Main effects

<table>
<thead>
<tr>
<th>RSBM (%)</th>
<th>Protease Body weight (days)</th>
<th>Weight of pancreas (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>282.2(^a)</td>
<td>1463</td>
</tr>
<tr>
<td>10</td>
<td>279.0(^a)</td>
<td>1420</td>
</tr>
<tr>
<td>20</td>
<td>265.4(^a)</td>
<td>1419</td>
</tr>
<tr>
<td>0.1</td>
<td>270.0(^a)</td>
<td>1424(^a)</td>
</tr>
<tr>
<td>0.2</td>
<td>275.1(^a)</td>
<td>1415(^a)</td>
</tr>
<tr>
<td>0.3</td>
<td>281.5(^a)</td>
<td>1463(^a)</td>
</tr>
</tbody>
</table>

Sources of variation

<table>
<thead>
<tr>
<th>RSBM</th>
<th>Protease</th>
<th>RSBM x protease</th>
</tr>
</thead>
<tbody>
<tr>
<td>***</td>
<td>NS</td>
<td>***</td>
</tr>
<tr>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Means bearing uncommon superscripts within a column are significantly different; *p<0.05; **p<0.01; ***p<0.001; NS= non-significant; RSBM = raw soybean meal; SEM= pooled standards error of means.

The results of the current study showed that RSBM has a negative effect on growth of broiler chickens but the material can replace commercial SBM at up to 20 % level provided the diets are supplemented with a suitable protease product.

Acknowledgement
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References
Reducing rumen starch fermentation of wheat with 3% NaOH has the potential to ameliorate the effect of heat stress in grain-fed sheep.

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Summary

Thirty-one Merino x Poll Dorset wethers were housed in two climate-controlled rooms and were fed either corn (CD), wheat (WD) or 3% NaOH treated whole wheat grain (TWD) plus forage during three experimental periods: P1) 7 d of thermoneutral conditions and 1.8 times maintenance intake; P2) 7 d of heat stress (HS) and 1.8 times maintenance intake; and P3) 7 d of HS and 2 times maintenance intake. Rectal temperature (RT), respiration rate (RR) and skin flank temperature (FT) were measured. All physiological parameters were elevated during HS, especially during P3. Sheep fed CD had lower RR and RT than WD and TWD especially during HS. Sheep fed TWD had lower RR and RT than WD. FT was higher for WD, while no differences were observed between CD and WTD. These data confirm that reducing the rate of fermentation with TWD improves tolerance to heat stress in grain-fed sheep.

Introduction

Despite having well developed thermoregulatory mechanisms, ruminants, especially European breeds, are very susceptible to heat stress (HS) because of the excessive heat released during feed fermentation in the rumen (Tajima et al. 2007). Wheat is a rapidly fermentable grain commonly used as energy source for ruminants in Australia and other parts of the world. The rapid rate of rumen starch fermentation of wheat is associated with sub-acute acidosis, laminitis (Nocek 1997) and heat stress (HS) (Mader et al. 1999). By contrast, slowly fermentable grains, like corn, are associated with a reduction in the heat from fermentation (Ørskov 1986; Owens et al. 1986) and better responses under HS (Gonzalez-Rivas et al. 2006). Alkaline treatment of grains with NaOH affects the rheological properties of the starch and it has been associated to slower in vitro rumen fermentation of wheat (Tománková and Homolka 2004) and reduced in vivo rumen starch fermentation and susceptibility to rumen acidosis (Schmidt et al. 2006). The objective of this experiment was to determine whether the reduction of rumen starch fermentation of wheat with 3%NaOH improved tolerance to HS in grain-fed sheep.

Materials and Methods

Ethical approval was provided by The University of Melbourne Veterinary and Agricultural Sciences Animal Ethics committees before experimentation.

Thirty one Merino x Poll Dorset crossbred wether lambs (11-12 mo, 46.3 ± 2.8 kg BW and 30-40 mm of fleece cover) were allocated to one of three diets in a randomized control experiment. The experimental diets were either 50% crushed corn grain (42% starch, CD, N=10), crushed wheat grain (39% starch, WD, N=10) or 3% NaOH treated whole wheat (39% starch, TWD, N=11) with 25% of oaten and 25% lucerne chaff. Whole wheat was treated with 3% NaOH according to the technique described by De Campeneere et al. (2006). Water was available ad libitum. The daily ration of feed was split into 3 equal meals fed at 0900, 1300 and 1700 h. Sheep were randomly allocated into individual metabolism crates housed in two climate controlled rooms for a total of 21 d divided into three experimental periods; P1) 7 d of thermoneutral conditions (TN) (18–21°C/40-50% relative humidity, [RH]) and 1.8 times maintenance feed intake; P2) 7 d of HS (28–38°C/30–50% RH) and 1.8 times maintenance feed intake; and P3) 7 d of HS as P2 and 2 times maintenance feed intake. The level of HS was quantified measuring rectal temperature (RT), respiration rate (RR) and skin flank temperature (FT) 4 times a day at 0900, 1300, 1700 and 2100 h. Average daily feed intake (ADFI) was recorded by weighing the orfs before the morning feeding. Body weight (BW) was recorded using walkover scales at the beginning of the experiment and at the end of each period. Data were analysed using the REML analysis procedure using GenStat v15. Treatment groups were considered statistically different at P ≤ 0.05.

Results and Discussion

Heat stress increased RR (P1 vs P2) and it was further elevated by increased ADFI during HS (P2 vs P3) (66, 149 and 171 breaths/min for P1, P2 and P3 respectively; P <0.001). Respiration rate increased over the day reaching the maximum during the afternoon before declining overnight (107, 138, 156 and 114 breaths/min at 0900, 1300, 1700 and 2100 h respectively; P <0.001). There was a main effect of diet on RR such that sheep fed CD had lower RR, followed by TWD and WD (119, 128 and 138 breaths/min for CD, TWD and WD respectively, P<0.001).

Heat stress increased RT (P1 vs P2) and RT was further elevated by increased ADFI during HS (P2 vs P3) (39.3, 39.6 and 39.7 °C for P1, P2 and P3 respectively; P <0.001). Rectal temperature increased over the day reaching the maximum during the afternoon before declining overnight (39.3, 39.6, 39.7 and 39.5 °C at 0900, 1300, 1700 and 2100 h respectively; P <0.001). There was a main effect of diet on RT such that sheep fed CD had lower RT than those fed WD and TWD (39.4, 39.5 and 39.6 °C for CD, WD and TWD, P<0.001).

Heat stress increased FT (P1 vs P2) and P3 and no differences between LFT and RFT were found during P2 and P3 (38.5/38.4, 38.9/38.9 and 39.0/39.0 °C LFT/RFT for P1, P2 and P3 respectively; P <0.001). Flank temperature increased over the day reaching the maximum during the afternoon and then declining overnight (38.6/38.6, 39.0/39.0, 39.0/39.0 °C LFT/RFT for P1, P2 and P3 respectively; P <0.001).
fermentable grains were confirmed; sheep fed CD had lower to those of corn under HS. These data support the hypothesis that by reducing the rate of starch fermentation in the rumen, the heat from fermentation can be reduced which could be of benefit to summer production systems.

Average daily feed intake was affected by diet such that sheep feed TWD had higher ADFI especially during P3, whereas no differences were found between CD and WD (1,178, 1,197 and 1,224 ± 11.6 g DM/d for CD, WD and TWD (P <0.001). There was no significant effect of diet on ADG (P >0.05). However, sheep fed WD and TWD finished the experiment with a higher BW than CD which maintained their initial BW (45.1/45.8, 46.4/48.6 and 47.2/48.4 Kg initial/ final BW for CD, WD and TWD; P <0.001).

Rumen fermentation allows ruminants to utilize plant materials otherwise indigestible and convert non-protein nitrogen and microbial protein into body amino acids. However, ammonia, methane and heat are end-products of fermentation that represent loses of nitrogen and energy (Hungate 1966). The heat from fermentation, although convenient in cold climates, represents an extra burden at high ambient temperatures. It has been estimated that the heat from fermentation accounts for approximately 30% of total heat production (Webster et al. 1976). Among the various grains fed to ruminants, there are differences in starch content, fermentability and digestibility (Herrera-Saldana et al. 1990). A previous study carried out in grain-fed sheep demonstrated a positive relationship between highly fermentable grain content in the diet, heat increment and heat stress susceptibility; sheep fed a slowly fermentable corn diet had lower RR, RT and FT than sheep fed a wheat diet under HS conditions (Gonzalez-Rivas et al. 2015). It has been hypothesized that protecting the starch from rumen fermentation improves the efficiency of ME utilisation due to smaller losses of energy as heat (Reynolds 2006). The use of processed grains to increase the rumen escape of starch has been largely studied; alkaline treatment of grains with NaOH affects the rheological properties of the starch and produces a slow release of the starch preventing large fluctuations in the rate of fermentation (Ørskov 1979; Roberts and Cameron 2002). This mechanism has been associated with slower in vitro and in situ rumen starch fermentation, higher rumen pH and improved productive responses (Tománková and Homolka 2004; De Campeneere et al. 2006).

In our experiment differences among slowly and rapidly fermentable grains were confirmed; sheep fed CD had lower RR, RT and FT that WD and it was also demonstrated that by reducing the rumen starch fermentation of wheat with 3% NaOH treatment RR and FT were reduced to a level similar to those of corn under HS. These data support the hypothesis that by reducing the rate of starch fermentation in the rumen, the heat from fermentation can be reduced which could be of benefit to summer production systems.

Acknowledgement

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References


Characterization of in vitro rumen fermentation parameters of 3% NaOH treated wheat grain.

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Summary

The fermentation and pH kinetics of ground corn, wheat and 3% NaOH treated wheat grains were quantified using an in vitro gas production system containing buffered rumen fluid incubated at 39 °C for 24 h. The rate of gas production of 3% NaOH treated wheat was 23 % slower than of wheat and 7% slower than of corn which in turn had 18 % slower rate of gas production than wheat. Corn grain had the lowest maximum gas production at 24 h while there was no difference between wheat and 3% NaOH treated wheat grain. The pH of wheat grain was the lowest and pH of 3% NaOH treated wheat the highest during the incubation. This experiment confirmed the lower starch fermentability of corn and demonstrated that the rate of rumen fermentation of wheat can be reduced with 3% NaOH treatment with protective effect on in vitro rumen pH.

Introduction

Wheat is a rapidly fermentable grain commonly utilized as an energy source for ruminants in Australia and other parts of the world. However, the rapid rate of rumen starch fermentation of wheat can be associated with sub-acute acidosis and laminitis (Nocek 1997; Oetzel 2000; Stone 2004). By contrast, slowly fermentable grains, like corn, are associated with a reduction in the heat from fermentation and improved utilization of ME (Ørskov 1986; Owens et al. 1986).

In vivo experiments have demonstrated that the treatment of whole wheat with sodium hydroxide (NaOH) was able to slow rumen starch fermentation and to reduce the susceptibility to rumen acidosis (Schmidt et al. 2006; Deckardt et al. 2013). Therefore, the objectives of this experiment were to determine the in vitro rumen fermentation kinetic parameters and pH variation of 3% NaOH treated wheat grain during 24 h fermentation.

Materials and Methods

The rate of fermentation of corn, wheat and 3% NaOH treated wheat grains was quantified using an in vitro gas production system containing buffered rumen fluid (RF). Previously, whole wheat was treated with 3% NaOH as described by De Campeneere et al. (2006). Then, 20 replicates of 1 g of 1 mm ground wheat ASW 10% (Australian standard wheat 10%; 66 % starch), corn (72 % starch) and 3% NaOH treated wheat (66 % starch) grain samples were weighed into 250 mL serum jars for every fermentation time (5, 8 and 24 h) in three in vitro fermentation runs. Rumen fluid used in this experiment was collected from two rumen cannulated mid- to late-lactation Holstein-Friesian dairy cows. The RF was removed from the cows before the morning meal and was maintained at 39 °C.

Rumen fluid was buffered with Kansas-State Buffer pH 6.8 (Marten and Barnes 1980; Ankom 2015) at a 1:3 ratio at 39 °C before the beginning of the in vitro fermentation runs. Samples were inoculated by adding 100 mL of buffered RF in to the jars. In addition, 6 background jars containing only buffered RF were included per incubation time in each run. All the steps involving RF manipulation before the incubation were conducted under a continuous flow of CO2. Gas recording modules were randomly allocated to each serum jar, all jars were incubated in a water bath at 39 °C and the fermentation was finished at 5, 8 and 24 h by placing the flask on an ice bath. pH was measured at each fermentation time using a pH meter. Internal gas pressure was recorded every 5 min during 24 h using an ANKOM RF wireless system (Ankom Technology, Macedon, NY). The cumulative gas pressure (psi) was then converted to volume of gas (mL/g DM) produced over time as per Ankom RF operator’s manual (Ankom 2015). Data from the in vitro gas production (mL/g DM) was analysed using the GenStat statistical package (GenStat release 15 VSN International Ltd., Hemel Hempstead, UK). The gas production curves were fitted to the Gompertz model to obtain all relevant kinetic parameters:

\[ Y = A + C \exp(-\exp(-B(X-M))) \]

Where B is the rate of gas production (mL h-1), M is the time at which the maximum rate of gas production is reached (h), C is the maximum gas produced (Max g, mL/g DM), and A is the Y-intercept. The Restricted Maximum Likelihood (REML) analysis was used to determine in vitro gas kinetic parameters and pH variation during incubation. Differences among grains were considered significant when P ≤ 0.05.

Results and Discussion

The rate of gas production of 3% NaOH treated wheat was 23 % lower than of wheat and 7% lower than of corn which in turn had 18 % slower rate of gas production than wheat (P < 0.001). The time to reach the maximum rate of gas production was greater (+18%) for 3% NaOH treated wheat than for wheat and 13% higher for corn than for wheat (P = 0.001), no differences were observed between corn and 3% NaOH treated wheat. Corn grain had the lowest maximum gas produced at 24 h while there was no difference between wheat and 3% NaOH treated wheat grain (128.7, 142.2 and 147.7 mL gas/d DM respectively; P = 0.001, Fig 1).

Media pH during incubation was affected by grain type such that 3% NaOH treated wheat had the highest pH followed by corn and wheat grain (6.27, 6.19 and 6.08 respectively; P < 0.001). The time of incubation also affected the pH such that there was a decrease of pH during the incubation being higher at 5 h and lower at 24 h (6.56, 6.41 and 5.99 for 5, 8 and 24 h incubation respectively; P < 0.001). Wheat grain had
the lowest pH compared to 3% NaOH treated wheat and corn, with 3% NaOH treated wheat being higher during all incubation times (\( P < 0.001 \)).

This \textit{in vitro} experiment demonstrated that 3% NaOH treated wheat was fermented 23% slower than wheat and 7% lower than of corn; however the total gas production and, therefore, total fermentation over 24 h was similar for treated and untreated wheat. These findings agree with the published rankings of rumen starch fermentation and digestibility where wheat had a faster fermentation rate than corn (Herrera-Saldana et al. 1990) and the findings of Tománková and Homolka (2004) who observed that treating whole wheat grains with 3% NaOH reduced the rate of \textit{in vitro} rumen fermentation when compared with untreated wheat. The slower rumen fermentability of corn despite a higher percentage of starch (72 vs 66 % DM for corn and wheat grain respectively) is caused by the characteristics and properties of the corn starch; a resistant protein matrix and a large amylose content that affects fermentability by limiting the microbial access to starch granules (McAllister et al. 1993; Huntington 1997). The use of processed grains to reduce rumen fermentability of starch has been largely studied; alkaline treatment of grains with NaOH affects the rheological properties of the starch and produces a slow release of the starch preventing large fluctuations in the rate of fermentation (Ørskov 1979; Roberts and Cameron 2002). The protective mechanism of NaOH on \textit{in vitro} pH variation observed in this experiment have been associated with slower \textit{in situ} rumen starch fermentation, higher rumen pH and improved productive responses (Tománková and Homolka 2004; De Campeneere et al. 2006).

This experiment confirmed the lower starch fermentability of corn and demonstrated that the rate of rumen fermentation of wheat can be reduced with 3% NaOH treatments with possible protective effect on rumen pH and energy utilization.

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\textbf{References}


Rumen bolus is a useful tool to monitor body core temperature as affected by ambient temperature in lactating dairy cows in a sub-tropical summer.

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Summary
Twenty four Holstein Friesian lactating dairy cows were fed either a TMR-Wheat (TMRW), TMR-Bioprotect (TMRB) or TMR-Corn (TMRC) diet in shaded pens during summer 2015 in Queensland. Rumen temperature (RuT) was recorded during 15 days and rectal temperature (RT) was measured every four days. THI was calculated from data obtained from an on-site weather station. RT was lower for TMRC fed cows than for TMRW and TMRB and was directly correlated to THI and RuT in most of the diets. Diet had no significant effect on RuT and cows had important variations in RuT during the day not associated to THI. There was a positive association between the RuT and THI during the experiment. These data demonstrate the variation of RuT according to the daily THI and the positive association between RT and RuT. Therefore, RuT enables a sensitive prediction of body core temperature variation at high ambient temperature.

Introduction
By 2035 the global average temperatures will increase up to 0.7°C (IPCC. 2014) with likely increased incidence of heat stress (HS) in livestock. Among livestock, ruminants can be very susceptible to HS because of the excessive heat produced during feed fermentation in the rumen (Tajima et al. 2007). Lactating dairy cows are specially affected by HS because of their higher metabolism, high volume of milk production and high feed intake (Kadzere et al. 2002). Dietary manipulation to reduce the heat from fermentation is one means of ameliorating the metabolic and physiological effects of HS in ruminants. Previous studies using grain-fed sheep have shown that differences in rumen starch fermentation patterns among grains are reflected in differences in core body temperature; sheep fed corn based diet- a slowly fermentable grain had lower rectal and skin temperatures than sheep fed wheat based diets under HS conditions (Gonzalez-Rivas et al. 2015). In addition, high ambient temperatures have been associated with variations in rumen temperature in cattle (Beatty et al. 2008). Recently, it was observed that treating wheat with a commercial starch-binding agent (Bioprotect, RealisticAgri, Ironbridge, UK) reduced the rate of in vitro rumen fermentation (Dunshea et al. 2012) and, therefore it is hypothesized that protection of starch could alter the rate of the heat increment from fermentation. This study investigated the impact of ambient temperature and the addition of a starch binding agent on dairy cow rumen temperature during summer in Queensland, Australia.

Materials and Methods
All the experimental procedures performed on the animals in this study were conducted with the approval of The University of Queensland Animal Ethics Committee. The study was undertaken at the University of Queensland, Gatton Campus, Dairy research facilities, 27.4986 °S, 153.0155 °E, 89 m elevation during the summer 2015 (February to March) in the sub-tropical region of Australia.

Twenty four Holstein Friesian lactating dairy cows (635 ± 78.5 kg BW, 3.5 BCS, 248.5 ±64.6 DIM, 24.1 ± 5.5 kg milk /day) ranging from first to third lactation were randomly allocated in a randomized control experiment with three dietary treatment groups; TMR-Wheat (TMRW), TMR-Bioprotect (TMRB) or TMR-Corn (TMRC) (44.1 DM, 31 % NDF, 18.4 % ADF % and 27.8 % starch as DM ) were offered ad libitum once a day during the experimental period. Wheat was treated with Bioprotect by spraying the product on the grain and mixed during 30 min; then, the grains were left to rest for 48 h before feeding. Cows were housed in a feed pad divided in three pens (40 × 12 m), one pen per treatment group. Each pen was equipped with a water trough and feed face with enough space for eight animals. Shade was provided in the feed face and in the middle of the pens by means of solid iron roof. The orientation of the feed pad was N-S.

Rumen temperature (RuT) was recorded over 15 days using transponder rumen boluses (RFID transmitter; Smartstock, USA) placed in the ventral sac of the rumen as per manufacturer’s standard protocol. Rumen temperature was transmitted at 20-min interval from two receivers; one at the feed pad and another in the milking area. The radio transmissions were converted from an analogue signal into a temperature value using proprietary software (TechTrol Inc., USA). Data was plotted by hour of the day and it was expressed as mean RuT. Rectal temperature (RT) was measured using a digital thermometer every four days between 0700 and 1000 h. Ambient temperature and relative humidity were obtained from an automated on-site weather station, and temperature humidity index (THI) was calculated using following the formula (Mader et al. 2006):

$$THI= (0.8 \times T) + [(RH/100) \times (T-14.30)] +46.4$$

Where T was the temperature (°C) and RH the relative humidity (%). Data were analysed using the Restricted maximum likelihood (REML) and Pearson correlation analysis procedures for GenStat v15. Treatment groups were considered statistically different at P ≤ 0.05.

Results and Discussion
Diet had a significant effect on RT (P < 0.001) such that RT was lower for TMRC fed cows than for TMRW and TMRB fed cows (38.8 vs 39.1 and 39.1 °C respectively; P < 0.001). Day of observation had a significant effect on RT (P < 0.001) such that there was a positive correlation between RT and mean THI for the morning (0700-1000 h) and mean THI for -1, -2 d
lag (P < 0.05) for TMRB and TMRC. However there was no significant correlation for -3 d lag and RT for those diets (P > 0.05). For TMRW there was significant correlation between RT and THI for -1 d lag and -2 d lag (P < 0.05). Again, there was no correlation between RT and mean THI for the morning and mean THI for -3 d lag was found (P > 0.05). There was a positive correlation between RT and RuT averaged between 0700 and 1000 h on for TMRB and TMRC (P < 0.001) but not significant for TMRW fed cows (P > 0.05).

Diet had no significant effect on RuT during the day (from 0000 to 2400 h; P > 0.05) and RuT was 39.6, 39.7, 39.5 °C for cows fed TMRD, TMRB, and TMRW respectively. Cows had large variations of RuT during the day (P < 0.001); it was higher overnight (2000 to 0500 h) with the maximum RuT at 2100 and 0300 h. The minimum RuT occurred around the AM feeding (0600 to 1000 h) and then RuT gradually increased during the day from 1000 to 2100 h. There was a negative correlation between RuT and THI by hour for TMRB (P =0.005). However there was no significant correlation for TMRD and TMRW (P > 0.05). There was a significant interaction between diet and hour such that TMRD fed cows had higher RuT than TMRB and TMRW between 0900 and 1400 h (P < 0.001).

Experimental day had a significant effect on RuT such that cows had considerable variations in RuT during the bolus data collection period (P < 0.001). There was a positive correlation between the RuT averaged by day and the mean THI for the day and for -1, -2 and -3 d lags for all diets (P < 0.05). There was a significant interaction between diet and day (P = 0.003) such that cows fed TMRD diets had higher RuT than cows fed TMRW or TMRB on some days of higher THI.

Variations in body temperature are a common thermoregulatory response in mammals. A continuous data set of body temperature records can assist in the prevention and monitoring of HS episodes. Rumen boluses allow frequent recording of body temperature in cattle with minimal impact on animal behaviour and wellbeing; rumen temperature is normally higher than RT by up to 2 °C due to the heat released from feed digestion and fermentation and both are positively associated (Beatty et al. 2008).

In this experiment, the average THI was 72.4 ± 2.0 SD and 76% of the days had THI ≥ 72; the critical THI threshold for dairy cows (Armstrong 1994). Rectal temperature was highly associated to THI and RuT and RT was lower than RuT. Cows fed TMRD had lower RT than TMRB or TMRW fed cows, slowly fermentable grain feeding was associated to lower RT respiration rate and skin temperature in sheep under HS conditions (Gonzalez-Rivas et al. 2015). However, the lower level of grain in the diet and the less frequent RT measurement in this experiment cannot confirm this hypothesis. The observed variation of RuT associated to the daily average THI is commonly related to a linear increment of body core temperature associated to high ambient temperature and heat stress (West 2003). The lack of association between RuT and THI during the day, was also reported in dairy and beef cows (Ipema et al. 2008; Cooper-Prado et al. 2011); this can be due to both, large water consumption during the day (Cooper-Prado et al. 2011) and higher metabolic activity during the night at cooler temperature as an important aspect of thermoregulatory control (Lefcourt and Adams 1996). These data demonstrated the variation of RuT according to the daily THI and the positive association between RT and RuT. Therefore, RuT enables a sensitive prediction of body core temperature variation at high ambient temperature.

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References


Feed-base strategies that reduce risk of feed-gaps in livestock systems across Australia’s mixed farming zone

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Summary

Australia’s highly variable climate means there is large variability in the supply of forage for livestock. Mixed farmers utilise a range of feed sources on their farms to help mitigate the risks associated with this climate variability and to maximise their livestock production. Using simulation models of diverse forage options, monthly whole-farm energy balance was calculated from the supply of energy from forages and the energy demand from a typical livestock enterprise in 6 locations across Australia’s mixed farming zone. Diversifying the feed-base to include combinations of forage sources provides the capacity to increase stocking rate significantly at the same time as reducing or maintaining the risk of feedgaps occurring on mixed farms. This demonstrates that there is significant potential to build forage-based feed systems that overcome critical feed gap periods and their-by mitigate the risks of increasing farm stocking rates required to improve the total productivity from livestock systems.

Introduction

Year-to-year variability and seasonality in forage supply cause a mismatch between forage supply and animal demand in many livestock production systems in Australia (Bell et al. 2008). This induces inefficiencies in production due to excess feed that is wasted or to unmet animal demand. Producers are often compelled to adopt more conservative stocking rates to ensure the risk of feed deficits or the associated costs (e.g. supplementary feeding) remain low. Hence, strategies and tactics that can be employed by farmers to provide feed at times when forage quantity and quality are low and fill these feed gaps can offer significant opportunities to increase livestock productivity by enabling better utilisation of pastures and reduce risk and costs of production (Moore et al. 2009). Approximately 40% of Australia’s livestock equivalents occur in the mixed farming zone where a diversity of forages sources can contribute to the farm feed-base (Bell et al. 2014). This analysis explores the potential to design feed systems that utilise a mix of these forages to overcome periods of feed deficits across a range of production environments.

Materials and Methods

Using a range of pasture and forage models (APSIM, Holzworth et al. 2014; GrazPlan, Moore et al. 1997; GRASP, McKeon et al. 1990) long-term simulations to predict monthly forage supply from key forage sources on mixed farms across six locations representing the key agro-climatic zones spanning Australia’s mixed farming regions. The monthly whole-farm energy balance was calculated from the supply of energy provided from these forages and the energy demand from typical livestock enterprises in each district. This was used to predict 3 complementary statistics of feed-gaps or periods of feed supply shortages; the frequency of months when feed supply was less than feed demand, the frequency of periods when the farm feed balance was negative, and the frequency of months when the stock of available forage on a farm fell below a minimum threshold of 500 kg DM/ha. Using this approach we examined the risk of feed gaps occurring under a range of combinations of livestock production intensity and mixtures of forages contributing to the farm feed-base.

Results

This analysis showed that incorporating a diversity of forages into a farm feed system can greatly reduce the frequency of feed gaps on mixed farms in a range of agro-climatic regions. At all locations examined there were benefits for potential farm productivity and risk mitigation by increasing the diversity of forage sources available on mixed farms. Systems relying on only one feed source were prone to higher risk or feed gaps and hence would often have to reduce stocking rates to mitigate these risks. Higher stocking rates could be maintained while limiting risk when combinations of other feed sources were introduced into the feed-base. In all cases we found diminishing returns from making the feed-base more complex, with combinations of 2-3 components typically achieving the maximum benefits in terms of reducing the risk of feed gaps.

Even in stubble retention farming systems in southern Australia, stubbles were found to be a particularly important forage resource for managing periods of low feed supply from other source during summer and autumn. Making stubbles available was highly valuable for avoiding whole-farm feed deficits where supplementary feeding or destocking would be necessary and reducing grazing pressure and the occurrence of low pasture availability on other parts of the farm. Dual-purpose crops and perennial pastures such as lucerne and temperate grasses which provided autumn and winter forage were also effective at providing more continuous supply of fresh forage and complimented stubbles to further reduce risk in mixed farm feed systems. In contrast to the southern locations, in the subtropical location (Roma) feed gaps were more common in winter and spring and hence the addition of summer feed sources had little benefit. On the other hand, oats providing high quality winter forage was found to be highly valuable.

Conclusions and Implications

Diversifying the feedbase to include combinations of improved pastures, crop residues and forage crop grazing demonstrates the capacity to increase stocking rate significantly at the same time as reducing or maintaining the risk of feedgaps occurring on mixed farms. While higher
stocking rates increase the risk of a feed deficit, diversified feed-bases were still able to maintain these higher stocking rates at the same time as lowering the frequency of farm feed deficits than would be achieved under low stocking rates (i.e. 45% of the high rate) on a feed-base consisting of a pasture-only. This demonstrates that there is significant potential to build forage-based feed systems that overcome critical feed gap periods and their-by mitigate the risks of increasing farm stocking rates required to improve the total productivity from livestock systems.

Acknowledgement

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References


The profitability of forage options for beef production in the subtropics of northern Australia

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Summary
Forage biomass production, diet quality, cattle liveweight (LW) gain, and economic performance were measured for 6 forage types across 21 sites on 12 commercial beef cattle properties in the Fitzroy River catchment of Queensland during 2011-2014 (28 annual data sets in total). Sown perennial legume-grass or annual forages resulted in 1.2-2.6 times the annual cattle LW gain per ha than perennial grass pastures. However, there was no correlation between annual cattle LW gain per ha and gross margin. Furthermore, neither forage establishment and management costs nor cattle price margin (sale price less purchase price, $/kg LW) were correlated with gross margin. The average gross margins were higher for legume-grass pastures than for annual forage crops or perennial grass pastures. This was the result of the combined effects of lower average forage costs and high cattle productivity.

Introduction
Northern beef producers continually need to find strategies to increase profitability (McLean et al. 2014). Targeted use of high quality forages has the potential to improve the profitability of northern beef enterprises through increasing enterprise turnover and productivity (Bowen et al. 2010). This study examined the key drivers of profitability for major annual and perennial dryland forage systems used for beef cattle production in the Fitzroy River catchment of Queensland.

Materials and Methods
Forage biomass production, diet quality, cattle LW gain, and economic performance was measured for 6 forage types at 21 sites across 12 commercial beef cattle properties in the Fitzroy River catchment of Queensland during 2011-2014 (28 annual data sets in total). The forages were annual forage crops (oats (Avena sativa), sorghum (Sorghum spp.) and lablab (Lablab purpureus)), sown perennial legume-grass pastures (leucaena-grass (Leucaena leucocephala spp. glabrata) + tropical grass (C4 species) and butterfly pea-grass (Clitoria ternatea + C4 grass species)), and perennial, C4 grass pastures.

Results and Discussion
The sown forages resulted in 1.2-2.6 times the annual cattle LW gain per ha compared to that measured for perennial grass pastures (Table 1; values mean ± SE). However, there was no relationship between annual cattle LW gain per ha and gross margin. Furthermore, neither forage establishment and management costs nor cattle price margin (sale price less purchase price, range -$0.40-0.45/kg LW) were correlated with gross margin. In conclusion, trends in the data indicated that perennial legume-grass pastures, and particularly leucaena, on average resulted in greater profitability than annual forage crops or perennial grass pastures. Lower forage costs for these legume-grass pastures, compared to annual forage crops, combined with high productivity, appear to be the primary factors.

Acknowledgement
This work was co-funded by the Department of Agriculture and Fisheries, Queensland, and Meat and Livestock Australia.

References

Table 1. Key performance measures for six forage types grazed by cattle on commercial properties in central Queensland

<table>
<thead>
<tr>
<th></th>
<th>Annual forages</th>
<th>Perennial forages</th>
<th>Perennial forages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oats</td>
<td>Sorghum</td>
<td>Lablab</td>
</tr>
<tr>
<td>No. of datasets (No. of sites)</td>
<td>8 (6)</td>
<td>5 (4)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Forage biomass (t DM/ha)</td>
<td>4.6 ± 0.35</td>
<td>12.2 ± 5.25</td>
<td>6.0 ± 0.53</td>
</tr>
<tr>
<td>Diet crude protein (g/kg DM)</td>
<td>123 ± 7.2</td>
<td>88 ± 8.0</td>
<td>115 ± 15.5</td>
</tr>
<tr>
<td>Diet DM digestibility (%)</td>
<td>59 ± 1.3</td>
<td>55 ± 1.2</td>
<td>59 ± 0.5</td>
</tr>
<tr>
<td>Total cattle LW gain (kg/ha/yr)</td>
<td>93 ± 12.9</td>
<td>108 ± 40.3</td>
<td>99 ± 57.5</td>
</tr>
<tr>
<td>Forage costs ($/ha/yr)</td>
<td>194 ± 24.1</td>
<td>142 ± 46.5</td>
<td>144 ± 16.5</td>
</tr>
<tr>
<td>Gross margin ($/ha/yr)</td>
<td>102 ± 19.6</td>
<td>24 ± 47.7</td>
<td>18 ± 2.5</td>
</tr>
</tbody>
</table>

*Measurements made in the grazed paddock. Values are the peak biomass for annuals and the average biomass over the annual cycle for perennials. Values for leucaena biomass represent only the edible material (i.e. leaves and stems <5mm in diameter).

bForage costs are expressed per sown area only. Annual forage costs for perennials were calculated by amortising establishment and maintenance costs. cGross margins are expressed per total grazing area in sown forage paddocks.
Quantifying the scale of livestock yield gaps in India and identifying opportunities for investment

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Summary

Yield gap analyses compare actual and potential yields and are used to provide insights into where and how agricultural production can be increased. Yield gaps are often reported for crops, but are seldom used for mixed crop and livestock production systems. Using dairy production in India as a case study, we combined two different methods (analysis of reported yields and household modelling) to estimate the scale of livestock yield gaps and to identify opportunities to increase production. The biggest increase in milk production and profits came from combining improved livestock genetics with better nutrition. This information can be used by government and development agencies to define reasonable production targets and intervention strategies.

Introduction

Yield gap analyses are often used to compare observed and potential yields for a particular farm or region and to identify factors constraining production. Yield gaps are regularly reported for crop production, but are not commonly applied to livestock production systems. This is significant given the importance of livestock and mixed farming systems to global food production and nutritional security.

Amongst the literature there are a variety of methods for calculating potential yields (van Ittersum et al. 2013). Broadly, potential maximum yields for a given location are estimated by modelling or statistical analyses of reported actual yields. A frequent criticism of modelled potential yields is that yields are based on optimal farming conditions (e.g. crops are sown at optimal sowing time with effective pest, weed and disease control), and ignore practical farm-level constraints. However, depending on the models used, this method can give insights into factors constraining production and how current yields might be improved. Conversely, while potential yields based on reported data may give a more realistic expectation of what is locally achievable, there is rarely enough detail in the data to provide insights into how farm yields can be increased. Many analyses also ignore the fact that increasing production is not always accompanied by an increase in household income or nutritional security, and may result in unwanted effects such as an increase in greenhouse gas emissions. They may also overlook socio-economic constraints such as availability of labour, prices of inputs and access to markets.

Using the dairy industry in India as an example, we used analyses of reported yields to establish potential milk yields and thereby identify the size of livestock yield gaps. We then used household modelling to investigate strategies to increase dairy production within the constraints of the current production systems and indicate likely economic outcomes.

Materials and Methods

This case study focussed on the rainfed agricultural zone, which covers much of central and southern India. Household level data on dairy production was collected from the OPEC (Duncan et al., 2013), LSMS (World Bank), IMPACTlite (CGIAR) and VDSA (ICRISAT) databases. Supplementary information on animal management and economics was gained from a review of the literature. Most smallholder farms are less than 1 ha in size with farmers keeping 2-3 adult dairy cows. Two thirds of bovines are indigenous cattle breeds. However, they account for only 21% of milk production, with average yields of 2.3 kg/head.day. Diets are mainly based on crop residues and grasses grown on common lands.

A benchmarking analysis compared milk yields of the top 10% of producers with the other 90% to estimate the size of the yield gap.

A household model, the Integrated Assessment Tool (Lisson et al. 2010), was used to simulate baseline production systems and changes to animal management over 20 years. In the baseline scenario, 1 ha of cropping land was used to grow maize, sorghum and wheat, with crop residues fed to livestock. Livestock were also fed native grass. Feed not grown on-farm was purchased. Interventions tested were based on improved animal nutrition and replacing local animals with crossbred cattle or buffalo. No changes were made to the cropping component of the production system.
Results
In the benchmarking analysis of Indian dairy production, average milk yields produced by the top 10% of households were 2,206 kg milk/head.year. The other 90% of households produced an average yield of 388 kg milk/head.year, leaving a yield gap of 1,819 kg milk/head.year.

Annual milk production was limited by low daily yields (1.8 kg/head.day for local cattle) coupled with high animal mortality and extended inter-calving intervals (Table 1). Improving animal nutrition through the provision of supplements provided substantial increases in milk yields as well as halving animal mortality and reducing the inter-calving interval. When animals were fed the low quality baseline diet of crop residues and grasses, replacing local cattle breeds with buffalo or crossbred cattle provided modest increases in production. Much larger increases in production and income were achieved by replacing local cattle with buffalo or crossbred cattle and providing a high quality supplement. Replacing local cattle with buffalo provided the biggest increases in income, even though the level of production was not as high as for crossbred cattle.

Discussion
Analysis of livestock yield gaps is still a relatively new field and there is no standard methodology. Our strategy of combining statistical analysis of existing livestock yields with household modelling provides realistic estimates of how much dairy production can be increased in rainfed Indian production systems. This information can be used by government, donors and development agencies to define reasonable production targets and highlight possible interventions that can be used to increase production.

Results from our analyses suggest that there is large potential to increase dairy production within the rainfed agricultural zone of India. Closing this yield gap should increase household incomes and food supply. Average annual milk yields can be increased by improving nutrition or genetics, but the biggest gains will be realised when multiple strategies are combined.

In scenarios to improve the feeding of livestock, additional feed resources had to be purchased off-farm. In areas where feed resources are limited and there are few options to produce more feed, this may necessitate a regional reduction in total livestock numbers. Blümmel et al. (2016) noted that by replacing half the local cattle with crossbred cattle, milk production in Bihar state could be increased from 19.7 to 26.5 thousand t/day. However, within the constraints of existing feed resources, the total number of animal equivalents (350 kg cow) would need to be reduced from 13.1 to 12.8 million.

It is also important to note that increasing livestock production does not always translate into increased profits at the household level. In our analysis, keeping crossbred cattle gave the highest annual milk yields, but keeping buffalo gave higher profits. Buffalo milk has a higher fat content than cow milk, usually attracting a price premium. This means that farmers may be able to achieve larger increases in income with smaller increases in production. This potentially translates to a smaller investment in feed resources and less risk – both of which are key considerations for smallholder farmers. In addition, beef is not commonly consumed in India, and male cattle usually have little value to farmers except as draught animals. This means that male calves, which are an inevitable by-product of the dairy industry, are difficult to sell and become a drain on farmer resources. In most states, it is legal to slaughter buffalo so male offspring have some value.

Acknowledgements
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References


Supplementation of zinc-proteinate on serum biochemical parameters, antioxidant status, immune response and ovarian folliculogenesis in buffalo heifers


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Summary

In a 120 d trial, eighteen graded Murrah buffalo heifers were randomly allotted to 3 dietary groups varying in source and level of Zn supplementation in concentrate mixture to study the effect of organic (O) Zn (Zn proteinate; Zn-prot) supplementation (80 or 140 ppm) compared to inorganic Zn (I) (ZnSO₄) on serum biochemical parameters, antioxidant status, immune response and ovarian folliculogenesis. Highest (P<0.01) Zn concentration in serum without affecting the retention of other minerals (Cu, Mn and Fe) was observed with 140 ppm Zn supplementation as Zn-prot (140O<80O=140I). Serum alkaline phosphatase, total protein, globulin, and glucose concentrations increased (P<0.05) with organic Zn supplementation. Organic Zn lowered (P<0.01) lipid peroxidation (140O<80O<140I) and improved (P<0.05) the antioxidant enzyme (RBC catalase, glutathione peroxidase, superoxide dismutase) activities (140O>80O>140I). Similarly, organic Zn supplementation significantly (P<0.05) improved the immune response (humoral and cell mediated) and increased the number of large follicle with greater follicular size in ovary.

Introduction

Zinc (Zn) is an essential trace mineral, which can influence various biological functions (growth, immunity, antioxidant status, reproductive system, etc.) by being a cofactor for more than 300 metalloenzymes (Chasapis et al., 2012) and is deficient in most parts of soils in India (Nagalakshmi et al., 2009). To avoid deficiency of this important mineral, supplementation of Zn with a large safety margin has become a common practice at field level. But it’s over supplementation could affect the availability of other minerals like Cu (Spears, 1996). To overcome this problem chemically inert, more stable and highly bioavailable organic minerals (OM) were developed. Furthermore, the higher bioavailable OM could lower the requirements of minerals in animal compared to inorganic minerals (Spears, 1996). Based on this issue present study was conducted to investigate the effect of Zn Proteinate supplementation at 80 or 140 ppm levels on serum biochemical parameters, antioxidant status, immune response and ovarian follicular development in buffalo heifers compared to 140 ppm Zn as ZnSO₄.

Materials and Methods

In 120 d trial, 18 Murrah buffalo heifers (20-28 months age; 279.2±7.10 kg) were randomly divided in to three dietary groups of six animals each in completely randomized design. The 3 diets were prepared by varying the source and level of Zn supplementation in concentrate mixture (CM). Control CM contained 140 ppm Zn from ZnSO₄, whereas experimental CM were prepared by adding 80 or 140 ppm Zn from Zn Proteinate (Zn-prot). All the animals were fed with their respective concentrate mixture to meet 80% of protein requirements and ad libitum Para grass (Bracharia mutica) to meet the nutrient requirements (ICAR, 2013).

Minerals (analysed by Atomic Absorption Spectrometer, Arentz et al., 1977) and biochemical constituents (using Qualigen diagnostic kits) in serum and lipid peroxidation (Placer et al., 1966), antioxidant enzyme activities in haemolysate [Glutathione peroxidase (Paglia and Valentine, 1967); RBC catalase (Bergmeyer, 1983) and superoxide dismutase (Madesh and Balasubramanian, 1998)] respectively were measured on 90th d of experiment. Antibody titres (log₂) against Brucella abortus S₉ (Alton et al., 1975) and chicken RBC antigens (Wegmann and Smithies, 1966) were measured in serum collected at 7, 14, 21 and 28th d post sensitization (humoral immunity) and cell mediated immunity was assessed by in-vivo delayed type hypersensitivity (DTH) against phytohemagglutinin-P (PHA-P) at 24, 48 and 72 h post injection (Quist et al. 1997). After 60 days of feeding, ovarian folliculogenesis study was made daily with ultrasound scanner (Model Prosound 2, Aloka Make) equipped with 7.5 M Hz transducer in all the animals for next 60 days. Based on size, the follicles were grouped as large (>8 mm), medium (5-8 mm) and small (3-5 mm). Obtained data was analysed using SPSS 16th version.

Results and Discussion

Highest (P<0.01) Zn concentration (ppm) in serum without affecting the retention of other minerals (Cu, Mn and Fe) was observed with 140 ppm Zn supplementation as Zn-prot (140O<80O=140I). In addition reducing the Zn supplementation approximately by 50% (80 ppm) as Zn-prot had no affect the serum Zn concentration compared to ZnSO₄ supplementation as Zn-prot (140O<80O=140I). This might be due to higher bioavailability of organic minerals (Spears, 1996). The ALP activity, which could be used as an indicator of animal Zn status (Miller et al., 1965) significantly (P<0.05) higher with organic Zn (80 or 140 ppm) supplementation compared to heifers fed 140 ppm inorganic Zn. Similarly, total protein and glucose concentrations increased (P<0.05) with organic Zn supplementation compared to inorganic Zn. Significantly (P<0.01) highest globulin concentration was observed with 140 ppm Zn-prot supplementation compared to other dietary treatments.
Lipid peroxidation (LPx) in haemolysate, indicative of oxidative stress was significantly (P<0.01) lower with Zn-prot supplementation compared ZnSO₄ supplementation (140O<80O<140I). Activities of glutathione peroxidase (GPx) (P<0.01) and catalase (CAT) (P<0.01) which are involved in the antioxidant defense system (Prasad, 2014) increased with organic Zn supplementation compared to inorganic Zn. Zn is a cofactor for superoxide dismutase (SOD) enzyme (Marklund et al., 1982) and also considered as marker for Zn bioavailability (Paik et al., 1999). This enzyme activity significantly (P<0.01) increased in heifers receiving 140 ppm Zn as Zn-prot, followed by 80 ppm as Zn-prot and lowest activity was observed with 140 ppm Zn supplemented as ZnSO₄. Higher bioavailability of Zn from organic source (Spears, 1996) might be improved the antioxidant status of the animals though they received lower Zn (80 ppm) compared to animals supplemented with 140 ppm Zn from inorganic source.

Effect of organic zinc supplementation on lipid peroxidation and antioxidant enzyme activity in buffalo heifers

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Inorg-140</th>
<th>Org-80</th>
<th>Org-140</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
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<tr>
<td>LPx</td>
<td>2.03ab</td>
<td>1.60b</td>
<td>1.26a</td>
<td>0.096</td>
<td>0.001</td>
</tr>
<tr>
<td>GPx</td>
<td>6.52ab</td>
<td>7.26b</td>
<td>7.91b</td>
<td>0.255</td>
<td>0.076</td>
</tr>
<tr>
<td>CAT</td>
<td>3.26ab</td>
<td>4.32b</td>
<td>4.76b</td>
<td>0.224</td>
<td>0.009</td>
</tr>
<tr>
<td>SOD</td>
<td>0.116a</td>
<td>0.149b</td>
<td>0.188b</td>
<td>0.008</td>
<td>0.001</td>
</tr>
</tbody>
</table>

LPx - μmol MDA/mg Hb; GPx - μmole NADPH oxidized/g Hb/min; CAT - mmol/mg Hb; SOD - IU/mg protein; abc Means with different superscripts in a row differed significantly: P<0.05; SEM: Standard error mean

The titres against B. abortus antigen on 21 and 28 d of post immunization were higher (P<0.05) with organic Zn supplemented animals. Similarly, titres against chicken RBC increased (P<0.05) with Zn-prot supplementation on 7, 21 and 28 d of post immunization compared to inorganic Zn. The CMI against PHA-P (24 and 48 h of post sensitization) was significantly (P<0.01) higher with low (80 ppm) or equal (140 ppm) levels of organic Zn supplementation compared to inorganic Zn supplemented at 140 ppm. Higher Zn availability and antioxidative enzyme activities in heifers with organic Zn supplementation could have protected the immune cells from free radicals damage resulting in higher immune response (Osaretin et al., 2009).

Organic Zn supplementation lowered (P<0.05) the average number of small follicles in right ovary and increased the number of large follicles compared to inorganic Zn. In left ovary, the number of small sized follicles were higher (P<0.05) and medium sized follicles were lower (P<0.01) with 140 ppm Zn supplemented as Zn-prot than those fed 80 ppm Zn from Zn-prot and 140 ppm Zn from ZnSO₄. The number of large sized follicles was higher with organic Zn supplementation compared to inorganic source of Zn and no difference was observed between the two doses of organic Zn supplementation. In addition, reducing Zn supplementation when supplemented as Zn-prot had no adverse effect the folliculogenesis in ovaries, which could be attributed to lower oxidative stress with organic Zn supplementation protecting the rapidly growing ovarian follicles form reactive oxygen species (Agarwal et al., 2012).

The study indicated that 140 ppm Zn supplementation as Zn proteinate resulted in better antioxidant status, immune response and folliculogenesis in ovaries than from inorganic source and the Zn supplementation could be reduced from 140 to 80 ppm when supplemented as Zn-prot without any adverse effect on antioxidant status, immune response and ovarian follicular development.

Figure: Ovary of heifers fed diets supplemented with 140ppm Zn as ZnSO₄

References

Being born a twin does not reduce pregnancy rates in 15-month-old heifers

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Summary

Twin and single born heifers in a commercial herd, grading up to US Meat Animal Research Center Twinner genetics have been mated as heifers. Twin born heifers were as fertile as single born animals, confirming that by 15 months of age they had grown and matured to be equivalent to the singles.

Introduction

Twin born calves are smaller at birth and weaning than singles and there is a widespread industry perception they “never grow out and perform satisfactorily”. Given the importance of weight and fat depth at mating for achieving satisfactory heifer pregnancy rates (Cummins 1984, Jones et al 2016), the question is “does being born a twin reduce heifer fertility?”

We commenced importing US Meat Animal Research Center (USMARC) Nebraska, Twinner genetics in 2004 and have run a grading-up program for these cattle in a small commercial beef herd at Cavendish. The USMARC Twinner line has been selected for increased twinning rate for over 30 years and had a calving rate of 1.56 per parturition in 2004 (Echternkamp et al 2007). This paper reports the reproductive performance of twin and single born heifers with 50 - 100% twinner blood at their first mating in our herd.

Methods

Calves were tagged at birth and weighed at weaning in late November (approximately 8 months of age). Steers and freemartins were sold soon after this and the breeding heifers retained. Freemartins were identified on the basis of birth type and short vaginal lengths. In the last 2 years, some breeding heifers have also been sold, but our bias for retaining heifers has been to increase the proportion of USMARC twinning genes, the polledness and develop a more market acceptable coat colour with little emphasis on weaning weight. A modest amount of supplementary feed was provided over the summer and autumn and the heifers mated at the start of June (about 15 months of age) for a period of 8 to 9 weeks. Ultrasound pregnancy testing was carried out at an average of 11 weeks after the start of mating. The herd has been managed in age groups with twin born and single born animals running together.

Results

Weaning weights have been recorded for the 2009 - 2014 drop calves. For 138 of the heifers whose fertility results are included in this paper, the twin born heifers had a predicted weaning weight of 255.7 Kg compared with 311.9 Kg for the single born heifers (L.S.D. 13.9 Kg).

The early pregnancy test allowed the identification of non-pregnant heifers, those carrying singles, those with twins, plus a combined figure for the total number of foetuses. The effect of birth type on the predicted pregnancy rates from the early examination for the 176 heifers born between 2005 and 2014 is shown in Table 1.

Table 1. Pregnancy Rates. The predicted values for heifers born as singles or twins shown in bold, with boundaries of the lower and upper predicted 95% confidence intervals in italics.

<table>
<thead>
<tr>
<th>Birth type</th>
<th>NP*</th>
<th>Single</th>
<th>Twin</th>
<th>RR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>0.21</td>
<td>0.61</td>
<td>0.18</td>
<td>0.98</td>
</tr>
<tr>
<td>Boundaries</td>
<td>0.19 - 0.23</td>
<td>0.57 - 0.64</td>
<td>0.17 - 0.20</td>
<td>0.91 - 1.04</td>
</tr>
<tr>
<td>Twin</td>
<td>0.17</td>
<td>0.60</td>
<td>0.23</td>
<td>1.06</td>
</tr>
<tr>
<td>Boundaries</td>
<td>0.13 - 0.21</td>
<td>0.51 - 0.68</td>
<td>0.19 - 0.28</td>
<td>0.89 - 1.24</td>
</tr>
</tbody>
</table>

*NP = not pregnant. *RR = reproductive rate combining singles as 1 and twins as 2. The t probability for pairwise differences was 0.45 (NS).

The effect of birth type on the predicted number of calves born for the 155 heifers born between 2005 and 2013 are shown in table 2.
Table 2. Calving Rates. The predicted values for heifers born as singles or twins shown in bold, with the boundaries of the lower and upper 95% confidence limits in italics.

<table>
<thead>
<tr>
<th>Birth type</th>
<th>Calving Status</th>
<th>N</th>
<th>C</th>
<th>#</th>
<th>RR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td></td>
<td>0.36</td>
<td>0.54</td>
<td>0.11</td>
<td>0.75</td>
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<tr>
<td>Boundaries</td>
<td>0.34 - 0.38</td>
<td>0.09 - 0.12</td>
<td>0.68 - 0.82</td>
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<td></td>
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<tr>
<td>Twin</td>
<td></td>
<td>0.27</td>
<td>0.58</td>
<td>0.15</td>
<td>0.89</td>
</tr>
<tr>
<td>Boundaries</td>
<td>0.21 - 0.33</td>
<td>0.11 - 0.20</td>
<td>0.70 - 1.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*NC = did not calve. *RR = reproductive rate combining singles as 1 and twins as 2. The t probability for pairwise differences was 0.29 (NS).

Discussion

The 18% reduction in weaning weight in these twin born heifers is consistent with the results obtained at Hamilton and Grafton with embryo transfer induced twinning (Cummins et al 1994 and Hennessy et al 1994) and confirms that a cow producing twins will produce around 160% of the weight of weaned calf compared with a cow rearing a single.

The pregnancy and calving data shows that being born a twin has not reduced the fertility of these 15- month-old heifers. This was not tested directly at USMARC because their heifers underwent up to 6 cycles of ovarian evaluation post puberty to generate the ovulation rates used in selection. Given the importance of weight and fatness at mating time to successful conception in beef heifers (Cummins 1984, Jones et al 2016), our results are perhaps surprising. In these observations we have not recorded post weaning growth rates, however in the embryo transfer work, the twin born calves showed post weaning compensatory growth (Clark et al 1994). It is our impression that by 2 years of age the twin born females do not differ in size compared with the singles. At USMARC, twin and single born heifers or steers did not differ significantly in ADG from birth to slaughter or most carcass traits. The twinner line steers gained faster and produced more desirable carcasses than a high performance reference group set up for comparison (Gregory et al 1996). The relatively low overall pregnancy rates include 2 very difficult seasons with probably less than optimal nutrition over summer and autumn. The older cows in the herd have performed better and had much higher twinning rates. Over the whole herd, the twin conception rate (per cow pregnant) was 39% (Cummins et al 2015).

In conclusion, by mating time at 15 months of age, twin born heifers had grown and matured sufficiently to be as fertile as single born heifers.

Acknowledgements

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References


The Nutritive Value and Eating Quality of Australian lamb cuts

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Summary

This paper describes work that is being undertaken to provide an information resource regarding large lamb cuts in terms of eating and nutritional qualities, estimated weights and the contribution to total yield, and best cooking methods. Furthermore, efforts to identify potential novel cuts with applicability to large lamb carcases is being undertaken using information from lamb and other animal species within Australian and international markets.

Introduction

A resource titled “The Nutritive Value and Eating Quality of Australian lamb cuts” has been developed to collect information on the current lamb cuts described in the Australian Meat Handbook (Anon, 2005).

The information was sourced from publicly available data, both published and unpublished, and includes preparation methods, cut weight prediction tables (based on hot carcase weight (HCW) and GR), recommended cook methods, eating quality information as well as the nutrient content for each cut. The nutrient content has been broken into grass-fed and grain fed animals as a market for grass-fed branded meat is emerging and future nutritional information would be beneficial to processors and retailers. An example of this information is shown in figure 1, for the Rump which is one of the more complete datasets. The absence of much information is apparent throughout the document and is especially pronounced regarding cut eating quality from different cooking methods as affected by lamb age (yearling versus lamb) and nutritional data.

There is also a database of current Beef, Lamb and Pork cuts utilised by retailers and processors in Australia as well as various other countries. This was included to highlight cuts that are currently utilised in other markets which have not been commercialised in Australia. Furthermore, evident from other animal species is the availability of some comparable cuts for future investigation. The document is available online at http://www.sheepcrc.org.au/files/pages/information/publications/publications-meat/information_Matrix_Ver_1.pdf.

With these observations arises the need for additional scientific research to fill the identified paucity and expand the matrix to include novel cuts from lambs and other species in other global markets. This will facilitate better cut selection for large lamb carcases.

This document will evolve as new information is captured, along with the addition of new cuts not currently identified in the Australian Meat Handbook (Anon, 2005) but currently used commercially by retailers and processors. These will be added to the database with preparation methods and any other available information.

Conclusion

This document is a valuable resource, pooling together current available information, as well as highlighting the need for further work. The addition of a cuts database also allows processors and retailers to broaden their selection of cuts, especially for the growing ‘larger lamb’ markets.

References

Figure 1. The “Rump” from the “The Nutritive Value and Eating Quality of Australian lamb cuts”.

<table>
<thead>
<tr>
<th>HCW</th>
<th>Prediction Table: Fat Score (GR)³⁷</th>
<th>Note: HAM: 5074</th>
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<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>26</td>
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</tr>
<tr>
<td></td>
<td>0.29</td>
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</tr>
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<td></td>
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<tr>
<td></td>
<td>2.1 serves</td>
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<td></td>
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<td>542</td>
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<tr>
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<td>Carbohydrates (g)</td>
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<td>Saturated Fat (g)</td>
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<td>Trans fat (g)</td>
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<td>EPA + DHA (mg)</td>
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<tr>
<td>Cholesterol (mg)</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>65</td>
<td>65</td>
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<tr>
<td>Potassium (mg)</td>
<td>350</td>
<td>350</td>
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<tr>
<td>Iron (mg)</td>
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<tr>
<td>Zinc (mg)</td>
<td>3.6</td>
<td>3.6</td>
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<tr>
<td>Selenium (mcg)</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Phosphorus (mg)</td>
<td>350</td>
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<tr>
<td>B1 (mg)</td>
<td>0.16</td>
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<tr>
<td>B2 (mg)</td>
<td>0.26</td>
<td>0.26</td>
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<tr>
<td>B3 (mg)</td>
<td>6.5</td>
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</tr>
<tr>
<td>B5 (mg)</td>
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</tr>
<tr>
<td>B6 (mg)</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>B12 (mcg)</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Recommended Cooking Methods²⁹, ³³, ³⁴:
- **Grill**
- **Roast**
- **Stir Fry**
- **Casserole**

Percentage contribution to total carcase yield (% wt): 1.10%

Yearling Grill: 66.4, Roast: 66.0, Stir Fry: 66.0, Casserole: 66.0

Flavour:
- Overall: 66.4
- Juiciness: 65.9
- Tenderness: 58.4

Lamb Grill: 64.8-86.7, Roast: 60.8-70.6, Stir Fry: 62.9-69.2, Casserole: 62.9-69.2

Leg – Chump On [24] > Rump >
Metabolome and microbiome associations after a grain and sugar challenge

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Summary
Associations between the metabolome and microbiome were investigated in a grain and fructose challenge using dairy heifers fed feed additives. Forty Holstein heifers allocated to 5 groups: (1) control (no additives); (2) virginiamycin; (3) monensin + tylosin; (4) monensin + yeast; and (5) sodium bicarbonate + magnesium oxide were fed a total mixed ration and respective feed additives for 20 days (d). Co-inertial analysis explained 31.9% of the total variation in the associations among rumen fermentation products, bacterial community composition, and groups using rumen samples collected 3.6 hrs after heifers were challenged with a ration of wheat and fructose on day 21. Histamine and valerate concentrations explained the most variation in the microbiome. The feed additives appeared to influence different microbial populations after the challenge.

Introduction
The prudent use of feed additives is one of the many prevention strategies that can be used to mitigate ruminal acidosis and therefore improve animal production, health, and welfare. Golder et al. (2014) showed a large variation in rumen fermentation products, among heifers fed within different feed additive groups, over a 3.6 hr period after consumption of a grain and fructose challenge. The feed additives investigated are proposed to have different modes of action and varied microbiome responses which was reflected in the metabolomics results (Golder et al. 2014). The aim of this study was to investigate the metabolome and microbiome associations in the heifers of Golder et al. (2014) to improve understandings of ruminal acidosis mitigation and modes of action of feed additives.

Materials and Methods
As described by Golder et al. (2014), Holstein heifers (n = 40) were allocated to 5 groups: (1) control (no additives); (2) virginiamycin (10 g/head.d:VM); (3) monensin (2.2 g/head.d) + tylosin (0.44 g/head.d:MT); (4) monensin (2.5 g/head.d) + yeast (Levucell SC Direct 25 g/head.d:MY); (5) sodium bicarbonate (200 g/head.d) + magnesium oxide (30 g/head.d:BUF).

Heifers were fed twice daily a 62% forage:38% concentrate total mixed ration at 1.25% of bodyweight (BW) dry matter (DM)/d for a 20-d adaptation period with their additive(s). Fructose (0.1% of BW/d) was added to the ration for the last 10 d of adaptation. On d-21 heifers were challenged with a ration consisting of 1.0% of BW DM wheat and 0.2% of BW fructose plus their additive(s). The non-fibre carbohydrate content of the challenge ration was estimated to be 76.3% of DM (CPM Dairy Ration Analyzer, Version 3.10; Cornell-Penn-Miner, Cornell University, Ithaca, NY, USA).

Rumen samples were collected 3.6 hrs after consumption of the challenge ration on d-21 using a custom designed stomach tube. Rumen fluid was scored for saliva contamination as described by Bramley et al. (2008). Rumen pH was measured immediately using a pH meter (Merck Pty Ltd., Kilsyth, VIC, Australia). Rumen samples were processed and analysed for concentrations of total volatile fatty acids (VFA), ammonia, D- and L-lactate, and histamine as described by Golder et al. (2014). Rumen samples used for total bacterial analysis were stored at -80°C, before genomic DNA extraction using modifications to the QIAmp DNA mini kit cat no. 51306 protocol (Qiagen GmbH, Hilden, North Rhine-Westphalia, Germany). The 16S rRNA gene spanning the V4 region was PCR amplified and sequenced using an Illumina MiSeq platform (Macrogen, Seou, South Korea).

Sequence data was analysed using the Quantitative Insights Into Microbial Ecology software package (QIIME; Caporaso et al. 2010). Co-inertia analysis, including monte-carlo estimations (Ad4 package, R software) was conducted using operational taxonomic units (OTUs) and rumen fermentation data from each group.

Results
The within group variation was very large for the majority of rumen fermentation measures (Table 1). A total of 31.9% of the variation in the associations among rumen fermentation products, OTUs, and groups was explained in the co-inertia analysis (Fig 1). The monte-carlo estimation was 0.231. The co-inertia analysis showed that bacterial community composition (BBC) had the largest association with concentration of histamine, followed by concentration of valerate. The next largest association was with rumen pH, followed by concentrations of propionate and ammonia and then concentration of butyrate. The BBC in VM heifers was associated with lower concentrations of valerate and propionate and higher pH. The BBC of MLY heifers was associated with lower concentrations of ammonia, butyrate, and histamine. In MT heifers, BBC was associated with higher concentrations of valerate, propionate, lactate and total VFA, and lower pH. Lactate and pH had an inverse association with BBC.

Discussion
Understanding the large within group variation in the metabolomic data by Golder et al. (2014) is important in increasing our understandings of the aetiology of ruminal acidosis and its control. Although only ~ 32% of the variation was explained in the co-inertia analysis it provides a visual representation of the associations between the metabolomics and microbial data from the feed additive groups. It demonstrates that the feed additives appear to be...
influencing different microbial populations. However, it is not clear which feed additives had the most favourable associations and responses did not always appear consistent within groups. Ruminal histamine has been proposed to be associated with the pathogenesis of ruminal acidosis (Ahrens, 1967), but its exact involvement is yet to be determined. The importance of safe hydrogen sinks and movement of hydrogen requires further investigation. The next stage of this study is to run pairwise comparisons of abundance of individual OTUs between groups to determine OTUs that are associated with particular feed additives under grain and fructose challenge conditions. We are also examining the relationship of the microbiome and metabolomics with host genomics.

Table 1. Group raw means (±SD) of rumen measures taken 3.6 hrs after consumption of respective challenge ration

<table>
<thead>
<tr>
<th>Parameter (mM)</th>
<th>Control</th>
<th>VM</th>
<th>MT</th>
<th>MLY</th>
<th>BUF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total VFA</td>
<td>108.1±33.6</td>
<td>99.1±31.4</td>
<td>115.4±28.6</td>
<td>102.4±24.4</td>
<td>119.8±23.9</td>
</tr>
<tr>
<td>Acetate</td>
<td>65.1±17.8</td>
<td>58.9±21.3</td>
<td>66.1±14.3</td>
<td>60.0±14.0</td>
<td>79.0±11.5</td>
</tr>
<tr>
<td>Propionate</td>
<td>22.1±11.5</td>
<td>16.9±4.3</td>
<td>25.8±11.7</td>
<td>25.4±10.8</td>
<td>19.6±7.9</td>
</tr>
<tr>
<td>Butyrate</td>
<td>18.2±9.3</td>
<td>21.7±8.6</td>
<td>18.4±7.6</td>
<td>13.2±5.9</td>
<td>19.3±7.5</td>
</tr>
<tr>
<td>Valerate</td>
<td>2.65±2.27</td>
<td>1.57±0.57</td>
<td>5.18±4.35</td>
<td>3.68±3.22</td>
<td>1.79±0.91</td>
</tr>
<tr>
<td>Total lactate</td>
<td>39.7±55.6</td>
<td>11.5±21.4</td>
<td>35.4±42.9</td>
<td>14.6±41.0</td>
<td>27.0±54.0</td>
</tr>
<tr>
<td>Ammonia</td>
<td>4.13±3.63</td>
<td>2.49±1.98</td>
<td>1.39±1.56</td>
<td>0.71±2.02</td>
<td>1.70±1.43</td>
</tr>
<tr>
<td>Histamine (ng/mL)</td>
<td>145.2±115.5</td>
<td>210.2±95.2</td>
<td>123.2±79.8</td>
<td>45.4±63.9</td>
<td>170.1±47.8</td>
</tr>
<tr>
<td>pH</td>
<td>5.65±0.40</td>
<td>6.07±0.60</td>
<td>5.38±0.50</td>
<td>6.09±0.73</td>
<td>5.89±0.64</td>
</tr>
</tbody>
</table>

VM = virginiamycin; MT = monensin + tylosin; MLY = monensin + live yeast; BUF = sodium bicarbonate + magnesium oxide

Fig 1. Duality diagram of co-inertia analysis of ruminal bacterial communities and measures of ruminal fermentation in dairy heifers from 1 of 5 feed additive groups (1) control (no additives); (2) virginiamycin (VM); (3) monensin + tylosin (MT); (4) monensin + yeast (MLY); (5) sodium bicarbonate + magnesium oxide (BUF) taken 3.6 hrs after consumption of a challenge ration of grain and fructose. On the bi-plot, the ruminal fermentation measures are represented as arrows. The direction of the arrow of each ruminal fermentation measure indicates an increasing magnitude of that measure. The angle between the arrows indicates their degree of correlation. The magnitude of the arrows indicates the importance of a measure on bacterial community composition. Measures with long arrows are more strongly correlated with the ordination axes than short arrows and have a greater influence on the pattern of variation (Carberry et al. 2012).

Acknowledgement

This research was funded by Scibus (Camden, NSW, Australia), DairyNSW (Camden, NSW, Australia), Lallemand Animal Nutrition (Maroochydore, QLD, Australia). The authors thank I. Tammen and The Farm Animal Health Group (The University of Sydney Camden, NSW, Australia) for bench space and use of equipment.

References

A dual function GR/Impedance probe was tested to determine its potential to accurately measure the GR tissue depth of 1016 lamb carcases measured over 4 days as they entered the chillers approximately 25 – 35 min after slaughter. Carcase weight, palpated fat score, GR depth measured with a GR knife and probe operator were also recorded. Overall, there was a limited ability ($R^2 = 0.19$) to measure GR tissue depth using the dual function probe, although this did vary with measurement days and operator. Despite the low predictions found, this study did highlight several improvements which could be made to the current probe, including reducing its size and weight, which would improve the accuracy of measurements.

Introduction

The GR tissue depth is defined as the total tissue thickness on a lamb or sheep carcase 110mm from the midline over the 12th rib. GR tissue depth is the basis of the current fat scoring system used in a number of sheep abattoirs and GR is commonly used as an indicator of carcase composition and yield in hot carcases. Although the AUS-MEAT sheep probe (ASP) was able to measure the GR tissue depth at chain speed (Hopkins et al. 1995), this probe is no longer available. Consequently, palpated fat scores are now the most commonly used method to estimate tissue depth at the GR site. Therefore, a more accurate measurement is required. The aim of this study was to determine the potential of a GR/Impedance probe to measure GR tissue depth on carcases in commercial processing plants.

Materials and Methods

One thousand and sixteen (1016) carcases were measured online or in the chillers during two complementary experiments. Carcases were measured approximately 25 – 35 min post slaughter using a GR knife as the gold standard and with the probe (Fig. 1). Carcase weight, fat score and probe operator were also recorded. Statistical analysis was completed using linear regression.

Results and Discussion

Overall the lambs in these studies represented the lambs which are typically processed within Australian lamb processing plants. Carcase weights ranged from 11 – 33 kgs (22.6 kg mean) with GR tissue depths measured with the knife ranging from 1.5 – 25 mm (11mm mean).

Modelling of the GR tissue depths measured using the GR knife and the GR/Impedance probe yielded a moderate relationship between the measurements for experiment 1, yet a weak relationship was found when larger numbers of carcases were measured in experiment 2 (Fig 1). Although it is difficult to directly compare the performance of the GR/Impedance probe with the ASP (Hopkins et al. 1995) and the Hennessey Grading probe (HGP) (Hopkins et al. 2013), these experiments highlight the challenges of implementing and validating technologies for GR depth measurement.
Variability in the conformation of lamb carcases is an ongoing challenge for the development of a probe to measure GR tissue depth, especially soon after slaughter when hot, given that they lack rigidity and are also slippery to handle. As the GR/Impedance probe is a similar design to the Fat-o-Meater developed for pork carcase assessment (Goenaga, Lloveras, and Améndola 2008), the front of the probe is too large and does not sit entirely flat against the ribs of the carcase. Therefore, future modifications should miniaturise the current probe face to facilitate measurement of carcases with varying conformation.

As with both the HGP and ASP (Hopkins et al. 1995, Hopkins et al. 2013), the ability to measure the GR depth using the GR/Impedance probe varied over the measurement days during experiment 2 with the lowest $R^2$ equalling 0.08 calculated for data collected on day 2. This suggests that modifying the probe to reduce the weight and size could improve its performance, reducing operator fatigue over continued measurement days.

Similar to Hopkins et al. (1995), experiment 2 emphasised the significance of operator training and operator monitoring, as the accuracy of the measurement changed with operator ($R^2 = 0.22$ and $R^2 = 0.12$, for operator 2 and 1 respectively). Consequently, technologies to measure GR tissue depth should include suitable protocols for measurement.

**Conclusion**

Based on the results of this study, the dual function GR/Impedance probe in its current design is unable to provide the accurate measurements of GR tissue depth required by industry. However, this study did identify several modifications to the probe that would enable accurate measurements at chain speed.

**Acknowledgements**

The authors would like to thank Gundagai Meat Processors, Beaufort River Meats and WAMMCO International for their assistance with this study and the Sheep CRC for funding the research.

**References**


The effect of weight and age on pregnancy rates in maiden Brahman heifers in northern Australia.

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Summary

Relationships between pre-mating weight and pregnancy rate were established for Brahman heifers mated as yearlings grazing on improved pasture in the Douglas Daly region (4 year groups of about 100 per year), and as 2 year olds grazing on native pasture in the Victoria River District (3 year groups of about 100 per year) where pre-mating weight was recorded in either late October/early November, or in late December. These relationships were used to model pregnancy rates that are likely to result from different pre-mating weights for these 3 scenarios. These estimates can be used to identify target mating weights for different situations, and to predict the pregnancy rates likely from groups of heifers when budgeting and assessing the profitability of different management strategies.

Introduction

It is generally accepted that live-weight is the major factor influencing the onset of puberty and pregnancy rates in maiden heifers, and that pregnancy rates increase as pre-mating weights increase (Entwistle 1983). However some studies have found that heifers on higher planes of nutrition reach puberty at younger ages and heavier weights than heifers that have grown slower and hence are older (Short and Bellows 1971; Greer et al. 1983). This suggests that the relationship between pre-mating weight (PM Wt) and pregnancy rates in maiden heifers is different for heifers mated at different ages, and that different target weights are required when heifers are mated at different ages.

Due to the strong relationship between PM Wt and pregnancy rate, it is possible to develop models that predict pregnancy rates from PM Wt’s and to set target mating weights that will ensure good pregnancy rates (Rudder et al. 1985; Doogan et al. 1991). Some studies have proposed models which predict maiden heifer pregnancy rates from PM Wt’s for Bos indicus cross heifers (e.g., Rudder et al. 1985; Doogan et al. 1991), but none are directly relevant to high grade Brahman heifers grazing on native pasture in extensive situations in northern Australia. This study aimed to quantify these relationships for Brahman heifers mated as 2 year olds and also as yearlings grazing on improved pasture, and also to determine whether these relationships differ for heifers of different ages and when PM Wt weight is recorded at different times prior to mating.

Materials and Methods

Commercial Brahman heifers were mated for the first time as 2 year olds at the Victoria River Research Station (VRRS), and as yearlings at the Douglas Daly Research Farm (DDRF) in the Northern Territory. Three year groups of heifers that were weaned at VRRS in 2004 (#4), 2005 (#5), and 2006 (#6) grazed on native pasture with year round access to inorganic supplements until they were mated from late December (Dec) when they were about 2 years old. In 4 consecutive years, starting in 2004, about 100 high grade Brahman heifers weighing between 195 and 260 kg shortly after weaning were purchased from a commercial NT cattle property (a different property each year) and transported to DDRF for mating as yearlings. At DDRF the heifers grazed on improved Buffel grass (Cenchrus ciliaris) pasture and had year round access to inorganic supplements.

At both sites mating was from late Dec (just before Christmas) until the end of March. PM Wt was recorded at the start of mating at DDRF, and in late October or early November (PM Wt - Oct/Nov) at VRRS. The PM Wt at the actual start of mating on the 20th of Dec (PM Wt – Dec) was estimated for each 2 year old heifer at VRRS using its growth rate between PM Wt - Oct and a weight recorded during mating.

All weights were recorded after an overnight curfew with no access to feed or water and all heifers were vaccinated for botulism, vibriosis, leptospirosis and clostridial diseases. Pregnancy testing (manual palpation per rectum) was conducted about 2 months after mating and real time ultrasound was used to confirm non-pregnancy and foetal age for early pregnancies.

The relationship between pregnancy rate and PM Wt for each of the data sets was assessed with generalised linear models using binomial errors and a logit link function (McCullagh and Nelder 1989). This was done for yearling PM Wt - Dec at DDRF, and for both PM Wt – Oct/Nov and PM Wt - Dec for 2 year old heifers at VRRS. For each of these analyses, year was fitted as a covariate. In each case there was no significant interaction between year and PM Wt on mating success, so pooled year data was used to predict the probability of successful mating from PM Wt using binomial generalized linear models (McCullagh and Nelder 1989). These models were used to produce tables predicting the pregnancy rates for different PM Wt’s.

Results and Discussion

The pregnancy rates, average PM Wt - Dec, and number of heifers mated each year are shown in Table 1 for heifers mated as yearlings at DDRF and 2 year olds at VRRS. Even though only heifers weighing over 190 kg at weaning were selected for yearling mating, only about one third of them conceived during the ~3 month mating period (Table 1). This is not surprising as Johnston et al. (2009) found that the average weight at puberty for Brahman heifers was 334 kg and many of the heifers did not reach this weight during the mating period. All 3 year groups of heifers mated as 2 year olds at VRRS achieved a pregnancy rate over 80% (Table 1). The average weight at first conception was 316 kg for yearlings and 338 kg for 2 year olds. However it should be noted that these averages only included heifers that conceived during the ~3 month mating period and rates...
would have been higher if mating had continued until all heifers had conceived.

Table 1. The performance of maiden Brahman heifers mated as yearlings (1) at DDRF, and 2 year olds at VRRS.

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Year Group</th>
<th>n</th>
<th>PM Wt – Dec (kg)</th>
<th>Pregnancy Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td># 4</td>
<td>110</td>
<td>259</td>
<td>27</td>
</tr>
<tr>
<td>1</td>
<td># 5</td>
<td>92</td>
<td>252</td>
<td>36</td>
</tr>
<tr>
<td>1</td>
<td># 6</td>
<td>98</td>
<td>265</td>
<td>36</td>
</tr>
<tr>
<td>1</td>
<td># 7</td>
<td>91</td>
<td>251</td>
<td>35</td>
</tr>
<tr>
<td>1</td>
<td>Average</td>
<td>98</td>
<td>257</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td># 4</td>
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<td>90</td>
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<td>2</td>
<td># 5</td>
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</tr>
<tr>
<td>2</td>
<td># 6</td>
<td>102</td>
<td>288</td>
<td>88</td>
</tr>
<tr>
<td>2</td>
<td>Average</td>
<td>93</td>
<td>286</td>
<td>87</td>
</tr>
</tbody>
</table>

Figure 1 and Table 2 show the pregnancy rates predicted from yearling mated heifers with different average pre-mating weights. These can be used in making management decisions about which heifers might be suitable for yearling mating and in economic evaluation of strategies to increase growth for yearling mating.

Figure 1. The effect of pre-mating weight on pregnancy rate in Brahman heifers.

Table 2. The predicted pregnancy rates for Brahman heifers of different pre-mating weights (PM Wt) recorded for: yearlings in Dec, and 2 year olds in Oct/Nov and in late Dec.

<table>
<thead>
<tr>
<th>PM Wt (kg)</th>
<th>Yearlings PM Wt – Dec (%)</th>
<th>2 year olds PM Wt – Oct/Nov (%)</th>
<th>2 year olds PM Wt – Dec (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>11</td>
<td>50</td>
<td>34</td>
</tr>
<tr>
<td>220</td>
<td>16</td>
<td>63</td>
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<td>240</td>
<td>24</td>
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<td>96</td>
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</tr>
<tr>
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<td>78</td>
<td>97</td>
<td>95</td>
</tr>
<tr>
<td>360</td>
<td>98</td>
<td>98</td>
<td>97</td>
</tr>
</tbody>
</table>

Fig. 1 shows that the relationships between PM Wt and pregnancy rate are different for heifers mated as yearlings, and heifers mated as 2 year olds where PM Wt was recorded either in Oct/Nov or Dec. Pregnancy rates were lower in yearling heifers than in 2 year old heifers of the same PM Wt. This is consistent with other studies that have found that heifers on higher planes of nutrition reach puberty at younger ages and heavier weights than heifers that have grown more slowly and hence are older (e.g., Short and Bellows 1971; Greer et al. 1983). It is widely accepted that weight has a greater effect on attainment of puberty than age (Entwistle 1983), however these results support the theory that there is an interaction between age and weight that modifies the effect of weight.

The relationships between pregnancy rate and PM Wt for 2 year old heifers in Fig. 1 show that pregnancy rates for a specified PM Wt were greater when PM Wt was measured in Oct/Nov compared to late Dec (especially at the lower PM Wt’s). This is not surprising as it is common for rainfall to occur in November and December and the “season break” in northern Australia results in rapid growth as cattle graze green pastures of much higher quality than late dry season pastures. The reason for measuring PM Wt at these different times is that it is common on extensive properties in northern Australia to weigh maiden heifers in Oct/Nov before most of the staff leave and there is a high risk of operations being disrupted by heavy rainfall. However many of the PM Wt’s quoted in scientific studies and extension materials are measured at the start of mating which is often in early January, by which time heifers may have gained a considerable amount of weight (in this study, the average PM Wt - Dec was 26 kg heavier than average PM Wt - Oct/Nov). Therefore cattle managers should be aware that it is important to know when PM Wt was recorded and whether growth has occurred between measurement of PM Wt and the start of mating. This distinction is important as different target PM Wt’s have been reported (and are often quoted by cattle advisors) which can be confusing for cattle managers. The relationships between pregnancy rate and PM Wt in this study predict a pregnancy rate of 80% in 2 year old maiden Brahman heifers from a PM Wt of 253 kg measured in Oct/Nov or 278 kg measured in late Dec. The actual pregnancy rates achieved on a property may differ from this if growth over the mating period is considerably more or less than those that occurred at VRRS during this study, however the average growth in this study (110 kg p.a) is representative of much of northern Australia.

The pregnancy rates predicted from different PM Wts in Table 2 will be a useful tool for managers of Brahman heifers in northern Australia. They can be used to identify target weights for different situations, and to predict the number of calves likely to be produced by groups of heifers, which will be useful for budgeting and assessing the profitability of different management strategies or scenarios.

Acknowledgement
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References
Animal welfare priorities in the Australian dairy industry

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Summary
The National Dairy Industry Animal Welfare Strategy was developed in 2004 and is supported by the whole dairy supply chain (farmers and processors). The strategy vision is that every dairy animal is well cared for. The current priority areas are: calf management, lameness, calving induction, euthanasia of livestock and low stress stockmanship. Improved on-farm management of painful procedures, heat stress and down cows are also being actively addressed by industry. The delivery of this strategy involves research, extension, education, evaluation and review. Providers include animal welfare research scientists, veterinarians and consultants, the National Centre for Dairy Education (NCDE), the Dairy Australia Regional Development Programs and partnerships with government extension services. Research currently underway is addressing the impact of farm scale on welfare outcomes, refining pre-weaning calf management practices, remote sensing of lameness and developing genomic markers for heat stress tolerance and health traits.

Introduction
There are many drivers that motivate dairy farmers to devote significant time and resources to ensure the wellbeing of their animals, including:
- A moral responsibility to provide good care for their animals;
- It makes good business sense – comfortable, healthy and relaxed animals are more productive;
- High standards of animal welfare underpin industry access to domestic and export markets, and
- Community acceptance of dairy production systems is essential to protect the industry’s social license to operate.

For more than a decade, the Australian Dairy Farmers (ADF) and Dairy Australia have supported the Australian dairy industry efforts to drive continuing improvements in animal husbandry practices. This has included working with industry and other stakeholders in setting and reviewing national strategies, developing consistent national animal welfare standards and guidelines, identifying priority issues for specific attention and delivering targeted projects to meet agreed objectives.

Discussion
Dairy Australia has maintained a strong focus on animal health, welfare and biosecurity since it was established, working in close collaboration with the ADF policy advisory group dedicated to animal health and welfare issues. This cooperative industry partnership has contributed to policy development and implementation for the dairy industry.

The National Dairy Industry Animal Welfare Strategy (NDIAWS) was developed in 2004. The NDIAWS has a vision that the welfare of all dairy animals in Australia is promoted and protected by the adoption of practical, effective and humane animal welfare standards. The NDIAWS also contributes to achievement of the targets for animal welfare under the Australian Dairy Industry Sustainability Framework.

Dairy Australia invests in research, development, education and extension projects to address the dairy industry priorities in animal welfare. Current areas of focus are:

Calf management
- Bobby calf supply chain integrity
- Healthy Calves initiative

Lameness (Healthy Hooves):
- Preventative strategies
- Detection and treatment of lame cows

Reproductive management (InCalf)
- Phase-out of calving induction

Painful procedures
- Eliminate tail docking
- Minimise pain in horn removal

Others
- Low stress stockmanship (NCDE)
- Mastitis prevention (Countdown)
- Heat stress mitigation (Cool Cows)
- Genetic research on health and heat tolerance traits (DEDJTR and DairyBio)
- Sick and injured cows (downers, euthanasia)
- Husbandry in large herds (University of Melbourne)

Further information about these initiatives can be found on the Dairy Australia website (www.dairyaustralia.com.au).

On-farm practice change is promoted indirectly through industry service providers and farm advisers and directly through farmer extension activities and structured training courses. Regional veterinarians, both private and public, provide important services to support and educate dairy farmers to adopt best practices.
There are eight dairying regions in Australia, each with their own conditions and requirements. Extension services to dairy farmers are delivered through one of eight Regional Development Programs established around Australia (Figure 1):

![Map of Australia with regions highlighted]

**Figure 1. Dairy Australia Regional Development Programs**

While RDPs receive funding and support from Dairy Australia, they are independent entities that can organise and deliver a range of farmer extension and training activities on demand to address regional priorities.

Accredited training in the dairy industry is delivered through the National Centre for Dairy Education, an alliance of eleven registered training organisations located across the eight dairy regions.

Monitoring progress and reviewing of industry practices is achieved through several mechanisms. Dairy Australia conducts a biennial farmer survey that tracks a range of husbandry practices on a stratified sample of 400 dairy farms across all 8 dairy regions. Relevant industry data is also obtained through veterinary practice records, meat and milk processors and herd improvement organisations.

Key achievements over the past decade include the banning of tail docking, introduction of NLIS scanning of bobby calves along the supply chain and implementation of an industry policy to phase out calving induction.

**Acknowledgement**

The National Dairy Industry Animal Welfare Strategy is funded by Dairy Australia on behalf of the Australian Dairy Industry Council, the national peak policy body for the Australian dairy industry that represents dairy farmers, manufacturers, processors and traders. Dairy Australia is the industry’s services provider; owned by the industry, whose members are farmers and industry bodies and invests approx. $30 million of dairy farmer levy payments and $15 million of taxpayer funds in projects and services for the benefit of the Australian dairy industry.

References

Influence of integration of dual-purpose wheat and canola crops in a pasture system on liveweight of Merino sheep

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Summary

Benefits and risks of incorporating dual purpose crops (DPC, namely wheat and canola) in the pasture feedbase system is being evaluated on the NSW Tablelands. The 4-year study consists of 3 treatments: pasture only (Control) and pasture with DPC grazed by either Merino ewes (ECG) or weaners (WCG). Replicated treatments occupy six plots (0.23 ha each). DPC in ECG and WCG are rotated within four plots. Crops are sown in early autumn and grazed in winter. We report treatment effects on liveweight (LW) of breeding ewes and their weaners during the first three years of the study (2013–2015). The 2014 season was favourable, with no treatment differences in sheep LW. In contrast, 2013 and 2015 were poor or intermediate seasons. In these two years, ECG ewes and WCG weaners were heavier (P<0.05) than their counterparts with partial or no access to DPC. DPC effectively fill the winter feed gap.

Introduction

Crop-livestock integration using dual-purpose crops (DPC, namely wheat and canola) is now practised throughout southern Australia’s cropping zone and is extending. DPC provide risk management benefits, diversify crop rotations, reduce pressure on pastures and can significantly increase both livestock and crop productivity from farms, with little increase in inputs (Bell et al. 2014, 2015; Dove and Kirkegaard 2014). Compared to pastures, DPC have superior winter growth, hence filling the feed gap that occurs at this time of the year and enabling farm stocking rate and overall livestock productivity per pasture area to be increased (Moore et al. 2009; Dove et al. 2015).

A four year study (2013–2016) is being conducted on the NSW Southern Tablelands (Canberra) to evaluate the benefits and risks of incorporating dual-purpose wheat and canola crops in a permanent pasture feedbase. Here, we report treatment effects on liveweight (LW) of breeding ewes and their weaners during the first three years of the study (2013–2015).

Materials and Methods

The experiment is being conducted at CSIRO’s Ginninderra Experiment Station near Canberra (35° 12’ S, 149° 4’ E, 600 m elevation, average annual rainfall 665 mm). Three treatments are involved: pasture only (Control), pasture with DPC grazed by breeding ewes (ewe crop grazing, ECG) and pasture with DPC grazed by weaners (weaner crop grazing, WCG). The experimental commenced in February 2012, with measurements started in November 2012. The grazing year runs between shearings (November to October). The weaners are lambs born in the experiment and retained following weaning. Each treatment has three replicates, each involving flocks of 6 breeding ewes and 6 weaners that are grazed separately and rotationally on six plots (0.23 ha each). DPC in ECG treatment are grazed only by ewes, whereas DPC in WCG treatment are grazed preferentially by weaners, with ewe grazing when in feed shortage. In the 2013 season, the Control treatment involved only four plots of permanent pasture (~19 DSE/ha stocking rate), resulting in high supplementary feeding of animals. Consequently, in November 2013, two new plots of permanent pasture were added to the Control experimental units, bringing down the stocking rate to 13 DSE/ha.

Cropping within each replication of the WCG and ECG treatments is contained within four plots, which rotate from year to year following the sequence: pasture → canola → wheat → pasture. Hence, in any grazing season, each replication in the WCG and ECG treatments includes one plot each of canola, wheat, first year pasture and second year pasture, and two plots of permanent pasture. DPC are sown early in autumn (February) and grazed from May to August. Timing and sequence of DPC grazing is decided on the basis of forage availability within a window of utilisation (before bud elongation), to set the minimum period on grain yields. Grazing rotations on pastures are conducted on the basis of forage availability and the nutritional requirements of the animals. Wheat stubbles are grazed by ewes (ECG and WCG) soon after grain harvest in December.

The management of flocks follows commercial husbandry practices. Supplementation with grain (wheat) occurs when forage availability is judged to limit feed intake needed to meet maintenance requirements. A loose lick mineral supplement Causmag®:salt:lime (1:1:1) is provided to animals grazing wheat crops, and a 1% w/w agricultural lime is added to supplementary grain.

Ewes used during 2012–2014 (five year-old) were replaced at shearing in October 2014 by a new group of ewes (three year-old) that were used in 2015 and will remain on site to the end of the study. Ewes are removed from the experiment for joining and replaced by placeholder wethers. During lambing, lambs are identified and weighed. Weaners exit the experiment in August/September, coinciding with the end of DPC grazing by WCG weaners.

Animals are routinely weighed at times of plot rotation. Except for pregnant and lactating animals, liveweight is measured after overnight fasting. Effects of treatments were evaluated at each LW measurement using one-way analysis of variance.
Results and Discussion

Rainfall in 2014 was higher and more evenly distributed than in 2013; in particular, autumn in 2013 was drier than in 2014. Sowing of DPC in 2013 and 2014 was in the second half of February, and early February in 2015. Crop establishment in 2015 was initially patchy due to lack of rainfall, but it recovered by end of April.

DPC were grazed between May and August (Fig. 1). Ewes in the ECG treatment grazed canola and wheat in all the years. WCG ewes were only able to be grazed on wheat in 2013, and canola and wheat in 2015. Weaners in the WCG treatment grazed canola both in 2013 and 2014, and wheat in 2015. In 2014, wheat in excess to weaner and ewe requirements in the WCG treatment was grazed by agisted wethers over 21 days (26 animals/plot; 110 g/hd/day LW gain). In 2013, due to feed shortage, the sheep required supplementary feeding from January to September, with Control animals needing more grain than ECG and WCG animals (90, 29, 54 kg/ewe and 48, 45 and 7 kg/weaner, respectively). In summer of 2014, animals in all treatments received supplementation (12–15% of that fed in 2013). In 2015, grain was fed from February to April only to ECG and WCG sheep (7.3 kg/ewe and 12.3 kg/weaner).

In 2013, ECG ewes were heavier (P<0.01) than their Control and WCG counterparts during the period of crop grazing, lactation, and at shearing in October (Fig. 1). In the same year, WCG and ECG weaners (2013-born) were heavier than Controls during the crop grazing period (Fig. 1). Further, lambs born to ewes with access to DPC had higher LW at weaning than those born to Control ewes (Fig. 1). Treatments did not differ (P>0.05) in ewe LW either in 2014 or during the first half of 2015. However, as for 2013, ewes with access to DPC (ECG and WCG) were heavier than their Control counterparts during the period of crop grazing and lactation, and numerically heavier by shearing time; producing heavier lambs at lambing, marking and weaning (Fig. 1). In 2015, WCG weaners exited the experiment with higher LW than their counterparts with no access to DPC.

In conclusion, in sub-optimal growing seasons (2013, 2015), including DPC in the grazing system significantly reduced the impact of winter feed shortage on animal LW and the need for supplementation. In a good year (2014), treatments resulted in similar animal LW, but DPC enabled extra livestock production via agisted stock and higher returns from superior grain yields.

Acknowledgement

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References


Does dam age effect gene expression in fetal and young sheep?

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Summary
Young dams provide a constrained uterine environment relative to their mature counterparts resulting in an impaired ability to meet fetal requirements. Offspring from immature dams are born smaller and in humans have a higher risk of obesity and related diseases in later life. The underlying mechanisms that drive these differences are unknown; however, epigenetic changes in gene expression are implicated. Changes in the expression of genes involved in glucose and lipid metabolism may alter these highly regulated and integrated metabolic pathways. The expression of three genes involved in these pathways was investigated; leptin receptor, insulin receptor, and glucose transporter 4. The expression of these genes was analysed in the liver and muscle tissue of offspring from one-year old ewes and compared to offspring from mature ewes. There were no significant changes in the expression of any of these genes between the two dam age groups.

Introduction
The developing fetus is very susceptible to the environment which surrounds them in-utero. Many aspects of this environment are maternally determined and act on the fetus to subsequently affect the physiology and metabolism of the offspring (Gluckman and Hanson, 2004; Bell and Greenwood, 2016). Adolscent dams are still growing and have decreased capacity to supply adequate nutrients to a growing fetus, leading to a reduction in the development of the placenta (Wallace et al., 1996; Kenyon and Blair, 2014). It has been proposed that ‘developmental programming’ is associated with metabolic and physiological changes, however, the underlying mechanisms which govern these effects are still poorly understood, both in farm animals and in humans.

Various nutritional studies and their resulting developmental programming effects suggest that components which affect the nutritional environment of the fetus are important for not only determining fetal growth rates, but also the availability of substrates needed for the biological reactions involved in the programming of gene expression (Sinclair et al., 2007, Wu et al., 2006). Programming events, such as DNA methylation, occur early in life and result in long-term changes in the function of the organism. Altered programming of the genes involved in glucose and lipid metabolism may provide some insight into the mechanisms responsible for the changes seen in offspring who were growth-restricted in-utero.

A large number of genes are involved in the intricate processes of glucose and lipid metabolism. In particular, three key gene products are implicated in hyperleptinemia, hyperinsulinemia and hypoglycemia that are commonly seen in intrauterine restricted individuals. Alterations in these pathways can be monitored through the expression levels of leptin receptor (LEPR), insulin receptor (INSR) and glucose transporter 4 (GLUT4). The leptin receptor is involved in many metabolic processes and together with its ligand, leptin, is central to both the hypothalamic stimulation of satiety as well as other intracellular processes. INSR is intricately involved with glucose and lipid metabolism in most tissues. The insulin receptor responds to the binding of its ligand, insulin, through many signalling pathways. The activation of one of these signalling pathways leads to the translocation of the glucose transporter 4 protein from the cytoplasm to the cell membrane where it mediates the transport of glucose from the blood stream into the cell. Consequently, the accurate regulation of each of these genes is crucial for correct glucose and lipid metabolism and the prevention of metabolic diseases.

The aims of this study were to determine the level of gene expression of LEPR, INSR and GLUT4 in the muscle and liver tissue of male and female day 140 fetuses and their 12 month old half-brothers from both yearling and mature ewes.

Materials and Methods
Fetal liver and skeletal muscle tissues were obtained from mixed-sex offspring of nine single-bearing primiparous Romney yearlings (mated at eight months of age) and eleven single-bearing multiparous Romney mature aged ewes (mated at three to five years of age). At day 140, ewes were euthanized and fetuses removed. Samples of fetal organs/tissues were extracted, placed in tin-foil or 2.5 mL cryovials, and snap-frozen in liquid nitrogen. Following freezing, the tissue was stored at -80°C. The tissues from the 12 month old wethers (ten singletons from each dam age) were prepared as for the day 140 fetuses. The dams and wethers were managed under commercial New Zealand grazing conditions.

The gene expression profiles of bovine and human genes of interest were analysed through ‘UniGene’ using the NCBI website. ‘UniGene’ was accessed from the ‘Gene’ site for each gene using accession numbers. GAPDH and ACTB were used as reference genes.

Statistical analysis was undertaken using the ANOVA GLM in Minitab (version 15.1.0.0) with ewe age, tissue and lamb age as fixed effects.

Results and Discussion
The presence of LEPR expression in liver and skeletal muscle tissue suggests that these tissues are responsive to leptin during late gestation and at 12 months of age. LEPR showed greater expression in liver than in muscle tissue. The role of leptin in these organs, and at these stages of development,
has not yet been fully elucidated. There was no difference in LEPR expression between the offspring of the two dam age groups (Table 1), which suggests that having a young dam does not affect the role of leptin in the liver and skeletal muscle.

There was no difference in the expression of INSR in skeletal muscle and liver between the offspring of adolescent ewes when compared to mature ewes (Table 1). This novel finding shows that there was no difference in the insulin sensitivity of these organs in offspring that may have been restricted in-utero compared to offspring that have experienced a normal in-utero environment. There was a slight increase in the level of hepatic INSR expression between day 140 of gestation and 12 months of age (data not shown), however, this change did not reach significance. This change in expression may indicate an increase in hepatic insulin sensitivity at 12 months of age compared to the fetus. INSR showed greater expression in liver than in muscle tissue.

Glucose transporter 4 gene expression has been predominantly characterised in muscle and adipose tissue, where it is thought to have its greatest effects. The observation that the level of GLUT4 expression was higher in ovine liver tissue compared to muscle tissue was surprising (Table 1). This finding suggests that insulin-responsive glucose transport may have an important role in the liver, perhaps in the opposite direction to GLUT4 transport in skeletal muscle and adipose tissue. The significant up-regulation of GLUT4 in 12 month liver, compared to fetal liver, may reflect the increased reliance upon gluconeogenesis in the adult ruminant. There was no difference in the expression of GLUT4 in the skeletal muscle and liver from offspring of young ewes when compared to the offspring of mature ewes.

A significant down-regulation of GAPDH was found in the offspring of young compared to mature dams (Table 1). This change may be due to the relative inter-individual stability of GAPDH expression when compared to the target genes. Yet the downstream effects of altered GAPDH expression in these individuals cannot be determined due to the multiple actions that GAPDH has in the cell. Taken together, the utility of GAPDH as a reference gene for ovine gene expression studies is questionable.

**Table 1. P-values for tissue, dam age, and individual age effects on gene expression**

<table>
<thead>
<tr>
<th>Gene</th>
<th>Tissue</th>
<th>Dam Age</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEPR</td>
<td>0.001</td>
<td>0.490</td>
<td>0.347</td>
</tr>
<tr>
<td>INSR</td>
<td>0.000</td>
<td>0.578</td>
<td>0.560</td>
</tr>
<tr>
<td>GLUT4</td>
<td>0.000</td>
<td>0.269</td>
<td>0.031</td>
</tr>
<tr>
<td>ACTB</td>
<td>0.002</td>
<td>0.063</td>
<td>0.739</td>
</tr>
<tr>
<td>GAPDH</td>
<td>0.000</td>
<td>0.040</td>
<td>0.196</td>
</tr>
</tbody>
</table>

Future studies should use a larger sample size than the current study to reduce between-animal variation, thereby allowing smaller difference changes in gene expression to be detected. Also, since the expression of INSR and LEPR is inducible (Tena-Sempere et al., 2001), it may have been more prudent to look at the expression of genes further along these signalling pathways, such as insulin and leptin. Changes in the expression of these genes could more accurately indicate possible differences in leptin and insulin intracellular signalling pathways. A more extensive search of differences in gene expression between offspring of young and mature dams is required in order to identify genes that may be epigenetically altered in-utero. Based upon the observed difference in GAPDH expression, there are likely to be additional differences in genes expression. This wider search could be achieved through transcriptome analysis. An understanding of the pathways that are most likely to be genetically altered will provide the background to work towards providing early rearing and/or pharmacological intervention.

It would be of interest to explore the excessive GLUT4 expression in the ovine liver. This result was unexpected as GLUT2 is supposedly the major glucose transporter in the liver. Therefore levels of GLUT2 expression in both dam age groups should be assessed to confirm the relative levels of expression between these two glucose transporters. As gene expression analysis only shows the amount of total mRNA transcription, it would be valuable to conduct an experiment to determine the sub-cellular localisation of these two glucose transporters in order to establish how much of the mRNA is expressed as protein at the plasma membrane. As GLUT4 is an insulin-responsive glucose transporter, it would also be important to see if it responds to insulin in the liver and in which direction it transports glucose, either into or out of the liver. The results that were observed in hepatic GLUT4 expression question the known glucose transport mechanisms in the liver. Whether these different mechanisms are an ovine-specific trait or seen across all species would be of interest.

**Acknowledgement**

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**References**


Development of a skin cleanliness scoring system for the Australian lamb industry

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Summary

A skin scoring system to evaluate the cleanliness of a mob of sheep or lambs in Australian production systems was developed. Scores were recorded on a scale of one to three and take into account visible soiling, wool length and wetness. Implementation of this scoring system showed average cleanliness scores of lambs at saleyards was not different from those scored on-farm, indicating that source does not affect cleanliness. There was a significant correlation between cleanliness score prior to loading and after transport to the abattoir (r=0.93; P<0.001) and there was an increase of 0.14 of a score after transport compared to pre-transport score (P<0.05). This scoring system will enable further research into the correlation of carcase microbial contamination and visual cleanliness, which will facilitate the development of this scoring system into a tool that can be used along the supply chain to predict carcass contamination, assist pre-slaughter management and enhance animal welfare.

Introduction

Excessively wet and dirty fleece on sheep and lambs can cause microbiological contamination of carcasses post-slaughter (Biss & Hathaway 1996b) which may pose serious health risks to humans (Duffy et al. 2010) and decrease the shelf life of meat products (Hadley et al. 1997). The likelihood of contamination can be predicted by visual appraisal of the level of soiling, with greater soiling resulting in a higher probability of contamination (Gill 2004; Byrne et al. 2007). Consequently, several countries, including Ireland (Byrne et al. 2007) the United Kingdom (UK) (McEvoy et al. 2000), Norway (Hauge et al. 2011) and Finland (Ridell & Korkeala 1993) have developed visual cleanliness scoring systems which can be used throughout the supply chain to inform processors of the likely risk of contamination. These scoring systems allow the option of excluding heavily soiled animals from slaughter. Currently, no such system exists in Australia. The aim of this study was to develop a scoring system that is applicable in Australian production systems and can be used to underpin further research into microbiological control and pre-slaughter management.

Methods

Factors that were considered important in the development of the cleanliness scoring system were dirt and/or faecal contamination, fleece length (Biss & Hathaway 1996b) wetness (Ridell and Korkeala 1993) and position of soiling in relation to cutting lines (Biss & Hathaway 1996a).

Table 1. Description of the skin cleanliness scores.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Location</th>
<th>Score 1</th>
<th>Score 2</th>
<th>Score 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faeces/dirt</td>
<td>Belly</td>
<td>Nil</td>
<td>Medium</td>
<td>Heavy</td>
</tr>
<tr>
<td>Body</td>
<td>Nil</td>
<td>Medium</td>
<td>Heavy</td>
<td></td>
</tr>
<tr>
<td>Breech</td>
<td>Nil</td>
<td>Medium</td>
<td>Heavy</td>
<td></td>
</tr>
<tr>
<td>Wool</td>
<td>Belly</td>
<td>&lt;50mm</td>
<td>&gt;50mm</td>
<td>&gt;50mm</td>
</tr>
<tr>
<td>Body</td>
<td>&lt;50mm</td>
<td>&gt;50mm</td>
<td>&gt;50mm</td>
<td></td>
</tr>
<tr>
<td>Crutch</td>
<td>&lt;8mm</td>
<td>&gt;8mm</td>
<td>&gt;8mm</td>
<td></td>
</tr>
<tr>
<td>Wetness</td>
<td>Belly &amp;</td>
<td>Dry</td>
<td>Damp</td>
<td>Saturated</td>
</tr>
<tr>
<td>Body</td>
<td>Dry</td>
<td>Damp</td>
<td>Saturated</td>
<td></td>
</tr>
<tr>
<td>Dags</td>
<td>Breech</td>
<td>Nil</td>
<td>Short dags</td>
<td>Long dags</td>
</tr>
</tbody>
</table>

Robustness of scoring system within and between assessors

Eleven pens of lambs were scored by four assessors (A, B, C, D) using the skin cleanliness scoring system (Table 1) at Dublin saleyards (South Australia). Five pens were scored twice by each assessor leaving at least 10 minutes between repeats to reduce bias. In large mobs (>100), 50 animals were scored as a representation of the mob and in smaller mobs (50 – 100), 20 animals were scored.

Subsequently, one original assessor (C) trained four additional assessors (E, F, G, H) in the skin cleanliness scoring system at Muchea saleyards (Western Australia), and 39 to 46 pens were scored by each assessor to evaluate intra- and inter-assessor repeatability.

Skin cleanliness assessment through the supply chain

Skin cleanliness scores (Table 1) were recorded for 27 loads of lambs at saleyards and again at lairage (10 in Victoria, 10 in South Australia and seven in Western Australia), and 17 loads of lambs directly consigned to slaughter were assessed on-farm and again at lairage (seven in Victoria, six in South Australia and four in Western Australia). An additional 13 loads had a single assessment; four loads of lambs consigned directly to the processor were assessed in lairage; three loads of lambs sourced from saleyards were assessed in lairage; and six loads of lambs were assessed in the saleyards.

On-farm skin cleanliness scores were recorded immediately prior to loading onto the truck, with on-farm curfew period prior to loading ranging from four to 24 hours. Skin cleanliness scores at saleyards were recorded two to six hours after being unloaded from trucks into saleyards. Curfew period for the saleyard lambs was not recorded. Skin cleanliness scores in lairage were recorded immediately after off-loading from the trucks. Travel time between site of origin and lairage ranged from two to six hours.

Statistical analysis

Pearson correlation coefficients were calculated to describe the correlations between assessors scoring the same pens of lambs. Chi-squared tests were used to analyse the pattern of scoring between assessors and the distribution of scores between assessors. Within and between assessor repeatability

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were determined using generalised linear mixed models with maximum-likelihood methods (PROC GLIMMIX; SAS Institute Inc. Cary, NC, USA 2008). Pen was included in the model as a random effect.

The effect of source (direct consignment or saleyard) and timing (pre-transport, lairage) on skin cleanliness was determined using generalised linear mixed models with maximum-likelihood methods (PROC GLIMMIX; SAS Institute Inc. Cary, NC, USA 2008). A multinomial model for ordinal data was used. Pen * assessor was included in the model as a random effect. Pearson correlation coefficients were calculated to describe the correlations between assessment at the source of the lambs (saleyard or on-farm) and in lairage.

**Results and Discussion**

**Robustness of skin cleanliness scoring system**

Across assessments, there was no significant difference within individual assessors (P=0.3674), indicating good repeatability. There were significant differences in skin cleanliness scores between pens of lambs, demonstrating that individual assessors were able to consistently score across a range of skin cleanliness scores.

Correlations of pen scores between assessors were significant at Dublin and Muchea. At Dublin, correlations ranged from r=0.913 between Assessors B and D to r=0.702 between Assessors C and D. Correlations from the assessment conducted at Muchea ranged from r=0.775 between Assessors H and F, and r=0.486 between Assessors F and C.

There was a significant difference in average cleanliness score, and pattern of scoring between assessors at Dublin (P<0.0001), with Assessors B and D scoring lambs at a lower score, while Assessors A and C scored fewer lambs as score 1 and more lambs as score 2. Likewise, there was a significant difference between assessors in the average skin cleanliness scores of each pen of lambs at the Muchea saleyards (P<0.0001). Assessor C scored more lambs as a score 2, whereas Assessors E, F, G and H scored more lambs as score 1.

Importantly, assessors at both sites were able to consistently identify lambs that were a score 3 (P<0.05). This demonstrates that assessors agreed on those lambs that are likely to present the greatest risk of contamination further along the chain. These remain the most important to identify.

**Skin cleanliness scores along the lamb supply chain**

There was a strong positive correlation (P=0.001) between skin cleanliness scores at the source (either saleyard or on-farm) and skin cleanliness scores of the same consignment of lambs in lairage. This trend was consistent across assessors and source (either saleyard or farm). Lambs assessed in lairage had 0.14±0.052 (P<0.05) of a score higher than lambs assessed prior to transport. This is likely to be due to increased faecal and dirt contamination on their bellies and/or brisket during transport.

Source of lambs did not affect skin cleanliness score, with the score of lambs sourced from saleyards not significantly different from directly consigned lambs (0.3±0.30 difference). There was no interaction between source of lambs and time of assessment. This lack of difference indicates that the additional time spent in transit of lambs that pass through the saleyard system had no significant effect on skin cleanliness. The time spent actually travelling may affect skin cleanliness score, but the time spent on board transport was not recorded, so we were unable to assess the effect of travel time on skin cleanliness. Nevertheless, the lack of interaction between source and final assessment in lairage indicates that both groups of lambs were changing in a similar pattern between initial assessment and assessment in lairage. The scoring system developed here is therefore sufficiently robust to be used at any point on the delivery chain to predict how a mob of lambs will score at another point.

Other factors that have an impact on the visual cleanliness of livestock include breed, age, parasite load, feed type, climate and truck cleanliness (Gill 2004; Fegan et al. 2009; Small & Buncic 2009). The season in which the current study was undertaken was considered to be fairly mild, and none of the consignments experienced extreme weather events. Most consignments came off relatively dry paddock feed, with anecdotal evidence suggesting lambs coming off actively growing pasture are significantly dirtier. Further research is required to investigate the effects these factors have on skin cleanliness at the source and their impact on changes throughout transport.

The skin cleanliness scoring system developed in the current study was repeatable within assessor, and was sufficiently robust to be used at one or more points along the supply chain to determine the visual cleanliness of a mob of sheep. With training of assessors, and further research to determine the correlation between visual cleanliness and actual microbial carcass contamination, this scoring system can become a tool that can be used along the supply chain to predict carcass contamination, assist in pre-slaughter management and enhance animal welfare.

**Acknowledgement**

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Variation in nutritional composition of lamb leg cuts

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Presenting author:

Summary

The nutritional composition of the knuckle, topside, outside and silverside excised from 15 lamb carcases were measured to determine the variation in protein, energy, total fat, minerals and fatty acids between muscles. The findings indicate that the silverside had significantly higher values for most fatty acids (excluding EPA + DHA) and higher energy content while the topside had higher concentrations of cholesterol, iron and zinc and the knuckle had higher concentrations of sodium and zinc. Overall this information will assist industry in promoting the benefits of consuming lamb to increasingly health conscious consumers.

Introduction

Over recent decades the nutritional composition of red meats has become an increasing concern to consumers. While there is a significant amount of research which has been conducted to determine the intramuscular fat (IMF) and fatty acid (FA) composition of some cuts such as the loin, little research has been conducted to ascertain the nutritional value of cuts from the leg of lambs commonly produced and consumed. Furthermore, there is limited literature on the variation in nutritional composition between muscles. Consequently, the aim of this research was to determine the nutritive composition of the knuckle, silverside, outside and topside.

Materials and Methods

For this study lambs were fed a barley based diet for 70 days before being processed using standard commercial procedures. At 24 h post mortem, the knuckle (HAM 5072; Anonymous, 2005), silverside (HAM 5071; Anonymous, 2005), outside (HAM 5075; Anonymous, 2005), and topside (HAM 5073; Anonymous, 2005) were removed from the carcases of 15 animals. Once freeze dried, samples underwent analysis for energy (The University of Sydney, 2015), total fat analysis (AOAC, 1992), protein (Jung et al.), fatty acid composition (O’Fallon et al., 2007), cholesterol (Katsanidis & Addis, 1999), iron, potassium, sodium, phosphorus, zinc and selenium (Carrilho et al., 2002).

Data were analysed using a REML procedure performed with Genstat® software (VSN International Ltd., 2015) using muscle as a fixed effect.

Results and Discussion

The mean nutritive values for the muscles and significant differences between muscles are outlined in Table 1. Overall the levels of energy, protein, fat, cholesterol and the fatty acid composition found in this study are consistent with what would be expected from lamb leg cuts in Australia (Williams et al., 2007, Ponnampalam et al., 2014).

Of the muscles, silverside had the largest variation in nutritive values due to significantly higher percentage of total fat from the heel muscle and silverskin which is not present on the knuckle, topside and outside. This is reflected in the significantly higher values for most fatty acids (excluding EPA + DHA) and the higher overall energy content. However, fat level was not significant when included as a covariate for modelling EPA + DHA concentrations.

Furthermore, it was found that topside had significantly higher concentrations of cholesterol and iron while the knuckle had higher concentrations of sodium.
Table 1. The mean nutritive composition of lamb knuckle, outside, silverside and topside cuts including the standard error of the mean (S.E.M).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Knuckle</th>
<th>Outside</th>
<th>Silverside</th>
<th>Topside</th>
<th>P-value</th>
<th>S.E. M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kJ/100g)</td>
<td>1125.3a</td>
<td>1149.1a</td>
<td>1423.0</td>
<td>1130.6a</td>
<td>&lt;0.001</td>
<td>22.3</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>30.6</td>
<td>32.0</td>
<td>31.2</td>
<td>32.2</td>
<td>n. s.</td>
<td>0.4</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>10.7a</td>
<td>10.7a</td>
<td>18.3</td>
<td>9.4</td>
<td>&lt;0.001</td>
<td>1.0</td>
</tr>
<tr>
<td>SFA (g/100g)</td>
<td>3.2a</td>
<td>3.1a</td>
<td>5.0</td>
<td>3.0a</td>
<td>&lt;0.001</td>
<td>0.2</td>
</tr>
<tr>
<td>PUFA (g/100g)</td>
<td>0.7a</td>
<td>0.7a</td>
<td>0.9</td>
<td>0.7a</td>
<td>&lt;0.001</td>
<td>0.3</td>
</tr>
<tr>
<td>EPA + DHA (mg/100g)</td>
<td>40.2</td>
<td>49.1</td>
<td>48.5</td>
<td>47.7</td>
<td>n. s.</td>
<td>2.0</td>
</tr>
<tr>
<td>MUFA (g/100g)</td>
<td>3.5a</td>
<td>3.4a</td>
<td>5.5</td>
<td>3.1a</td>
<td>&lt;0.001</td>
<td>0.2</td>
</tr>
<tr>
<td>Omega-3 (mg/100g)</td>
<td>183.5a</td>
<td>175.4a</td>
<td>213.4</td>
<td>177.2a</td>
<td>&lt;0.001</td>
<td>6.0</td>
</tr>
<tr>
<td>Omega-6 (mg/100g)</td>
<td>485.7a</td>
<td>477.2a</td>
<td>596.4</td>
<td>461.1a</td>
<td>&lt;0.001</td>
<td>21.3</td>
</tr>
<tr>
<td>Cholesterol (mg/100g)</td>
<td>34.4a</td>
<td>36.3a</td>
<td>26.1</td>
<td>46.0</td>
<td>&lt;0.001</td>
<td>2.1</td>
</tr>
<tr>
<td>Iron (mg/100g)</td>
<td>2.8a</td>
<td>2.9a</td>
<td>2.6a</td>
<td>3.2</td>
<td>&lt;0.001</td>
<td>0.08</td>
</tr>
<tr>
<td>Potassium (mg/100g)</td>
<td>516.4</td>
<td>530.3</td>
<td>505.2</td>
<td>538.5</td>
<td>n. s.</td>
<td>9.8</td>
</tr>
<tr>
<td>Sodium (mg/100g)</td>
<td>101.3</td>
<td>94.6a</td>
<td>90.2a</td>
<td>87.9a</td>
<td>&lt;0.001</td>
<td>2.1</td>
</tr>
<tr>
<td>Phosphorus (µg/100g)</td>
<td>312.5</td>
<td>329.6</td>
<td>312.3</td>
<td>336.0</td>
<td>n. s.</td>
<td>6.4</td>
</tr>
<tr>
<td>Selenium (µg/100g)</td>
<td>27.1</td>
<td>26.7</td>
<td>26.2</td>
<td>26.9</td>
<td>n. s.</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Values within a row followed by a are not statistically different. n. s. denotes not significant

At present there is a scarcity of literature reporting the mineral composition of these specific lamb leg cuts. For example, Williams et al. (2007) have omitted results for the mineral composition of lamb leg cuts, while others have focused on the measurement of zinc and iron in lamb loin (Pannier et al., 2014) or the mineral composition of an easy carve semi-trimmed lamb leg roast (Food Standards Australia New Zealand, 2010).

A comparison with these studies, suggests that the topside, knuckle, silverside and outside in this study tended to have higher concentrations of iron, phosphorus, potassium, sodium, SFA and PUFA then previously reported for the easy carve leg roast and loin (Food Standards Australia New Zealand, 2010, Pannier et al., 2014). However, they also had a much lower concentration of cholesterol compared to the 70 mg/100g previously reported for a leg roast (Food Standards Australia New Zealand, 2010).

Conclusion

Overall this study demonstrates that there is significant variation in nutritive composition of lamb leg cuts. Consequently, there is a benefit to industry in developing and promoting new cuts using these muscles which meet nutritional targets for human health.

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Modelling the potential for flushing or improved pregnancy rate to increase gross margins for sheep flocks

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Summary

The number of lambs weaned per ewe is an important factor contributing to both the level of production and producer income. The production and gross margins resulting from varying pregnancy rate, twinning rate, and the use of flushing were compared for a Terminal over Merino ewe enterprise using simulation modelling of a farm at Tarcutta (New South Wales) with 20\% of area sown to lucerne. A 20\% lower pregnancy rate had a larger impact on gross margins than a 50\% reduction in twinning rate. Flushing, on average, increased lamb production and gross margins compared with the standard, but was only possible in 50\% of years. On-farm management which avoids reductions in pregnancy rate may be more important for producers than aiming to increase twinning rate, but large gains are possible by flushing ewes to increase twinning rates if this can be achieved frequently and the survival of twins is high.

Introduction

The level of reproduction (lambs marked per ewe joined) in sheep flocks directly impacts on gross margins for sheep producers (Warn et al., 2006), and is the net result of number of ewes pregnant, fecundity and lamb survival. Cost-effective improvement in survival can be relatively difficult to achieve unless survival is poor to start, even though there is a large potential for improvement (Trompf et al. 2013). Recent work (Robertson et al., 2015a) has shown short-term flushing (increased nutrition pre-joining) with lucerne can achieve an increase (115\% versus 96\%) in Merino lambs marked per ewe joined, in a region where survival of twins is typically between 70 and 80\%. The financial benefit of flushing can therefore be substantial. However, consumption of high quantities of feed during early pregnancy, as may be done when flushing ewes, can cause embryo mortality, reducing pregnancy rates by 20\% (Parr et al., 1987) or reducing the proportion of ewes with multiple foetuses by 50\% (Robertson et al., 2015b). These levels of loss are present in commercial flocks, where non-pregnancy rates for ewes mated have been reported to range from 0 to 24\%, with partial failure of multiple ovulations ranging from 0 to 40\% (Kleemann and Walker, 2005). The level of benefit from changing management to avoid such losses or achieve an increase in lambs marked requires consideration.

The aim of this study was to evaluate the impact on gross margins from flushing ewes on lucerne, and from achieving lower rates of pregnancy or fecundity through increased embryo mortality.

Materials and Methods

Simulation modelling was conducted using AusFarm version 1.4.9, using an updated stock module to allow twin-bearing ewes to be purchased. The simulation was conducted between 1970 and 2011, with data from the first year excluded. A model 1000 ha grazing property located at Tarcutta in southern NSW was used, which had previously been validated against field data. The farm comprised two phalaris based paddocks (each 40\% of farm area), and one lucerne paddock (20\% of farm area).

Two enterprises were simulated. 1. A Terminal over Merino ewe flock joined in February, with all lambs sold at 55 kg or in December, whichever occurred first. The stocking rate was 5 ewes/ha. 2. A self-replacing Merino flock joined in February, with all wether lambs sold at 55 kg or in December. Ewe lambs were retained as replacements. The stocking rate was 6 ewes+replacements/ha.

To simulate embryo mortality, either the proportion of ewes pregnant, or the proportion of pregnant ewes with twins, was adjusted immediately after the completion of joining. Pregnancy rates were reduced by 20\%, and twinning rates were reduced by 50\%.

To simulate flushing, the average growth rate of lucerne in the 15 days prior to joining was calculated and used to set the level of increase in twinning rate in each year. If lucerne growth was ≤ 10 kg DM/ha/day, the proportion of pregnant ewes with twins was unchanged; if growth was > 10 and < 20, the proportion twinning was increased by 30\%; and if growth was ≥ 20, the proportion twinning was increased by 70\%. These response rates have been based on research which indicates that the quantity of live pasture available influences the flushing response (King et al., 2010). Flushing can double the ovulation rate of ewes (Killeen, 1967), while a 36\% increase has been reported by grazing stalky lucerne under low growth conditions (King et al., 2010), while a 70\% increase in the proportion with multiple foetuses has been recorded for ewes grazing lush pasture (Robertson et al. unpublished).

The simulations were run using historical and current meat prices. A wool price grid used 2003 to 2011 average prices (ABARES, 2011) (19.1 to 20.0 micron 927 c/kg). A price grid (carcase weight) of > 22 kg 354c/kg, 18-22 kg 361 c/kg (55th percentile for national saleyard lamb price) (ABARES, 2011), 16-18 kg 343 c/kg and < 16 kg 312 c/kg for crossbred lambs used higher values than the Merino lamb price grid of > 22 kg 283c/kg, 18-22 kg 289 c/kg, 16-18 kg 275 c/kg and < 16 kg
250 c/kg for historical values. Current lamb prices used 588, 600, 570, 519 for the crossbred grid and 470, 480, 457, and 416 for the Merino lamb grid. Cast for age ewe prices were $47 historical, and $100 current, while replacement ewes and excess ewe hoggets were valued at $71 historical, and $150 current.

Results
The percentage change in gross margin due to changing reproductive performance was similar under historical and current meat values, but the change in gross margin was larger at current higher meat values (Table 1). The relative change in gross margins from different rates of reproduction was similar in a self-replacing Merino flock (data not shown) to the crossbreeding enterprise.

Reducing the pregnancy rate by 20% reduced gross margins by 20%, while a 50% reduction in the proportion of pregnant ewes with twins reduced gross margins by 4%, compared with the standard rate of reproduction in the Terminal over Merino flock. This was due to a larger reduction in the number of lambs sold where the rate of pregnancy was reduced. Flushing increased mean gross margins by 5% over the standard by increasing the number of lambs sold, although the weight of lambs sold was reduced. However, the cumulative gross margin after 40 years for flushing was $550/ha ($549,864/farm) higher than for the standard reproductive rate, using current meat values. Flushing was possible in 50% of years, with an average 24% increase (range 11 to 34%) in the proportion of ewes bearing twins in the years when they were flushed.

Discussion
This study indicates that management to avoid large reductions in pregnancy rate would have a larger benefit to producer gross margins than increasing twinning rates. The relative difference can be expected to vary depending on the proportion of ewes which normally carry twins. The standard twinning rate in the simulated flock (45%) was relatively high compared with industry averages (Kleemann and Walker, 2005), meaning that there may be a larger potential benefit of flushing in flocks than that shown here.

The benefit of flushing was dependant on the proportion of years when summer/autumn rainfall allowed sufficient pasture growth, and may have been underestimated in this analysis due to the high rate of twinning in the standard flock. The proportion of years in which ewes can be flushed will vary between locations and differing pasture types.

Table 1. Mean reproductive performance and gross margins for a terminal over Merino ewe enterprise at 5 ewes/ha

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Reduced Pregnancy rate</th>
<th>Reduced Twinning rate</th>
<th>Flushing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross margin ($/ha) (historical meat values)</td>
<td>200</td>
<td>164</td>
<td>192</td>
<td>210</td>
</tr>
<tr>
<td>Gross margin ($/ha) (current meat values)</td>
<td>317</td>
<td>250</td>
<td>304</td>
<td>330</td>
</tr>
<tr>
<td>No. lambs sold/ha</td>
<td>4.6</td>
<td>3.8</td>
<td>4.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Weight wether lambs sold (kg)</td>
<td>42.7</td>
<td>44.8</td>
<td>44.2</td>
<td>42.1</td>
</tr>
<tr>
<td>Lambs born/ewe (%)</td>
<td>129</td>
<td>106</td>
<td>109</td>
<td>139</td>
</tr>
<tr>
<td>Lamb survival to marking (%)</td>
<td>74</td>
<td>73</td>
<td>79</td>
<td>73</td>
</tr>
<tr>
<td>Lambs marked/ewe (%)</td>
<td>95</td>
<td>77</td>
<td>86</td>
<td>100</td>
</tr>
<tr>
<td>Pregnant ewes (%)</td>
<td>91</td>
<td>71</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>Twin bearing ewes of pregnant ewes (%)</td>
<td>45</td>
<td>45</td>
<td>23</td>
<td>56</td>
</tr>
</tbody>
</table>

While altering components of the reproductive rate may only result in modest changes in long-term average gross margin, the cumulative effect can be large, meaning management to avoid reductions in pregnancy rates and improve twinning can have a positive effect on cash flow and financial performance.

References
The impact of a feather-pecking outbreak in an experimental free-range layer flock on growth, egg production, plumage damage and mortality

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Summary

Feather pecking is a serious hen welfare issue with adverse economic consequences for free-range egg production. We investigated the effects of providing straw as forage and imposing 'stressors' (combined transport, relocation and mixing) during rearing on the development of severe feather pecking and plumage damage. The experiment involved 16 pens of 50 ISA Brown commercial laying hens, with outdoor range access from 21 weeks. A feather-pecking outbreak commenced at 26 weeks, and by 40 weeks 98% of hens displayed plumage damage. Between 16-40 weeks hen mortality was 8.3% of the flock, with the main causes being vent pecking (38.1%), pecked uropygial area (15.9%) and grass impaction of the crop/gizzard (27%). While the experiment did not provide evidence that forage and the combined 'stressors' were implicated in initiating, or preventing progress of, a feather-pecking outbreak, these results show the impact of a feather-pecking outbreak on production and welfare variables.

Introduction

Feather pecking is a behavioural vice of poultry that poses a welfare risk to the birds and has economic consequences for the farmer (Savory, 1995; Bestman et al., 2009). In laying hens (Gallus gallus domesticus) feather pecking is generally performed as a non-aggressive behaviour directed at the feathers of conspecifics (Savory, 1995; Gilani et al., 2013). The morphology of the behaviour may range from gentle nibbling to vigorous pulling with resultant removal of feathers. The bird performing the act may also eat the feather (Hartcher et al., 2016). When performed repeatedly and in a ‘severe’ form, feather pecking results in plumage loss, predisposing wounding of the skin and mortality (cannibalism). This syndrome can be a problem in both cage and non-cage housing systems (Tauson, 2005; Rodenburg et al., 2008). However, the consequences are reportedly greater in non-cage systems such as barn or free-range that involve large groups (i.e. whole flocks) compared to cage systems. This is due to the difficulty in stopping the social-transmission of this behavioural vice in large groups.

The present experiment aimed to investigate the effects of two factors imposed during rearing of birds destined for free-range egg production, on the development of severe feather pecking. Factor 1 was the addition of environmental enrichment in the form of long straw from 6 weeks to stimulate foraging. Factor 2 involved imposing stressors at 16 weeks in the form of transport, relocation and mixing combined (TRM), to simulate industry practice of transferring pullets from the rearing farm to the layer farm. During the course of the experiment however, there was a significant rainfall event which seemed to trigger an outbreak of severe feather pecking. Thus, this paper also reports the temporal changes in flock growth, egg production, plumage condition and mortality coincidental with the severe feather pecking outbreak.

Materials and Methods

ISA Brown laying strain chicks were purchased at day-old from a commercial hatchery and floor-reared in pens with a base of wood shavings. The experiment, which had a 2x2 factorial arrangement, was conducted at the Free Range Research Facility, Camden NSW under the approval of the University of Sydney AEC. No chicks were beak-trimmed. At 6 weeks all chicks were weighed then allotted at random to one of 16 pens measuring 3.25 x 1.83 m, with about 56 chicks per pen. Each pen had a plastic mesh straw dispenser (diameter 15 cm, length 50 cm) suspended from the roof at bird head height. For 8 pens selected at random within two blocks, ~200 g long straw (Forage) was added daily in the plastic baskets, while for the other 8 pens no straw was added (No forage). The function of the straw was to stimulate foraging behaviour, including pecking, grasping and pulling the straw out from the dispenser through the 20 mm gaps in the mesh. From 6-14 weeks the lighting program was 12 h light and 12 h dark. From 14 weeks the photoperiod was increased at weekly intervals to provide an additional 30 min light per day until a photoperiod of 15 h light : 9 h dark was reached in week 19. At 15 weeks all pullets were weighed, inspected for plumage condition and injury, and the number of pullets per pen was reduced to 50 birds. At 16 weeks, 8 pens of 50 pullets were picked up and placed in poultry transport crates and transported by motor vehicle for 35-40 minutes (Factor 2: TRM). Upon returning to the shed, the crates of pullets were unloaded and the birds were placed in a new pen, in which they were mixed 50/50 with both familiar and unfamiliar pullets. At 21 weeks the pop-holes to the outdoor runs were opened, and a second plastic mesh basket (v-shaped) was attached to the far end of each 1.83 m x 10 m outdoor run. Pens in the Forage treatment received an additional ~100 g of straw daily in the outdoor baskets.

In weeks 15, 21, 29, 34 and 40 all birds were individually inspected for plumage condition and injury, and weighed. Growth was measured as mean hen weight per pen, and mean weight gain per pen. Flock consistency was measured as uniformity (proportion of birds within ±10% of the pen mean) and coefficient of variation. Egg production per pen was recorded on 4 days per week from 16 weeks, when the nest boxes were opened. A post-mortem was
conducted for any bird that died or was euthanized during the experiment. The experiment concluded when the hens were 40 weeks of age. Live weight, flock consistency, and number of plumage-damaged sites per hen were analyzed using ANOVA within weeks of age. A plumage damage score was also calculated for each pen in weeks 29, 34 and 40 from the sum of the products of the proportion of hens with nil to 6 damaged sites on the body, multiplied by the number of damaged sites. Hen mortality data (incidence and causes) between weeks 16-40 were analyzed using survival analysis with censored data based on week of age, and Chi-squared tests in Genstat v14, based on counts of hens that died or were removed from pens due to injury. Proportional (hen-day egg production) data were normalized using the angular transformation.

Results and Discussion

When the hens were aged 25 weeks, a rainfall event occurred during which 169.4 mm of rain was recorded over 13 days. During weeks 27-28 we observed the onset of plumage damage; at the planned inspections of birds in weeks 15 and 21, no birds had shown plumage damage consistent with feather pecking. However, at 29 weeks 32% of hens had at least one damaged site. This proportion increased to 77% of hens at 34 weeks and 98% at 40 weeks. Reviews by Rodenburg et al. (2013) and Hartcher et al. (2016) report that plumage damage may progress to injury and death by cannibalism. In the present experiment a total of 66 hens (8.3%) died or were euthanized on veterinary advice between 16-40 weeks of age. Fifty-four percent of hen deaths (or 6.75% of the flock) were due to injurious pecking: Vent (cloacal) pecking and pecking of the urogenital area of the rump accounted for 38.1% and 15.9% of deaths, respectively. In addition, 27.0% of deaths were attributed to grass impaction of the crop and gizzard; it was noted that all herbage in the outdoor runs had been consumed within 2 weeks. Disease (mainly coccidiosis) was diagnosed for 15.9% of deaths. On a per-hen basis, 10.5% compared to 6.0% of hens in the Forage and No forage treatments, respectively (P = 0.012), and 4.5% compared to 12.0% of hens in the Not TRM compared to TRM treatments, respectively (P < 0.001), had died. There were no interaction effects (P = 0.280). Based on the ISA Brown Management Guide (2010), cumulative flock mortality between 18-40 weeks should be 2% of hens.

As expected, hen-day egg production peaked in week 27 (ISA Brown Management Guide, 2010), but in the 13 weeks after peak-of-lay egg production decreased by 5.6%. The decrease in egg production was 3.5 times greater than expected (ISA Brown Management Guide, 2010; 1.6% decrease). Glatz (1998) reported that egg production was reduced in older hens with poorer plumage cover, and Stewart et al. (2006) recorded a decline in egg production following a cannibalism outbreak in a barn system, supporting our observation of reduced egg production following the feather-pecking outbreak. Egg production however, was not affected by the Forage or TRM treatments.

The provision of Forage improved (P=0.013) mean live weight gain by hens between 34-40 weeks (0.7 vs -0.6 g/d, respectively, for Forage and No forage pens; sed 0.45). Otherwise, there were no differences due to the Forage or TRM main effects on mean bird weight, live weight gain or the measures of flock consistency (Uniformity and Coefficient of Variation) at any age. While hen live weight gain between weeks 29-34 averaged 1.6 g / day, which was similar to expectation (ISA Brown Management Guide, 2010; 1-2 g per day), after 34 weeks hens on average had a nett zero weight gain. However, as mentioned above, birds with access to straw gained weight whereas birds without access to straw lost weight. Increasing the fibre content of the diet, as occurred in the Forage added treatment through the daily provision of straw, has been reported to increase gizzard size and improve nutrient uptake (Svihus, 2011). In the present experiment therefore, the daily provision of straw probably contributed to improved hen nutrition and survival when the flock was being “challenged” by the feather-pecking outbreak, and this may have contributed to improved weight gain by Forage treatment hens.

In conclusion, a key outcome of this research was that a feather-pecking outbreak, that resulted in plumage damage, commenced about two weeks after the start of a significant rainfall event. Prior to the rainfall event no birds in the flock displayed plumage damage, the incidence of hen mortality was low, and there was no cannibalism. The specific rearing factors of added straw to stimulate foraging behaviour, and imposed stressors associated with combined transport, relocation and mixing point-of-lay pullets applied in the present experiment however, did not show clear influences on the initiation or prevention of feather pecking. Welfare costs to the hens included injury due to pecking (and pain / fear), increased mortality and loss of plumage. Loss of feather cover increases feed intake without achieving weight gain (Glatz, 1998), and together these factors may contribute to loss of body condition. A decline in production occurred, with fewer eggs produced and accelerated loss of hens from the flock. Our findings suggest a possible association between the occurrence of a significant rainfall event preceding the onset of severe feather-pecking outbreaks on free-range farms. Further research is clearly required to improve our understanding of the causal factors involved in triggering severe feather-pecking outbreaks.

Acknowledgement

The research was funded by the Australian Egg Corporation Ltd. We are grateful to Dr Evelyn Hall for statistical advice.

References


The Effect of In ovo Administration of L-Arginine on the Hatchability and Embryological Development of Broiler Chicks

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Summary

Arginine is an essential amino acid and a precursor for the synthesis of polyamines, growth hormone, insulin like growth factor and nitric oxide (Chevalley et al., 1998). Arginine is known to influence factors that are involved in cell proliferation and growth and improves intestinal integrity via nitric oxide-mediated vasodilatation and blood flow in neonatal piglets (Puiman et al., 2011). Our study aimed to determine if in ovo administration of arginine could alter gut development of broiler chicken embryos for improved gut health and efficiency of meat production. Administration was carried out by injection into different compartments of the egg and at two different time points throughout incubation. Arginine significantly increased gut weight and length, increased jejunal villi number, increased the weight of the liver, gizzard and bursa of Fabricius and improved hatchability of the chicks.

Introduction

Gut development in all species is a precise and ordered process. The differentiation of the gut into duodenum, jejunum and ileum occurs very early in development with the loop of the duodenum apparent by day five of incubation (Romanoff, 1960). The epithelial lining of the small intestine develops in a cranial to caudal wave. Both the development of the pre-villous ridges and the ‘zigzag’ pattern which leads to individual villi formation have been reported to begin in the duodenum and progress posteriorly (Coulombre and Coulombre, 1958).

Arginine is an essential amino acid and precursor for the synthesis of polyamines, growth hormone (GH), insulin like growth factor-1 (IGF-1) and nitric oxide (Chevalley et al., 1998). Oral administration of arginine in humans has been shown to raise serum levels of GH and IGF-1, both strong mediators of cellular proliferation (Isidori et al., 1981; Hurson et al., 1995).

We hypothesised that delivery of arginine to the gut of the chicken embryo at a key time point in small intestinal development would alter the formation of the gut tissues.

Materials and Methods

Previous work by PI Hynd, NM Edwards, and ND Heberle (unpublished) determined that the villi of the modern broiler chick were not present until day 10 of incubation. Two administration time points were tested; day nine of incubation just before villi appear and day zero prior to eggs being set for incubation. The amnion was selected as the route of delivery at day nine of incubation so that the arginine would be swallowed by the embryo with the amniotic fluid thereby having direct contact with the epithelium of the small intestine. For the day zero administration the route of delivery was into the albumen of the egg. Control dye solutions were injected into the amnion of fertilised eggs at day nine and then checked 3-4 hours after injection to check that the solution was indeed being swallowed by the embryos.

Incubation of Eggs

For each experiment, approximately 220 fertilised broiler eggs kindly donated by Baiada Hatchery, Gawler SA, Australia were pre-warmed at 27°C, 55% humidity and then set at 38°C, 55% humidity and maintained with turning every hour until day eighteen. At day eighteen remaining eggs were transferred to hatch trays and kept at 36.7°C, 60% humidity until hatch.

Amniotic Injections of Arginine at Day Nine

The eggs were candled at day eight and any non-viable or non-fertile eggs were removed. The rest of the eggs were weighed and sorted into treatment groups using stratified randomisation. On day nine eggs were injected intra-amniotically with 100µL of either a control of physiological saline containing a 1:20 dilution of blue food colouring or control solution with the addition of 10mg or 20mg of L-Arginine (Sigma Aldrich, St Louis, Missouri, USA). The eggs were then sealed with silicone and returned to the incubator. The position of the blue dye enabled determination of a successful injection. If the blue dye dissipated into the entire egg contents the egg was discarded.

Albumen Injections Pre-Set

Eggs were weighed, stratified and randomised as above and injected just prior to setting in the incubator with either 100µL of distilled water, 100µL of water containing 10mg of L-Arginine or, 100µL of water containing 15mg of L-Arginine. The injection was done into the albumen of the eggs through the pointed end of the egg. Eggs were sealed and then set in the incubator.

Chick Sampling

Chicks were sampled at either embryonic day fifteen or at day of hatch. The bodyweight, weight of total breast muscle, liver, proventriculus, gizzard, heart, spleen, Bursa of Fabricius, and the weight and length of the ileum, jejunum and duodenum were measured. For chicks from the amniotic injections at day nine small intestine segments were also examined and measured histologically. Hatch rates were also determined.

Results

Amniotic Injections, Day Nine

Dye was successfully swallowed by the embryo and found in the duodenal loop several hours after amniotic injection with the control dye solution at embryonic day nine (see figure 1).
L-Arginine significantly increased the weight and length of the ileum in chicks at both embryonic day 14 and day of hatch (See Figures 2 & 3).

**Figure 2. Effect of amniotic arginine on ileum weight at embryonic day 14 and at hatch (p<.05, values are means ± sem)**

![Graph showing ileum weight at embryonic day 14 and hatch.]

Amniotic injections of 10mg of L-Arginine at day nine of incubation resulted in an increase in the number of jejunal villi in tissue collected from embryonic day 14 chicks by 10%. All other parameters measured from the amniotic injections of arginine were not significantly different.

**Albunmen Injections, Day Zero**

Hatchability of eggs injected into the albumen with arginine prior to setting was significantly improved.

**Table 1. Hatchability of eggs injected with arginine at day zero**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percentage hatched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>84(^a)</td>
</tr>
<tr>
<td>10mg</td>
<td>100(^b)</td>
</tr>
<tr>
<td>15mg</td>
<td>95(^c)</td>
</tr>
</tbody>
</table>

There was no effect of injection at this time point on the small intestinal segment weights or lengths. However the liver, gizzard and Bursa of Fabricius were all significantly heavier when eggs were injected with 15mg of L-Arginine into the albumen prior to setting. There were no other changes in the parameters measured and there was no change in the bodyweights of the chicks at hatch.

**Discussion**

Increased weight, length and villi number of intestinal tracts of chickens injected in ovo at day nine of development has significant potential impact on subsequent chicken growth and efficiency. Increased development of the intestines presumably results from the known impacts of arginine on growth-regulatory pathways (Chevally et al., 1998), with IGF-1 and Growth Hormone strong candidates through their known effects on cell proliferation (Isidori et al., 1981). The increase in gizzard and liver weight at hatch produced by arginine injection at day zero into the albumen, may also lead to improved efficiency of the chickens post hatch. If the liver weight increase is due to increased glycogen stores this would be especially beneficial for chicks that spend time fasting post hatch before given access to feed. It is reported that commercially many birds are restricted from feed access for 36-48 hours after hatching, and during this time body weight rapidly decreases. This fasting period has lasting effects on the bird’s lifetime performance (Pinchasov and Noy, 1993).

Enhanced liver development and possible storage of energy substrates may reduce the impact of this restricted period.

The large increase in hatchability of eggs when provided with arginine prior to setting has significant potential economic benefits for the poultry industry if a practical means of providing the additional arginine in ovo can be found. We are currently examining the potential for dietary arginine supplementation of the breeder hen.

**Acknowledgement**

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**References**


No production response of injectable trace minerals in young cattle grazing pasture based systems in the Northern Territory

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Summary

Three existing liveweight gain datasets were analysed where cohorts of animals were systematically allocated to either being provided injectable trace minerals or not. Two datasets represented heifers and steers grazing either native tropical tallgrass pastures or floodplains typical of the Top End major river systems. A third dataset related to 2 y.o. heifers that had been relocated from the Sturt Plateau region to the Adelaide River district for backgrounding was also monitored. In each dataset, there was no production response to injectable trace minerals being provided.

Introduction

Rainfall, soil type, pasture species and pasture growth rates are all factors associated with the availability of trace minerals for grazing animals. With the exception of a few recognised areas, such as coastal and marine plains, trace mineral deficiencies in grazing cattle are uncommon in Australia (Hamlin-Hill, 2015). However, the results of tissue analyses of cattle in the north-west coastal region of the Northern Territory have indicated depleted copper levels (Westley-Smith and Schlink, 1990). This finding is consistent with copper and selenium deficiency being associated with waterlogged soils which is common for floodplain areas. Zinc deficiency has also been associated with dry mature pasture (Judson and McFarlane, 1998) which is typical of dry season monsoonal tallgrass pastures.

As marginal deficiencies are less readily identifiable a number of beef breeding herd managers within the Northern Territory provide a trace mineral injection to cattle at various times in the production chain with the view of strategically ‘topping up’ and addressing any underlying mineral deficiencies. Commercial products containing copper; zinc; selenium and manganese are typically provided to animals to do this.

As there are few published results on the production responses from providing trace minerals in northern Australia, herd managers have limited information to evaluate the cost effectiveness of providing trace minerals. The aim of this study was to compare the liveweight gain of animals provided a trace mineral injection to those that were not.

Materials and Methods

This desktop study utilised three existing datasets containing liveweight performance data which facilitated a comparison between animals within the same cohort that were provided a trace mineral injection (TRACE) to those that were not (CONTROL). Each dataset related to a single study site and differed in either/or both seasonal pasture conditions and class of animal.

Site A. At Mataranka Station (14.75⁰S 133.13⁰E) a cohort of 124 high-grade Brahman heifers and steers weaned in either April (53%) or September (47%) 2013 and a 2nd cohort of heifers and steers that were weaned in 2012 were randomly allocated to either a TREAT or CONTROL group in November 2013. Following allocation, year group’s grazed individual paddocks that were predominantly pastured by black speargrass (H. contortus) and were stocked under commercial conditions. Liveweight was recorded at allocation (0d) and in either April 2014 (162d; 2012 year drop) or in June 2014 (217d; 2013 year drop) following a 12h off-feed on-water curfew and growth over this period calculated. Study animals had access to supplemental phosphorus during the study period.

Site B. At Beatrice Hill Research Farm (12.65⁰S 131.32⁰E) a group of 131 Composite (76%) and Brahman (24%) heifers and entire males were randomly allocated to either a TRACE or CONTROL group in May 2011. Following allocation study animals grazed black soil floodplains typical of sub-coastal floodplain regions of the NT which were pastured by pangola grass (D. eriantha), gamba (A. gayanus), Tully (B. humidicola), para grass (U. mutica), Amity aleman grass (E. polystachya), and Olive hymenachne (H. amplexicaulis). Differences in growth were determined from allocation (0d) to 93d when liveweight was recorded following a 12h off-feed on-water curfew.

Site C. In February 2014, a group of 183 2 y.o. heifers were relocated from Gilnockie Station (15.91⁰ 132.4⁰E) in the Sturt Plateau district to Pell Airstrip Station (13.13⁰S, 131.11⁰E) in the Adelaide River district prior to live export in late March, 2014. A starting liveweight was individually recorded prior to transport at Gilnockie Station after a 12h off feed on-water curfew. On arrival at Pell Airstrip Station, study animals were randomly allocated to either a TREAT or CONTROL group and liveweight recorded at the time of sale in March (45d). Study animals grazed tropical tallgrass native pastures typical of the Adelaide River district that were mixed with Gamba (A. gayanus) and Tully (B. humidicola) grasses.

All statistical analyses were performed using Stata 13.1. Pairwise comparisons of mean liveweight gain for treatment groups were performed following an analysis of covariance. Attempts were made to partition the associated effects of other extraneous factors such as Sex, Weaning Group and Breed.
Results and Discussion

In each dataset the study animals were under nutritional conditions that were above maintenance requirements and supported growth. The individual performance of TRACE group was not dissimilar from that of the CONTROL group in all three analysed datasets (Table 1). Therefore, a production advantage from providing a trace mineral injection was not observed under the nutritional conditions in which the three datasets represented.

These results are not definitive as marginal deficiencies vary between years and locations. However, even in a study where tissue analyses indicated a low to marginal copper deficiency, a production response to supplemental copper was not detected (Westley-Smith and Schlink, 1990).

Table 1. Summary of average liveweight gain of TRACE and CONTROL treatment groups.

<table>
<thead>
<tr>
<th>Animal class and pasture conditions</th>
<th>No.</th>
<th>TRACE</th>
<th>CONTROL</th>
<th>Difference</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical tallgrass wet season pasture (Site A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013 year drop</td>
<td>124</td>
<td>313 (298, 329)</td>
<td>311 (296, 326)</td>
<td>1.9 (-19.7, 23.5)</td>
<td>0.86</td>
</tr>
<tr>
<td>2012 year drop</td>
<td>136</td>
<td>735 (712, 758)</td>
<td>757 (735, 780)</td>
<td>-22.6 (-54.7, 9.4)</td>
<td>0.17</td>
</tr>
<tr>
<td>Yearling heifers and entire males: Floodplain (Site B)</td>
<td>131</td>
<td>203 (186, 221)</td>
<td>197 (180, 213)</td>
<td>6.7 (-17.3, 30.7)</td>
<td>0.71</td>
</tr>
<tr>
<td>2yo heifers: Tropical tallgrass late-wet season pasture (Site C)</td>
<td>183</td>
<td>861 (786, 937)</td>
<td>870 (790, 950)</td>
<td>-9.0 (-119.0, 101.0)</td>
<td>0.87</td>
</tr>
</tbody>
</table>

In conclusion, these results are consistent with existing knowledge that unless known consistent trace mineral deficiencies exist a production response to a trace mineral injection is unlikely. Therefore, nutritional management should primarily place emphasis on meeting the major known nutritional requirements of energy (through the appropriate management of pasture resources) and supported by strategic supplementation of nitrogen in the dry season and phosphorus in the wet season.

Acknowledgement

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References


Phenotypes to meet pasture-fed market requirements

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Summary

Three distinct phenotypes of Angus steers were finished at pasture as four consignments for a farm assured pasture-fed target market between 14 August 2014 and 8 December 2015. The target market required meeting processor specifications including carcase weight and fat depth as well as meat colour and ultimate pH (pHu). Steers were monitored for weight gains at pasture. After processing meat quality attributes according to Meat Standards Australia (MSA) grading were collated from feed-back sources. Steers were able to be successfully finished on pasture to meet target market weight, fat and meat quality criteria. One phenotype showed pHu>5.7 in 4% and 13% of carcases processed. Weight gains on pasture over summer and winter were maintained to support a rising plane of nutrition up to processing. Carcase feed-back provided objective measures to improve understanding of production performance of different phenotypes.

Introduction

Consumers of beef expect high quality and a consistent eating experience associated with a product that is traceable to support animal production and welfare expectations at the consumer level.

Industry developed and introduced Meat Standards Australia (MSA) to underpin eating quality and programs such as the Pasture-fed Cattle Assurance System (PCAS, 2014) have been introduced to verify claims relating to pasture-fed production methods.

Farm quality assurance programs are used by producers and processors, for example, the JBS Australia Farm Assurance programme (2015) to support quality and reputation of branded products in a number of domestic and export markets.

To provide product which meets carcase weight, fat depth and meat quality specifications after slaughter producers need to consign quality animals that have functioned well in a pasture-fed production system.

Measures of performance of different phenotypes on farm and after slaughter enable producers to seek preferred genetics that will increase the likelihood of meeting market specifications.

This paper describes the performance of three consignments of pasture-fed Angus steers of different phenotypes in relation to growth and meat quality for a farm assured pasture-fed market segment.

Materials and Methods

The farm was located at Bowna, NSW having an average annual rainfall of 650mm. Pastures for steer finishing comprised phalaris and clover with a small amount (<5%) of annual grasses (eg Barley grass) and weeds (eg Soft Brome). Feed testing of pasture samples showed 10-11 MJ ME/kg DM and 16-25% crude protein.

Vendor bred steer lots were purchased at the Northern Victorian Livestock Exchange following confirmation with the breeder regarding animals’ genetic backgrounds and vendor bred, yard weaned, grass-assured and hormone-free status per the National Vendor Declaration.

Steers were purchased in commercial lots, vaccinated (Websters 5 in 1 Vaccine®) and drenched (Cydectin Long Acting Injection®) onto the property and acclimatised to the pasture-based finishing system.

Pastures were managed through rotational grazing with steers being removed when pasture dry matter was reduced to approximately 1,500 kg/ha. No supplementary feed was provided apart from high quality wheat straw provided ad lib in spring in an attempt to manage high pasture protein. Water supply was from rain-fed earthen dams.

Table 1 shows the phenotypes, entry and finish dates for processing and rainfall through grow-out.

Table 1. Phenotype, entry and finish dates and rainfall.

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Entry date</th>
<th>Finish Date</th>
<th>Rainfall mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR1</td>
<td>14 Aug 2014</td>
<td>16 Jun 2015</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(n = 30)</td>
<td></td>
</tr>
<tr>
<td>RxC2</td>
<td>19 Mar 2015</td>
<td>26 Oct 2015</td>
<td>318</td>
</tr>
<tr>
<td></td>
<td>(n = 29)</td>
<td>(n = 29)</td>
<td></td>
</tr>
<tr>
<td>MxC3 – a</td>
<td>16 Apr 2015</td>
<td>26 Oct 2015</td>
<td>314</td>
</tr>
<tr>
<td></td>
<td>(n = 40)</td>
<td>(n = 15)</td>
<td></td>
</tr>
<tr>
<td>MxC – b</td>
<td>8 Dec 2015</td>
<td>8 Dec 2015</td>
<td>395</td>
</tr>
<tr>
<td></td>
<td>(n = 25)</td>
<td>(n = 25)</td>
<td></td>
</tr>
</tbody>
</table>

1 Glenruben, 2 Rennylea x Cascade, 3 Merridale x Cascade

Pasture growth rates (PGR) for the area estimated by remote sensing though the Pastures from Space (CSIRO, 2014) programme showed PGR to be 20 kg/ha/d in August 2014, 5-10 kg/ha/d in March and April 2015 and 40 and 10 kg/ha/d and in June 2015 and October and December 2015 respectively. On a seasonal basis, PGR ranged from 20-40 and 60-80 kg/ha/d in autumn and spring respectively.

Steers were regularly weighed (Ruddweigh 300) to assess average daily liveweight gains (ADG) through to finish. Animals were consigned for slaughter under the MSA protocols.

ASAP Animal Production 2016, Adelaide
Phenotypes RxC and MxC were run as one mob from April until finish. Heavier MxC steers (n=15) were consigned with the RxC consignment on 26 October 2015 with the remaining MxC steers consigned on 8 Dec 2015.

Target market specifications included: Hot standard carcase weight 250-350 kg, P8 rump site fat depth 5-10 mm fat, Meat colour 1b-3, Meat pH<5.71.

MSA feed-back was obtained directly from the processor for the June consignment and through MLA’s Livestock Data Link for the October and December consignments.

Results and Discussion

In this pasture-based production system pastures were managed to support weight gains in steers over summer and over winter without any supplementary feed being provided.

Table 2 shows days to finish on pasture ranged from 193 to 305 days with phenotypes showing ADG of 0.8 to 1.1 kg/day.

Phenotypes showed a variation in liveweights as shown by coefficient of variations of 3.9% to 6.8%. Hot standard carcase weights showed coefficient of variations ranging from 4.1% to 6.6% .

Table 2. Mean (± standard deviation) of entry and finish liveweights (LWT), average daily gain (ADG) and days on pasture.

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Entry LWT kg</th>
<th>Finish LWT kg</th>
<th>ADG LWT/d</th>
<th>Days on pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>351 (±242)</td>
<td>620 (±40)</td>
<td>0.9</td>
<td>305</td>
</tr>
<tr>
<td>RxC</td>
<td>384 (±26)</td>
<td>637 (±27)</td>
<td>1.1</td>
<td>221</td>
</tr>
<tr>
<td>MxC – a</td>
<td>343 (±22)</td>
<td>536 (±36)</td>
<td>1.0</td>
<td>193</td>
</tr>
<tr>
<td>MxC – b</td>
<td>352 (±21)</td>
<td>532 (±36)</td>
<td>0.8</td>
<td>236</td>
</tr>
</tbody>
</table>

Table 3 shows hot standard carcase eight, P8 and rib fat depths and MSA marbling scores. Phenotype MxC tended to have lower fat cover and MSA marbling at finish.

The MxC consignment tended towards marginally lower P8 rib and fat depths compared to GR and RxC consignments.

Table 3. Mean (± standard deviation) of hot standard carcase weight (HSCW), P8 rump fat depth, rib fat depth and MSA marbling scores.

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>HSCW kg</th>
<th>P8 fat mm</th>
<th>Rib fat mm</th>
<th>MSA marbling</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>335 (±22)</td>
<td>13 (±4)</td>
<td>11 (±3)</td>
<td>434 (±67)</td>
</tr>
<tr>
<td>RxC</td>
<td>326 (±15)</td>
<td>9 (±3)</td>
<td>9 (±4)</td>
<td>404 (±108)</td>
</tr>
<tr>
<td>MxC – a</td>
<td>290 (±19)</td>
<td>7 (±2)</td>
<td>8 (±3)</td>
<td>297 (±63)</td>
</tr>
<tr>
<td>MxC – b</td>
<td>293 (±12)</td>
<td>8 (±2)</td>
<td>8 (±2)</td>
<td>305 (±82)</td>
</tr>
</tbody>
</table>

Table 4 shows average EMA ranged from 69 to 75 cm² across the three consignments. Elevated pHₜ (>5.7) occurred in two and one carcases in the two MxC consignments respectively.

Table 4. Mean (± standard deviation) of eye muscle area (EMA), ultimate meat pH (pHₜ), number pHₜ greater than 5.7 and MSA Ossification (Oss) and MSA Index.

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>EMA cm²</th>
<th>pHₜ</th>
<th>No. pHₜ</th>
<th>MSA Oss</th>
<th>MSA Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>75.1 (±6.4)</td>
<td>5.51</td>
<td>0</td>
<td>140 (±19)</td>
<td>63.4 (±1.3)</td>
</tr>
<tr>
<td>RxC</td>
<td>72.4 (±4.7)</td>
<td>5.55</td>
<td>0</td>
<td>131 (±13)</td>
<td>63.2 (±2.0)</td>
</tr>
<tr>
<td>MxC – a</td>
<td>69.3 (±7.4)</td>
<td>5.57</td>
<td>2</td>
<td>111 (±7)</td>
<td>63.2 (±1.3)</td>
</tr>
<tr>
<td>MxC – b</td>
<td>74.6 (±5.5)</td>
<td>5.50</td>
<td>1</td>
<td>112 (±10)</td>
<td>63.2 (±1.5)</td>
</tr>
</tbody>
</table>

Carcasses in consignments MxC- a and b with pHₜ >5.7 had rib fats of 6, 6 and 9mm and EMA of 72, 76 and 85cm² respectively. In a study of more than 200,000 carcases McGilchrist et al (2012) found that the probability of pHₜ >5.7 increased when carcase rib fat was <7mm.

In this pasture-based production system the MxC phenotype had a higher number of elevated pHₜ compared to the other phenotypes. The higher number of elevated pHₜ may have resulted from lower rib fat cover as reported by McGilchrist et al (2012). Associated with lower rib fat were lower MSA marbling scores in the MxC consignments.

In conclusion, despite the occurrence of elevated pHₜ in one phenotype, this pasture-fed beef production system, without supplementary feed, was able to consistently meet market requirements with the phenotypes utilised. For producers targeting particular markets such as pasture-fed beef, phenotypes supporting good production on pasture should be sought. MSA feedback information assists in understanding the performance of different phenotypes.

Acknowledgement

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Accessed February 2016
Shade utilisation by *Bos taurus* and *Bos indicus* steers during summer

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### Summary

It has been well established that the provision of shade is advantageous for *Bos taurus* cattle. However there are perceptions that shade is only beneficial for *Bos taurus* cattle. For the current study shade utilisation data were obtained from Angus, Charolais and Brahman steers during summer. Breed, time of day and heat load index (HLI) had the greatest influence on shade utilisation. Maximum shade utilisation was at 1200 h for Angus (85.5% of Angus under shade), Charolais (32.7%) and Brahman (33.3%) steers. Angus steers also showed the highest percentage increase in shade utilisation (61.3% increase in shade utilisation), when HLI increased from cool (HLI ≤ 77) to very hot (HLI > 86), compared with Charolais (28.1 % increase) and Brahman (15.4% increase) steers. These results indicate that Brahman cattle will utilise shade to seek relief from hot conditions.

### Introduction

Heat stress is a significant welfare and production issue for the feedlot industry worldwide. Chronic heat stress is present in many regions worldwide during the summer months and is often a major stressor for healthy feedlot cattle (Gaughan et al., 2013). It has been well established that the provision of shade is advantageous for *Bos taurus* feedlot cattle in regions where summer heat load is an issue. Providing shade to feedlot cattle alters the microclimate within the pen (Mitlöchner et al., 2002), providing an area where the accumulation of body heat is reduced thus supporting the maintenance of homeostasis. The advantage of providing shade is that the application is passive, whereby cattle are able to utilise shaded areas voluntarily. The aim of the study presented here was to determine differences in shade utilisation of *Bos taurus* and *Bos indicus* cattle during summer in a sub-tropical environment.

### Materials and Methods

The study described herein was part of a larger 154 day feedlot study involving 36 steers (12 Angus, 12 Charolais and 12 Brahman) with an initial non-fasted live weight of 318.5 ± 6.7 kg. This study was conducted with the approval of The University of Queensland (UQ) animal ethics committee (SAFS/335/11/MLA).

The experiment was undertaken in Southeast Queensland, Australia, at the UQ (27.54°S, 152.34°E; 100 m above mean sea level) research feedlot during the southern hemisphere summer (October to April). During the summer the location is characterized by a hot, humid sub-tropical climate.

The study described in this paper only describes shade utilisation data from 18 steers (6 Angus, 6 Charolais and 6 Brahman) housed in shaded feedlot pens within the UQ research feedlot. There were 3 shaded pens, 162 m\(^2\) (27 m × 6 m) with 6 steers per pen and each pen consisted of 2 Angus, 2 Brahman and 2 Charolais. The pens were situated in an east-west alignment. Shade was provided by shade-cloth (black, 90% solar block, Darling Downs Tarpaulins, Toowoomba, QLD, Australia) attached to a 4 m framed steel high structure. The shade structure provided a shade footprint of 3.0 m\(^2\)/animal (6 m × 3 m) at midday.

Weather data were collected at 10 min intervals using an automated weather station (Davis Pro V2, Davis Weather Station, Hayward, CA, USA) located at the front of the feedlot (west). Weather data collected included ambient temperature (\(T_a\); °C); relative humidity (RH; %); wind speed (WS; m/s) and direction; solar radiation (SR; W/m\(^2\)); and 24 h daily rainfall (measured at 0900 h). From these data the HLI was calculated as described by Gaughan et al. (2008). Additionally HLI was divided into four stress categories; 1) cool (thermoneutral), HLI ≤ 70; 2) moderate, HLI 70.1 ≤ 77; 3) hot, HLI 77.1 ≤ 86; and 4) very hot, HLI > 86 (Gaughan et al., 2008; Gaughan et al., 2010).

Shade utilisation was determined by observing each individual steer at 2 hour intervals between 0600 h and 1800 h daily between d 1 to d 154. A steer was considered to be utilising shade where ≥ 60% of the animal’s body was covered by shade.

Ten minute weather data were converted to an hourly average for each individual climatic variable, including HLI. Observational data were converted to count for each breed for each observation time point. Shade utilisation was then calculated by determining the count of steers standing or laying under the shaded region. Counts per breed were then converted to a proportion per breed.

Shade utilisation was analysed using an analysis of variance, Generalised Linear Model with a binomial structure (R, R Foundation for Statistical Computing, Vienna, Austria). The model assessed the effect of breed, time of day, day, HLI, breed × day, time of day × day, breed × HLI and breed × time of day × day.

### Results

The weather conditions during the study period were similar to the long-term averages for the location with some intermittent hot days above 35 °C. During the study there were 127 days with a maximum HLI ≥ 86. Of these 127 days, 91 days had a HLI ≥ 90, 37 days had a HLI ≥ 95 and 4 days had a HLI ≥ 100. Overall there were 117 nights where HLI was ≤ 60, and 43 of these nights HLI was ≤ 55.

Shade utilisation was influenced by breed (\(P < 0.0001\)), time of day (\(P < 0.0001\); Figure 1), HLI (\(P < 0.0001\); Figure 2), breed × time of day (\(P < 0.0001\)), breed × HLI (\(P < 0.0001\)), breed × day (\(P > 0.0001\)) and time of day × day (\(P < 0.0001\)). There were no effects of day (\(P = 0.49\)) or breed × time of day × day (\(P = 0.83\)). Maximum shade utilisation was 85.5%, 32.7% and 33.3% for Angus, Charolais and Brahman steers respectively at 1200 h. Interestingly Brahman steers had a 27.1% increase in shade utilisation between 0800 h and 1200 h.
Discussion
Feedlot cattle are particularly susceptible to changes in climatic conditions, often exhibiting reduced performance and wellbeing during periods of hot weather (Hahn, 1999; Mader, 2003). When utilising shaded areas the benefit is primarily associated with a reduction of the animal’s direct exposure to SR. Numerous authors have reported benefits of providing shade for the regulation of core body temperature during hot weather conditions (Mader et al., 1999; Brown-Brandl et al., 2005; Mader et al., 2010).

Shade utilisation for all breeds increased as HLI increased. As expected the proportion of Angus steers utilising shade was greater ($P < 0.05$) than Charolais and Brahman steers between 0800 h and 1600 h. However, the proportion of Brahman steers utilising shade increased from 4.0% to 19.4% when HLI increased from cool (HLI $\leq 77$) to very hot (HLI $\geq 86$) respectively. Shade utilisation was similar between Brahman and Charolais steers when HLI was classified as cool (HLI $\leq 77$; 4.0% versus 2.4%), moderate (HLI 70.1 $\leq 77$; 8.4% versus 6.8%) and hot (HLI 77.1 $\leq 86$; 11.2% versus 12.6%). However, differences were observed between Brahman and Charolais steers when HLI was classified as very hot (HLI $\geq 86$; 19.4% versus 30.5%). Angus steers had the highest percentage increase in shade utilisation with a 61.3% increase when HLI increased from cool (HLI $\leq 77$) to very hot (HLI $\geq 86$), compared with Charolais (28.1 % increase). Interestingly Brahman steers showed a 15.4% increase when HLI increased from cool (HLI $\leq 77$) to very hot (HLI $\geq 86$). The increase in shade utilisation by the Brahmans steers as heat load increased, indicates that Bos indicus cattle will use shade to reduce heat load when conditions are classified as very hot. Although Bos indicus cattle are thermotolerant, the strong expression of shade seeking behaviour of the Brahman steers within this study indicates that these cattle were seeking relief from hot conditions.

As the HLI stress category increased in intensity there was an increase in shade utilisation of Angus, Charolais and Brahman steers. These results emphasise the importance of providing shade to feedlot cattle, irrespective of genotype.

Acknowledgement
Funding for this study was provided by Meat and Livestock Australia P/L., Nth Sydney, NSW, Australia.

Literature Cited
Moult that wool from their tail appeared in an experimental flock that had not been tail docked. Wool moulted during spring in yearlings, and was assessed by gently plucking small staples using the thumb and index finger. Yearlings (n = 1263) either moulted all the wool from along their tail and around the base (46%), part way along the tail (22%), or not at all (32%). Yearlings expressing complete moulting had lower (P<0.001) dag score at shearing (mean ± standard deviation, 1.2 ± 1.1), than those that partially moulted (1.9 ± 1.4), or did not moult at all (2.1 ± 1.6). Animals that completely moulted had shorter tails (11 mm) at 5 weeks of age, greater breech bareness (0.66 units) at 4 months and 170g lighter clean fleece weight at 14 months than those that did not moult. Together these traits will reduce husbandry costs and improve welfare.

Materials and Methods

The yearlings from a self-replacing flock of composite breed sheep were maintained on pasture in Canterbury. A total of 30 sires were mated to produce offspring between 2006 and 2012, observed as yearlings (n=1263) from 2007 to 2013. Tail length was measured on the lambs at 5 weeks of age, using the method of Scobie et al. (2007). Breech bareness score (1 to 5) and dag score (0 none to 5 extensive) were both recorded at weaning at 4 months old (Scobie et al. 2007). Note, extensive breech bareness was scored as 5, the opposite of that used in Australia. The sexes were run separately from weaning onwards and weighed at 12 months of age. All animals were shorn as lambs at 5 months and then again as yearlings at 14 months old, with slight differences between years according to the weather and availability of shearsers. Wool samples were collected and dag score was recorded again just prior to shearing, and fleece weight was recorded at shearing.

Moult of tail wool was recorded every two weeks from August when the sheep were 11 months old. A light plucking force was applied to a small staple of wool using the thumb and index finger, beginning at the distal end of the tail. If the wool easily came away from the tail, that sheep was determined to be moultling and plucking was attempted further along the tail towards the body. Notes were taken with respect to how far along the tail moulting occurred. When the entire tail had lost wool and a moulted patch had developed around the top of the tail and onto the body, tail moulting was regarded as complete (Complete) and recording ceased for that animal. In some animals moulting stopped part way along the tail and had thus only partially completed moulting by the time they were shorn (Partial). Mouling did not occur prior to yearling shearing in some animals (Not). The association of moulting with some other traits was investigated by fitting the trait in a mixed model that included year, sex, birth/rearing rank, birth day of year and moulting score as fixed effects, and the sire as a random effect.

A small number of animals (n=63) became so daggy that it was not possible to record moulting of the wool on their tail, these were removed from the experiment. They were shorn along the tail and around the breech to remove dags and prevent flystrike.

Results

Some yearlings never showed any sign of moulting tail wool (32%), while complete (46%) or partial (22%) moulting was observed on most tails by the time of yearling shearing.

Figure 1. Proportion of completely moultling yearlings that had commenced moulting tail wool (solid line) and reached maximum tail moulting (dashed line) through the spring.
of the animals that completely moulted their tail wool by yearling shearing, the progression of the proportion commencing and completing moulting is shown in Figure 1. The moulting of tail wool had begun prior to recording in a small number of yearlings, and then reached a peak in the number commencing moulting by mid-September. This was followed by a less defined peak in the number completing moulting along the tail and around the base of the tail by mid-October.

Dag score of the yearlings was significantly different between groups based on moulting of tail wool (P=0.001) (Table 1), and overall dag score varied between years (P<0.001). There was a significant effect of sire group on dag score of yearlings (P=0.008). Dag score was not significantly different between the sexes as yearlings, although these had been separated since weaning. An effect of birth and rearing rank on dag score remained in these animals (P=0.019), despite being a year old. During the period of recording, live weight increased from 45kg at 11 months of age to 60kg at 14 months. Rams were considerably (7kg) heavier than ewes at 12 months (P<0.001). Surprisingly, the ewes grew slightly more (0.06kg) fleece (P=0.001) than the rams.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Tail moulting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not</td>
</tr>
<tr>
<td>n</td>
<td>401</td>
</tr>
<tr>
<td>Tail (mm)</td>
<td>221</td>
</tr>
<tr>
<td>Breech sc</td>
<td>2.70</td>
</tr>
<tr>
<td>Dag wean</td>
<td>0.65</td>
</tr>
<tr>
<td>Live wt (kg)</td>
<td>43.8</td>
</tr>
<tr>
<td>Dag shear</td>
<td>2.11</td>
</tr>
<tr>
<td>CFW (kg)</td>
<td>1.65</td>
</tr>
<tr>
<td>FD (µm)</td>
<td>30.2</td>
</tr>
</tbody>
</table>

**Discussion**

Tail wool moulting is a previously unreported trait expressed in sheep. The widespread use of tail docking and crutching has possibly obscured the expression of this trait. Moult started at the distal end of the tail in spring in yearlings. Moult observed in a very small number of lambs prior to lamb shearing, but these observations are not reported here. This phenomenon is similar to moulting of body wool, and the flock reported here were run together with the yearlings of the New Zealand Wiltshire sheep flock studied by O’Connell et al. (2012). Complete moulting of body wool in Wiltshire sheep tended to occur more rapidly on faster growing lambs and young sheep (O’Connell et al. 2012). This was not obvious among the composite flock used here, perhaps because live weight increased rapidly during the observation period in all animals.

The influence of sire group on tail wool moulting suggests a genetic basis that will be reported elsewhere. Yearlings expressing complete moulting carried less dags, but also had shorter tails (P<0.001) and barer breeches (P<0.001), either of which could cause lower dag scores. Understanding correlations among these traits will require genetic analysis, but all of these traits could be used to reduce dag accumulation and flystrike and therefore improve the welfare of sheep.

Initial mating experiments indicated that a single gene was not solely responsible for the expression of this trait. However, it is likely that a small number of genes control this trait, and it should therefore be transferable to a number of breeds. This could create new phenotypes with subsequent back-crossing to restore other desirable traits such as fibre diameter.

Although the trait has possibly been present for many years in the East Friesian breed, it has not been reported in the scientific literature. The trait has also been observed in Finnish Landrace and Texel sheep in New Zealand, and the exact origin of the trait in this flock is not known. Romney sheep have long woolly tails with a tendency to become daggy if not docked, so Romney was unlikely to be the source.

A small number of lambs from this flock were flystruck around weaning (n=50), and these were treated immediately by shearing around the breech and along the tail and then applying insecticide. These lambs were not used in the current experiment because the skin damage from flystrike compromised the observation of moulting, and in some cases caused fleece shedding. Flystrike was sufficiently common in one year to suggest the progeny of some sires were more susceptible to flystrike than others (Scobie and O’Connell, 2010). Flystrike on a lamb in autumn is not likely to be directly affected by moulting of tail wool in spring as a yearling, but hopefully moulting will reduce flystrike in yearlings.

It would seem that this is a very useful trait for commercial sheep breeders to incorporate in their flock. In the best case, the tail wool will moult and take with it any dags that have adhered along the tail and around the breech. Using breech bareness as a replacement for mulesing, short tails to replace tail docking, and adding tail moulting to reduce the need for dagging and crutching, sheep can be bred for improved welfare and greater profitability.

**Acknowledgement**

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**References**


Development of the One Biosecurity program in South Australia

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Summary

Biosecurity South Australia (a division of Primary Industries and Regions SA) has been developing a new approach to risk management of livestock diseases through farm livestock biosecurity and market assurance, known as ‘One Biosecurity.’ The approach uses a unique biosecurity scoring system for use by farmers to create a biosecure compartment within which intrastate trade can occur. It is designed to assure disease freedom, enhance productivity, bolster market access and prevent exotic disease spread.

This paper describes the concept and mechanisms of One Biosecurity and the background research that has been done to assess its viability.

Background

Historically, livestock disease management has been the responsibility of livestock owners with the State Government (through the Department of Primary Industries and Regions SA Biosecurity SA- Animal Health group) providing regulatory support for the control of diseases of industry concern and various surveillance programs to detect changes in animal health status.

Within South Australia, the government delivers four industry-funded endemic disease control programs (cattle and sheep Johne’s disease, footrot and sheep lice control programs) plus the underpinning National Livestock Identification System (NLIS) traceability program. These programs have a role in reducing on-farm husbandry costs, provide some improvement in productivity and maintain government-industry networks. Important as these are, these programs have no role in export market access which is crucial for industry sustainability. Consumers and trading partners demand livestock and livestock products which are healthy, wholesome and do not pose a threat to human or livestock health. Increasingly abattoirs and others along the livestock supply-chain are requiring biosecurity and welfare measures of their suppliers to demonstrate the wholesomeness and safety of their products to their domestic and overseas customers.

Biosecurity SA - Animal Health is developing a programme which will change the focus of its role in endemic disease control from disease specific control programs to a greater emphasis on risk management based on biosecurity at the farm level.

Concept

To better focus these industry programs on international markets, the ‘One Biosecurity’ initiative was developed. One Biosecurity is a new initiative that departs from the current disease control approach, to emphasise on-farm biosecurity as the primary focus, with specific diseases as indicators of good biosecurity practices. Improved farm biosecurity has a number of spin-offs: cleaner production; greater market credibility, less vulnerability to uncontrolled disease spread (creates resilience); better disease reporting and better traceability.

The foundation of One Biosecurity is a simple farm-based biosecurity scoring system. Each participating producer will calculate a Farm Biosecurity Rating (FBR) by scoring on a farm level practices on a checklist and Farm Disease Risk Rating (FDRR) reflecting the sophistication of their on-farm risk-mitigation biosecurity practices. These ratings must be auditable and verifiable.

When offering livestock for sale, these ratings are declared to the potential purchaser/s. In order to promote accessibility the declarations are made by the vendor via a web facility that will be analogous to a social networking site. Site access will be for ‘members only’ and will allow the creation of a network of producers of similar biosecurity status within which safe livestock trade may occur.

The concept of a biosecure network is based on the OIE model of a ‘compartment.’ (OIE, 2015)

Participation will be voluntary; the rating system is described in a One Biosecurity Manual and minimum standards of behaviour are outlined in a One Biosecurity Code of Conduct.

Progress and Outputs

The scheme has been designed by a Joint Industry-Biosecurity SA working group, chaired by the President of Livestock SA. Technical inputs are provided largely by Biosecurity SA staff.

Since its inception at the beginning of 2015, the working group has achieved the following milestones:

Completion of the One Biosecurity Manual, Code of Conduct and framework for conducting farm audits A buyer’s guide to assist producers in making decisions is being developed.

One Biosecurity Phase 1 trial: an attitudinal survey of farmers to assess the level of producer support for the concept. A randomised survey of 3,000 producers (response rate 33%) indicated that nearly two-thirds of those surveyed supported such an initiative.

One Biosecurity Phase 2 trial: on-farm work on 19 farms in different farming systems tested the use of the Code, Manual and biosecurity scoring system. Feedback from the producers involved was that the documentation was simple, easy to understand and the system was workable. Valuable
Implementation of One Biosecurity will involve a large-scale communication campaign during the time that the web pages are activated and producers join the scheme. This part of the project is still in the early planning phase.

Outcomes

Apart from final implementation planning and building of the web pages, most of the groundwork for One Biosecurity has been completed. Funding submissions have been put forward within the Primary Industries and Regions SA department. It is hoped that sufficient funding will be obtained to begin rollout of One Biosecurity in the second half of 2016.

Freedom from major pests and diseases will provide South Australia with a significant trade advantage over competitors and is critical for securing and maintaining export markets.

Acknowledgements

The work of the members of the One Biosecurity Working Group is gratefully acknowledged, as is the contribution of all Biosecurity SA staff and producers who have so willingly participated in the Phase 1 and 2 trials.

References

Effect of eight weeks chilled or frozen storage on consumer-defined sensory quality traits of lamb

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Summary

The effects of eight weeks chilled and frozen storage on lamb m. longissimus lumborum (LL) were evaluated in this study. A total of 24 randomly selected LL were kept under chilled or frozen storage – the latter involving two different frozen storage temperatures of -12°C and -18°C. At the completion of the treatment phase, all LL were sub-sampled, cooked and tested by 30 untrained consumer panellists for tenderness, juiciness, flavour and overall liking quality traits. This study found that all quality traits were lower when LL were kept under frozen storage compared to chilled storage ($P < 0.01$). No difference between frozen storage temperatures was found ($P > 0.05$). These results demonstrate the consumer preference for chilled storage, in terms of LL eating quality when the storage duration is eight weeks.

Introduction

Sensory quality, as measured by consumer panels of varied levels of training, is fundamental to determining the effects of chilled and frozen storage on meat. Tenderness, juiciness, flavour and overall liking have been used in several studies to determine quality (Thompson et al., 2005). Past studies have reported frozen storage duration to have no detrimental effect on these quality traits of lamb, even following 2 years frozen storage (Winger, 1984). Chilled stored lamb, however, has been found to remain of acceptable quality for up to 12 weeks (Sumner & Jenson, 2011). Evident in these studies is the absence of a chilled and frozen storage comparison, and an evaluation of frozen storage temperature. This study therefore aimed to investigate this paucity using an untrained consumer sensory panel.

Materials and Methods

At 24 h post-mortem, 24 lamb LL muscles were randomly sampled from the boning room of a commercial Australian abattoir. All LL were vacuum-packaged and allocated to either chilled ($n = 12$; 8 weeks at 1-4°C) or frozen storage ($n = 6$ at -12°C and $n = 6$ at -18°C). At the conclusion of the frozen storage period, samples were allowed to thaw overnight under refrigeration. Each LL was sliced into 5 slices, and then each slice halved to form 10 bite-size pieces per sample for scoring, with slices and half-slices for each sample tracked. These were grilled to an internal temperature of 71°C and presented to a panel of 30 untrained consumer panellists across two sessions, so that each LL was evaluated by 10 panellists. Panellists were provided a blank sample prior to experimental samples. Samples were rated out of 100 using sliding scales for tenderness, juiciness, flavour and overall liking (Thompson et al., 2005).

Data were statistically analysed using a linear mixed model (R Core Team, 2015). Fixed effects were treatment (chilled storage and frozen storage at -12°C and -18°C) and sensory panel session. Uncorrelated random effects were individual sample, slice within sample, tester and freezer, as well as random error. The level of significance of this study was set at $P < 0.05$.

Results

Frozen storage resulted in lower rankings for all quality traits ($P < 0.01$) when compared with chilled storage, especially evident for tenderness and juiciness (Table 1). It was also evident that frozen storage temperature did not influence the evaluated sensory quality traits ($P > 0.05$).
Discussion

This study demonstrated that untrained consumer panellists can differentiate between chilled and frozen storage of lamb LL in terms of sensory quality traits. Past research has complemented these results, reporting diminished sensory quality with frozen storage, albeit using trained sensory panellists (Lagerstedt et al., 2008; Vieira et al., 2009). However, the present findings differ from other studies, for example Muela et al. (2012) reported that frozen storage for up to six months did not influence any sensory parameters in lamb. Another study only reported decreased juiciness in lamb after one month frozen storage (Bueno et al., 2013). The divergence of these and the present findings is thought to be based upon the differences in storage duration of chilled product to which frozen product was compared. Essentially, the chilled storage duration was much less in previous studies than that applied in the present study, and Vieira et al. (2009) noted that increasing the chilled storage duration from 3 days to 10 days significantly improved both tenderness and overall acceptability regardless of frozen storage duration, which is in agreement with other studies reporting peak lamb tenderness to occur between one and two weeks chilled storage (Dransfield, 1994).

From this study, it can be concluded that regardless of temperature, lamb LL stored chilled for 8 weeks was of superior sensory quality compared to lamb LL stored frozen for 8 weeks. For future studies, the use of chilled storage prior to frozen storage may prove beneficial to lamb meat quality.

Acknowledgements

The authors thank the Australian Meat Processor Corporation (AMPC) for their financial assistance as well as the NSW Department of Primary Industries (NSW DPI) staff for their expertise and technical support.

Table 1. Mean consumer rankings (%) and standard error for lamb *m. longissimus lumborum* sensory quality traits kept for eight weeks under chilled or frozen storage

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tenderness</th>
<th>Juiciness</th>
<th>Flavour</th>
<th>Overall Liking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled</td>
<td>66.6 (4.2)*****</td>
<td>72.4 (4.8)*****</td>
<td>66.3 (2.6)**</td>
<td>67.4 (3.4)**</td>
</tr>
<tr>
<td>Frozen (-12°C)</td>
<td>37 (5.7)</td>
<td>61.1 (5.2)</td>
<td>56.7 (3.3)</td>
<td>48.7 (4.6)</td>
</tr>
<tr>
<td>Frozen (-18°C)</td>
<td>48.4 (5.7)</td>
<td>64.3 (5.2)</td>
<td>59.5 (3.3)</td>
<td>54.6 (4.6)</td>
</tr>
</tbody>
</table>

** and *** denote significance as *P* < 0.01 and *P* < 0.001, respectively, for Chilled vs. Frozen comparison.

References


Evaluation of Recoverability of Mycoplasma-like organisms causing mastitis in dairy cattle in South Australia under different freezing conditions.

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Background and Objectives:
The current recoverability of Mycoplasma spp in milk samples stored in fridge or freezer is assumed to be very low (<30%). Mycoplasma mastitis can cause significant losses to an affected herd. Testing for these bacteria requires specific culture media and methodology but it is usually attempted late after traditional culture fails to detect the primary cause of the problem. The time lag between sampling and testing may therefore result in false-negative Mycoplasma culture. The study aim was to estimate the recovery of Mycoplasma spp. isolated from bovine milk samples under different freezing conditions. Furthermore, the study compared few cryoprotectants with aim to avoid the intra and extracellular freezing injuries of Mycoplasma spp. This study should provide veterinarians and farmers with knowledge on designing appropriate procedures to keep milk samples for detection of Mycoplasma mastitis.

Materials and Methods:
Three different regimens of freezing conditions were used to compare the recoverability of Mycoplasma spp isolates after four fixed time periods (2, 4, 6 and 12 weeks). Samples were collected from a single dairy farm in Mount Gambier, South Australia. After culture and PCR confirmation of the Mycoplasma spp isolates, thirty of Mycoplasma-positive milk samples have been selected for testing the recovery after freezing. Each of these samples was aliquoted into twelve (0.5 mL) Eppendorf tubes for each experiment. The first experiment was carried out using 40% of glycerol, 10% Dimethyl Sulphoxide (DMSO) and 50% (v-v) of 10 days Mycoplasma-culture broth. Similarly, Foetal Bovine Serum (FBS) was used in the second experiment instead of glycerol at 40% concentration in addition to 10% DMSO and 50% of the Mycoplasma-positive culture. Samples from the first and second experiments were stored in -80°C freezer. Freezing of the raw milk samples at -20°C in non-self-defrosting freezer was used as the third freezing method. After thawing at ambient temperature, 250 μL of each aliquot were cultured at the specified periods and growth on Mycoplasma-specific media plates was recorded.

Results and Discussion:
Results have shown variable Mycoplasma recoverability after freezing. Mycoplasma spp survived well in glycerol and DMSO enriched milk samples with 100.0%, 96.3%, 88.9% and 74.1% for weeks 2, 4, 6 and 12, respectively. The combination of FBS and DMSO has shown lesser survival with 77.8%, 66.7%, 48.2% and 40.7% recovery for weeks 2, 4, 6 and 12 respectively at -80°C. The lowest recoveries were observed in original milk samples frozen at -20°C with 74.1%, 66.7%, 51.9% and 48.2% recovery for the same periods of assessment. Mycoplasma spp. are highly fastidious pathogens and their survivability during storage is often affected by other bacterial growth or pH alteration of milk. Additionally, they are highly susceptible to injuries by freezing and thawing. We hypothesise that optimum survivability in freezing compound containing DMSO was due to prevention of the cell damage. Glycerol has a similar role in cryopreservation that likely results from binding the hydrogen-hydrogen bonds
of water intracellularly. In addition, glycerol has likely contributed by inhibition of other bacterial growth due to its bacteriostatic.

**Conclusions:**
Unless using fresh milk samples, a combination of glycerol and DMSO was found as the best cryoprotectant for recovery of *Mycoplasma* spp in bovine milk samples. Results of this study may contribute to overcome the survival challenges of *Mycoplasmas* due to their fastidiousness. Additionally, this methodology can be used for long distance transport of microbiological milk samples. For farmers and veterinarians, storage of milk samples in -20°C may require addition of glycerol and DMSO.
Beyond consumer defined welfare – paddock based egg production

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Summary

This paper describes the re-emergence and ongoing development of paddock based egg production systems in response to consumer demand and willingness to pay a premium for the credence values attributed to these eggs, including perceived higher welfare. Paddock based farms make up a high proportion of free range enterprises and are thus a significant part of the layer industry, and continue to grow in number and scale. While these systems meet the expectations of some consumers they produce challenges to welfare and animal health, environmental management, productivity and profitability, and require adaptation, innovation and specialist management.

Introduction

Demand for free range eggs has increased significantly in recent years, and consumers are willing to pay more for this attribute. In response the Australian layer industry has transitioned to include outdoor production, which in 2011 included 75% of NSW farms being free range (NSW Food Authority 2013).

Free range farms in Australia include two primary types: (i) fixed shedding, where birds have access to the outdoors and (ii) paddock based, with moveable housing structures.

Some consumers perceive paddock based free range systems as providing higher welfare (based on the ability of animals to exhibit natural behaviours) and other credence values attributed to this type of production. Eggs produced in this way are a differentiated product category, which is important in positioning paddock produced eggs in the free range and broader market.

However, consumers typically have little other knowledge or concern for the challenges of managing bird welfare in an outdoor uncontrolled environment.

Meeting demand

The number of paddock based free range egg enterprises has expanded rapidly in Australia in recent years, and continues to grow. It is estimated that for NSW in 2016 about two thirds of free range farms are paddock based, supplying approximately 5% of the free range egg market.

The ability to meet consumer demand is determined by (i) willingness of some consumers to pay a premium for eggs produced in systems with attributes that they value providing the opportunity for paddock based egg farms, and (ii) the ability of the biological system to be able to accommodate outdoor production.

Beyond the important factor of meeting consumer demand, farmers adopt these systems for reasons aligned to those identified by consumers; bird welfare, and to produce better quality product (Ruhnke et al., 2015).

Paddock based poultry egg enterprises

These systems typically involve mobile sheds incorporating the laying facilities and hen housing within the structures which are moved in a rotation to provide birds with access to fresh paddock areas. The actual structures used vary widely, from converted buses and caravans, makeshift sheds on skids to purpose built facilities.

Compared to conventional farms with fixed shedding, the paddock based flocks are small with production from only a few hundred eggs per day to the largest farms with up to 10,000 eggs per day.

As a niche product, eggs produced in these systems are not sold to conventional egg markets. The eggs are sold via direct sales to customers, farmers markets, online marketing, and through food service and speciality retail outlets, including cafes, butchers and whole food stores.

Challenges

Paddock based free range egg production systems experience challenges that are both similar and different to other sectors of the egg industry. These include maintaining production supply, capital for investment in improvements, access to relevant information and technology pertaining to outdoor systems, and an understanding of production requirements including food safety, nutrition, housing, environmental management and animal health and welfare.

Significantly, the adoption of paddock based housing reduces production efficiency due to the scale of production and characteristics of the system. An example of this is the difficulty in introducing automation in egg collection and handling. In NSW 77% of businesses collect eggs by hand and 89% grade eggs by hand (NSW Food Authority 2013) which adds cost and limits performance.

Business risk is also high due to potential for loss of markets as a result of the inability to provide a steady supply of eggs, related to flock replacement, season and climatic influences and unplanned production losses related to health and disease issues.

Additionally, paddock based free range layer hens are subject to challenges that are difficult to mitigate in outdoor systems, and thus have higher mortality and lower production performance than birds in conventional layer systems. Major causes of mortality in free range systems are heat stress (37%), predation (42%), cannibalism (37%) and impaction (21%) (Ruhnke et al., 2015).

Productivity and profitability – NSW Farms

Small scale paddock based layer farms offer an opportunity to start a business at entry level, with relatively low
establishment costs, easy market access, and immediate cash flow. With low barriers to entry, the rate of new industry entrants is relatively high, including some with little or no poultry or egg industry experience. Many farms start with flocks of 500 birds and limited capital investment to trial their business strategy, with approximately 40% of free range egg farms producing less than 1000 eggs per day (NSW Food Authority 2013). Facilities vary widely, but may include a converted caravan or modified shed on sleds with hand built nesting boxes, and the practice of hand feeding and watering common. However the rate of closure of these small, basic farms within 1-2 production cycles is considerable. Poor knowledge of stockmanship and animal health management, inability to manage the complexity of the system, low productivity, and very high continuous workload over an extended period (associated with lack of capital investment and inability to pay for outsourced labour and pass on the additional cost) are major factors associated with business closure.

While these farms produce an insignificant proportion of the State’s daily egg production (less than 0.001%) the reasons for their lack of success are important in understanding that simply meeting consumer perception of a higher welfare product is not adequate to ensure animal welfare or business success.

To gain productivity and profitability farms expand, growing to produce 1000 to 10,000 eggs per day. In 2011, 31% of NSW free range farms were in this category (NSW Food Authority 2013). These farms are geographically dispersed, although typically located within 2 hours of major market centres. However despite the impact of climate on free range production systems there is little evidence of this consideration in farm location. Paddock based farms are located across the range of NSW climatic zones, with some flocks experiencing both snow and temperatures above 40 °C, despite both extremes being associated with welfare and productivity challenges.

While farms typically act individually there is evidence of some group production and interest in marketing alliances to increase marketing opportunities and improve continuity of egg supply to the marketplace. Such schemes benefit new industry entrants and are similar to the integrator model that operates throughout the commercial poultry industry.

Successful paddock based farms are not a resurrection of small farms that were common in the mid twentieth century, but a modern version having adopted technologies such as roll-away nest boxes, solar power, electric fencing, low cost plastic pipes, and improved housing design. The success of these farms also involves the application of practices of the wider industry including bird genetics, vaccination, nutrition and food safety.

However, farmers report much trial and error and the need to adapt and develop production methods and equipment. Productivity improvements are constrained by the limited knowledge of appropriate systems and techniques.

Further advances in housing design, health and disease management are needed to improve bird welfare and survival, notably in relation to bird cooling, biosecurity risk management and range management.

Additionally, lowering production costs per egg is difficult due to the scale and characteristics of the production system. Profitability requires a premium price for eggs. In 2015 the price of eggs ranged between $4.70 and $10.70 per dozen (750 grams) (CHOICE 2015) which farms report as being adequate and necessary to cover higher costs of production.

**Conclusion**

Paddock based egg production systems have proliferated in recent years in number and size in response to consumer demand. While many consumers consider these systems as higher welfare, and are willing to pay a premium for this attribute and other credence values, they have little knowledge of the challenges inherent in the production system, including to bird welfare.

Free range farmers need to have excellent knowledge of stockmanship and animal health to manage the complexity of outdoor production systems. Success of these farms is related to adoption of new technologies and practices adapted from the larger commercial intensive industry. It is problematic that these complex and difficult production systems are often managed by those with the least poultry experience who lack the support networks to assist in building their skills base.

While there is evidence of adoption and adaptation to overcome the challenges of these systems, further research, development and education is required to improve understanding of management and mitigation options for key risks and issues.

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CHOICE (2015)

Barley grain supplementation in late gestation to improve lamb survival in twin-bearing Merino ewes grazing pasture of high biomass and quality

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Introduction
Survival of lambs to weaning influences the productivity of Merino enterprises, with up to 34% of lambs born as twins dying prior to marking (Hatcher et al. 2009) leading to reduced welfare and profits for the producer. Previous studies have focused on the ability of grains to increase colostrum production, which has the ability to increase passive immunity transfer to the lamb following birth, increasing survival. To determine whether lamb survival to marking was increased by this method when grazing abundant pasture, naturally joined twin-bearing Merino ewes (n=240) were supplemented with barley grain in the last two weeks of gestation and first two weeks of lambing. Lamb survival (81%) was similar in supplemented and control treatments. This study indicates that when large quantities of quality pasture are available there may be no increase in the survival of twin-born lambs due to barley grain supplementation of ewes.

Materials and Methods
The experiment was conducted at Peak Hill, New South Wales from 28 June 2015 to 2 September 2015. There were two treatments (1) Barley grain fed at 550g/hd/day per ewe for two weeks prior and two weeks into lambing and (2) control with no supplement. Two replicates of each treatment were used, in a randomised block design. Two paddocks were subdivided to give plot sizes of 16 hectares (replicate 1) or 32.5 hectares (replicate 2). All plots contained a mixture of grasses, clover and lucerne. Twin-bearing Merino ewes which had been joined with Merino rams from 17 February 2015 for seven weeks were tagged, weighed and sex and mother recorded. Ewes were randomly allocated to groups 33 days prior to lambing. They were weighed and BCS, while lambs were weighed.

Lambing commenced 18 July 2015 and finished 27 August 2015. The ewes were checked twice daily and lambs were tagged, weighed and sex and mother recorded. Ewes were given a Maternal Behaviour Score (Dwyer et al. 2003) as per Table 1. Six days following the last lamb being born ewes were weighed and BCS, while lambs were weighed.

Table 1. Maternal Behaviour scoring system. (source: Dwyer et al. 2003)

<table>
<thead>
<tr>
<th>Ewe Behaviour</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ewe flees as person approaches, has no interest in lambs and does not return</td>
<td>1</td>
</tr>
<tr>
<td>Ewe retreats further than 10 m as person approaches, and returns as human retreats</td>
<td>2</td>
</tr>
<tr>
<td>Ewe retreats 5-10 m as person approaches, and comes back to lambs as person retreats</td>
<td>3</td>
</tr>
<tr>
<td>Ewe retreats less than 5 m as person approaches</td>
<td>4</td>
</tr>
<tr>
<td>Ewe stays close to the person during tagging</td>
<td>5</td>
</tr>
</tbody>
</table>

Pasture biomass was visually assessed (Haydock and Shaw 1975) ten days prior to lambing. Herbage pluck samples and the barley grain were analysed to determine the crude protein, dry matter digestibility and metabolisable energy.

Statistical analysis
Data for 222 ewes and their 444 lambs was available for analysis. Data was analysed using Genstat® 16th edition (VSN International, 2013). Pasture data and sheep data other than survival was analysed using linear mixed modelling with treatment x sex, where appropriate, as the fixed effect and replicate as the random effect. This data is presented as means ± sem. Lamb survival data was analysed using generalised linear mixed modelling using a binomial distribution with logit transformations, with treatment x sex as the fixed and replicate as the random effect.

Results
Live pasture biomass was 1712 ± 63.9 kg/ha in both treatments (P>0.05). The crude protein (18.5 ± 4.49%), dry matter digestibility (59.8 ± 2.3%) and metabolisable energy (17.3 ± 0.7 MJ/kg DM) were all significantly increased (P<0.05) in the supplemented treatments. Lamb survival (81%) was similar in supplemented and control treatments. This study indicates that when large quantities of quality pasture are available there may be no increase in the survival of twin-born lambs due to barley grain supplementation of ewes.
matter digestibility (76 ± 1.9%) and ME (control 12.3 ± 0.38 and barley 12.4 ± 0.38 MJ/kg DM) content of live herbage was similar (P>0.05) between treatments. The barley grain contained 10% protein and 12.3 MJ ME/kg DM.

The pre-lambing weight (65 ± 0.6 kg), post-lambing weight (76 ± 1.0 kg) and weight gain of ewes over the lambing period (10.5 ± 1.03 kg and 10.8 ± 1.03 kg for control and barley, respectively) was similar (P>0.05) between treatments. Ewe condition did not differ (P>0.05) between treatments pre-lambing (3.0 or 3.1 ± 0.07) or post-lambing (3.5 ± 0.15), and the gain in condition over the lambing period (0.5 ± 0.1) was similar.

The proportion survival of lambs to marking was similar between treatments (0.81, P=0.898) but there was an interaction between treatment and sex (Table 2). The average birthweight of lambs (5.4 ± 0.07 kg) was similar (P=0.501) in both treatments.

Table 2. Mean proportion lamb survival and mean (± sem) marking weight (kg) for male and female lambs in different treatments.

<table>
<thead>
<tr>
<th></th>
<th>Control Male</th>
<th>Control Female</th>
<th>Barley Male</th>
<th>Barley Female</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival</td>
<td>0.75 a</td>
<td>0.86 b</td>
<td>0.83 ab</td>
<td>0.79 ab</td>
<td>0.039</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>15.7 ± 1.50</td>
<td>± 16.5 ± 13.7 ± 0.023</td>
<td>0.71 bc</td>
<td>0.72 b</td>
<td>0.70 c</td>
</tr>
</tbody>
</table>

Means within a row differ (P<0.05).

The marking weight of lambs did not significantly differ between treatments, but there was an interaction with sex as seen in Table 2. The marking weight of lambs raised as singles was higher (P=0.014) for the barley treatment (17.1 ± 0.95 kg) than the control (14.8 ± 1.07 kg), but for lambs raised as twins, marking weights were similar between treatments (14.7 ± 0.71 and 15.5 ± 0.7 kg, respectively).

The number of lambs marked per ewe was lower for ewes with a MBS of 1 (1.2 ± 0.17) compared with ewes with a MBS of 3 (1.7 ± 0.08) or more.

Discussion

Barley grain supplementation at 550g/ewe.day to unsynchronised twin bearing ewes grazing pasture of high biomass and quality in the final weeks of gestation and first two weeks of lambing did not increase lamb survival and growth when compared to control ewes. Banchero et al (2007) observed barley grain could increase colostrum production, potentially leading to higher twin lamb survival. The lack of survival response in the current study was likely due to the high quality and availability of feed, where ewes were already in good body condition and gained considerable condition over the lambing period even without supplementation. The high protein pasture may have increased bypass protein creating a lactose precursor which resulted in increased colostrum production (Hinch et al., 1996) for both treatments and similar survival. The high level of survival may have contributed to the lack of response to supplementation. Survival of twin lambs was greater than a previous study by Hatcher et al (2009) which had 66% survival compared to the observed 81% survival in this experiment. The optimal feed conditions and mild weather during lambing may have meant that not only would additional feed have little benefit, but that the levels of survival were approaching the potential achievable under extensive conditions (Hinch and Brien, 2014).

An interaction between lamb sex and supplementation of their dams on survival has not been previously reported. Future research should investigate whether the sex of the lamb may influence the efficacy of supplementation aimed at increasing colostrum to improve survival. However, the increased marking weights of single reared barley lambs is consistent with Banchero et al. (2004). The barley feeding did not allow greater growth of twin reared lambs likely due to the lush pasture conditions of this study.

The observation on MBS is consistent with previous data (Brown et al. 2015) demonstrating MBS’s effect on a ewe’s ability to rear lambs to marking.

Future work should consider whether there is a relationship between lamb survival and barley supplementation at differing levels of pasture availability. This would allow recommendations for farmers on the situations where supplementation may be cost-effective. Based on the current study, supplementation to increase lamb survival is not recommended for twin bearing Merino ewes which are in good condition and grazing abundant, quality pasture.

Acknowledgements

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References

The effect of different dietary fats on tissue fatty acid composition and growth performance of broilers

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Summary

Male broilers (n=480) were fed five different diets containing 4% (w/w) plant oils (high in saturated, n-9, n-7, n-6 or n-3 fatty acids) or beef tallow (control) for 42 days. All birds grew well without significant differences (P>0.05) among their growth parameters. Different tissues were analysed for crude fat content and fatty acid composition. The crude fat content differed between the various tissues but were similar across all dietary treatments. There were very strong positive correlations between the fatty acid composition of the diets and those of the blood, adipose tissue, breast and leg meat; the correlation was weaker for the liver and heart but complicated for the brain. N-3 showed a strong correlation in all cases. At the fat level implemented in this study, broilers grew perfectly regardless of the fat type; however, the fatty acid profile of most tissues was highly correlated to the diet.

Introduction

Chicken meat is the most consumed meat in Australia (Australian Chicken Meat Federation Inc. 2016). Normally, chicken meat is a poor source of n-3 long chain polyunsaturated fatty acids (LCPUFA) such as EPA, DPA and DHA, leading researchers to investigate approaches to increase the n-3 LCPUFA content of chicken products through feed formulation. Adding flaxseed oil containing a high level of alpha linolenic acid (ALA; a short chain n-3 polyunsaturated fatty acid) has been shown to significantly increase the n-3 LCPUFA content of chicken products (e.g. Khaled et al. 2012). However, it was not clear whether these effects related to the different fatty acid profiles of the diets (e.g. n-3 polyunsaturates vs monounsaturates and saturates), because one is liquid and the other solid at room temperature, or perhaps either a specific benefit of ALA or an absence of tallow in the feed.

Materials and Methods

One-day-old Cobb 500 male chickens (n=480) were randomly distributed into 48 pens, 10 birds in each. A complete randomised block design (8 floor pens/treatment) was equally implemented in two environmentally controlled sheds. Four liquid plant oils: flaxseed, corn, canola and macadamia, and one solid: coconut oil in addition to the control beef tallow were used. A 4% (w/w) amount of each fat was mixed with starter and finisher basal diets to make the experimental feeds. Apart from the variation in the fatty acid composition, all experimental diets were nutritionally identical and met requirements for healthy growth. With free access to both feed and water, birds were reared for 6 weeks. Growth performance indicators e.g. body weight (BW), feed intake (FI), feed conversion rate (FCR) and mortality (MORT) were determined on a weekly basis during the growing period. On day 42, 48 birds were randomly harvested (1 per pen). Tissue samples of skinless breast and leg meat, adipose, brain, liver, heart and blood (using the PUFAcoat dried blood spot (DBS) system (Liu et al. 2014)) were collected. Total lipid was extracted from feed and tissues samples (Folch et al. 1957). The gravimetric approach was used to estimate total crude lipid percentages. Fatty acid profiling was performed by transmethylation of the extracted crude lipid (Gregory et al. 2010; Tu et al. 2010) and separation of the fatty acid methyl esters by gas chromatography (GC) equipped with a flame ionisation detector (FID) (Kartikasari et al. 2012).

Results and Discussion

The fatty acids composition of the experimental diets is shown in Table 1:

| Table 1. Fatty acid composition of the six different diets.* |
|-------------|---|---|---|---|---|
| Dietary Fat | SFA | MUFA n-9 | MUFA n-7 | MUFA n-6 | PUFA n-3 | PUFA n-7 | PUFA n-9 |
| Tallow | 36.1 | 34.0 | 4.7 | 2.7 | 20.1 |
| Flaxseed | 19.1 | 25.3 | 2.2 | 29.0 | 23.6 |
| Corn | 20.5 | 29.6 | 2.5 | 44.4 |
| Canola | 17.3 | 44.4 | 3.7 | 6.6 | 27.0 |
| Macadamia | 28.9 | 24.7 | 20.6 | 2.5 | 22.2 |
| Coconut | 63.5 | 16.0 | 1.8 | 1.7 | 16.2 |

*Percentage of total fatty acids. SFA = total saturates; MUFA n-9 = total n-9 monounsaturates; MUFA n-7 = total n-7 monounsaturates; PUFA n-3 = total n-3 polyunsaturates; PUFA n-6 = total n-6 polyunsaturates

None of the main growth performance parameters including: BW, FI or FCR was found to be significantly different between the dietary treatments neither on a weekly basis nor at the end of the experiment. Mortality rates of the different treatments were low and not sufficiently powered to be compared statistically (Table 2). The crude fat content of each of the different tissues was similar across different dietary treatments, the only exception was in the brain tissue, where the corn oil...
Table 2. ANOVA summary of growth results to 40 days.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Root MSE</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bodyweight (g)</td>
<td>3367</td>
<td>123</td>
<td>ns</td>
</tr>
<tr>
<td>Food Intake (g)</td>
<td>5311</td>
<td>298</td>
<td>ns</td>
</tr>
<tr>
<td>Feed Conversion Ratio</td>
<td>1.6</td>
<td>0.07</td>
<td>ns</td>
</tr>
<tr>
<td>Mortality rate (%)</td>
<td>4.4</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

ns = not significant P>0.05; na – not analysed; Root MSE = square root of mean square error

Table 3. The tissue vs diet correlations (R) for different types of fatty acids.

<table>
<thead>
<tr>
<th>Tissue</th>
<th>SFA n-9</th>
<th>MUFA n-7</th>
<th>MUFA n-3</th>
<th>PUFA n-6</th>
<th>PUFA n-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood</td>
<td>0.98**</td>
<td>0.90*</td>
<td>0.94**</td>
<td>0.96**</td>
<td>0.91*</td>
</tr>
<tr>
<td>Breast meat</td>
<td>0.99**</td>
<td>0.98**</td>
<td>0.94**</td>
<td>1.00**</td>
<td>0.97**</td>
</tr>
<tr>
<td>Leg meat</td>
<td>1.00**</td>
<td>0.92**</td>
<td>0.94**</td>
<td>1.00**</td>
<td>0.96**</td>
</tr>
<tr>
<td>Liver</td>
<td>0.84*</td>
<td>0.58</td>
<td>0.54</td>
<td>0.96**</td>
<td>0.62</td>
</tr>
<tr>
<td>Heart</td>
<td>0.87*</td>
<td>0.58</td>
<td>0.94**</td>
<td>0.99**</td>
<td>0.84*</td>
</tr>
<tr>
<td>Brain</td>
<td>0.09</td>
<td>-0.31</td>
<td>0.78</td>
<td>0.94**</td>
<td>0.54</td>
</tr>
<tr>
<td>Adipose</td>
<td>0.99**</td>
<td>0.99**</td>
<td>0.90*</td>
<td>1.00**</td>
<td>1.00**</td>
</tr>
</tbody>
</table>

*significant P≤0.05, ** significant P≤0.01

In general, there were strong positive correlations between the fatty acid composition of the diet and the blood, adipose and meat tissues, moderate to strong for the liver and heart and it was unrelated, negatively weak, moderate or strong of the brain. Figure 1 (a and b). shows the correlation in brain and adipose tissues.

In conclusion, our results show that, at the levels used in this trial, n-3 deposition in all tissues is related to the chemical composition of the fat in the diet, but not its physical state (liquid/solid) or origin (plant/animal).

Acknowledgements

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Offering legume based pastures to sheep reduced methane emissions and increased growth rates compared with perennial ryegrass pastures in spring and summer

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Summary
We examined the potential of legume based pastures to maintain growth and reduce methane emissions in ‘maternal composite’ (predominantly Coopworth based) ewes during late spring and summer. Two hundred and forty ewes grazed perennial ryegrass, lucerne, subterranean clover or arrowleaf clover pastures for 6 weeks during late spring and early summer. Live weight gain was greater in legume based pastures than perennial ryegrass pasture. Short term methane measurements using portable accumulation chambers (PACs) during the grazing period suggested lower absolute methane emissions (i.e. g CH$_4$ per day) from sheep grazing arrowleaf and subterranean clover pasture than sheep grazing perennial ryegrass pastures. Legume based pastures may provide an option to increase growth rates and decrease methane emissions (total and emissions intensity) during a period when perennial ryegrass pastures are declining in nutritive value.

Introduction
Methane emissions intensity or the amount of methane produced per kg of product from extensive livestock systems can be reduced by increasing production efficiency. Gains in emissions intensity can be achieved through increasing live weight gain relative to the amount of feed consumed or by reducing methane emissions per kg of feed consumed whilst maintaining production. Sheep meat production systems in south western Victoria are predominantly perennial ryegrass based (Thompson et al. 2010). Pasture production is highly seasonal and declining feed quality and quantity in late spring and summer can reduce productivity. Feeding legume based pastures has been proposed as an approach to reduce methane emissions (Hammond et al. 2011), and increase growth rates during late spring and summer (Thompson et al. 2010). This study examined the potential of legume based pastures to maintain or increase growth rates of ewes and reduce methane emissions intensity compared with perennial ryegrass based pastures in late spring and summer.

Materials and Methods
Two hundred and forty maternal composite (predominantly Coopworth based) ewes (2013 born, 426 ± 27 days of age, 47 ± 3.5 kg live weight, not pregnant or lactating) were allocated to one of 4 pasture based systems, perennial ryegrass (Lolium Perenne cv. Avalon), lucerne (Medicago Sativa cv. SARDI 7 Series II), subterranean clover (Trifolium subterraneum cv. Leura) and Arrowleaf clover (Trifolium vesiculosum cv. Arrotas). Pastures (1 ha plots) were established between spring 2013 and winter 2014, at Hamilton in south west Victoria (37.7333° S, 142.0167° E). Each forage type was replicated 3 times (excluding perennial ryegrass which was replicated 6 times) with sheep grazing experimental pastures at a stocking rate of 16 ewes/ha for 6 weeks during late spring/early summer (November- December 2014). Feed on Offer (FOO) was measured weekly by cutting 10 quadrats (0.25m$^2$) ground level. Additional ‘toe-cut’ samples were taken from each plot weekly for analysis of nutritive characteristics. Nutritive characteristics of FOO were measured using near infra-red (NIR) spectroscopy for digestibility, crude protein, neutral detergent fibre, acid detergent fibre, ash and water soluble carbohydrates (DEDJTR Horsham).

Live weight and body condition score was measured weekly. Methane emissions were measured using the portable accumulation chamber (PAC) technique described by Goopy et al. (2011) with modifications. PACs were sealed using a water bath and the concentration of methane (CH$_4$), carbon dioxide (CO$_2$) and oxygen (O$_2$) was measured at 15 minute intervals for 45 minutes. The concentration of methane was measured using a laser detector (Gazomat Inspectra laser, Bischheim, France), whilst CO$_2$ and O$_2$ concentration were measured using an infra-red gas analyser (Gas Data GFM Series, Coventry, United Kingdom). Emission measurements were repeated for each sheep during weeks 5 and 6 of the experimental period. To minimise the effect of diurnal patterns on
methane emissions, the order in which an animal’s emissions were measured were analysed to account for sampling order.

Table 1. Methane emissions (g CH\(_4\)/day) considering the effects of forage type and live weight at time of measurement

<table>
<thead>
<tr>
<th>Model (fixed effect term/s)</th>
<th>R(^2)</th>
<th>Arrowleaf</th>
<th>Sub clover</th>
<th>Lucerne</th>
<th>Ryegrass</th>
<th>min</th>
<th>max</th>
<th>sed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage</td>
<td>65.5</td>
<td>22.16</td>
<td>25.77</td>
<td>27.22</td>
<td>31.02</td>
<td>1.979</td>
<td>2.292</td>
<td></td>
</tr>
<tr>
<td>Forage + LWT</td>
<td>65.8</td>
<td>22.99</td>
<td>24.92</td>
<td>27.13</td>
<td>31.14</td>
<td>1.851</td>
<td>2.145</td>
<td></td>
</tr>
</tbody>
</table>

Analysis of FOO, pasture nutritive characteristics and animal live weight was undertaken using REML with a variance-covariance structure to account for repeated measurements over time. Data was transformed (Ln(x)) where required. Finally, REML was used to fit the various methane analyses with live weight (at time of methane sampling). Variance accounted for was calculated from the estimated variance components derived using REML analysis. All statistical analyses were performed using GENSTAT (VSN International 2012).

**Results and Discussion**

Feed on offer (kg DM/ha) over the grazing period was significantly different between forage types (P<0.001). However, within forage types, there was no significant change in FOO over the grazing period. Mean FOO (±SD) over the 6 weeks of grazing period were 562 (±66.3), 1276 (±450.8), 1614 (±379.9) and 2903 (±571.6) kg DM/ha for arrowleaf clover, lucerne, sub clover and perennial ryegrass respectively. Metabolisable energy (ME) content of the forages differed between forages (P<0.001) and declined over the grazing period. Mean ME concentrations were 10.2 (±0.68), 6.8 (±1.97), 9.5 (±1.45) and 9.6 (±1.12) MJ ME/kg DM for arrowleaf clover, lucerne, sub clover and ryegrass respectively. Similarly, neutral detergent fibre (NDF) concentration was lowest in arrowleaf clover and remained lower for the duration of the experimental period (P<0.001). Mean NDF concentration ranged from 212 g/kg DM (±27.3) arrowleaf clover to 571 g/kg DM (±58.7) perennial ryegrass. Crude protein (CP) concentration ranged from 95.9 g/kg DM (±1.72) in perennial ryegrass to 192 (±1.53) g/kg DM in arrowleaf clover.

Animal live weight increased (P<0.001) over the grazing period in sheep offered all forage types and were significantly different between forage types (P<0.001). On average, sheep grazing arrowleaf clover gained 1.9 kg, lucerne 2.7 kg sub clover, 3.3 kg and ryegrass 0.6 kg and live weight over the six weeks of grazing. These effects indicate that legume based pastures may be able to support increased growth rates when compared with perennial ryegrass pasture of declining ‘quality’. However, overriding differences in FOO and potentially restricted intake (less than *ad libitum*), does not allow us to draw a definitive conclusion.

Methane emissions were significantly affected by both forage type and live weight at the time of the methane measurement. When forage type alone was fitted (Table 1) methane emissions were lowest from animals offered arrowleaf clover (22.2 g CH\(_4\)/day) and highest from animals offered perennial ryegrass (32.0 g CH\(_4\)/day). Methane emissions were consistently lowest in arrowleaf clover and sub clover treatments and highest for perennial ryegrass. When including live weight in the model into the statistical model, methane emissions were consistently lowest in animals grazing arrowleaf clover and sub clover and highest in animals grazing perennial ryegrass. These observations were consistent with Hammond et al. (2011); who observed lower methane emissions (i.e. g CH\(_4\)/day) from sheep consuming white clover compared with perennial ryegrass at moderate intake levels, however this effect was not consistent with different nutritive characteristics or intake levels.

Integration of Legume pastures offer the producer an option to increase production (ewe growth rates) and reduced emissions at a time of year when nutritive value of perennial ryegrass was diminishing. The reduced daily methane emissions in the sheep consuming legume based pastures cannot be attributed to a single factor. Differences in FOO and nutritive characteristics (ME and NDF) are likely to be driving the difference observed. Legume based pastures may provide an alternative to supplementary feeds to increase growth rates during late spring and summer, whilst reducing daily methane emissions.

**Acknowledgements**

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**References**


Is sheep meat production viable? The Spanish perspective

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Summary

Taking into account the relationship between rainfall and temperature, 64% of the Spanish territory can be classified as arid (25%) or semiarid (39%). In these areas, vegetal surface includes natural pastures and meadows (34.0%), fallows (13.4%), winter cereals for grain production (21.2%), forage crops (mainly lucerne, and winter cereals harvested as green forage; 2.6%) and woodland hills. Ruminants in these zones account for 24 million heads of which nearly 80% are sheep. In the present paper, the possibilities of integrating sheep in cropping systems are discussed, and an alternative based on the use of permanent sowed prairies (lucerne), self-sowing annuals (Wimmera ryegrass), and winter cereals (barley) will be analyzed.

Introduction

According to the Statistics Division of the Food and Agriculture Organization (FAO) of the United Nations (http://faostat3.fao.org/download/Q/QA/E), in 2014 there were 1,482,144,415 cattle (20% slaughtered for meat production), 1,209,908,142 sheep (44% slaughtered for meat production), and 1,006,785,726 goats (44% slaughtered for meat production) in the world which produced 25% of the overall meat. To this figures, Spain contributed 0.74% of the slaughtered cattle, 1.92% of the slaughtered sheep and 0.28% of the slaughtered goats, and 0.91%, 1.38% and 0.17% of the beef, sheep and goat world’s meat production, respectively. It is worth to note that, although the carcass weight for cattle slaughtered in Spain was well above that of the world’s average (261 vs. 214 kg), the opposite occurred for sheep (11.5 vs. 16.0 kg) or goats (7.4 vs. 12.3 kg), indicating that animals killed in Spain from these two species are younger, on average, than those killed in the rest of the world. This fact, obviously, has a key role in the viability of the farms.

In line with the Emberger’s (1952) climographs, 64% of the Spanish territory can be classified as arid (25%) or semiarid (39%) (http://www.aemet.es). In these areas, vegetal surface includes natural pastures and meadows (34.0%), fallows (13.4%), winter cereals for grain production (21.2%), forage crops (mainly lucerne, and winter cereals harvested as green forage; 2.6%) and woodland hills. Ruminants in these zones account for 15.4 million heads of which more than 80% are sheep (http://www.ine.es).

In 2014, the total cost per kg of lamb meat sold (5.22 €) exceeded the retail price (3.88 €/kg), which led to a negative average net margin per ewe (-4.34 €), mainly due to the cost of concentrates (106.86 €/ewe and 6.42 kg/kg sold lamb) which accounted for 28.6% of the total production costs (http://www.magrama.gob.es). In these conditions, the search for a cheaper source of feed seems compulsory for the survival, without subsidies, of the sheep meat sector in Spain.

Use of winter cereal crops as pasture

Of the total surface set aside for winter cereals production in the arid and semi-arid zones of Spain, 92.2% is not irrigated, and barley is the cereal most cultivated for small ruminant feeding in dry areas (Droushiotis 1984; http://www.ine.es). According to Arnal (2010), it is necessary to harvest at least 2200 kg of barley grain per ha to cover productions costs, whereas average production in these areas is 1500-1800 kg of barley grain per ha. In the latter case, animals can either graze the barley completely or for just a few days, allowing the recovery of the crop for grain harvest.

The evaluation of mature barley as pasture for non-pregnant, non-lactating adult sheep (47 ± 1.3 kg average live weight) has been carried out by Valiente (2004) in trials with different stocking rates (60, 120 and 180 ewes/ha) during summer. The effect of supplementation with rumen-degradable nitrogen (6 g/sheep and day as sunflower meal) was also studied. Optimal stocking rates that maximized animal production (kg sheep/ha) were estimated at 83 and 71 heads/ha (average initial biomass availability of 5000 kg dry matter (DM)/ha, including heads and stems), and 20 days of grazing, for non-supplemented and supplemented animals, respectively. Average daily gain (ADG) of 99 and 105 g/sheep were reached. The lower stocking rates and the higher weight gains in supplemented animals were probably due to the fact that nitrogen supplementation increased microbial biomass, fibre degradation and hence intake (Hoover 1986). However, the higher individual ADG in supplemented sheep did not compensate for the lower stocking rate, hence the yield in terms of kg sheep/ha was lower. If no weight change is aimed, the crop could theoretically maintain 166 and 142 ewes/ha, during 20 days of grazing, in case of no supplementation or supplementation with rumen-degradable nitrogen, respectively. As a conclusion, feeding sunflower meal to non-pregnant, non-lactating adult ewes grazing mature barley seems rather useless.

Alkane-estimated DM intake was fairly constant along the grazing period for the lowest stocking rate (60 ewes/ha), where the biomass availability was not limiting, whereas it decreased with time for the highest stocking rate (180 ewes/ha), mainly during the last five days. An interesting...
finding was that, when biomass availability was not limiting (60 ewes/ha), sheep tended to consume a “constant” diet (72% heads and 28% stems; alkane-estimated values). However, at higher stocking rates (180 ewes/ha) the animals were able to maintain this constancy for only the first few grazing days. Digestibility values (67%, on average, for DM) followed the same tendency.

With respect to the use of barley crops as winter/spring pasture in the vegetative stage, this practice is widely spread in the Mediterranean countries (Jones 1992). This use of the crops (only once a year) provides the animals with high-quality forage without giving up the harvest of the grain in summer. However, climatic, cultural and management aspects may affect both the production of green pasture and the amount of grain collected. Rainfall and winter temperatures are the main responsible for DM production (Jones 1992) which is also affected by sowing date, fertilization, time and intensity of grazing from seeding.

In non-irrigated lands, early sowing allows a higher DM production in winter, and higher grain production in summer, due to a better use of temperatures and rainfall by the plant in autumn. Regarding grazing conditions, the factors that most influence both forage production in winter and grain production in summer are the number and intensity of grazing periods and, overall, the time from seeding (Olmos 2006). This author found that when barley crop was grazed early in the year (February), the stocking rate that allowed the maximum yield (kg sheep/ha) was 44 ewes during 14 days, with ADG of 132 g/sheep and day. If no weight change is aimed, the crop could theoretically maintain 88 ewes/ha during 14 days, or 43 ewes/ha during 28 days.

Use of self-sowing annuals (Wimmera ryegrass) in combination with lucerne

Lucerne and Wimmera ryegrass (Lolium rigidum) are important resources of integrated sheep farming systems in many semi-arid areas of the world (Keli et al. 2013), but the main problem here is that the amount of protein reaching the abomasum when animals are fed different grass/legume mixtures (Janovick et al. 2005) is largely unknown, with most of the work having been carried out with silages and dairy animals (Mikolayunas et al. 2011). In the work by Keli et al. (2013), the proportion of nitrogen intake recovered as non-ammonia nitrogen in the duodenum increased with the proportion of grass in the diet, and was complete for a NH₃ concentration in the rumen below approximately 110 g/l (equivalent to a crude protein (CP) concentration of 100 g/kg digestible organic matter). This suggests that not only the plants’ CP concentration is important in determining the net transfer of ingested protein to the duodenum, but also its rate of degradation. Exploring ways of reducing it may be worthy, at least in the particular case of lucerne. Such an approach should not have any deleterious effect on efficiency of synthesis of microbial protein.

In conclusion, using permanent sowed prairies (lucerne), self-sowing annuals (Wimmera ryegrass), and winter cereals (barley) all year round would be an adequate feeding strategy for sheep in the arid and semiarid zones of Spain. It is estimated (http://www.magrama.gob.es) that using cereal crops as pasture, instead of the harvested grain, would reduce production costs by 15% of the meat retail price. In addition, a fertility return to the soil, estimated in 225 g organic matter and 8 g nitrogen per sheep and day, would have positive environmental implications. The lack of need of harvest and grain transport would add to these “green” considerations.

References

Spanish Ministry for Agriculture, Fisheries and Food http://www.magrama.gob.es
Longer distances are better for measuring flight speed in sheep
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Summary
This study investigated the repeatability and variance of flight speed measured at a range of distances from 0.5m to 2.0m in order to recommend the most suitable distance for measurement in sheep. Flight speed was repeatable across days ($R^2 = 0.88-0.97$) and within days ($R^2 = 0.54-0.66$). Residual correlations between speeds measured at the different distances were very high (>0.82), suggesting that while greater distances are better to maximise variance, shorter distances will still be adequate where necessary. Between sheep variance increased with distance of measurement so within the range of distances assessed, the greater distance is preferable. Ability to detect differences between sheep based on sex, pen and day of measurement increased with distance of measurement. These results indicate that flight speed is better measured over longer distances up to 2.0m, is highly repeatable in young lambs and phenotypic variation exists with which to discriminate between animals.

Introduction
Flight speed was developed as a measure of cattle behaviour in the late 1980s, after it was observed that agitated cattle exit the weigh crate more rapidly than their calmer counterparts (Burrow et al. 1988). The test has subsequently been used in sheep, utilising the 1.7m distance specified in the methods of the original paper describing flight speed in cattle (Burrow et al. 1988). This distance was selected for practical reasons, being slightly less than the length of a standard cattle crush, and comparative studies of other distances are lacking.

Two studies in sheep differ from the original cattle literature in their methodology. Due to practical constraints, one study used distances of 1.0m and 2.0m measured concurrently (Horton et al. 2009). They found high correlations between speeds to each distance ($r = 0.86-0.92$) and a high degree of consistency ($r = 0.46-0.65$) between repeated measures within a day regardless of distance (Horton et al. 2009). In contrast, in another study which also used distances of 1.0m and 2.0m flight speed was not at all repeatable ($r < 0.01$) (Blache and Ferguson 2005). The present study aimed to determine if the distance over which flight speed is measured is important for the variance and repeatability of flight speed.

Methods
This trial utilised four pens of 12, 10-14 week old Merino x Border Leicester lambs (total 48 lambs). Animal use was approved by the Animal Ethics Committees of the University of Adelaide and Primary Industries and Resources of South Australia. The trial was conducted over two days, one week apart. Although temperatures were similar on the two days (maximums 14 and 17°C), day 1 was clear and sunny while day 2 was overcast and raining. Lambs were moved one at a time into a sheep crate, then released, allowing the lamb to exit the crate via a route defined by two open-sided fences set parallel to each other forming a 2m long raceway. A striped scale showing 1cm delineations was attached to one fence and the flight of the lamb past this scale was video recorded. This was completed with all four pens of lambs before repeating in random order, such that all four pens were handled twice on Day 1. All pens were measured again on Day 2, but due to rain, only one pen was repeated. In total, lambs from three pens were handled three times and lambs from one pen were handled four times. The times taken for lambs to travel 0.5m, 1.0m, 1.3m, 1.7m and 2.0m were calculated from the video footage and converted to speeds (m/s) to each distance.

Analyses of flight speeds were conducted in ASReml version 3 (Gilmour et al. 2009) using a univariate model containing lamb, sex, pen, day and handler. This model was used to test significance for each of the fixed effects, in addition to the proportion of variance attributable to handlers and repeatability of flight speed within and across days. A significance threshold of $P<0.05$ was used for the fixed effects. A multivariate model with fixed effects of sex, pen and day and random effects of sheep x day and handler was fitted to flight speeds at all five distances simultaneously to obtain residual correlations between flight speed measured at different distances for a sheep on a given day for a given run.

Results
Between sheep variance both within and across days increased with distance, while residual and handler variance remained static (Figure 1). Overall there was a 27% increase in total variance across the distances measured (Table 1). Differences in handlers accounted for less than 5% of the variance in flight speed.

![Figure 1. Variance components of flight speed in sheep over five distances from 0.5m to 2.0m.](Image 305x93 to 553x238)
Repeatability both within a day (technical repeatability) and across days (biological repeatability) was very high (Table 1). Flight speeds were highly correlated across distances, with all correlations between consecutive distances >0.92 and a correlation between flight speed at 0.5m and 2.0m of 0.82.

Table 1. Repeatability ($R^2$) within and across days for flight speed measured over five distances from 0.5m to 2.0m, and residual correlations between flight speed measured at different distances for a sheep on a given day.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>0.5</th>
<th>1.0</th>
<th>1.3</th>
<th>1.7</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1 single distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total variance ($m^2/s^2$)</td>
<td>0.36</td>
<td>0.41</td>
<td>0.46</td>
<td>0.50</td>
<td>0.52</td>
</tr>
<tr>
<td>$R^2$ within Day</td>
<td>0.54</td>
<td>0.61</td>
<td>0.63</td>
<td>0.65</td>
<td>0.66</td>
</tr>
<tr>
<td>$R^2$ across Day</td>
<td>0.97</td>
<td>0.94</td>
<td>0.92</td>
<td>0.90</td>
<td>0.88</td>
</tr>
<tr>
<td>Model 2 multi-distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5m</td>
<td>0.92</td>
<td>0.88</td>
<td>0.85</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>1.0m</td>
<td>0.98</td>
<td>0.95</td>
<td>0.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3m</td>
<td></td>
<td>0.98</td>
<td>0.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7m</td>
<td></td>
<td></td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A significant effect of pen occurred at distances of 1.0m and greater, with differences in flight speed of 26-29% between pens. At distances of 1.3m and above, ewe lambs were 12-14% faster (3.2-3.3m/s ±0.14) than wether lambs (2.8-2.9m/s ±1.4). Lambs were slightly faster on the initial day of testing (3.2m/s ±0.11) compared to the second day one week later (2.9-3.0m/s ±0.12) over 1.7m and 2.0m distances.

Discussion

Flight speed was highly repeatable, a result supported by previous findings in sheep (Horton et al. 2009). The low values reported by Blache and Ferguson (2005) were likely a result of their protocol, with flight speed measured upon exit from a solid sided box after a period of visual isolation from flock mates. In contrast, exit from a weigh crate where animals are restrained, but not completely enclosed is standard practice for both cattle and sheep. The between sheep variance increased but the residual was relatively constant across distances, while both technical (within day) and biological (across day) repeatability remained high. This indicates that, within the range of distances assessed, the greater distances are preferable. Biological repeatability was very high over the period (one week), suggesting that multiple measurements on a single day would be sufficient to estimate flight speed in lambs. Greater distances have greater power to detect treatment differences, with an increase in between sheep variance from 52% at 0.5m to 56% at 2.0m. However, correlations between distances were very high, indicating that shorter distances will still be adequate where necessary, as suggested previously (Horton et al. 2009). Further work is needed to establish that this is also true in older sheep.

Variance increased with the distance of measurement. Additionally, at longer distances the ability of the test to differentiate between lambs based on pen, day of measurement and sex also increased. There were differences between days for flight speed measured at the distances of 1.7m and 2.0, with lambs travelling faster on the first day than on the second. Given the high repeatability of flight speed, this day effect would not have resulted in re-ranking of lambs; the difference between days is likely due to habituation to the testing protocol, and has been reported previously. Flight speed in cattle was also observed to decrease with successive measurements (King et al. 2006), and reductions in reactivity and fear behaviours are seen with repeated arena testing in sheep (Erhard et al. 2006). As lambs gain experience of handling, their behavioural responses adapt to their perception of the situation. Differences in the rate of this adaptation could have important consequences for the consistency of relative ranking of individuals over time.

At distances of 1.3m and greater, ewe lambs had faster flight speeds than wether lambs. This sex effect has been reported many times, with previous studies concluding that females are more fearful of restraint, humans, novelty, surprise and isolation than males (Dodd et al. 2012). While it has been suggested that females are more socially motivated than males, functional differences in the hypothalamic-pituitary-adrenal axis between sexes have also been demonstrated (Tilbrook and Clark 2006).

In conclusion, the results of this study indicate that flight speed is best measured at distances of 1.7-2.0m, although it is impossible to say based on this data whether distances greater than 2.0m may be even better. These distances maximise repeatability of the measure and show the greatest degree of between sheep variance, improving the ability of the test to detect differences between lambs.

References


Mortality in adult ewes associated with cold conditions despite moderate length wool

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Summary

The survival of Merino ewes in 8 flocks around Australia was examined in relation to weather conditions at the time of loss. Ewes with very low bodyweight or low condition score were at high risk, compared to ewes in good condition. For ewes with up to 190 days of wool growth during periods of cold weather, or when a sudden increase in chill index occurred, the risk of loss was increased 6-fold, compared with periods of warm weather or stable conditions and more than 190 days wool. Ewes with condition score <2.5 were at greatest risk of loss during these periods. Ewe losses in short wool may be reduced by weather localised weather forecasts to warn of high risk events, combined with more frequent monitoring of weight and condition.

Introduction

Sheep with low bodyweight or low condition score are at greater risk of death than those in average or better weight and condition (Kelly et al. 2014). The risk of loss of sheep in poor condition was shown to be greater in autumn and winter than in spring and summer, suggesting that these sheep are at greater risk of loss in adverse weather conditions.

Cold stress is known to be responsible for deaths in newborn lambs (Donnelly 1984) and freshly shorn sheep (Hutchinson 1966), but is not generally considered a significant cause of loss in adult sheep with more than 14 days wool. However, GPS studies (Taylor et al. 2011) have shown that sheep with more than 28 days wool will seek shelter in cold conditions suggesting that there may be adverse effects beyond the immediate post-shaer period. Sheep have an increased metabolic rate in cold weather, so those in poor body condition may also be more susceptible to other stressful events during cold periods, such as high parasite burden.

Materials and Methods

Merino ewes in the Information Nucleus Flock (INF) were included in this analysis if they were between 360 and 960 days of age. Dates of death were not recorded exactly, but were determined from the date at which records were last obtained from the ewe. Weights and condition scores were recorded at least four times a year and as a result of additional measurements at other times, the date of death could be identified within a 2 month period. Sheep were shorn once each year and other information recorded as noted previously (Fogarty et al. 2007)

Weather records were available for all eight sites for the period of these observations. A chill index was calculated using the formula used by the Bureau of Meteorology for lamb chill alerts.

\[ C = (11.7 + 3.1\sqrt{W})(40 - T) + 481 + 418(1 - e^{-0.04R}) \]

W is the average wind speed over the whole day, T is the average temperature and R is the daily rainfall.

Results

The annual rate of loss of adult ewes was 3.4% per year, over the period 360 to 960 days of age. For ewes with a weight and condition score recorded in this period, 0.56% were not present at the next recording date for those sheep, consistent with a loss over a period of 2 months.

Of the ewes with body weight less than 30kg, 8% were lost in the next 60 days, but there were very few in this category. Those 35kg and over did not have significantly increased losses. Ewes with low condition score also had a higher risk of loss, with about 1.2% losses for those with a condition score under 2.5. There was no consistent effect related to loss of weight since the previous weighing (2-3 months previously), but severe loss of condition score (more than 1 unit) was associated with losses of 2.5%.

The loss rate for ewes with less than 190 days wool, while under conditions of high chill index (>1176) or a high increase in chill index (>168) was 6.5 times greater than the loss of ewes with longer wool and low chill index (<0.001) (ignoring weight and condition). The rate of loss for ewes with only one of these risk factors was double the risk for those with neither (relative risk 2.1-2.4, p<0.05).

Table 1 shows the % ewes lost in groups subdivided by wool length (<190 days vs longer wool), weight and condition score (either weight <33.4 kg or condition score <2.5 vs above both these limits) and cold conditions (Chill index >1176 or increase in chill index >168 vs below both these limits).
Only 3 ewes in 3737 (0.08%) were lost when none of the risk factors were present. For ewes with satisfactory weight and condition the losses were only 0.32 to 0.39% for cold weather in long wool or warmer weather in shorter wool. However, losses were 1.06% for ewes in good condition in cold weather and less than 190 days wool length.

Ewes with low weight or poor condition suffered losses of 0.67% or more without other risk factors, but losses were highest (1.65%) for the ewes in poor condition, with short wool in condition of high chill index.

Examination of individual weather measures suggested that temperature had the greatest effect, followed by rain and then wind. This is consistent with their weighting in the index.

Table 1. Adult ewe losses over 2 months with short (<190 days) or long wool, low weight (<33.4kg) or low condition score (< 2.5) in cold conditions (chill index >1176 or chill increase >168) or warmer weather

<table>
<thead>
<tr>
<th>Wool</th>
<th>Wt/CS</th>
<th>Warm</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long</td>
<td>High</td>
<td>0.08% (3737)</td>
<td>0.39% (5831)</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.04% (386)</td>
<td>0.67% (297)</td>
</tr>
<tr>
<td>Short</td>
<td>High</td>
<td>0.32% (3109)</td>
<td>1.06% (5369)*</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>0.98% (205)</td>
<td>1.65% (545)*</td>
</tr>
</tbody>
</table>

*Significantly higher risk (p<0.001) than the combined group: no risk factors + short wool only + cold only.

Discussion

Adult ewes had a higher rate of loss during periods of cold weather with above average chill index. The losses were not due to very short wool immediately after shearing, but were spread over periods up to 190 days after the previous shearing. The management of these flocks required the provision of shelter during periods in which cold stress was predicted, so losses soon after shearing would not be expected in these sheep.

Losses were highest in periods during which there were large increases in the chill index from one day to the next. Some of these losses were during periods of low chill index, suggesting that sheep had acclimatised to warmer weather conditions and were stressed by sudden changes in the weather. The managers were required to provide shelter in poor weather, so the potential effects of the highest chill index may have reduced by good management in these flocks, whereas sudden changes in chill index may not have been anticipated. Losses could be reduced if sheep producers ensured that shelter was available in these situations in which they would not normally expect the sheep to require additional shelter.

It is not likely that adult ewes died of exposure, as can be the case for recently shorn sheep under severe conditions (Hutchinson 1966). However, the stress of severe weather or sudden changes in weather may have increased the susceptibility of the ewes to other conditions, such as parasites or nutritional problems, particularly if they were in below average condition, with limited fat reserves.

Weather forecasts are relatively accurate up to 7 days in advance and can be provided specifically for small regions. Although warnings of adverse weather are issued, these are only considered relevant for newborn lambs and freshly shorn sheep. The use of these forecasts could allow early warnings of adverse weather that would be more precise and better targeted than current warnings.

Sheep in poor condition may require more shelter than those in good condition, in addition to extra feed to improve their condition. Frequent monitoring of weight and condition is difficult (Brown et al. 2015), but groups of sheep could be separated on weight and condition at times when they are available for other purposes, then the groups adjusted as necessary when measurements are next available. Alternatively walk-over weighing (Brown et al. 2014) could be used to monitor individual sheep more frequently to allow action when required by forecast of inclement weather.

Acknowledgements

The Information Nucleus and associated programs were supported by the Cooperative Research Centres program of the Australian Government, Meat & Livestock Australia and Australian Wool Innovation. We thank the managers and technical staff at the research stations for the data collection.

References


Soil moisture monitoring in grazing systems assists decision-making

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Summary

In 2013, the Barossa Improved Grazing Group (BIGG) initiated a project to monitor soil moisture in grazing systems. This involved the establishment of automatic weather stations in three local pasture paddocks and represents the first time a farming systems group in Australia has demonstrated soil moisture monitoring in pastures. Through determining the plant available water (PAW) and rate of water use in these paddocks, the project highlighted how soil moisture monitoring may be used to assist producers in making grazing management decisions. In the future, BIGG plans to further develop the soil moisture and climate data being generated from the weather stations into more useable information for producers.

Background

The BIGG is a community-driven network of five livestock production and farming groups from the Barossa region in South Australia, including sheep, beef, dairy and two local Agricultural Bureaux. The group delivers and communicates innovative projects for sustainable grazing systems while promoting natural resource management (NRM) outcomes.

During 2013 and 2014, BIGG conducted a project to monitor soil moisture in grazing systems. At the heart of the project was the establishment of demonstration weather stations located in three representative pasture paddocks throughout the Barossa region (Flaxman Valley, Keyneton and Koonunga). Each weather station comprised a sub-surface capacitance probe (Figure 1a), automatic rain gauge and sensors measuring air temperature, relative humidity and wind speed, which was connected to a solar powered telemetry unit (Figure 1b). The data output was publically available in near real-time via the BIGG website (BIGG 2016).

These weather stations represent the first time a farming systems group in Australia has demonstrated soil moisture monitoring in pastures, a practice that has proven invaluable in other agricultural industries such as horticulture and cropping. The project also highlighted how soil moisture monitoring may be used to assist producers in making grazing management decisions.

Results and Discussion

The measurement of soil moisture (between 15-85cm) throughout the project allowed PAW (the total amount of water that can be accessed by the plants) to be estimated for each pasture paddock. Significant differences in PAW capacity were determined, with Flaxman Valley estimated to be able to store 112mm of water; more than double the PAW of Keyneton (47mm), while Koonunga’s was 75mm.

The PAW value, combined with an understanding of the rate which plants use the available water is critical for decision-making. To illustrate the rate of PAW use in each paddock, the available soil water capacity was graphed from the point of soil saturation (July) until near depletion (November) in 2014 (Figure 2).

The rapid use of water after August reflected the very dry spring experienced in the Barossa region, with PAW significantly exhausted by October (particularly Keyneton and Koonunga). This coupled with the dry outlook for the remainder of spring gave local producers strong reason to critically evaluate their livestock numbers and possibly sell them given the anticipated reduced pasture production. Alternatively if producers wanted to maintain their stock numbers, this information gave them an ‘early signal’ to seek agistment or buy in supplementary feed (given fodder tends to be more expensive if purchased later in dry periods).

Figure 1a and 1b. The demonstration weather stations established for the project included a sub-surface capacitance probe measuring soil moisture (1a) and associated equipment measuring rainfall, air temperature, relative humidity and wind speed (1b). (Photos: B Nietschke).

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An extension to using soil moisture information to assist decision making in dry periods, is the implementation of seasonal trigger points, whereby if soil moisture levels are not at desired levels by a pre-determined date(s), an action is ‘triggered’ to destock. The adoption of an exit strategy in this manner therefore helps producers take a proactive approach to destocking and also improves NRM outcomes by destocking before groundcover levels are compromised.

Alternatively if soil moisture levels were known to be ‘above average’ throughout the year, producers could use this as an opportunity to buy in stock (in the knowledge there is sufficient moisture available to produce enough pasture for the purchased stock) or sow pasture feed (in the knowledge there is sufficient moisture available to produce adequate production for grazing).

Future plans

Funding has been recently secured from Natural Resources Adelaide and Mt Lofty Ranges to continue the operation and web hosting of the weather stations until 2018. In the future BIGG would like to develop the soil moisture and climate data being generated from the weather stations into more useable information for producers, specifically pasture growth.

The use of current climate outlooks and recent weather measurements may be used to measure pasture growth rates (Rawnsley et al. 2015). BIGG plans to link its weather station data with weather forecasting and localised pasture monitoring information (either determined in paddock or via Pasture from Space) to model pasture growth. This tool could then be used by producers to predict pasture production for feed budgeting and stocking rates decisions.

Other applications of the climate data generated from the weather stations are to link it with forecast data to predict conditions of livestock chill and heat risk, and sheep blowfly risk.

References


Acknowledgements

This project was funded through the federal governments 2013-14 Caring for our Country Community Landcare Grant and by Natural Resources Adelaide and Mt Lofty Ranges. In addition, numerous industry stakeholders donated equipment for the weather stations and provided in-kind technical assistance, particularly Peter Toome from TOIP Pty Ltd.

BIGG is also grateful for the landowner’s assistance where the demonstration weather stations were established: Michael Evans (Flaxman Valley), Graham Keynes (Keyneton) and Peter and Andrew Kleinig (Koonunga).
Turning dual-purpose wheat into meat: comparison of Merino and White Dorper maternal systems on a mixed-farming feedbase

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Summary
White Dorper ewes joined to White Dorper rams, White Dorper ewes joined to White Suffolk rams and Merino ewes joined to White Suffolk rams grazed dual-purpose wheat during lambing from 27 June and a lucerne and clover pasture from 14 August to weaning on 2 October in a replicated experiment in 2013 at Wagga Wagga, NSW. The feed on offer at the commencement of grazing the wheat crop was low (mean 330 kg DM/ha) but increased during the experiment. Liveweight and body condition score of White Dorper ewes was significantly greater than Merino ewes throughout the experiment. Weaning weight of White Suffolk x Dorper lambs was significantly higher than other lamb genotypes in this study.

Introduction
Grazing late-pregnant and lactating ewes on dual-purpose wheat may be an effective strategy to reduce the impact of the winter feed gap in the mixed farming systems of southern Australia. This study sought to identify the advantages for meat production of utilising dual-purpose wheat for grazing by lambing ewes. The strong prices for lambs over the past decade has resulted in a focus on meat production in these systems compared to traditional a focus on wool production.

Non-wool breeds such as Dorpers and White Dorpers have increased in popularity in Australia since their introduction in 1996 (Kilminster and Greeff 2011), due to no requirement for shearing and crutching and hardiness in rangeland systems (Knights 2010). Little is known about the relative performance of Dorper sheep when grazing a high-quality feedbase that includes dual-purpose crops and lucerne, which is common in the mixed-farming systems of southern NSW.

Materials and Methods
Dual-purpose wheat (cv. EGA Wedgetail) was sown on 18 April 2013 into 9 x 0.93 hectare plots on the Charles Sturt University farm at Wagga Wagga, NSW. Emergence and initial growth rates were slow, and plots were spread with urea on 11 June at a rate of 80 kg/ha to boost production prior to grazing.

White Dorper (Dorper) and Merino ewes were joined for 35 days from 6 February 2013. Forty Merino ewes (born 2008) and 35 Dorper ewes (born 2011) were joined to three White Suffolk rams, and 35 Dorper ewes were joined to two White Dorper rams.

Ewes were weighed, body condition scored and allocated onto grazing wheat plots on 27 June, with three treatments (Dorper ewes joined to Dorper rams [DD], Dorper ewes joined to White Suffolk rams [WSD] and Merino ewes joined to White Suffolk rams [WSM]; genotypes grazing separate plots) and three replicates. Nine ewes were allocated to each plot (stocking rate 10 ewes/ha) based on mid-pregnancy scanning data; three single bearing ewes and six twin-bearing ewes per plot (with exception of one Merino replicate which contained 4 single-bearing ewes due to insufficient twin-bearing ewes available). The dry matter availability at the commencement of grazing was low (Table 1) and ewes were provided pellets at a rate of 0.5 kg/hd on 27 June, 1 July and 3 July (1.5 kg/hd total) to assist transition to wheat and to minimise the risk of pregnancy toxaemia. Mineral supplement was also supplied (magnesium oxide, lime and salt in a 2:2:1 mix) at an initial allowance of 0.025 kg/hd.day. One ewe died following lambing while grazing wheat (Dorper) and was replaced by a Dorper ewe with a single lamb (data not included in analysis), and one recumbent ewe (Dorper) was injected with Calcigol Plus and subsequently recovered.

Lambing commenced on 1 July. All lambs were weighed and tagged within 24 hours of birth, and dead lambs were recorded and removed from the site. The last lamb was born on 29 July and only one ewe failed to lamb. Lambs were marked within two weeks of birth. On 14 August, ewes and lambs were moved to lucerne and clover pasture that had been subdivided into 9 x 2.2 ha plots. Replicates were maintained as per the wheat grazing phase. Ewes and lambs were weighed and ewe BCS recorded at the end of grazing the crop and at weaning on 2 October.

Feed on offer (FOO; kg DM/ha) was measured fortnightly using the technique of Haydock and Shaw (1975). Pluck samples were collected from wheat plots on 9 July and 2 August and from lucerne/clover plots on 29 August and 27 September and tested by in a commercial lab by NIR spectroscopy to estimate diet quality.

Statistical analysis
Data were analysed using linear mixed models with random effects of replicate/plot and ewe, lamb and date included where required. Treatment (genotype) and birth status (single- or twin-born) and interactions were tested in fixed effects, and lamb sex also tested as a covariate and included when significant.

Results
The feed on offer at the commencement of grazing wheat was low but increased during the wheat grazing period (Table 1). Feed availability was high during the period when sheep grazed the lucerne and clover pasture and would not be considered to be at a level that could restrict intake. Differences in feed on offer did not differ significantly between genotypes at the conclusion of grazing.

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There was no interaction of nutritive value of forage with plots grazed by the different sheep genotypes, and digestibility and crude protein content of diets of ewes grazing wheat or lucerne/clover were high (data not shown).

Body condition score (BCS) of White Dorper ewes was significantly higher than Merino ewes from the start of crop grazing until end of crop grazing (3.5 v. 2.9; \( P<0.001 \)) and there was no breed x date interaction. Mean BCS of ewes was slightly higher at the end of grazing the crop compared to at the start (3.2 v. 3.1; \( P=0.042 \)). Liveweight of White Dorper ewes was significantly heavier than Merino ewes (81.2 v. 75.2 kg; \( P=0.009 \)) and liveweight of ewes were heavier at the start compared to the end of grazing crops (81.3 v. 75.1 kg; \( P<0.001 \)) associated with ewes giving birth during this period.

Single-born lambs had higher birth weights than twin-born lambs (5.5 v. 4.6kg; \( P<0.001 \)) and Dorper lambs had significantly lighter birth weights than other genotypes (Table 2; \( P=0.012 \)), and there was no genotype*birth status interaction. Genotype*birth status was significant (\( P=0.039 \)) for the survival of lambs to weaning with the percentage of single-born Dorper lambs surviving being lower than other genotypes (Table 2), although this was only based on a small number of Dorper lambs (\( n=8 \)).

Single-born lambs were heavier than twin-born lambs at weaning (39.8 v. 35.0kg; \( P<0.001 \)) and the difference in weaning weight between twin-born lambs raised as singles or twins was not significant. Age at weaning was also a significant covariate (\( P=0.005 \)). WSD lambs were significantly heavier at weaning than Dorper or WSM lambs (\( P<0.001 \)) compared to the end of grazing the crop (81.3 v. 75.1 kg; \( P=0.009 \)). Liveweight of White Dorper ewes was significantly higher than Merino ewes (81.2 v. 75.2 kg; \( P=0.009 \)) and liveweight of ewes was heavier at the start compared to the end of grazing crops (81.3 v. 75.1 kg; \( P<0.001 \)) associated with ewes giving birth during this period.

**Table 1. Feed on offer (t DM/ha) of wheat and lucerne/clover pasture**

<table>
<thead>
<tr>
<th></th>
<th>28 Jun</th>
<th>10 Jul</th>
<th>23 Jul</th>
<th>1 Aug</th>
<th>14 Aug</th>
<th>s.e.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wheat</strong></td>
<td>0.33</td>
<td>0.35</td>
<td>0.48</td>
<td>0.71</td>
<td>0.64</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Lucerne/ clover</strong></td>
<td>2.39</td>
<td>2.86</td>
<td>4.94</td>
<td>4.40</td>
<td>0.04</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Comparison of lamb data for different maternal systems**

<table>
<thead>
<tr>
<th></th>
<th>DD</th>
<th>WSD</th>
<th>WSM</th>
<th>s.e.d.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Birth weight (kg)</strong></td>
<td>4.7</td>
<td>5.2</td>
<td>5.2</td>
<td>0.2</td>
<td>0.012</td>
</tr>
<tr>
<td><strong>Survival to weaning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>single-born</td>
<td>0.38</td>
<td>0.78</td>
<td>0.90</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>twin-born</td>
<td>0.88</td>
<td>0.81</td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weaning weight (kg)</strong></td>
<td>35.4</td>
<td>40.3</td>
<td>36.4</td>
<td>1.0</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Lamb production systems from non-wool breeds need to produce more meat per hectare to achieve returns commensurate with Merino-based systems. In the current study, weaning weights of WSM lambs did not differ significantly to White Dorper lambs (Table 2). Although such studies are limited by the genetic potential of the livestock used, the higher weaning weights of WSD lambs compared to both Dorper and WSM lambs suggests that using a terminal sire over White Dorper ewes may be a method of increasing lamb production from non-wool maternal systems.

**Acknowledgement**

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**References**


Thermo-alkaline Degradation of Hepatotoxic Indospicine in Camel Meat

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Summary

Dog deaths have been recorded from the consumption of Australian camel meat and horse meat contaminated with indospicine, a hepatotoxic amino acid that accumulates in meat of animals grazing *Indigofera* plants. In this study, thermal degradation of indospicine was investigated under different pH conditions in both aqueous solution and in contaminated meat. Aqueous solutions with either indospicine or indospicine-contaminated camel meat were autoclaved for 0–60 min with and without inclusion of food-grade additives, either 0.05% acetic acid or 0.05% sodium bicarbonate. Indospicine in sodium bicarbonate solution demonstrated the greatest breakdown with total degradation after 15 min autoclaving. Similar thermal treatment of sodium bicarbonate treated indospicine-contaminated camel meat produced 50% degradation after 15 min autoclaving and 87% degradation after 60 min autoclaving. The results suggest that alkaline conditions during autoclaving have the capacity to reduce indospicine contamination in camel meat, and could potentially be used to degrade indospicine in indospicine-contaminated meat.

Introduction

Indospicine is a hepatotoxic analogue of arginine found only in *Indigofera* plants and in Australia, Birdsville indigo (*I. linnaei*) and creeping indigo (*I. spicata*) are known to contain high levels of this toxin (Fletcher et al. 2014; Oxedryver et al. 2013). Dogs are particularly sensitive to indospicine, and while they do not themselves consume the plant, dogs have been poisoned indirectly through the consumption of indospicine-contaminated meat from horses and camels grazing in regions where *I. linnaei* is common (FitzGerald et al. 2011; Hegarty et al. 1988). Despite the potential food and feed safety concerns posed by indospicine residues in camel meat, the degradation of indospicine in meat matrices has not been extensively investigated.

Materials and Methods

**Contaminated camel meat material.** Indospicine-contaminated camel meat was obtained from an exsanguinated and necropsied camel that had been fed *Indigofera spicata* in a previous subacute 32-day animal feeding trial approved by the Animal Ethics Committee of The University of Queensland (AEC Approval: SAFS/047/14/SLAI).

**Experimental design.** Replicate treatments (*n* = 2) were prepared in 50 mL conical centrifuge tubes. Indospicine (1 mL, 50 mg/L) was added separately to reverse osmosis (RO) deionised water (9 mL, pH 6.0), acetic acid (9 mL, 0.05% v/v, pH 3.4) and sodium bicarbonate (9 mL, 0.05% w/v, pH 8.8). Minced indospicine-contaminated camel meat (1 g) was added separately to RO water (10 mL, water, pH 6.0), acetic acid (10 mL, 0.05% v/v, pH 3.4) and sodium bicarbonate (10 mL, 0.05 % w/v, pH 8.8). Aqueous solutions of indospicine/indospicine-contaminated meat were heat treated with Atherton sterilizer (NDE, Brisbane, Australia) to emulate retort food processing; the samples were incubated in the sterilizer at 121 °C and 15 psi for 15, 30 and 60 min. All thermally incubated samples were cooled to ambient temperature, and acidified with 100 µL of 10% heptafluorobutyric acid (HFBA), and diluted further with 0.1% HFBA (15 mL) prior to UPLC−MS/MS analysis.

**Indospicine analysis.** Indospicine UPLC−MS/MS analysis was performed according to our previously validated method (Tan et al. 2014). Indospicine quantitation was carried out by a Waters ACQUITY UPLC system liquid chromatograph (Waters, Rydalmere, Australia) and a Waters Micromass Quattro Premier triple quadrupole mass spectrometer with an electrospray ionisation (ESI) source (Waters, Rydalmere, Australia). Synthesized indospicine (external standard, >99% pure) and D<sub>3</sub>-L-indospicine (internal standard, >99% pure) used in this study were provided by Prof James De Voss and Dr Robert Lang, The University of Queensland.

Results and Discussion

The effect of thermal treatment on pure indospicine in water varied with pH (Figure 1). Complete indospicine degradation after 15 min of autoclaving was achieved in alkaline solution (addition of 0.05% (w/v) of sodium bicarbonate in the aqueous solution with an initial pH of 8.8). In contrast to the alkaline conditions, indospicine in RO water and acetic acid remained stable; with no significant degradation even after 60 min of autoclaving.

Figure 1. Stability of pure indospicine when autoclaved in alkaline, water and acidic aqueous solutions.

Combinations of alkali and heating in degrading foodborne toxins are not uncommon, and such treatments have successfully reduced the toxicity of mycotoxin-contaminated food (Bretz et al. 2006; Humpf and Voss 2004). Our
investigations indicated that pure indospicine was highly unstable in autoclaved alkaline aqueous solution.

Thermal treatment of indospicine-contaminated meat was also dependent on pH (Figure 2). One of the risks of indospicine occurrences in meat tissue is due to its previously reported heat resistant physiochemical property (FitzGerald et al. 2011; Simpson and Hegarty 1987). Our current findings suggest that this stability is only observed under neutral and acidic conditions. Under basic conditions, approximately 50% of indospicine in the meat was degraded by autoclaving for 15 min, increasing to 87% at 60 minutes. The results of the present study demonstrate the complexities of dealing with indospicine in a meat matrix (Figure 2) as opposed to the pure indospicine solutions (Figure 1), but provide clear evidence that it is possible to degrade indospicine residue in meat when subjected to a relatively mild conditions of heat and pH.

![Figure 2. Stability of indospicine in contaminated camel meat when autoclaved in alkaline, water and acidic aqueous solutions.](image)

This is an encouraging result as sodium bicarbonate used in the preparation of alkaline solutions in the current degradation study is a common food additive utilized in meat processing and has been used to improve texture, palatability, juiciness and cooking yield of meat (Hui 2012). The indospicine degradation results measured with indospicine-contaminated camel meat samples (Figure 2) demonstrated a greater stability of indospicine when compared to similar autoclave treatment of pure indospicine solutions (Figure 1) and may in part be due to the meat matrix and effects of cooking. Changes in charges and unfolding of proteins can occur during meat cooking resulting in the shift of the isoelectric point to a higher pH (Hamm and Deatherage 1960).

The procedures utilized in this study employ procedures and chemicals much more amenable to food processing than the lengthy heating time and use of non-food grade chemicals employed in previous indospicine degradation studies (Hegarty and Pound 1970). Sodium bicarbonate is considered a legitimate additive used in postharvest handling and decontamination of certain molds and toxins in the food industry (Bullerman and Bianchini 2007). In conclusion, this study suggests that indospicine is relatively resistant to heat treatment under acidic and neutral conditions but less so under basic conditions. Current study also demonstrated that autoclave processing of indospicine contaminated camel meat with alkaline aqueous solution may reduce the risk of indospicine contamination.

Acknowledgement

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Genomic breeding values for Lean Meat Yield, Intramuscular Fat and Shear Force do not affect live lamb production traits

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10Cooperative Research Centre for Sheep Industry Innovation, Australia

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Summary

The impact of the new research breeding values (RBVs) for lean meat yield (LMY), intramuscular fat (IMF) and tenderness (SF5), was determined in 16 prime lamb production systems. Lambs were finished according to normal on-farm practices for seven lamb supply chains and processed through 13 plants in New South Wales, Victoria, Tasmania, South Australia and Western Australia. In terminal lamb production systems, there were no negative effects of RBVs for LMY, IMF, SF5 on liveweight or liveweight gain across disparate production and finishing systems. The new LMY and eating quality RBVs can be used with confidence in the prime lamb industry.

Introduction

Lamb processors and consumers are demanding increased meat and decreased fat in their purchased product, whilst maintaining lamb eating quality (Pethick et al., 2011). To meet this demand, the lamb industry has made significant genetic change in growth rate, leanness and muscling, but has not been able to efficiently manage change in eating quality (EQ) and other hard to measure traits in lamb such as lean meat yield (LMY), dressing percentage or other carcass traits due to the difficulty in measuring and selecting for these traits. The development of research breeding values (RBVs) for these hard to measure traits by the Sheep Genomics Project, the Sheep CRC and Sheep Genetics will enable the sheep industry to improve LMY and EQ of lamb simultaneously (Daetwyler et al., 2012).

The overarching purpose of the Lean Meat Yield and Eating Quality Producer Demonstration Sites (LMY & EQ PDS) was to deliver “proof of concept” for LMY and EQ attributes within major lamb supply chains by facilitating, empowering and developing a common focus and normal trading mechanisms on future key industry profit drivers along the supply chain. This brief communication reports the on-farm impacts that selection of rams for these newly generated carcass and EQ RBVs will have on on-farm profit drivers such as liveweight and growth rate. Producer Demonstration Sites (PDS) were established to demonstrate the impact RBVs for LMY and EQ, particularly intramuscular fat (IMF) and shear force (SF5), will have on lamb production in multiple environments.

Materials and Methods

Producer demonstration sites (PDS) were located in Western Australia (N=2), South Australia (N=2), Victoria (N=6), Tasmania (N=3) and New South Wales (N=3). Animal use in the project was approved by the respective organisational Animal Ethics Committees.

Commercial lamb producers prepared ewes for artificial insemination (AI) and commercial AI operators were engaged to undertake the process. Composite, Merino, White Suffolk x Merino, Corriedale, Cormo and Coopworth ewes (N=5752) were mated with semen from terminal sires (Poll Dorset and White Suffolk). Rams were selected for divergent RBVs for LMY, IMF and SF5. RBVs were calculated using single step genomic prediction that included all known genomic information from sheep with a 50K SNP test and all phenotypic information collected from the Sheep CRC Information Nucleus and Resource Flocks. Eight rams were used at each site, with one exception where only seven rams were used due to unavailable semen from one sire. A total of 86 terminal sires (39 Poll Dorset (PD); 47 White Suffolk (WS)) were used, with 24 sires (9 PD; 15 WS) used at more than one site. Sire RBVs were provided by Sheep Genetics from a run completed in September 2014, which did not contain data from the progeny in this experiment. A small blood sample was collected from the ear of each lamb at marking and sent to a commercial genotyping provider for parentage testing (sire only). Lambs were finished under commercial conditions to meet the individual producers target market and were slaughtered at 13 different processing plants.

Liveweights of the lambs (N=3457) were collected at weaning (WWT). Lambs were generally weaned at approximately 100 days of age, and two sites finished the lambs as suckers. The majority of sites collected pre-slaughter weights (PSWT) with a range in pre-weight curfew periods (TOFW; Table 1). Lambs were killed between 116 to 302 days of age. At 10 of the PDS, lambs were slaughtered on multiple dates (SLDATE), balanced for sire. Daily weight gain (ADG) was calculated from WWT to PSWT. Dressing percentage (DP) was calculated from the ratio of carcase weight and PSWT.

ASAP Animal Production 2016, Adelaide
Statistical Analysis. WWT, PSWT, ADG and DP were analysed as dependent variables in a linear mixed effects model in SAS (SAS v9.3, SAS Institute, Cary, NS, USA). The fixed effects in the model were PDS, sex, their interaction and SLDATE within PDS. As birth type (BT) was not recorded at two sites, BT within PDS was also included as a fixed effect. RBVs for LMY, IMF and SF5 were included as covariates in the model. Sire was included as the random effect.

Results
Lambs had an average WWT of 33.9kg (SD=7.61kg) across the 3690 WWT records, with a range from 9.5kg to 59.8kg at weaning (Table 1). Average PSWT was 47.5kg (SD=5.34kg) for the 2935 lambs. The ADG was 171g/d from weaning to slaughter (N=2761) and the lambs had an average DP of 46.9% (SD=3.15%; N=2341).

Table 1. Number of lambs weaned at each site with raw means (s.d.) for WWT, PSWT, ADG and DP, and age at slaughter (range of average age across slaughter dates within PDS) and time off feed and water prior to pre-slaughter weight (TOFW) at each of the PDS.

<table>
<thead>
<tr>
<th>PDS</th>
<th>N</th>
<th>WWT (kg)</th>
<th>PSWT (kg)</th>
<th>Age (d)</th>
<th>TOFW (h)</th>
<th>ADG (kg)</th>
<th>DP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>557</td>
<td>36.9</td>
<td>(5.5)</td>
<td>-</td>
<td>165</td>
<td>234</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>233</td>
<td>32.7</td>
<td>(5.6)</td>
<td>-</td>
<td>165</td>
<td>234</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>264</td>
<td>22.0</td>
<td>(3.9)</td>
<td>46.3</td>
<td>(6.4)</td>
<td>162</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>126</td>
<td>29.4</td>
<td>(3.8)</td>
<td>47.6</td>
<td>(6.1)</td>
<td>164</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>-</td>
<td>(3.9)</td>
<td>44.6</td>
<td>(3.9)</td>
<td>134</td>
<td>16-19</td>
</tr>
<tr>
<td>6</td>
<td>258</td>
<td>40.6</td>
<td>(6.1)</td>
<td>48.5</td>
<td>(4.8)</td>
<td>159</td>
<td>17-23</td>
</tr>
<tr>
<td>7</td>
<td>181</td>
<td>40.3</td>
<td>(5.3)</td>
<td>50.5</td>
<td>(4.0)</td>
<td>116</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>191</td>
<td>38.0</td>
<td>(4.9)</td>
<td>44.6</td>
<td>(4.8)</td>
<td>259</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>253</td>
<td>33.2</td>
<td>(5.3)</td>
<td>44.2</td>
<td>(6.2)</td>
<td>146</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>224</td>
<td>38.9</td>
<td>(5.3)</td>
<td>43.4</td>
<td>(4.3)</td>
<td>136</td>
<td>6</td>
</tr>
<tr>
<td>11</td>
<td>217</td>
<td>33.9</td>
<td>(5.0)</td>
<td>46.3</td>
<td>(3.4)</td>
<td>121</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>131</td>
<td>23.3</td>
<td>(3.6)</td>
<td>48.8</td>
<td>(4.6)</td>
<td>302</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>200</td>
<td>36.2</td>
<td>(5.4)</td>
<td>51.5</td>
<td>(5.4)</td>
<td>153</td>
<td>9-14</td>
</tr>
<tr>
<td>14</td>
<td>220</td>
<td>32.6</td>
<td>(4.4)</td>
<td>49.0</td>
<td>(4.7)</td>
<td>152</td>
<td>0-15</td>
</tr>
<tr>
<td>15</td>
<td>144</td>
<td>35.5</td>
<td>(4.6)</td>
<td>50.5</td>
<td>(3.7)</td>
<td>238</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>188</td>
<td>31.4</td>
<td>(4.6)</td>
<td>47.9</td>
<td>(3.1)</td>
<td>153</td>
<td>1-6</td>
</tr>
</tbody>
</table>

Sex and PDS had an effect on WWT, PSWT, ADG and DP (P<0.05; Table 2). Females were 0.8kg lighter at weaning, grew 9g/h/d slower between weaning and slaughter and were 1.4kg lighter at slaughter than males. DP of progeny from PD rams was 0.5% greater than DP of WS lambs. Lamb BT and SLDATE within site had a significant effect on WWT, PSWT, ADG and DP (P<0.001; Table 2).

Discussion
There were no negative effects found on on-farm production traits from the new RBVs in terminal sired lambs. Importantly, there was no decrease in growth rate associated with sires that have larger LMY or IMF RBVs.

Sire RBVs for LMY, SF5 or IMF were not significant covariates for WWT, PSWT or DP of the lambs (P>0.05; Table 2). RBVs for LMY and SF5 were not significant covariates for ADG (P>0.05; Table 2). However, IMF RBV was a significant covariate for ADG of weaning to slaughter (P=0.016; Table 2). A 1 unit increase in IMF RBV was associated with an additional 16 ± 7.9g/d growth in the lambs.

Table 2. Number of records analysed (N) and the probability of significance of the RBV covariates and the fixed effects in the mixed model for live animal traits.

<table>
<thead>
<tr>
<th>Trait</th>
<th>WWT</th>
<th>PSWT</th>
<th>ADG</th>
<th>DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>N records</td>
<td>2527</td>
<td>2654</td>
<td>2488</td>
<td>2316</td>
</tr>
<tr>
<td>LMY RBV</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>IMF RBV</td>
<td>n.s.</td>
<td>n.s.</td>
<td>0.044</td>
<td>n.s.</td>
</tr>
<tr>
<td>SF5 RBV</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>Sex</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>0.012</td>
<td>n.s.</td>
</tr>
<tr>
<td>PDS</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>BT (PDS)</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>SLDATE(PDS)</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
</tr>
</tbody>
</table>

Acknowledgement
The LMY & EQ PDS project was supported by Australian lamb producers through Meat & Livestock Australia. The contribution of 20 site hosts, 60 ram breeders, 9 site facilitators, 3 lamb supply chain officers, 7 supply chains, 13 processing plants, 4 slaughter measurement teams, 5 laboratories and Sheep Genetics is greatly appreciated.

References
Producer behaviour regarding animal welfare practices

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Summary

In 2011 and 2014 surveys of producers were conducted nationally on behalf of the CRC for Sheep Innovation (Sheep CRC) in order to benchmark practices and behaviours of producers in the areas of reproduction and welfare, genetics and breeding and management of parasites. This paper summarises how producers have changed their practices in these important areas during that time. Results from the surveys show that the enterprise mix, size of flocks and proportion of breeds across five regions and states and producers approaches to managing their sheep flocks with best practice have changed significantly.

Background

The CRC for Sheep Industry Innovation (Sheep CRC) was established to address the prominent industry issues for wool and sheep meat. The on-farm program ‘Sheep and their Management’ addressed key on-farm industry issues including animal welfare, reproductive efficiency and parasite control. The outcomes were for producers to have:
1. Improved Sheep Management and Decision Making
2. Improved Animal Welfare and Increased Reproductive Rates
3. Improved Parasite Control and More Effective Use of Chemicals

The evaluation of the Program assessed how sheep producers across Australia had changed their behaviours from the beginning of the extension phase of the project in 2011 to the end of the project in 2014.

Methodology

In-depth telephone surveys were undertaken to map changes in producer behaviour in 2011 and 2014. Respondents were selected if they had more than 500 sheep and were in one of the five production zones targeted by the Sheep CRC. Both surveys collected randomly-selected (stratified) responses from 1000 producers.

Production statistics

Survey respondents were asked about their sheep numbers, grazing area, primary purpose of enterprise, breeds mated and breeding strategy. This allowed us to categorise respondents into enterprise type and size, and to identify specialist breeders.

In 2014, 29% of respondents identified themselves as ‘wool’ producers (up from 27% in 2011), 27% as ‘prime lamb’ producers (up from 23%) and 44% as both ‘wool and prime lamb’ producers (down from 50%). Most notably, the proportion of prime lamb producers in the MRZ increased from 25% in 2011 to 39% in 2014.

There has been an 8% decline in the average flock size across Australia. The mean flock size reduced from 3953 to 3622 sheep per farm and the median flock size shrank from 2800 to 2500. The reduction is particularly noticeable in the HRZ where the flock size has reduced by 12%. The MRZ and CSZ flock sizes were not significantly different.

The respondents in the HRZ had the largest average sheep flock (4115 sheep) and the CSZ the smallest (3293 sheep). By state, Western Australia has the largest at 4,524 and Queensland the smallest at 2,505. The average number of sheep run in ‘wool’ and ‘wool and prime lamb’ enterprises is about 4000 while the ‘prime lamb’ producers run an average of about 2500 sheep. South Australian producers have the smallest ‘wool’ flock size but the largest ‘prime lamb’ flock size while Western Australia shows the opposite trend.

The respondents in the HRZ had the largest average sheep flock (4115 sheep) and the CSZ the smallest (3293 sheep). By state, Western Australia has the largest at 4,524 and Queensland the smallest at 2,505. The average number of sheep run in ‘wool’ and ‘wool and prime lamb’ enterprises is about 4000 while the ‘prime lamb’ producers run an average of about 2500 sheep. South Australian producers have the smallest ‘wool’ flock size but the largest ‘prime lamb’ flock size while Western Australia shows the opposite trend.

Producers were asked whether they run a commercial flock and buy rams, breed rams for own commercial flock or breed rams for sale. Multiple responses were allowed.

Victoria, 18% from Western Australia, 18% from South Australia, 3% from Tasmania and 1% from Queensland.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Rain MRZ</td>
<td>28% (22)</td>
<td>29% (28)</td>
<td>43% (50)</td>
</tr>
<tr>
<td>High winter rain HRZ</td>
<td>27% (31)</td>
<td>39% (25)</td>
<td>35% (44)</td>
</tr>
<tr>
<td>Cereal-Sheep CSZ</td>
<td>27% (24)</td>
<td>16% (19)</td>
<td>57% (57)</td>
</tr>
<tr>
<td>High Summer Rain</td>
<td>47% (43)</td>
<td>15% (12)</td>
<td>38% (46)</td>
</tr>
<tr>
<td>Med Summer Rain</td>
<td>42% (30)</td>
<td>21% (25)</td>
<td>37% (45)</td>
</tr>
<tr>
<td>Nation</td>
<td>29% (27)</td>
<td>27% (23)</td>
<td>44% (50)</td>
</tr>
</tbody>
</table>

Table 1. The proportion of producers by nominated enterprise and production zone (n=1000). The figures in parenthesis are 2011 results.
In 2014 producers were asked if they had undertaken any specific steps to improve lambing percent over the previous five years. Seventy-six per cent of producers said they had and 72% of those who said they had, “ensured that the ewes higher energy demands are met before and during lambing” and 67% said they had “protected lambing ewes from predators”.

**Parasite control**

The number of producers conducting faecal worm egg counts (FWEC) nationally, increased from 39% in 2010 to 42% in 2013 although the change was not statistically significant. Producers with a prime lamb enterprise were least likely to conduct a FWEC (also just not significant). As might be expected there were very large differences between zones. More than half of the respondents in the summer rainfall zones and the HRZ undertook FWECs but only a quarter of those in the CSZ carried out FWECs in the 12 months prior to the 2014 survey.

**Understanding of Australian Sheep Breeding Values (ASBVs) and use of genetic information in breeding choice**

In 2011, 11% of respondents use ASBVs or selection indexes to select a breeder that best matched their breeding objective. This rose to 18% in 2014. Although West Australian respondents more likely to use ASBV information or selection indexes that match their breeding objective (22%), they were also more likely to stay with their regular stud breeder (37%). However, of these, nearly 50% said they stayed with their regular stud breeder due to their performance data. Victorian producers were more likely to use a classer or agent than other states (28%).

While the proportion of respondents that chose rams based on genetic information only had not changed (6%), the proportion that chose rams with a balance of visual appeal and some genetic information such as ASBVs rose from 32% to 42%. Those producers using only visual appeal or acting only on the advice of their agent or classer was smaller.

Information on key traits that buyers were looking for such as parasite resistance and reproduction, are explored in the full report.

**Conclusion**

Australian sheep producers have made considerable headway in recent years in adopting practices that improve the health and wellbeing of their sheep. These survey results show improvement in the management of pregnant ewes, weaning rates of lambs and control of parasites. It is also clear that exposure to information on these topics through workshops and training events has had an impact on uptake of best practice.

**Acknowledgements**

This data was collected as part of the impact evaluation of the Sheep CRC. Development of the questionnaires was in collaboration with Kimbal Curtis (DAFWA), Lu Hogan, Geoff Hinch and Brown Besier (formerly of the Sheep CRC). The full report is available on the sheep CRC website (www.sheepcrc.org.au) ‘Report on the National Producers and Service Providers Surveys 2014’.
Remote monitoring for wellbeing in grazing sheep: are social behaviours useful?

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Summary

The increase in the use of electronic identification ear tags means that production traits specific to an individual sheep can be recorded and that presence, and possibly wellbeing, of individual sheep may be able to be monitored remotely. If data from monitoring systems is to be used to identify wellbeing status of individual sheep then behavioural measures recorded need to be broad in the sense of reflecting a variety of welfare and health issues. To date roll call, movement order and social networks have been assessed as potential measures of wellbeing. These measures are not ideal as identifiers of change in welfare state of grazing sheep as they do not meet the time frame or stability and repeatability requirements. Further work on a variety of other measures is underway using additional technologies such as temperature sensing microchips and video image analysis.

Background

While current methods of managing sheep health and welfare generally focus on mob-based measurements (i.e. average body condition score taken across a portion of a mob and used as a reflection of the body condition score of the whole mob), it is becoming increasingly apparent that the welfare of an individual animal is important, both from a consumer and welfare perspective. The recently endorsed Australian Animal Welfare Standards and Guidelines for Sheep (Animal Health Australia 2014) states that a “risk to welfare is the potential for a factor to affect the welfare of sheep in a way that causes pain, injury or distress to sheep...where sheep is defined as a single ovine animal”. Given this, practical, reliable methods of monitoring the welfare of an individual grazing animal without significantly increasing the labour and time inputs of the producer is desirable.

Phythian et al. (2011) has reported that indicators such as live weight, body condition, lameness, general demeanour, separation from the flock, time spent standing and rumen fill, may all be worth further investigation and scientific validation (e.g. Phythian et al. 2012; 2013) for usefulness in the welfare assessment of sheep. One of the difficulties with this type of assessment is that it can only occur at specific points in time and not as a continuous trait throughout the production cycle (Colditz et al. 2014). This paper explores some social behavioural measures that could potentially be assessed continuously and used as wellbeing indicators in a remote system monitoring individual sheep.

Measurement parameters and infrastructure

For measures to be of use to the producer they must meet several requirements. They must have a short lag time i.e. they need to appear quickly once an animal has experienced or been exposed to the welfare issue. Additionally, they will need to be broad in the sense of reflecting a variety of welfare compromises caused by illness, injury, disease or inadequate nutrition.

To monitor the welfare of individual sheep, animals must first be able to be identified individually. Currently, the most commonly used technology for this is an electronic identification ear tag (eID). This links a unique 16 digit number to each animal and it can be recorded when the animal is in proximity to an antennae (wand or panel reader). In a paddock environment a sheep would need to walk past a tag reader to have its eID recorded so much of the work being done in this program is based on the passive movement of sheep entering and exiting a controlled traffic zone (CTZ) for access to water and in doing so move past a stationary tag reader.

A variety of measures have been investigated throughout the course of this work. The results and usefulness of these will be briefly discussed.

Roll call

How accurately various equipment records all eIDs as sheep move past a static point or a ‘roll call’ was investigated. Accuracy is paramount in a system where ‘missing’ sheep (i.e. a sheep that hasn’t come to water for several days) may be cause to alert a producer and prompt a visual check. To test this one hundred Merino ewes were moved around a paddock on 13 different occasions and walked through various types of tag readers upon reaching their destination. The panel reader (a panel attached to the side of the laneway) recorded between 87 to 93% of sheep eIDs on different occasions. In contrast, a portal reader (an oval shaped reader that sheep walk through) was more accurate and collected between 95 and 100% of eIDs. Further work has been undertaken on this in a paddock setting (i.e. where sheep have free access to a CTZ) and the data appear to be less accurate in this environment. In one trial between 7 and 16% of recordings were single detections i.e. sheep were recorded only entering or exiting the CTZ. In a second trial approximately 50% of the visits appeared to be single detections. This suggests that entry and exit to the CTZ may be altered by social behaviours (milling around, blocking entry etc.).
Movement order

Anecdotal evidence suggests that sheep with health issues tend to form a ‘tail’, or lag behind, when moved between two points. If this is correct and movement order is stable then deviations in position should increase if an animal has compromised welfare. Analysing the same data collected for the roll call experiment (above) showed that the position of each ewe varied greatly between runs, except for the lead sheep who was always either in first or second position. A coefficient of variation (CV) was calculated for the position of each ewe for all the runs and was ranked into low, mid and high blocks. Kendall’s tau coefficient was -0.77 when correlating the CV against the mean position of each ewe, indicating that ewes at the back of the flock showed significantly less variation in position to those at the front (P<0.001). These results indicate that movement order was not stable across a flock and therefore may not be particularly useful when identifying deviations from normal positions.

Social network

Social networks between sheep may be another way to identify animals that are experiencing a health or welfare issue and this compromise may change social linkages within a mob. Two groups of 100 sheep (n=200) were located in a paddock where they moved into and out of the CTZ for access to water. After 20 days of recording, 60 of the 200 sheep were dosed with *Haemonchus contortus* larvae (stage L3), and movement observations continued for a further 40 days. Social networks were formed and measures of centrality showed that control sheep had a greater level of connection (higher scores) than infected sheep where ‘degree’ measured the number of direct contacts and ‘power’ measured how well connected each sheep was to all others in the group (Table 1).

Table 1. Measures of centrality in Group 1 sheep treated with internal parasites (Mean ± SE) for networks based on a separation distance of 2, 3, 4 or 5 sheep.

<table>
<thead>
<tr>
<th>Centrality Measure</th>
<th>Separation distance</th>
<th>Control (n=60)</th>
<th>Treated (n=30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree</td>
<td>2</td>
<td>3.27 ± 0.24</td>
<td>2.10 ± 0.27</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5.84 ± 0.36</td>
<td>3.97 ± 0.47</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8.69 ± 0.50</td>
<td>6.73 ± 0.74</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>12.14 ± 0.66</td>
<td>9.80 ± 0.97</td>
</tr>
<tr>
<td>Power</td>
<td>2</td>
<td>556 ± 57</td>
<td>362 ± 54</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1125 ± 81</td>
<td>718 ± 86</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1732 ± 104</td>
<td>1219 ± 149</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2436 ± 134</td>
<td>1840 ± 195</td>
</tr>
</tbody>
</table>

The treated groups were significantly different from the control in all cases.

While there appears to be an effect of infection on the social networks these data still have animals who are rarely identified in the CTZ. Video analysis of the behaviour of sheep at the entry/exit to the CTZ is currently being analysed to determine why such patterns occur and the impact of accuracy of the eID recordings on network calculations. Although social networks can be identified it appears to take at least 20-30 days of data to stabilize relationships and this is too long in a production environment where sheep mob structure can be altered regularly in line with husbandry events.

Conclusion

Neither roll call, movement order nor social networks appear to be useful identifiers of changes in welfare and health status of individual sheep. Other measures are currently being assessed including remote monitoring of temperature change (Kearton et al, this issue) and image analysis to assess acute issues such as lameness, fly strike and general illness and injury as indicated by postural/demeanour changes.

Implications

Initial measures assessed for inclusion in a continuous remote monitoring system have not been successful. Alternative measures need to be assessed if technologies are going to be successfully used to ensure producers are given the opportunity to more proactively manage their flocks and reduce the incidence and severity of any acute welfare issues as they occur, with little additional labour cost.

Acknowledgement

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The effects of heat stress on porcine oocyte maturation, fertilisation and embryo development and methods of alleviation

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Summary
During summer and early autumn, female pigs experience a decrease in fertility (seasonal infertility) (Lopes et al. 2014) which is caused by the combination of inappropriate photoperiods and elevated ambient temperatures (heat stress) (Auvigne et al. 2010). Seasonal infertility accounts for an approximate annual loss of $40 million to the pig industry, this is exacerbated by heat stress which has been reported to cost the US pig industry $450 million annually (Lewis and Bunter 2011). These numbers alone warrant further research into methods to alleviate the effects of heat stress on pigs, as this will reduce seasonal infertility effects seen annually. This project aims to alleviate the negative effects of heat stress through supplementation of antioxidants in order to reduce damaging reactive oxygen species. This will be achieved using an in vitro model that will first assess the stage of oocyte maturation and embryo development most affected by heat stress, in order to target antioxidant treatment. Thus the second experiment involves supplementation with the antioxidants, melatonin or vitamin A, in an attempt to reduce the negative impact that heat stress has on oocyte maturation and early embryo development.

Introduction
Seasonal infertility is a major economic problem within the pork industry as it greatly impairs the reproductive performance of sows (Tast et al. 2002; Bertoldo et al. 2010), with lower reproductive rates resulting in significant financial losses for the production industry (Ross et al. 2015). A 3-7% decrease in fertility has been demonstrated between the late summer and early autumn periods (Bertoldo et al. 2010). Poor sow performance as a direct result of heat stress (excluding reduced offspring growth and carcass quality) costs the USA $450 million annually. The USA livestock industry holds heat stress accountable for between 1.6 and 2.4 billion dollars in economic losses, 15% of that is associated to pigs (Lewis and Bunter 2011), however this phenomenon is a global issue affecting the United Kingdom, Spain and Australia.

Reproductive efficiency is a key driver of profitability within the pork industry and is determined by litter size and farrowing rate, with both of these reduced in sows mated during summer–early autumn (Bertoldo et al. 2010). Although understanding is incomplete, the overarching premise is that high ambient temperatures depress the reproductive axis, with photoperiod having the prominent role and heat stress exacerbating the negative effects (Auvigne et al. 2010).

Seasonal infertility most commonly manifests as delayed oestrous (both pubertal and post weaning), reduced pregnancy maintenance and low litter sizes (Bertoldo et al. 2011). It has been determined that luteinising hormone (LH) (Tast et al. 2002; Bertoldo et al. 2011) oestradiol, follicle stimulating hormone (FSH) and gonadotrophin releasing hormone (GnRH) (Armstrong et al. 1989) are all produced in lower concentrations throughout the summer-autumn period, reducing reproductive capabilities.

Photoperiod is the principal regulator of fertility in seasonal breeders (Giraldo et al. 2014), and is detected by the transmission of light from the retina, inhibiting the production of melatonin (Prunier et al. 1996). The low levels of melatonin inhibit the release of gonadotropin releasing hormone (GnRH) and this alters LH and FSH secretion (Malpaux et al. 1999 & Prunier et al. 1996). Pigs are particularly sensitive to rises in temperature because they are poor thermoregulators, as they lack functional sweat glands and have a thick layer of subcutaneous fat (Ross et al. 2015). This alone is enough to consider heat stress as a key area of focus for research. At a basic level heat stress compromises female fertility because the successful development of gametes and embryos is comprised during high ambient temperatures (Ross et al. 2015). Heat stress disrupted follicle development, oocyte maturation, embryo development and fetal growth (Fu et al. 2014).

Heat stress increases oxidative stress within cells, and this is a key factor in the failure of embryo development (Sakatani et al. 2004; Matsuzuka et al. 2005). Oxidative stress caused reactive oxygen species (ROS) to be produced. ROS carry reactive free radicals, and they react with other molecules and cells within the body, changing their natural mechanisms (Agarwal et al. 2012). When produced in excess ROS are incredibly disruptive to cellular function, causing losses to membrane integrity, induces structural changes to proteins and damage to nucleic acids (Tamura et al. 2012). Antioxidants, in particular Melatonin and Vitamin A, are able to reduce the effects of ROS.

Melatonin is recognised as a universal antioxidant because it is highly hydrophobic and hydrophilic meaning it is readily passed through almost all organs and fluids (Tamura et al.
2012). Melatonin can be transferred from the blood into the follicular fluid and its antioxidant properties allows melatonin to scavenge ROS (Tamura et al. 2012). Melatonin is also found in follicular fluid and directly influences functioning of the follicle-oocyte compartment (Cruz et al. 2014). Vitamin A is a natural retinoid that also has scavenger activity against free radicals (Ikeda et al. 2005). Vitamin A is a regulator of cell growth, cell differentiation and embryo morphogenesis and thus play a fundamental role in signalling and controlling cell proliferation (Hidalgo et al. 2005). The effects of each of these antioxidants on their ability to alleviate heat will be determined.

The primary aim of this project (to be undertaken in 2016) is to determine when heat stress has the greatest effect, during oocyte maturation or early embryo development. The secondary aim, is to determine whether supplementation of vitamin A or melatonin to the media will alleviate the impacts of heat stress. We hypothesise that heat stress will have the greatest impact during maturation of the oocyte as it has previously been shown by Kraeling and Webel (2015) that the most detrimental periods are during the first 30 days of gestation, due to a large increase in embryonic death. It is also hypothesised that melatonin and retinol will alleviate the negative effects of heat stress, because these two compounds have previously been shown to improve oocyte and embryo survival in pigs and have, to some degree, alleviated the effects of heat stress in other species.

Materials and Methods

Oocytes will be aspirated from abattoir derived ovaries and matured in vitro (IVM) for 44 hours at either 38°C (control) or 41°C (heat stress). Following IVM oocytes will be collected and stained to determine nuclear maturation: germinal vesicle, germinal vesicle breakdown, metaphase 1, anaphase to telophase and metaphase II will be assessed. The spent media will be tested for glucose consumption and lactate production and the ADP:ATP ratio of the pools of 5 oocytes will be assessed using a luminescence assay. A subset of oocytes will be assessed for polar body formation to determine the effect of heat on maturation rates.

The remaining matured oocytes will then be moved through hyaluronidase and then undergo in vitro fertilization (IVF) at either 38°C or 41°C for 6 hours. After this time the oocytes will be assessed for fertilisation based on cleavage rate. Excess sperm will be removed and the presumptive zygotes will be transferred to in vitro culture (IVC) media and incubated at either 38°C or 41°C. Blastocyst development will be assessed at day 8 and total cell counts determined using a Hoechst 33342 staining protocol. The percentage of 2 cell, morula and blastocyst formed will determined to assess the effects of heat stress on early embryo development. Following this, the stage of in vitro embryo production that is most affected by heat stress will be statistically identified and the experiment described above will be repeated with the addition of either melatonin or retinol during IVM, IVF and/or IVC.

Discussion

The current production and economic losses to pork production farmers during the summer-autumn period is the main purpose behind conducting this research. Defining the underlying causes of seasonal infertility in sows is an ongoing problem, and proof of the paramount significance of this research. Determining whether the detrimental effects of heat stress in vitro are most severe during porcine oocyte maturation, fertilisation or early embryo development, will allow a targeted on farm approach to overcoming this issue. Additionally, the research relating to the action of certain antioxidants may allow a practical method for farmers to combat the problem.

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Heart rate variability as an indicator of pig welfare

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Summary

Animal welfare has mainly been quantified in animals using behavioural or endocrinological measures. Given the importance of the nervous system in response to, and perception of, stress, a metric of neural involvement in animal welfare would significantly add to our ability to gauge an animal’s stress response. Heart rate variability (HRV), the extent of variation in the R-R interval on an ECG trace, is thought to reflect individual differences in the strength of the sympathetic versus parasympathetic arms of the autonomic nervous system. In this study, HRV was used to evaluate sow welfare in three different housing systems; individual stalls, group pens and ecoshelters. Relationships between HRV, plasma cortisol levels and injury scores were also quantified in these pigs. Group housing significantly elevated the components of HRV associated with sympathetic nervous system activity. This HRV component was associated with plasma cortisol level and injury score. HRV analysis appears to indicate an involvement of the autonomic nervous system in the stress responses of pigs to housing conditions, and may be a useful addition to the development of stress indices for pig welfare.

Introduction

Sow stalls in pig production are being phased out in Australian pig production systems, which means sows will be housed together in group pens. The welfare implications of group housing have yet to be fully evaluated. In this trial heart rate variation (HRV) was used alongside more conventional measures of welfare, namely plasma cortisol levels and injury scores, to quantify stress responses in sows under different housing systems. HRV is thought to reflect the neural responses to stressors by quantifying the relative strengths of the parasympathetic and sympathetic arms of the autonomic nervous system (von Borell et al. 2007).

Materials and Methods

In this study, fifty-four Large White X Landrace multiparous sows were used. On day zero, sows were placed into individual sow stalls and artificially inseminated. On day six, sows were moved into groups of six in partially-slated group housing pens. Sows remained in these groups until day 30 and were the moved into straw based ecoshelters (Figure 1).

Heart rate variation was recorded by placing electrocardiograph (ECG) electrodes behind each foreleg and on the chest. Prior to placing on the electrodes ( Alive Technologies) the area was cleaned using Chlorhex 0.1% and 70% ethanol. Once the electrodes were in place, Bluetooth ECG and Activity Monitors (Alive Technologies Pty Ltd, Australia) were attached using 1.8m lead wires and recording began. The electrodes were strapped to the sow using 5cm x 2.5cm Tensoplast elastic adhesive tape. Once securely in place, monitors were left on sows for a minimum of 30 minutes. Only ECG traces with greater than 5 minutes of uninterrupted recording were analysed.

Variation in the R-R interval in each QRS complex in the cardiac cycle, was measured on the ECG reading using the LabChart 7 program (ADinstruments Powerlab Systems Australia). The components of the analysis and their respective interpretations are presented in Table 1.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Indication of Heart Rate Variation (HRV)</th>
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<tbody>
<tr>
<td>RMSSD</td>
<td>Parasympathetic regulation of the heart</td>
</tr>
<tr>
<td>SDNN</td>
<td>Variation in beat-to-beat intervals</td>
</tr>
<tr>
<td>LF</td>
<td>Sympathetic activity</td>
</tr>
<tr>
<td>HF</td>
<td>Parasympathetic activity</td>
</tr>
<tr>
<td>LF/HF</td>
<td>Sympathetic/parasympathetic ratio</td>
</tr>
</tbody>
</table>

Saliva samples were collected from sows between 12:30 and 13:00 using salivates with a cable tie attached to the swab. The swab was then placed inside the mouth of the sow with as little handling as possible and moved to stimulate saliva production. Swabs were then centrifuged at 5000rpm for 20 minutes and stored at -10°C. Samples were analysed at the University of Western Australia (Animal Biology Department) using a cortisol radioimmunoassay where porcine saliva was modified by adding 75µl of buffer to 100µl of saliva. Limit of detection was 0.9nmol/L and the mean intra and inter-assay coefficients were 2.5% and 4.8%, respectively.

Injury scores were counted after saliva sample collection. The scoring system used was adapted from (Karlen et al. 2007). Specific areas including the head, neck, ears side and rump

Figure1: Timing of measurements taken from sows on day five in sow stalls, on day seven in group mixing pens and the final measure on day 70 in an ecoshelter.
were scored for injuries including scratches, fresh wounds and abscesses.

Statistical analysis was performed using SPSS 2.0 statistics program with a P value of <0.05 considered significant. A general linear model (GLM) was used to analyse HRV measures with the effect of housing design, space and social hierarchy analysed. Fixed effects in the model included replicate, sow parity, housing, space and social hierarchy. HRV measures were transformed using log transformation to normalise distribution.

Results

A significant effect of housing design on the logLF component (ms²) of the HRV was found (P<0.05). When housed in group pens, sows had increased logLF (ms²) (3.025±0.141) compared to when they were in stalls (2.338 ± 0.127) or an ecoshelter (2.468 ± 0.120) (Figure 2).

Figure 2: Log low frequency (LF) heart rate variation (ms²) for sows housed in stalls, group pens and ecoshelters. Values are log means ± SEM. Differing superscripts (a, b) represent significant difference (P < 0.05).

When sows were housed in pens they also had significantly higher salivary cortisol (P<0.05) at 18 ± 5.3 nmol/L compared to 3.2 ± 4.6 nmol/L and 5.2 ± 5.2 nmol/L in stalls and ecoshelters, respectively. As with salivary cortisol, a significant difference was found in sows in group pens, on injury score (p<0.05). When in pens, sows had higher injury scores (21 ± 4.9) than in stalls (9.1 ± 4.4) and an ecoshelter (6.8 ± 4), indicating increased fighting between sows.

Salivary cortisol levels and the logLF component of the HRV analysis were related (r = 0.51, P<0.05), as shown in Figure 3.

Figure 3: Relationship between log LF (ms²) and log salivary cortisol concentration (nmol/L) (r = 0.51, P<0.05).

Discussion

HRV analysis in pigs under different housing systems revealed a significant effect of housing on the component of the analysis (LF) thought to reflect the activity of the sympathetic arm of the autonomic nervous system (Poletto et al. 2011). This increase in sympathetic nervous control in sows when housed in groups, appears to reflect an acute stress response associated with the mixing event. Known measures of acute stress such as elevated plasma cortisol and increased injury scores were correlated with these HRV changes, presumably reflecting increased competition and fighting in a group of sows with an unfamiliar hierarchy (Seguin et al. 2006). If the LF component of the HRV analysis reflects sympathetic activity, elevated LF values would indicate increased catecholamine response, hence a neural response to acute stress. As such it may provide useful additional information to more traditional measures of stress responses such as circulating cortisol levels.

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Pre-slaughter washing increases dark cutting incidence in beef


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Summary

Dark cutting is a significant problem affecting the Australian beef industry, as meat of an inferior quality does not meet consumer expectations. This study aimed to determine the relationship between pre-slaughter hide washing and the incidence of dark cutting beef. Pasture (n=1,437) and grain-finished (n=1,447) cattle were observed at Teys Australia Naracoorte Complex from the time they arrived at the facilities until slaughter. Pre-slaughter washing treatments were recorded and their effect on the incidence of dark cutting determined using a restricted maximum likelihood linear mixed model. Dark cutting incidence in this study was 24% in pasture and 2% in grain-finished cattle. Pre-slaughter hide washing in lairage pens increased dark cutting incidence by 2% per wash (P<0.01). This study confirmed that lairage factors can increase dark cutting incidence in beef. Minimisation of unnecessary pre-slaughter washing could help mitigate this problem, reducing associated financial losses and improving animal welfare.

Introduction

Dark cutting carcasses (pH>5.7, meat colour>AUS-MEAT colour 3; McGilchrist et al. 2014) are the most significant contributors to Meat Standards Australia non-compliance (Meat and Livestock Australia 2014). Dark cutting occurs due to insufficient carcass acidification resulting from glycogen breakdown prior to slaughter, which may be initiated by stress. The causes of dark cutting are multifactorial, however there is a paucity of information on the effect of acute stress occurring during lairage, the period comprising up to 48 hours prior to slaughter, and its effect on dark cutting incidence. This study examined the effect of pre-slaughter hide washing treatments and animal behaviour in lairage on the incidence of dark cutting beef.

Materials and Methods

Data for this observational cohort study were collected from Teys Australia Naracoorte Complex during June-September 2015. Pre-slaughter hide washing treatments and animal behaviour were recorded for pasture- (n=1,437) and grain-finished (n=1,447) cattle from 62 mobs. Following unloading at the facilities cattle were held in lairage pens. Prior to slaughter, cattle moved within their mobs through a holding pen, a belly wash pen, and a forcing pen before entering the knocking box.

Animal behaviour

Animal behaviour was recorded at four points: during unloading; in lairage pens on the afternoon of arrival; in lairage pens on the morning of slaughter; and in the holding and belly wash pens prior to slaughter. Behavioural observations in lairage were made from the gantry above the lairage pen over a 15 minute period. Behavioural observations included the number of cattle vocalising and mounting within the mob. Behavioural traits were expressed as the proportion of the mob exhibiting the behaviour.

Pre-slaughter hide washing

The duration, number, and timing of washes were recorded for each mob in three categories: lairage, high-pressure hose, and belly wash. Lairage washes were those conducted in lairage pens using an in-floor sprinkler system. High-pressure hose washes included those in the holding pen and from above the belly wash and forcing pen using hand-operated high-pressure hoses. Belly washes were those using an in-floor high-pressure sprinkler system in the belly wash pen. Mobs entered the belly wash pen in groups of 19±6 (mean±SD), which formed the unit of replication for this study.

Carcass grading Data

Meat colour and pH were used to classify individual carcasses as dark cutters (pH >5.70 and/or meat colour >3) within belly wash groups.

Statistical analysis

The data were analysed using a restricted maximum likelihood linear mixed model in GenStat (GenStat, 15th Edition, VSN International, Hemel Hempstead, UK) to determine the effect of pre-slaughter hide washing on the percent of dark cutters within belly wash groups. The model included fixed effects of feed (grain, pasture), sex (heifer, steer, mixed) and their interaction. Kill day was included as a random term to allow for factors out of control of management. Significance was defined as P<0.01 as there were many variables tested. Variables or their interactions with feed that were significant were then identified and their effect on dark cutting incidence determined.

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Results and Discussion

The overall incidence of dark cutting was 13% within this study. Feed, sex and their interaction each had a highly significant effect on dark cutting incidence (P<0.001). Dark cutting incidence was higher in pasture (23.8%) than grain-finished cattle (2.1%) and pasture-finished animals accounted for 92% of affected carcasses. Females, and to a lesser extent mixed groups, had higher mean pH, meat colour, and dark cutting incidence than males.

Animals were washed using the three treatments described 2 to 13 times, which culminated in a total washing duration of 70±29 minutes (mean±SD). Each wash in lairage increased dark cutting incidence by 2% (P<0.01), but duration was not significant. There was no effect of number and duration of high-pressure hose washes and belly washes (P>0.01). Pre-slaughter washing and its relationship with meat quality has only been examined once previously; a study in sheep where a linear relationship between the number of washes and ultimate pH was reported (Petersen 1983). However, sheep in this study by Petersen were washed by swimming the length of a 1.56m bath. Thus, the high pH of sheep washed a greater number of times may have been a result of exercise induced glycogen losses. The study herein provides evidence that pre-slaughter hide washing can be a stressful event increasing dark cutting incidence.

The number and duration of high-pressure hose washes did not affect dark cutting incidence, but its potential as a source of acute stress should not be disregarded. Mounting has previously been correlated to decreased muscle glycogen and dark cutting (Kenny and Tarrant 1988). The number of mountings in the holding pen was strongly positively correlated with the number of high-pressure hose washes (r=0.46). There was no correlation between mounting occurring during unloading, the afternoon of arrival, the morning of slaughter, and the holding pen (r<0.13). The highest numbers of mountings were recorded in the holding pen. Together, this suggests that mounting occurred as a result of environment rather than mob characteristics and that high-pressure hose washing is a potential source of stress requiring further investigation.

The number of belly washes did not significantly affect dark cutting incidence (P>0.01) despite being conducted in an almost identical manner to lairage washes, with differences in the fore-mentioned treatment being smaller group sizes and a higher intensity of washing that occurred closer to slaughter. A possible explanation for the difference in significance of these similar treatments is the duration of the period between when they occurred and the time of slaughter. The time taken for lactic acid to clear muscle and enter the plasma is unknown. Glycogen breakdown resulting in lactic acid production occurring within a period not permitting clearance of lactate from the muscle will aid pH decline post mortem. Although muscle glycogen levels would resultanty be lowered, the lactate produced would remain in the muscle, increasing the rate of pH decline, thus masking the effect of the stressor and not increasing dark cutting incidence. Belly washes and other potential sources of stress, such as high-pressure hosing, conducted within such a period as described require further examination.

This research has provided evidence that dark cutting incidence is affected by environment and behaviour during all stages of lairage. Pre-slaughter hide washing was a key and novel factor investigated by this study, which has previously been shown to be ineffective in reducing carcass contamination (Biss and Hathaway 1996; Mies et al. 2004). The results indicated that washing increases dark cutting incidence in cattle and may cause changes in behaviour, such as mounting, which can also increase dark cutting incidence. At the very least, pre-slaughter hide washing should be limited to only the dirtiest mobs for the minimum time necessary to reduce visible contaminants to an acceptable level. This would help mitigate dark cutting incidence and associated financial losses to producers and processors, concurrently improving animal welfare.

Teyes Australia Naracoorte are currently reviewing their washing practices as a result of this study.

Acknowledgements

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Relevance of public attitudes to animal welfare for the pork industry.

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Summary

Concerns about livestock animal welfare are well documented worldwide. Public attitudes are often studied as indicators of risk for the livestock industries, but are less often studies in relation to the behavioural outcomes that are likely to impact on the livestock industries. This paper examines the relationships between public attitudes, and opinion leadership and self-reported pork consumption and community behaviours that are likely to impact on the sustainability of the livestock industries. While few variables predicted pork consumption and accounted for 10% of the variance, several variables predicted community behaviours and accounted for 43% of the variance in community behaviours. Opinion leaders tended to eat less pork and engaged in many more community behaviours. Together these results suggest that more needs to be done to identify the population segment of opinion leaders and to engage them in dialogue about pork production.

Introduction

While public concerns about animal welfare are well documented worldwide (e.g. Coleman, Rohlf, Toukhsati and Blache, 2015; European Commission, 2007; Gracia, 2013; Parbery & Wilkinson, 2012), the impact of these concerns for the livestock industries is unclear because there is limited evidence to directly attribute purchasing behaviour to public attitudes to animal welfare. While many consumers report thinking about animal welfare when they purchase meat and meat products (Department for Environment Food and Rural Affairs, 2011; European Commission, 2007), concerns about welfare are not the major attributes that consumers deem important in their purchasing decisions. Finally, there is accumulating evidence that public attitudes to animal welfare may be more relevant to community behaviours that impact on the livestock industries than they are to purchasing behaviour. According to Coleman and Toukhsati (2006, p.21) “community behaviour is less deliberate” (than lobbying for example) “and involves taking advantage of situational opportunities to express an attitude through action”. Further, within the community there is some evidence to suggest that opinion leaders may lead debate on social issues and provide a conduit for information from various sources to reach their social groups. Berkman and Gilson (1986) suggest that information received from opinion leaders is perceived by the public as more credible than information received from the media. There is some evidence that opinion leaders can be identified in the livestock welfare domain (Coleman et. al., 2015).

Aims

The aim in this paper is to extend the results from research reported previously (Coleman et. al., 2015), to examine the relationships between public attitudes and self-reported pork consumption and community behaviours.

Method

A total of 479 participants (228 males, 251 females) were randomly selected from all states within Australia. Participants ranged in age from 19 to 90 (M = 48.55, SD = 17.35). A questionnaire was developed using an iterative process beginning with a literature review and discussions with key industry, government and research representatives. The questionnaire assessed attitudes, behaviours to express dissatisfaction with the Australian livestock industries, the frequency with which they consumed pork, the frequency with which they accessed or distributed livestock animal welfare information and the extent to which they trusted various sources of livestock animal welfare information.

Statistical analyses

Attitudes assessed included Positive attitude towards eating meat, Positive attitude towards Australian livestock industries, Trust in the people involved in Australian livestock industries, Farm animal welfare, Attitudes towards Australian livestock industries and the environment, Approval
of livestock practices, Importance of husbandry attributes and Importance of natural living attributes. Opinion leadership was assessed using three questions about respondents’ communication activities in the community adapted from Childers (1986). Data were analysed using Pearson product-moment correlations and linear regression.

Results and discussion

Self-reported frequency of pork consumption correlated negatively with positive attitudes to livestock welfare \( (r = .21, p < .01) \) and positively with positive attitude towards eating meat \( (r = .27, p < .01) \), positive attitude towards the livestock industries \( (r = .24, p < .01) \), trust in people involved in the livestock industries \( (r = .21, p < .01) \), positive ratings of livestock welfare \( (r = .26, p < .01) \) and approval of livestock practices \( (r = .233, p < .01) \). When entered into a regression equation with self-reported frequency of pork consumption as the dependent variable, three variables (gender [being male], positive attitude towards eating meat and positive ratings of animal welfare) emerged as significant predictors of and accounted for 10% of the variance in pork consumption. This result is very similar to results reported from previous research (Coleman, Hay and Toukhsati, 2005) even though the measures used here were slightly different. Correlations between self-reported community behaviours and a range of variables were substantially higher than for pork consumption. Community behaviour correlated most strongly with gender (females more active; \( r = .24, p < .01 \)), positive attitudes to livestock welfare \( (r = .40, p < .01) \), membership of an animal welfare group \( (r = .35, p < .01) \) trust in available information \( (r = .32, p < .01) \), accessing information on livestock welfare \( (r = .48, p < .01) \) and negatively with positive attitudes towards the livestock industries and the environment \( (p = .33, p < .01) \), positive attitude towards eating meat \( (r = .35, p < .01) \), positive attitude towards the livestock industries \( (r = .41, p < .01) \), trust in people involved in the livestock industries \( (r = .37, p < .01) \), positive ratings of livestock welfare \( (r = .42, p < .01) \) and approval of livestock practices \( (r = .38, p < .01) \). When entered into a regression equation with self-reported community behaviour as the dependent variable, seven variables (accessing information on livestock welfare, trust in available information positive ratings of livestock welfare, membership of an animal welfare group, positive attitudes to livestock welfare, income and positive attitudes towards the livestock industries and the environment) emerged as significant predictors and accounted for 43% of the variance in community behaviour. This is a substantial result and indicates the important role that public attitudes play not just in consumer behaviour, but in the wide range of activities that people engage in that can affect the sustainability of the pork industry and licence to farm. Of the 479 respondents, 74 were identified as opinion leaders, and they were characterised by a greater proportion that never ate pork compared with the rest of the sample and engaged in many more community behaviours than did the rest of the sample \( (\text{Mean } = 3.5 \text{ vs } 1.8) \). This suggests that not only might opinion leaders be disseminating information to the rest of the community but also that the information is likely to be negative towards the pork industry. This indicates that this group should be engaged in dialogues about pork production.

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Inferring rumination behaviour from a tri-axial accelerometer

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Summary

Feed intake, feeding and rumination time are important parameters for the identification of normal, healthy feeding patterns, as well as suboptimal feeding conditions and possible health and welfare issues. Free-ranging sheep were fitted with a halter that had a tri-axial accelerometer attached to the under jaw strap. Rumination behaviour was captured using video and synchronised to the accelerometer signals. The sequence of movements during rumination was: chewing, swallowing, nothing and regurgitating. The accelerometer identified this pattern whether the sheep was in either a lying or standing position. More testing is required to determine the accuracy, sensitivity, specificity and precision of the accelerometer to infer rumination behaviour.

Introduction

The interest in monitoring animal behaviour using sensors such as tri-axial accelerometers has steadily grown in recent years. In particular, sensors are commercially available for dairy enterprises which can monitor activity to alert the manager for the onset of oestrus, lameness and other health issues. Tri-axial accelerometers have been used to infer various behaviours of free-ranging cattle (eg González et al. 2015; Trotter et al. 2012; Watanabe et al. 2008) and sheep (Alvarenga et al. 2016). Feed intake, feeding and rumination time are important parameters for the identification of normal, healthy feeding patterns, as well as suboptimal feeding conditions and possible health issues. Previous studies have used a variety of techniques to measure feeding and rumination time. These include human observers (labour intensive and expensive), pressure transducers, electrical deformation sensors (jaw movement), acoustic biotelemetry, electromyography and accelerometers. The most popular research device developed to date has been the IGER Behaviour Recorder (Rutter et al. 1997). However, this device is no longer readily available and an alternative is required. There is a lack of knowledge on how such devices perform on free-ranging sheep. In this paper, we report on preliminary results of inferring rumination from a larger experiment to determine activity in free-ranging sheep using tri-axial accelerometers.

Materials and Methods

This experiment was approved by the University of New England Animal Ethics Committee and followed the University of New England code of conduct for research in meeting the Australian Code of Practice for the Care and Use of animals (AEC 14-114). Two studies were conducted using South African Meat Merino x Merino ewes averaging 55 (± 5) kg and 22 months of age. The first study involved four sheep and the second involved six sheep. Both studies utilised a tri-axial accelerometer (AML Logger v1.0, AerobTec, s.r.o., Ilkovičova 3, 841 04 Bratislava, Slovakia). The logger recorded accelerations caused by changes in velocity, shock and vibration (dynamic) as well as static accelerations due to Earth’s gravity. The device was attached to the lower strap of a halter so as to be located below the sheep’s jaw and configured to record accelerations at one of three sampling rates: 5, 10 and 25 Hz. Behaviours of sheep were recorded between 0800 and 1600h over 2 days for each study using a video camera (JVC Everio GZ-R10, JVC Kenwood, Malaysia). Before deployment, each logger was calibrated by placing it on a flat surface and moving each axis independently to record signals. No loggers failed during deployment and no signals were rejected after download. Further details of experimental design can be found in Alvarenga et al. (2016).

The "signal vector magnitude" (SVM) was calculated as follows:

\[ SVM = \sqrt{X^2 + Y^2 + Z^2} \]

where X, Y and Z are the acceleration values for each axis of the accelerometer.

The SVM was plotted against time (ms) to inspect how well the accelerometer inferred rumination behaviour.

Results

Data from the two studies were combined. The number of sheep, sampling rate (Hz), stature and data points collected during the two studies is shown in Table 1.

Table 1. Number of sheep, sampling rate (Hz), stature and data points collected during the two studies for rumination behaviour.

<table>
<thead>
<tr>
<th>Sheep ID</th>
<th>Hz</th>
<th>Stature</th>
<th>Data points</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>10</td>
<td>Lying</td>
<td>20,918</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standing</td>
<td>1,120</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>Lying</td>
<td>19,441</td>
</tr>
<tr>
<td>5026</td>
<td>5</td>
<td>Lying</td>
<td>695</td>
</tr>
<tr>
<td>5027</td>
<td>5</td>
<td>Lying</td>
<td>708</td>
</tr>
<tr>
<td>5096</td>
<td>5</td>
<td>Lying</td>
<td>2,906</td>
</tr>
<tr>
<td>5162</td>
<td>10</td>
<td>Lying</td>
<td>5,496</td>
</tr>
</tbody>
</table>

The sequence of movements during rumination was: chewing, swallowing, nothing and regurgitating. The accelerometer identified this pattern adequately whether
the sheep was in either a lying or standing position (stature). Figure 1 illustrates this sequence based on one sheep’s data in the two statures, lying and standing at a sampling rate of 10 Hz.

The plots of SVM vs time indicate that the tri-axial accelerometer attached to the under section of a halter can infer rumination behaviour.

**Discussion**

A number of free-ranging sheep were fitted with a halter that had a tri-axial accelerometer attached to the under jaw strap of the halter. Behaviours were collected using video and annotated against accelerometer signals. Accelerometer signals were transformed using SVM to determine if they could infer rumination behaviour.

With the reduced availability of the IGER Behaviour Recorder, another convenient method is required to measure feeding behaviour in free-ranging ruminants. The increase in interest in the use of animal-borne sensors to identify animal state as an aid to improve their health and welfare, and therefore achieving their best performance. There is a lack of knowledge on how such devices perform on free-ranging sheep. Five mutually exclusive behaviours (grazing, lying, running, standing and walking) were observed in free-ranging sheep with halter attached tri-axial accelerometers (Alvarenga et al. 2016). They found that the behaviours were correctly classified 90.5, 92.5 and 91.3% for epoch lengths of 3, 5 and 10s, respectively. Our preliminary analysis of tri-axial accelerometer signals using SVM indicates that an accelerometer can infer rumination behaviour in free-ranging sheep.

Further testing is required as we were only able to obtain a reasonable data set for one sheep in both lying and standing positions.

**Acknowledgement**

Thanks to the NSW Dept. of Primary Industries, Beef Industry Centre of Excellence, Armidale, Australia, for hosting the 2nd author as a PhD student from Federal Univ. of Minas Gerais - Brazil, and for scholarship funding from CAPES (8116/14-8) - Brazil. This work was supported by the Commonwealth Department of Agriculture’s project ‘Genetic technologies to reduce methane from Australian sheep’ and Meat and Livestock Australia. Part of this report appears in “Spatially Enabled Livestock Management” symposium held at Camden Valley Inn, 31 March and 1st April 2016.

**References**


JBS Southern Producer of the year 2015 – utilising Livestock Data Link (LDL) as a model for Supply Chain incentivisation

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Presenting Author: Josephine Webb fm14jose@marcusoldham.vic.edu

Summary

JBS Australia in conjunction with Meat and Livestock Australia (MLA) launched Livestock Data Link (LDL) on the 15th of May 2015, to the JBS Farm Assurance (FA) producers. LDL is an industry wide, online carcase analysis tool that links slaughter data from the National Livestock Identification System (NLIS) and Meat Standards Australia (MSA) databases. This tool identifies non-compliant carcases, non-compliant issues and the associated costs. LDL also provides a library of solutions and gives producers and processors the ability to benchmark within lots, by property, by region and or at state level. LDL was used to determine the inaugural beef and lamb producers of the year from a cohort of 3000 producers. This was achieved by analysing a number of traits, such as percentage of compliant animals, MSA Index, along with other factors such as number of head supplied, spread of supply and loyalty to the program, and is developing into a model for supply chain incentivisation.

Background

Information flow barriers of carcase feedback information and poor quality feedback back (Goers and Craig 2008) to meat producers prompted JBS to implement LDL (http://www.ldl.mla.com.au/) within the southern business. Because of these issues JBS wanted to provide enhanced feedback to the JBS FA producers which in turn would allow producers to analyse their business performance and make continual improvements to their business through understanding and obtaining advanced carcase feedback information.

Strategy

Identifying and acknowledging the most compliant beef and lamb producers that continuously provide compliant carcases and meet company and market specifications will not only reduce the non-compliant cost to producers and processors but to industry as well. Pro And Associates (2012) estimated that within the beef industry alone, $51 million is lost every year from cattle not meeting market specifications and in addition another $64 million is lost annually from carcase condemnations and between $12 million and $49 million in offal and meat condemnations, largely due to animal disease .

By pin-pointing non-compliant carcase issues, JBS is able to identify and work with industry and producers to reduce or mitigate the issues through further research and development, within producer groups such as the JBS FA grass fed group.

Materials & Methods

Data was gathered from the LDL database, MSA database, JBS livestock booking system and the JBS FA database to determine the JBS FA beef and lamb producers of the year.

Table 1 and Table 2 outline the marking criteria used to determine the JBS FA beef and lamb producers of the year. Each compliance percentage was weighted to ensure all traits were assessed appropriately.

Table 1: Determining the JBS beef producer of the year 2015

<table>
<thead>
<tr>
<th>JBS Farm Assured Beef ONLY</th>
<th>Calculated and analysed supplied period 01/01/14 – 10/04/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighting</td>
<td>Compliance</td>
</tr>
<tr>
<td>(60%)</td>
<td>Carcase Specifications - % of animals meeting the carcase parameters around JBS FA</td>
</tr>
<tr>
<td>20%</td>
<td>Weight – 240-360kg</td>
</tr>
<tr>
<td></td>
<td>Dentition - 0-4 teeth</td>
</tr>
<tr>
<td></td>
<td>P8 Fat – 5-52mm</td>
</tr>
<tr>
<td></td>
<td>Bruising – 0</td>
</tr>
<tr>
<td></td>
<td>Meat Colour – 1b-3</td>
</tr>
<tr>
<td></td>
<td>Fat Colour – 0-3</td>
</tr>
<tr>
<td></td>
<td>Butt Shape A-C</td>
</tr>
<tr>
<td>15%</td>
<td>MSA Index - % of Animals above MSA Index 60</td>
</tr>
<tr>
<td>25%</td>
<td>MSA - % of Animals meeting MSA requirements</td>
</tr>
<tr>
<td></td>
<td>Meat Colour - 1b-3</td>
</tr>
<tr>
<td></td>
<td>pH &lt;5.7</td>
</tr>
<tr>
<td></td>
<td>Rib Fat &gt;3mm</td>
</tr>
<tr>
<td>20%</td>
<td>5% for every 50 supplied up to 200</td>
</tr>
<tr>
<td>12%</td>
<td>Spread of kill - 1% for each delivery</td>
</tr>
<tr>
<td>8%</td>
<td>Loyalty - 2% per year up to 4 years</td>
</tr>
<tr>
<td>Total 100%</td>
<td></td>
</tr>
</tbody>
</table>

ASAP Animal Production 2016, Adelaide
Results and Discussion

Shown in Table 3 are the top ten JBS FA beef producer of the year, with the overall winner Brad Gale. Likewise similar data for the JBS Lamb producers (see table 4), with the overall winner Wayne Hawkins.

### Table 3 JBS Beef producer of the year results 2015

<table>
<thead>
<tr>
<th>Producer</th>
<th>Property</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brad Gale</td>
<td>Ross Farm</td>
<td>84.59</td>
</tr>
<tr>
<td>Jock Richmond</td>
<td>Rosegrange</td>
<td>84.56</td>
</tr>
<tr>
<td>Anna Bozovitis</td>
<td>Bindah</td>
<td>84.36</td>
</tr>
<tr>
<td>Aaron Margery</td>
<td>Rocky Point</td>
<td>84.10</td>
</tr>
<tr>
<td>Graham Osborne&amp; Julie Khalid</td>
<td>Scaddens Run</td>
<td>83.72</td>
</tr>
<tr>
<td>John &amp; Fay Barnes</td>
<td>Docker</td>
<td>82.45</td>
</tr>
<tr>
<td>WJ Murray</td>
<td>Tarrawingege</td>
<td>82.42</td>
</tr>
<tr>
<td>Tom Ellis</td>
<td>Coola Station</td>
<td>81.92</td>
</tr>
<tr>
<td>Ross Dimond</td>
<td>G. Dimond &amp; Sons</td>
<td>81.56</td>
</tr>
<tr>
<td>Andrew Dyke</td>
<td>Cloverlea</td>
<td>81.40</td>
</tr>
</tbody>
</table>

### Table 4 JBS Lamb producer of the year results 2015

<table>
<thead>
<tr>
<th>Producer</th>
<th>Property</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wayne Hawkins</td>
<td>Circle H Farms</td>
<td>96.50</td>
</tr>
<tr>
<td>Damien O’Keefe</td>
<td>AB &amp; DG O’Keefe</td>
<td>93.00</td>
</tr>
<tr>
<td>John Davies</td>
<td>Davies Ag</td>
<td>92.05</td>
</tr>
<tr>
<td>Koch Family</td>
<td>Tallageira Pastoral</td>
<td>91.97</td>
</tr>
<tr>
<td>Rowari Giles</td>
<td>PE &amp; SB Giles</td>
<td>91.92</td>
</tr>
<tr>
<td>Tim Williams</td>
<td>Willswood Farms</td>
<td>91.55</td>
</tr>
<tr>
<td>Graham Pickles</td>
<td>GL Pickles</td>
<td>91.32</td>
</tr>
<tr>
<td>Shane Longbottom</td>
<td>Tatiara Industries</td>
<td>90.47</td>
</tr>
<tr>
<td>Jarrod &amp; Jeff Andrews</td>
<td>J &amp; J Andrews</td>
<td>90.32</td>
</tr>
<tr>
<td>Scott Davidson</td>
<td>Goulburn Valley Water</td>
<td>90.12</td>
</tr>
</tbody>
</table>

Table 5 and Table 6 summarise the descriptive statistics of overall score showing values for the mean and, standard deviation (STDEV).

### Table 5 Beef descriptive statistics of overall score of beef

<table>
<thead>
<tr>
<th>Values Analysed</th>
<th>Overall Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>69.67</td>
</tr>
<tr>
<td>STDEV</td>
<td>9.11</td>
</tr>
</tbody>
</table>

For beef, the mean score was 69.67 with a STDEV of 9.11 which would mean that for an average producer to move into a top percentile they could consider practice changes in volume and spread of supply and weight and MSA compliance as listed in table 1.

### Table 6 Lamb descriptive statistics table of overall scoring

<table>
<thead>
<tr>
<th>Values Analysed</th>
<th>Overall Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>67.56</td>
</tr>
<tr>
<td>STDEV</td>
<td>13.54</td>
</tr>
</tbody>
</table>

For lamb, the mean score was 67.56 with a STDEV of 13.54 which would mean that for an average producer to move into a top percentile they could consider practice changes in volume and spread of supply and weight and fat class as listed in table 2.

Outcome

The JBS Southern producer of the year acts as a point of reference to show other beef and lamb producers what the top suppliers are achieving. The competition allows producers to refine target markets, provides recognition and a celebration of the top level production, and this is important for producers so they continue to improve overall performance.

The JBS producer of the year award also creates awareness around what JBS (the processor) wants in terms of HSCW and GR or HSCW and P8 and MSA specifications. This information provides incentivisation within the supply chain by creating measureable improvement in future years.

Acknowledgements

The author would like to acknowledge Dr G.E Gardner for his encouragement.

Thank you to JBS Australia, Meat and Livestock Australia, Sheep CRC and The Sheep CRC/MLA National Lamb Supply Chain Group for their support throughout the Livestock Data Link project during 2015.

Further acknowledgements to Marcus Oldham College and CAS Hawker Scholarship for supporting my further studies and allowing me to attend and present at the ASAP 2016.

References

Lamb survival should be considered separate genetic traits across different birth types

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Summary

Poor lamb survival is a major limitation to the productivity of the Australian sheep industry. Despite this, lamb survival has not yet been included in the national recording schemes as low heritability and lack of suitable indicator traits have led most to conclude that making genetic gains would be slow. Finding better options to improve survival were investigated using data from the Sheep CRC Information Nucleus Flock. Data was analysed using ASReml to calculate heritability estimates and correlations between survival across birth type with gestation length and birthweight. Heritability of survival was low when calculated across all data but higher for multiples so survival should be considered a separate trait across birth type. Gestation length and survival in multiple-born lambs was positively correlated (0.24) suggesting that gestation length could be a potential indicator trait to improve survival of triplet lambs.

Introduction

Poor lamb survival severely limits the productivity of the Australian sheep flock (Hinch and Brien 2014). Twins have survival rates well below those of single-born lambs (Kleemann and Walker 2005) and also have lower birthweights and growth rates (Dwyer and Morgan 2006). Gestation length is also shorter for larger litters, leading to lower birthweights and lower lamb viability (Dwyer and Morgan 2006; Li and Brown 2015). Sheep Genetics, Australia’s national genetic evaluation service, includes number of lambs weaned as an index trait, which encompasses fertility, litter size and survival, but does not currently place any emphasis on the individual components. This study examines lamb survival by birth type and whether gestation length is a viable indicator trait for improving survival.

Materials and Methods

Data was from by the Sheep CRC Information Nucleus Flock (INF), run from 2007-2011 over eight locations across Australia. The flock contains Merino and crossbred ewes that were mated to Merino, maternal and terminal breed rams. Further details on design, data collection and management of the INF have been reported by Fogarty et al. (2007) and Geenty et al. (2014). Gestation length (GL) was calculated from AI dates and lamb birth dates, with records above 160 days and below 138 days removed due to biological improbability. Lamb survival to three days following birth (LS3) was chosen as the primary focus as it accounts for 66% of lamb mortalities to weaning, and birthweight (BWT) was also analysed.

Statistical Analysis

The statistical package ASReml (Gilmour 2015) was used to estimate genetic and phenotypic variance and covariance components, heritability, and correlations between GL, BWT, and LS3 by fitting a linear mixed model with restricted maximum likelihood. An animal model with a pedigree was initially attempted, however this was unsuccessful and so a sire model was used throughout the analysis.

Results and Discussion

This study aimed to find better strategies for genetic improvement of lamb survival, by examining the benefit of analysing lamb survival by birth type and by researching the potential of gestation length as an indirect selection criterion. Initial analysis estimated the base heritabilities was 0.53, 0.16, and 0.02 for GL, BWT, and LS3 respectively. Correlations between each trait were also calculated (Table 1), with no significant correlation between gestation length and lamb survival and low correlations between birthweight and survival. Examining survival as an overall trait, birthweight would appear to be an appropriate indicator trait. However, this does not remain true when the traits are separated by birth type (Table 3).

Table 1: Genetic correlation of gestation length (GL), birthweight (BWT) and lamb survival to three days (LS3) as single traits.

<table>
<thead>
<tr>
<th></th>
<th>GL</th>
<th>BWT</th>
<th>LS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWT</td>
<td>0.36 ± 0.06</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LS3</td>
<td>-0.01 ± 0.11</td>
<td>-0.31 ± 0.13</td>
<td>-</td>
</tr>
</tbody>
</table>

Survival separated by birth type had significantly different heritability estimates (Figure 1), with a model that was statistically improved compared to treating it as a single trait.

Figure 1: Heritability of gestation length (GL), birthweight (BWT) and lamb survival to three days (LS3) by birth type.
The genetic correlations between lamb survival traits for different types of birth were also moderate to negligible, ranging from -0.08-0.60 (Table 2). The improvement in the model fitting the data and the non-unity correlations between lamb survival traits for differing birth types are both supportive of treating lamb survival as separate traits by birth type. With the heritability of twin (0.04) and particularly multiple-born lambs (0.15) significantly higher than single-born lambs (0.01), direct genetic improvement on twins and multiples could be made more efficiently and consequently increase number of lambs weaned (Figure 1). As the base survival heritability (0.02) is in agreement with previous literature (Safari et al. 2005), we have confidence that our results are indicative of the industry and can be practically extrapolated. The recommendation from this study is that Sheep Genetics should consider including lamb survival as a recording index trait, treating lamb survival of twins and multiples as separate traits from overall lamb survival to increase genetic progress in number of lambs weaned.

Table 2: Genetic correlation between gestation length (GL), birthweight (BWT) and lamb survival to three days (LS3) between type of birth (S-Single, T-Twin, M-Multiple).

<table>
<thead>
<tr>
<th></th>
<th>GL</th>
<th>BWT</th>
<th>LS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-T</td>
<td>0.99 ± 0.03</td>
<td>0.96 ± 0.08</td>
<td>0.60 ± 0.60</td>
</tr>
<tr>
<td>S-M</td>
<td>0.99 ± 0.10</td>
<td>0.64 ± 0.18</td>
<td>0.40 ± 0.62</td>
</tr>
<tr>
<td>T-M</td>
<td>0.99 ± 0.10</td>
<td>0.73 ± 0.19</td>
<td>-0.08 ± 0.26</td>
</tr>
</tbody>
</table>

Gestation length has the potential to be a good indicator trait for genetically improving lamb survival, as it has a high heritability (0.53), in agreement with previous studies (Brown 2007; Li and Brown 2015) and has previously been shown to be genetically correlated with lambing ease, a known indicator trait for lamb survival. Although the genetic correlation between gestation length and lamb survival was insignificant in this study for overall survival at -0.01 (Table 1) as well as single and twin-born lambs at 0.07 and -0.03 respectively (Table 3), it was positive for multiple-born lambs (0.27).

Table 3: Sire correlations between gestation length (GL), birthweight (BWT) and lamb survival to three days (LS3) by type of birth (S-Single, T-Twin, M-Multiple).

<table>
<thead>
<tr>
<th></th>
<th>GL/BWT</th>
<th>GL-LS3</th>
<th>BWT-LS3</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>0.31 ± 0.08</td>
<td>0.07 ± 0.30</td>
<td>-0.29 ± 0.42</td>
</tr>
<tr>
<td>T</td>
<td>0.41 ± 0.08</td>
<td>-0.03 ± 0.13</td>
<td>-0.15 ± 0.17</td>
</tr>
<tr>
<td>M</td>
<td>0.53 ± 0.22</td>
<td>0.27 ± 0.24</td>
<td>0.37 ± 0.29</td>
</tr>
</tbody>
</table>

These results are a contrast to the genetic correlations of birthweight and survival across birth type, which are low negatively correlated for single and twins, -0.29 and -0.15 respectively, but low positively correlated for multiple-born lambs, 0.37 (Table 3). This suggests that birthweight is unsuitable as an indicator trait for lamb survival, as attempting to select for lower birthweight to improve survival for single and twin lambs will have an adverse genetic effect on multiple-born lambs, whereas selecting for increased weight to improve multiple survival will have adverse genetic effect for single and twin lamb survival. This provides evidence that gestation length may be a useful indicator trait for improving the survival of multiple-born lambs without adverse effect to the survival of single and twin lambs.

Further study should be instigated to examine the effect of gestation length and birthweight on lamb survival of multiple-born lambs. This study only examined a sire model, due to difficulties with fitting an animal model. Were an animal model with a pedigree able to be fitted, this is likely to increase the accuracy of these estimates and provide more definitive applications to the key findings. Further genetic modelling of the relationship of birthweight and gestation length with lamb survival should be performed, as the results indicate that genetic trends may follow phenotypic trends of having a curved relationship and could potentially be more accurately analysed using a different model.

Acknowledgements

This research was possible through the cooperation of the Cooperative Research Centre for Sheep Industry Innovation.

References

Does melatonin enhance reproductive performance of Border Leicester rams mated to Merino ewes in spring?


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Del Ro Pastoral Co Pty Ltd, Naracoorte SA 5271 Australia
Livestock Systems Alliance, South Australian Research and Development Institute, Roseworthy SA 5371 Australia

Presenting author: David Kleemann dave.kleemann@sa.gov.au

Summary

Variable reproductive performance of Merino ewes mated to Border Leicester (BL) rams in spring could be due to seasonality. Previous work by the authors suggested that treatment of young BL rams with melatonin was beneficial. This study examined if the response was repeatable in young and mature BL rams (property 1) and if treated young rams performed as well as either untreated (properties 2 and 3) or treated mature rams (property 4). On property 1, melatonin increased scrotal circumference (P<0.05) but there was no response in pregnancy rate and litter size. On properties 2 and 3, treated young rams performed similarly to untreated mature rams for pregnancy rate and litter size. However, on property 4, pregnancy rate and litter size were both higher (P<0.05) for treated mature rams compared with treated young rams. In conclusion, the response to melatonin of young BL rams is inconsistent between years for pregnancy rate.

Introduction

The Border Leicester (BL) breed forms an integral part of the Australian lamb-meat industry where Merino ewes are mated to BL rams to produce highly valued crossbred mothers. However, reproduction in the BL ewe is highly seasonal with the breeding season restricted from February to April. Sexual activity of BL rams is less affected by season but activity is reduced in the spring-early summer period. Success of mating Merino ewes to BL rams during the spring can be highly variable with 10-20% fewer lambs weaned compared with Merino rams. A recent study (Kleemann et al. 2014) examined if treatment of BL rams with melatonin implants might ameliorate the problem. Treatment of young rams increased pregnancy rate in Merino ewes from 5% to 93% and, whilst there was no difference in mixed age rams (overall pregnancy rate of 94%), twinning rate was improved in the latter (1.35 vs 1.49 fetuses per pregnancy, P<0.05). The current study investigated if these findings could be repeated in commercial flocks.

Materials and Methods

Property 1. Two flocks of mature Merino ewes (n=500 and 280) were available. The larger flock was randomised into two groups and assigned to melatonin treated and untreated young rams. Similarly the smaller flock was randomised into two groups and assigned to melatonin treated or untreated mature rams. Fourteen young (1-year old) and 10 mature (≥2-year old) BL rams were randomised within each age group to two groups on the basis of scrotal circumference and live weight. Three melatonin implants (Ceva Animal Health Pty Ltd, Glenorie, NSW) were inserted subcutaneously at the base of the ear. Scrotal circumference, live weight and body condition score were measured at the beginning (mid-November) and end (mid-January) of the mating period. Pregnancy rate, litter size and fetal age were measured via ultrasonography at 40-100 days of gestation.

Properties 2-4. Properties 2 and 3 compared the performance of Merino ewes when mated during the spring to either treated young BL rams or untreated mature rams. Ewes on each property were allocated at random to give 145 (Property 2) and 600 (Property 3) per treatment. Property 4 followed a similar procedure but compared young and old rams treated with melatonin. Treatment groups varied in size (112 for young rams and 266 for mature rams). On each property, ram activity (number of rams seen either in or outside of the ewe flock) was noted at weekly intervals. Pregnancy and litter size were determined via
ultrasound during mid-pregnancy. Approval was granted by PIRSA/SARDI AEC.

Results

Property 1. Melatonin treatment increased scrotal circumference (P<0.05: Fig 1a) at the beginning of mating but this difference was reversed (P<0.05) by the end of mating. These effects were independent of ram age. However, there was no response to melatonin treatment for pregnancy rate or litter size in either young or mature ram treatments (Fig 1b) although litter size tended to increase in melatonin treated mature rams.

Fig.1 Effect of melatonin on (a) scrotal circumference, (b) pregnancy rate and litter size and (c) distribution of pregnancies with fetal age for young BL rams. Means with different letters vary significantly (P<0.05).

Properties 2-4. Activity of young rams treated with melatonin was similar to that of either treated or untreated mature rams on all properties. Neither pregnancy rate nor litter size varied between flocks mated to treated young rams and untreated mature rams on both properties 2 and 3. Both pregnancy rate and litter size were higher (P<0.05) for flocks mated to treated mature rams compared with treated young rams on property 4 (91.4 vs 83.9% and 151.0 vs 137.2, respectively).

Discussion

Melatonin treatment of young and mature BL rams enhanced testicular growth in a manner similar to that of Kleemann et al. (2014). However, in the current study, testicular size was lower in the melatonin groups by the end of mating (mid-January). This may have been due to greater sexual activity in melatonin treated rams and/or they may have been refractory to the stimulus of shortening day length post summer solstice. The response in testicular growth to melatonin in the study of Kleemann et al. (2014) was also associated with an increase in pregnancy rate but only in Merino ewes mated to young treated rams. This response was not seen in the current experiment and highlights the difficulty of understanding the interplay of factors that govern ram behaviour and reproductive performance. Interestingly, melatonin treatment skewed the distribution of pregnant ewes toward earlier lambing which would be an economic advantage. Reasons for the skewed distribution could relate to greater sexual activity of rams and/or improved sperm quality. Support was gained for the notion that the performance of young treated BL rams was equivalent to that of untreated mature BL rams from results observed on properties 2 and 3. However, if mature rams were treated (property 4) gains could be made relative to treated young rams. In conclusion, a consistent response of young BL rams to melatonin treatment in the spring was evident for testicular growth but not pregnancy rates in Merino ewes indicating a significant and unexplained year to year variation.

Acknowledgements

Ceva Animal Health Pty Ltd supplied implants. MLA provided funding. We thank property managers: Gary Purdie, Ian Sparks and John Solly.

References

Considerations for future research to improve the welfare of livestock held in stock containment areas

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Summary

Utilisation of stock containment areas (SCA) is increasing in southern Australia as a management tool to preserve soil and pastures. The strategy involves removing livestock from pastures during prolonged dry seasonal conditions and returning them when the grazing conditions improve. Several surveys of producers experience with SCA have been conducted and as a result guidelines have been updated for SCA management. Reviewed guidelines include feed rations, design, disease issues, location and stocking density. Guidelines have touched on, but not resolved issues of welfare expressed by producers, particularly when stock are contained for long periods of greater than 3 months.

This study reviewed survey responses and identified some potential criteria for future research into improving the welfare of livestock contained in SCA including removal of shy feeders, provision of shelter, minimising boredom, and the effective management of dusty and wet conditions.

Introduction

Stock containment areas (SCA), or droughtlots, are increasingly being used by southern Australian livestock producers as a management option to protect soil and pastures during dry seasonal conditions and recovery from fires. SCAs are yarded areas where stock are fed for survival or maintenance on a full ration (DEDJTR, 2015).

Following the dry seasonal conditions in 2002 and 2006, several surveys of producers’ experiences in managing stock in SCA were conducted across Victoria, NSW and South Australia. This paper reviews these surveys in regard to identifying the main welfare issues associated with the length of time stock were contained, stock density, mortality and other issues including general commentary regarding the welfare of sheep. Survey results are considered in regards to making recommendations on areas of future research to improve the welfare of stock. Given that future forecasts are of lower rainfall and increased dry seasons, the use of SCAs is likely to continue to rise as an important management tool.

Materials and Methods

This study reviewed four surveys conducted with producers who had managed sheep or cattle in containment areas in Victoria, NSW and South Australia in 2002 or 2006.

As summarised in Table 1, the Australian Wool Innovation (AWI) (2003) survey covered 50 sheep producers managing 125 SCA over the 2002 drought in NSW, Victoria and South Australia. The Field et al (2002) survey (NW) covered sheep producers during the 2002 drought in the north central and north west of Victoria (number of surveys not reported). A third survey (NE) by Court (unpublished 2003) covered 50 sheep and cattle producers, managing 185 stock containment areas in NE Victoria and the Kerang region in the 2006 drought and Ashton (2007) recorded sheep producers experiences in South Australia (SA) after the 2006 drought. Only the NE survey included cattle in SCA and therefore most of the results discussed in this paper relate to sheep in SCA.

<table>
<thead>
<tr>
<th>Survey</th>
<th>Respondents (no.)</th>
<th>No. of stock contained</th>
<th>No. of SCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002 AWI</td>
<td>50</td>
<td>151,750 (estimated)</td>
<td>125</td>
</tr>
<tr>
<td>NW</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>2006 NE</td>
<td>50</td>
<td>130,000**</td>
<td>185</td>
</tr>
<tr>
<td>SA</td>
<td>36</td>
<td>64,000</td>
<td>*</td>
</tr>
</tbody>
</table>

* unknown
** includes 3,692 head of beef cattle

Results

Length of containment time

Across the survey areas, sheep were contained for an average of 4 months, however the length of time that stock were contained varied considerably within studies. Time in containment for sheep ranged between 1.5 to 13 months, with merinos generally confined longer than crossbred ewes. Cattle were generally contained for less time than sheep, (and only included in one study) ranging from 1.4 to 3.3 months.

Stock Density

The minimum area required for different classes of sheep under the code of accepted farming practice for welfare of sheep (Victoria) are 1 m² for lambs and 1.3 m² for adult sheep (DPI 2007). AWI guidelines (2013) recommend 5 m²/head (2000 sheep/ha). Practices varied and were...
Most stock were confined over the summer months and the average reported mortality rate was 1.2% with merino ewes having a higher rate than crossbred ewes, possibly since merinos were contained for longer, and 32% of respondents reported no mortalities. The AWI study averaged 2.8% with a median rate of 1.4% and the SA survey averaged 1.1% with a maximum of 7.5% mortality. The overall consensus from respondents was that the main cause was acidosis followed by shy feeders. The occurrence of ‘shy feeders’ is a generic description and so is likely to cover a range of causes, conditions or diseases including acidosis, competition for feed, low nutrition and disease.

Whilst the incidence of shy feeders was reported as a major cause of mortality across surveys, only some producers removed these stock from containment to treat separately. In the NE, 85% of deaths were reportedly due to acidosis and shy feeders however only 50% of respondents removed shy feeders from containment. In the Field et al survey, 17% of deaths were caused by acidosis and a further 13% attributed to shy feeders with 24% of deaths undiagnosed. The next most common cause was fly strike and misadventure such as smothering at gates or around feeders.

The AWI survey recorded that higher stock densities tended to be associated with higher mortality and an increased incidence of shy feeders, but this was not identified elsewhere.

Whilst acidosis was considered to be the major cause of mortalities, strategies for prevention are well documented and covered in most drought feeding and containment guidelines.

All producers in the NE study fed some form of roughage (hay or straw). The AWI study reported that feeding roughage reduced mortality rates from 1.34% to 0.76%. The SA study found that feeding roughage did not reduce deaths but did reduce the incidence of shy feeders.

Dust
Dust was a major issue recorded across surveys. It is unclear whether the problem was for reasons of animal health (pink eye), general unpleasantness, or lower wool quality. Numbers were too small and variable in the NE study to make correlations between stock density or mortality rates due to dust but generally, problems with dust increased the longer stock were contained. Other anecdotal comments in the NE, were that it was difficult to get sheep back in containment areas if released briefly due to rain.

Most farmers claimed to be satisfied with the result in preserving pasture and preventing soil degradation and were prepared to utilise SCAs again if required.

Discussion
Since none of the surveys attempted to record specific observations of animal welfare other than that of general health and mortality rates, further research recommendations have been made based on the broad responses provided in the surveys. Further research will enable specific aspects of animal welfare to be identified.

Future climate predictions forecast increasing dryness and incidence of drought so it is probable that the use of some form of stock containment will increasingly be used as a tool for the protection of soil and pasture resources. In Victoria, producers are encouraged to contain stock with government grants made available through state government and catchment management authorities. Whilst death rates are generally low and management solutions well documented for acidosis as the main reported cause of ill-health and mortality, it is considered that further avenues of research focus on improving the performance and welfare of stock in containment, particularly when animals are contained for longer than 3 months. These include:
- Easy identification and early intervention for removal of shy feeders
- Comprehensive disease and mortality investigation
- Strategies for reducing environmental issues such as dust and muddy conditions
- Options for the provision of shelter and shade
- The welfare (boredom) of sheep in containment for long periods.

References


Microbiology and molecular tools for detection of *Mycoplasma* mastitis in South Australia

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**Background and Objectives:**
*Mycoplasma* mastitis is an emerging problem in Australia. The objectives of this study were to estimate and compare the detection capability of a novel PCR with traditional bacteriological culture method of *Mycoplasma* spp from bovine milk samples collected from a single dairy farm in Mount Gambier, South Australia, Australia. The farm had a high incidence of clinical mastitis but also many cows with a high SCC and the treatment with antimicrobials was of little value.

**Materials and Methods:**
A total of 366 milk samples at cow level were used. Samples originated from cows aged 2-10 years from the hospital mob or being with high somatic cell count (SCC) at the farm with 2400 milking cows. Approximately 5 mL of milk per cow were placed immediately for enrichment into a Mycoplasma-selective media broth. At the lab, samples were incubated anaerobically with 10% CO2 at 37°C. Seven days later, the samples were plated on *Mycoplasma*-selective agar. The presence of *Mycoplasma* colonies was detected using light microscopy at 10x magnification. The DNA was extracted using original milk samples and a PCR technique was used to detect the presence of *Mycoplasma* spp using specific primers for *Mycoplasma* (16S RNA).

**Results and discussion:**
*Mycoplasma* species was isolated from 190/368 (51.6%) of milk samples using the microscopic bacterial culture method. These samples were considered positive when there is a growing of at least one Mycoplasma colony in the plate. Mycoplasma spp. was identified more frequently using PCR technique with 234/368 (63.6%). The agreement between the two tests was achieved in 205/368 (55.7%) samples. A number of samples were positive on PCR and negative on culture (n=112; 30.4%). Some samples had positive culture and negative PCR (n=51; 13.9%). The better detection with PCR was expected as culture recovery of *Mycoplasma* spp from milk is usually low. Contrary, the PCR may detect residual DNA from already dead bacteria. Unfortunately, some level of discrepancy (being culture positive and PCR negative) was detected. This was not expected. Likely explanation is that the bacteria detected by culture are *Mycoplasma*-like bacteria (e.g. *Ureaplasma, Acholeplasma*), not *Mycoplasma* spp. As the PCR is specific for *Mycoplasma* spp it was unable to detect some *Mycoplasma*-like bacteria.

**Conclusions:**
The results of this study indicate the significant difference of the detection of *Mycoplasma* mastitis using the novel PCR technique in comparison with the traditional bacterial culture method. In addition, the accuracy of novel PCR detection technique, particularly for the frozen milk samples, may have a great value for veterinarians and farmers dealing with difficult to cure mastitis cases.
A modified barrier test can be used to assess breed differences in lamb vigour

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Summary

The ability of lambs to respond to the ewe in the early neonatal period is important for subsequent lamb survival. This experiment used a modified barrier test to assess lamb vigour in two breeds known to differ in other methods of measuring vigour and at different ages (4h and 10h of age). It was found that Scottish Blackface lambs performed better in the test than Suffolk lambs with more Blackface lambs reaching the ewe (25.4% vs 8.5%). Older lambs reached the ewe more quickly (88.87s vs 150.94s). This test may provide an alternative measure of lamb vigour in terms of the ability of lambs to make contact with the ewe as it can be done at an early age and it does not require the presence of the dam.

Introduction

Various methods of measuring lamb vigour and the ability of lambs to respond to the ewe in the first few days of life have been developed. These include time to progress through a series of critical early behaviours (Dwyer 2003; Slee and Springbett 1986) and behavioural tests such as discrimination tests (Bickell et al. 2009; Nowak and Lindsay 1992; Nowak et al. 1987; Sebe et al. 2007). Measuring early behaviours requires intensive observations over a period of a number of hours which may be difficult or impractical to do in many situations. A barrier test has been used to assess behavioural differences in lambs exposed to poisonous locoweed in utero (Pfister et al. 2006). It was proposed that a modified barrier test could be used to assess lamb vigour in the first 10 hours of life using two breeds of lambs known to differ in other vigour measures, namely Scottish Blackface and Black Suffolk lambs (Dwyer et al. 2005; Dwyer and Lawrence 2000; Dwyer et al. 1996).

Materials and Methods

This experiment was conducted at Scotland’s Rural College Woodhouselee Farm as part of a broader lamb vigour experiment. Experiments were conducted under a licence granted under the Animal Scientific Procedures (1986) Act, licence no. PPL 60/4081.

Fifty-six Blackface (B) lambs and twenty-seven Suffolk (S) lambs were used in this experiment. Single (B n=10; S n=9), twin (B n=26; S n=12) and triplet lambs (B n=9; S n=6) were used. At 4 and 10 hours of age, each lamb was tested in a modified barrier test. Prior to the 4 h test lambs had been under intensive observation to record time to perform early behaviours and had rectal temperature recorded and were moved into an individual pen with their mother. Between the 4 and 10 h tests lambs were generally left undisturbed. The test took place in a separate building to where ewes and lambs were housed so there was no visual or auditory contact with other ewes or lambs. The test consisted of a Comparison early behaviours (Dwyer 2003; Slee and Springbett 1986) and behavioural tests such as discrimination tests (Bickell et al. 2009; Nowak and Lindsay 1992; Nowak et al. 1987; Sebe et al. 2007). Measuring early behaviours requires intensive observations over a period of a number of hours which may be difficult or impractical to do in many situations. A barrier test has been used to assess behavioural differences in lambs exposed to poisonous locoweed in utero (Pfister et al. 2006). It was proposed that a modified barrier test could be used to assess lamb vigour in the first 10 hours of life using two breeds of lambs known to differ in other vigour measures, namely Scottish Blackface and Black Suffolk lambs (Dwyer et al. 2005; Dwyer and Lawrence 2000; Dwyer et al. 1996).

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```markdown
<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Sits, does not bleat or move. Is not alert</td>
</tr>
<tr>
<td>1</td>
<td>Standing still, may look around and bleat occasionally</td>
</tr>
<tr>
<td>2</td>
<td>Circles behind barrier, bleats occasionally. May move but not towards ewe or in a sensible manner</td>
</tr>
<tr>
<td>3</td>
<td>Lamb actively trying to get past barrier, bleating frequently, alert.</td>
</tr>
<tr>
<td>4</td>
<td>Moves past barrier towards ewe, bleating frequently, alert.</td>
</tr>
<tr>
<td>5</td>
<td>Reaches ewe, bleating frequently, alert.</td>
</tr>
</tbody>
</table>
```

Statistical Analysis

Data were analysed using SAS (version 9.1.3). PROC FREQ was used to determine any differences in the proportion of lambs reaching the ewe due to breed (Suffolk or Blackface) or test time (4 or 10 hours). PROC GLM was used to determine differences in the time to reach the ewe and the number of grids crossed to reach the ewe with breed, test time and litter size included as fixed effects. PROC GLM was used to determine differences in the total number of moves in the three minute test period, number of moves to the end of the test, movement rate and overall score with breed, test, litter size and to ewe (yes or no if the lamb did or did not reach the ewe, respectively) as fixed effects. Birth weight was included as a covariate. Correlations between overall barrier test score and time to perform early behaviours were determined. Only the behaviours: time to shake head, reach knees, attempt to stand, stand and reach the udder were used as there was not enough data available.

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on time to unsuccessfully or successfully suckle for calculation of correlations. For more detailed information on how these behaviours were recorded and defined see Dwyer et al. (1996; 2008).

Results
A significantly (P<0.05) greater proportion of Blackface lambs reached the ewe than Suffolk lambs (25.4% vs. 8.5%, respectively). The proportion of lambs reaching the ewe did not differ due to test time (4 hour: 14.8%, 10 hour: 19.0%, P<0.05). Of the lambs that reached the ewe, the time taken was significantly faster at 10 h compared to 4 h (88.87±13.09s and 150.94±15.25s respectively P<0.05) but did not differ due to breed.

The number of grids crossed to the end of the test differed significantly due to breed (P<0.001) and whether or not the lamb reached the ewe; the Blackface lambs took more moves to reach the ewe (11.33±0.87 grids vs 6.64±1.01 grids; P<0.05). Lambs that reached the ewe crossed 11.46±1.09 grids while those that did not reach the ewe crossed 6.52±0.72 grids.

Blackface lambs crossed significantly more grids than Suffolk lambs during the 3 minute test period (17.87±1.09 and 10.97±1.32 grids respectively; P<0.001) and more grids were crossed at the 10 h test than the 4 h test (17.59±1.15 and 11.24±1.27 grids, respectively; P<0.001).

The rate at which the lambs crossed grids differed significantly between breeds, test times and whether the lamb reached the ewe (P<0.001). Suffolk lambs moved slower than Blackface lambs (0.07±0.01 and 0.11±0.01 grids/s respectively). Lambs in the 4 h test moved slower than at the 10 h test (0.07±0.01 and 0.12±0.01 grids/s; respectively) and lambs that reached the ewe moved more quickly than those that did not (0.15±0.01 and 0.04±0.01 grids/s respectively).

Overall score differed significantly (P<0.05) due to breed (Blackface 3.87±0.10 and Suffolk 3.32±0.13) and whether the lamb reached the ewe (5.07±0.14 and 2.13±0.09 respectively) but not due to test time.

Correlations between overall score and time to perform early critical behaviours (up to time to reach the udder) were very low at the 4h test. However, at the 10 h test, there were moderate favourable correlations between overall score and time to stand (-0.28) and reach the udder (-0.29) which approached significance (P=0.06 and 0.08, respectively).

Discussion
The results from this experiment suggest that the modified barrier test using a model ewe and audio cue could be a useful way of measuring vigour at an early age in neonatal lambs. The contrasting performance of Blackface and Suffolk lambs in the test was consistent with the findings of Dwyer et al. (2005; 1996) where Blackface lambs were more vigorous than Suffolk lambs.

More Blackface lambs successfully reached the model ewe and there was also a significant breed difference in the overall score in the test with Blackface lambs having a higher average score than Suffolk lambs. The number of grids crossed to the end of the test (where the end is defined as reaching the ewe or 3 minutes, whichever occurs first) and across the three minute test period was also greater for Blackface lambs. However, the time taken to reach the ewe did not differ with breed which suggests that Blackface lambs took a less direct route to reach the ewe and once they reached the ewe, they did not remain close to her. This may mean that the lamb was not completely deceived by the model ewe and the audio bleats, but it may also be that the lamb was not detecting appropriate responses having reached the ewe, so it continued moving around the arena in search of its mother.

The time the test was performed appears to be important with the performance of lambs generally improving at the later 10 hour test suggesting that the lambs may be showing an element of learning between tests or that older lambs are more able to respond.

This test may provide an alternative and more practical measure of lamb vigour in terms of the ability of lambs to make contact with the ewe as it can be done at an early age and it does not require the presence of the dam. This test may become particularly important as a measure of lamb vigour around the time the ewe moves away from the birth site, when the lamb has increased responsibility to retain contact with its dam.

References


Withholding lucerne in summer to feed in subsequent winter feed deficits modestly increases feed efficiency of small mixed farms in western China

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Summary

Lambs were fed sub-maintenance rations with or without additional nitrogen in the form of lucerne, which were isometric for metabolisable energy. After 20 days, lambs were transferred to an ad libitum diet that included lucerne for a further 20 days. The capacity for underfed Tan weaner lambs to absorb energy from the low nitrogen ration rapidly degraded whilst lucerne had prevented this decline. Furthermore, lambs initially denied lucerne were not able to digest as much of the ad libitum ration following underfeeding. Feed use efficiency at most intakes was higher when lucerne was as available at underfeeding, however practical implementation of this management would incur costs that are unlikely to be offset at the efficiencies observed, given the small difference in weight between treatments in the observed timeframe. The advantage of withholding lucerne to feed in winter would increase if lambs continued to use feeds with the same mean efficiency.

Introduction

Improving the performance of integrated forage-livestock farming systems is one pathway for the sustainable improvement of rural livelihoods in developing economies (Herrero et al. 2010), however seasonal fluctuations in feed quantity and quality cause small ruminant producers in most parts of the world to experience regular deficits of available feed resources. In the Loess Plateau of north-western China, loss of weight during winter feed deficits followed by weight recovery when feed supply improves remains the normal seasonal pattern in the growth for weaned ruminants despite recent government programmes which have promoted an increase in livestock numbers by increasing the area of lucerne (Robertson et al. 2014). Currently, livestock producers typically feed a higher proportion of lucerne during its growing season, but seldom conserve any for use during winter, instead relying on low quality crop residues (Philp et al. 2015) Hence, it seems probable that animal performance in systems where lucerne is available could be improved by modifying the timing with which lucerne is incorporated into rations. We explored the potential benefits to production of storing enough lucerne to meet the minimum nitrogen (N) requirements of rumen function during the winter deficit with an experiment at Qingyang Loess Plateau field station of Lanzhou University, located in the western Loess Plateau, Gansu Province, China (35°39′N, 107°51′E), from June to August 2013.

Materials and Methods

The use of animals was approved by the University of Western Sydney’s Animal Care and Ethics Committee under protocol no. A10109. 26 Tan weaner lambs (mean weight 15.4 kg) were fed corn straw, corn grain and lucerne hay in respective ratios of 80:20:0 (ME = 7.4 MJ kg-1 DM; N = 6.2g kg-1 DM; “S1”) or 55:20:25 (ME = 8.2 MJ kg-1 DM, N = 10g kg-1 DM; “S2”) for 20 days. Rations were offered daily in a constant quantity that supplied approximately 80% of daily ME requirements as calculated at the start of the experiment.

After 20 days of underfeeding on either the S1 or S2 rations, all lambs were offered an ad libitum supply of the S2 ration for a further 20 days. Dry matter digestibility (DMD), energy intake and live weight were measured at 5 day intervals.

We then used a multiphasic growth model adapted from (Kamalzadeh et al. 1997) to compute feed use efficiency (FUE) from the relationship between cumulative dry matter intake and live weight in as:

\[
\frac{dW}{dt}(t) = b_0 - \frac{(b_0 - b_1)}{(1 + e^{-(t-t_0)/\tau})}
\]

Where \(W_t\) is live weight at time \(t\); \(W_0\) is live weight when \(t = 0\); \(F_t\) is cumulative DM intake (DMI) measured from \(t = 0\); \(F_i\) is the cumulative DMI at the transition point of one line to another; \(r\) is a smoothness parameter; \(b_0\) is an estimate of the FUE in the range \(F_i < F_t\); \(b_1\) is an estimate of the FUE in the range \(F_t > F_i\). This function represents a stair step FUE curve with a transition from one step to another occurring when \(F_t = F_i\). The equation was used to model live weight change throughout the experiment. The goodness of fit for the curve was assessed from the residual standard deviation (RSD) of observed live weight at known intakes.

Results

Lambs fed S2 retained on average 0.7 kg more than those fed S1 during the 20 days of underfeeding, with a mean weight change of -0.089 kg day-1 for S1 and -0.055 kg day-1 for S2. Lambs fed S1 experienced a sustained loss in digestive function over time, with ration DMD decreasing by 0.56% per day, and M/D decreasing by 0.06 MJ kg-1 DM per day. By day 20, the mean M/D of S1 had fallen to 6.1. The mean DMD and M/D observed in S2 fed animals remained comparatively stable, with no statistically significant differences between starting and finishing values.

The linear average rate of live weight gain for the ad libitum feeding period was found to be 0.07 kg/day for all lambs, with a further 0.01 kg interaction effect of S2 and days (\(P < 0.05\)). The difference in the effect of the two restrictive
feeding treatments on the digestibility of the ad libitum S2 ration gradually decreased over time. The rate of DMD recovery post-realimentation was greater in the S1 lambs.

The feed intake and live weight data that we used to parameterise the growth model is presented in Table 1. We found that the model could accurately predict live weight and feed use efficiency during underfeeding with a very low residual standard deviation. The model showed that feed use efficiency at most intakes was greater under S2, however S1 lambs temporarily experienced higher feed use efficiency than S2 lambs in the period immediately following realimentation. Neither bodyweight nor intake presented any statistically significant difference between treatments at intakes where feed use efficiency was higher under S1. We also found that that the transition between lines in the efficiency curves occurs differently in each scenario; notably the feed efficiency during restricted feeding under S2 gradually increases towards 0 prior to transition, whereas the transition under S1 occurs abruptly, with very little increase in feed use efficiency prior to transition (Figure 1).

Table 1. Mean estimates of parameters ± standard deviation for computing feed use efficiency from cumulative live weight and cumulative feed intake in Tan weaner lambs transitioning from 20 days of restricted feeding with either S1 or S2 rations to 20 days of ad libitum feeding on the S2 ration.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>S1</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W_0$</td>
<td>15.57 ± 1.91</td>
<td>15.25 ± 1.49</td>
</tr>
<tr>
<td>$F_i$</td>
<td>6.70 ± 0.40</td>
<td>5.83 ± 0.31</td>
</tr>
<tr>
<td>$b_0$</td>
<td>-0.26 ± 0.14</td>
<td>-0.26 ± 0.12</td>
</tr>
<tr>
<td>$b_1$</td>
<td>0.17 ± 0.06</td>
<td>0.21 ± 0.04</td>
</tr>
<tr>
<td>$r$</td>
<td>0.77 ± 0.78</td>
<td>1.07 ± 0.54</td>
</tr>
<tr>
<td>RSD (Eq. 1)</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>RSD (Eq. 2)</td>
<td>0.09</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Discussion**

The capacity for underfed Tan weaner lambs to absorb energy from low protein rations typical of winter rapidly degrades and that the lucerne hay in the diet prevented this decline (Philp et al. 2015). Furthermore, lambs previously fed the S1 ration were not able to digest as much of the ad libitum S2 ration following underfeeding (Philp et al. 2016).

Collectively, our results demonstrate that the comparatively higher nutritive value of the S2 ration maintains the digestive efficiency of Tan lambs during sustained underfeeding marginally better than S1, contributing to greater retention of live weight on restricted feeds, and greater feed use efficiency after being refed in adequate quantities. As the S2 ration has a greater investment of lucerne, practical implementation of S2 management would incur costs associated with changing farmer practice that are unlikely to be offset at the efficiencies observed, given the small difference in weight between treatments in the observed timeframe. The results do indicate however that the advantage of S2 over S1 would continue to increase if lambs were to continue using feeds with the same mean efficiency at higher cumulative DMI.

**Acknowledgement**

This research was funded by the School of Science and Health at the University of Western Sydney, with support from the Australian Postgraduate Award.

**References**


Can nutritional level and parental EPD for rib eye area influence feed conversion efficiency and carcass yield in steers?

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Summary

The objective of this trial was to measure the effect of two Winter Stocker Growth Rates (WSGR) and two groups of sires with different values of Expected Progeny Differences (EPD) for Rib Eye Area (REA) on feed conversion efficiency (FCE) and carcass yield of Uruguayan Hereford steers. The evaluated WSGR were ‘low’ and ‘high’ and the REA EPDs were ‘high’ and ‘average’. Tree generations of steers (321 animals) were sorted out into a 2x2 factorial design. After winter treatments, all animals grazed pastures with an herbage allowance of 5% of live weight (LW) per day. When animals reached 350 kg of LW, they started the finishing phase under lot feeding. Slaughtering was reached on average at 525 kg LW. High WSGR did not influence FCE but increased Hot Carcass Weight (HCW) and carcass yield. Sires with high REA EPD did not influence FCE but generated animals with higher carcass yield.

Introduction

Under Uruguayan pastoral conditions, the critical nutritional moments for beef stockers are the first and second winter of life since climatic conditions and rangeland forage production and quality do not permit adequate animal growth. Severe feeding restrictions at these periods may affect the productive performance of the animals during their whole life (Brito et al., 2005).

Stocker cattle producers are primarily concerned with achieving optimum performance and profitability during their ownership phase but should also consider the effects of their production practices on subsequent finishing phase and carcass performance (Reuter and Beck, 2013).

Sire selection criteria relates directly with the quality of the outcome product. Male sires with superior genetic merit for carcass traits will transmit part of that superiority to their progeny obtaining steers with better performance compared to steers born to bulls with less genetic merit. The Expected Progeny Differences (EPD) summarizes all available information into a prediction of genetic merit for an individual that can be used to make selection decisions (Thrift and Thrift, 2006).

The objective of the present work was to quantify the effect of different Winter Stocker Growth Rate (WSGR) and the utilization of male sires with different EPD for Rib Eye Area (REA) on feed conversion efficiency and carcass yield.

Materials and Methods

The information belongs to an experiment carried out between 2011 and 2016 at the Beef Unit of the Experimental Station “Alberto Boerger” of INIA La Estanzuela at 34º20’45 South latitude and 57º42’40 West longitude, Uruguay.

For the experiment, 321 Hereford calves born to 23 bulls selected by their EPD for REA were used; 12 sires for high and 11 sires for average values of REA EPD obtained from the PANAM genetic evaluation of the Hereford breed. Bulls for high and average EPD values were in the percentile 20 and 50 respectively. One bull from each group connected between years.
Bunks were monitored periodically on the morning (8:00 AM). The diet offered increased 3% when the animals cleaned bunks for three consecutive days. Each animal had 30 m² and 40 cm in front through per head. Feed conversion efficiency (FCE) was calculated as the relation between daily intake and daily gain.

The animals were slaughtered at 525 Kg of average LW. Hot carcass weights were recorded pre-dressing and post-dressing. The yield carcass was estimated as the relation between HCW pre-dressing or post-dressing and LW at slaughtering (LWS).

The different variables were analysed by GLM models considering: block effect (high and low weaning weight), year (calves 2011, 2012 and 2013), WSGR (high and low), REA EPD (high and average) and the interaction between both.

**Results and Discussion**

The results are presented in Table 1. The interaction between WSGR and REA EPD was significant only for daily gain. For the rest of variable measured, the interaction was not significant, so the factors can be analysed independently.

Highest daily gain was obtained for high REA EPD and high WSGR (1.33±0.02a), followed by average REA EPD and low WSGR (1.31±0.02ab), high REA EPD and low WSGR (1.26±0.02bc) and last by average REA EPD and high WSGR (1.24±0.02c). Dry matter intake and feed conversion efficiency were not affected by winter stocker growth rate or for the use of bulls with greater values of EPD for REA.

Calves managed under high WSGR achieved higher HCW either pre-dressing or post-dressing. Similar results were obtained by Hersom et al. (2004) and Duckett et al. (2007) who demonstrated that high growth rates during winter resulted in higher HCW.

High WSGR or high REA EPD increased the yield carcass both pre-dressing and post-dressing. Similar results were obtained by Neel et al. (2007) with low (0.29 kg/d) and high (0.79kg/d) winter stocker growth rate, were they found difference favourable to high winter stocker growth rate (58.8 vs. 57.1%).

Results indicate that utilization of sires with high REA EPD or high growth rate during the first winter of life, do not influence feed conversion efficiency on finishing phase but positively affect carcass yield.

**Acknowledgement**

We acknowledge the Sociedad de Criadores Hereford del Uruguay for providing semen from sires, Diego Vila, owner of the farm “Laguna Blanca”, for insemination of the cows and recording of the calves until weaning. And all farm staff for their care of the animals and technical assistance.

**Table 1. Initial and final live weight, daily gain, final fasted live weight, hot carcass weight pre-dressing and post-dressing, dry matter intake and feed conversion efficiency (± standard error) in steers sired with different values of expected progeny difference (high and average) for the rib eye area (REA_EPD) and with different weight gain during the first winter (WSGR), high and low.**

<table>
<thead>
<tr>
<th>Initial Live Weight (LW), kg</th>
<th>REA EPD</th>
<th>WSGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>374 ± 3</td>
<td>380 ± 3</td>
</tr>
<tr>
<td>Average</td>
<td>377 ± 3</td>
<td>377 ± 3</td>
</tr>
<tr>
<td>High</td>
<td>526 ± 3</td>
<td>530 ± 3</td>
</tr>
<tr>
<td>Average</td>
<td>531 ± 3</td>
<td>525 ± 3</td>
</tr>
<tr>
<td>High</td>
<td>118 ± 3</td>
<td>118 ± 3</td>
</tr>
<tr>
<td>Average</td>
<td>121 ± 3</td>
<td>116 ± 3</td>
</tr>
<tr>
<td>Daily gain, kg/d</td>
<td>1.30 ± 0.02</td>
<td>1.27 ± 0.02</td>
</tr>
<tr>
<td>Intake, kg DM/d</td>
<td>10.2 ± 0.1</td>
<td>10.2 ± 0.1</td>
</tr>
<tr>
<td>Feed conversion efficiency, kg DM/kg LW</td>
<td>8.0 ± 0.2</td>
<td>8.1 ± 0.2</td>
</tr>
<tr>
<td>Slaughter LW, kg</td>
<td>488 ± 3</td>
<td>490 ± 3</td>
</tr>
<tr>
<td>Pre-dressing Hot Carcass Weight (HCW), kg</td>
<td>293 ± 2</td>
<td>292 ± 2</td>
</tr>
<tr>
<td>Post-dressing Hot Carcass Weight (HCW), kg</td>
<td>268 ± 2</td>
<td>267 ± 2</td>
</tr>
<tr>
<td>Carcass Yield pre-dressing, %</td>
<td>60.1 ± 0.1</td>
<td>59.4 ± 0.1</td>
</tr>
<tr>
<td>Carcass Yield post-dressing, %</td>
<td>55.0 ± 0.1</td>
<td>54.4 ± 0.1</td>
</tr>
</tbody>
</table>

Note: The interaction between REA EPD and WSGR was not significant (P>0.05). With each factor, lines followed by different letters are significantly different (P<0.05).

**References**


ASAP Animal Production 2016, Adelaide
Growth, meat yield and meat quality of lambs born to ewes submitted to energy restriction during mid gestation

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Summary

The effect of energy restriction from day 45 to day 115 of gestation in adult ewes bearing single or twin lambs on lamb’s birth, weaning and slaughter weight, carcass and some meat traits was studied. Ewes were fed during mid gestation (45 to 115 days of gestation) with 70 or 100% of their energy requirements. Lambs were weaned at 109 days of age and ad fed until slaughter. There was no difference in growth between treatments (P>0.05). However, lambs born to restricted ewes deposited more back fat during the finishing period (P<0.05), had lower weight of the French rack and leg weight of and French rack yield compared to lambs born to non-restricted ewes. It is important to remark that the French rack cut is the most valuable cut of the lamb carcass, followed by the leg therefore, it is expected that lamb carcass from restricted ewes would be less valued.

Introduction

In the South Hemisphere, most of the flocks are reared on natural pastures and nutritional restriction is frequent during winter. Generally, this period is coincident with the middle third of gestation of the ewe and could affect the performance of her offspring during rearing and fattening. There are critical periods in the fetal life of sheep when tissues and body functions develop and mature. The structure and function of some of them could be affected by the nutritional level the fetus received during its gestation. For example, the fetal phase is critical for skeletal muscle development since the number of muscle fibers is defined before the animal is born. The objective of this experiment was to evaluate the effect of energy restriction from day 45 to day 115 of gestation in adult ewes bearing single or twin lambs on lamb’s birth, weaning and slaughter weight, carcass and some meat traits.

Materials and Methods

Seventy eight adult Polwarth ewes sired with Texel rams, bearing single (n=39) or twin (n=39) lambs were allotted to two treatments by day 45 of gestation: 70 ewes offered a total mixed ration (TMR)(863,2g DM.kg-1; 137,2g CP.kg DM-1; 237,6 gADF.kg DM- 1) to provide 70% of the energy requirements for gestation from day 45 to day 115 of gestation and T100 ewes with 100% energy requirements, using Graz Feed™ v5.03, 2010). On day 120 all ewes were shorn and grazed oat grass until weaning (109 days of age). After weaning, 90 lambs (34 single and 56 twins from both treatments) were lot-fed ad libitum to determine ADG. The finishing TMR had 152 g CP.kg DM -1 and 2.6 MCal ME/kg DM-1. Body fat thickness (BFT) and rib area (REA) were measured by ultrasonography at 0, 25, 48 and 63 days from the beginning of the fattening period. REA was measured between the 12th and 13th rib and BFT at the 12th rib, 11 cm from the dorsal media line using an Aloka 500 ultrasound equipment equipped with a 12-MHz linear transducer for sheep (Aloka Co. Ltd., Tokyo, Japan). At 167 days of age, lambs were shorn and slaughtered. Slaughter weight (SW), carcass weight (CW), fat depth (GR), carcass (CL) and leg length (LL), French rack (FR) and leg (L) weight and yield were measured. The Warner Brazierle Shear Force (WBSF) was determined according the guidelines of the AMSA, (2005) in the filet. The pH was determined in the filet aging for 7 days. All traits were analysed by ANOVA using SAS (SAS 9.2). The model included the type of birth, sex, treatment, and the interaction between these factors. For weaning and final weight and carcass characteristics, age was included as covariate. Carcass and meat traits were adjusted by slaughter weight. Means were compared by the Tukey test.

Results and Discussion

Energy restriction during pregnancy affected the lamb birth weight (p<0.05), however, no effects were observed (p>0.05) on later live weights, such as weaning or final weight, or live weight gain (Table 1). Lambs born from restricted ewes were heavier at lambing than lambs from non-restricted ewes. Probably, after the restriction period the ewes undergo a compensatory period, since received an ad-libitum feeding, resulting in heavier lambs at lambing.

There was no (p>0.05) interaction between sex with treatment or litter size with treatment for all the traits analyzed. Litter size affected lamb live weights at birth, weaning or final (p<0.05), but no effects (p>0.05) were obtained for pre and post weaning live weight gain. The sex significantly influenced (p<0.05) the birth and final live weight and the pre weaning live weight gain. There was no interaction (p>0.05) between sex with treatment and litter size with treatment for any of the carcass and meat traits. The sex and litter size affected the slaughter weight (p<0.05), however no effects (p>0.05) were obtained for treatment. These results were expected since the treatment had no effect neither on previous live weights nor growth rate (Table 1). Despite the carcass and meat traits were adjusted for slaughter weight, there was an effect (p<0.05) of treatment on the weight and yield of the French rack cut. Lambs born to restricted ewes had lower weight and yield of French rack cut compared to lambs from non-restricted ewes. Moreover, restricted lambs had lighter legs (p<0.05) which tended (p=0.12) to yield less than those of lambs from...
non-restricted ewes. It is important to note that the French rack cut is the most valuable cut of the lamb carcass, followed by the leg therefore, it is expected that lamb carcass from restricted ewes would be less valued. The meat of lambs born to restricted ewes tended (p=0.11) to be tougher compared to meat of lambs from non-restricted ewes.

Single born lambs presented higher (p<0.05) REA and BF at the onset and end of finishing period than twin born lambs (Table 2). Male lambs showed higher (p<0.05) REA at the end of finishing period compared to females lambs. The treatment variable had no effect (p>0.05) on any of the studied carcass traits. However, it is important to note that the increase in back fat thickness during the finishing period was higher (p<0.05) for lamb from restricted ewes (0.37 mm) compared to non-restricted (0.21mm). According to Brameld et al (2010), restricted lambs showed higher adipose tissue deposition with respect to non-restricted lambs. Several studies have showed that the increase in the degree of fatness during finishing is higher for animals that suffer or undergone dietary restrictions at early ages.

In conclusion, restriction of energy during gestation might alter lamb carcass composition with more fat deposition, less yield of valuable cuts and a tougher meat. But most important, it does not seem to be a compensatory effect when lambs are fed properly during lactation or fattening.

### Table 1. Least square means ± standard error for birth (BW), weaning (WW) final and slaughter live weight (FW); pre (preWG) and post-weaning weight-gain (postWG); slaughter weight (SW), carcass weight (CW), carcass yield (Yd), fat depth (GR), French racks weight (FR), legs weight (LW), French rack yield (FRy), leg yield (Ly), and Warner-Bratzler shear force (SF) per treatment (Trt), sex and litter size (LS)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Treatment</th>
<th>Sex</th>
<th>LS</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T70</td>
<td>T100</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>BW, kg</td>
<td>4.55±0.09</td>
<td>4.22±0.09</td>
<td>4.53±0.09</td>
<td>4.24±0.08</td>
</tr>
<tr>
<td>WW, kg</td>
<td>25.1±0.60</td>
<td>26.4±0.63</td>
<td>26.5±0.66</td>
<td>24.9±0.55</td>
</tr>
<tr>
<td>FW, kg</td>
<td>37.5±0.77</td>
<td>38.4±0.80</td>
<td>39.6±0.84</td>
<td>36.2±0.70</td>
</tr>
<tr>
<td>preWG, cm</td>
<td>0.207±0.005</td>
<td>0.201±0.005</td>
<td>0.203±0.005</td>
<td>0.205±0.005</td>
</tr>
<tr>
<td>postWG, cm</td>
<td>0.188±0.007</td>
<td>0.199±0.006</td>
<td>0.186±0.007</td>
<td>0.200±0.007</td>
</tr>
<tr>
<td>SW, kg</td>
<td>32.0±0.67</td>
<td>33.0±0.69</td>
<td>34.2±0.74</td>
<td>30.9±0.61</td>
</tr>
<tr>
<td>CW, kg</td>
<td>16.7±0.10</td>
<td>16.8±0.12</td>
<td>16.6±0.12</td>
<td>16.8±0.09</td>
</tr>
<tr>
<td>Yd, %</td>
<td>51.9±0.31</td>
<td>52.3±0.33</td>
<td>51.8±0.36</td>
<td>52.5±0.29</td>
</tr>
<tr>
<td>GR, mm</td>
<td>11.0±0.37</td>
<td>11.7±0.39</td>
<td>10.8±0.44</td>
<td>1986±0.35</td>
</tr>
<tr>
<td>FR, grs</td>
<td>718±9.31</td>
<td>746±9.83</td>
<td>730±10.8</td>
<td>734±6.69</td>
</tr>
<tr>
<td>LW, grs</td>
<td>3873±39.1</td>
<td>3775±41.3</td>
<td>3775±45.3</td>
<td>3872±36.5</td>
</tr>
<tr>
<td>FRy, %</td>
<td>2.25±0.03</td>
<td>2.33±0.03</td>
<td>2.28±0.03</td>
<td>2.29±0.03</td>
</tr>
<tr>
<td>Ly, %</td>
<td>12.2±0.14</td>
<td>11.9±0.15</td>
<td>11.9±0.17</td>
<td>12.2±0.14</td>
</tr>
<tr>
<td>SF, kgr</td>
<td>4.43±0.35</td>
<td>3.63±0.35</td>
<td>3.91±0.35</td>
<td>4.15±0.35</td>
</tr>
</tbody>
</table>

Note: the interaction between Trt and Sex or Tret an LS were not significant (P>0.05) so they are not presented.

### Table 2. Least square means ± standard error for rib eye area initial (REAi) and final (REAf) and back fat thickness initial (BFi) and final (BFf) measured by ultrasonography at the begin and end of finishing period per treatment (Trt), sex and litter size (LS)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Treatment</th>
<th>Sex</th>
<th>LS</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T70</td>
<td>T100</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>REAi, cm</td>
<td>7.93±0.22</td>
<td>8.41±0.23</td>
<td>8.25±0.25</td>
<td>8.09±0.21</td>
</tr>
<tr>
<td>REAf, cm</td>
<td>11.1±0.26</td>
<td>11.6±0.27</td>
<td>11.0±0.28</td>
<td>11.0±0.24</td>
</tr>
<tr>
<td>BFi, cm</td>
<td>2.38±0.09</td>
<td>2.65±0.10</td>
<td>2.51±0.11</td>
<td>2.52±0.09</td>
</tr>
<tr>
<td>BFf, cm</td>
<td>2.75±0.11</td>
<td>2.86±0.11</td>
<td>2.92±0.12</td>
<td>2.69±0.10</td>
</tr>
</tbody>
</table>

Note: the interaction between Trt and Sex or Tret an LS were not significant (P>0.05) so they are not presented.

### References


Can an Australian native plant (Eremophylla spp.) reduce methane output from cattle?

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Summary

Thirty two Bos indicus steers were used in a replicated study investigating the efficacy of Eremophylla spp. in reducing methane output. Air samples were taken across a 3 day period at 2 hourly intervals in a climate controlled facility after a 28 day dietary acclimatisation period. Overall, Eremophylla spp. is beneficial in reducing methane output from Bos indicus cattle consuming low quality roughage when supplemented at 2.0 and 3.0kg/animal/day. The optimal feeding level in the current study was the MED treatment (2.0kg EP); DMI intake highest and methane output lowest as measured in terms of LW, DMI and dietary energy. CON steers produced 3.48g methane/MJ dietary energy, whereas MED steers produced 2.37g methane/MJ dietary energy. Optimal supplementation rate of EP appears to be between 2-3kg/d, however this requires further investigation. This supplement shows potential as a native forage with the capacity to reduce methane output in cattle.

Introduction

The production of methane by cattle and other ruminants has become a subject of considerable debate as awareness and concern over global warming increase (McCaughhey et al. 1999). Methane emissions are a by-product of agriculture production and occur as part of the natural digestive process of animals (enteric fermentation) and manure management in livestock operations. Annual methane emissions from agriculture are estimated at 89.4Mt CO₂-e (Australian Government 2014) and farmed livestock accounts for ~10.7% of methane data due to variations in dry matter intake (DMI) across diet treatments. Air samples were taken across a 3 day period at 2 hourly intervals in a climate controlled facility after a 28 day dietary acclimatisation period. The steers within a weight group (n=8) entered a climate controlled facility and were housed in individual pens after 28 days on their respective diets. The climate facility consists of 4 rooms - two pens/room (2.5m × 5m pens with rubber mat flooring on top of metal grill floor to allow for drainage). The steers were allocated to a room as a treatment pair (only one treatment per room), with 1 steer per pen. Steers were weighed weekly, and on entry and exit from the rooms. The steers remained in the facility for 5 days; 2 days of acclimatisation and 3 days of sample collection. The cattle were fed chaff in equal amounts twice daily (when in rooms and pre/post room period) at 0730 and 1630h to allow for ad lib access to chaff and EP once daily at 0730h. The rooms were cleaned each day between 0830 and 093h by hosing off all surfaces until free of faeces and urine. DMI and water intake were measured daily. After the final sample collection the steers were removed from the climate facility and returned as a group to an outside pen.

Materials and methods

This use of animals and the study design were approved by the University of Queensland Production and Companion Animal ethics committee.

The steers were removed from the climate facility and returned to an outside pen. The steers remained in the facility for 5 days; 2 days of acclimatisation and 3 days of sample collection. The cattle were fed chaff in equal amounts twice daily (when in rooms and pre/post room period) at 0730 and 1630h to allow for ad lib access to chaff and EP once daily at 0730h. The rooms were cleaned each day between 0830 and 093h by hosing off all surfaces until free of faeces and urine. DMI and water intake were measured daily. After the final sample collection the steers were removed from the climate facility and returned as a group to an outside pen.

Within each weight group cattle were randomly assigned to 1 of 4 dietary treatments, so that there were two animals per weight group per dietary treatment: (i) Control (CON), ad libitum access to Rhodes grass chaff (ii) CON + 1kg Eremophylla pellets (EP) (LOW) (iii) CON + 2kg EP (MED) and (iv) CON + 3kg EP (HIGH). Pellets were approximately 4 mm in diameter and had a formulation of approximately 24% Eremophylla seed and 76% mill mix (bran and pollard) (Laucke Mills, Daveyston, South Australia). The EP supplement was allocated to LOW, MED and HIGH daily at 0730h. Animals were acclimatised to diet over a period of 28 days and remained on full dose (treatment dependant) for 14 days prior to methane measurements. Dietary acclimatisation for each group commenced 28 days prior to the entry of that group to the climate controlled facility.

Thirty-two Bos indicus steers 24 months old with a liveweight (LW) of 373 ± 18 kg were used in the study. The steers were allocated to a group according to weight; (i) Heavy group (389 ± 11.94 kg), (ii) Moderate group 1 (368 ± 11.48 kg), (iii) Moderate group 2 (378 ± 12.67 kg) and (iv) Light group (357 ± 20.09 kg). This grouping was done to ensure that the heavy group did not deviate weight wise from the experimental population at commencement of dietary acclimatisation and to allow the light group to increase in weight. The room were maintained at 20 ºC and 50% relative humidity for the duration of the study. Fans were used to ensure that any potential room effects were accounted for. The steers were removed from the climate facility and returned as a group to an outside pen.

The steers were removed from the climate facility and were housed in individual pens after 28 days on their respective diets. The climate facility consists of 4 rooms - two pens/room (2.5m × 5m pens with rubber mat flooring on top of metal grill floor to allow for drainage). The steers were allocated to a room as a treatment pair (only one treatment per room), with 1 steer per pen. Steers were weighed weekly, and on entry and exit from the rooms. The steers remained in the facility for 5 days; 2 days of acclimatisation and 3 days of sample collection. The cattle were fed chaff in equal amounts twice daily (when in rooms and pre/post room period) at 0730 and 1630h to allow for ad lib access to chaff and EP once daily at 0730h. The rooms were cleaned each day between 0830 and 093h by hosing off all surfaces until free of faeces and urine. DMI and water intake were measured daily. After the final sample collection the steers were removed from the climate facility and returned as a group to an outside pen.

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Methane within each room was determined by collecting air samples. Air samples were obtained using a 20 mL syringe at the exhaust duct in each room. The air sample was then injected into a 20 mL vial (glass vial with metal seal crimped prior to sample collection) using a 21g needle. Pre-entry air samples were obtained in each room sample at the commencement of each run. Each room had a specific syringe to avoid any cross-contamination of samples. Samples were taken at 2h intervals from 0600 to 1800h for 3 days. The samples were stored in the vials away from direct sunlight and at room temperature (25ºC) until analysed for CH₄ and CO₂ concentrations.

Methane and CO₂ analysis was undertaken using a Shimadzu GC2010 Plus (Shimadzu, Japan), fitted with a HS-20 headspace auto sampler, and a flame ionization detector (FID) with methanizer (Restek, Shimadzu Scientific Instruments (Oceania) P/L, Sydney). Standards were run at the start, during and at the end of each run. Standard levels for CO₂ were run at 3000ppm for CO₂. Standards were run at the start, during and at the end of each run. Standard levels across treatments. The HIGH group had an ME intake of 11.3MJ/kg DM (74.1MJ/d). The actual DMI of HIGH was slightly lower than MED and even though the energy content of the HIGH diet was greater, overall MEI was greater in the MED group. The CON group had a ME intake of 9.0 MJ/kg DM (45.6 MJ/d) which was the lowest intake of 7.56 kg/hd/d). Metabolisable energy intake (MEI) was also influenced by treatment. CON group had a ME intake of 9.0 MJ/kg DM (45.6 MJ/d) which was the lowest across treatments. The HIGH group had an ME intake of 11.3 MJ/kg DM (74.1MJ/d). The actual DMI of HIGH was slightly lower than MED and even though the energy content of the HIGH diet was greater, overall MEI was greater in the MED group.

There were no differences (P > 0.05) between treatments for total methane production. However when expressed as g/kg DMI, the output from MED group was numerically lower (22%; P = 0.13) when compared with CON. In addition methane production from MED was numerically lower for methane production measured as g/kg LW and g/kg DMI compared with the LOW and HIGH groups (P = 0.76 for g/kg LW; P = 0.13 for g/kg DMI). Statistically the differences are not significant even though MED had an approximately 22% lower methane output (g/kg DMI) than the other three treatments.

The CON group produced 3.48g methane per MJ of dietary energy, whereas the MED group produced 2.37g methane per MJ of dietary energy. This is a 31.9% reduction in methane output per MJ of dietary energy, which is a substantial reduction in energy lost via eructation.

The addition of EP to the diet improved ME content and this is reflected in the greater intakes by the cattle with access to EP both in real terms and as a percentage of LW. In the HIGH group there appears to be a ‘substitution effect’, i.e. chaff intake is being replaced with EP intake which is often seen when high quality supplements are offered. The intake data supports the palatability of EP, and that there was preferential intake of EP when offered with low quality roughage. The nutrient composition of EP combined with its palatability makes the supplement an appealing inclusion in both extensive and intensive cattle production systems. Chaff intake is low relative to the other treatments, however this is somewhat offset by the higher energy value of the HIGH diet. As previously MED group had the greatest chaff intake and also the greatest overall energy intake. Therefore it is probable that feeding EP ≥ 2 kg/d (as-fed) in addition to a low quality roughage diet may not improve intakes. A larger study would be warranted to fully determine the effects of EP on methane production.

**Results and Discussion**

DMI was influenced by treatment (Table 1). The CON group had the highest intake (5.06 kg/hd/d) and the MED group the greatest intake (7.56 kg/hd/d). Metabolisable energy intake (MEI) was also influenced by treatment. CON group had a ME intake of 9.0 MJ/kg DM (45.6 MJ/d) which was the lowest across treatments. The HIGH group had an ME intake of 11.3 MJ/kg DM (74.1MJ/d). The actual DMI of HIGH was slightly lower than MED and even though the energy content of the HIGH diet was greater, overall MEI was greater in the MED group.

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**Table 1. Effect of EP supplementation on DMI (kg/d), chaff intake (kg/d), EP intake (kg/d), metabolisable energy (ME) content of diet (MJ/kg), daily energy intake (MEI, MJ/d), water intake (WI, l/d), DMI as a percentage of LW, water intake to DMI ratio, methane production (g/kg LW and g/kg DMI) and methane to ME ratio.**

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
</tr>
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<tbody>
<tr>
<td>LW, kg⁴</td>
<td>359.9</td>
<td>370.2</td>
<td>380.8</td>
<td>382.8</td>
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<tr>
<td>DMI, kg/d</td>
<td>5.06</td>
<td>5.77</td>
<td>7.56</td>
<td>6.57</td>
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<tr>
<td>Chaff Intake ⁵</td>
<td>5.06</td>
<td>4.92</td>
<td>5.85</td>
<td>4.01</td>
</tr>
<tr>
<td>EP Intake, kg/d</td>
<td>0.85</td>
<td>1.71</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>ME, MJ/kg DM</td>
<td>9.0</td>
<td>9.9</td>
<td>10.3</td>
<td>11.3</td>
</tr>
<tr>
<td>MEI, MJ/d</td>
<td>45.6</td>
<td>56.9</td>
<td>77.9</td>
<td>74.1</td>
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<tr>
<td>WI, l/d</td>
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<td>12.6</td>
<td>17.8</td>
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<tr>
<td>DMI, % LW</td>
<td>1.41</td>
<td>1.56</td>
<td>1.99</td>
<td>1.72</td>
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<tr>
<td>Methane⁶, g/kg LW</td>
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<td>0.65</td>
<td>0.58</td>
<td>0.62</td>
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<tr>
<td>Methane, g/kg DMI</td>
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<td>33.89</td>
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<td>30.24</td>
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<tr>
<td>Methane:ME, g/MJ</td>
<td>3.48</td>
<td>3.42</td>
<td>2.37</td>
<td>2.67</td>
</tr>
</tbody>
</table>

⁴ Eremophylla pellets; ⁵ Liveweight on entry into climate rooms; ⁶ All feed related data presented on a dry matter basis; ⁷ Methane output (means) from samples collected every 2 h between 0600 h to 1800 h for 12 days

**Acknowledgements**

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**References**


The effect of *Mycoplasma* mastitis on somatic cell counts patterns and bovine milk production in South Australia

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**Background and objectives:**

*Mycoplasma* spp. caused mastitis results in elevated somatic cell count (SCC). This is similar to bovine mastitis by any nature. Somatic cells mainly include macrophages, lymphocytes, polymorphonuclear and epithelial cells. The elevation of these cells in affected quarters reflects the possibility of infection and is the standard method to discriminate between healthy and mastitis-infected cows. Most of the world has established acceptable limit of individual cow SCC in raw milk at 200,000 cell/mL. However, currently in Australia the acceptable limit is 250,000 cells/mL. Similarly, mastitis of any nature causes decreases milk production. Specific effects of *Mycoplasma* spp caused mastitis on SCC and milk production compared to mastitis caused by undifferentiated pathogens are unknown. This study aimed to evaluate the effect of *Mycoplasma* mastitis on SCC and milk production compared to other undifferentiated mastitis and the rest of the herd in a single farm in South Australia.

**Materials and methods:**

A total of 368 milk samples at cow level were collected from a single dairy farm located near Mount Gambier, South Australia on two occasions in February and September 2015. The farm had a history of chronic mastitis with poor response to antimicrobials and an increasing number of cows with high somatic cell count (SCC). Samples originated from cows aged 2-10 years in the hospital mob or main milking mob if they had a high SCC. Most cows appeared clinically normal at the time of sample collection. Approximately 50mL of milk was collected aseptically from all functional quarters of each cow. A conventional microscopic culture method was used to detect *Mycoplasma* spp. The presence of *Mycoplasma* spp. colonies was detected using a stereomicroscope at 10x magnification after 7-14 days. Cultures were considered positive when growth of at least one *Mycoplasma* spp. and *Mycoplasma* spp.-like colony was recorded. Individual cow yield production parameters (e.g. volume, fat and protein percentage) and SCC for sampled and non-sampled cows was obtained by means of herd testing information. The
effect of mastitis (Mycoplasma spp or undifferentiated was compared to the rest of the herd (assumed to be without mastitis) using analysis of variance (ANOVA).

Results and Discussion:
The SCC showed significant difference between sampled cows and the remainder of the herd with 259.901±1.1 and 71.801±1.0 cell/mL, respectively. However, no significant difference was observed between cows with Mycoplasma spp. caused or undifferentiated mastitis with 274.980±1.1 and 246.608±1.1 cell/mL, respectively. Milk production was significantly affected being 33.5±0.2 and 29.9±0.5 L/cow/day in cows with mastitis and the rest of the herd. While there was a significant difference between sampled and non-sampled cows, milk production of Mycoplasma spp. induced mastitis cows did not differ from cows with undifferentiated mastitis with 29.9±0.5 and 28.8±0.1 L/cow/day, respectively. On the other hand, individual records of some milk compositions tested in this study were unaffected by Mycoplasma spp.-like bacteria, particularly fat and protein (data not shown). The non-significant difference observed between Mycoplasma spp. induced mastitis and undifferentiated mastitis in this study, likely reflected the similarity in the influence of these pathogens on SCC. Correspondingly, milk yield was similarly affected by Mycoplasma spp.-like bacteria and undifferentiated pathogens. These findings point the importance of the detection of these bacteria amongst other common mastitis pathogens.

Conclusion:
Mycoplasma spp. caused mastitis has a similar effect on SCC and yield production as other common pathogens of mastitis.
Reliability and feasibility of animal-based indicators to assess the welfare of extensively managed ewes.

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Summary

The reliability and feasibility of 10 animal-based indicators of ewes welfare (body condition score (BCS), rumen fill, fleece cleanliness, fleece condition, skin lesions, tail length, dag score, foot-wall integrity, hoof overgrowth and lameness) were examined for on-farm use in extensive sheep production systems. The indicators were independently examined on 100 Merino ewes (from 2 to 4 years old) during late-pregnancy (LP), mid-lactation (ML) and weaning (WN) by a pool of nine trained observers. Levels of observer agreement were determined by Kendall's coefficient (W) and Kappa statistics. Overall, good agreement (from ‘moderate’ to ‘almost perfect’ agreement) were found for the indicators BCS, fleece condition, skin lesions, dag score and lameness, and the inter- and intra-observer agreement of these indicators increased from LP through to WN. This study presents five valid, reputable and feasible indicators for on-farm assessments of extensively managed ewes.

Introduction

Welfare assessments can be a useful way to demonstrate compliance with national and international legal welfare standards and for on-farm monitoring and benchmarking by farmers and veterinarians (Phythian et al., 2013). Thus, studies have recently started to examine indicators that could be used in welfare protocols for sheep (Stubsjøen et al., 2011; Phythian et al., 2013). Animal-based indicators are seen as the outcome of resource inputs and management practices, and therefore there is increasing interest in the incorporation of these indicators in welfare assessments, as they provide an integrative and direct measurement of the welfare state of animals.

Welfare problems that affect sheep are mainly influenced by the farming system, production cycle and geographical location (Phythian, 2011). Thus, not all animal-based indicators identified for sheep can be broadly applied. Indicators need to be examined in terms of their validity (meaningful with respect to animal welfare), reliability (repeatable outcomes when applied by different observers), and feasibility (practical under farm conditions). The aim of the present study was to identify if 10 animal-based indicators were both reliable and feasible, and therefore appropriate for inclusion in welfare protocols for extensively managed ewes.

Materials and methods

Animals and management

A longitudinal on-farm study was performed in Victoria, Australia from July to December 2015. The reliability and feasibility of 10 welfare indicators extensively used in research, (BCS, rumen fill, fleece cleanliness, fleece condition, skin lesions, tail length, dag score, foot-wall integrity, hoof overgrowth and lameness), were examined on 100 Merino ewes (2-4 years old) by a pool of nine trained observers. Ewes were marked within a large flock of approximately 3000 sheep and examined during late-pregnancy (LP) (July), mid-lactation (ML) (November) and weaning (WN) (December). These periods were selected because they are critical times in the concerns for ewe welfare (Stubsjøen et al., 2011). The ewes were managed under extensive conditions, in a year-round outdoor system, grazing annual pastures, and managed under commercial conditions. The indicators were assessed in all animals individually, and the assessment was performed in a raceway.

The validity of these indicators was established by a literature review of indicators commonly used in research, by consultations with an expert group and from European-based protocols for sheep, so they were assumed to be valid.

Animal based-Indicators and reliability assessment

Nine observers, all with animal science backgrounds, with different levels of expertise of working with sheep, were recruited. Prior to individual assessments, observers were provided with an assessment protocol, and an on-farm training session using on average 25 ewes. Thereafter, each observer independently evaluated the 10 indicators on each sheep. The protocols were taken from Phythian (2011) and AWIN (2015). Reliability was assessed by evaluating test agreement between different observers, in line with previous studies of welfare indicators for sheep (Phythian et al., 2013). This is done by comparing the score given by each observer against a reference or ’test standard observer’ (TSO). In the present study, observer 1...
(CM), a veterinarian who developed the list of the indicators and provided training to the other observers was nominated as the TSO. From the pool of nine observers, combinations of four observers performed the assessments on each observation period, but the TSO performed the assessment in all the observation periods. To assess intra-reliability (the degree to which measurements taken by the same observer are consistent), all sheep were reassessed by the observers within a 15-day period in late-pregnancy, and within 24 hours at both mid-lactation and weaning. The observers subjectively evaluated the feasibility of assessing these indicators after the farm visits.

Statistical analysis

Reliability data were analysed using SAS statistical package (Statistical Analysis System, Release 9.4, 2012). The overall level of inter-observer reliability for multiple observer assessments was determined by Kendall’s coefficient of concordance (W) for ordinal data (BCS, fleece cleanliness, fleece condition, skin lesions, dag score, wall integrity, wall overgrowth and lameness) and Fleiss’s Kappa for binary data (rumen fill and tail length). The level of pair agreement (agreement between the TSO and observers 2 to 9) and intra-observer agreement was analysed by Kendall’s (W) and Weighted Cohen’s k for ordinal data and Simple Cohen’s k for binary data. All W and k results were interpreted according to Landis and Koch (1977), therefore values ≥ 0.81 suggested ‘almost perfect’ agreement, values from 0.61 to 0.80 indicated ‘substantial’ agreement, values from 0.41 to 0.60 suggested ‘moderate’ agreement, values from 0.21 to 0.40 suggested ‘fair’ agreement and values ≤ 0.20 indicated ‘slight’ to ‘poor’ agreement.

Results and Discussion

Overall, good observer agreements were found for the majority of the indicators, and the inter- and intra-observer agreement increased from LP through to WN. The indicators fleece cleanliness, fleece condition and dag score obtained ‘moderate’ to ‘almost perfect’ agreement during the three observation periods. Similarly, the indicators BCS and skin lesions increased from ‘moderate’ agreement at late-pregnancy to ‘substantial-almost perfect’ agreement at weaning (BCS W=0.60 (LP) 0.74 (ML) 0.80 (WN) skin lesions W= 0.41 (LP) 0.75 (ML) 0.93 (WN)). Lameness was not assessed for inter-observer reliability because all the observers assisted with the identification of lame animals, but showed good intra-observer agreement (W= 0.53 (LP) 0.79 (ML) 0.86 (WN)). On the other hand, rumen fill, tail length, foot-wall integrity and hoof overgrowth were the indicators with only ‘poor’ to ‘moderate’ agreement. The difficulties of assessing these indicators (as numerous ewes where gathered in a race), along with the number of scoring categories and the descriptive terms used, may have adversely affected the levels of observer agreement in this study.

Rumen fill, fleece cleanliness, foot-wall integrity and hoof overgrowth were considered not very relevant for assessing welfare under extensive management conditions, even though some of these measures were repeatable and reliable. For example, fleece cleanliness had good reliability and feasibility. However, this indicator may be more valuable for indoor conditions to assess the cleanliness of the pens, but might provide less information on the condition of paddocks, and associated sheep welfare, in extensive settings. On the other hand, the indicator rumen fill showed low reliability and feasibility. This indicator is heavily influenced by how long sheep have been yarded, and although it could provide short-term information of food access, its inclusion in assessment protocols may be more valuable and feasible in lambs rather than ewes (Pythian et al., 2013). In the same way, the assessment of foot-wall integrity may be less relevant and feasible than the assessment of other indicators that are broader and thus provide an integrative assessment such as lameness (Kaler et al., 2011). In general, the indicators tested proved to be feasible, requiring 2 to 4 min to assess an individual ewe.

Conclusion

The outcomes of this study indicate that BCS, fleece condition, skin lesions, dag score and lameness are valid, reliable and feasible indicators for on-farm use in welfare protocols for extensively managed ewes. When combined, these indicators provide a snapshot of the current welfare status of ewes, as well as evidence of previous or potential welfare issues. Further research examining the effectiveness of these indicators in assessing seasonal variation and between-farm differences will provide additional evidence of their usefulness for incorporation into on-farm welfare assessments for extensively managed ewes.

Acknowledgement

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References

Forage quantity and quality of dual-purpose wheat: changes during grazing and implications for livestock production

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Summary

Sheep can graze dual-purpose wheat at feed on offer levels below recommendations for pasture due to the different presentation of feed. The quality of wheat forage can decline during the grazing period, which has implications for the management of livestock.

Introduction

Dual-purpose wheat (Triticum aestivum) is recognised as a high quality forage for livestock during late-autumn and winter, and is important in filling the winter feed gap in mixed-farming systems. New research suggests that the quality of forage can vary with grazing pressure and during the grazing period, and this may have implications for sheep grazing wheat crops.

Forage availability

Industry benchmarks for ewes grazing pasture recommend a minimum of 1200 kg green DM/ha for late-pregnant twin-bearing ewes grazing pastures (Hatcher 2006). The above-ground biomass, or feed on offer (FOO), of wheat crops was 552 and 1092 kg DM/ha at the commencement of grazing by ewes in two experiments in southern NSW (McGrath et al. 2015), and we have now observed ewes safely graze pastures with a mean starting FOO of 330 kg DM/ha (McGrath et al., this issue). The availability of pasture for prehension is a function of both herbage weight and height (Smith et al. 1972), and pasture availability below requirements can have important implications including reduced colostrum production, loss of ewe weight and low lamb birth and growth rates (Penning et al. 1991; Morris and Kenyon 2004; Kenyon et al. 2005), and under-nutrition in late pregnancy can increase the risk of perinatal lamb losses (Kenyon and Webby 2007). Poor nutrition in late-pregnant ewes can also precipitate pregnancy toxaemia (Mavrogianni and Brozos 2008). Ewes did not lose condition and no cases of pregnancy toxaemia were observed in the experiments of McGrath et al. (2015), suggesting ewes were able to meet intake requirements at the low FOO levels used in these experiments.

The height of grazed wheat and annual ryegrass swards were characterised in an experiment in 2012, with height and FOO measurements as described by McGrath et al. (2013). The relationship between FOO and height was analysed for wheat swards sown at row spacing 17.5 cm or 35 cm, and an annual ryegrass sward. The presentation of forage to grazing livestock was different for the three treatments, and an example of predicted height across a quadrat is displayed in Figure 1. The height of wheat within the row compared to annual ryegrass would likely assist prehension, and explains why sheep can graze wheat and gain weight at a lower FOO compared to annual pastures, presuming that the quality of the forage remains as high at the lower FOO.

Figure 1. Changes in height across quadrats in grazed swards of annual ryegrass (solid line) and wheat at row spacing of 17.5 cm (dashed line) and 35 cm (dotted line) at feed on offer 500 kg DM/ha (McGrath 2014).

Forage quality

Many of the studies with dual-purpose wheat have represented this forage as being of high quality, with the potential to allow high livestock production levels. Our research has measured changes in quality during the grazing period and noted that the quality of wheat forage can be influenced by grazing conditions prior to stem elongation (GS31). Toe-cut samples of wheat being grazed by lambing ewes demonstrated a significant decline in digestible organic matter digestibility (DOMD) from 85.3% to 72.2% in 2011 (McGrath et al. 2015), and a similar result was observed from pluck samples in a replicated experiment in 2014 (McGrath and Friend 2015).

High stocking rates resulted in a decline in FOO when lambs grazed wheat or annual ryegrass plots in 2012 (McGrath 2014). DOMD of wheat forage was measured for quadrat samples cut to ground level. The experiment was characterised by a ‘high’ digestibility period for wheat in the first part of the grazing period (DOMD range 73-78%; 26 July to 15 August), which aligns with the ‘normal’ grazing period in the region, and a ‘low’ digestibility period (DOMD 61-67%; 22 August to 4 September). Regression of lamb growth rates against FOO, and accounting for the two digestibility periods showed that lamb growth rates were affected by both FOO and digestibility (Figure 2). It is also notable that crude protein levels of wheat forage were ≤ 15% from 8 August, a level that could also have restricted lamb growth rates.

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A decline in forage quality has previously been noted when wheat plants transition to the reproductive stage (Jacobs et al. 2009); however it is clear that grazing management may also have an impact. Virgona et al. (2006) observed that sheep selectively grazed leaf laminae, leaving the sheaths and pseudostem. In an experiment with lambs grazing wheat in 2013, quadrat samples cut at ground level were separated for laminae and other plant components (De Mattia 2013). DOMD was analysed using a linear mixed model with random term Plot/Date. Treatment was not significant as a term in the model (P>0.05), however both date (P<0.001) and proportion of leaf (P=0.039) were significant terms. As in previous experiments, DOMD declined during the experiment (Table 1). Regression of the proportion of leaf dry matter (as part of the whole plant) against DOMD of the sample was significant (P<0.001; R² = 62.4%). In this experiment GS31 was first detected on 22 August.

Table 1. Digestible organic matter digestibility (% DM) of wheat forage grazed by lambs in 2013

<table>
<thead>
<tr>
<th>Date</th>
<th>Feed on offer (kg DM/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 July</td>
<td>88</td>
</tr>
<tr>
<td>7 August</td>
<td>77</td>
</tr>
<tr>
<td>21 August</td>
<td>71</td>
</tr>
<tr>
<td>s.e.d.</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Concluding comments

The above studies suggest that wheat can be grazed at lower levels of feed on offer compared to pasture, however under high stocking rates that affect a rapid decline in FOO there may be a decline in forage quality associated with preferential removal of leaf. Given high stocking intensities may also be detrimental to survival of new-born lambs (Robertson et al. 2012), moderate stocking rates may be more appropriate for ewes grazing wheat, although utilisation levels of the forage will be lower.

Acknowledgement

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References


Pedigree MatchMaker accurately identifies dams in naturally joined sheep flocks

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Summary

The Pedigree MatchMaker is a relatively low cost method of determining dam parentage in sheep flocks, and is well suited for use in commercial settings. The Pedigree MatchMaker records ewe and lamb RFID tags as they walk past a panel reader, and a software program determines the association between each ewe and lamb. By reducing animal handling, animal wellbeing is improved and labour is reduced. The number and accuracy of the Pedigree MatchMaker ewe/lamb matches was evaluated across two sites involving 1488 ewes and 1615 lambs. In total, 84.5-93.3\% of lambs were matched to a dam after 6-8 weeks of recording. The matches made by the Pedigree MatchMaker were compared to DNA parentage results for 473 lambs; 96-97\% of dams matched to a lamb by the PMM were correct.

Introduction

To improve the rate of genetic gain in sheep flocks it is essential to identify pedigree. While DNA is so far the most accurate way to determine lamb parentage, it is not infallible and is often too expensive to use in a non-stud enterprise. Visually mothering-up lambs at birth is labour intensive, and can result in 6.8 to 15.5 incorrect ewe/lamb matches (Barnett et al. 1999). The Sheep CRC developed the Pedigree MatchMaker (PMM) to determine dam parentage in sheep flocks by using radiofrequency technology to build associations between ewes and lambs, reducing overall costs and labour input. Additionally, this system reduces animal handling, therefore improving individual animal wellbeing. The system is designed for use in the field, recording ewe and lamb RFID tags as they walk to water or some other attractant. Some work has been done to validate the accuracy of the PMM against DNA parentage and visual mothering-up (Court et al. 2010; Richards et al. 2006), however further validation is needed in a commercial setting. The aim of this study was to determine whether the number of matches made by the PMM and the accuracy of those matches was comparable to DNA parentage results, with naturally joined ewes in a situation similar to a commercial farm environment.

Materials and Methods

The trial was conducted at two sites: Kirby Research Station (Ardimale NSW) and Katanning Research station (Katanning WA) involving ewes from the Sheep CRC Follower flock. The trial was conducted with the relevant animal ethics authorities at each location. At Kirby the PMM was tested on two groups of 2007-2012 drop ewes (Merino, Merino x Border Leicester and Merino x Dohne), which lambed in September-October 2014 (Table 1; Kir-1, Kir-2). The lambs were marked and tagged with an RFID in late November, and blood from an ear snip was collected on a card for DNA parentage analysis (GeneSeek, Neogen Corp. NE USA). Pregnancy was confirmed by abdominal ultrasound in July 2014, and dry ewes remained with the mob (Kir-1 n=29; Kir-2 n=57). At Katanning there were two groups of 2007-2013 drop ewes (Merino and Merino x Border Leicester), which lambed in April-June 2015 (Table 1; Kat-1, Kat-2). The lambs were tagged at birth with an RFID tag and the DNA blood cards were collected at marking in June/July 2015. All ewes had been previously tagged with an RFID tag.

At Kirby, portable sheep panels were erected around the water troughs in each paddock, forming a yard approximately 5m x 6m. Sheep entered the yard by walking through a wooden crate (0.5m wide) fitted with the PMM panel reader (Pedigreescan, Sapien Technology Ltd.), which recorded their RFID tag as they passed through. Other water sources in the paddock were fenced off. A grain feeder was placed inside the yard to attract the sheep and a hay feeder was placed some distance away to encourage movement into and out of the yard. The sheep were trained to walk through the crate over a period of several weeks. The panels were opened wide (>3m) and were gradually closed every few days until the crate was the only entry point. Recording began after lamb marking and finished 6 and 8 weeks later for Kir-1 and Kir-2, respectively. Sheep were moved to new paddocks according to pasture availability.

An alternative method was used at Katanning, where the PMM was set up in the gateway between two paddocks with water sources in both. Ewes were free to move between each paddock, through the PMM. The PMM was placed in the paddock either the day before or on the day recording starting, so there was no training period. Ewes were regularly fed grain, which was trailed in the paddock with the least number of ewes to encourage the others to walk through the PMM. Recording began in mid July and finished 6 and 7 weeks later for Kat-1 and Kat-2, respectively.

The RFID records were analysed using the Pedigree MatchMaker software (Pedigree Matrix, NSW DPI), which matched each lamb to a ewe based on the number of times they walked past the PMM together (Table 1). Each match was assigned a reliability score (R-score), indicating the strength of the association (definitions were provided by the NSW DPI). R-scores 1-3 were considered reliable (Score 1 = same ewe/lamb combination recorded on >10 occasions and lamb matched to same ewe 100\% of the time; Score 2 = >3 occasions and 75-100\% of the time; Score 3 = <3 occasions and >50\% of the time). R-score 4 associations are not considered to be matches, and were rejected due to their uncertainty (<3 occasions, <50\% of the time).

ASAP Animal Production 2016, Adelaide
Statistical analyses were conducted using a Chi-Square test for independence (with Yates correction for continuity) in the IBM SPSS program (IBM Corp, 2013).

Results and Discussion

The total number of lambs matched by the PMM was similar between groups except for Kat-2, which matched significantly fewer lambs than the other groups, despite having the highest number of records (Table 1). It is possible that when grain was trail-fed, ewes in the opposite paddock moved quickly through the PMM to access food and left their lambs behind. Also, as water was available on both sides of the PMM, shy ewes did not need to go through the PMM. Training the ewes to accept the PMM prior to recording would be likely to increase the number of useful ewe/lamb records (Morris et al. 2012).

Table 1. Percentage of lambs matched by PMM and DNA

<table>
<thead>
<tr>
<th>Group</th>
<th>No. ewes (lambs) in mob</th>
<th>No. RFID records</th>
<th>Lambs matched by PMM*</th>
<th>Lambs matched by DNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kir-1</td>
<td>292 (219)</td>
<td>74,028</td>
<td>90.0%</td>
<td>94.1%</td>
</tr>
<tr>
<td>Kir-2</td>
<td>304 (254)</td>
<td>74,151</td>
<td>93.3%</td>
<td>95.7%</td>
</tr>
<tr>
<td>Kat-1</td>
<td>428 (548)</td>
<td>57,599</td>
<td>89.1%</td>
<td>-</td>
</tr>
<tr>
<td>Kat-2</td>
<td>464 (594)</td>
<td>159,414</td>
<td>84.5%</td>
<td>-</td>
</tr>
</tbody>
</table>

* Different letters within columns indicate a difference at the 5% probability level

The PMM matched a similar number of lambs as the DNA parentage test for both Kirby groups (P>0.1). DNA parentage results are not yet available for Katanning. The PMM results were compared with DNA parentage to determine the accuracy of the PMM matches (Table 2). The DNA test failed for a small percentage of lambs in each Kirby group (Table 1), so the analysis only included lambs that had a dam assigned by both the PMM and DNA test (Table 2). Although DNA parentage is not always 100% accurate (Court et al. 2010), for the purpose of this analysis it was assumed that the dam identified by the DNA test is correct. When validated by the DNA test, the PMM was able to match ewes to lambs with a higher degree of accuracy than that reported by Court et al. (2010), who achieved 83-88% accuracy (compared with DNA parentage), and Richards et al. (2006) who compared the PMM results to visual mothering-up with 81% accuracy.

Table 2. Validation of PMM accuracy against DNA

<table>
<thead>
<tr>
<th>Group</th>
<th>No. lambs in analysis</th>
<th>Correct PMM dam</th>
<th>No. incorrectly matched lambs (R-score)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Kir-1</td>
<td>185</td>
<td>96%</td>
<td>6</td>
</tr>
<tr>
<td>Kir-2</td>
<td>226</td>
<td>97%</td>
<td>4</td>
</tr>
</tbody>
</table>

The majority of lambs that were matched incorrectly had an R-score of 1 (Table 2); it is most likely that these lambs were mismothered soon after birth and reared by a different ewe. Based on the limited number of inaccurate matches, it cannot be recommended that R-score 1 should be relied on any more than R-score 3 for example.

To determine the minimum time period required for PMM recording, the number of records made each week was compared to the total number of PMM matches. The number of lambs matched by the PMM each week was similar for Kir-1 and Kir-2 (P>0.05), so data was combined. The majority of Kirby lambs were matched to a ewe by the third week of recording (89.4%), after which there was no significant increase in the number of lambs matched (P=0.265). Likewise, the majority of lambs were matched after four and three weeks for Kat-1 (88.3%; P=0.775) and Kat-2 (82.5%; P=0.057), respectively. There is a risk that a shorter recording period may reduce the accuracy of the matches when compared to DNA, however Richards and Atkins (2007) found that 3-4 weeks of recording was sufficient to match lambs with 85-96% accuracy.

In conclusion, it has been demonstrated that using a PMM system, a similar number of lambs can be correctly matched to their dam compared to DNA parentage testing. It appears that recording for 3-4 weeks post lamb marking is sufficient to match the significant majority of lambs. Data quality, and thus total lamb matches can be improved by training the ewes to accept the PMM prior to recording. Using water as an attractant (rather than intermittent grain feeding) may also improve the quality of data, as lambs are less likely to be left behind. Although DNA parentage has the advantage of identifying both a dam and sire, the PMM in conjunction with sire joining records can provide accurate parentage information.

Acknowledgement

This research was funded through the Cooperative Research Centre for Sheep Innovation. Many thanks to the technical staff involved in the data collection at both sites.

References


Analysis of three methods for the estimation of in vitro CH₄ production from vented bottles.

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Summary

In vitro methane production from three experiments incubating 1.0 gm DM of wheat and Lucerne, different amounts (0, 0.5, 1.0 and 1.5 gm DM) of wheat and lucerne and Lucerne, corn, wheat and barley with different degrees of processing, was calculated using [CH₄ concentration in headspace x headspace volume] + [CH₄ concentration in gas bag x GP] as the gold standard method and compared to the five algorithms proposed by Hannah et al. (2016). The algorithms predicted methane production well. Method 1a had the greatest correlation and Lin’s concordance coefficient with the gold standard and can be recommended for estimating methane production when vented gas is not collected in gas bags.

Introduction

Several strategies have been proposed for reducing enteric methane production (MP), and it is therefore important to quantify MP. One method for measuring total gas production (GP) and MP is through an in vitro fermentation technique using the Ankom™ system. The “gold standard” method for estimating MP using the Ankom™ system requires collection and analysis of the headspace and the vented gas (Hannah et al. 2016). However, Hannah et al. (2016) proposed other options to calculate methane production without the need to collect and analyse the vented gas. These options involve algorithms to estimate methane production based on the volumes of vented gas and the final methane concentration in the headspace of the Ankom™ incubation flask. This study aimed to evaluate the five algorithms proposed by Hannah et al. (2016) with the “gold standard” method for estimating MP by the Ankom™ technique under three incubation scenarios.

Materials and Method

The substrates (1.0 gm DM) in the first experiment comprised wheat and lucerne. The substrates in the second experiment comprised different amounts (0, 0.5, 1.0 and 1.5 gm DM) of wheat and lucerne. The substrates (1.0 gm DM) in the third experiment comprised Lucerne, corn, wheat and barley with different degrees of processing. Each treatment was tested in eight replicates. In all incubations, substrate was incubated in Ankom™ bottles each containing 75 mls of Kansas State buffer solution and 25 mls of ruminal fluid. Cumulative pressure and the ideal gas law were used to estimate GP over the course of the incubation period. As the gold standard method, MP was calculated as: [CH₄ concentration in headspace x headspace volume] + [CH₄ concentration in gas bag x GP].

Results and Discussion

The five algorithms proposed by Hannah et al. (2016) were compared against the gold standard.

All algorithms predicted MP very well with close concordance with the gold standard method. Method 1a had the greatest correlation (R=0.956) and Lin’s concordance coefficient (CC = 0.952) with the gold standard, although only just. In method 1a, MP is calculated as:
\[
MP = \frac{C_n}{K_n}(U + A),
\]

Where; \( K_i = r_i K_{i-1} + s_i \), \( r_i = \frac{V_i}{V_i + u_i} \),

\( s_i = \frac{u_i + a_i}{V_i + u_i} \), \( K_0 = 0 \), \( C_n \) = CH\(_4\) mixing ratio in headspace, \( U \) = gas volume added to headspace (ml), \( A \) = volume of CO\(_2\) absorbed into ruminal fluid (ml), \( V_i \) = pressure at the start of venting interval (atm), \( u_i \) = change in pressure during venting interval (atm), \( a_i \) = negative change in pressure in blank control during the venting interval (atm), \( n \) = number of ventings, and \( i = 1...n \) is venting number.

**Table 1** Lin’s concordance, correlation coefficient and experimental coefficient of variation of the five algorithms proposed by Hannah et al. (2016) with the gold standard for which %CV=9.0.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Concordance</th>
<th>Correlation</th>
<th>%CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>0.952</td>
<td>0.956</td>
<td>10.3</td>
</tr>
<tr>
<td>1b</td>
<td>0.945</td>
<td>0.951</td>
<td>10.5</td>
</tr>
<tr>
<td>1c</td>
<td>0.945</td>
<td>0.951</td>
<td>10.5</td>
</tr>
<tr>
<td>2a</td>
<td>0.948</td>
<td>0.950</td>
<td>10.2</td>
</tr>
<tr>
<td>2b</td>
<td>0.950</td>
<td>0.950</td>
<td>10.1</td>
</tr>
</tbody>
</table>

It is concluded that if vented gas is not collected during *in vitro* studies with the Ankom\textsuperscript{TM} system, then total methane production can be accurately estimated by using any algorithm listed in Table 1, with small cost to experimental precision.

**Acknowledgments**

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**References**


The impact of divergent selection for methane yield on age at puberty

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Summary

Angus heifers (n=134) that had been divergently selected for Low and High methane yield (MY) were used to examine onset of puberty. Ultrasonography was used to scan the ovaries of 2014-born heifers (n=134) on four occasions following weaning. Weight (WT), height (HT) and fat depth at rump (P8) of the heifers were also recorded. Descriptor traits at onset of puberty were calculated, including age (AGECL), weight (WTCL) and P8 (P8CL). No significant differences were observed between MY selection lines for WT, HT and P8 recorded at the initial and final ovarian scanning. In addition, no significant differences were observed between MY selection lines for AGECL, WTCL, P8CL or proportion of heifers that had ovulated by the last scan. Thus selection for divergent MY had no significant impact on pubertal traits in this study.

Introduction

The contribution of livestock to worldwide greenhouse gas emissions is significant (14.5%), and primarily from ruminants (Gerber et al., 2013). Methane traits have been reported as moderately heritable in sheep (Pinares-Patino et al., 2011) and cattle (Donoghue et al., 2016). While selection for low methane genotypes is now possible, the impact of this selection on female fertility traits is unknown. The objective of this study was to investigate whether differences exist in the age that High and Low methane genotypes reach puberty as heifers so as to gain a better understanding of the relationships between methane and reproduction traits.

Materials and Methods

This females used in this project were the 134 heifers born in 2014 from the methane yield (MY) selection lines at the Agricultural Research Centre, Trangie, NSW, Australia. A heifer was considered to have commenced onset of puberty when a corpus luteum (CL) was observed on one of the ovaries. This was the primary trait of interest, providing evidence of ovulation. Initial assessment of luteal activity was conducted in July 2015 when the average weight of the heifers was ~290 kg and the average age was 326 days. Further assessments were undertaken in August and early October, with the final assessment just prior to joining in late October. The cycling status of a heifer at each ovarian scanning assessment was coded as a binomial trait, with a heifer which had cycled (presence of CL) receiving a value of 1, while a heifer that had not cycled received a value of 0. All heifers had weight, height and fat depth at the rump (P8) recorded at the initial (July) and final (late October) ovarian scanning assessments. Only heifers that had not yet cycled had weight and P8 recorded at the August and early October ovarian scanning assessments. Descriptor traits at onset of puberty were calculated, and they included age at onset of puberty (AGECL), defined as the age in days of the heifer at the first-observed CL (Johnston et al. 2009), and corresponding weight (WTCL) and P8 (P8CL).

The heifers used in this project were not tested for MY in respiration chambers. However, their sires and dams were tested for MY in respiration chambers and had MY EBV. These EBV were averaged to calculate the mid-parent EBV for MY, which was used as an estimate for MY EBV for each heifer. The dataset analysed contained records for 59 Low MY and 75 High MY heifers.

All the traits studied were analysed using PROC MIXED, except the binomial trait (cycling status), which was analysed using the Generalised Linear Model (PROC GENMOD) procedure of SAS with a logit link function. The model used for the analysis of weight, height, age, P8 and MY EBV included the fixed effect of selection line, random effect of sire (within selection line) and the random residual error. For the analysis of cycling status as a binary trait the model included the fixed effects of selection line and sire, plus the random residual error. Regression of onset of puberty descriptor traits on the mid-parent MY EBV were also used to detect whether there was evidence for a genetic association between onset of puberty and MY.

Results and Discussion

Least-squares means for growth, fatness and cycling traits at the initial and final ovarian scanning assessments for heifers divergently selected for MY are presented in Table 1. There was a marked genetic divergence in MY between the two selection lines as shown by the highly significant difference (0.46 g CH4/kg DMI) in mid-parent MY EBV between Low and High line heifers. No significant MY selection line differences were observed in age, weight, height or P8 of the heifers at either scanning dates. There was a consistent trend for a lower proportion of low MY heifers to have ovulated at both the initial and final ovarian scanning assessments, but it was not significant at either date.

Least-squares means for growth and cycling traits measured at the onset of puberty for heifers divergently selected for MY are presented in Table 2. No significant differences were observed in the age, weight or fatness of the heifers at onset of puberty. The coefficients for the regression of puberty traits on mid-parent MY EBV were not significant for age, weight or fatness at onset of puberty, but the trends suggested that a decrease in MY EBV was associated with later age at puberty. A significant relationship was observed for the regression of percentage of heifers who had cycled on mid-parent MY EBV, with a decrease in MY EBV...
associated with lower number of heifers reaching puberty by time of joining. This result indicates that further investigations may be necessary to better understand the genetic associations between selection for low MY and puberty.

Table 1. Least-squares means (±se) for growth, fatness and cycling traits of heifers at specific corpus luteum scanning dates.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Selection line</th>
<th>Significance a</th>
<th>Regression on MY b EBV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Low MY 59</td>
<td>High MY 75</td>
<td></td>
</tr>
<tr>
<td>MY EBV</td>
<td>-0.27 (0.05)</td>
<td>0.19 (0.04)</td>
<td>**</td>
</tr>
<tr>
<td>July 2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Age (days)</td>
<td>321 (2.3)</td>
<td>329 (2.0)</td>
<td>*</td>
</tr>
<tr>
<td>-WT (kg)</td>
<td>292 (3.6)</td>
<td>292 (3.1)</td>
<td>ns</td>
</tr>
<tr>
<td>-HT (cm)</td>
<td>113 (0.4)</td>
<td>113 (0.4)</td>
<td>ns</td>
</tr>
<tr>
<td>-P8 (mm)</td>
<td>5.5 (0.5)</td>
<td>5.0 (0.5)</td>
<td>ns</td>
</tr>
<tr>
<td>-% cycled</td>
<td>31</td>
<td>41</td>
<td>ns</td>
</tr>
<tr>
<td>October 2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-WT (kg)</td>
<td>358 (4.4)</td>
<td>361 (3.9)</td>
<td>ns</td>
</tr>
<tr>
<td>-HT (cm)</td>
<td>117 (0.5)</td>
<td>118 (0.4)</td>
<td>ns</td>
</tr>
<tr>
<td>-P8 (mm)</td>
<td>8.1 (0.3)</td>
<td>7.5 (0.3)</td>
<td>ns</td>
</tr>
<tr>
<td>-% cycled</td>
<td>76</td>
<td>92</td>
<td>ns</td>
</tr>
</tbody>
</table>

a ** P<0.0001; * P<0.05; ns P>0.05

b Mid-parent MY EBV

Table 2. Least-squares means (±se) for growth, fatness and cycling traits measured at the onset of puberty.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Selection line</th>
<th>Significance a</th>
<th>Regression on MY b EBV</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGECL (days)</td>
<td>Low MY 365</td>
<td>High MY 376</td>
<td>ns</td>
</tr>
<tr>
<td>WTCL (kg)</td>
<td>329 (13.7)</td>
<td>335 (12.1)</td>
<td>ns</td>
</tr>
<tr>
<td>P8CL (mm)</td>
<td>6.7 (0.4)</td>
<td>6.0 (0.3)</td>
<td>ns</td>
</tr>
<tr>
<td>% cycled</td>
<td>76</td>
<td>92</td>
<td>ns</td>
</tr>
</tbody>
</table>

a ns P>0.05

b Mid-parent MY EBV

There were no significant MY selection line differences in female early-life reproductive performance traits in this small study. However, the significant association between MY EBV and puberty, as highlighted by the significant regression of MY EBV on proportion of heifers that had reached puberty, suggests that further research may be necessary.

Acknowledgement

Project funds came from the Australian Government Department of Agriculture as part of its Carbon Farming Futures Filling the Research Gap Program, and Meat and Livestock Australia.

References

Testing a model to initiate feather pecking in free-range laying hens

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Summary
Severe feather-pecking and cannibalism are considered major welfare problems in free-range laying hens and with the proportion of eggs from non-cage housing on Australian farms predicted to increase, a better understanding of the factors that elicit these problems is required to improve farm animal welfare and profitability. The aim of the first experiment is to test whether the onset of feather-pecking outbreaks in free-range hens is a consequence of the inability of hens to perform effective dust-bathing behaviour and whether the link between these situations is related to build-up of microbial content on feathers and skin due to ineffective feather and integument cleaning. If this is determined, we propose to conduct further experiments to examine the effects of some specific treatment applications on onset of feather pecking, plumage damage and cannibalism.

Introduction
Severe feather-pecking, whereby birds peck and pull out the feathers of conspecifics is considered to be a major welfare concern in laying hens (Bestman, Koene & Wagenaar 2009; Gilani, Knowles & Nicol 2013). Once an outbreak starts it is difficult to control, especially due to social transmission of the abnormal behaviour in non-cage housing systems (Zeltner et al. 2000). The underlying causes are multifactorial, complex and influenced by many different environmental stimuli (Rodenburg et al. 2004; Jensen et al. 2005; Uitdehaag et al. 2009; Janczak & Riber 2015). While many studies have investigated feather pecking, researches have failed to definitively induce feather pecking. Therefore, a reliable model to initiate feather pecking is needed to facilitate research to identify a solution that prevents outbreaks before they start. The aim was to prove the model of quality dust-bathing substrate and onset of severe feather-pecking.

Materials and Methods

Animal husbandry and housing

The experiment will be conducted at the Free Range Research Facility at the Poultry Research Unit, University of Sydney, Camden, NSW. A total of 528 ISA brown pullets (non-beak-trimmed) will be purchased from a commercial supplier at 14 weeks of age. Pullets will be allocated randomly to 8 pens measuring 3.66 m x 3.25 m. At 15 weeks the pullets will be weighed and wing tagged. At 16 weeks nest boxes will be opened and from 21 weeks birds will be given access to outdoor runs. Feed and water will be provided ab libitum.

All experimental protocols will be conducted under approval from the University of Sydney Animal Ethics Committee and in accordance with the Australian code of practice for the care and use of animals for scientific purposes (National Health and Medical Research Council, 2004).

Treatments

The treatments to be applied will include 1) the provision of ‘suitable’ (peat moss) compared to ‘non-suitable’ (washed gravel) dust bathing substrate and 2) hen age (time). At week 20, all 8 pens will be provided with a litter tray containing peat moss and floor litter both inside and outside will be minimised, so as to encourage the pullets to dust-bathe in that specific location. At 24 weeks, the peat-moss substrate will be withdrawn from 2 pens selected at random and it will be replaced with the washed gravel substrate for a period of 4 weeks. All 8 pens will experience both treatments.

Focal birds

Focal birds will be chosen at random using a random number generator. A total of 10 birds per pen (80 in total) will be selected at 18 weeks of age. These birds will be identified with a numbered hen apron. Continual video surveillance will then be used to monitor focal bird behaviour throughout the length of the experiment and detailed plumage scoring will be applied for each focal bird from 20, 26, 34, 42, 50 and 56 weeks of age.

Microbiology

Swabs from the head, neck, back, vent and rump will be collected from 5 sample birds at week 17 and tested for the presence of bacteria and fungi on sheep blood agar and sabouraud dextrose agar, respectively. If successful, the aim will then be to monitor feather and skin microbiota by quantifying bacteria and fungi fortnightly from weeks 18 to 60 on all focal birds, across 8 pens.

Acknowledgement

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References


The Lamb Supply Chain Group provides a model for engaging value chains

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Summary

Blockages in information flow along the value chain still limit the impact of research and development in Australia’s livestock industries. The Sheep CRC and Meat & Livestock Australia (MLA) has developed the Lamb Supply Chain Group as a model to build stronger partnerships and embed research and development and the associated commercialisation and adoption new technologies with the end-users. This has led to engaging five supply chains with a very high collective footprint in the Australian lamb industry. We recommend this as model for future work, and is portable across industries.

Background

One of the major aims in establishing the Cooperative Research Centre (CRC) program was to strengthen links between the scientific, tertiary education and industry (Pethick et al. 2014). In the agricultural sector, CRCs are regarded as being particularly successful because of the research and development being applied within small-medium enterprises in regional Australia (CRC for Sheep Industry Innovation 2015). However, blockages in information flow from objective product measurement along the value chain prevent partnerships from operating at their potential (Goers and Craig 2008).

Strategy

The Lamb Supply Chain Group (LSCG) is a Sheep CRC initiative established in 2007 to facilitate collaboration with supply chains to enhance their ability to meet consumer expectations for increasing both lean meat yield and eating quality. Our goal is to increase lean meat yield by 0.1% per annum while maintaining/improving eating quality – a key objective of the Australian Sheep Industry Strategic Plan 2015-20. The 20-25 members of the LSCG are from the Sheep CRC, MLA, Australian Meat Processing Corporation, State DPI’s and Murdoch University.

The LSCG takes a structured approach when engaging new supply chains. At the initial engagement a portfolio of Sheep CRC and MLA opportunities/technologies are presented, after which a scoping discussion establishes areas of mutual interest and a plan of action agreed upon. A detailed and confidential economic analysis is then undertaken to clarify the business case for measuring and utilising lean meat yield and eating quality information. To facilitate this we developed “The Lamb Value Calculator” which is a decision support tool for processors enabling benchmarking, economic analysis, and scenario analysis. A prioritised list of measurements/technologies is then established to test, pilot and develop proof of concept within their supply chain. (Figure 1)

Figure 1: The Lamb Value Calculator, an LMY analysis tool
Progress and Outputs

Considerable progress has been made since the inception of this group, including:

1. Engaging with five supply chains (processors / supermarkets) and assisting them and other supply chain’s with implementation and compliance of Meat Standards Australia (MSA),
2. Collaborative employment of Lamb Supply Chain Coordinators with expertise in meat science, carcase measurement, large scale data management, statistics and producer engagement,
3. Development of a lean meat yield Technical Guide as an information support tool (Pearce K 2015),
4. Establishment of 20 national demonstration sites showcasing elite genotypes (Hocking Edwards 2015),
5. Development of enhanced feedback to producers using tools such as MLA’s Livestock Data Link (LDL),
6. Provision of an essential forum for mentoring new human capacity within the sheep industry.

This consortium has also focused on national collaboration and co-investment into projects such as:

1. MLA Ewetime and LambEx (2010-12-14-16),
2. The National Grass Seeds Action Plan and Working Group,
3. The Sheep CRC Extension (2015-19), and,
4. Made a significant contribution to national Meat and Sheep industry strategic plans, and for MSA and LDL implementation.

Outcomes

By June 2019, it is expected that the LSCG will have facilitated lean meat yield measurement and MSA-Mark 2 grading of 4 million lambs per annum, and 20% of the slaughter of yearling sheep-meat will be under-pinned by MSA.

Acknowledgement

This collaborative engagement of value chains by the LSCG is bought together by co-investment from the value chains and the Sheep CRC, MLA, State DPI’s, Murdoch University, and automation and objective measurement technology companies through the Cooperative Research Centre for Sheep Industry Innovation.

References


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Lambex – Australian Lamb Expo 2016.


Can farmers select good rams based on phenotype?

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Summary

Farmers can use genetic and/or phenotypic information to select flock sires. This experiment aimed to determine farmers’ ability to identify high-performing rams based on phenotype alone. A group of 20 rams were available for selection, which consisted of 10 “high” and 10 “low” genetic merit rams based on their breeding values for live weight at 8 months of age. Farmers (n=29) each selected a team of 10 rams from the group on the basis of phenotypic information. All 20 rams were bred with two ewe flocks and lambs were assigned to sires using DNA parentage. The mean number of high merit rams picked by farmers was 4.4, and the farmer-selected ram teams produced lambs with a mean weaning weight of 34.9 kg, which were lighter than the high team (35.4 kg) and heavier than the low team (34.7 kg). Farmers did not identify superior rams based on phenotypic information.

Introduction

Ram selection is the first opportunity for sheep farmers to make genetic gain in commercial flocks, so the selection of rams is critical to their on-farm performance. Estimated breeding values (EBV) have been widely available for rams in New Zealand since the initiation of Sheep Improvement Limited (SIL) in 1999, yet a 2015 survey of sheep farmers revealed that only 22% of farmers considered EBVs when making ram selection decisions (Corner-Thomas, et al., 2015). The aim of this experiment was to compare the effectiveness of selecting sires based on phenotypic performance with selection based on EBVs to maximise weaning weight of lambs born to terminal sires.

Materials and Methods

Twenty 8-month old ram lambs were selected from a single flock of Focus Genetics Primera ram lambs, a terminal sire type breed. The ram team included 10 of the 15 rams that had the highest EBV for live weight at 8 months (LW8) and 10 of the 15 rams that had the lowest EBV for LW8. The 10 high merit and 10 low merit rams were selected so that the mean and range in live weight was similar for the high and low teams (58.0 kg (range 52.0–63.8 kg) versus 58.4 kg (55.0–64.8 kg), respectively).

All 20 rams were mob-mated with two ewe flocks (Mt Herbert Station in Waipukurau, New Zealand, n=519 ewes and Taratahi Agricultural Training Centre’s Glenside farm in Gladstone, New Zealand, n=560 ewes), for 17 days at each farm. On the day rams were introduced at each farm, a farmer group was hosted (n=16 and n=13, respectively). Farmers were presented with the rams, and provided with information on birth rank, age of ram, age of dam and live weight 2 weeks prior to the first field day, and each farmer was asked to choose the 10 rams they would use, based on the information available, with no access to information on genetic merit. At docking lambs were individually identified with electronic tags and DNA tested to assign parentage to individual sires. Lambs were weighed at weaning at approximately 100 days of age.

Weaning weights of the lambs were compared within sire groups and any lambs that were >3 standard deviations below the mean for their sire-group were excluded from the experiment (n=1). Weaning weight was analysed using SAS (Statistical Analysis Software, Version 9.4, SAS Institute Inc, Carey, North Carolina, USA, 2014) using a general linear model that included the fixed effects of sex, birth rank, and birth rank-by-farm interaction. Least squares means for weaning weight for each sire were then used to predict the weaning weight of each farmer’s theoretical lamb crop. Mean weaning weight of each sire team was calculated in two ways – first assuming equal number of lambs per sire, and secondly, weighted for the actual number of lambs weaned per sire.

Two rams contributed very few lambs (≤5) on one or both farms and these rams were excluded from the analysis. Farmers who had selected one or both of these rams had a mean weaning weight calculated on the basis of a team of 9 or 8 rams, respectively.

Results and Discussion

In this project farmers chose their team of terminal sire rams solely on phenotype, with no information on predicted genetic performance. Farmers appeared unable to pick the high genetic merit rams based on phenotype, with farmers selecting a mean of only 4.4 high genetic merit sires for their sire teams. This compares to the expected results that
randomly selected teams would result in 5 high merit rams in the team. Median farmer team EBVs were 3.29 for WWT (weaning weight) and 6.86 for LW8, intermediate between the high and low teams (Figure 1). There were popular and unpopular rams in the group, but this was not related to the genetic merit or to the actual performance of the rams (Figure 2).

Total number of weaned lambs from the 18 successful sires was 680 at Mt Herbert Station, and 479 at Glenside Station. Number of progeny per sire ranged from 19 to 177 included in this analysis.

**Figure 1:** Box and whisker plot of team means for lamb weaning weights and EBVs for live weight at 8 months (EBV LW8) and weaning (EBV WWT). Weaning weights of farmers’ sire teams are weighted for actual number of lambs per sire (WWT Actual), and assuming all sires had an equal number of lambs (WWT Equal). Means of the high (- - High) and low (- - Low) genetic merit teams are indicated.

The majority of farmers selected rams that produced lambs with a mean weaning weight between that of the high and low merit teams. Based on equal numbers of lambs per sire to calculate team means for weaning weight, the median of the farmer-selected teams was 35.4 kg, compared to 35.1 kg for the low and 35.7 kg for the high teams. This is equal to the expectation for weaning weight had rams been selected at random.

There was a large range in the number of lambs produced per sire, and the most prolific ram (n=177 progeny) was a popular choice (selected by 27/29 farmers). This ram was a single, early-born lamb from a 3-year-old dam and was one of the heaviest animals at ram selection. On average his lambs were light, and when the number of lambs per sire was factored into the weight of each theoretical lamb crop, their influence markedly reduced the mean weaning weight for all farmers that selected this ram. There are few reports of ram contributions in industry, but it seems likely that an uneven contribution by sires is a common occurrence. Allison (1975) reported uneven proportions of ewes mated and variable conception rates per ram for rams in multi-sire mating scenarios. The potential for one or a few prolific rams to have a large influence on the mean performance of the lamb crop highlights the need for selecting a team of good performers, rather than relying on a few high-merit sires to lift the team average.

**Figure 2:** Mean weaning weights of lambs from both farms for each individual sire in relation to the number of times the ram was selected for a ram team by 29 surveyed farmers. $y = -0.0047x + 35.756$ $R^2 = 0.0005$

**Conclusions**

This study showed it was not possible for farmers to identify superior sires based on phenotype alone. Selection of sires based on EBV was a more reliable method to increase weaning weight of lambs.

**Acknowledgements**

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**References**


Providing pasture choice to sheep reduced intensity of methane emissions and increased growth compared with annual ryegrass

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Summary

Our objective was to assess the influence of a grass/legume choice pasture and novel legumes including the potentially low methane pasture, biserrula on animal performance and methane intensity (CH4/ live weight gain). Ten groups of 24 dry merino ewes were offered unrestricted grazing on duplicate plots of annual ryegrass (ARG), subterranean clover (Sub), side-by-side monocultures of annual ryegrass and subterranean clover (Choice), serradella (Serr) and biserrula (Bis) over two spring growing seasons. Methane was measured fortnightly from individual sheep using portable accumulation chambers. Daily weight gains from the Choice pastures were equivalent to those from Sub pastures and higher than from ARG. Methane intensity tended to be lowest from the choice pasture, pending a full data analysis. Choice pastures can potentially improve sheep production and reduce the impact of greenhouse gas emissions by improving the efficiency of the conversion of pasture into growth.

Introduction

Sheep that graze legumes often have greater growth performance and produce less methane compared to those grazing grasses (McCaughey et al. 1999; Waghorn et al. 2002; Archimède et al. 2011). Managing pastures to maintain a higher proportion of legumes is therefore a strategy that farmers could adopt to reduce methane emission intensity. However, legumes are not as productive as grasses during the winter months and when used in a mixed sward it is difficult to maintain proportions of legumes above 20%.

Spatially arranging legume/grass monocultures in a side-by-side ‘choice’ fashion enables ease of management, diet selection and can be as effective on animal performance as legume monocultures. When offered unrestricted access to side-by-side monocultures of legume and grass sheep consistently consume 70% legume and 30% ryegrass (Chapman et al. 2007). Novel legumes with antimethanogenic potential could potentially be included in legume/grass monocultures to further reduce ICH4 (methane intensity g/Kg average daily live weight gain (ADG)). Our objective was to assess the effects of a grass/legume choice pasture and novel legumes including the potentially low methane pasture, biserrula (Biserrula pelecinus) on ADG and ICH4.

Material and methods

This was a spring-grazing experiment over 2 seasons at The University of Western Australia Research Farm at Pingelly, Western Australia (32.5097°S, 116.9955°E). Two groups of 240 dry merino ewes that were 14 months of age and weighing 50.6 kg (+/- 8.2) were stratified for live weight and sire (based on estimated breeding values for methane emissions relative to live weight) to groups of 24. Each group was assigned to one of ten plots (1.5 to 3 ha/plot) using a completely randomised design with two replicates of five pasture treatments; annual ryegrass (ARG; Lolium rigidum cv. robust); subterranean clover (Sub; Trifolium subterraneum L cv. Dalkeith); side-by-side monocultures of ryegrass and subclover (Choice); serradella (Serr; Ornothopus sativas cv. margurita) and; biserrula (Bis: Biserrula pelecinus cv. casbah). The sheep grazed unrestricted feed on offer (FOO) in spring for 8 to 10 weeks over during 2014 and 2015. Weekly measurements included; FOO using 0.1m² quadrats and cutting to ground level; ‘toe-cut’ samples from each plot for nutritive assessment by Near Infra-red Spectroscopy supported by wet chemistry (CSIRO, Floreat); and live weight and scoring of body condition. Each fortnight methane emissions were determined by measuring individual animals using portable accumulation chambers (Goopy et al. 2011) and a portable flame ionisation detector (Photovac MicroFID).

Effects of treatments on nutritive values, live weights, and methane production were determined on GenStat (VSN International, 2012) using Restricted Maximum Likelihood (REML) with Restricted Maximum Likelihood (REM) with methane production and yield fitted as fixed effects and methane measurement day and run, and sire fitted as random effects. For nutritive values treatment was fitted as the fixed effect and experiment, week and plot were the random effects.

Results and discussion

Full analysis of methane emissions is pending (only 2014 data for methane emissions is shown here) but indications are that the choice pasture produced the lowest methane intensity (Table 1) suggesting greater rumen efficiency of feed conversion. Hill et al. (2009) theorised that allowing sheep to choose between clover and ryegrass increases meal time and optimises dietary balance of energy to
soluble protein. Similar ADGs between the choice and sub sheep provides further evidence for greater rumen efficiency from the choice treatment given that around 30% of the intake of the choice sheep would have been ARG whereas when ARG was the sole diet ADG was 25% lower than sheep grazing the sub pasture.

Table 1. Average nutritive values of pastures and the effect on average daily weight gain and methane intensity.

<table>
<thead>
<tr>
<th></th>
<th>Choice</th>
<th>Sub</th>
<th>ARG</th>
<th>Serr</th>
<th>Bis</th>
<th>F prc</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOO %</td>
<td>3.0</td>
<td>3.0</td>
<td>2.7</td>
<td>2.4</td>
<td>2.6</td>
<td>ns</td>
</tr>
<tr>
<td>Purity %</td>
<td>86</td>
<td>89</td>
<td>96</td>
<td>80</td>
<td>86</td>
<td>ns</td>
</tr>
<tr>
<td>ADF %</td>
<td>26</td>
<td>26</td>
<td>23</td>
<td>25</td>
<td>22</td>
<td>.05</td>
</tr>
<tr>
<td>NDF %</td>
<td>47</td>
<td>45</td>
<td>46</td>
<td>41</td>
<td>37</td>
<td>.05</td>
</tr>
<tr>
<td>CP %</td>
<td>17</td>
<td>19</td>
<td>10</td>
<td>18</td>
<td>18</td>
<td>.001</td>
</tr>
<tr>
<td>ME MJ/kg DM</td>
<td>9.3</td>
<td>9.3</td>
<td>10.2</td>
<td>8.9</td>
<td>9.5</td>
<td>.05</td>
</tr>
<tr>
<td>ADG g/day</td>
<td>219</td>
<td>223</td>
<td>168</td>
<td>213</td>
<td>177</td>
<td>.05</td>
</tr>
<tr>
<td>iCH₄ g/Kg ADG</td>
<td>128</td>
<td>143</td>
<td>162</td>
<td>142</td>
<td>168</td>
<td>-</td>
</tr>
</tbody>
</table>

ADGs were lowest in the sheep grazing Bis and ARG despite higher ME (metabolisable energy MJ/Kg DM) and lower fibre fractions (ADF, acid detergent fibre; and NDF, neutral detergent fibre) in Bis compared to the other pasture types (P<0.05). It is therefore probable that the feed intakes were lower from the sheep grazing Bis and ARG. Sheep have been observed to avoid grazing biserrula at certain stages of growth possibly due to the presence of plant secondary compounds (Thomas et al. 2014). The intake of legumes by sheep and cattle is usually higher than that of grasses of the same digestibility (Kenney and Black 1984) because legumes can be eaten at a faster rate than grasses. The rate of intake is influenced by sward characteristics (height, density and dry matter content). The crude protein (CP) content of ARG, though significantly lower than the legumes, was not limiting to dry ewe growth.

Side-by-side monocultures of legume and grass pasture can provide the production benefits of clover when only half of the grazing area is sown to clover. Additionally there may be an advantage in side-by-side monocultures for reducing methane emissions intensity. It is possible that introducing other legumes such as serradella into a choice grazing system will reduce emissions intensity further while maintaining performance.

References


Acknowledgements

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Functional annotation to understand how imprinting affects phenotypes in pure bred and hybrid cattle

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Summary

A fundamental question in developmental biology is how the DNA sequence is linked with the phenotype, and specifically the mechanisms involved in appropriate gene regulation to guarantee that the tissues and organs of an individual are formed and function correctly. Advances in technology mean that it data on gene expression, epigenetic variations and chromatin structure can be produced quickly and relatively cheaply in order to annotate functionally important genome features. In the present work, the transcriptome and epigenetic variations in cattle are being examined to contribute to understanding the regulation of gene expression and identify imprinted loci in Bos taurus and Bos indicus cattle that affect development processes and formation of phenotypes.

Introduction

A fundamental question in developmental biology is how the DNA sequence is linked with the phenotype, and specifically the regulatory mechanisms involved in appropriate gene expression with respect to distribution, timing and level to guarantee that the tissues and organs of an individual are formed and function correctly. Early work on model organisms identified key genes involved in pattern formation, such as the homeobox genes from Drosophila, many of which are conserved and play a critical role in regulating the development of both vertebrate and non-vertebrate species (review Krumlauf, 1994). With the publication of the draft human genome sequence (International Human Genome Sequencing Consortium 2001), it has become possible to study genome-wide epistatic interactions and the regulatory elements operating to ensure correct expression of coding sequences, and the functional significance of intergenic elements, long dubbed “junk DNA”. However, with less than 10% of the genome in coding regions of the 20K+ identified genes, the challenge remains to understand which sequences among the remaining 90% of the genome have functional significance and how expression is regulated.

The human Encyclopaedia of DNA Elements (ENCODEx) project set out to provide an understanding of the functional role of the non-coding genome. The consortium assigned function to 80% of the genome (The ENCODE Project Consortium 2012) by studying the transcriptome, transcription factor binding sites and epigenetic variation. However, with a few exceptions, related to specific diseases, the phenotypic effects of these functional elements were not defined.

Information derived from other species is necessary identify and understand conserved and divergent features. The mouse ENCODE project, has examined transcription, DNase1 hypersensitivity, transcription factor binding, chromatin modifications and replication domains in a range of cell and tissue types (The mouse ENCODE consortium 2014). These data revealed that many regulatory sequences identified in humans are also present in the mouse. While transcription factors and chromatin domains seem to have the highest conservation, regulatory sequences show significant divergence between man and mouse. In order to make sense of these similarities and variations, additional data beyond these two mammalian species are required. Transcription binding sites in liver have been found to be highly variable among human, mouse, dog, opossum, and chicken (Schmidt et al 2010). This may be a reflection of the interplay among epigenetic variation, chromatin structure and DNA sequence in gene regulation, which argues strongly for measuring all these components simultaneously on the same tissue samples.

Whole genome DNA methylation can be revealed by treating DNA with bi-sulphite which converts un-methylated cytosine into uracil and then comparing treated and non-treated samples. DNA regions associated with epigenetic modifications can be identified by CHromatin Immu-NoPrecipitation sequencing CHIP-Seq, using specific antibodies for modifications including DNA methylation or histone acetylation, phosphorylation, ubiquitination etc (review Bannister and Kouzarides, 2011). Chromatin structure can be explored using DNase1 sensitivity to reveal open chromatin permissive for transcription (Review Elgin 1981), and recently, chromatin conformation has been probed in an assay for transposase accessible chromatin (ATACseq), which shows good correlation with DNase1 data (Buenrostro, et al 2015).

Normal development of the embryo is associated with the specific expression of either the paternal or maternal allele of a sub-set of genes, a phenomenon called imprinting. Imprinted genes are clustered into about 100 loci in human and mouse genomes with nearly 1,500 imprinted genes (Bartolomei and Ferguson-Smith, 2011). These genes affect normal pre-natal development and can impact on health, obesity and other phenotypes in the adult (Peters, 2014).

There are two cattle sub-species, the non-humped Bos taurus which is found predominantly in temperate climates and the humped Bos indicus cattle which are better adapted to hot arid conditions. These sub-species were domesticated separately from Bos primigenius (Hiendleder et al. 2008). Both types of cattle have 30 chromosomes and readily interbreed. Bos taurus cattle have been selected to be highly productive under in good environmental conditions while Bos indicus cattle survive in hostile environments. Hybrids have a blend of survival traits of Bos indicus which is found predominantly in temperate climates and the humped Bos indicus cattle which are better adapted to hot arid conditions. These sub-species were domesticated separately from Bos primigenius (Hiendleder et al. 2008). Both types of cattle have 30 chromosomes and readily interbreed. Bos taurus cattle have been selected to be highly productive under in good environmental conditions while Bos indicus cattle survive in hostile environments. Hybrids have a blend of survival traits of Bos indicus and increased productivity traits of the Bos taurus. Imprinting has been implicated in the phenotypic variation in birth weight and growth in Bos taurus x Bos indicus hybrids (Imumorin et al 2011, Xiang et al 2012, Xiang et al. 2014).
The project described here will explore the chromatin structure, gene expression and epigenetic variation in the bovine genome focusing on differences between Bos indicus and Bos taurus in order to assist in the identification of imprinted genes.

Materials and Methods

Seventy-three pure-bred Angus (Bos taurus) and Brahman (Bos indicus) and reciprocal cross foetuses were generated after standard oestrous cycle synchronization and recovered at Day 153 of gestation (Xiang et al. 2014). Tissues were collected and stored both in RNA later and as snap frozen samples. This material is now being used to examine gene expression, small non-coding RNA, chromatin structure and epigenetic modifications.

Expression will be analysed for messenger RNA and long non-coding RNA by PACIFIC BIOSCIENCES sequencing to capture full length transcripts and reveal variant transcripts, while Illumina short read sequence will reveal expression levels, allele specific expression, ncRNA and small RNA.

DNA methylation is associated with gene silencing and methylation patterns will be explored using whole genome bisulphite treatment and Illumina 50bp short reads.

Chromatin structure plays a key role in the regulation of gene expression, from binding of transcription factors to target promotor sequences to access for polymerases. Structurally active chromatin will be probed using the Assay for Transposase Active Chromatin (ATAC-seq). Tags are inserted into active sites by retroposase, the tags then recovered and their integration location identified from flanking sequence (Buenrostro et al. 2015).

Discussion

Advances in technology, largely stimulated by the human genome sequencing project, mean that whole genome sequence data can be produced rapidly and reliably at relatively low cost. The accompanying technology is rapidly being developed and refined to interrogate DNA modification and chromatin structure and its modifications.

With the falling cost of sequencing and improvements in the robustness of techniques for interrogating genome structure, the functional annotation of the genomes of domestic animal species will be addressed by an international consortium (The FAANG Consortium, 2015). This consortium will focus on those species which have a reasonable quality reference genome.

The data from the Bos taurus, Bos indicus pure-bred and hybrid foetuses will be contributed to the FAANG initiative. These data will advance knowledge of genome function, including how the epigenome and chromatin structure interact in the regulation of gene expression and the control of development and ultimately, how the genetic potential of an individual is expressed in the formation of diverse phenotypes. Knowledge of these processes will underpin future genomics research and its application in medicine, animal breeding and the preservation of functional variation in domestic and wild species.

Acknowledgement

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References


Introduction

Reducing methane production in the ruminant livestock industries is essential in reducing GHG emissions. Methane production (MPR) in cattle is heritable but is correlated with feed intake (DMI), growth and production traits (Donoghue et al. 2016). To overcome this methane yield (MY, methane production per unit of feed intake) and residual methane production (methane production net of expected methane production from DMI) were identified as preferable traits for selection. Most of the research has been conducted on cattle fed a restricted feed intake when measuring MPR in respiration chambers. Alternative methods which can be used in conjunction with either ad libitum or restricted feeding are now available, and include measurement of several short-term fluxes in methane and carbon dioxide which can then be averaged to produce daily MPR and carbon dioxide production rate (CPR). The objective of this study was to estimate phenotypic correlations between methane traits in cattle on an ad libitum roughage diet.

Materials and Methods

The heifers used for this project were from two Angus research herds (Autumn and Spring calving) located at the Trangie Agricultural Research Centre, NSW, Australia. A total of 135 heifers born in 2014 were raised on pasture until methane testing at approximately yearling age (371d). Methane production (MPR), carbon dioxide production (CPR) and feed intake (dry matter intake, DMI) were measured in a yard using GreenFeed Emission Monitoring (GEM, by C-Lock Inc., Rapid City, SD, USA) units and automated feed intake recorder units. The GEM units provide several short-term fluxes in methane and carbon dioxide which can then be averaged to produce daily MPR and carbon dioxide production rate (CPR). Heifers were stratified by sire into contemporary groups comprising 20 animals per group for methane testing and were weighed every 7 days. Each group underwent a 21 day adjustment period in the prior to the commencement of the methane test (duration 14 to 15 days). During the adjustment and test period, the heifers had ad libitum access to a commercial lucerne and oaten chaff mix, which comprised 88.8% Dry Matter (DM) and 9.7 MJ ME/kg DM. Individual chaff consumption was recorded with automated feed intake machines. Two automated feeders were allocated to each contemporary group and only one animal could access a feeder at a time. One GEM machine was allocated to each contemporary group and these machines administered a pelletized supplement which comprised 91.5% DM and 13.3 MJ ME/kg DM. GEM machines were programmed to deliver 5 feeds per head/day and the cattle consumed on average 1.0 kg pellet DM/day. A detailed description of GEM machine operation is provided by Hammond et al. (2016) Records on 119 heifers which had 30 or more valid records from the GEM units were used for analyses.

Table 1 outlines the traits used for analyses and how they were calculated. Mid weight (MIDWT) was derived from non-fasted live weights taken at the beginning and end of the methane test period. The adjusted dry matter intake (DMIadj) was the total metabolizable energy (ME) of pellets and chaff consumed per day standardised to 10 MJ ME. The model used to derive phenotypic correlations between methane traits included, age at the start of the test as a covariate and contemporary group as a fixed effect.

Results and Discussion

Carbon dioxide production had a strong positive correlation with MPR and DMI, $r_p = 0.78$ and 0.59 respectively and were higher than estimates reported by Herd et al. (2016) for cattle on a high grain feedlot ration (Table 2). A weaker association between CPR and RMPDMI ($r_p = 0.39$) was obtained in this study compared to those published by Herd et al. (2016). Strong positive correlations were obtained between CPR, MI and RMPMIDWT traits, but CRP was not correlated with MY.

Methane yield was moderate to strongly negatively correlated with DMI ($r_p = -0.63$) and had a low association with MPR ($r_p = 0.12$). These results differ from estimates derived on restricted roughage diets for MY: (MY with DMI $r_p = -0.01$; MY with MPR $r_p = 0.68$) reported by Donoghue et al. (2016) and Herd et al. (2014). Herd et al. (2016) reported R-square values for feedlot cattle, between MY and DMI, but did not indicate whether it was a negative or positive association. The correlation obtained between MY and MI...
was considerably lower ($r_p = 0.36$) than the estimate ($r_p = 0.89$) reported for restricted roughage by Donoghue et al. (2013).

Methane production had a moderate to strong correlation with DMI ($r_p = 0.68$) and the four RMP traits ($r_p = 0.63$ to 0.67). The association between MPR and DMI and the RMP traits were similar in magnitude to estimates reported by Herd et al. (2014) and Donoghue et al. (2016) on restricted roughage diets.

The low correlation between MPR and MY and the strong negative correlation between MY and DMI indicates the relationship between MPR and DMI, while linear under restricted feeding, may be curvilinear under ad libitum feeding. A negative correlation between MPR and feeding level was also reported by Blaxter and Clapperton (1965), where intake was above maintenance requirements. The total amount of MPR will increase as feed intake increases, but MPR/unit of feed consumed reduces with increasing feed levels (Blaxter and Clapperton 1965). Feed quality (digestibility) was also reported to affect MPR, with highly digestible feed having a similar relationship for ad libitum intake, with a reduction in MPR/MJ of feed consumed (Blaxter and Clapperton 1965).

There were strong positive correlations between RMP\textsubscript{WT} traits and MI ($r_p = 0.90$) and RMP\textsubscript{DMI} traits ($r_p = 0.78$), but a lower association was found between RMP\textsubscript{MIDWT} and MY.

The results of this preliminary study where cattle were fed ad libitum roughage diet, were similar to those reported for cattle under restricted roughage feeding in respiration chambers. However the relationship between MPR and DMI under ad libitum feeding may not be linear as has been observed under restricted feeding.

**Acknowledgement**

This research was funded NSW Department of Primary Industries, University of New England, Meat and Livestock Australia and the Australian government, as part of the National Livestock Methane Program. Technical support provided by David Mula, Glen Walker, Chris Weber and Karen Dibley is gratefully acknowledged.

**References**


Table 1. Definition of traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Abbreviation</th>
<th>Units</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid weight</td>
<td>MIDWT</td>
<td>kg</td>
<td>Average weight during test period, (start and end weight/2)</td>
</tr>
<tr>
<td>Metabolic weight</td>
<td>METWT</td>
<td>kg</td>
<td>MIDWT\textsuperscript{0.75}</td>
</tr>
<tr>
<td>Methane production</td>
<td>MPR</td>
<td>g/day</td>
<td>Average methane produced per day</td>
</tr>
<tr>
<td>CO\textsubscript{2} production</td>
<td>CPR</td>
<td>g/day</td>
<td>Average carbon-dioxide produced per day</td>
</tr>
<tr>
<td>Feed intake</td>
<td>DMI</td>
<td>kg/day</td>
<td>Average dry matter of feed consumed per day(chaff and pellets)</td>
</tr>
<tr>
<td>Standardised DMI</td>
<td>DMI\textsubscript{10}</td>
<td>kg/day</td>
<td>DMI standardised to 10 MJ metabolizable energy</td>
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<tr>
<td>Methane intensity</td>
<td>MI</td>
<td>g/kg</td>
<td>MPR per kg of weight (MPR/MIDWT)</td>
</tr>
<tr>
<td>Methane yield</td>
<td>MY</td>
<td>g/kg</td>
<td>MPR per unit DMI (MPR/DMI)</td>
</tr>
<tr>
<td>Residual methane\textsubscript{DMI}</td>
<td>RMP\textsubscript{DMI}</td>
<td>g/day</td>
<td>MPR net of expected, obtained by regression of MPR on DMI</td>
</tr>
<tr>
<td>Residual methane\textsubscript{DMI10}</td>
<td>RMP\textsubscript{DMI10}</td>
<td>g/day</td>
<td>MPR net of expected, obtained by regression of MPR on DMI\textsubscript{10}</td>
</tr>
<tr>
<td>Residual methane\textsubscript{MIDWT}</td>
<td>RMP\textsubscript{MIDWT}</td>
<td>g/day</td>
<td>MPR net of expected, obtained by regression of MPR on MIDWT</td>
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<tr>
<td>Residual methane\textsubscript{METWT}</td>
<td>RMP\textsubscript{METWT}</td>
<td>g/day</td>
<td>MPR net of expected, obtained by regression of MPR on METWT</td>
</tr>
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</table>

Table 2. Phenotypic correlations between methane traits derived from heifers on an ad libitum roughage diet

<table>
<thead>
<tr>
<th>Trait</th>
<th>MPR</th>
<th>CPR</th>
<th>DMI</th>
<th>DMI\textsubscript{10}</th>
<th>MI</th>
<th>MY</th>
<th>RMP\textsubscript{DMI}</th>
<th>RMP\textsubscript{DMI10}</th>
<th>RMP\textsubscript{MIDWT}</th>
<th>RMP\textsubscript{METWT}</th>
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<tbody>
<tr>
<td>CPR</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI</td>
<td>0.68</td>
<td>0.59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI\textsubscript{10}</td>
<td>0.66</td>
<td>0.61</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>0.60</td>
<td>0.28</td>
<td>0.20</td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>MY</td>
<td>0.12</td>
<td>0.01</td>
<td>-0.63</td>
<td>-0.61</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMP\textsubscript{DMI}</td>
<td>0.63</td>
<td>0.39</td>
<td>0.00</td>
<td>0.01</td>
<td>0.63</td>
<td>0.65</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>RMP\textsubscript{DMI10}</td>
<td>0.63</td>
<td>0.39</td>
<td>0.01</td>
<td>0.00</td>
<td>0.62</td>
<td>0.64</td>
<td>0.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMP\textsubscript{MIDWT}</td>
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<td>0.42</td>
<td>0.31</td>
<td>0.30</td>
<td>0.90</td>
<td>0.29</td>
<td>0.78</td>
<td>0.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMP\textsubscript{METWT}</td>
<td>0.67</td>
<td>0.42</td>
<td>0.30</td>
<td>0.29</td>
<td>0.90</td>
<td>0.30</td>
<td>0.78</td>
<td>0.77</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>
Effect of ensiled crimped grape marc on growth performance and methane emissions of Angus steers

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Summary
The effect of ensiled crimped grape marc (ECGM) on growth performance and methane (CH4) emissions of beef cattle was examined. Twenty steers (390.3 ± 38.09 kg initial BW) were used in a completely-randomised design to test two diets: control and grape (GP; 30% of ECGM on DM basis). The final BW was 5% greater for steers fed the control diet than those fed GP diet (P < 0.01), but there were no differences between diets in average daily gain (ADG). Steers fed GP had higher DM intake (P < 0.01) and feed:gain (P = 0.02). There were no differences between diets in CH4 per kg final BW, CH4 per kg ADG and CH4 per kg of DM intake, however daily CH4 was lower for GP group (P < 0.01). In conclusion, ECGM reduced total daily methane output but not methane intensity, presumably due to a reduction in energy availability.

Introduction
Strategies to reduce methane emissions from beef cattle have a two-fold benefit, as high emissions not only incur an environmental impact, but also represent an energy loss to the animal. Modulating feeding regimes using primary and secondary compounds has been investigated to reduce the CH4 output of ruminants. Grape marc is the residue from wine making and consists of grape seeds and skins. Grape seeds and skins contain high levels of condensed tannins which has raised interest around the use of grape marc as a greenhouse gas reducing supplement. To further increase the nutritional value through particle breakdown and release of seed lipids, grape marc is milled to produce crimped grape marc, and can be ensiled to improve the storage characteristics. The objective of the current study was to evaluate the effect of ensiled crimped grape marc (ECGM) on growth performance and methane (CH4) emissions of beef cattle fed a roughage-based diet.

Materials and Methods
Crimped grape marc was obtained (Tarac Technologies Pty. Ltd., Nuriootpa, SA, Australia) and unloaded into a bay with concrete floor and sides, pushed-up and compacted with a loader. The compacted heap was then covered with a double layer silage pit cover (150 µm thick) and ensiled for 4 months before being fed, at which point the moisture content was 48.2%.

Twenty pure Angus steers (390.3 ± 38.09 kg initial BW; 14 months of age) were used in a completely-randomised design, to test two diets: control (10% oaten chaff and 90% chaff pellet) and grape (GP; 10% oaten chaff, 60% chaff pellet and 30% ECGM; containing 3% condensed tannins in the total mixed ration on DM basis). Steers were allocated to the treatments based on initial BW. Steers were housed in group pens for a four-day adaptation period, where they were fed twice daily to promote ad libitum intake. Feed refusals were collected every 2 days. Two (5th day) and four steers (13th and 21st day) of each treatment were allocated to individual pens (12m² each) and the remainder were housed in treatment-specific group-pens (75m² each). Over the next 24 days steers were moved between individual and group pens every 8 days, thereby allowing individual DM intake to be taken for each individual. Daily feed refusals were collected from both individual and group pens. Subsamples of refusals was taken at 5% and stored. Daily average DM intake was calculated for steers in group pens. After 24 days of individual and group measurements, steers were group-housed according to their treatment and fed for a further 13 days (refusals were not measured). Composite samples of total diets, refusals and ingredients were analysed for DM (AOAC, 1995). Body weight was measured four times during the trial and used to calculate average daily gain by linear regression (Ferreiro and Preston 1976).

Methane emission was measured using two portable, automated, open-circuit gas quantification systems (GQS; Greenfeed, C-Lock Inc., Rapid City, SD, USA). Oaten chaff pellets were provided via the GQS and the intake was accounted for daily DM intake. Each steer was allowed to visit the machine every 2 hours, with a maximum of 12 visits per day (total allowance of 4.8 kg of chaff pellet). One GQS unit was placed in an individual pen for one day and moved daily to the next pen whilst the second GQS unit was placed in a group pen and moved every two days to the next group pen, allowing measurements of both treatments in the same day and every animal in individual and group pens by the end of the trial. In total, gas measurements were taken for 40 days (one missing day data) including the adaptation period. CH4 and CO2 measurements were averaged to provide a daily figure for each animal.

Methane and growth performance data were analysed using the MIXED procedure (SAS Inst. Inc., Cary, NC). Initial BW (covariate) and diets (control vs GP) were considered a fixed effect and animal was the experimental unit. Animal and day were included as random effects for DM intake, daily CH4 and CH4 when expressed per kg of DM intake. Treatment means were determined using LSMEANS. Pairwise tests for fixed effects with P ≤ 0.05 were considered significant.

Results
Initial BW was the same for both treatments (Table 1). The final BW was 5% greater for steers fed the control diet than those fed GP diet (P < 0.01), but there were no differences between diets in average daily gain (ADG). Steers fed GP diet
had greater DM intake ($P < 0.01$) and feed:gain ($P = 0.02$) than those fed the control diet.

Daily CH$_4$ output was 14% lower ($P < 0.01$) for steers fed GP diet although no differences were found between treatments when CH$_4$ emissions were expressed per kg final BW, kg average daily gain and kg of DM intake.

Table 1. Effect of grape diet (GP) containing 30% ensiled crimped grape marc on performance and methane emissions of Angus steers.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>GP</th>
<th>SEM</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial BW (kg)</td>
<td>390.3</td>
<td>390.3</td>
<td>12.37</td>
<td>0.99</td>
</tr>
<tr>
<td>Final BW (kg)</td>
<td>443.5</td>
<td>424.0</td>
<td>3.01</td>
<td>$&lt; 0.01$</td>
</tr>
<tr>
<td>ADG (kg)</td>
<td>1.758</td>
<td>1.600</td>
<td>0.07</td>
<td>0.14</td>
</tr>
<tr>
<td>DM intake (kg/day)</td>
<td>11.81</td>
<td>12.29</td>
<td>0.30</td>
<td>$&lt; 0.01$</td>
</tr>
<tr>
<td>Feed:Gain (g/kg ADG)</td>
<td>6.81</td>
<td>7.88</td>
<td>0.29</td>
<td>0.02</td>
</tr>
<tr>
<td>CH$_4$ (g/kg final BW)</td>
<td>236.9</td>
<td>204.2</td>
<td>9.35</td>
<td>0.01</td>
</tr>
<tr>
<td>CH$_4$ (g/kg ADG)</td>
<td>0.516</td>
<td>0.503</td>
<td>0.02</td>
<td>0.67</td>
</tr>
<tr>
<td>CH$_4$ (g/kg DMI)</td>
<td>130.63</td>
<td>135.03</td>
<td>6.46</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Discussion

The high condensed tannins level in the GP diet may have contributed to reduced digestibility of the fibre (Orlandi et al. 2015) and protein components of the ration (Carulla et al. 2005; Grainger et al. 2009). Khiosa-ard et al. (2015) tested diets containing dried distillers grains plus solubles fortified with grape seed meal. These authors observed that the inclusion of grape seed meal decreased the DM and organic matter degradation linearly via depression of non-fibre carbohydrate degradation. Grainger et al. (2009) found that cows in a grazing system supplemented with cracked triticale grain decreased milk yield by 3.6 and 9.7% when fed moderate and high doses (163 and 326 g, respectively) of condensed tannins. Cows produced 14 and 29% less CH$_4$ per day, and 10 and 22% less CH$_4$ yield (g/kg DM intake) when moderate and high doses of condensed tannins were supplied, but there was no effect on CH$_4$ emissions in g/kg fat plus protein yield. Moate et al. (2014) used ensiled and dried grape marc to replace 5 kg of alfalfa hay in the diet of dairy cattle, and reported no difference in DM intake, but cows fed ensiled grape marc produced less milk and lower protein and lactose yield than cows fed control or dried grape marc. Landau et al. (2000) suggested a reduction of DM intake of dairy heifers when 5% of condensed tannins (Aspidosperma quebracho) was used. Conversely, Orlandi et al. (2015) found that inclusions of tannin up to 1.8% of DM (Acacia mearnsii) improved the amino acids supply with no difference in total OM digestibility. The effect of tannins will depend on the type of polyphenolics, their level in the ration, the level of crude protein in the ration, and the level of animal production (Grainger et al. 2009). In the current study, the greater DM intake from steers fed 30% ECGM was not sufficient to enable the animals to achieve the same final BW as their control-fed counterparts, so the feed conversion ratio was higher for the GP group. Moate et al. (2014) observed lower daily CH$_4$ emissions and CH$_4$ yield (g/kg DM intake) for cows fed dried and ensiled grape marc compared to control, however the lowest value was observed for dried grape marc. These authors also found that CH$_4$ intensity (g/kg of milk) was reduced when cows were fed dried grape marc, but no difference existed between ensiled grape marc and control treatments.

Inclusion of grape marc at 30% of cattle rations reduced growth efficiency. Grape marc reduced daily methane emissions probably as a consequence of its low energy content and high level of condensed tannins but did not reduce methane intensity under the conditions of this trial.

Acknowledgement

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References


Including biserrula chaff in the diet of sheep reduced methane yield on the basis of energy intake

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Summary
The legume biserrula has the potential to reduce methane emissions when included in extensive sheep grazing systems. We tested the hypotheses that increasing biserrula in the diet of sheep reduces acetate: propionate in rumen fluid and decreases methane yield (g methane/intake) from sheep. Merino wethers (n = 41) were fed one of four treatments with varying proportions of chopped biserrula and annual ryegrass at 1.4 times maintenance requirements for 38 days. Daily feed intake, live weight change and 23h methane production in respiration chambers were measured. Rumen fluid was collected two hours after feeding and nutritive values of the chaff were determined by near-infrared spectroscopy supported by wet chemistry analysis. As biserrula in the diet increased acetate: propionate decreased, methane production decreased and methane yield decreased on the basis of metabolisable energy and gross energy intake with intermediate effects from the proportions of biserrula in the diet (P<0.05).

Introduction
Biserrula (Biserrula pelecinus L.) is a legume with potential to be included in extensive sheep grazing systems to reduce methane production (methane/day) and methane yield (methane/intake). The effect may result from a shift in microbial populations which favours the formation of propionate and represents a competitive pathway for the utilisation of hydrogen in the rumen (George et al., 2008). Therefore, an increase in the proportion of propionate in the rumen will reduce methane production. We tested the hypotheses that increasing biserrula in the diet of sheep reduces acetate: propionate in rumen fluid and decreases methane yield (g methane/intake) from sheep.

Materials and Methods
Merino wethers (n = 41) were fed one of four treatments with varying proportions of chopped biserrula (9.4MJ ME, 40% NDF, 27% ADF, 14.5% CP) and annual ryegrass (Lolium rigidum cv. robust) (7.2MJ ME, 64% NDF, 35% ADF, 7.5% CP) at 1.4 times their metabolisable energy requirement for maintenance for 38 days. Daily feed intake and live weight change were measured, and 23h methane production in respiration chambers. Rumen fluid was collected two hours after feeding through a stomach/oesophageal tube using an electrical vacuum pump. The liquid portion was used to determine volatile fatty acid concentrations as described by Durmic et al (2010). Nutritive values of the chaff were determined by near-infrared spectroscopy supported by wet chemistry analysis (CSIRO, Floreat).

Statistical analysis
All statistical analyses were performed using GenStat (VSN International, 2012). Effects of treatments on feed intakes, live weights, rumen samples, and methane production were assessed using Restricted Maximum Likelihood (REML) with methane production and yield fitted as fixed effects and methane measurement day, chamber number, and sire fitted as random effects. Methane yield was calculated from feed intake in the 24 hours prior to and on the day of methane measurement.

Results and Discussion
In general, as the proportion of biserrula in the diet increased acetate: propionate decreased and methane production decreased (P<0.05) (Table 1). Biserrula reduced (P<0.05) methane yield on the basis of metabolisable energy and gross energy intake with intermediate effects from the proportions of biserrula in the diet. There was no difference (P = 0.20) in methane yield between biserrula and ryegrass groups on the basis of dry matter intakes. Therefore, my hypothesis was partially accepted as increasing biserrula in the diet of sheep did not reduce methane yield on the basis of dry matter intake, yet did reduce methane yield on the basis of metabolisable energy and gross energy intake. The main driver of methane production were the fibre fractions of the diet, including intakes of neutral detergent fibre and acid detergent fibre (36% and 36% of variance in methane production explained, respectively). Decreasing intakes of fibre reduced acetate: propionate (44% of variance accounted for). This work supports Banik et al (2013) who demonstrated in batch cultures that biserrula consistently reduced acetate to propionate ratios and methane yield in comparison to a range of commercial pasture species in Australia.

Conclusion
In conclusion, my hypothesis was partially accepted as increasing biserrula in the diet of sheep did not reduce methane yield on the basis of dry matter intake, yet did reduce methane yield on the basis of metabolisable energy and gross energy intake. Furthermore, there was no treatment effect over and above percentage of fibre fractions on methane, and therefore the fibre content of biserrula needs to be further investigated. The inability of dried biserrula to significantly reduce methane yield suggest that volatile compounds disappeared due to the conversion of biserrula into hay. Further research is needed to test the ability of green biserrula in reducing methane yield from...
sheep in mixed diets as biserrula in the green state appears to be more anti-methanogenic and could help reduce methane emissions in the agricultural sector. Nevertheless, the potential whole farm impacts of feeding biserrula to reduce emissions from sheep appear to be much less than originally thought. This is because the anti-methanogenic effect appears to be evident only when utilised in the green state, and biserrula is more likely to be fed as dried pasture during summer and autumn feed gap.

Table 1. Mean methane production and methane yield for sheep fed 100% ryegrass (RG 100%), 67% ryegrass 33% biserrula (RG 67% B 33%), 33% ryegrass 67% biserrula (RG 33% B 67%) and 100% biserrula (B 100%). Dry matter intake (DMI), metabolisable energy intake (MEI), gross energy intake (GEI).

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>RG 100%</th>
<th>RG 67% B 33%</th>
<th>RG 33% B 67%</th>
<th>B 100%</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter intake (as fed g/day)</td>
<td>986 (^{ab})</td>
<td>1025 (^{a})</td>
<td>934 (^{b})</td>
<td>833 (^{c})</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Average live weight gain (g/day)</td>
<td>15 (^{a})</td>
<td>57 (^{b})</td>
<td>43 (^{b})</td>
<td>44 (^{b})</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Total volatile fatty acids (mmol/L)</td>
<td>52 (^{a})</td>
<td>67 (^{b})</td>
<td>78 (^{c})</td>
<td>76 (^{c})</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Acetate : Propionate</td>
<td>4.2 (^{a})</td>
<td>3.8 (^{ab})</td>
<td>3.4 (^{bc})</td>
<td>2.9 (^{c})</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Methane production (g/day)</td>
<td>10.5 (^{a})</td>
<td>9.9 (^{ab})</td>
<td>8.7 (^{ab})</td>
<td>8.4 (^{b})</td>
<td>0.05</td>
</tr>
<tr>
<td>Methane yield (g/day) /kg DMI</td>
<td>12.3 (^{a})</td>
<td>10.4 (^{a})</td>
<td>10.0 (^{a})</td>
<td>10.5 (^{a})</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Methane yield (g/day) /MJ MEI</td>
<td>1.8 (^{a})</td>
<td>1.4 (^{b})</td>
<td>1.1 (^{bc})</td>
<td>1.0 (^{c})</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Methane yield (g/day) /MJ GEI</td>
<td>0.67 (^{a})</td>
<td>0.67 (^{a})</td>
<td>0.51 (^{ab})</td>
<td>0.49 (^{b})</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Acknowledgement

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References


Assessing the biodiversity of kikuyu grass genotypes: Growth and forage quality
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Summary

Kikuyu grass (*Pennisetum clandestinum*) is adapted to climates from warm temperate to tropical and is the second most important grass for dairy production in Australia after ryegrass. Kikuyu has the capability of supporting high stocking rates and milk production per hectare (Reeves et al. 1996). The milk production potential could be greatly enhanced by selecting superior ecotypes that are resistant to kikuyu yellows (*Verrucalvus flavofaciens*), a fungal disease, are more highly digestible, and are tolerant to cool temperatures. A trial to evaluate kikuyu ecotypes that had potential for winter growth commenced with 1600 genetically diverse potted plants which originated from collections across Queensland and NSW. Plant numbers were reduced to 100, based on plant vigour, for screening of summer and winter growth, maturation, growth habit, neutral detergent fibre (NDF) content and indigestible NDF (iNDF) content. It was found that some of the lines of kikuyu grass can perform extremely well at lower temperatures but the top five DM yield producers had higher NDF and iNDF contents. The taller the plants, the more NDF and iNDF was laid down, and as a result the digestibility would decrease. Thus vigour was inversely proportional to digestive quality.

Introduction

Kikuyu grass (*Pennisetum clandestinum*) is a perennial C4 grass that has become naturalised along the entire east coast of Australia, from the Atherton Tablelands to eastern Victoria, and it is also found in irrigated dairy pastures in Western Australia. Kikuyu grass comprises the most predominant pasture species during the summer and autumn in coastal zones of Queensland, and New South Wales (Garcia et al. 2014). Kikuyu pasture has a dense rooting system, high yield potential, persistence, and is resistant to trampling (Garcia et al. 2014). During the summer this pasture can present vigorous growth, which can lead to high yields under adequate soil nitrogen levels (Reeves et al. 1996). However, milk production/cow from kikuyu pasture is relatively low in comparison to temperate spp. such as ryegrass (*Lolium* spp.). This is related to its low nutritive value although it can support higher stocking rates and milk production per hectare (Reeves et al. 1996; Reeves and Fulkerson 1996; Marais 2001; Garcia 2014). The production potential of kikuyu grass could be greatly enhanced by selecting superior plants that are resistant to kikuyu yellows, a debilitating fungal infection (*Verrucalvas flavofaciens*) which can destroy whole swards, highly digestible, and cold temperature tolerant agents. Plants were maintained by cutting to 5 cm every 6 weeks and fertilized with all purpose Osmocote® at the recommended level to maintain DM production. These plants were culled back to a more manageable 100, based on lack of vigour and poor plant health and were then accessed for quality (iNDF and NDF), winter activity and resistance to kikuyu yellow disease. This paper reports the results of screening for winter activity and the associated nutritive value.

A 35 day experiment commenced in May with kikuyu plants at around the 4 leaf/stolon stage (Reeves et al. 1996), being assessed for growth stage, height and then harvested to measure DM production. The plant material for each pot was used to determine the iNDF and NDF content. Forage samples were analysed for iNDF, using long term (10 day) in vitro fermentation. This procedure is based on a fermentation procedure described by Goering and Van Soest (1970), adapted for the use with Ankom filter bags. NDF content was determined using the procedure described by Goering and Van Soest (1970) and adapted for an Ankom fibre analyser.

Results and discussion

The optimum temperature for kikuyu plant growth is considered to be between 16°C and 21°C (Marais 2001) and although the majority of ecotypes evaluated grew slowly at lower temperatures, some ecotypes had higher growth rates under the cooler autumn temperatures of May (Min 1.5°C and Max 16.5°C). The top five cooler temperature growing plants produced on average 13.74 g of DM/plant compared to the overall average of 8.08 g of DM (Table 1).

The 4.5-leaf stage is considered optimum period to defoliate kikuyu (Reeves et al. 1996) both in terms of regrowth and quality of forage (Reeves & Fulkerson 1996). The five- plants were taller and had a higher content of NDF and iNDF. These higher NDF results were not unexpected as other studies

Methodology

The study commenced with 1600 potted kikuyu plants (10 cm in diameter) at Queensland Animal Science Precinct (QASP), Gatton Campus, the University of Queensland. These plants originated from genetically diverse kikuyu collections which had included 2000 plants located at the Gatton Campus of the University of Queensland (plants originated from DAQ12470 - ecotypes collected by Mr K. Lowe and from DAN063 developed at Wollongbar Agricultural institute on the North coast of NSW) as well as 250 ecotypes held at Camden and selected throughout NSW by Dr P. Martin. These plants had variations in genotype due to the collection from contrasting environments as well as the result of exposure to mutagenic

Goering and Van Soest (1970), adapted for the use with Ankom filter bags. NDF and iNDF were determined using an Ankom fibre analyser.
(Marais 2001) have shown that lower temperature slows growth of kikuyu plants and improved digestibility. It therefore follows that a faster growing plant, perhaps regardless of environmental temperature, will lay down more NDF (and iNDF) because of the need to maintain structural integrity. The overall NDF content of the plants with higher cool temperature growth rate were on average 62.9% compared with the overall population average of 62.3%. These values are similar to other studies (Lowe et al. 2010; Garcia et al. 2014). Fulkerson et al. (1998) also found similar NDF values (60%) in kikuyu growing during the summer growing season and 40% from plants grown in winter. In terms of iNDF content the results are similar to NDF - the top five highest yielding plants over the cooler season also had the highest iNDF. As high iNDF has been shown to be related to the digestibility of fibre associated with low metabolizable energy content (Nousianen et al. 2003) and lower feed intake (Lippke 1986). Therefore, this negative relationship between growth and quality appears unavoidable.

Table 1: Performance of five kikuyu plants with the highest dry matter yields in the May growth trial and associated NDF and iNDF content.

<table>
<thead>
<tr>
<th>ID</th>
<th>Ht (cm)</th>
<th>Leaf/stolon</th>
<th>DM (g)</th>
<th>NDF (%)</th>
<th>iNDF (%)</th>
<th>iNDF/NDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>18c</td>
<td>27</td>
<td>4</td>
<td>16.6</td>
<td>70.1</td>
<td>24.2</td>
<td>34.4</td>
</tr>
<tr>
<td>15b</td>
<td>30</td>
<td>5.5</td>
<td>13.3</td>
<td>60.3</td>
<td>18.6</td>
<td>30.8</td>
</tr>
<tr>
<td>20c</td>
<td>30</td>
<td>5</td>
<td>13.2</td>
<td>60.9</td>
<td>18.2</td>
<td>29.8</td>
</tr>
<tr>
<td>25c</td>
<td>22</td>
<td>5</td>
<td>13.1</td>
<td>60.9</td>
<td>18.2</td>
<td>29.8</td>
</tr>
<tr>
<td>11d</td>
<td>23</td>
<td>5.5</td>
<td>12.5</td>
<td>62.6</td>
<td>22.1</td>
<td>35.4</td>
</tr>
</tbody>
</table>

Conclusion

Some kikuyu plants grew well at lower temperatures, but their NDF and iNDF was higher in comparison to the lower yielding plants. The taller the plants, the more NDF was laid down, and as a result the digestibility decreases. An ecotype that still grows effectively over winter but exhibits moderate to low iNDF levels would be ideal.

Acknowledgment

The authors appreciate the financial support provided by Dairy Australia at Gatton and of the support provided by the dairy DAF team, and the Dairy Industry group in NSW.

References

Importance of ewe and cow body condition in breeding programs

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Summary
Producers have the potential to improve both the welfare and productivity of sheep and cattle production systems by including body condition score (BCS) in the breeding program. The value of recording BCS is greatest in the breeding dam, with low BCS associated with poor reproduction and health. However, the value of BCS in breeding programs is not found in the weak positive genetic association with reproduction but because selection for BCS will improve the dam’s ability to maintain condition throughout the production cycle and allow her to express her full genetic potential for reproduction.

Introduction
The welfare of production animals is becoming increasingly important to the consumer and while producers receive few direct financial incentives to improve welfare there is value in incorporating welfare traits in the breeding objectives. As financial benefits for improving welfare traits will be achieved indirectly, breeding programs need to maintain a focus on productivity whilst improving welfare traits or at a minimum avoid inadvertently breeding for animals that are not robust enough to survive in the production system. Body condition score (BCS) is a welfare trait which has minimal financial incentives associated with it, but by optimising BCS producers are likely to see improvements in reproduction and reduced the costs associated with feeding and replacing breeding stock (Curnow \textit{et al.} 2011). This paper explores both the value and potential to incorporate welfare traits in sheep and cattle breeding programs, using BCS as an example welfare trait.

Body Condition Score Definition
Body condition score provides an indication of the animal’s energy balance or body reserves and through regular measurement of BCS producers can get a clear and reliable indication of the impact that environmental or health stressors are having on the flock and/or animal’s health and wellbeing (Curnow \textit{et al.} 2011). BCS in sheep is a subjective measure of fat and muscle coverage over the anterior lumbar vertebrae and is commonly scored on a 1 to 5 scale (Russel \textit{et al.} 1969). The scoring of BCS in southern cattle is assessed on a 1–5 scale, and refers to the cover of fat over the spinous processes or short ribs and around the tail head (Graham 2006). In northern cattle BCS is a visual assessment of the overall energy balance of the cow based on fat and muscle coverage (Blackwood \textit{et al.} 2013).

Heritability of Body Condition Score in Mature Dams
Ewe BCS has been estimated to be lowly to moderately heritable in Merino (0.08 to 0.11; Walkom \textit{et al.} 2014b), first cross Merino (0.21 to 0.26; Walkom \textit{et al.} 2014a, 0.15; Walkom and Brown 2016), maternal breeds (0.17; Walkom 2015a, 0.21 to 0.30; Shackell \textit{et al.} 2011,) and Scottish Blackface ewes (0.15 to 0.21; Walkom 2014). The heritability of BCS in tropical cows ranges from 0.27 to 0.48 in Brahman and 0.25 to 0.32 in tropical composites (Wolcott \textit{et al.} 2014). In Angus and Hereford cows the heritability of BCS ranged from 0.14 to 0.22 and 0.20 to 0.37, respectively (Donoghue \textit{et al.} 2016).

BCS measurements across the production cycle have been reported to be highly genetically correlated and can be considered the same trait across ages in sheep (Shackell \textit{et al.}, 2011, Walkom \textit{et al.} 2014a, b, Walkom and Brown 2016). Moderate to strong genetic correlation between BCS measurements across the mating lifetime of the cow have been observed in southern cattle \((r_g=0.29\) to 0.99) (Donoghue \textit{et al.} 2016) and tropical cattle \((r_g=0.46)\) (Wolcott \textit{et al.} 2014a).

Genetic Relationships between BCS and Production
Adult BCS is moderately to strongly positively genetically correlated with weight (Walkom \textit{et al.} 2014a, b, Walkom and Brown 2016), fat and muscle depth at the post-weaning stage (Walkom \textit{et al.} 2015a) and on the carcase (Walkom and Brown 2016). Moderate positive genetic correlations were observed in Brahman and Tropical composite cattle for heifer BCS (0.65, 0.56) and rump fat (0.54, 0.41) with the BCS of mature cows entering their second annual mating period (Wolcott \textit{et al.} 2014b). The strength of the correlations indicate that BCS and its component traits (muscle and fat depth) are moderately to strongly genetically correlated throughout the animal’s life (across ages).

Predicted responses for MERINOSELECT indexes suggest that selection on current indexes are likely to have a small positive influence (average increase of 0.10 scores after 10 years) on mature ewe BCS (Walkom and Brown 2014). The genetic correlations for BCS with fleece weight, staple strength and length and fibre diameter are low to moderately positive (Walkom and Brown 2016).

Genetic Relationships between BCS and Reproduction
The important phenotypic relationship between body condition and reproduction is widely quoted within the sheep industry. Lifetime Wool guidelines recommend a midrange condition score at mating and lambing to improve maternal performance (Curnow \textit{et al.} 2011; Edwards \textit{et al.} 2011).

The genetic relationship between ewe body condition and reproduction is, however, poorly reported in literature. In maternal composite ewes the genetic correlation between
adult ewe BCS and number of lambs weaned (NLW) across multiple parities was estimated at -0.17 (Walkom et al. 2015). Walkom and Brown (2016) presented estimates in Merino and first cross Merino ewes with genetic correlations of 0.30 and -0.03 for BCS with number of lambs born and NLW, respectively. In a study of Scottish Black Face ewes the genetic correlation for mating BCS with NLW ranged from -0.03 to 0.45 across the ewe’s first four mating opportunities (Walkom 2014). In Brahmans, the BCS of heifers was favourably genetically correlated with weaning rates at first (0.08) and second mating (0.12) (Wolcott et al. 2014b). Genetic correlations for cow mating BCS with weaning rate at their second mating were 0.35 and 0.11 in Brahmans and tropical composites, respectively (Wolcott et al. 2014b). The overall genetic relationship between BCS and reproduction is positive but weak.

Valuing Body Condition

The importance of BCS in breeding dams as a welfare trait (Walkom and Brown 2014) and in turn its association with reproduction is based on the principle that animals in optimum condition are in a physiological state where the energy requirements for maintenance are being met and the animal has enough energy to continue to grow, reproduce, lactate or produce a fleece. Below optimum BCS is associated in its extreme with death due to malnutrition and at lesser levels associated with reduced reproduction and productivity. Producers who need to increase dam BCS will be forced to either reduce stocking rates, weaning progeny early or increase supplementary feeding, all of which comes at a cost. In studies of sheep (Walkom et al. 2016) and southern cattle (Accioly et al. 2015) it was hypothesised that the genetically fatter animals are genetically fatter at all ages and across the production cycle, have an increased appetite allowing the animals to take advantage of periods of excess feed, which provides the animal with greater energy reserves to rely upon and because they consume fat reserves at the same rate, will require less supplementary feeding during “tough” times and avoid the unfavourable phenotypic influence of low BCS on reproduction.

Excessive condition is a key indicator of inefficiencies within the production system. Animals in above optimum BCS are storing excess energy as fat which can lead to carcase penalties in slaughter animals or potential declines in reproductive rates if the BCS become extreme (Walkom et al. 2015a). From a management point of view excess BCS is an indication of lower than desirable stocking rates and feed wastage, and hence cost.

Conclusion: Incorporating Welfare in Breeding Programs

Increasing reproductive rate is an important breeding objective. Selection on reproduction alone will lead to a breeding flock which has superior genetic potential but, due to the increased nutritional demands, is at risk of failing to fall pregnant and having reduced production lives due to an inability to restore body condition. The increased nutritional demands could be met by increasing feed on offer but this can become costly in extensive grazing systems. Therefore, the value of including mature dam BCS and or its component traits in breeding programs is not as a proxy trait for reproduction, which is reliant on at times a weak genetic association, but because its value is in improving the producers ability to optimise BCS and allow the breeding flock or herd to express their genetic potential for reproduction. BCS and reproduction should both be recorded as part of sheep and cattle breeding programs or at a minimum used as management tools to control the energy reserves of the breeding dams. Pre-mating BCS is likely to be the preferred trait in breeding programs as it provides an indication of how well the dam has recovered from the previous reproductive cycle and her preparedness for the next pregnancy.

Genetics and the formulation of breeding programs provide producers with the ability to improve or optimise the welfare of the animal whilst achieving genetic improvement in key production traits.

References


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Abstract - Pastures From Space® Plus

Pastures From Space® Plus (PFS Plus) is a tool that uses near real time satellite remote sensing technology to enable farmers to monitor pasture growth rates (PGR), green feed on offer (FOO) and the total dry matter (TDM) production on a weekly basis at the paddock level. With this information, they can optimise their pasture production and utilisation and better plan stocking rates and rotations. The pasture growth rate model was originally developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and validated in the south west of Western Australia by the Department of Agriculture and Food WA (DAFWA). Landgate is responsible for capturing and processing the satellite imagery, and integrating this with soil and climatic data to derive the PGR and FOO information.

Enhancements to the superseded PFS have been developed in conjunction with industry and have been made available via a subscription service for producers and agronomists at the paddock scale. These new enhancements include a paddock digitising tool, higher resolution satellite imagery, improved paddock charting capabilities, a paddock summary report which makes the data easier to interpret and a stocking rate calculator which removes the amount of guess work required for estimating paddock PGRs and FOOs. The new PFS Plus can be accessed at https://pfs.landgate.wa.gov.au.

The paddock digitising tool allows new subscribers to zoom into a high-resolution image of their properties and digitise their paddocks with a high level of spatial accuracy. Once all the paddocks are digitised and named, they are submitted to Landgate’s Satellite Remote Sensing Services for back-processing. This back-processing calculates paddock-averaged values of FOO, PGR, TDM, NDVI and rainfall for every week going back to 2004.

Previously, data from the Moderate-resolution Imaging Spectroradiometer (MODIS) instruments was composited on a weekly basis and integrated with climatic data to produce PGR and FOO information at a resolution of 250 m, or 6.25 ha. With the launch of Landsat 8 and the United States Geological Survey (USGS) making the data freely available, an enormous opportunity has been seized upon to provide PGR and FOO information at a resolution of just 30 m. This improved resolution allows producers to see variability within paddocks, such as which parts of a paddock are growing faster, which regions are being grazed more heavily and which areas are recovering faster post-grazing. With the imagery being updated every 16 days, it may also be possible to identify regions of a paddock that have summer weeds germinating following unseasonal summer rainfall and which areas within a paddock are suffering from poor moisture penetration/hydrophobia following the break of season. Individual Landsat 8 scenes are combined with the climatic conditions from the same day in order to make the resulting PGR imagery more sensitive to frost events than was possible with the weekly data.
Following feedback from producers, a paddock summary report was developed, making interpretation of the paddock PGR and FOO data easier. The report is updated each week and shows the paddock-averaged PGR and FOO values for each paddock and how much the detected FOO has varied since the previous week. The table can be sorted either alphabetically by paddock name or in order of increasing/decreasing PGR, FOO or change in FOO. Each paddock in the report also has a built in stocking rate calculator.

Landgate developed a stocking rate calculator application (FATstock) for Android and iOS operating systems in 2014. This technology has been adapted and integrated into the PFS Plus paddock summary report. It currently calculates one of two possible grazing outcomes – how many livestock can graze a paddock for a given number of days or how many days can a given number of livestock graze a paddock for. The stocking rate calculator removes the guess work of these calculations by incorporating the paddock area and by using the PFS Plus-calculated PGR and FOO values by default. It has the flexibility to override these values if required and also to enter the target FOO level and daily animal pasture intake.

PFS Plus includes improved charting capabilities allowing the user to compare the performance of a paddock over multiple growing seasons or to compare the performance of multiple paddocks within a growing season. The data that can be charted at the paddock level includes PGR, FOO, NDVI, TDM and rainfall. If the TDM is plotted for all years that a paddock was in pasture, this can be very useful as a predictive tool. As the growing season of interest progresses, it can be seen how that season is performing relative to all other years that the paddock was in pasture. It can also show the final outcomes of similarly performing seasons and give an expectation of the range of possible outcomes of the currently growing season. The historical TDM charts also show the range of carrying capacities that the paddock has had throughout good, average and bad growing seasons. If paddocks growing the same crop type in a given year are plotted in terms of NDVI, then this can show which of those paddocks are performing better than others and which paddocks may be struggling.

A survey was conducted comprising of producers and agronomists who had been testing the PFS Plus subscription service for 3 months. The survey revealed that 87% of those said they would recommend PFS Plus to others as they found it to be a useful tool that was easy to use. The survey also revealed that 70% of users who completed the survey agreed or strongly agreed that it will save them time operating their farm business, 82% agreed or strongly agreed that it will save/make money for the business and 94% agreed or strongly agreed that it will increase efficiencies in their business.
Preference of weaner calves for pellets is improved by inclusion of *Bacillus amyloliquefaciens* spores as an ingredient

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Summary

We investigated the preference of weaned calves for pellets formulated with or without a novel strain of *Bacillus amyloliquefaciens* (H57). Twenty dairy calves were trained over 3 days and preference tested over 7 days by monitoring the intake of a test feed relative to that of a reference feed, with each being offered *ad libitum*, in adjacent troughs per calf, for 6 hour per day, 8am - 2pm. Calves showed similar preference (0.502, P > 0.10) when –H57 pellets were offered in adjacent troughs for day 4, 5 and 6 but preferred the test +H57 pellets when offered simultaneously with the control –H57 pellets for days 7, 8 and 9 (0.671, P<0.001) and this preference rating was maintained even after –H57 pellets were sweetened with glucose powder (10% by weight) on day 10 (0.722, P<0.001). H57 spores have the potential to be used as an attractant in supplements for ruminants.

Introduction

We have previously shown that pellets formulated with *Bacillus amyloliquefaciens* H57 (H57) spores can increase dry matter intake (DMI) and growth rate of pregnant ewes and improve feed conversion and reduce the risk of diarrhoea in pre-weaned dairy calves (Le *et al.* 2016a; Le *et al.* 2016b). It was hypothesized that the greater intake was consequential to the H57 spores improving preference for pellets, and thus increase intake. This paper reports on a study to determine preference for H57 inoculated pellets by weaned dairy calves.

Materials and Methods

Feed preference was tested for 6 hour periods (8am - 2pm) daily, based on a protocol developed for weaned calves by Montoro *et al.* (2012), using twenty Holstein-Friesian calves (8 heifers and 13 bulls, mean liveweight 178 kg, aged approximately 20 weeks) over 10 days. For day 1 to 3 the calves were adapted to individual pens and offered, *ad libitum*, day and night, familiar commercial calf pellets and oaten chaff. From day 4 onwards, at the start of the 6 hour test period, all troughs were removed and a pair of clean troughs were placed in front of each calf, one contained the “test” feed and the other the “control” feed. From day 4 to 6, the test and control feeds were the same, an *ad libitum* amount of –H57 pellets, in order to determine whether the calves were selecting evenly between the two troughs. From day 7 to 10, the test feed was +H57 (3.16 x 10^8 cfu of H57 spores /kg DM of pellets). Pellets comprised a mixture of (g/kg DM) 113 wheat grain, 558 sorghum grain, 170 canola meal, 136 soy meal, 90 legume hulls, 34 molasses, 31 vitamins and minerals. The control feed was the same pellets but without H57 (–H57). On day 10, glucose powder (10% by weight, as fed) was added to the –H57 pellets in an attempt to improve preference for –H57. Each day the position of the troughs was swapped to reduce bias. Within each 6 hour period, DMI per trough was calculated as the difference between weight of DM offered less DM refused. Preference data each day was subjected to one-sample comparison t-test using 0.5 as the reference value.

Results and Discussion

The intake data was analyzed using a mixed-effects model included treatment, animal sex, position of the troughs and any interaction among them as fixed effects, calves as random effects. The preference data each day was subjected to one-sample comparison t-test using 0.5 as the reference value.

The DMI for +H57 pellets increased by 47.7% (1131 vs 592 g DM/d, P < 0.01) from day 7 to 9 and 56.5% for day 10 (1251 vs 544 g DM/d, P < 0.001), compared to the DMI of –H57 and +H57 pellets. Outside of the 6 hour period, the calves were offered the familiar commercial pellets and chaff *ad libitum*.

The intake data was analyzed using a mixed-effects model included treatment, animal sex, position of the troughs and any interaction among them as fixed effects, calves as random effects. The preference data each day was subjected to one-sample comparison t-test using 0.5 as the reference value.
were sweetened, but the preference for +H57 pellets remained higher (0.722, P < 0.001).

The calves clearly preferred the pellets formulated with H57 spores. Although others have reported that the addition of Bacillus spores can improve DMI in ruminants (Kowalski et al. 2009), we are not aware of any that have shown such rapid and consistent improvements in preference. The mechanism by which H57 spores might improve preference is yet to be elucidated. We had considered that it may be related to the ability of the spores to become vegetative and efficiently convert the starch in pellets to glucose, making them sweeter and therefore more attractive (Hellekant et al. 1994). B. amylo liquefaciens is well known in the biofuel industry as a source of amylase and so could have facilitated the production of glucose in the pellets (Abd-Elhalem et al. 2015). However, if sweetness was a driver of preference in the current study, the addition of glucose to the –H57 pellets should have enhanced preference for them and it did not. H57 spores show great promise as a means of improving the attractiveness of pellets for weaned calves and further investigation across a wider range of feedstuffs and ruminant classes is suggested.

Acknowledgments

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References

Effect of dietary natural betaine on broiler breeder hen performance and egg quality characteristics

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Summary

The effect of dietary natural betaine supplementation on broiler breeder hen performance was evaluated. In total, 630 Cobb 500 broiler breeder hens were allocated to one of three dietary treatment groups. The control diet was a standard basal broiler breeder diet and the two treatment diets were supplemented with natural betaine at either 1000ppm or 2000ppm. Hens were fed the diets for six weeks. Hens receiving betaine-supplemented diets gained more weight (p=0.006). The average weekly egg production of the hens receiving the 1000ppm and 2000ppm betaine-supplemented diets increased by 2.4 and 5.5% respectively (p<0.0001). The eggs from hens fed 2,000pppm betaine also had greater fertility (p<0.0001). Egg characteristic differences included a decrease in albumen weight (p=0.034) and eggshell thickness (p=0.001) and an increase in yolk:albumen ratio (p=0.009) of eggs from betaine-supplemented hens. Overall, breeder hens supplemented with 2000ppm betaine performed better than control or hens supplemented with 1000ppm betaine.

Introduction

Betaine is an amino acid derivative found naturally in high quantities in both plant and animal foods (Craig, 2004). Betaine is commercially available as an animal feed supplement.

Betaine is not an essential nutrient for poultry but is beneficial when added to the diet of physiologically-challenged birds (Kidd et al., 1997). Broiler breeder hens are subjected to a number of stressors, the most significant being a restriction of feed (up to 60% of their normal daily intake) and water intake. Hens are also expected to have a high egg laying performance. The additive effect of these stressors can be poor welfare for the hen.

Incorporation of betaine in the diet may alleviate the impact of these stressors and improve performance. The two main mechanisms of action proposed for betaine are as a methyl donor and as an osmolyte. Betaine provides methyl groups to substances critical in protein and energy metabolism and accumulates in cells and cell organelles to maintain water homeostasis (Kidd et al., 1997; Craig, 2004; Eklund et al., 2005).

We tested the hypothesis that betaine in the diet of broiler breeder hens would improve the quantity and quality of eggs produced.

Materials and Methods

Birds and Housing. A total of 630 Cobb 500 broiler breeder hens (Great Grandparent, heavy meat HiChick line) were housed in 45 pens (14 hens and one cockerel per pen). Each of the three dietary treatment groups were allocated to 15 pens which were repeated in blocks of three throughout the shed. The hens were 40 weeks of age at the commencement of dietary betaine supplementation. The diet was fed for six weeks. Hens were housed on litter with five nest boxes in each pen. Feed and water were restricted with hens receiving 164g and the cockerels 131g of feed, daily. Water was provided for 4-6 hours a day. Cockerels were fed the control diet. Hens were provided with 13 hours light and temperature of the shed was maintained at 25±3°C.

Subset hens. Three pens of hens from each dietary treatment group were closely followed. These hens were weighed weekly and all eggs they laid on Mondays were collected and egg characteristics measured (Table 2).

Dietary Treatments. All hens were fed a control diet (basal broiler breeder diet) until 40 weeks of age. From week 40, control hens and cockerels continued with the control diet and the two treatment groups were fed diets containing either 1000ppm or 2000ppm betaine (Betalin® S1, 96% natural betaine, Danisco Animal Nutrition, Marlborough, UK).

Performance measurements. Egg production from all pens was recorded daily. All eggs were candled to assess fertility. Hatchability was calculated as the number of viable chicks that hatched from known fertile eggs.

Statistical Analysis. Data were analysed using SPSS Statistics Version 21(IBM) using the GLM function. When treatment was significant (p ≤ 0.05) pairwise comparisons using the LSD were made. Results in tables are presented as estimates of means ± standard errors. Breeder hen data were analysed over the entire period, for breeder hen weight and lay percentage the week prior to the betaine being added to the diet was used as a covariate. Fertility, hatchability and mortality were analysed using the chi-squared method.

Results and Discussion

Hen weight. Both betaine-supplemented groups gained more weight than the control hens (p=0.006) (Table 1). An increase in the body weight of betaine-fed hens most probably reflects improved nutrient digestibility, due to osmolytic protection of intestinal cells (Lever and Slow, 2010). It is likely that broiler breeder hens that are water restricted may be in a state of dehydration and that the osmolytic function of betaine assisted with maintaining intestinal cell integrity.

ASAP Animal Production 2016, Adelaide
There was no difference in hatchability (p=0.683) (Table 2). In previous work betaine fed to hens at 2000ppm improved hatchability (Cadogan et al., 2014), however, the improved hatchability may have been due to an improved fertility which was not quantified in that study.

**Hatchability.** There was no difference in hatchability (p=0.683) (Table 2). In previous work betaine fed to hens at 2000ppm improved hatchability (Cadogan et al., 2014), however, the improved hatchability may have been due to an improved fertility which was not quantified in that study.

**Egg Characteristics.** Both betaine-supplemented groups had decreased albumen weight (p=0.034) and egg shell thickness (p=0.001) and an increased yolk:albumen ratio (p=0.009) (Table 2).

These differences are likely a reflection of the increase in bodyweight of the betaine-fed hens with others reporting that heavier hens have an increased yolk:albumen ratio and a reduction in proportion of eggshell (Perez-Bonilla et al., 2012).

**Average weekly lay rate (%)**. The combination of improved lay percentage and fertility of represents a significant impact on reproductive performance. The osmolytic function of betaine is the likely reason for these improvements. Reducing the osmotic stress of the hen would allow for more efficient cellular function and ability to consistently produce fertile eggs under stress.

The fertility of eggs was assessed at day 14 of incubation. Embryos that had died were classified as fertile. The number of deaths in proportion to fertile eggs between groups was similar (data not presented). Eggs classified as infertile were not opened to determine if early development had begun. It is possible that early embryonic death was not identified. The control and 1000ppm betaine groups may have had more early embryonic deaths. A greater amount of betaine in the egg achieved with the 2000ppm diet may be required to provide osmotic protection of early embryos.

**Egg Characteristics.** Both betaine-supplemented groups had decreased albumen weight (p=0.034) and egg shell thickness (p=0.001) and an increased yolk:albumen ratio (p=0.009) (Table 2).

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Developing and implementing the South Australian Sheep Industry Blueprint

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Summary

The South Australian Sheep Industry Blueprint (Blueprint) has a target of increasing the value of the industry by 20% from $1.48 billion to $1.80 billion by 2020. The Blueprint development was guided by a working group with experience spanning the sheep industry, a wider reference group, comprehensive industry consultation and consideration of national and state plans. The primary areas of focus of the Blueprint are 1. Resilient and profitable production systems, 2. Efficient value chains that optimize efficiency and value through the supply chain. The Blueprint strategy has been informed through extensive regional and small group consultation and consideration of relevant industry and regional strategic plans. Consultation included four sheep specific and two livestock workshops across South Australia to identify the key priorities that would enable producers and the industry to increase productivity and industry value. More than 150 producers and industry stakeholders participated at the workshops. Despite the range in production conditions and enterprise mix, common opportunities and challenges were identified which have informed the Blueprint’s priorities and actions for both on-farm and through-value chain initiatives.

Background

The sheep industry is an important contributor to the South Australian economy and employment with an estimated value of $1.48 billion and 13,000 people employed (South Australian Sheep and Wool Industry ScoreCard Overview 2013-14, 2015). Moreover, South Australia’s sheep industry is becoming increasingly important at a national level with proportionally more sheep than at any other time (ABS 2013). However, this is a result of a lower decline in the SA flock than in other states. The South Australian flock declined from >18M in 1990 to 10M in 2009. The SA flock has since recovered to an estimated 10.8M sheep in 2015. In addition, the proportion of value derived by sheep industry has changed from predominately wool to primarily sheep meat which comprises an estimated 74% of gross value for sheep meat and wool combined (South Australian Sheep and Wool Industry ScoreCard Overview 2013-14, 2015). There are significant opportunities for expansion in production, greater efficiency and value through the supply chain. The Blueprint has been developed to identify and pursue these opportunities with a primary target of growing value by 20%.

Blueprint development

The Blueprint was industry driven with the success of Lambex 2014 as the catalyst. The development commenced in February 2015 as a result of a scoping workshop coordinated by Livestock SA (LSA) and the South Australian Sheep Advisory Group (SASAG). In addition to financial support from LSA and SASAG, The University of Adelaide and Primary Industries and Regions SA have also invested in the development and implementation of the Blueprint. From the initial scoping workshop it was apparent there was significant interest in having state-wide industry growth and value targets with a path to implementation centred on value chain wide collaboration to achieve the targets. An important aspect of the Blueprint is focused on engaging all members of the sheep industry. Importantly, fostering greater and closer collaboration throughout the sheep industry was identified as critical to the success of achieving the targets. To this end, a 17 member Blueprint working group was established with experience covering the entire value chain. The Blueprint working group also services the role of the SA regional committee for the Southern Australian Meat Regional Council informing research, development and adoption priorities for Meat and Livestock Australia. In addition to the working group, a 50+ person wider reference group was also developed to inform particular aspects of the Blueprint development and subsequent implementation.

Over 20 one-on-one and small group meetings were held with stakeholders at regional, state and national level to identify priorities and how the stakeholders could contribute towards the success of the Blueprint implementation. These meetings were critical in obtaining stakeholder commitment to pursuing action to increase SA sheep industry growth.

The SA sheep industry is influenced by a significant number of plans. In developing the Blueprint these plans were considered and where possible Blueprint priorities and targets were aligned with national, state and regional priorities. This was a purposeful approach to increase the likelihood of successful collaborative projects.

Blueprint priorities and themes

Based on outcomes from consultation and consideration of relevant regional, state and national plans the Blueprint actions and targets were detailed under four themes:

1. Resilient and profitable farms / production systems
2. Efficient value chains that optimize returns
3. Enhance community and consumer support  
4. Growing industry capability and capacity

There are clear trends influencing the national and state sheep industries and have been widely reported, for example in numerous plans including the Australian Sheepmeat Industry Strategic Plan, 2015-20 and the NSW Wool Industry and Future Opportunities report. Broadly, these trends include a) the need to have resilient and profitable production systems that increase productivity beyond trend, b) the opportunities associated with technology development in data collection and analysis to inform decision making c) the importance of meeting consumer expectations, and d) ensuring the industry is well equipped for future growth.

For many agricultural production regions in southern Australia, the predicted impacts of climate change on feedbase, productivity and gross margin are negative (Climate Council of Australia, 2015). In general, with current feedbase and grazing practices, warmer mean temperatures and reduced and variable rainfall are expected to be associated with reduced pasture feed and reduced animal productivity. Continued gains in farm productivity are critical to mitigate the potential productivity falls associated with climate change and compete with competing potential land use (Grundy et al. 2016). This requires further adoption of proven existing initiatives that increase on-farm productivity as well as development of production systems that can maintain productivity in constrained resource environments.

Much of South Australia’s livestock production is in extensive and/or pasture based regions and there is significant potential to increase livestock production in cropping systems. Within these systems animals typically will experience periods of low growth due to low feed availability and quality. This can subsequently impact reproductive rates via suboptimal body condition in sheep and cattle. Furthermore, low feed availability creates an impediment to having animals suitable for pasture finished production on a consistent basis impacting both consistency of supply and meat quality. Potential exists to develop systems that have a wider window in which animals can be productive and which can be resilient to variable seasons.

The strategies and actions detailed in the Blueprint recognise the critical importance of the consumer and meeting their requirements. This requires understanding consumer and community expectations for product quality, integrity, value, environmental stewardship and ethical production and then having production systems and value chains that meet the expectations and effectively communicate the industry integrity across the spheres aforementioned.

Technology development has considerable potential benefits to sheep production and sheep value chains. This presents an opportunity for automated methods for collecting and synthesizing data from range of sources to inform decision making across animal management, processing and packaging, marketing and business management. However, despite the considerable potential, these opportunities will only be realised through value chain collaboration, preparedness to share data and development of clear value propositions for producers, industry and government to invest. The Blueprint will seek to stimulate data collection and where appropriate data-sharing at both on-farm and through the value chain. On-farm data collection has the capacity to significantly aid animal management, for example through management of single vs. twin bearing ewes. Moreover, with advent of walk-of-weigh technology animal weight can be monitored thus aiding in determining resource requirements. At the value chain level there is significant efforts through the CRC for Sheep Industry Innovation and others to enable recording of traits of economic importance including lean meat yield and eating quality. When coupled with individual identification this provides scope for value based payments to suppliers.

Outcomes

Collaborative projects will drive stakeholder engagement in the Blueprint. By 2020, it is expected that the SA sheep industry will have achieved gains in flock size and weaning rate leading to 12.5% more lambs weaned. Further on-farm gains will be achieved through increased growth rates and reduced cost of production through improved labour efficiency. This will be supported by a 20% increase in use in the decision support tools of quality consultants and advisers. Gains are also being targeted throughout the value chain. These include 35% of sheep supplied via direct consignment will have individual feedback with payment to suppliers reflecting quality and yield differences. Further gains in processing efficiency of 2% are being targeted. The Blueprint seeks to have the sheep industry recognised as excellent industry in which to forge a career.

Acknowledgements

The authors thank the Blueprint working group for their significant effort in development and on-going implementation of the Blueprint.

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NSW Wool Industry & Future Opportunities (2015)  

CRC for Sheep Industry Innovation (2016)  

Biserrula pelecinus reduces leptin secretion in dry merino ewes

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Introduction

Plasma concentration of leptin and insulin, two metabolic hormones, are responsive to change in energy balance, and consequently could be linked to animal performance. Leptin is secreted from adipose cells (Roh et al. 2016). The secretion of leptin can regulate feeding and metabolism and maintain homeostasis in the body. Lents et al. (2005) suggested that plasma concentrations of leptin are positively correlated with body fatness in ruminants. Insulin is secreted from the liver and it is responsible for the storage of energy and is positively correlated with positive energy balances in ruminants (Blache, 2007).

Sheep that graze legumes often perform better compared to those grazing grasses (Archimède et al. 2011). This may reflect the higher digestibility and lower concentrations of indigestible fiber of legumes compared to grasses (McDonald et al. 1988). Feed quality can affect the intake of nutrients and the accumulation of adipose stores which in turn influence the secretion of leptin and insulin (Blache, 2007). Our hypothesis was that legume pastures would be of higher quality (Higher ME and lower neutral and acid detergent fiber, NDF and ADF) than grass pastures and would increase body condition and consequently plasma concentrations of leptin and insulin.

Materials and methods

In a plot scale grazing trial in spring 2015 at The University of Western Australia research farm, Pingelly (32.5097°S, 116.9955°E) 60 dry merino ewes that were 14 months of age with live weight (LW) 48.1 kg (+/-2.5) and condition score (CS) 2.7 (+/-0.22) were stratified by LW and CS into groups of 12 and assigned to one of five pasture treatments for eight weeks at unrestricted Feed On Offer (FOO, >1200kg DM/ha). The pastures included; annual ryegrass (ARG; Lolium rigidium cv. robust); subterranean clover (Sub; Trifolium subterraneum L cv. Dalkeith); side-by-side monocultures of ryegrass and subclover (Choice); serradella (Serr; Ochnothopus sativas cv. margurita) and; biserrula (Bis: Biserrula pelecinus cv. casbah). Weekly measurements included; FOO using 0.1m² quadrats and cutting to ground level; ‘toe-cut’ samples from each plot for nutritive assessment by Near Infra-red Spectroscopy supported by wet chemistry (CSIRO, Floreat); and LW and CS. Scoring of body condition provides an acceptable estimate of the proportion of fat in a live animal which is a superior to using LW as an estimate of body fat (Russel 1969). Two weeks after the start of grazing blood samples were taken from each sheep (T1) and on two more occasions (T2 and T3) during the grazing period. Jugular blood was evacuated into 10 ml lithium-heparin tubes and the samples were kept on ice until centrifugation (800 × g, 30 min) to recover plasma that was stored at −20 °C until required for analyses. Plasma leptin and insulin was assayed in duplicate by a double antibody RIA as described previously (Blache et al. 2000; Tindal et al. 1978). Effects of pasture treatments on insulin and leptin concentrations and LW and CS were assessed on GenStat (VSN International, 2012) using Restricted Maximum Likelihood (REML) with pasture type and LW fitted as fixed effects and individual animal and/or test tube fitted as random effects.

Results and discussion

The metabolisable energy (ME) of the ryegrass tended to be higher than the legumes and the fiber fractions, (NDF and ADF) than grass pasture and would increase body condition and consequently plasma concentrations of leptin and insulin.

Materials and methods

In a plot scale grazing trial in spring 2015 at The University of Western Australia research farm, Pingelly (32.5097°S, 116.9955°E) 60 dry merino ewes that were 14 months of age with live weight (LW) 48.1 kg (+/-2.5) and condition score (CS) 2.7 (+/-0.22) were stratified by LW and CS into groups of 12 and assigned to one of five pasture treatments for eight weeks at unrestricted Feed On Offer (FOO, >1200kg DM/ha). The pastures included; annual ryegrass (ARG; Lolium rigidium cv. robust); subterranean clover (Sub; Trifolium subterraneum L cv. Dalkeith); side-by-side monocultures of ryegrass and subclover (Choice); serradella (Serr; Ornothopus sativas cv. margurita) and; biserrula (Bis: Biserrula pelecinus cv. casbah). Weekly measurements included; FOO using 0.1m² quadrats and cutting to ground level; ‘toe-cut’ samples from each plot for nutritive assessment by Near Infra-red Spectroscopy supported by wet chemistry (CSIRO, Floreat); and LW and CS. Scoring of body condition provides an acceptable estimate of the proportion of fat in a live animal which is a superior to using LW as an estimate of body fat (Russel 1969). Two weeks after the start of grazing blood samples were taken from each sheep (T1) and on two more occasions (T2 and T3) during the grazing period. Jugular blood was evacuated into 10 ml lithium-heparin tubes and the samples were kept on ice until centrifugation (800 × g, 30 min) to recover plasma that was stored at −20 °C until required for analyses. Plasma leptin and insulin was assayed in duplicate by a double antibody RIA as described previously (Blache et al. 2000; Tindal et al. 1978). Effects of pasture treatments on insulin and leptin concentrations and LW and CS were assessed on GenStat (VSN International, 2012) using Restricted Maximum Likelihood (REML) with pasture type and LW fitted as fixed effects and individual animal and/or test tube fitted as random effects.

Results and discussion

The metabolisable energy (ME) of the ryegrass tended to be higher than the legumes and the fiber fractions, (NDF and ADF) were similar to the Choice, Sub and Serr pastures and the first hypothesis was rejected (Table 1). The ARG was a tetraploid which typically contain higher soluble contents than diploid varieties and have higher ME and lower fiber content (Solomon et al. 2014).

In this study body condition was used as a proxy for adipose tissue in the sheep. CS and plasma concentrations of leptin were lower in the Bis sheep at T1 compared to the Sub sheep and at T2 compared with the ARG, Serr and Sub sheep (Table 2). CS and leptin were lower at T2 in the Choice sheep compared to the Serr and sub sheep. Sheep are known to avoid grazing biserrula possibly due to the presence of plant secondary compounds (Thomas et al. 2014). Reduced feed intake of biserrula due to aversion may have contributed to lower CS in these sheep because feed quality was not a limiting factor. However, given that ADGs in
the Bis sheep were similar to the sheep that grazed the other pastures with the exception of the Choice sheep at T2 it is possible that the Bis sheep partitioned energy towards lean meat production rather than adipose tissue. The implications for lean meat production warrant further investigation. There was no apparent effect of diet on circulating insulin possibly because the energy balances between sheep was similar due to unrestricted grazing and that insulin response to intake change is transient (Zhang, 2004). It appears that leptin secretion is more sensitive to changes in body condition than insulin and may be a better predictor of carcass composition which may be influenced by pasture species.

**Acknowledgements**

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**Table 1.** Nutritive values of pastures fed at ad libitum levels to dry merino ewes (n=12 per treatment) and corresponding to blood sampling days. Choice pasture assumes 70:30 intake of clover:ryegrass (Chapman et al. 2007). ME, Megajoules/Kg of dry matter; ADF, %; NDF, %; CP, %.

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**Table 2.** Effects of pastures on metabolic hormones, growth and body condition of dry merino ewes. Predicted means with different superscripts within a column differ (P<0.05). Leptin and insulin units are ng/mL. ADG; average daily live weight gain g/day; CS, condition score, scale 1-5.

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**References**


Genetic parameters of female reproductive traits measured by ultrasound in beef cattle

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Summary

Reproductive status of 4649 heifers and 2051 lactating cows was recorded in 7 herds representing Brahman, Droughtmaster and Santa Gertrudis beef cattle breeds. The traits measured were incidence of ovarian corpus luteum (CL) discerned by real-time ultrasound inspection of the reproductive tract at approximately 600d of age in heifers, and stage of pregnancy in first-calf lactating cows. At 600d the heifers averaged 340kg and 40% had detectable CL; lactating cows averaged 474kg and a 64% pregnancy rate. Estimates of heritability of incidence of CL at 600d (0.20 to 0.32) and stage of pregnancy in lactating cows (0.10 to 0.17) in the herds suggested that a substantial proportion of the traits variation was due to additive gene action. Small to moderate genetic correlation with other important traits and the range in trait EBVs suggested ample opportunity for genetic improvement of the traits by selection of superior breeding animals.

Introduction

Detection of ovarian corpus luteum (CL) using ultrasound allows accurate determination of key component traits of female reproductive performance, such as age at puberty in heifers (Johnston et al. 2009) and post-partum anoestrus interval in first-calf cows (Johnston et al. 2014a). Heritability of these two traits was reported as moderate to high and both showed moderate to strong association with lifetime reproductive performance (Johnston et al. 2014b and Johnston et al. 2014a). However, to accurately derive age at first CL and post-partum anoestrus interval, multiple transrectal examinations were required. Such intensity of measurement is necessary for rigorously designed research programs but may not be practical for most beef producers. The extensive beef herds of Australia need a robust but simple system of trait recording to identify superior animals for reproduction attributes to accelerate genetic improvement. The aim of the current research project was to record the presence of ovarian CL in peri-pubertal heifers and stage of pregnancy in lactating cows in Australian seed-stock herds to test the practicality of using ultrasound to derive reproductive traits and evaluate the strength of inheritance of these traits. The hypothesis was that a single ultrasound examination of presence of ovarian CL in heifers at 600d and one of pregnancy stage in lactating cows will provide useful traits for genetic evaluation of reproductive capability.

Materials and Methods

Ovarian activity and stage of pregnancy in heifers and cows was assessed transrectally by real-time ultrasonography performed by one of three trained operators. At scanning, each ovary and the uterus was examined using ultrasound imaging with a Honda HS-2000V with linear array 10MHz transducer, and the most advanced structure of the reproductive tract was recorded e.g. weeks pregnant, presence of CL or CA (corpus albicans), presence of large (>10mm) or only small (≤10mm) ovarian follicles. In heifers scanned at 600d, CL rate was converted to a score (HeiferCL) incorporating information on CL presence, ovarian follicle size, uterine tract size and abnormalities so that 0 = infantile tract or freemartin; 1 = small follicles only; 2 = follicle > 10mm; and 3 = CL presence on either ovary. In first-calf lactating cows, stage of pregnancy in weeks was estimated 5 weeks after the end of the joining period by using ultrasound imagery to measure foetal size (CowPD).

The cattle were located in 7 seed-stock herds across Queensland. The collaborating herds represent Brahman, Droughtmaster and Santa Gertrudis beef cattle breeds, each being widely used for beef production in the subtropical and tropical regions of Australia. The cattle were born, and raised as contemporaries in their cohorts at each location. A total 4649 heifers and 2051 lactating cows were examined from September 2012 through to July 2015. Animal ethics approval was provided by The University of Queensland Production and Companion Animal Ethics Committee as approval QAAFI/050/13/Smart Futures.

Significant fixed effects were identified separately for each breed using linear mixed model procedures (GenStat). Models included the fixed effects of year (2012 to 2015), herd (2 or 3 herds per breed), birth month, dam age (2 to 12 years), body condition, P8 rump fat, management group, their interactions and sire as a random effect. The effect of animal age was included as a covariate for all traits. Non-significant terms were sequentially removed from the models to yield the final model for each trait. Final models for HeiferCL generally consisted of a concatenated term for Herd + Year + Birth month, P8 fat and the age covariate. Models for CowPD also included birth month of the calf at foot.

Additive genetic variance and heritability for each trait was estimated in univariate analyses separately for each breed using restricted maximum likelihood procedures (ASReml).
Estimated breeding values (EBV) were generated as solutions for the random effect of animal. Genetic correlations between traits were estimated by pair-wise correlations between the EBVs of each trait for all individuals in the pedigree with EBV accuracy greater than 40% for all traits. In addition to the traits recorded in this study, EBVs for the trait days to calving (DC) for the Brahman and Santa Gertrudis herds were provided by ABRI to include in the correlation matrix. DC is currently included in BREEDPLAN genetic evaluation for Brahman and Santa Gertrudis but not Droughtmaster breeds. Pedigree files spanning several generations were available for each breed and in total contained 24,598 Brahman, 10,339 Droughtmaster and 46,815 Santa Gertrudis identities. A total of, 180 Brahman, 69 Droughtmaster and 116 Santa Gertrudis sires were represented in the study, on average they each sired approximately 12 heifer progeny with 600d ultrasound scan records.

Results and Discussion

The numbers of females, their mean live weight, trait incidence and heritability of the scanned reproductive measures within breed are presented in Table 1. The scanning of heifers at 600d captured an incidence of CL of 0.39, 0.17 and 0.53 respectively for Brahman, Droughtmaster and Santa Gertrudis breeds. The differences in CL rate between breeds is confounded by herd and therefore prevailing seasonal conditions at the various locations. The breeds were not run together so a valid breed comparison cannot be drawn.

### Table 1. Heritability estimates for scanned female traits*.

<table>
<thead>
<tr>
<th>Trait</th>
<th>N</th>
<th>Mass</th>
<th>p</th>
<th>h²</th>
</tr>
</thead>
<tbody>
<tr>
<td>HeiferCL</td>
<td>1714</td>
<td>336</td>
<td>0.39</td>
<td>0.20 (0.06)</td>
</tr>
<tr>
<td>CowPD</td>
<td>875</td>
<td>461</td>
<td>0.63</td>
<td>0.17 (0.10)</td>
</tr>
<tr>
<td>HeiferCL</td>
<td>1087</td>
<td>342</td>
<td>0.17</td>
<td>0.32 (0.09)</td>
</tr>
<tr>
<td>CowPD</td>
<td>595</td>
<td>476</td>
<td>0.66</td>
<td>0.10 (0.09)</td>
</tr>
<tr>
<td>HeiferCL</td>
<td>1848</td>
<td>361</td>
<td>0.53</td>
<td>0.20 (0.05)</td>
</tr>
<tr>
<td>CowPD</td>
<td>581</td>
<td>488</td>
<td>0.64</td>
<td>0.13 (0.10)</td>
</tr>
</tbody>
</table>

*HeiferCL = CL rate at 600d; CowPD = weeks pregnant in first lactation cows; N = number of animals; Mass = live weight in kilograms; p = incidence of CL or pregnancy; h² = heritability (standard error)

Heritability of CL rate in heifers at 600d (HeiferCL) was moderate and highest in Droughtmaster females (0.32) which also had the lowest incidence of CL. Heritability of weeks pregnant in first-lactation cows (CowPD) was low, ranging from 0.10 to 0.17 and, due to fewer animals, had relatively high standard error.

Correlation between trait EBVs for the female scanned traits (HeiferCL and CowPD) and DC, a trait currently recorded for BREEDPLAN analyses in Brahman and Santa Gertrudis, are presented in Table 2. In Brahmans there was little or no relationship of HeiferCL with CowPD and DC but a small to moderate favourable correlation between CowPD and DTC. In Santa Gertrudis females there was moderate favourable correlation amongst all three reproductive measures. EBVs for the HeiferCL score generally ranged from +1.0 to -1.0 across breeds and the range of EBVs for CowPD was highest in Brahman at +4 to -4 weeks and lowest in Droughtmaster at +2 to -2 weeks. The range in EBV for the traits represents opportunity for identifying superior individuals. Further work is required to collate the Droughtmaster records so that DC can be genetically evaluated and EBVs assigned.

### Table 2. Correlation between EBVs for scanned female traits and days to calving.

<table>
<thead>
<tr>
<th>Trait</th>
<th>CowPD</th>
<th>DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>HeiferCL</td>
<td>0.06</td>
<td>-0.08</td>
</tr>
<tr>
<td>CowPD</td>
<td>-</td>
<td>-0.25</td>
</tr>
<tr>
<td>HeiferCL</td>
<td>0.31</td>
<td>-0.38</td>
</tr>
<tr>
<td>CowPD</td>
<td>-</td>
<td>-0.41</td>
</tr>
</tbody>
</table>

Scanning heifers at 600d of age was a good fit with typical herd-management procedures in the herds studied and provided an early-in-life measure of reproductive capability. Although the heritability of HeiferCL was moderate compared to the high heritability of age at puberty (0.51 to 0.57) estimated by Johnston et al. (2009), HeiferCL a trait derived from a single scan at 600d poses a viable alternative to monthly scanning of heifers from prior to yearling to mating at 2 year-old to ascertain age at puberty.

Further work is required to determine the relationship of these single scan traits with measures of whole herd productivity but heritability, relationships with DC and the range of EBVs suggest that HeiferCL and CowPD traits might value add to current genetic evaluation, possibly in the form of an index for reproductive capability.

Acknowledgments

We gratefully acknowledge the generous in-kind contributions of the collaborating herds denoted here by their stud prefixes: ALC, COM, ELR, GYR, LIS, ROS and SCC. The research was funded by Queensland Government Smart Futures Research Partnerships Program.

References


Qualitative behavioural assessment (QBA) of remotely captured video footage can identify positive and negative welfare states in sheep

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Summary

Qualitative behavioural assessment (QBA) may be a useful on-farm technique for measuring both positive and negative welfare states of sheep. Video footage was collected from 36 Merino wethers within four treatments: control, habituated, lame and inappetant, and assessed by a total of 38 observers using the two QBA approaches of Free Choice Profile (FCP) and Fixed List (FL). Generalised procrustes analysis (GPA) was used to generate a consensus profile for each QBA approach, and treatment differences were identified using ANOVA. Using both FCP and FL, observers were able to distinguish habituated and lame individuals from the control group based on their behavioural expression (P<0.05). However, observers were not successful at distinguishing inappetant individuals from control individuals using either QBA approach. Overall, it appears that QBA is sensitive to both positive (habituation) and negative (lameness) welfare states, and can be used on remotely captured video footage collected on-farm.

Introduction

With current management strategies and labour constraints it is difficult to monitor and assess sheep welfare on farm. Welfare is an important yet complex issue comprising of an animals physical health and fitness, and its mental or emotional wellbeing (Webster et al. 2005). Comprehensive welfare assessments that cover both components of welfare are lacking in the sheep industry. Qualitative behavioural assessment (QBA) has been proposed as a method to integrate and guide welfare assessments to a clear and meaningful picture of animal welfare (Wemelsfelder & Lawrence, 2001). As such, this study investigates whether behavioural expression could be used as an on-farm welfare tool in the sheep industry. The hypothesis tested was that QBA can be used to identify individual sheep that are habituated, lame and inappetant from remotely captured video footage.

Materials and methods

Video footage was remotely collected from 36 Merino wethers in a walk-over-weigh (WoW) system, whereby each of the sheep were within one of four treatment groups: control (n=12), habituated (n=8), lame (n=8) and inappetant (n=8). The sheep were initially selected from a group of 878 1 year old wethers. Selection processes for the lame and inappetant sheep were done by lameness scoring (Kaler & Green, 2008) and individual electronic sensor records of feeding behaviour, respectively. The habituated sheep underwent a low-stress handling regime, and the control group were selected ensuring that they were not lame, inappetant or habituated to handling. Video footage was collected remotely (i.e. no human present) from individual sheep as they moved through the WoW system. This footage was compiled into a series of assessment clips, one clip for each animal (n=36). These assessment clips were assessed using two approaches to the QBA method, whereby 18 observers followed the Free Choice Profiling (FCP) approach (as detailed by Wemelsfelder et al. 2001), and 20 were instructed to follow the Fixed List (FL) approach where they were provided with a list of 12 descriptive terms. Observers watched the assessment clips and were instructed to score each animal on its behavioural expression using their descriptive terms on a visual analogue scale ranging from minimum to maximum expression. These scores were then analysed using generalised procrustes analysis (GPA) and principle component analysis (PCA) resulting in the creation of a multidimensional matrix where each animal is represented along the continuum of the descriptive terms that best describe each dimension. Treatment differences in the behavioural expression of the sheep as represented by their respective GPA scores were analysed using ANOVA.

Results

The GPA profiles explained 58.2% and 54.9% of the variation observed between the sheep, under the FCP and FL approaches, respectively. The three main dimensions for the FCP approach explained 73.1%, 8.7% and 2.9% of this variation, respectively. While, the three main dimensions for the FL approach explained 66.1%, 11.9% and 4.9% of this variation, respectively.

Table 1. Comparison of the behavioural expression scores between different treatments (i.e. control, habituated, lame and inappetant) for both FCP and FL approaches to QBA. Bold p-values denote significant differences between compared treatment groups.

<table>
<thead>
<tr>
<th>Treatment groups</th>
<th>FCP dimension</th>
<th>FL dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Control vs. Habituated</td>
<td>0.0136</td>
<td>0.941</td>
</tr>
<tr>
<td>Control vs. Lame</td>
<td>0.0096</td>
<td>0.351</td>
</tr>
<tr>
<td>Control vs. Inappetant</td>
<td>0.0693</td>
<td>0.924</td>
</tr>
</tbody>
</table>
Significant treatment effects were identified between the sheep on both GPA dimensions 1 and 2 using the FL approach (Table 1). However, treatment differences were only identified on dimension 1 with the FCP approach. In both approaches observers were able to successfully distinguish habituated and lame individuals from those within the control group using behavioural expression. The observers using the FCP approach described both the habituated and lame individuals as having a more ‘focused’, ‘collected’ and ‘assured’ demeanour than the control individuals, as indicated by their lower GPA scores along dimension 1 (Figure 1) Similarly, within the FL approach observers described the habituated and lame wethers as more ‘confident’, ‘determined’ and ‘calm’ than the control ones (Figure 2). Interestingly, within the FL approach a treatment effect was also identified between the control and lame groups on dimension 2, where the lame individuals were seen as more ‘lethargic’, ‘calm’ and ‘curious’ when compared to the control animals (Figure 2). No significant differences in GPA scores were identified between the inappetant animals and the control animals across the three main dimensions for both QBA approaches (Table 1).

Discussion

In support of our hypothesis observers were able to use behavioural expression to identify individual sheep in both positive and negative welfare states from remotely captured video footage. Indeed, observers were able to distinguish habituated and lame individuals from the control individuals using QBA. However, it appears that the behavioural expression of inappetant sheep is too subtle for QBA to successfully identify. It may also be attributed to the fact that video footage from all treatments were assessed together by observers, and the behavioural expression caused by inappetance may have been ‘masked’ by the footage of the other treatments in this protocol. Regardless, the success of QBA to identify different maladies or treatments may vary and therefore the extent of QBAs sensitivity needs to be determined.

This study also demonstrated that both approaches to the QBA method, FCP and FL, have potential in terms of their validity as a welfare assessment tool given that both approaches successfully identified the same welfare conditions. This has clear benefits in terms of practical application, whereby either approach may be useful and the assessor can choose which approach is best suited to the situation and context of the assessment. The FCP approach is generally believed to allow for greater flexibility, attributed to the greater range of descriptive terms, when initially assessing overall welfare issues. Whilst the FL approach can be ‘tuned’ to specific welfare issues, and is considered more practical in terms of ease of use and time requirements. However, the use of a FL approach carries the caveat that the descriptive terms need to be carefully chosen and observers need to be trained in their meaning (Phythian et al. 2015).

In conclusion, based on these results it is reasonable to suggest that QBA represents a simple tool that can be used to help integrate and guide welfare assessments, offering an insight into the affective state, both positive and negative, of the animal. Furthermore, the potential exists for QBA to act as an alarm system, whereby assessments of behavioural expression could facilitate the earlier detection of welfare problems and improve overall stock health.

Acknowledgements

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References

Relationships between handling, behaviour and stress in lambs at abattoirs

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2Department of Economic Development, Jobs, Transport and Resources, Attwood VIC 3049 Australia

Summary

Relationships between stockperson, dog and lamb variables pre-slaughter and plasma cortisol and glucose in lambs post-slaughter were studied in 400 lambs. CCTV video footage was used to record stockperson, dog and lamb behaviour immediately pre-slaughter. Blood samples for cortisol and glucose analysis was collected immediately post-slaughter. The regression models that best predicted plasma cortisol and glucose concentrations post-slaughter included a mixture of stockperson and dog variables as well as lamb variables both on-farm and pre-slaughter. These regression models accounted for 21% and 20% of the variance in plasma cortisol and glucose concentrations, respectively. The identification of these predictor variables of cortisol and glucose, which may be a mixture of independent and mediating variables, support the well-demonstrated effect of handling on fear and stress responses in livestock. These relationships, although not conclusive evidence of causal relationships, highlight the value of training stockpeople to reduce fear and stress in livestock at abattoirs.

Introduction

It is recognised that most of the animals that society uses can suffer and since we can exercise varying degrees of control over the quality and duration of the lives of these animals, we have the opportunity and indeed obligation to manage them humanely (Mellor et al., 2009). Housing and husbandry of farm animals are contentious animal welfare issues for many, but there are also increasing community concerns about the treatment of farm animals post-farm gate, particularly handling pre-slaughter (Grandin, 2007). Recent research has shown considerable variation, both between- and within-abattoirs, in the pre-slaughter behaviour and stress of sheep (Hemsworth et al., 2011). Furthermore it has been shown that pre-slaughter handling is associated with behaviour and stress of sheep (Hemsworth et al., 2011) and the attitudes of abattoir stockpeople are associated with their pre-slaughter handling of sheep (Coleman et al., 2012). Stress is the inevitable outcome in the process of transferring animals from farm to slaughter. However, as with any animal use practice, there is the obligation on the animal users to reduce stress in order to safeguard animal welfare.

Another imperative to minimise stress pre-slaughter is meat eating quality. Glycogen concentration in the muscle at the time of slaughter is a key determinant of meat ultimate pH and correspondingly the meat quality attributes regulated by the ultimate pH and is predominately influenced by management before and during the pre-slaughter process (Ferguson, 2014).

The aim of this study was to determine relationships between handling and lamb behaviour prior to slaughter and the plasma cortisol and glucose concentrations post-slaughter in lambs.

Materials and Methods

Over a 2-month period in summer in SW Victoria, 4 groups of 100 lambs (mean live weight of 43.26 ± 0.23 (SE) kg) were sourced from an experimental farm and transported 170 km overnight to a commercial abattoir and slaughtered the following morning.

CCTV video footage was used to continuously record the behaviour of stockpeople, dogs and individual lambs as each lamb was moved from the overnight lairage area to the single file race prior to stunning. Five stockpeople handled the animals and all dogs were muzzled. Data are only presented here on data in the squeeze exit of the forcing pen and the following ascending single file race. Continuous observations on the CCTV video footage was used to record the following behaviours:

Stockperson behaviour towards lamb – duration of tactile interactions (touching, slapping, hitting, lifting/pulling/pushing), auditory interactions (talking, whistling, shouting, clapping, and use of artificial noises (e.g., shaking metallic rattles and banging on pen fittings) and stationary, walking, running or waving within 1 m of lamb.

Dog behaviour towards lamb – duration of tactile interactions (muzzle contact with lamb, on lamb’s back), and within 1 m of lamb.

Lamb behaviour – duration of mounting a lamb, being mounted by a lamb, jumping and head down posture.

An individual blood sample was collected from each lamb within 1 min of the ventral-neck incision for subsequent analysis for plasma cortisol and glucose concentrations using a commercial assay kit (Immulite 2000 cortisol, Advia 1200 Glucose, Seimens Health Care Diagnostics).

Three to five days prior to transport, each lamb was weighed, spray marked for individual identification, observed in three behavioural tests, novel arena test (based on King et al., 2003), flight distance test to an approaching human (based on Roussel et al., 2006) and a ‘temperament’ test (based on Murphy et al., 1994). Blood was collected from each lamb via jugular venepuncture following the temperament test in order to be subsequently analysed for plasma cortisol and glucose concentrations using a commercial assay (see earlier).

Statistical analyses
The behavioural variables in the three behavioural tests conducted on-farm were subjected to a principle component analysis (PCA) to identify sets of ‘factors’ that represent the underlying relationships among the variables in these tests.

Pearson correlation coefficients (SPSS statistical package, SPSS 23.0, SPSS Inc., Chicago, Illinois, USA) were used to examine the associations between plasma cortisol, glucose and lactate concentrations post-slaughter of the animal and the animal behavioural and physiological variables on-farm and stockperson and dog variables and the animal behavioural variables pre-slaughter.

Linear regression models were constructed using the backward elimination method (SPSS Statistical Package 23.0) to identify the model of stockperson, dog and animal behaviour variables that most significantly predicted plasma cortisol and glucose concentrations post-slaughter in sheep. The independent variables entered into the model were those identified in the preliminary correlation analysis to have at least moderate correlation (P<0.05) with the dependent variable. This method of multiple regression analysis sequentially removed the weakest predictor variables until only the useful predictor variables remained in the model. The removal criterion used was that to be removed from the equation the variable must have an F value greater than or equal to 0.10.

**Results and Discussion**

A PCA of the behavioural variables in the three behavioural tests conducted on-farm extracted three components, all with eigenvalue greater than 1. One component, which was labelled ‘Social reinstatement’ because it included frequency vocalizations in each of the three test, accounted for 17% of variance. The second component, which was labelled ‘Fear of humans’ because it included avoidance of the human in the flight distance test, accounted for 14% of variance. The third component, which was labelled ‘Confinement’ because it included activity in the novel arena test and steps and turns in the temperament tests, accounted for 11% of variance.

Complete data were obtained on 400 lambs. There were numerous significant correlations between plasma cortisol, glucose and lactate concentrations post-slaughter of the animal and the animal behavioural and physiological variables on-farm and stockperson and dog variables and the animal behavioural variables pre-slaughter.

The regression model that best predicted plasma cortisol concentrations post-slaughter included the variables the PCA component Confinement, plasma cortisol and post-behavioural tests on-farm, live weight, time stockperson was in visual contact with lamb, dog riding lamb, and time lamb was in the forcing pen and race, mounting and jumping (model accounted for 21% of the variance in cortisol concentrations (adjusted $R^2 = 0.21, F_{8,527} = 12606, P=0.000))]. The regression model that best predicted plasma glucose concentrations post-slaughter included the variables the PCA component Confinement, plasma cortisol and glucose post-behavioural tests on-farm, time stockperson was in visual contact with lamb and lifting/pulling lamb, time dog was within 1 m of lamb, and time lamb was mounting and jumping (model accounted for 20% of the variance in glucose (adjusted $R^2 = 0.20, F_{8,330} = 12606, P=0.000))].

These relationships suggest that both animal factors and handling pre-slaughter of lambs can affect stress, with implications on animal welfare and meat quality. It is well known that in response to stressors, triglycerides are broken down (lipolysis) and free fatty acids are flushed into the circulation, while muscle glycogen and proteins are degraded (glycogenolysis and proteolysis) and glucose and amino acids are flushed into the circulation (Sapolsky, 2002). Furthermore, glucocorticoids, catecholamines and glucagon stimulate the liver to convert fatty acids and amino acids to glucose (gluconeogenesis). Thus the increases in plasma cortisol and glucose at slaughter observed in association with changes in lamb behaviour, such as mounting activity, are indicative of animals under stress and consequently the risk of compromised welfare.

In conclusion, while the significant relationships between handling and animal behaviour and stress and metabolic variables post-slaughter suggest the possibility of causality, evidence of causality can only be demonstrated by changes in handling affecting the stress and metabolic variables. Furthermore, these predictor variables of stress and metabolic change may be a mixture of independent and mediating variables. Understanding stressful handling practices, including use of the dog, by abattoir stockpeople and their underlying attitudes, which is the aim of this present project, is obviously critical in reducing handling risks to animal welfare as well as meat quality. These and previous findings by the research team also indicate that some subtle lamb behaviours, such as mounting other lambs and jumping when confined in the forcing pen, as well as head down at the end of the single file race prior to stunning (Hemsworth et al., 2011), are useful indicators for abattoir stockpeople to identify animals under stress.

**Acknowledgement**

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**References**


Gilts from female-biased litters behave differently than gilts from male-biased litters

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Summary

Gilts from male-biased and female-biased litters were assessed for anxiety and aggression. Anxiety tests were performed at 11 and 21 days of age in an arena, recording emergence time from a test box, movement, vocalisation, and interactions with an object. Piglet behaviour was recorded for 1 h at 3 and 27 h post weaning, recording fight number and duration. Injury scores were also noted at these times. Female-biased gilts took longer (P=0.016) to enter the anxiety arena on day 21 than male-biased gilts. There were no other differences in anxiety measures. Fight number and duration at weaning were not different but a trend (P=0.063) towards a higher number of scratches for male-biased gilts the day after weaning indicate more intense fights occurred. Further research is needed to determine whether behavioural differences associated with litter gender bias are fixed and so potentially useful as a part of the gilt selection programme.

Introduction

Gilts from male-biased and female-biased litters were assessed for anxiety and aggression. Anxiety tests were performed at 11 and 21 days of age in an arena, recording emergence time from a test box, movement, vocalisation, and interactions with an object. Piglet behaviour was recorded for 1 h at 3 and 27 h post weaning, recording fight number and duration. Injury scores were also noted at these times. Female-biased gilts took longer (P=0.016) to enter the anxiety arena on day 21 than male-biased gilts. There were no other differences in anxiety measures. Fight number and duration at weaning were not different but a trend (P=0.063) towards a higher number of scratches for male-biased gilts the day after weaning indicate more intense fights occurred. Further research is needed to determine whether behavioural differences associated with litter gender bias are fixed and so potentially useful as a part of the gilt selection programme.

Materials and Methods

Selection

This experiment was conducted at the Roseworthy piggery (Roseworthy, South Australia, Australia) using Large White x Landrace gilts raised under standard commercial conditions with a batch farrow system and an average 28-day weaning age. Gilts were selected and weighed at birth from litters consisting of >60% male (male-biased) or female (female-biased) piglets, including stillborn piglets. Up to 3 gilts per litter were selected and tagged as focus piglets for behavioural testing during lactation and after weaning.

Anxiety

On days 11 and 21 of age, anxiety tests were performed on individual male-biased gilts (n=24) and female-biased gilts (n=30). For the anxiety test the piglet was placed in a start box for 1 min, then allowed to emerge into a 2mx2m test arena. Behaviours were recorded for 3 min in the arena. After 3 min a bucket was introduced to the arena and the test continued for a further 1 min. Following the test the piglets were returned to their litter. We recorded a range of behaviours including time to emerge from the start box, movement and vocalisation in the arena, as well as latency to contact the bucket and interactions with the bucket.

Data were analysed using a linear mixed model in SPSS. Day 11 and 21 results were analysed separately, with fixed factors being litter size reared, day of farrowing, batch, age at weaning, birth weight category, and sex bias of litter. Sow was as a random factor. Data that was not normally distributed were log transformed for analysis but the means presented have been back-transformed.

Aggression

At approximately 28 days of age gilts were weaned into 2 pens of 20 gilts with ad libitum creep feed, with male-biased gilts (n=45) and female-biased gilts (n=44) in separate pens. Scores for redness (0-3), scratches (0-3), and an overall combined injury score (0-6) were recorded immediately prior to weaning and the following day. Gilts were video recorded for 1 h at 3 hours post weaning again 24 hours later. Fight numbers and durations were recorded. The data were analysed separately for each day in a linear mixed model with fixed factors of litter size reared, day of farrowing, batch, age at weaning, birth weight category, and sex bias of litter. Sow was a random factor.
Results

Anxiety

The day 11 anxiety test did not detect any difference in behaviour between male-biased gilts and female-biased gilts. At the day 21 anxiety test, gilts from a female-biased litter took more time (P=0.016) to emerge from the start box than gilts from male-biased litters (42.2±11.7 vs. 15.5±2.1 sec for female-biased and male-biased, respectively). There were no other differences in behaviour between male-biased gilts and female-biased gilts.

Aggression

At weaning there was no difference in redness, scratches, or combined injury scores. The day following weaning there was a trend toward male-biased gilts having a greater number of scratches than female biased gilts (P=0.063). There was no difference in the redness or combined injury score the day after weaning. There was no difference in fight number or time.

Discussion

Anxiety

The longer emergence time at day 21 for female-biased gilts indicates a latency to explore the arena and possibly greater levels of anxiety. Conversely, the reduced emergence time at day 21 for male-biased gilts suggests they were more likely to explore and possibly were less anxious. Masculinised female mice are less likely to show avoidance behaviours indicating that attenuated levels of anxiety are also associated with masculinization in other species (Hauser and Gandelman 1983). Our data suggest that gilts from male-biased litters are less anxious and will more readily explore an arena. The importance of these observations in young animals is yet to be determined but these data support continued research in this area, particularly with older animals in groups.

The day 11 anxiety test did not detect any differences and we believe this to be due to the piglets being too young and as a result all piglets were equally anxious. On day 21 it was their second attempt in the arena and they were older, highlighting that the differences seen in emergence time may be due to the male-biased gilts adjusting better.

Aggression

There was no difference in fight time or number, but a trend towards increased scratches in the male-biased gilts the day after weaning suggests the fights these gilts engaged in were more intense or perhaps occurred outside of the hour observed each day. This has implications for their growth and risk of injuries in the nursery which may affect their performance later in life. If this trend towards increased aggression is indicative of lifetime behaviour, higher aggression may also be expressed around puberty, and therefore impact welfare in the breeding herd. As the fights were only recorded for one hour each day it may be that the time chosen was not appropriate to highlight aggression differences. Feeding time is usually a highly active time but as the gilts were fed ad libitum we were unable to record aggression at feeding. As there are other factors that affect aggression, such as rearing sex ratio and litter size (Mendl and Paul 1991), it was not possible to see a clear effect of birth litter sex ratio on aggression at weaning.

Conclusion

We have shown that young gilts from male-biased litters more readily enter an arena and are likely to engage in fights of greater intensity. Further research is needed to assess the behaviour of older pigs, particularly around puberty, during oestrus and in early gestation. Future research of this nature will determine if our data from young gilts predicts greater levels of aggression in older gilts and if the sex ratio of a gilts birth litter can affect her suitability for selection into the reproductive herd.

Acknowledgement

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References


Changing the sex ratio of lambs may alter gross margins in sheep flocks

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Summary

The proportion of male to female lambs weaned has the potential to alter flock performance. A simulation study compared the gross margins resulting from altering the proportion of wether or ewe lambs in a crossbreeding (Merino ewe producing crossbred lambs) flock and in a self-replacing Merino flock in southern New South Wales for the period 1971-2011. The mean gross margin was increased with more ewe lambs when a price premium was obtained for ewe compared with wether progeny, but was increased by more wethers if ewe and wether lambs were sold at the same age. The particular management and price variables used have a large impact on whether an increased proportion of ewe or wether lambs will increase or reduce gross margins. Producers need to consider the market options for their enterprise and systemic effects on production and costs before skewing the sex ratio of their flock.

Introduction

A change in the sex ratio of lambs alters the value of production. The proportion of female lambs has been increased by feeding cereal grains, which are high in omega 6 fatty acids, to synchronised ewes for around 40 days prior to mating, while the proportion of male lambs was higher when ewes were fed forage diets high in omega-3 (Clayton et al., 2015). The aim of this study was to evaluate the impact on gross margins from changing the proportion of male and female lambs in self-replacing Merino and prime lamb producing flocks.

Materials and Methods

Simulation modelling was conducted using AusFarm version 1.4.9, between 1970 and 2011, with data from the first year excluded. A model 1000 ha grazing property located at Tarcutta in southern NSW was used, which had previously been validated against field data. The farm comprised two phalaris based paddocks (each 40% of farm area), and one lucerne paddock (20% of farm area).

A crossbreeding flock was simulated, with Merino ewes joined in February at a stocking rate of 5 ewes/ha. Lambs were sold either 1: At a set price - $110 for wethers sold at 45 kg or by 11 months of age, and $160 for ewes which were shorn and retained to 14 months of age; 2: Lambs were sold using a price grid – as for 1, but at a price per kg live weight; or 3. All lambs were sold on 15 December by live weight.

A self-replacing Merino flock was simulated, with ewes joined in February, and a stocking rate of 6 sheep (breeding ewes plus younger replacements)/ha. Progeny were sold either at a set price ($80 wether lambs at 45 kg or by December, and $150 for surplus 18 month old ewes immediately prior to joining), or by live weight.

A wool price grid used 2003 to 2011 average prices (ABARES, 2011) (19.1 to 20.0 micron 927 c/kg). The price grid (carcase weight) for crossbred lambs used: > 22 kg 588c/kg, 18-22 kg 600 c/kg, 16-18 kg 570 c/kg and < 16 kg 519 c/kg, and for Merino lambs 470, 480, 457, and 416 c/kg, respectively.

The mean gross margin for the crossbreeding flock increased by $22/ha if the proportion of female lambs was increased and ewes were sold at 14 months of age at a $50 premium compared with wethers (set prices) (Table 1). If lambs were sold on liveweight value, mean gross margin was reduced by increasing the proportion of ewe lambs because where ewes were retained to 14 months of age, ewes were sold at lighter weights and expenses increased, whereas if sold at the same age as wethers, ewes were lighter. A similar mean gross margin was achieved when selling ewes at 14 months or on the same date as wethers, with more females, compared with standard sex, if the ewes achieved a 6% higher meat price grid than wether lambs.

Results

Mean gross margins were higher if the proportion of wethers was increased and ewe and wether lambs were sold at the same age in the crossbreeding flock. However, gross margins were reduced by more wethers, compared with the standard sex ratio, if ewes were sold at 14 months.

The mean gross margin for a self-replacing Merino flock was increased from $311/ha to $324/ha where an increased proportion of ewe lambs were sold at a set price. Where Merino lambs/excess young ewes were sold by liveweight, the mean gross margin was similar for standard ($295/ha) and increased ($292) proportions of ewe lambs. The
increase in the number of ewe replacements reduced the number of breeding ewes from 4.1/ha to 3.7/ha.

Discussion

Mean gross margins were increased by a higher proportion of female lambs in a crossbreeding enterprise where a large price premium was obtained for ewe over wether lambs. Gross margins were reduced where a price premium was not achieved, due to the lighter sale weights of ewes when sold on the same date as wethers, or due to increased costs and a reduction in sale weight if ewes were retained to 14 months of age. In contrast, an increase in the proportion of wether lambs was beneficial in systems when sold at the same age as ewes.

These analyses did not alter the stocking rate of ewes with differing lamb sale policies, and it is likely that carrying extra ewe lambs to 14 months of age would reduce the number of breeding ewes able to be carried, although this is partially accounted for by feeding costs in the present analysis. However, if ewes were sold at a younger age for joining as ewe lambs, there would be no implication for the stocking rate of breeding ewes.

Mean gross margin was not higher for an increased proportion of ewe lambs in a self-replacing Merino flock, because carrying more replacements reduced the number of breeding ewes that can be carried at the same stocking rate. An increased proportion of female lambs may be of larger benefit in self-replacing Merino flocks than indicated in this analysis, however, through allowing heavier selection pressure on ewes and greater genetic gain, particularly if the genetics meant that joining as ewe lambs was possible, or if stocking rates were below optimum.

Large premiums for ewe over wether progeny may not be achieved in all seasons and market conditions. The risk of not attaining premiums should be considered, as should systemic effects of changing the sex ratio on costs and production.

Table 1. Mean gross margins and production for standard and a 15% increased proportion of ewe (E) or wether (W) lambs, for a crossbreeding Merino ewe enterprise stocked at 5 ewes/ha, with differing lamb sale policies (1971-2011)

<table>
<thead>
<tr>
<th></th>
<th>Sale by set price</th>
<th></th>
<th>Sale by grid</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Ewes 14 months</td>
<td></td>
<td>Ewes 14 months</td>
<td></td>
<td>Sell 15 Dec</td>
</tr>
<tr>
<td>standard</td>
<td></td>
<td>+15% E</td>
<td>standard</td>
<td>+15% E</td>
<td>standard</td>
</tr>
<tr>
<td>Gross margin ($/ha)</td>
<td>413</td>
<td>435</td>
<td>361</td>
<td>339</td>
<td>311</td>
</tr>
<tr>
<td>Cumulative gross margin ($/ha)</td>
<td>16940</td>
<td>17849</td>
<td>14834</td>
<td>13918</td>
<td>12767</td>
</tr>
<tr>
<td>No. wether lambs sold/ha</td>
<td>2.27</td>
<td>1.58</td>
<td>2.27</td>
<td>1.59</td>
<td>2.35</td>
</tr>
<tr>
<td>Weight wether lambs sold (kg)</td>
<td>44.2</td>
<td>44.5</td>
<td>44.2</td>
<td>44.4</td>
<td>42.3</td>
</tr>
<tr>
<td>No. ewes sold/ha</td>
<td>2.28</td>
<td>2.96</td>
<td>2.28</td>
<td>2.96</td>
<td>2.35</td>
</tr>
<tr>
<td>Weight ewes sold (kg)</td>
<td>54.7</td>
<td>51.0</td>
<td>54.7</td>
<td>50.9</td>
<td>37.4</td>
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<tr>
<td>Value wethers sold ($/ha)</td>
<td>249</td>
<td>174</td>
<td>253</td>
<td>179</td>
<td>243</td>
</tr>
<tr>
<td>Value ewes sold ($/ha)</td>
<td>364</td>
<td>474</td>
<td>308</td>
<td>373</td>
<td>207</td>
</tr>
<tr>
<td>Premium E over W ($/head)</td>
<td>50</td>
<td>50</td>
<td>24</td>
<td>14</td>
<td>-15</td>
</tr>
<tr>
<td>Supplement fed (t/ha)</td>
<td>0.26</td>
<td>0.31</td>
<td>0.26</td>
<td>0.31</td>
<td>0.05</td>
</tr>
<tr>
<td>Income ($)</td>
<td>857</td>
<td>899</td>
<td>805</td>
<td>803</td>
<td>672</td>
</tr>
<tr>
<td>Expenses ($)</td>
<td>444</td>
<td>463</td>
<td>443</td>
<td>463</td>
<td>360</td>
</tr>
</tbody>
</table>

The cost of supplement to change the sex ratio was not considered in this analysis. Further research is required to determine the optimal feeding strategy, and therefore costs.

Changing the sex ratio of lambs born in a flock may have a positive or negative effect on gross margins, depending on the management used and price assumptions. Management structures and expected markets need to be considered in order to maximise potential benefits.

References

Use of strategic sow confinement with farrowing induction can achieve similar stillborn mortality and reduce overlay caused piglet mortality compared to loose housed sows

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Summary

Sow confinement around farrowing can negatively affect farrowing performance, alternatively reducing confinement can increase live born piglet mortality. This experiment investigated the effect of reducing sow confinement pre-partum and applying confinement prior farrowing on farrowing performance and piglet mortality compared to loose housed sows. Sows were allocated to one of two treatments: 1) OPEN: sows were housed in an open swing-sided pen, and farrowed naturally, 2) CLOSED: sows were housed in an open swing-sided pen until 8am on the day of farrowing and the pen remained closed thereafter, and farrowing was induced with synthetic prostaglandin. Inter-piglet birth intervals, stillborn number and total live born piglet mortality were similar between treatments. CLOSED sows had less piglets die due to overlay (P<0.01). Reducing sow confinement pre-partum and applying confinement prior to farrowing, with the use of farrowing inducement, can achieve similar farrowing performance and reduce overlay mortality compared to loose housed sows.

Introduction

There is increasing concern about the welfare implications for sows housed in farrowing crates during farrowing and lactation because the restrictive environment prevents a number of behaviours, in particular the performance of nesting behaviours prior to farrowing (Barnett \textit{et al.} 2001). Restricted nest building behaviour, due to space restriction prior to farrowing, is thought to cause an increased stress response and impair oxytocin release in the sow (Lawrence \textit{et al.} 1994), resulting in prolonged farrowing durations and an increase in the number of stillborn piglets compared to loose housed sows (Oliviero \textit{et al.} 2010). While sow loose housing systems have the potential to improve sow welfare they have been associated with an increase in live born piglet mortality compared to confinement systems (Hales \textit{et al.} 2014; Marchant \textit{et al.} 2000), primarily due to an increase in overlay caused mortality. This experiment investigated whether loose housing a sow in the pre-partum period to allow nesting behaviour and then confining the sow prior to farrowing can result in similar inter-piglet birth intervals stillborn mortality and reduce overlay caused live born piglet mortality compared to loose housed sows.

Materials and Methods

Multiparous sows were allocated to one of two treatments: 1) OPEN: sows were housed in an open swing-sided pen for the entire period, and farrowed naturally (n = 32), 2) CLOSED: sows were housed in a swing-sided pen with the pen open until 8am on the day of farrowing (day 114 of gestation) and remained closed thereafter, and farrowing was induced with synthetic prostaglandin (Juramate; Jurox, Australia) (n = 22). Farrowing was induced in the CLOSED treatment so that farrowing occurred on a known day, allowing the confinement protocol to be achieved. The swing-sided pen measured 2.8x1.8m (Figure 1) and no nesting materials were supplied.

Piglet mortality and cause were recorded from farrowing until day three post-partum. The cause of mortality was determined using the following definitions. Piglets with a white appearance and periople on hooves were determined as ‘stillborn’, those with visible signs of crushing were determined as ‘overlay’ and all other piglets that died were recorded as ‘other’. The inter-piglet birth intervals were recorded for a subset of sows from each farrowing treatment (15 sows/ treatment).

Materials and Methods

Multiparous sows were allocated to one of two treatments: 1) OPEN: sows were housed in an open swing-sided pen for the entire period, and farrowed naturally (n = 32), 2) CLOSED: sows were housed in a swing-sided pen with the pen open until 8am on the day of farrowing (day 114 of gestation) and remained closed thereafter, and farrowing was induced with synthetic prostaglandin (Juramate; Jurox, Australia) (n = 22). Farrowing was induced in the CLOSED treatment so that farrowing occurred on a known day, allowing the confinement protocol to be achieved. The swing-sided pen measured 2.8x1.8m (Figure 1) and no nesting materials were supplied.

All analyses were performed using SPSS, V 21 and data expressed as means ± SEM. The sow was the experimental unit. Average number of piglets born alive and inter-piglet birth interval were analysed using a general linear model, with replicate and treatment as fixed effects and sow parity and total litter size as covariates. Number of stillborn piglets and live born mortality were analysed using a generalised linear model with a poisson distribution because data were not normally distributed. The model included replicate and treatment as fixed effects and sow parity and total litter size as covariates. Statistical significance between groups was
determined using least significant difference test. All results were considered significant at P < 0.05.

**Results and Discussion**

The number of total and live born piglets was not different between treatments, and averaged 12.6 ± 0.4 and 11.9 ± 0.3 piglets per sow, respectively. There was no difference in inter-piglet birth intervals between treatments (open: 23.1 ± 2.2 vs closed: 20.8 ± 3.6 min; P = 0.13). There was no difference in stillborn mortality or total live born mortality from birth until day three post-partum between treatments (Table 1). Sows in the CLOSED treatment had less live born piglets die due to other causes from birth until day 3 post-partum compared to the OPEN sows (P = 0.002). Sows in the OPEN treatment had less live born piglets die due to other causes from birth until day 3 post-partum compared to the CLOSED sows (P = 0.01).

**Table 1.** Stillborn and live born piglet mortality from birth until day 3 post-partum for sows housed in an open swing-sided pen that farrowed naturally (OPEN) and sows housed in open swing-sided pen until the morning of farrowing and closed thereafter that were hormonally induced to farrow (CLOSED).

<table>
<thead>
<tr>
<th></th>
<th>OPEN</th>
<th>CLOSED</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number piglets/litter, Stillborn</td>
<td>0.45 ± 0.13</td>
<td>0.42 ± 0.15</td>
<td>0.85</td>
</tr>
<tr>
<td>Overlay</td>
<td>1.43 ± 0.22</td>
<td>0.57 ± 0.16</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Other</td>
<td>0.32 ± 0.10</td>
<td>0.85 ± 0.21</td>
<td>0.01</td>
</tr>
<tr>
<td>Total live born mortality</td>
<td>1.77 ± 0.24</td>
<td>1.41 ± 0.28</td>
<td>0.32</td>
</tr>
</tbody>
</table>

The similar inter-piglet birth intervals and stillborn number between the treatments, may suggest that allowing the sow space to perform nesting behaviours prior to confinement during farrowing may be able to reduce the stress response in the sow and consequently achieve similar farrowing performance as loose housed sows.

The live born piglet mortality results show that while there was a reduction in overlay piglet mortality in the CLOSED treatment, this did not result in a decrease total piglet mortality, due to an increase in other causes of piglet mortality compared to the OPEN treatment. This may suggest that reduced confinement housing systems have the potential to achieve similar performance outcomes in terms of live born piglet mortality, compared to confinement systems. However, the live born piglet mortality in this experiment was only recorded until day three post-partum. While the majority of piglet mortality is observed during this period (Marchant et al. 2000), it is possible that the incidence and cause of live born piglet mortality beyond day three post-partum could have effected total piglet mortality. Alternatively, the use of inducement may have contributed to an increase in the other causes of mortality in the CLOSED treatment, however it is generally understood that inducing farrowing in sows has no effect on live born piglet mortality (Kirkden et al. 2013).

In conclusion, reducing sow confinement during the pre-partum period and then applying confinement prior to farrowing, with the use of a swing-sided farrowing pen and farrowing inducement, can achieve similar stillborn mortality and reduce the incidence of overlay caused live born piglet mortality compared to sows that are loose housed continuously in a swing-sided pen.

**Acknowledgement**

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**References**


Examining the relationship between colorimetric measurements and microbial loading of beef meat

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Summary

This study aimed to evaluate the relationship between instrumental colour measurements of \textit{m. longissimus lumborum} (LL) beef steaks and microbial profile. A total of 128 LL were used in this study, kept under simulated retail display and measured for colorimetrics (L*, a*, b*) and the ratio of absorbance at 630 nm and 580 nm (R630/580) at 1 day intervals over 3 day display periods (0, 1, 2 and 3 days). LL samples were taken at the commencement of the display period (day 0) and analysed for lactic acid bacteria (LAB) and Enterobacteriaceae (ENT) loading. LAB was significantly correlated to all colorimetric measures – with the exception of L*. The strength of these correlations generally increased with display period. Only ΔE (the change in colorimetric measures over the display period) was correlated with ENT. Insufficient loading of other microbial types limited further comparisons. These results suggest that colorimetrics may have potential for monitoring beef microbial content, although the strengths of these correlations severely restrict its practical adoption. Thus, the basis of these correlations and their robustness should be further explored.

Introduction

 Spoiled meat is often discoloured, and this leads to large discounts or wastage at retail level due to consumer quality and food safety concerns (Mancini & Hunt, 2005). Spoilage can result from unacceptable levels of specific microbes (Gram et al., 2002). Previous research reported the colour of beef chilled aerobically for up to 10 days to be associated with the microbial loadings of total viable count, ENT, LAB, \textit{Pseudomonas spp.} and \textit{Acinetobacter spp.} (Li et al., 2015). Discolouration can be monitored as colorimetric traits that include CIE measures (Mancini & Hunt, 2005). This study investigated the relationship between microbial loading and beef colour traits following anaerobic storage, measured over 3 days simulated retail display.

Materials and Methods

Vacuum-packaged sub-samples (n= 128) from 48 beef LL were randomly sampled following experimental chilled and frozen storage and placed on black foam trays overwrapped with PVC film and permitted to bloom in a chiller under simulated retail display conditions (mean 895 lux, 3-4°C) for 3 days. CIE colorimetrics: L* (lightness), a* (redness), b* (yellowness) and R630/580 were measured daily over the 3 days (0, 1, 2 and 3 days) using a calibrated HunterLab colorimeter (aperture size 25 mm, illuminant D65, 10° standard observer) as per Holman et al. (2015).

For microbial loading, approximately 10 g of each sub-sample (n = 128) was taken aseptically on day 0, diluted with 90 mL peptone salt solution (0.1%) for 30-60 seconds. For LAB, diluted samples were plated at 0.1 mg on MRS agar and incubated in an anaerobe jar with addition of Campygen for 72 ± 2 hours at 30 ± 1 °C prior to counting. For ENT, 1 mL of each dilution was poured plated on VRBG agar and overlaid with the VRBG agar and incubated for 21 ± 3 hours at 36 ± 2 °C prior to counting. LAB present as Gram positive cocci, cocccobacilli or rods and are catalase negative; ENT colonies are 0.5 to 2 mm in diameter and present as dark red or purple in colour.

Microbial loading data was left-centred at the limit of detection (LOD = 100 for LAB, 10 for ENT). The correlations shown are the \textit{r}-likelihood correlation coefficients from fitting a censored linear regression between the logarithm of each microbial response versus each colorimetric measure using the cenreg function in the NADA library of R (R Core Team, 2014). Linearity was assumed via graphical examination. In addition,
the corresponding non-parametric Kendall correlations (not shown) were found to be similar to the reported correlations.

Results

The colorimetric parameters a* and R630/580 presented significant positive correlations with LAB loading on day 0, while on day 3, all parameters excluding L* presented highly significant correlations with LAB loading (Table 1). Colour change (ΔE) presented a negative correlation with ENT (P < 0.05).

Discussion

The lack of relationship of ENT to most colorimetric parameters in this study can be explained by the low level of ENT loading detected. Given anaerobic storage was used, a microbial profile dominated by LAB is expected (Gram et al., 2002; Mills et al., 2014). Increased concentrations of LAB have previously been linked to greening and off-odours due to the production of hydrogen sulphide gas at excessively high levels (Mills et al., 2014).

Microbial species can consume surface oxygen and contribute to discoloration prior to the normal oxidation of myoglobin which occurs as storage duration increases (Mancini & Hunt, 2005). Li et al. (2015) reported that LAB loading was related to decreased a* (-0.72) and increased myoglobin oxidation (+0.66) despite a lack of proliferation in aerobic conditions. Anaerobic conditions are associated with the formation of purplish meat colour due to deoxymyoglobin (Mancini & Hunt, 2005). In this study, however, much lower yet positive correlations were observed for LAB with a* and R630/580 (Table 1), relating increased concentrations of LAB to more bloomed meat. Blooming likely occurred due to anaerobic storage of meat (Callejas-Cárdenas et al., 2014) displayed under light (Holman et al., 2015), whereas the prior study measured the colour of meat stored aerobically in darkness (Li et al., 2015).

Conclusion

Increased proliferation of LAB due to long-term anaerobic storage of beef meat resulted in increased colorimetric measures of meat. Proliferation of ENT was found to be associated with meat discoloration over three days of retail display.

Acknowledgements

The authors thank the Australian Meat Processor Corporation (AMPC) and NSW Department of Primary Industries (NSW DPI) for their support.

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<table>
<thead>
<tr>
<th>Day</th>
<th>L*</th>
<th>ENT</th>
<th>LAB</th>
<th>ENT</th>
<th>L*</th>
<th>ENT</th>
<th>LAB</th>
<th>ENT</th>
<th>R630/580</th>
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<tr>
<td>0</td>
<td>0.11</td>
<td>0.04</td>
<td>0.25**</td>
<td>0.02</td>
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<td>1</td>
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<td>0.01</td>
<td>0.42***</td>
<td>0.04</td>
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<td>0.38***</td>
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<td>2</td>
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<td>0.08</td>
<td>0.30***</td>
<td>0.16</td>
<td>0.36***</td>
<td>0.12</td>
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</tr>
</tbody>
</table>

* = P < 0.05; ** = P < 0.01; *** = P < 0.001.
Development of a remote sensing device to detect duration of parturition in ewes

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Summary

Lamb survival is a multifactorial problem for the sheep industry, with particular relevance to Australian Merinos. Dystocia is a major contributor, both directly and indirectly through increased prevalence of lambs affected by the Starvation/Mismanthering/Exposure complex. Prolonged labour is linked to increased risk of hypoxia in lambs, resulting in ischemic brain damage and consequentially impaired cognition, vocalisation and ability to display appropriate behaviours. Here we describe our strategy in developing an accelerometer based movement sensor to detect lambing, with a view to providing a tool for remote measurement of parturition duration in sheep.

Introduction

Lamb survival is a multifactorial problem for the sheep industry, with particular relevance to Australian Merinos. Dystocia is a major contributor, both directly and indirectly through increasing the chances of lambs being affected by the Starvation/Mismanthering/Exposure complex (Hinch and Brien 2014). Prolonged labour is linked to increased risk of hypoxia in lambs, which can result in ischemic brain damage and consequentially impaired cognition, vocalisation and ability to display appropriate behaviours (Hinch and Brien 2014). Dystocia has been recently identified as a high priority area for research in lamb survival (Schmoelzl et al. 2015).

Novel sensor technologies are beginning to enter livestock production research and hold great promise for research and industry applications, with the development of wireless sensor networks enabling paddock based recording of livestock behaviours (Gonzalez et al. 2014). Global navigation satellite system (GNSS) data has been used to detect behaviours before and after lambing in the ewe (Dobos et al. 2014), while birth membrane-activated devices attached to the vulva have been described to detect birth in dairy cows (Marchesi et al. 2013). Successful birth event detection through movement loggers has to date not been described. In our current project, we utilise a customisable sensor platform to investigate the feasibility of detecting the length of the parturition event through movement loggers, with the initial goal of deployment as a research tool. As a first step, we have focussed on the detection of the birth event itself which we report here.

Materials and Methods

Animal experimentation was approved by the CSIRO Armidale Animal Ethics Committee (Animal Research Authority 15/29). A group of 40 multiparous Merino ewes with ultrasound-scanning confirmed pregnancies to Merino sires were kept in a lambing paddock from one week prior to expected lambing dates. Closer to the expected lambing date, ewes were moved to adjacent holding paddocks of 25 – 40 m2 in groups of 5 – 7 ewes per paddock. Ewe movements were recorded during daylight using a video surveillance system. No artificial lighting was used. Custom-made movement loggers comprising a 3-axis accelerometer and gyroscope were attached on the lower hind leg (metatarsus). Sampling rate was 10 Hertz. Accelerometer data was downloaded using the in-house developed software tool Chiswick Logger 2, and graphed to show average movement per one minute interval obtained using the CSIRO Livestock Phenomics Information System (CLIPIS). Video records were analysed for time of birth and first observable signs of labour by staff experienced in behaviour annotation. Birth time data and movements per minute were aligned manually in MS Excel.

Figure 1: Average movements over time

Shown are representative graphs of sums of three axes accelerometer data around video-annotated lambing time.
Results and Discussion

In this trial, we employed experimental devices recording over comparatively short time spans (24 h), with the potential to utilise gyroscope data to explore the feasibility of detecting lambing behaviours and parturition duration through remote sensing. Alignment of video-annotated lambing time with accelerometer data allowed a preliminary analysis of movement patterns (Figure 1). Graphed is the sum of each of the X, Y & Z axes of the accelerometer. The value is a measure of the absolute change of the accelerometer data between samplings (10 samplings per second). All values represent the average over a 1 minute period. In concordance with previous findings indicating that increased activity rates over time were indicative of impending lambing (Small et al. 2013), we observed an increase in activity over time which was associated with most of the recorded birth events, followed by a sharp drop in activity after parturition.

Further analyses of the data will determine whether a descriptive algorithm can be generated to a) reliably detect the lambing event and b) estimate the length of parturition from movement data. Collection of movement data over longer periods of time will aid in the development of the algorithm.

The successful development of a remote sensing tool for parturition duration will be an important milestone in the validation of novel phenotypes for dystocia and, hence, for lamb survival.

Acknowledgement

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References


Livestock production – 2050 and beyond

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Summary

In the debate about feeding a growing world population, rarely is consideration given to the effect this might have on farm animal welfare. Livestock farming practices can adversely affect welfare by failing to provide animals with their basic needs, such as adequate space and the freedom to express innate behaviours. If we are to grow animals for food or fibre, surely we can do so without compromising their welfare? What if we first address the glaring deficiencies in today’s food supply chain? Up to 50% of all food produced is wasted. In addition to food wastage, the livestock industry’s contribution to greenhouse gas emissions poses a challenge to the sector. Poor eating choices contribute to a significant public health concern affecting Australians. It is only when we include ‘animal welfare’ in the mix of these economic, social and environmental factors that livestock production systems will be truly sustainable.

The projected increase in world population to more than 9 billion by the year 2050 (UN 2013) is seen by many in the livestock industries as an opportunity to increase the scale or the intensity of their operations. How else are we going to feed this growing population? World meat production is expected to double by 2050 and most of this production is expected to take place in developing countries (FAO n.d.).

But how reasonable is it to expect to keep doing what we’re doing – just more of it – when there are clear signals along the food chain that change is imminent, if not already underway. For livestock production to be sustainable in the long term, consideration needs to be given to the impact of the farming system on the environment, on people and on the animals being farmed, while at the same time ensuring the business remains productive and profitable.

Today, regardless of whether the farming system is intensive or extensive, at some point animal welfare is compromised. It might be due to chronic stress as a result of intensive confinement, or it might be acute pain during an invasive procedure. And don’t we love chopping bits off animals – tail docking, beak trimming, disbudding, dehorning, castration, mulesing— the list goes on. We feed antibiotics prophylactically, we give hormones to make animals grow faster and bigger, we give hormones to induce birth, and we give other additives that promote leanness. All in an effort to adapt the animal to a market demand or housing conditions or management practices that suit us more than they suit the animal. In some industries, whether you are male or female determines whether you live a productive life or are considered a waste product. Breeding for productivity rather than robustness, health and longevity can have poor animal welfare outcomes. Not to mention poor stockmanship and animal-handling skills. And what about the suffering of livestock on marginal or drought-stricken lands where feed is minimal at best?

Livestock farming uses land, water and energy resources most of which are finite or scarce. Seventy percent of greenhouse gas emissions by the agricultural sector are attributable to livestock production which contributes about 10% to total national emissions (Australian Government 2015). Climate change and the associated increase in drought, fire and flood events, put in question the viability of livestock production in affected areas. The livestock industry’s contribution to greenhouse gas emissions (methane (56%) and nitrous oxide (73%)) (Government of Western Australia n.d.) pose a challenge to the sector. FAO’s mitigation interventions for beef cattle production systems propose improving pasture quality and better grazing management, preventive health measures as well as stress reduction through the provision of shade and water for cattle. Grain supplementation was not included as an emissions mitigation intervention for ruminants due partly to concerns that it reduces grain available for human consumption (FAO 2013).

Poor lifestyle and eating choices have contributed to a public health concern in Australia. Sixty-three percent of adults in Australia are considered overweight or obese (AIHW n.d.). Consumption of meats high in saturated fat and salt is a contributor to heart disease - the single biggest killer of Australians according to the Heart Foundation (NHFA 2013). There is convincing evidence that high levels of red and processed meat consumption (>200g/day) increases the risk of bowel cancer (IARC 2015). The Australian Dietary Guidelines (NHMRC 2013) recommend no more than 100g/day (raw weight) of lean red or poultry meats and advise including other protein-rich foods in our diet such as fish, eggs, nuts, seeds and legumes that provide the same essential nutrients (iron, zinc, vitamins, essential fatty acids).

Between 30 to 50% of food produced for human consumption is wasted globally (FAO n.d.; IME 2013). In Australia, at household level alone, it is estimated that 20% of all food purchased is discarded (Foodwise n.d.). This is an appalling statistic. Wastage also occurs at retailer level, in food service, and further down the supply chain during storage, slaughter, lairage, transport and on farm. Food waste represents a waste of resources and, in the case of animal-based foods, a waste of an animal’s life.
Certain foods are generally so cheap that some consumers don’t think twice before throwing it in the shopping trolley – $1/litre milk, or $5 chicken, or $3 cage eggs. If food is cheap, then it’s not surprising to see wastage. Throwing cheap food in the bin is just as easy as throwing it in the shopping trolley.

On the other hand, a small but increasing number of consumers are seeking a closer connection with the land and the people that produce their food – they want locally produced food, grown with consideration for the environment, human health and animal welfare – and they are willing to pay for it. Throw into this mix the concerns about the impacts of pesticide use, veterinary products, additives in processed foods and antibiotic use, and it’s not difficult to see the popular appeal of farmers’ markets and the 15% yearly increase in organic food production – particularly beef and dairy (Australian Organic 2014).

So, what does all this mean for the future of livestock particularly beef and dairy (Australian Organic 2014). The 15% yearly increase in organic food production – difficult to see the popular appeal of farmers’ markets and the 15% yearly increase in organic food production – particularly beef and dairy (Australian Organic 2014).

So, what does all this mean for the future of livestock production in Australia? Are we going to produce ever more food with more animals and more resources and at any cost? Or is it perhaps possible to consider an alternative food supply chain that truly encompasses the concept of sustainability? A supply chain that:

- is supported by a government that takes a leadership role in animal welfare and dedicates resources to progressing national animal welfare standards and animal welfare research;
- is supported by a government that recognises the importance of productive land, access to water and renewable resources to the production of food and therefore prioritises climate change mitigation and biodiversity conservation;
- acknowledges that food production and consumption should avoid negative environmental, health or social impacts;
- is research-driven and innovative in its use of technology;
- recognises that food waste is an unacceptable consequence of food production and seeks opportunities to reduce or eliminate wastage at each stage of the chain;
- pays farmers a fair price for the food they produce, that allows farmers to invest in improving infrastructure, to take measures to mitigate the impacts of climate change, to manage their land for future generations, to ensure staff are trained and competent, to provide a high level of animal welfare, as well as earn a decent living;
- recognises that food is valuable because the cost of production needs to take into account all the resources required to produce it and the impact its production has on those resources;
- believes good animal welfare is an inherent part of livestock production and provides animals with a life worth living. A life that encompasses good nutrition, a suitable environment, good health, the ability to express innate behaviours, and the opportunity to experience positive affective states (Mellor and Beausoleil 2015).

All those with an interest in the food supply chain should work together towards achieving a sustainable livestock production system that sees no party disadvantaged – least of all the animals we farm for food. Livestock production in Australia should be focussed on creating a high-value product with strong environmental, human health and animal welfare credentials, which is reflective of the true cost of production.

If we can’t provide that value-add, what’s going to stop consumers buying in vitro meat?

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Demonstrating a successful premium pasture-fed beef value chain

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Summary

Consumer demand for naturally raised and ethically produced beef, backed up by on farm assurance programs is growing globally. JBS Australia has partnered with the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR) to initiate the development of a value chain project for beef producers supplying into their premium pasture fed branded market, underpinned by a third party audited on farm assurance program. Through the establishment of facilitated supplier groups and engagement with the JBS procurement and marketing team a unique value chain approach has been established whereby regular interaction, open communication, transparency and clear pricing signals through the chain have enhanced relationships and added value to all segments.

Background

Cattle grazing enterprises in South East Australia are well placed to target premium high quality ‘natural’ pasture raised branded beef. Emerging export and domestic market opportunities exist for a premium grass fed beef product that is underpinned by an on farm assurance program that incorporates traceability, animal welfare and ethics along with high eating quality. Traditional supply chains lack the degree of integration, communication, relationships and clear market signals required to efficiently and consistently supply these markets. The challenges are supplying pasture finished beef year round that meet market specifications and a lack of information flow, including appropriate pricing signals. This further restricts informed decision making and confident adoption of new technologies.

A facilitated engagement process through the value chain provides for open and improved two way communication between the market and the producer. This process encourages transparency of procurement strategies and provides for clear pricing signals to be demonstrated by JBS; ultimately enabling the suppliers with confidence to make production system changes on farm. Minimising the potential of lost income and increased costs from non-compliance to specification through the chain is a critical feature of measuring success in year round supply of pasture fed beef. Through the producer groups an opportunity exists for suppliers to utilise established tools and new feedback technologies, such as MLA’s Livestock Data Link (LDL), to analyse their carcase performance, monitor their lost opportunity through non-compliance and use feedback solution tools for more informed decision making.

Outcomes and industry impact

1. Completion of an analysis of non-compliance within a Victorian pasture based beef supply chain (Crawford, Ferrier and Griffith 2014). This analysis provides a base line for measuring improvement in compliance and the cost of non-compliance within the FA program,

2. Six JBS FA supplier groups have now been established, (four in Victoria one in Tasmania and one in Southern...
Producer case studies with a focus on profitable long term outcomes are available outside the regional supplier groups. Information across the wider FA network, ensuring project supporting the annual supplier forums for dissemination of sustainable Australian beef industry. McDonalds are coordinators and suppliers. An economic impact as a result of tangible impacts have been particularly positive. Non tangible impacts have been the impact on industry from the project outcomes have their own profitability, but sharing that added value through consignments, minimise the lost opportunity and through ensures timely decisions are made to influence future production systems to enable supply of cattle meeting market specifications out of season.

Convening of an annual forum (2015) for JBS Farm Assurance suppliers, disseminating project outcomes and fostering knowledge sharing, innovation and open communication throughout the value chain.

A demonstration case study and analysis of eligible supplements for use within the JBS FA program,

Completion of training days for JBS FA suppliers in the use of LDL. Seven workshops have been completed across Victoria and three in Tasmania, specifically designed for the regional groups. Workshops are currently being planned for Southern NSW.

The impact on industry from the project outcomes have been particularly positive. Non tangible impacts have been an observable change in supplier attitude and trust within the value chain, an outcome derived from the unique interactions and partnerships built between JBS, group coordinators and suppliers. An economic impact as a result of the project has been an improvement in producer’s ability to meet target FA specifications, improving not only their own profitability, but sharing that added value through to end use markets. Through the use of LDL, producers and JBS are able to readily access all feedback data in a way that ensures timely decisions are made to influence future consignments, minimise the lost opportunity and through group discussion and demonstration adopt new practices on farm or adapt current ones.

Project growth/additional components

The Victorian success led to the extension of the project into Southern NSW and Tasmania in 2015 through collaborations with Pear Consulting (Tas) and NSW Department of Primary Industries. Two new JBS FA supplier groups have been established allowing producers in those regions access to the proven project approach, project resources, training opportunities and improved engagement with JBS and the value chain.

An additional contributor to this project is McDonalds, who are working in collaboration with industry in support of a sustainable Australian beef industry. McDonalds are supporting the annual supplier forums for dissemination of information across the wider FA network, ensuring project outcomes are available outside the regional supplier groups. Producer case studies with a focus on profitable long term production systems, environmental impacts, animal welfare and ethics and product integrity are being completed across Victoria. These will contribute to the wider global McDonalds initiative on sustainable beef production systems.

The JBS producer forum held in Victoria (2015) and two in Tasmania (2014 and 2015) have included presentations from buyers (retailers / restaurants) of the branded pasture fed product. The nature of export focused value chains and large distance between supply and end market mean that it is often difficult for suppliers to interact and obtain feedback from end users of their product. This opportunity builds supplier understanding of consumer perceptions of the brand and develops pride that their product is highly regarded and valued by end users.

Another outcome of the regular interaction and open communication enabled through the supplier group meetings and forums is the strengthening of relationships between vaule chain members. It is well known that value chain management is based on foundations, trust and commitment (Lee and Billington as cited in Spekman, Kamauff Jr and Myhr (1998). Effective relationships derived from regular exchanges and effective communication leads to the development of social capital within the value chain. Putnam (1995) describes social capital as comprising elements of networks, shared norms and trust that enables participants to work together to pursue shared goals. The social capital enhanced though this project will assist JBS Australia and their suppliers to work together to supply a premium grass fed product, compliant with market specifications year round.

Additional work yet to be completed within the project includes an analysis of procurement strategies and further work on integrating electronic information systems such as e-decs throughout the JBS FA value chain.

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The use of carbon dioxide to stun pigs – benefits, drawbacks, and the way forward from here: a review

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Summary

The two main methods of inducing unconsciousness in pigs prior to slaughter in Australia are exposure to carbon dioxide gas, and electric stunning. Stunning using carbon dioxide offers benefits including improved meat quality, the ability to stun animals in groups and with minimal restraint, and less pre-stunning handling compared to other methods of stunning. However, in recent years, there have been a number of welfare considerations identified with carbon dioxide stunning. These include the highly aversive nature of the gas, the variability between individual responses, that pigs are not rendered unconscious immediately, and that studies have identified that the procedure is not free of pain and distress as was initially suggested. Further research is urgently needed to develop stunning systems which retain the positives of carbon dioxide stunning while minimising the negatives.

Introduction

Stunning prior to slaughter is required in many countries including Australia. The aim is for stunning to induce unconsciousness and insensibility so that slaughter may be carried out without avoidable fear, anxiety, pain, suffering, and distress (EFSA, 2004). The most frequently used methods to stun pigs prior to slaughter are electric stunning and exposure to carbon dioxide (Becerril-Herrera et al., 2009).

Carbon dioxide is a gas which, when inhaled at high concentrations, induces hypercapnic hypoxia. This leads to changes in the blood including pH, carbon dioxide partial pressure, oxygen partial pressure, oxygen saturation, and bicarbonate concentration. Consequently, there is a decrease in the pH of cerebrospinal fluid and the animal loses consciousness (Rodriguez 2008).

Some earlier studies suggested that there is no marked reaction of pigs to carbon dioxide, even when immersed in 90% carbon dioxide, and that panic or flight reactions do not occur (EFSA, 2004). Troeger and Woltersdorf (1991) concluded that first contact with carbon dioxide for stunning does not produce a definite sensation of pain or unease in pigs (EFSA 2004). However, a number of studies have since revealed that carbon dioxide is in fact highly aversive to pigs, and that pigs experience significant pain and distress during stunning when exposed to high concentrations of the gas (Velarde et al., 2007).

The time required for pigs to lose consciousness after immersion in carbon dioxide is currently contentious, as is the pigs’ experiences after immersion in carbon dioxide gas prior to the loss of consciousness (Rault and Jongman, 2014). In addition, there is a lack of knowledge about why there is variability between individual pigs in their behavioural responses to carbon dioxide gas, and the effects of experiences prior to gas stunning (Rault and Jongman, 2014).

This paper will discuss some of the advantages and disadvantages of carbon dioxide stunning, and identify areas for future research.

Advantages

Stunning with carbon dioxide does not require restraint during the procedure, other than confinement in a gondola. In addition, more than one animal may be stunned at one time. Restraint and social isolation are thought to be stress inducing in pigs. Therefore, a reduction in pre-stunning handling and a lack of social isolation (compared to electric and captive-bolt stunning) may reduce the stress associated with stunning (Rault et al., 2015).

Pigs may be required to move down single-file raceways prior to entering the gondola However, newer group stunning systems reduce the amount of handling prior to stunning, and do not require pigs to walk in single file prior to entering the system (EFSA, 2004).

Stunning with carbon dioxide is thought to generally result in better meat quality, and also does not cause convulsions following stunning (EFSA, 2004).

Electrical and captive-bolt stunning are highly reliant on the skills of the operator. Conversely, the exposure of pigs to high concentrations of gases is, from an operating point of view, a less variable procedure, although there may be high variability between individual pigs’ responses (Rault and Jongman, 2014).

Individual variability

Despite consistency in procedure, it has been identified that there is considerable variation between animals in their responsiveness when exposed to carbon dioxide gas. This variability may be attributed to individual biological variation (Atkinson et al., 2012), the presence of the halothane gene (Velarde et al., 2007), or potentially the animals’ experiences prior to stunning (Rault and Jongman, 2014).

There have been a number of studies conducted to investigate the effectiveness of stunning and the length of time to unconsciousness. However, differences between methodologies can make comparisons between studies difficult (Atkinson et al., 2012), and there is a current lack of knowledge on the variability in responses during stunning with carbon dioxide.
Disadvantages

One of the major disadvantages in the use of carbon dioxide for stunning is that it does not induce insensibility immediately (Rault and Jongman, 2014), and that loss of consciousness can take between 30 and 60 seconds (EFSA, 2004, Rodriguez et al., 2008).


Behavioural studies have found that the majority of pigs avoid and quickly withdraw from high concentrations of carbon dioxide (Raj and Gregory, 1995), and that almost 90% of pigs preferred to go without water for 72 hours than experience exposure to carbon dioxide gas (EFSA, 2004). It has also been identified that carbon dioxide may not result in an effective stun, depending on concentrations and exposure times, and that animals may recover from stunning (Hartung et al., 2002).

Alternative gases

Evidence suggests that gas mixtures such as argon, nitrogen, or nitrous oxide may offer a higher welfare option for stunning pigs (EFSA, 2004, Rault et al., 2013, 2015). However, following the use of hypoxic gas mixtures to induce stunning, the stun-to-stick interval needs to be carefully monitored.

Combinations of argon with carbon dioxide have been proposed, with the various concentrations and exposure times requiring different stun-to-stick intervals. Important considerations when using hypoxic gas mixtures include short stun-to-stick intervals, and longer exposure times in the gas mixtures to cause death (EFSA, 2004).

Some studies have examined the use of a combination of hypoxic gas mixtures to induce unconsciousness in a humane manner, followed by electrical cardiac fibrillation. Another potential method to improve welfare involves a two-step procedure, by which pigs are initially anaesthetised using an anoxic gas mixture such as nitrous oxide, followed by euthanasia by immersion in carbon dioxide (EFSA, 2004, Rault et al., 2013).

Conclusions and implications

Stunning is intended to induce insensibility and unconsciousness in animals so that slaughter may occur without avoidable fear, anxiety, pain, suffering, and distress. Gas stunning has a high potential for humane stunning if non-aversive gases are used. However, there is overwhelming scientific evidence which demonstrates that stunning with carbon dioxide does not guarantee an absence of avoidable pain, suffering, and distress in pigs.

Carbon dioxide gas, as with most forms of stunning, has both advantages and disadvantages in terms of animal welfare. Some of the advantages of carbon dioxide include the ability to stun animals in groups rather than individually, and a reduction in handling and therefore stress. Disadvantages include variability in responses to the gas, the ability for pigs to regain consciousness, and the fact that high concentrations of carbon dioxide gas are highly aversive to pigs.

There is a need for research to develop stunning systems which retain the positives of carbon dioxide stunning including meat quality, group stunning, and low pre-handling stress, while minimising the negatives, including a shorter time to induce unconsciousness, and less variability between individuals.

References


On farm factors increasing dark cutting in beef cattle

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Summary

King Island pasture raised cattle (n=3,185) sent for slaughter on mainland Tasmania were evaluated to determine which on farm factors increased the incidence of dark cutting. Cattle were sent in groups (n=61) to slaughter from March - June 2015. Animal and management factors were recorded and forage quantity and quality was measured. The incidence of dark cutting in groups of cattle accessing dam water decreased by 22.9% from 25.2% ± 3.2 as pasture magnesium concentration increased from 0.18% to 0.28% DM (P<0.01). Groups of cattle with a dam water source had 5.9% higher dark cutting than groups with access to trough water (8.5% ± 1.8, P<0.01). Groups of cattle which did not receive supplementary feed (hay/silage) had a 6.1% increase in dark cutting compared to groups on pasture alone (8.4% ± 1.7, P<0.01). Steer groups had an 11.3% ± 2.6 higher rate of dark cutting than heifer groups (P<0.01).

Introduction

Dark cutting beef costs the Australian beef industry up to $55m per annum (Jose et al. 2015) due to not meeting Meat Standards Australia grading requirements for pH and/or meat colour. Dark cutting is caused by low muscle glycogen at slaughter, which is a result of reduced storage or increased breakdown of glycogen pre-slaughter. Dark cutting is particularly prevalent in southern Australian cattle coming off pasture during autumn and early winter (McGilchrist et al. 2014). During this period grass dominant pastures that are young, short and rapidly growing are likely to have high potassium (K) and low magnesium (Mg) concentrations which could result in hypomagnesaemia (HypoMg) and clinical grass tetany (Schonewille 2013). High dietary K can reduce Mg absorption and predispose cattle to HypoMg, thus the ratio of K to Mg (the grass tetany index) may be a useful indicator of HypoMg. HypoMg may cause dark cutting by reducing feed intake thus glycogen storage and by increasing glycogen breakdown due to neuromuscular hyperexcitability and increased adrenaline responsiveness to stress. Thus we hypothesise that cattle grazing pastures with a higher grass tetany index will have an increased incidence of dark cutting.

Materials and Methods

Groups (n=61) of cattle (n=3,185) of varying sexes, ages and breeds, were pasture raised on King Island, Tasmania before shipping to mainland Tasmania between March and June for slaughter at the same processing plant. The pasture and supplementary feed (hay/silage) consumed by each group were sampled and analysed for metabolisable energy, crude protein, Mg, K, calcium (Ca) and many other parameters of forage quality using Near Infra-Red (Dairy One, Ithaca, New York, USA). The grass tetany index was calculated using the equation (K/(Calcium+Mg)) in milliequivalents, where indices greater than 2.2 suggest an increased risk of HypoMg (Schonewille 2013). All carcasses were graded by qualified Meat Standards Australia graders where meat must be pH ≤5.7 and/or meat colour <3 to be eligible for grading. The percentage of dark cutting per group was analysed using a general linear model in SAS® (SAS Institute 2001). Fixed effects included animal factors (sex and consignment date) and management factors (supplementary feed and water source). Continuous terms included in the model were other management factors (lifetime yarding’s, days since last draft, weaning age, trucking distance on King Island and paddock size), pasture quantity (available pasture), quality (Metabolisable Energy, Crude Protein, Neutral Detergent Fiber and Acid Detergent Fiber) the grass tetany index and other minerals (K, Mg, Ca, Sodium, Molybdenum and Chloride) along with their relevant interactions. Curvilinear terms for each continuous variable were also tested. Terms which were not significant (P>0.05) were removed from the model.

Results

Magnesium

The incidence of dark cutting per group was not associated with the grass tetany index (P>0.05) however low pasture Mg independent of K and Ca did increase incidence of dark cutting (P<0.01). In groups of cattle sourcing water from dams, there was a 22.9% reduction (25.2% ± 3.2 to 2.3% ±3.3) in incidence of dark cutting as pasture Mg increased from 0.18% to 0.28% Dry Matter (DM) (Figure 1). Pasture Mg concentration had no impact on the incidence of dark cutting in cattle with access to trough water (P>0.05, Figure 1).

Figure 1: The effect of water source and pasture Magnesium concentration on the incidence of dark cutting beef per group. Solid lines represent the least squared means, small dashed lines represent the standard error.
Water

Water source had a significant impact on the incidence of dark cutting per group (P<0.01). Cattle with a dam water source had an average dark cutting rate of 14.4% ± 1.6 dark cutting per group. This was 5.9% ± 2.1 higher than cattle with trough water access whose average incidence was 8.5% ± 1.8 (P<0.01).

Supplementary feed

Supplementation improved the rate of dark cutting from 14.5% ±1.6 in the pasture only group to 8.4% ± 1.7 in the supplemented groups (P<0.01). However the supplement metabolisable energy and crude protein were significantly lower (P<0.05) than the pastures and supplement Neutral Detergent Fiber and Acid Detergent Fiber were significantly higher than the pastures (P<0.01).

Sex

The sex of the groups had a significant impact in the incidence of dark cutting (P<0.01). Heifer groups had a 5.7% ± 2.1 incidence of dark cutting compared to steer groups that had an incidence of 17.0% ± 1.4 (11.3% ± 2.6). Groups with a mix of sexes had an incidence of 11.6% ± 3.1 (P<0.01).

Discussion

Contrary to our hypothesis, the grass tetany index did not impact the incidence of dark cutting beef, however increasing pasture Mg did reduce dark cutting in groups of cattle sourcing water from dams. The interaction between pasture Mg and water source has not been previously described. The effect of low pasture Mg increasing dark cutting with a dam water source suggests that water palatability reduced forage consumption and in turn reduced overall Mg intake. The significant increase in dark cutting rate with low pasture Mg suggests that HypoMg may have been occurring in these cattle. Increased incidence of HypoMg and grass tetany has been associated with numerous factors including low pasture Mg (<0.2% DM), short pasture <1,000kg DM/ha, high pasture K levels (>3.5% DM) and grass tetany index >2.2 milliequivalents (Schonewille, 2013). In contrast to our hypothesis the fact that low pasture Mg increased dark cutting independent of K suggests that reduced Mg intake underpins this finding rather than K-induced malabsorption of Mg.

These results suggest that water quality is impacting Mg intake as there is a positive interaction between clean water source and forage intake (Hyder et al 1968, Willms et al 2002). Water is critical in forage digestion as rumen microbial attachment to feed particles is largely facilitated by the rumen fluid matrix (McAllister et al 1994). Willms (2002) reported grazing cattle with a dam water source had a 23% reduction in weight gain compared to those with clean trough water access which may also be decreasing glycogen deposition. Water intake directly affects grazing habits (Willms et al 2002). Cattle with clean water trough access have been shown to spend longer time grazing compared to those with a faecal contaminated water sources such as a dam (Willms et al 2002). Hence water source may impact dark cutting due to the water palatability impacting overall forage intake, weight gain and glycogen storage (Willms et al 2002).

The association between supplementary feeding and dark cutting in this study was not due to increased quality of feed on offer. The quality of the supplementary feed, evaluated by crude protein, metabolisable energy, Neutral Detergent Fiber and Acid Detergent Fiber were lower than pasture on offer. The suggested mechanism of action of supplementary feed reducing dark cutting is reduction in stress response from improved human habituation. Another mechanism may have been from increased fibre content of feed on offer improving gut fill during transport, reducing stress on the animal however this requires further investigation.

The sex effect of heifers having reduced incidence of dark cutting compared to mixed mobs and steers was an unexpected and contradictory finding to other data sets (McGilchrist et al. 2012).

Conclusion

This study suggests that producers should monitor pasture Mg levels when dam water is used and potentially supplement Mg to reduce dark cutting. Confirmation of the mechanism by which low pasture Mg increases dark cutting in cattle with dam water access requires further research. Providing good quality clean water, free from faecal contamination is important in maximising feed intake and glycogen storage thus reducing the incidence of dark cutting. Further investigation into why supplementary feed of inferior quality to available pasture reduces incidence of dark cutting is required. Habituation to humans is important to reduce stress with transport and lairage handling however the optimum preparation type and level is still unknown. Improving water palatability, human habituation and monitoring pasture magnesium can help reduce dark cutting and thereby minimise its large economic impact on the beef industry.

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Maximum survival of lambs to weaning is achieved when Merino ewes are in condition score three prior to lambing.

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Summary

We examined the effect of pre-lambing condition score of ewes on the survival of their lambs to weaning. Pre-lambing condition scores from adult ewes (n=1545) were collected over six years and analysed with their lambing and weaning records (n=3582). Maximum survival of both twin and single-born lambs prevailed when the pre-lambing condition score of ewes was between 2.5 and 3.5. This optimum range was consistent across all lambing years and implies that a pre-lambing condition score target of 3 is adequate for Merino ewes carrying single or twin foetuses.

Introduction

Increasing the survival of twin-born lambs has been identified as the most valuable research priority irrespective of wool or meat prices (Young et al. 2016). Survival of lambs to weaning increases with their birthweight quadratically, with maximum survival occurring between 4-7 kg (Oldham et al. 2011; Paganoni et al. 2014). Increasing ewe liveweights between day ninety of pregnancy and lambing is known to increase lamb birthweights, and this in-turn can improve their survival (Thompson et al. 2011; Oldham et al. 2011; Paganoni et al. 2014). It would therefore seem logical that increasing the pre-lambing condition score of Merino ewes should also improve lamb survival to weaning, but with a similar optimum range, after which lamb survival may decline. This study examined the direct effect of ewe condition score pre-lambing on the survival of their lambs to weaning, with the hypothesis that there would be an optimum range of condition scores pre-lambing that would maximise lamb survival.

Materials and Methods

Ewes from the Maternal Efficiency Flock (n=1545) were joined with rams over six lambing seasons (2010-2015) at Ridgefield Future Farm. The average age of the ewes at joining was 3.4 years and over the six seasons the average joining date was 24-January. Ewes were managed under commercial grazing conditions from joining until weaning. Condition scores (1=emaciated, 5=obese; Russel and Doney, 1969) were recorded at joining (ram introduction), mid pregnancy (between days 50-100 of pregnancy) and pre-lambing (between days 100-150 of pregnancy). Lambs (n=3582) were identified to their dams at birth enabling number of lambs born and weaned to be recorded for each dam.

Survival of lambs to weaning was calculated from the difference between lambs born and lambs weaned. Lamb survival was analysed using a General Linear Mixed Model with a binomial distribution and a logit link function in GENSTAT (VSN International 2012). Lamb sex, birth type, ewe age, year, ewe condition score at joining and ewe condition score pre-lambing and the quadratic function of condition score pre-lambing plus all 2-level interactions were fitted as fixed effects. Lambing year and ewe id within lambing year plus joining date were fitted as random effects.

Results and Discussion

Pre-lambing condition score of ewes had a significant quadratic effect on lamb survival (P<0.05) supporting our hypothesis. Maximum survival of both twins and singles occurred when the pre-lambing condition score of ewes was between 2.5 and 3.5 (Figure 1). There was no significant effect of ewe condition at joining or at day 90 on lamb survival, nor were there any significant interactions between condition score and birth type.

Overall twin-lamb survival was excellent (87 ± 1.4%) but still less than for singles (91 ± 1.1%; P<0.05). Females had higher survival than males such that survival of twin-born females was not different to single born males (90 ± 1.4%). Single-born females had the highest survival (94 ± 1.1%; P<0.05). Lambing year also had significant effects on lamb survival for both singles (range 87-98%) and twins (80-96%).

Figure 1: The mean effect of pre-lambing condition score of ewes on the survival to weaning (%) of their single and twin-born lambs over six lambing years (2010-2015).
This ‘optimum’ condition score range for maximum lamb survival of 2.5 to 3.5 is consistent with ewe management guidelines from the Lifetime Wool Project (Thompson et al. 2011) that recommend ewes reach a target condition score of 3 in late pregnancy (Curnow et al. 2008).

There was no direct effect of ewe condition score at joining on the survival of their lambs to weaning in this study. Nevertheless, improving ewe condition at joining is known to increase lamb birthweights (reviewed Kenyon et al. 2014) and this can indirectly improve lamb survival to weaning. Therefore increasing condition score at joining should not be dismissed as a means to improve lamb survival.

The interaction between ewe condition score pre-lambing and birth type was also not significant, indicating that similar pre-lambing condition score targets are appropriate for all pregnant ewes of this genotype. This does not however discount the practice of separating single and twin bearing ewes after pregnancy scanning, as twin-bearing ewes still require more feed to maintain their weight in addition to fetal and placental growth, therefore warranting the allocation of extra feed resources (Edwards et al. 2011).

Lamb survival from this flock was consistently higher than that reported for other Merino research flocks, particularly for twins (Hall et al. 1995; Holst et al. 2002; Thompson et al. 2011). The higher survival achieved for this flock may be attributed to genetic selection for high growth, muscle and fat, however, it should also be considered that only lambs that were correctly identified to dams were used in this analysis. Over the six lambing years of the study there were an additional 574 lambs born (12%) that were not accurately identified to their dams. Of these unidentified lambs, 194 (4%) were found dead or died before weaning. As these lambs were excluded from the analysis because they lacked dam information, the survival figures presented will be higher than actuals.

Acknowledgements

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References


Caffeine increases an neonatal piglets body temperature and negatively effects survival at 24 hours of age

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Summary

Piglet pre weaning mortality is a major economic and welfare concern. Caffeine administration prior to, or after, parturition positively affects metabolic parameters associated with neonatal survival. However the impact of dosing piglets with caffeine at varied time points within 24 hours of birth on temperature and survival to post-natal day 20 (weaning) has not yet been evaluated. Piglets received caffeine orally at birth and 24 hours post-partum or 8-12 hours and 24 hours post-partum. Body temperature was collected 10 minutes, 24 and 72 hours after birth and mortality recorded to post-natal day 20. Regardless of timing of administration, caffeine increased piglet body temperature 24 and 72 hours post-partum (P<0.05). Piglet mortality within 24 hours post-partum was higher (P<0.05) for the caffeine at birth treatment group (8.5%) compared to all other treatment groups (range: 2.5% - 3.5%). Although caffeine positively affected thermoregulation, survival of piglets receiving caffeine at birth was reduced.

Introduction

Within the Australian pig industry, approximately 710,500 live born piglets (11.3%) die each year prior to weaning (Australian Pork Limited 2013). This high rate of pre-weaning piglet mortality represents a major economic and welfare concern to the industry (Deroth and Downie 1976). Pre- and peri-partum causes of piglet death include: large litter sizes, piglet mortality represents a major economic and welfare concern to the industry (Deroth and Downie 1976). Pre- and peri-partum causes of piglet death include: large litter sizes, long parturition times, placental detachment, and umbilical cord occlusions, ruptures or breaks (Alonso-Spilsbury et al. 2005; Borges et al. 2005). These factors decrease blood flow and oxygen delivery to the fetus during parturition, leading to hypoxia, which commonly results in stillbirths or low viability piglets (Son et al. 2014). Caffeine administration prior to, or after, parturition positively affects metabolic parameters associated with survival in newborn animals and can reduce the negative effects of hypoxia (Orozco-Gregorio et al. 2011). However, its effect on piglet body temperature during the first three days of life, and survival to 20 d of age when given at varied times within the first 24 h of life has not been evaluated. It was hypothesised that orally dosing piglets with caffeine either at birth and 24 h of age or 8-12 and 24 h of age would increase survival of piglets, and improve regulation of body temperature.

Materials and Methods

A total of 634 piglets were studied. The four treatments administered were caffeine at birth (n = 129), control solution at birth (n = 118), caffeine 8 – 12 h post-partum (n = 203) and control solution 8 – 12 h post-partum (n = 184). Treatments were randomly allocated within each sow’s litter prior to farrowing, and were distributed evenly across birthing order. Caffeine (30 mg) was dissolved in 2 ml of water. Control solution was 2 ml of water. Treatments were administered orally using a piglet applicator gun. The caffeine at birth (Caff) and control at birth (Con) groups received 30 mg caffeine (Caff) or 2 ml of water (Con) at birth and at 24 h. After treatment at birth, piglets were placed near their mother’s vulva to imitate where they were born. The caffeine eight-hour treatment group (Caff8) and control eight-hour treatment group (Con8) received 30 mg of caffeine (Caff8) or 2 ml of water (Con8) at 8-12 h and at 24 h of age. If a sow farrowed overnight, all piglets in that litter were randomly allocated to either Caff8 or Con8.

Results

Piglet mortality

There was no significant effect of treatment on total piglet mortality between birth and day 20, 24 hours and day three, or days three and 20 post-partum (Table 1). However, dosing piglets with caffeine at birth increased mortalities within the first 24 h after birth compared with all other treatment groups (P = 0.04, Table 1).

Table 1. Percentage of mortalities that occurred within each treatment group at different time points in piglets in four treatment groups: control (Con), control 8 hours (Con8), caffeine (Caff), caffeine 8 hours (Caff8) (n (total deaths) = 65)

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Piglets dying (%) between: Birth – 24 h post-partum</th>
<th>24 h and day 3 post-partum</th>
<th>Days 3 and 20 post-partum</th>
<th>Birth and day 20 post-partum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Con</td>
<td>2.5%a</td>
<td>2.6%</td>
<td>3.6%</td>
<td>8.5%</td>
</tr>
<tr>
<td>Con8</td>
<td>2.7%a</td>
<td>1.7%</td>
<td>0.9%</td>
<td>8.2%</td>
</tr>
<tr>
<td>Caff</td>
<td>8.5%b</td>
<td>6.8%</td>
<td>0.9%</td>
<td>15.5%</td>
</tr>
<tr>
<td>Caff8</td>
<td>3.5%a</td>
<td>3.6%</td>
<td>3.2%</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

Values in the same row with different superscripts differ significantly (p ≤ 0.05)

Table 1.

<table>
<thead>
<tr>
<th>Treatment group</th>
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</tr>
<tr>
<td>Con8</td>
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<td>0.9%</td>
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</tr>
<tr>
<td>Caff</td>
<td>8.5%b</td>
<td>6.8%</td>
<td>0.9%</td>
<td>15.5%</td>
</tr>
<tr>
<td>Caff8</td>
<td>3.5%a</td>
<td>3.6%</td>
<td>3.2%</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

Values in the same row with different superscripts differ significantly (p ≤ 0.05)
**Temperature Characteristics**

At 24 h of age, rectal temperature was higher for piglets in the Caff8 compared with all other treatment groups (P < 0.05, Figure 1). At three days of age, rectal temperature was higher for piglets in Caff compared with the Con and Con8 treatments (P < 0.05, Figure 1).

![Figure 1. Rectal temperature in piglets 24 h and 3 d post-partum in four treatment groups: control (Con), control 8 hours (Con8), caffeine (Caff), caffeine 8 hours (Caff8). Data shown as estimated marginal means ± SEM, the different subscripts indicate that the values differ significantly (P ≤ 0.05) (n at 24hr: Con = 113, Con8 = 178, Caff = 118 and Caff8 = 195; n at day 3: Con = 109, Con8 = 174, Caff = 109 and Caff8 = 189)](image)

**Discussion**

The increased mortality of piglets receiving caffeine at birth was unexpected, as previous studies have reported no adverse effects on survival following caffeine supplementation pre- or post-natally. This high mortality in the piglets treated with caffeine at birth may be attributed to piglets being born with low body energy stores and no serum immunoglobulins (IgG) (Le Dividich et al. 2005; Baxter et al. 2008; Rootwelt et al. 2012). Consequently, piglets rely on their ability to reach a teat to obtain colostrum for energy and immune protection (Herpin et al. 1996; Baxter et al. 2008; Rootwelt et al. 2012). Further, caffeine influences catecholamines, which are known to increase energy availability and utilization (Orozco-Gregorio et al. 2012; Superchi et al. 2013). Both of these factors would positively influence animals with abundant energy stores, as it would result in hyperactivity, which may enable them to reach a teat and attain antibodies and energy faster. This was not, however, the case for the piglets treated with caffeine in this experiment.

Caffeine can increase body temperature via its interaction with the purinergic system and other central neurotransmitters and neuromodulators involved in thermoregulation (Superchi et al. 2013). As a result, caffeine would be assumed to elevate body temperature while present within the body, however it would have no lasting effect once metabolised and excreted. This may explain the increase in body temperature recorded 24 h after birth. As the half-life of caffeine in humans is 2.5-10 hours (Orozco-Gregorio et al. 2011) the likelihood of caffeine being present at 24 h in piglets treated with caffeine at birth is low, however, it is likely that caffeine would still be present in piglets given caffeine at 8-12 h.

Interestingly, rectal temperature was higher at three days of age in piglets treated with caffeine at birth but not in piglets treated with caffeine at 8-12 h. It is unlikely that caffeine would still be present in the piglets’ system 48 hours after administration. As both groups of piglets received a second dose of caffeine at 24 h of age, if caffeine were still present, both caffeine treated groups should have demonstrated a similar elevation in body temperature at 3 d of age. This increase in body temperature at 3 d may be explained by the fact that mortality was highest in the caffeine at birth treatment group within the first 24 hours of life. It can be assumed that those that died were low viability or low weight animals. As a result, the average body temperature for this group may be higher due to fewer low viability animals in this group compared to other groups. Ultimately, more research is required in order to establish the full extent to which caffeine influences the body temperature of piglets.

We conclude that caffeine’s effect on energy expenditure, adversely affects those that do not have enough body energy stores to withstand it. Further research on caffeine dosage and timing post-partum is required to establish its efficacy.

**Acknowledgments**

The authors acknowledge the Ronald J Lienert Memorial Scholarship, Australian Pork Limited Scholarship and the University of Adelaide and Roseworthy Piggery for the use of its funding, animals and facilities. Jemma Seyfang, Kate Plush, Cameron Ralph and Patricia Condous for all of their expert technical assistance.

**References**


Feed intake for sheep can be measured precisely in less than 35 days

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Summary

The protocol for measuring feed intake in sheep has been adapted from research with cattle, which recommends a 35-day test period. We used feed intake data from ~1000 sheep to see if the optimum test period was different. Variation in daily feed intake of sheep became stable in less than 35 days, and correlations between 21 and 35 day test periods were ≥0.95. Therefore, there is little advantage in measuring feed intake for more than 21 days. Feed intake can therefore be measured in less time for sheep than cattle. Shortening the test period will cost less and improve the welfare of the sheep tested.

Introduction

Sheep that eat less but produce more are more efficient and profitable. Measuring feed intake is therefore necessary to select more efficient sheep. Currently, feed intake is expensive to measure at centralised research stations. Therefore, reducing the duration of feed intake measurements will cost less and more sheep can be tested. These improvements will make it easier to identify and breed efficient sheep.

There is little data published on feed intake from sheep. Therefore, protocols for measuring feed intake in sheep are adapted from experiments with beef cattle. In the standard beef cattle model, 35 days of measuring feed intake is the minimum time required for sufficient precision for young growing heifers (Archer et al. 1997). Sheep, however, have different physiology and feeding behaviour to cattle. Therefore, the length of time required for precise feed intake measurements may be shorter. This shortening of time could reduce measurement costs significantly.

Therefore, we tested the hypothesis that the length of feed intake measurements for sheep will be different to the 35 days recommended for cattle.

Materials and Methods

We measured feed intake between 2012 and 2016 in Merino ewes (n=1010) born between 2012 and 2014. Feed intake was measured at three ages for the same sheep, post weaning age (160-340 days old, n = 1010), hogget age (410-550 days old, n = 1010), and adult age (530+ days old, n = 445). We measured the sheep at the indoor feeding facility at Medina Research Station, Department of Agriculture and Food of Western Australia.

All sheep were fed the same pellet, formulated for growth with average metabolisable energy 12.05 MJ/kg DM (range 11.8-12.2), protein 17.13 % of DM (range 16-18.4) and fat 2.95 % of DM (range 1.9-4).

After a two week adaptation to the diet, we randomised the ewes by sire into fifteen pens (n=12-15). Each pen had a feeder that allowed only one sheep to access feed at a time. For post weaning we also randomised by weight so only one sheep could access the feeder at a time. To access the feeder, sheep walked past an aerial that recorded their electronic tag number via radio-frequency to a main computer. The duration of feeding and the weight of feed eaten was automatically recorded through electronic scales and weigh bars using FeedTracker software. Feed intake was recorded for 35 days. We removed Individual feed events if intake was more than three standard deviations from the mean for all animals.

Daily intake was calculated from this cleaned data by summing the total feed eaten over each day. Post weaning records from one group (n=190) were removed from this analysis due to contamination with external sources of error. Average daily intake was calculated by summing the total daily intakes by the number of whole days that intake was collected.

To find the optimum number of days feed intake should be measured, we estimated the variance of daily feed intake. We then compared the variance of intake measured over 1, 2, 3, to 35 days. We also estimated the correlations of feed intake measured of different time periods to feed intake measured over 35 days. These correlations can compare how similar measuring feed intake for 1 day, 4 days or 20 days is to measuring for 35 days.

Results and Discussion

Variation in daily feed intake became stable in less than 35 days (Figure 1), and correlations between 21 and 35 day test periods were around 0.95 for all age groups (Figure 2). These results support our hypothesis that feed intake in sheep can be measured for a different time period than cattle which are measured for 35 days.

Adults ate the most (average 2.39 kg/hd/day) followed by hoggets (2.20/hd/day) and post-weaners (1.53 kg/hd/day) over the 35 day measurement period. Variation in feed intake measurements was higher for adults than hoggets and post weaners (Figure 1). This is because adults are more varied in size and eat more than hoggets and post weaners. Variation required less days to become stable for adults and post weaners than for hoggets.
The correlations between feed intake measured over 35 days and between 1 and 35 days ranged between 0.2 to 1 (Figure 2). Feed intake measured over a short period (less than 10 days) was least correlated to intake measured over 35 days in post weaners. This may mean that post weaners take more time to adjust to the environment in the feeding pen than older animals. This adjustment period requires the sheep to adapt to social structure, become confident using the feed chutes and further adapt their gut physiology to the diet.

Older sheep had a shorter adjustment period. This is logical since the sheep measured at hogget and adult ages have already been through the station at least once.

The biggest increase in correlations with 35 days measurement was between 1 and 12 days. Feed intake measured in adults over 5 days in hoggets over 9 and post weaners over 10 days had a correlation of 0.8 with feed intake measured over 35 days. The correlation increased to 0.95 after 27 days in adults, 22 in hoggets and 21 in post weaners. Therefore, there is little advantage in measuring feed intake for more than 20-25 days.

It is difficult to compare our results to other studies because feed intake was collected from housed animals using an electronic data capture system (FeedTracker). Most other feed intake is measured by weighing feed in and out for animals housed in individual pens. FeedTracker is less reliable than using individual pens but requires less labour and represents feeding behaviour better.

Having many sheep in one pen includes the social interactions that sheep would encounter in commercial conditions. The sheep may also require more time to adapt to the environment. Therefore, this system is probably more relevant to producers, requiring a robust protocol.

The formulated pellets used in this study cost $465/t, therefore a two week reduction in measurement time will reduce costs by $14.17/hd for hoggets. Other benefits of reducing the measurement time include;

- Lower labour costs
- More animals measured
- Faster roll out of data to producers
- Lower likelihood of data corruption
- Less animal health issues
- Improved animal welfare conditions

Now that we know the best length of feed intake measurement, future analysis should also focus on the genetic correlations between different measurement periods. It is possible that differences in feed intake across days is caused by changes in environment. Therefore, sheep that have a high breeding value for intake over a short period could also have a high value across a long period. This would further reduce the time needed for measurements.

In conclusion, feed intake in sheep does not need to be measured for as long as cattle. If the test period is shortened by 2 weeks, it cost less and improve the welfare of the sheep tested.

Acknowledgements

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References

Ewes classified as good mothers have greater cortisol responses when separated from their lambs than ewes classified as poor mothers

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Summary

This study evaluated the responsiveness of the HPA axis of ewes to lamb removal to assess if HPA axis responsiveness is an important attribute of maternal behaviour. We used a 5 point maternal temperament score to characterise the behaviour of a flock of Merino ewes at Minnipa Agricultural Centre, Minnipa, South Australia, Australia from 2012 to 2015. We selected six ewes that received a maternal temperament score of 4 or 5 in each year and reared 100% of their lambs and defined them good mothers. We selected six ewes that received a maternal temperament score of 3 or less and reared <100% of their young and defined them as poor mothers. Ewes categorised as good mothers had a greater cortisol response to lamb removal than ewes classified as poor mothers. The greater cortisol response in good mothers may contribute to behavioural and physiological mechanisms to protect lambs in threatening environments.

Introduction

The responsiveness of the hypothalamo-pituitary adrenal axis (HPA axis) is attenuated during lactation and the degree of this attenuation depends on the type of stressor and the access of the mother to her young (Ralph and Tilbrook, 2016). For example, during lactation isolation and restraint does not evoke a cortisol response in ewes, as long the ewe can suckle her lambs. Exposure to barking dogs does evoke a cortisol response and this suggests that if a ewe is exposed to a stressor that directly threatens her or her offspring that stressor will evoke a cortisol response (Ralph and Tilbrook, 2016). In the current experiment, we aimed to determine if there was a difference in cortisol response between ewes that had been characterised as good mothers and ewes that had been categorised as poor mothers based on their behaviour in response to handling of their lambs during lamb marking. We hypothesised that ewes categorised as good mothers would have a greater cortisol response to removal of their lambs than ewes categorised as poor mothers.

Materials and Methods

We used a 5 point maternal temperament score, described by O’Connor et al (1985), to characterise the maternal behaviour of a flock of Merino ewes at Minnipa Agricultural Centre, Minnipa, South Australia, Australia from 2012 to 2015. The maternal temperament score was a scale of 1 to 5 and was assessed at lamb marking within 24 h of the birth of the lambs. A score of 1 was given to a ewe that fled when her lamb was handled by a human during lamb marking and did not return to the lamb when the lamb was released. A score of 5 was given to a ewe that stayed within 5 metres of the lamb and handler and immediately returned to the lamb when it was released (O’Connor et al, 1985). These data were collected at lambing in June to July each year. We selected six ewes that received a maternal temperament score of 4 or 5 in each year and reared 100% of their lambs and defined them as good mothers. We selected six ewes that received a maternal temperament score of 1 or 2 and reared <100% of their young and defined them as poor mothers.

Ewes and their lambs were moved from pasture to an animal house when the lambs were 6 weeks old. Ewes were housed in groups of six with their lambs for two weeks to acclimatise to the housing conditions, to a maintenance ration and to being fed at 1630. On the experimental day blood was collected via indwelling jugular catheters every 15 min for 6 h. Lambs were removed from the ewes for 2 min every h. The first bout of lamb removal was 1 h after bleeding commenced. During these two minutes the ewe and lamb did not have visual contact but may have had auditory and olfactory contact. Plasma was harvested from blood by centrifugation and stored at -20°C. Plasma was assayed for cortisol using radioimmunoassay (IBL International, Hamburg, Germany). The intra assay coefficient of variation was 9.6%. Data were analysed using a repeated measures analysis of variance that incorporated all sources of variation. This experiment was approved by the PIRSA ethics committee, ethics approval number 35/15.

Results and Discussion

Ewes categorised as good mothers had greater cortisol concentrations than ewes categorised as poor mothers after the first lamb removal (P<0.05), the second lamb removal (P<0.05) and the third lamb removal (P<0.05).

Figure 1. Mean (±SEM) total cortisol response of ewes to removal of their lambs for 2 min.

These data support our hypothesis, indicating that ewes classified as good mothers have a greater cortisol response to handling of their lambs than ewes classified as poor mothers. This may mean that ewes that are more likely to defend their
young are more responsive to stressors that threaten their lambs.

Previously we demonstrated that the cortisol response of ewes to 5 min of exposure to three barking dogs peaked at between 30 ng/ml and 50 ng/ml (Ralph and Tilbrook, 2016). In the current experiment the cortisol response of the good mothers to 2 min of lamb removal peaked at 57 ng/ml after the first lamb removal and then peaked at 37 ng/ml and 32 ng/ml. Therefore, handling of lambs by humans evokes a similar cortisol response as exposure to barking dogs. This suggests that ewes perceive humans as an immediate threat to the survival of their young. This has implications for animal welfare. Clearly handling of lambs handling may be perceived as stressful by some ewes.

The results of this experiment raise the possibility that the responsiveness of the HPA axis of ewes to lamb removal is an important attribute of maternal behaviour. A greater responsiveness of the HPA axis to lamb removal may invoke physiological and behavioural mechanisms that allow the ewe to protect her lamb in a threatening environment. This has implications for genetic selection and indicates that ewes with greater cortisol responses to lamb removal may be well suited to successfully rear more lambs than ewes with reduced cortisol responses to lamb removal. Further research is required to test this hypothesis.

Acknowledgements
Brian Dzoma and Jack Irvine for their expert technical assistance.

References
Metabolisable energy intake but not crude protein intake or bovine somatotropin hormone (bST) increased hip height in Bos indicus cross steers

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Summary

The objective of this research was to determine factors contributing to skeletal growth in growing steers. Thirty Brahman cross steers were allocated to one of six treatments with five steers per treatment. Steers were fed a low crude protein (CP) diet (Mitchell grass ad libitum (MAL)), high CP and high metabolisable energy (ME) diet (lucerne ad libitum (LAL)) or a diet that contained high CP and low ME (lucerne restricted (LR)). All diets were injected with either 500 mg bovine somatotropin (bST) or saline control every 14 days. Feed intake was measured daily, liveweight (LW) and hip height (HH) were measured weekly. Hip width (HW) and body condition score (BCS) was measured every 14 days. LAL steers had higher feed intake, liveweight gain (LWG), HH, HW and BCS compared to steers fed other diets. bST injection increased LWG only if diets contained CP and ME for growth were provided.

Introduction

The quality and quantity of feed during the dry season in northern Australia is insufficient to support high growth rates of cattle. However, the skeleton grows continuously, even during periods of feed restriction (McLennan and Poppi 2011). Cattle can achieve a bigger frame size if the skeleton keeps growing during the dry season as they will gain weight quickly when feed becomes available in the wet season. The bone elongation may provide passive stretch for growth of muscle; so animals will potentially produce more meat if the rate at which mature frame size is attained can be manipulated.

The hormone bovine somatotropin (bST) may influence bone elongation in cattle directly or by increasing the concentration of plasma insulin-like growth factor (IGF-1). IGF-1 has an anabolic action on the formation of bone by increasing cell proliferation (Li et al. 2009) and cell hypertrophy of chondrocytes (Wang et al. 1999).

This experiment tested the hypotheses that increasing ME and CP intake will increase LWG and skeletal elongation rate, and that exogenous bST will increase LWG and skeletal elongation rate irrespective of level of ME intake or CP content of the diet.

Materials and Methods

Thirty Brahman cross steers (187 ± 2 kg liveweight, mean ± sem) were allocated to one of six treatments in a 3 x 2 factorial design, with three nutritional treatments and two hormone treatments. The three nutritional treatments were a low ME and low CP diet of similar quality to dry-season pasture [Mitchell grass (Astrebla spp.) hay ad libitum, MAL], a high ME and high CP diet [lucerne (Medicago sativa) chaff ad libitum, LAL], and a treatment that contained low ME and high CP (lucerne chaff restricted so that ME intake was similar to steers in MAL group, LR). The two hormone treatments were bST injection (500 mg Sometribove zinc suspension, Elanco Animal Health) or a saline control administered subcutaneously every 14 days.

The experiment consisted of a 14 day adaptation period followed by a 98 day experimental period. Steers were housed in individual pens at the Queensland Animal Science Precinct (QASP), The University of Queensland, Gatton. Feed intake was measured daily, LW and HH were measured prior to feeding every 7 days. HW and BCS were measured every 14 days. Blood samples were collected on days 0, 28, 56, 84 and 98 of the experimental period. Plasma IGF-1 concentration was measured using a commercial immunoradiometric assay kit (A15729, Beckman Coulter) with extraction as per the manufacturer’s protocol.

Table 1. Feed intake and growth in Brahman cross steers fed a low CP and low ME (Mitchell grass hay ad libitum, MAL), high CP and high ME (lucerne chaff ad libitum, LAL) or high CP and low ME (lucerne chaff restricted, LR) diet with or without a bST injection (+/- bST).

<table>
<thead>
<tr>
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<th>MAL (Low CP, low ME)</th>
<th>LAL (High CP, high ME)</th>
<th>LR (High CP, low ME)</th>
<th>SE</th>
<th>Effect of diet</th>
<th>Effect of bST</th>
<th>Effect of diet * bST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed intake (g DM/kg LW.day)</td>
<td>16.6ᵃ</td>
<td>17.4ᵇ</td>
<td>28.7ᵇ</td>
<td>28.4ᵇ</td>
<td>9.4ᵇ</td>
<td>9.9ᵇ</td>
<td>0.04</td>
</tr>
<tr>
<td>Liveweight gain (kg/day)</td>
<td>-0.02ᵃ</td>
<td>-0.02ᵇ</td>
<td>1.34ᵇ</td>
<td>1.16ᵇ</td>
<td>0.12ᵇ</td>
<td>-0.02ᵈ</td>
<td>0.03</td>
</tr>
<tr>
<td>Change in hip height (mm/100 day)</td>
<td>31.0ᵇ</td>
<td>31.4ᵇ</td>
<td>103.4ᵇ</td>
<td>94.5ᵇ</td>
<td>41.6ᵇ</td>
<td>35.4ᵇ</td>
<td>3.50</td>
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<tr>
<td>Change in hip width (mm/100 day)</td>
<td>-1.1ᶜ</td>
<td>4.0ᵇ</td>
<td>75.0ᵇ</td>
<td>69.8ᵇ</td>
<td>4.7ᶜ</td>
<td>7.5ᵇ</td>
<td>2.40</td>
</tr>
<tr>
<td>Final body condition score (1-5 scale)</td>
<td>2.3ᵇ</td>
<td>2.2ᵇ</td>
<td>3.8ᵇ</td>
<td>3.7ᵇ</td>
<td>2.3ᵇ</td>
<td>2.4ᵇ</td>
<td>0.07</td>
</tr>
</tbody>
</table>

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Results

Steers fed LAL diets had higher feed intake, LWG, HH, HW and BCS (P < 0.05) compared to steers fed the MAL and LR diets (Table 1). With the exception of LWG, there was no difference in measured parameters between steers in MAL and LR diet groups.

bST injection increased the LWG of steers fed LAL and LR diets. There was no effect of bST injection on feed intake, HH, HW and BCS of steers fed any of the diets.

The bST injection increased IGF-1 plasma concentration. Steers fed LAL diets had the highest IGF-1 concentration compared to other diets, and bST injection increased IGF-1 level in LAL+ on day 84. There were significantly increases of IGF-1 level in steers fed LR on day 28 to 84, no significant effect on day 98 in this group. Interestingly, bST only influenced IGF-1 level on steers in MAL diet on day 28.

In conclusion, bST can increase liveweight gain of Brahman steers if they are fed diets containing adequate CP and ME for growth. Based on our results, bST injections are not a useful strategy for increasing skeletal size of steers grazing low quality dry season pastures in northern Australia.

Acknowledgements

We thank Meat Livestock Australia for funding this research, the Australian Centre for International Agricultural Research for the presenting author’s scholarship, QASP for the use of their facilities and Allan Lisle for help with the statistical analysis of results.

References


Figure 1. The concentration of IGF-1 in the plasma of steers fed Mitchell grass ad libitum (MAL), lucerne ad libitum (LAL) and lucerne restricted to an equivalent ME intake as MAL (LR) receiving either bovine somatotropin (+) or saline (-) administered subcutaneously every 14 days. Different superscripts indicate significant differences between treatments P < 0.05.
Effect of combined cold, transport and handling stress in mid- and late-pregnancy on morphometric measures in lambs

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Summary

Lamb mortality is an important issue for animal welfare and livestock productivity. Previous research has shown that shearing during pregnancy can increase lamb birth weights; however, the contributing roles played by stress or resulting cold exposure have yet to be fully understood. This trial was designed to examine the effects of repeated acute and cold stress in pregnant ewes on the live weight, girth circumference, crown-rump length, forelimb length and cannon bone length of lambs. Pregnant animals were exposed to a combination of stressors (yarding, transport, hosing and 3hr cold exposure) 5 times over a period of 10 days at either mid-pregnancy (90d) or late-pregnancy (120d). A control group was not exposed to the stressors. Blood samples were collected from ewes to observe possible changes in glucose levels. Prenatal stress in mid-pregnancy resulted in reduced birth weight in singletons but not in twins.

Introduction

Poor lamb survival rates are an important animal welfare issue and represent a significant economic loss due to reproductive wastage. In Australia under more optimised management conditions survival rates are expected to reach 85 to 90% in singles and 65% in twins (Hinch and Brien 2014). Various studies have shown that birth weights are positively correlated with survival rates (Kenyon et al. 2006b). However, high birthweight (>6.5 kg) is an established risk factor for difficult labour and dystocia (Hocking Edwards et al. 2011). Shearing during pregnancy has been shown to positively affect lamb birthweight (Revell et al. 2002; De Barbieri et al. 2014). This positive effect has been particularly seen for shearing at mid-pregnancy (Kenyon et al. 2006a; De Barbieri et al. 2014). Shearing can be described as an acute stress due to handling but there is also a subsequent risk of cold stress due to fleece removal (Hargreaves and Hutson, 1990). The respective roles of these stressors contributing to the impact of shearing during pregnancy are not fully understood. In previous trials we studied the effects of shearing vs handling and late-pregnancy cold exposure on lamb vigour traits, and found shearing during mid-pregnancy increased twin lamb birthweights and size (girth circumference and crown-rump length) when compared to sham handled animals (Labeur et al. 2015). In the present trial, we examined the effect of a repeated prenatal stress that combined acute handling and repeated cold stress on lamb physical traits. We also examined the effects of the timing of this combination of stressors (mid pregnancy vs late pregnancy).

Materials and Methods

Merino ewes (n = 108) were divided into three groups balanced for pregnancy status. Two groups of ewes were treated, at either 90 days (mid-pregnancy; MID) or 120 days of pregnancy (late-pregnancy; LATE). The stress treatment consisted of fifteen minutes of intense yarding, fifteen minutes of transport in a stock trailer, ten minutes high water pressure hosing and three hours in a 4°C cold room. Both treated groups were exposed to the combination of stressors five times over a period of 10 days. A control group (CTRL) with no stressors applied was maintained with the other animals except during stress treatment. Ewes were bled using an 18 gauge needle and a 10mL heparinised vacutainer before and after stress application (at 90d and 100d, respectively) and at 120d. Ewe blood glucose, as a measure of the impact of the combined stressors on the ewes, was measured using a portable glucometer (Accu-check® Performa, Roche, Switzerland) from fresh blood samples. During the lambing period, ewes were checked at least three times daily for signs of parturition. A total of 87 lambs were assessed after birth. At 4 hrs after birth, lamb rectal temperature, lamb body weight, girth circumference, crown-rump length, forelimb (distance from the shoulder joint to the tip of the hoof on the left leg) and cannon bone length of lambs were measured. The physical and glucometer data were tested for normality. Distribution was non-normal and hence the data were analysed using a non-parametric Mann-Whitney test.

Results and Discussion

![Figure 1](image.png)

Figure 1 Lamb physical measurements per treatment and litter size. * represents p<0.05

Single MID lambs were lighter than CTRL single lambs (P=0.031; 4.19 vs 4.72kg; figure 1). LATE twins tended to be lighter than LATE single lambs (4.69 vs 4.19 kg) but the difference was not statistically different. Single lambs born to

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MID ewes had smaller girth circumferences than CTRL single lambs (P=0.011; 37.03 vs 38.9 cm). Single LATE lambs had longer bodies (crown-rump) than MID single lambs (P=0.046; 53.3 vs 53.9 cm).

At 120d, ewe blood glucose levels in all three treatment groups were significantly different, and LATE were higher than MID and lower than CTRL (P=0.03 and P<0.001, respectively; figure 2). At the same time point, MID glucose levels were lower than CTRL (P<0.001) although they were increased directly after the stress treatment at 100d (P<0.001). At 120d, CTRL blood glucose levels increased, while both MID and LATE glucose levels remained or declined in comparison to pre-treatment levels.

Ewes treated with a combination of acute stress and cold stress applied at mid-pregnancy gave birth to smaller and lighter singleton lambs. Stressors during pregnancy seem to have a greater impact on single than twin foetuses. In our previous experiment studying the effects of shearing, we observed significantly increased birthweights in twins born to ewes subject to shearing stress in mid-pregnancy (Labeur et al. 2015). The combination of stressors reported here did not replicate the results of our previous shearing experiment; however in both cases, treatment in mid-pregnancy resulted in a narrowing of the birth weight gap between singles and twins. In our current experiment, we observed a decrease in singleton birth weight in ewes stressed in mid-pregnancy through a combination of cold, transport and handling stress. Chronic stress has been shown to potentially retard growth and impair reproductive function (Dwyer and Bornett 2004) which could result in foetal development disorders. However, repeated isolation during the last 5 weeks of pregnancy, resulted in increased lamb birth weights (Roussel et al. 2004). Although the combined stressors of the current experiment appear to be more severe than the previous shearing stress, as indicated by the decrease in singleton birth weight, no negative effect was observed in twins.

Our results show that the long-term effect of repeated stress in mid-pregnancy can result in lower ewe blood glucose in late pregnancy. Glucose is the most important energy yielding substrate for lamb growth, and it appears that the short-term increase in ewe blood glucose is not sufficient to compensate the late effects of mid-pregnancy stress on ewe blood glucose in late pregnancy, resulting in lower singleton birth weights.

Acknowledgement
The authors would like to thank the CSIRO Armidale Phenomics team for the technical support during this experiment. This research was funded by a CSIRO Agriculture Strategic Investment Project. L.L. was supported by an Ian McMaster Bequest PhD scholarship and a UNERA International Fee scholarship.

References
Variation in sexual activity of young Border Leicester rams treated with melatonin in spring

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Summary
Lack of sexual behaviour in young Border Leicester (BL) rams may be responsible for occasional low pregnancy rates when rams are mated to Merino ewes in spring. This study examined if treatment with melatonin improved sexual activity of BL rams managed on two properties in South Australia. All 7 melatonin treated rams and 6 out of 7 untreated rams displayed normal libido at one location. In contrast, 4 out of 7 treated rams were active while none of the untreated rams mounted oestrous ewes at the other site (P<0.05). Reasons for the variation observed between sites are not known and require further study.

Introduction
Responses to melatonin treatment of young BL rams when mated to Merino ewes in spring have been consistent between years for increasing testicular mass but variable for pregnancy rate (Kleemann et al 2016). The current study examined if the between year variation for pregnancy rate might be associated with differences in ram libido (mounting of ewes).

Materials and Methods
Libido tests of 14 and 15 1-year old BL rams from Inverbrackie Stud were conducted at Naracoorte and Turretfield, South Australia, respectively. Rams at each location were randomised on the basis of scrotal circumference and live weight to form 2 groups. Three melatonin implants (Ceva Animal Health Pty Ltd, Glenorie, NSW) were inserted subcutaneously in one group of rams in early September at each site. Three standard 20-minute libido tests were conducted on consecutive days on all rams 60 days after treatment. Ewes were treated with progesterone CIDRs for 12 days plus PMSG (400 iu; im) at CIDR withdrawal. Approval was granted by the PIRSA/SARDI AEC.

Results
At Naracoorte, all (n=14) except one untreated ram mounted ewes by the third test (Fig 1). In contrast, only 4 out of 7 melatonin treated rams at Turretfield were active while none of the 8 untreated rams mounted ewes (Fig 1; P<0.05). Neither live weight nor scrotal circumference differed significantly between sites. Mean scrotal circumference was higher (P<0.05) for treated compared with untreated rams at each location.

Discussion
The difference in libido of young BL rams to melatonin treatment between locations cannot be explained by variations in either live weight or testicular size. These data may help explain the large between-year variation observed in pregnancy rates when young BL rams are mated in spring (Kleemann et al 2014) but other factors, particularly those susceptible to seasonal variation, cannot be dismissed.

Acknowledgements
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References
The National Grass Seed Action Plan provides a model for addressing an issue impacting the whole supply chain

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Summary

Grass seed contamination of carcases is a problem that affects all sectors of the lamb supply chain nationally. The Australian lamb industry has adopted an approach to a solution that involves all sectors of the supply chain. Critical success factors have been a “shared plan” and a desire to collaborate for greater collective benefit, a desire to increase transparency along the supply chain, a focus on delivering quality product that meets customer expectations, and a Research Development Corporation (RDC) that valued the industry productivity and profitability potential of addressing a whole of value chain issue. This approach has been successful in creating awareness of the issue and providing solutions to create greater transparency within the industry and resulting in ownership of the problem by all sectors.

Background

In 2012, Australian lamb processors identified grass seed infestation of carcases as the biggest single issue facing the whole supply chain of the Australian prime lamb industry. Even with an increase in over-the-hooks sales, increased producer feedback, and in some cases penalties as much as $1.50/kg HSCW, there was a lack of ownership of every sectors’ contribution to the problem, and lack of development of supply chain owned solutions.

Processors potentially carry significant losses in terms of reduced daily throughput, increased labour costs, downgraded product, reduced meat yield, risk of market compensation claims and an unhappy work force (Figure 1). Producers may forego a loss of income through reduced production potential and reduced returns through carcase trimming and penalties. There are also animal welfare implications.

Strategy

In 2012, Meat & Livestock Australia (MLA) commissioned a national survey of Australian sheep and lamb processors which found that, for many, grass seed contamination was the number one problem facing their business (Collins 2013b). At the time, processors estimated that seedy carcases were costing up to $30 per head, with suppliers being penalised between 10c and $1.00/kg carcase weight.

It was recognised that producer awareness and education was an essential strategy for addressing the problem. MLA commissioned a review and update of their existing educational resources including:

- Winning Against Seeds (Collins 2013a)

Key industry sectors’ desire to collaborate and develop a national focus and communication strategy, led to the development of a National Grass Seed Action Plan (2013-2015), involving the whole of the supply chain.

A National Action Plan scoping workshop was convened in Melbourne in May 2013, with 25 representatives from all sectors of the industry, including major processors & supermarkets, stock agents, saleyard operators, government agencies, private consultants, producers, MLA, Australian Wool Innovation (AWI) and Animal Health Australia (AHA).

This workshop was critical in gaining industry acknowledgement and ownership of the problem. A key outcome was an across sector commitment to participate in a national leadership group to drive strategic outcomes and provide oversight of implementation of the Action Plan.

With MLA as the lead agency, a commitment was made to the National Grass Seed Action Plan (NGSAP) and a consultant appointed as the National Coordinator to drive the strategy. Key components of the plan were:

1. National Grass Seed Leadership Group
2. National Coordinator
3. Carcase Seed Measurement
4. Lamb Value Calculator (Figure 2)
5. Carcase Seed Reporting and Feedback Systems
6. National Communications Program
7. Producer Engagement
8. Resources
9. Industry Database and Livestock Data Link (LDL)
Figure 2. The Lamb Value Calculator, a seed cost analysis tool

GSEED ESTIMATED COSTS ANALYSIS
Trade: Over the Hooks. X-Bre

<table>
<thead>
<tr>
<th>MOB ANALYSIS</th>
<th>COSTS ($/hd)</th>
<th>REVENUE ($/hd)</th>
</tr>
</thead>
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<tr>
<td>Tim Wastage Revenue</td>
<td>$0.35</td>
<td></td>
</tr>
<tr>
<td>CTH Price Difference</td>
<td></td>
<td>$8.98</td>
</tr>
<tr>
<td>Extra S/F Costs</td>
<td>$3.75</td>
<td></td>
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<td>Extra Boring Room Costs</td>
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<td>$6.00</td>
</tr>
<tr>
<td>Reduction in Primal Cut weight Costs</td>
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<td></td>
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<tr>
<td>Primal Cut Downgrade Costs</td>
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<td></td>
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<tr>
<td></td>
<td>$60.80</td>
<td>$39.33</td>
</tr>
</tbody>
</table>

GSEED COST ($/hd): $50.47
GSEED COST ($/kg MSCW): $2.10

Progress and Outputs

Much has been achieved since work commenced on the NGSAP. Absolute measurement of success in achieving the objective of reducing the number of seed contaminated lambs that are processed in Australia each year is difficult due to the fluctuating nature of the problem which is significantly influenced by seasonal conditions. Achievements to date include:

1. Development of a significant body of resources aimed at increasing producer awareness of the problem and providing tools and solutions to help address the issues. These resources have been centralised in one location at www.mla.com.au/grassseeds. Resources include producer case studies and videos demonstrating management options.
2. Ongoing placement of timely information in the rural press aimed at informing producers and service providers and calling them to action.
3. Development and delivery of a “Winning Against Seeds” producer and service provider workshop, including one workshop delivered in collaboration with a processor which attracted more than fifty producers.
4. A pilot training session for service providers on the workshop content and producer value proposition to modify management practices to address grass seed issues.
5. Development, piloting and ongoing roll out of a standardised language for processors to describe seed contamination of carcases, and to provide standardised feedback to producers.
6. Grass Seed Analysis module of the Sheep CRC/MLA Lamb Value Calculator which is a decision support tool for processors enabling economic modelling and cost analysis of different scenarios. Use of this tool has demonstrated costs to processors of up to $4/kg for seedy lambs.
7. Raising the importance and urgency of including abattoir collected grass seed data in producer feedback systems such as Livestock Data Link.
8. The establishment of an MLA, South Australian Sheep Advisory Group (SASAG) jointly funded Producer Demonstration Site (PDS) in association with the MacKillop Farm Management Group in the Upper South East of South Australia to look at alternative fodder supply strategies for this region.

Critical Success Factors

Critical success factors to cross sector engagement and commitment to a coordinated approach were a “shared plan”, and a desire to collaborate for greater collective benefit, financial loss incurred by stakeholders within each sector, a desire to increase transparency along the supply chain, a focus on delivering quality product that meets customer expectations, and an RDC that valued the industry productivity and profitability potential of addressing a whole of value chain issue.

The National Grass Seeds Action Plan has been an example of the benefits that can be derived when all sectors of an industry work together to address a problem that impacts the whole supply chain.

Acknowledgements

The members of the National Grass Seeds Leadership Group have contributed significant time to leading this initiative. Members have at times included:

- Geoff Duddy, Sheep Solutions
- Patrick Hutchinson, Blue Sky Ag
- Dave Rutley, Steve Chapman, Thomas Foods International
- Kate Joseph, Kat Ferme, Sheepmeat Council of Australia
- Clive Richardson, National Meat Industry Training Advisory Council (MINTRAC)
- Dale Cameron, JBS
- Bill Scott, GM Scott
- Andrew Hay, Dale Pemberton, Coles
- Ben Verrall, Australian Lamb Company
- Robert Radford, Radfords
- Richard Apps, MLA
- Kelvin Westbrook, Jane Kellock, SA Sheep Advisory Group
- Tim Hollier, Melissa Neal, Victorian Department of Economic Development, Jobs, Transport and Resources
- Geoff Casburn, NSW Department of Primary Industries
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- Rob Davidson, WAMMCO
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- Fahri Fahri, Australian Meat Processor Corporation Ltd
- Christian Mulders, Australian Meat Industry Council
- Mark McDonald, Livestock Saleyard Assoc. of Victoria

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An evaluation of post-partum re-mating intervals in grasscutter (Thryonomys swinderianus) does

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Summary

A breeding experiment was conducted using 24 (6 bucks and 18 does) sexually matured grasscutters to evaluate the post-partum re-mating interval on some reproductive traits (number of pups born alive, still born, average litter size at birth, average litter weight at birth, average litter size at weaning and mortality) of grasscutter does. Sexual maturity of the experimental animals were certified using birth records, darkened perineum and vaginal plug (for females) all of which are signs of sexual maturity peculiar to grasscutters. Animals were assigned eight (2 males and 6 females) per treatment in a completely randomized design. Treatments were re-mating intervals of 2, 4 and 6 weeks adopted for the study. After first parity was obtained from does in each treatment group, they were re-mated according to re-mating intervals and pups weaned accordingly. Results revealed that re-mating intervals had no effect on reproductive traits assessed.

Introduction

There has been serious need to source for an alternative source of animal protein, which can be easily reared and will address the demands of the rural and urban centres in Nigeria. Grasscutters commonly known in Western, Southern and Central African countries as cane rat or cutting grass has been identified as one of the micro livestock specie capable of bridging the gap of animal protein requirement for rural and urban dwellers. This animal which is currently harvested from the wild in large numbers to cater for the need of consumers (Ayeni and Ajayi, 1983, Hardouin et al., 2003) requires sufficient research information on breeding to enable intensive rearing. The main determinant of successful domestication is the maintenance of reproductive competence (Fox, 1987; Adams, 1989). Therefore, information bearing on its successful breeding under intensive management is of immediate importance. In livestock, reproductive efficiency is greatly determined by the level of post parturition fertility and re-mating interval (Topps, 1977). Journet-Boullery (1986) and Cicogna (2000) observed high post-partum fertility rates associated with breeding just a few hours after birth in reproducing guinea pigs.

Materials and Method

The research was conducted at a grasscutter research station supervised by the Department of Animal Science, Faculty of Agriculture, University of Calabar, Cross River State, Nigeria. Twenty-four sexually matured grasscutters comprising of 18 does and 6 bucks were used for the study and housed individually within properly labeled cells to ensure accurate monitoring. Animals were randomly allotted into three treatment groups with 2 bucks and 6 does. Treatment groups were named according to post partum mating interval (PPMI) assigned to the group. PPI were 2, 4 and 6 weeks. Model for analysis of variance was:

\[ Y_{ij} = \mu + R_i + e_{ij} \]

Where,
- \( Y_{ij} \) = individual observation on the \( i \)th treatment
- \( \mu \) = overall mean of all observations
- \( R_i \) = fixed effect of post partum mating interval (\( i = 1 - 3 \))
- \( e_{ij} \) = random error, identically and independently normally distributed with zero mean and constant variance [iind (0, \( \sigma^2 \))]

All the does were crossed to obtain first parity after which they were re-bred according to post partum mating intervals assigned to the group to obtain second parities. Does were monitored for the following parameters: litter size at birth and weaning, litter weight at birth, number of pups born alive, still birth and mortality.

Results

Total number of pups born alive was 25, 23 and 22 for PPMI of 2, 4 and 6 weeks respectively (Table 1). None of the does within the groups recorded any incidence of still birth. Average litter size at birth was 3.57 (2 weeks), 3.29 (4 weeks) and 3.14 (6 weeks). Average litter weight at birth was non-significantly (\( P>0.05 \)) higher for pups of does rebred 2 weeks post parturition (457.15g). mortality was highest (\( P>0.05 \)) for pups of does rebred 2 weeks post parturition (457.15g). mortality was highest (\( P>0.05 \)) for pups of does rebred 2 weeks post parturition (12.00%) and the lowest for pups of does re-bred 6 weeks post parturition (4.35%).
Table 1. Reproductive performance of grasscutter does re-bred at different post partum mating interval

<table>
<thead>
<tr>
<th>Traits</th>
<th>Post-partum mating intervals ±SEM</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 wks</td>
<td>4 wks</td>
</tr>
<tr>
<td>TNBA</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>SB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ALSB</td>
<td>3.57</td>
<td>3.29</td>
</tr>
<tr>
<td>ALWB (g)</td>
<td>457.15</td>
<td>447.30</td>
</tr>
<tr>
<td>ALSW</td>
<td>3.14</td>
<td>3.14</td>
</tr>
<tr>
<td>MOT. (%)</td>
<td>12.00</td>
<td>4.35</td>
</tr>
</tbody>
</table>

sig. – significance; NS – non significant; wks – weeks, TNBA – total number born alive, SB – still birth, ALSB – average litter size at birth, ALWB – average litter weight at birth, ALSW – average litter size at weaning, MOT. - mortality

Discussion

The differences observed between treatment groups for number of litter born alive could have been attributable to post parturition fertility rates which are associated with re-breeding at shorter intervals after birth. It was also observed that no still birth was recorded within the groups which indicated that PPMIs adopted for the study posed no stress to the does and the developing fetuses. It was also observed from results of the study that average litter size for does re-bred 2 weeks post partum showed better performance than its contemporaries from other groups. This result is a reflection of total number of pups born alive. However, individual pup weight at birth which is cumulatively expressed in litter weight at birth was heavier for pups of does re-mated 2 weeks post partum, followed by 4 weeks while 6 weeks had the lowest value. Mortalities obtained within the groups may have resulted from a number of factors, ranging from number of suckle/day and duration of suckle, injury and cold, despite the pens being properly shielded from wind. It should be noted that the fur of the grasscutter is not intertwined as is the case with other animals such as rabbit. This natural nature of theirs poses as a disadvantage in windy situations. Mortality was however lowest among group re-bred 4 weeks post parturition.

In conclusion, grasscutter does can be re-bred at 2 weeks post parturition earlier than 6 and 8 weeks reported by some researchers. This will in no doubt reduce mating time post parturition, as pups can be weaned also at this age and survive due to their precocious nature (Henry et al., 2012). Further studies could be done to evaluate milk yield and quality produced by does as nursing progresses. Studying the hormonal assay of reproductive hormones at the time of breeding could provide additional information to enhance breeding and improve productivity for the breeders.

References


Saleable meat yield affects lamb carcase value


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4 Meat & Livestock Australia, Armidale, NSW, 2351, Australia
5 Australian Cooperative Research Centre for Sheep Industry Innovation, Australia

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Summary

The value of saleable meat yield (SMY) to lamb processors was investigated using two Australian abattoirs as case studies. The Lamb Value Calculator was used to simulate the effect of carcase weight and fabrication on yield. The value of SMY to the lamb processor was dependant on carcase weight, level of fabrication and discounts applied to individual cuts. A 1% change in SMY had a greater effect on net return of heavy carcases (27kg) compared to lighter carcases (21kg). However, discounts applied to some heavy carcase cuts decreased the effect on the value of yield. Indeed, there was no difference in the value of yield to the processor between 24kg and 27kg carcases. Increasing the level of fabrication increased the value of yield to the processors. The value of SMY to processors is plant specific and can be used to assist in sorting decisions and to support value based trading.

Introduction

Yield of product from a carcase can be described in many ways. Lean meat yield (LMY) is a term that is becoming common in the Australian lamb industry as the importance of increased meat and decreased fat is recognised along supply chain from the producer to the consumer (reviewed by Pethick et al., 2011). However, LMY does not accurately represent what the processor and retailer deal with. Rather, a product will have varying levels of bone (ie bone-in or boneless) and fat, in addition to the meat, and the term saleable meat yield (SMY) is used to encompass the whole product. SMY is influenced by the level of fabrication and by the LMY of the lamb.

In the Australian lamb industry, the majority of lamb is purchased from lamb producers on the basis of carcase weight, with price penalties for very fat (fat score 5 - GR tissue depth >20mm) or very lean carcases (fat score 1 - GR tissue depth <5mm). Although the use of pricing Australian lamb on the basis of yield has been discussed for over 20 years (Hopkins, 1994), little sustained progress has been made. Currently there are no strong price signals to lamb producers to increase yield and decrease the amount of fat in their lambs. This is partly due to the limited availability of objective measurement technologies in the Australian lamb industry (Pethick et al., 2011), despite processors willingness to use improved measures of yield if they are cost effective and easy to use (Goers & Craig, 2008). Demonstrating the value of yield to the processor may encourage rapid uptake new measurement technologies as they become available.

This paper describes the use of computer modelling to demonstrate the effect of carcase weight, carcase fabrication and cut discounts on the value of SMY to Australian lamb processors.

Materials and Methods

Saleable meat yield was estimated using the Lamb Value Calculator (LVC) model (v4.32; Chris Smith). This model estimates the weights of a set of specified commercial cuts using HCWT and GR tissue depth as predictors. These weights can be multiplied by cut values to arrive at total carcase value. They can also be directly added and divided by carcase weight to provide an estimate of SMY. Furthermore the weights of these commercial cuts can be estimated at different levels of fabrication based upon the cuts and levels of fat trim specified by the user.

The LVC was used to quantify the impact that carcase weight has on the value of yield processed to two levels of fabrication – “Standard” and “Value added”. Cut specifications for Standard SMY and Value added SMY are outlined in Table 1.

Table 1. Cut specification for standard and value added carcase fabrication.

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square cut shoulder (6mm fat)</td>
<td>Eye of shoulder</td>
<td>Boneless shoulder</td>
</tr>
<tr>
<td>Fore shank tipped</td>
<td>Fore shank tipped</td>
<td></td>
</tr>
<tr>
<td>Breast</td>
<td>Breast</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>Neck</td>
<td></td>
</tr>
<tr>
<td>Short loin trimmed (25mm tail, 6mm fat)</td>
<td>Eye of short loin</td>
<td>Tenderloin butt off</td>
</tr>
<tr>
<td>Trimmed rack (6mm)</td>
<td>Trimmed rack (6mm)</td>
<td>Flap</td>
</tr>
<tr>
<td>Flap</td>
<td>Boneless leg, chump on, shank off</td>
<td></td>
</tr>
<tr>
<td>Bone in leg, aitch bone removed.</td>
<td>Hind shank, bone in.</td>
<td></td>
</tr>
</tbody>
</table>
Data from two lamb processing plants were used in the Lamb Value Calculator model. Input and output costs were based on September 2014 (Plant 1) and October 2013 (Plant 2) prices, including cost of lamb ($/kg HCWT), boning costs and fixed costs.

Outputs were expressed as net return compared to net return of a basic carcase. A basic carcase was classified as having 21kg HCWT and 12mm GR depth. The basic carcase had a Standard SMY of 90.1% at Plant 1 and 89.6% at Plant 2. Value Added SMY of the basic carcase at Plant 1 was 69.6%.

The effect of SMY on net return was investigated at three HCWT, representative of Australian markets; domestic (light = 21kg), mid-range (24kg) and export (heavy = 27kg). The impact of discounts in cuts from light carcases (21kg) and heavy carcases (27kg) that do not meet cut specifications on the effect of SMY on net return was modelled using data from Plant 2. Discounts were applied to square cut shoulder and leg of the heavy carcases and to the rack in light carcases. No discounts were applied to any cuts from a 24kg carcase.

Results and Discussion

The value of saleable meat yield to the lamb processor was dependant on carcase weight, level of fabrication and discounts applied to individual cuts (Table 2). SMY had a greater effect on the value of heavier carcases compared to lighter carcases. A 1% increase in yield of a 21kg carcase, processed to a standard fabrication, increased net return by an average of $1.29/carcase and there was an additional average $0.48 net return per carcase for a 1% increase in yield from a 27kg carcase.

Net return increased as carcase weight increased at a constant yield. A heavy carcase had a net return of $18/carcase greater than the basic carcase (21kg HCWT, 12mm GR) with a standard processing yield and $27 more per carcase with Value Added Yield. This is not unexpected since heavier carcases produce more meat and the fixed costs and costs per carcase are less per kg in heavier carcases.

Table 2 Average net return (±S.E.) per 1% increase in saleable meat yield with standard and value added fabrication and standard fabrication with discounts (+Disc) at three carcase weights (HCWT).

<table>
<thead>
<tr>
<th>HCWT</th>
<th>Standard ¹</th>
<th>Value added ¹</th>
<th>Standard +Disc²</th>
</tr>
</thead>
<tbody>
<tr>
<td>21kg</td>
<td>$1.29±0.129</td>
<td>$3.44±0.067</td>
<td>$1.15±0.116</td>
</tr>
<tr>
<td>24kg</td>
<td>$1.59±0.122</td>
<td>$3.92±0.040</td>
<td>$1.39±0.112</td>
</tr>
<tr>
<td>27kg</td>
<td>$1.77±0.100</td>
<td>$4.39±0.034</td>
<td>$1.34±0.107</td>
</tr>
</tbody>
</table>

¹ Plant 1; ² Plant 2

GR depth had greater effect on net return of heavier carcases than lighter carcases. In heavier carcases, an increase of 5mm GR (1 fat score) decreased carcase value by 11%, whereas in lighter carcases, an increase of 5mm GR depth decreased carcase value by approximately 7%. The effect of fatness on carcase value increased as fatness increased such that fat score 5 carcases need to be 2-3kg heavier than fat score 2 and 3 carcases to achieve the same net return.

When discounts were applied to cuts that were above or below weight specifications, the value of yield to the processor remained dependant on carcase weight, although to a lesser extent. A 1% increase in SMY of a 21kg carcase increased net return to the processor by an average of $1.15/carcase and there was greater increase in net return from heavier carcases (Table 2). However, there was little difference in the effect of SMY on net return between 24 and 27kg carcases ($0.05).

The model demonstrated that there are plant and time effects on the value of yield to the processor. A comparison of the net return per 1% increase in saleable yield (Table 2) shows a $0.20 difference in the value of a 1% change in yield from a 24 kg carcase with a standard fabrication between plant 1 and plant 2, using prices at different time points. The 24kg carcases did not have any discounts, therefore this difference is due to different cut specifications, different input costs and returns and different processing yields. This demonstrates that it is important for processors to undertake plant specific assessment of the value of yield to the processor. The Lamb Value Calculator is one tool that can be used to do this assessment.

Care must be taken if this information is used to develop value based trading. If price signals to the lamb producer favour increased LMY, there is the risk that eating quality of the product will be reduced (Gardner et al., 2010; Pannier et al., 2014). Therefore, there must be mechanisms incorporated into value based trading that ensure the eating quality of the product is not negatively affected.

Acknowledgement

Financial support for this project was provided by Australian lamb producers through Meat & Livestock Australia. The CRC for Sheep Industry Innovation was supported by the Australian Governments Cooperative Research Centres Program, Australian Wool Innovation Ltd, Meat & Livestock Australia and Australian Meat Processor Corporation. The assistance of key staff from the two processing plants used as case studies in the modelling is greatly appreciated.

References


ASAP Animal Production 2016, Adelaide
Exposure of bulls to high heat load decreases efficacy of scrotal thermoregulation

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Summary

Optimal sperm production requires bulls to maintain scrotal temperature (ST) within a narrow range below that of body temperature (BT). This experiment examined the bulls’ capacity to maintain ST under high heat load. Six Wagyu bulls with temperature recording data loggers surgically implanted in their flank and attached to the visceral vaginal tunic were subject to two types of heat treatments, in a 4 period crossover design with a recovery phase in between treatments. Treatments included a 5 d acute treatment representative of heat wave conditions and a 13 d chronic treatment representative of a hot summer. Climate controlled facilities were used for treatments and outdoor individual pens for recovery. Acute treatment significantly increased the BT diurnal cycle compared with recovery (P < 0.05). Scrotal temperature showed larger ranges during treatments compared with recovery. During acute treatment ST rose to 35.59 ± 0.29 °C potentially indicating compromise of thermoregulatory homeostasis.

Introduction

Predicted increases in global temperatures and a higher incidence of hot summers and heat waves (IPCC, 2013) means cattle throughout Australia will be subjected to more high heat load conditions. In addition to adverse welfare and production effects, this will also have implications for reproduction. For optimal spermatogenesis the bull’s testicles must remain 2-6 °C below body temperature (BT) (Waites, 1970). Continuous recording of ST while the bull is experiencing high heat load conditions has not yet been reported. This experiment documented continuous BT and ST while bulls were experiencing high heat loads in order to investigate the extent to which they can maintain ST.

Materials and Methods

Experimental design

This experiment was conducted at the Queensland Animal Science Precinct at the University of Queensland, Gatton Campus under animal ethics SAS/243/10. The experiment was designed as a 4 period crossover design with 2 treatments of acute (A) and chronic (C) and a recovery phase (R) in between each, that for analysis purposes was classed as a treatment. Each bull acted as an experimental unit. The 6 bulls were divided into 2 unequal blocks so that there were animals in both treatments at all times (n=2 treatment schedule - A,C,C,A; n=4 treatment schedule – C,A,A,C).

Climate control rooms

Climate control rooms had 2 individually controlled rooms with each room having two chambers separated by clear perspex. Each chamber had 2 pens constructed from steel panels. Bulls were housed individually within the pen but had direct eye contact with the bull in the adjacent pen. Each bull had ad lib water and was fed a mixed ration of feedlot finisher grain and chaff. Lighting in the rooms was set to increase over a 5 min period to sunlight at 0545h and then dim, again over a 5 min period to moonlight at 2030h. The acute cycle consisted of heating to 35 °C to be held for 6 h before cooling to 27 °C overnight and this was repeated for 5 d. The chronic cycle was also heated to 35 °C for 6 h, but then cooled to 21 °C overnight and repeated for 13 d. For recovery treatments, bulls were housed in outdoor individual pens. The climate rooms maintained the set temperatures within ranges of 1.95 °C and 2.03 °C for acute and chronic treatments respectively (Figure 1).

Data collection

Bulls were surgically implanted with data loggers (iButton, DS1922T, Maxim Integrated; recording every 30min) in both the scrotum (tethered to visceral vaginal tunic) and right hand side flank muscle wall (Wallage et al. unpublished). The temperature and humidity of each chamber was recorded using data loggers (Hobo U23 Pro V2, OneTemp Pty Ltd) recording at 10 min intervals and downloaded using HoboWare® (OneTemp Pty Ltd) after each treatment.
Due to computational difficulties statistical analysis was conducted as a linear mixed model for BT and ST during each treatment with R (v3.2.0, R Core Team, Vienna, Austria) using the nlme package (v3.2.0). Date and hour were variables and an autoregressive parameter was included. Once means for each treatment were obtained, Z-Tests were used to compare means between treatments.

Results and Discussion

Mean diurnal BT and ST for each treatment (A, C and R) are shown in figure 1. Date and hour were significant for all models (P < 0.001). Body temperature during recovery was consistent with the diurnal BT rhythm displayed by bulls (Refinetti and Menaker, 1992) and showed that animals recovered from the previous heat treatment before entering the next. Diurnal BT during acute was significantly higher than during recovery (P < 0.05). The BT range during recovery was the largest at 2.29 °C, whilst the range during chronic treatment was smaller at 0.56 °C, and smaller again for the acute treatment (0.44 °C), indicating that animals would likely be entering the next day with an accumulated heat load (Gaughan et al., 2008).

The temperature cycles seen along with maximum ST during both acute and chronic treatments are extremely interesting and indicate a potential breakdown in testicular thermoregulation when TA is elevated above 34 °C. Even short-term compromise in scrotal thermoregulation has been shown to have deleterious effects on bull fertility (Skinner and Louw, 1966). Further analysis of these cycles with additional physiological and behavioural data will provide more information on the effect of high heat load conditions on scrotal thermoregulation.

References


Wild dog predation and flock productivity – field methods to quantify stress and behavioural responses of sheep in the line of fire

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Summary
Predation of sheep by wild dogs causes a substantial cost to production and animal welfare in dog-affected regions. However, there have been few attempts to measure physiological and behavioural responses to predation events, mostly because measurement technologies have not been sufficiently developed to remotely measure those responses. Here we describe the use of inexpensive custom-made tools using off-the-shelf technologies to measure core temperature, cortisol and heart rate changes of ewes during simulated wild dog attacks. The technologies all showed potential and some preliminary data are presented to demonstrate the efficacy of each tool.

Introduction
The direct impacts of wild dog predation on sheep flocks are obvious. Significant costs and production losses are incurred by the sheep industry from dead and maimed stock and control activities (Fleming et al. 2014). However, the overall productivity and profitability of a sheep flock affected by wild dog presence is potentially further compromised by the energy costs of anti-predator behaviours through the direct energy expenditure of flight responses and the vigilance:grazing time trade-off. Suboptimal use of grazing space and prolonged activation of the hypothalamic, pituitary and adrenal (HPA) axis also need to be considered. These costs are currently unquantified and this project sought to field test the efficacy of devices that could be used for remote monitoring of stress indicators and behavioural responses of Merino sheep to wild dog presence.

Materials and Methods
A small-scale, spatially unreplicated randomised block experiment with two groups, control and treatment, with the latter experiencing short simulated wild dog attack events over 3 days (Tuesday to Thursday) in the 2nd and 3rd weeks of a 3 week period. Sixty Merino ewes ($\bar{x} = 66.6$kg) were randomly allocated to either the control or treatment groups (n=30). The two groups were moved to spelled paddocks (~5 ha) with similar topography and vegetation separated by sufficient distance (~1km apart) to ensure auditory and visual buffers.

The simulated wild dog predation events involved either 1 (week 2 and day 1 of week 3) or 2 dogs (day 2 & 3 of week 3) being directed by their owners to run around the mob of treatment group ewes and move them about their paddock for between 8 and 10 minutes. We measured physiological and behavioural responses to simulated wild dog attacks including core temperature, salivary cortisol and heart rates. Spatial patterns were also measured using GPS technology and drone-based videography, but we do not report those results here.

Core temperature. Serial vaginal temperature data were captured using indwelling data loggers. Thermochron iButton (TCS) temperature sensors (Maxim Integrated Products Inc., USA) were attached to EAzi-BREED®CIDR® Sheep and Goat Devices (Pfizer, Australia) (Figure 1). Each iButton was programmed to record temperature ($\pm 0.0625°C$) every 2 minutes, providing 720 temperature recordings per day allowing the iButton to remain inside the ewes for 4 days without the memory overwriting the oldest results when full. The iButton devices were inserted into the vagina of 10 ewes randomly chosen in the both the treatment and control groups each Monday and removed on Thursday afternoon.

Salivary cortisol. Saliva was collected by aspiration from the sheep’s mouth opposite to the 3rd or 4th cheek tooth, close to the parotid duct using a salivary sampling device described by Fell et al. (1985) and a modified Salivette® Cortisol collection tube (Sarstedt, Germany) (Figure 2).

Figure 1. iButton temperature loggers.

Figure 2. Components of the Salivette® Cortisol collection tube (top left), modified closed insert (top right), modified vacuum source (bottom left) and centrifuged sample (bottom right).
Collected saliva samples were immediately placed on ice, then later centrifuged (4,100rpm for 20 minutes) and frozen prior to analysis. Saliva samples were collected from the same 10 ewes in both groups fitted with the iButton data loggers after each simulated predation event.

**Heart rate (HR).** Polar A300 Fitness and Activity trackers paired with Polar H7 Bluetooth chest strap heart rate monitors (HRM) (Polar Electro, Finland) were used to capture both activity (kcal) and HR data (beats per minute). The chest strap was fitted directly behind the front legs with the electrodes placed near the caudal angle of the scapula and close to the sternum. Any fleece growing in this area was shaved off as close to the skin as possible. Obstetric lubricant was applied to the electrodes to ensure good contact with the skin. HRM were fitted to 5 of the 10 monitored ewes in both groups each morning prior to the simulated predation events and removed approximately 2½ hours later when the sheep were yarded for saliva extraction. The same ewes wore HRM for the duration of the experiment. Following the measurement period, data from the A300 was uploaded to the Polar Flow website (https://flow.polar.com/) from which the data for each session was downloaded to Microsoft Excel.

**Results and Discussion**

We achieved an 80% retention rate of the iButton data loggers in the treatment group in week 1 of the experiment and 100% for the following 2 weeks. No data loggers were lost from the control group. Peak temperature readings were recorded immediately after handling the ewes to both insert and remove the iButton devices, however these tended to reduce within 30-60 minutes after handling (Figure 3). The saliva sampling was both effective and quick, with between 2 and 5 ml of saliva collected with measurement to be conducted by a commercial laboratory.

**Table 1. Heart rate and activity level data capture, as a percent of the total measurement period, as well as heart rate and activity for the both groups.**

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats per minute)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>102</td>
<td>115</td>
</tr>
<tr>
<td>Range</td>
<td>57 – 226</td>
<td>66 - 194</td>
</tr>
<tr>
<td>Activity (kcal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>657</td>
<td>599</td>
</tr>
<tr>
<td>Range</td>
<td>462 - 1327</td>
<td>387 - 1921</td>
</tr>
</tbody>
</table>

The HR data comprised the entire measurement period including when the HRM were fitted each day, the simulated predation event for the treatment group ewes and movement of each group to the yards for HRM removal and saliva sampling. Fitting and removal of the HRM caused a rapid transient increase in the HR of the ewes shown by the peaks at each end of the measurement period (Figure 4) with the peak occurring just after 1 hour 32 minutes coinciding with the simulated predation event. Based on the complete measurement period, the average HR of the treatment and control groups were 102 and 115 bpm respectively, with the treatment group having a wider range (Table 1). The average activity level of the treatment ewes was higher than the control ewes, although the latter had the larger range.

**Acknowledgement**

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**References**


Productivity, leg health and range use of individual broiler chickens on a free-range commercial farm

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Summary

Individual broiler chicken range access was monitored until final pick up for slaughter. Birds were weighed and gait scored prior to and post range access (35 and 45 days of age) to investigate the relationships between body weight, leg health and range use. There were no weight differences prior to range access between birds that did and those that did not access the range. Birds that did access the range more than once had lower body weights at first and final pick up than birds that did not access the range. No birds were observed with a gait score ≥3 prior to range access. However by final pick up, birds that used the range more than once had more normal gaits than birds that never used the range. This study provides evidence of relationships between accessing an outdoor range and production and welfare characteristics in commercial free-range broiler chickens.

Introduction

Accessing an outdoor range may affect productivity and welfare. Reduced activity and poor leg health are two major welfare concerns in the broiler industry and accessing a range may have a positive impact. Indeed the frequency of walking strides has shown to increase in an outdoor area compared to an indoor environment (Jones et al., 2007; Zhao, Li, Li, & Bao, 2014). Increased activity associated with range use has the potential to positively affect broiler leg health; as locomotion is important for ossification in growing animals. However increased activity and/or other aspects of range use may have detrimental effects on growth rate. Whether broiler ranging behaviour on commercial free-range broiler farms is sufficient to affect leg health and productivity is unknown.

Few studies have investigated the effects of access to an outdoor range in broiler chickens, with various (sometimes conflicting) findings. Often studies compare indicators at a flock/group level. This however is not sufficient to identify what alternate housing conditions are affecting the birds (e.g. ventilation system and stocking density) and what are the direct effects of accessing the range. Broiler free-range studies suggest that not all birds access the range (Dawkins, Cook, Whittingham, Mansell, & Harper, 2003). Therefore identifying individuals that do and do not access the range and measuring bird characteristics may truly identify range effects; furthermore this method may help to identify predictors of range use. We investigated relationships between individual range access, leg health and body weight in commercial free-range broiler chickens.

Materials and Methods

Range access and relationships with leg health and body weight were investigated on two winter and two summer flocks of 6000-12000 mixed sex ROSS 308 broiler chickens on one commercial farm with pop-hole opening on one side of the sheds. Individual bird range access (n=1200) was monitored via radio frequency identification (RFID) technology (Benzing, Austria). Birds were caught in random groups of 20 from various areas within each shed and assigned a unique identification chip attached via a silicone adjustable leg band. Two rows of antennas were placed at each exit point of the shed to identify direction of movement, and frequency of range access was identified.

Range access was monitored from the first day of range access (permitted when birds were fully feathered; 21 days of age) until first pick up for slaughter (35 days of age) for winter flocks and until final pick up for slaughter (42 days of age) for summer flocks. At the same time points birds were weighed and gait scored using a 6 point gait scoring method (Kestin, Knowles, Tinch, & Gregory, 1992). For analysis, gait scores were collapsed into three categories; normal gait (score of 0), slightly altered gait (scores 1-2) and moderate lameness (scores 3-4). Birds with scores of 5 were immediately culled and not included in the study.

Relationships between body weight and ranging were analysed using a general linear model. Gait scores and predictors of range use were analysed using a generalised linear model with an underlying multinomial distribution, generalised logistic link function, and the ‘Likelihood ratio Chi-square’ statistic. Sex, season and flock (nested in season) were included in each model as covariates or random factors. Any interactions that were not significant were removed from the model. Two-tailed Pearson correlations were used to determine relationships between frequency of range access and weight. All statistical analysis was performed with SPSS.
Results

Ranging characteristics

As expected not all tagged birds accessed the range throughout the study. A relatively consistent percentage of tagged birds only accessed the range once in all flocks (6-14%). Therefore birds were categorised according to level of range use: birds that never accessed the range (no: “N”), accessed the range only once (low: “L”) and accessed the range more than once (high: “H”).

Pre range access

No differences in body weight were observed prior to range access between N, L and H birds ($\chi^2 = 0.02$, df = 1, $p > 0.05$). However there was a moderate negative correlation between body weight prior to range access and frequency of range access afterwards ($r = -0.24$, $p < 0.001$). Pre range access gait scores differed statistically between N, L and H birds ($\chi^2 = 3.96$, df = 1, $p < 0.05$, table 1). No birds were observed with a score ≥3 prior to range access.

Post range access

At first pick up, H birds had lower body weights (1.58 ± 0.02 kg) than L birds (1.72 ± 0.05 kg, $p < 0.05$) and N birds (1.76 ± 0.02 kg, $p < 0.001$). This difference increased by final pick up (H: 2.57 ± 0.03; L: 2.83 ± 0.08; N: 2.93 ± 0.05; H vs L: $p < 0.01$; H vs N: $p < 0.001$; N vs L: $p > 0.05$). There was no relationship between range use and gait score at first pick up ($\chi^2 = 5.34$, df = 2, $p = 0.07$). There was a relationship between range use and gait scores at final pick up ($\chi^2 = 9.23$, df = 2, $p = 0.01$), with higher percentage of normal gait scores and lower percentage for moderate lameness for H birds than L and N birds (table 1).

| Table 1. Percentage of birds in each ranging category (No (N), Low (L), High (H)) with normal gait, slightly altered gait and moderate lameness prior to range access, at first pick up and final pick up. |
|---------------|---------------|---------------|----------|
|               | N             | L             | H        |
| Normal (%)    |               |               |          |
| Pre range     | 94            | 77            | 83       |
| First pick up | 77            | 71            | 76       |
| Final pick up | 16            | 39            | 65       |
| Slightly altered (%) |               |               |          |
| Pre range     | 6             | 23            | 17       |
| First pick up | 16            | 15            | 17       |
| Final pick up | 64            | 39            | 31       |
| Moderately lame (%) |               |               |          |
| Pre range     | 0             | 0             | 0        |
| First pick up | 8             | 15            | 8        |
| Final pick up | 20            | 22            | 4        |

Discussion

Although there was no difference in weight prior to range access, the frequency of range access was negatively related to weight, suggesting decreased growth rate may be a predictor of ranging behaviour. Furthermore weight appears to be related to range use as birds that accessed the range more than once were 100 – 200g lighter than birds that never accessed the range or only accessed the range once, at first and final pick up. This supports the findings of Durali, Groves, and Cowieson (2012) who found growth rate was negatively associated with ranging. Decreased growth rate associated with range use could be caused by various (and potentially additive) factors including increased activity, temperature fluctuations and nutrient dilution.

Gait scores were relatively low in these flocks, particularly before range access; few birds had signs of moderate lameness. Although statistically significant, these differences may not be of biological significance as scores of <3 do not raise welfare concerns such as reduced activity or pain (Caplen, 2014). Birds that access the range more than once had more normal gaits and less moderate lameness at final pick up. This may be indicative of positive ranging effects on leg health but could also suggest that birds with pre-existing leg issues did not access the range. How these issues relate to increased activity in the range remains to be determined.

Further research that may track growth rate and leg health within shortened intervals, as well as identify the mechanisms for decreased growth rate, may be able pull apart effects of range use and individual bird characteristics that may drive range use.

Acknowledgement

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References


Emerging inherited diseases and animal welfare: A case study of congenital mandibular prognathia in Droughtmaster cattle

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Summary

Emerging recessive inherited diseases within livestock can have detrimental impacts upon animal welfare and can cause significant economic losses. Congenital mandibular prognathia in Australian Droughtmaster cattle is an emerging inherited disease that has a minor impact upon animal welfare. This study aimed to sequence the coding regions of the previously identified positional candidate gene FOXI2 to identify disease-causing mutations. Our results were inconclusive due to failed amplification of one of the exons. This study highlights the ease in which mapping recessive inherited diseases can be achieved, although the identification of disease causing mutations may still be challenging and can therefore delay the development of diagnostic DNA tests that can support the management of emerging inherited diseases through the improvement of animal welfare.

Introduction

Since the domestication of livestock, the controlled breeding of cattle (Bos taurus) has accelerated the genetic gain of desirable production traits (Mignon-Grasteau et al. 2005; Hayes et al. 2013). The dispersal of superior genetics has been assisted by advanced reproductive techniques (ART), however in some instances the application of controlled breeding and ART can inadvertently contribute to elevated rates of inbreeding and decreased effective population sizes, especially if popular sire lines are used frequently (Charlier et al. 2008; Whitlock et al. 2008). As a consequence, the possibility for deleterious recessive alleles to disperse and be inherited in homozygous form can increase (Whitlock et al. 2008; Windsor et al. 2011).

The molecular characterisation of 117 inherited diseases showing Mendelian inheritance in cattle (OMIA 2016) has allowed for improved management of these inherited diseases. Despite the advances in molecular and quantitative genetics, we are still aware of the under-reporting of emerging inherited diseases, which poses an issue for future management (Windsor et al. 2011). An example of an emerging inherited disease is congenital mandibular prognathia (CMP) in Australian Droughtmaster cattle. CMP is a craniofacial deformity that is characterised by the inability of the mandible and maxilla to meet uniformly. The presentation of CMP is a concern due to the inability of animals to meet their optimal nutritional requirements, which also represents an economic loss to producers through reduced production efficiency. This study aimed to sequence the coding regions of the positional candidate gene FOXI2 which was selected by using a homozygosity mapping approach of nine affected and four carrier Droughtmaster cattle on an 80K SNP chip (Tsimnadis, unpublished data) to identify potential disease-causing genetic variants.

Materials and Methods

Samples
EDTA blood samples from nine affected and four carrier

Droughtmaster cattle were obtained by the Elizabeth Macarthur Agricultural Institute (EMAI), Australia from regional veterinarians and/or producers. One affected Droughtmaster, one normal Droughtmaster and one unrelated normal Angus control were used in this study and DNA was extracted as part of a previous study (Tsimnadis, unpublished data).

PCR, sequencing and bioinformatics
Bovine sequence data for the candidate gene was obtained from the National Center for Biotechnology Information (NCBI) (Pruitt et al. 2014). Primers were designed using PrimerBLAST (Ye et al. 2012) and PCRs were performed using standard protocols in a final volume of 20μL. Purified PCR products were sent to the Australian Genome Research Facility (AGRF) for Sanger sequencing with the associated forward and reverse primers. Sequencing data was analysed using Sequencher® (Gene Codes Corporation, MI, USA) and allelic variants were compared to the variations database in Ensembl (Cunningham et al. 2015).

Results and Discussion

Amplification of exon one of the FOXI2 gene failed to generate a PCR product of expected size for various primer pair combinations in affected Droughtmaster and normal Droughtmaster and Angus DNA samples. Sequencing of non-specific PCR products resulted in sequences that failed to align to the FOXI2 gene. Exon two of FOXI2 was sequenced previously with no causative mutations identified (Tsimnadis, unpublished data).

The results from this case study highlight that whilst the advancement in molecular and quantitative genetics can assist in identifying disease-causing mutations, the confirmation of FOXI2 as the disease causing gene harbouring a causal mutation for CMP has so far not been possible. Potential reasons for the failed amplification of exon one of FOXI2 include possible errors in the bovine genome sequence of FOXI2 or a differing genomic sequence of exon one from the Bos taurus reference sequence due to the Droughtmaster breed consisting of both Bos taurus and
Bos indicus breeds (Bongso et al. 1981; Bolormaa et al. 2013). Future research centred on the re-sequencing of the candidate gene in other affected and control animals is planned.

The resultant delays for the development of a direct diagnostic DNA test can impact on producers as informed breeding decisions can become increasingly difficult, especially if reliable pedigree data is unavailable (Man et al. 2007). Consequently, affected animals are likely to be born in the future. The animal welfare implications of CMP are limited compared to other inherited diseases that are observed in livestock. This case study highlights the need to identify causative mutations for recessive inherited diseases in livestock to improve animal welfare and economic outlooks through the prevention of breeding affected animals (Healy 1996).

Acknowledgement
We acknowledge and thank the producers and veterinarians for the submission of samples to EMAI. We thank the genetics laboratory staff at EMAI for their assistance during this project and the University of Sydney, Faculty of Veterinary Science for the award of research support for two honours projects and the award of the Dorothy Minchin Bequest to support this research.

References
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High protein content stimulates bone elongation on energy-restricted cattle

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Summary

The effect of metabolisable energy (ME) restriction with high and low (LR and MAL) levels of crude protein (CP) and high ME intake with high CP in the diet was studied using two distinct cattle genotypes. There were five steers per treatment with the three treatments being high ME and high CP (LAL), low ME and high CP (LR) and low ME and low CP (MAL). The steers were fed the treatment diets in individual pens for 103 days. Liveweight (LW) and feed intake were measured weekly and hip height every two weeks. Blood samples were collected on days 78 and 103 for plasma metabolites and hormone analysis, respectively. Higher level of CP during ME restriction (LR) did not increase plasma concentration of IGF-1 but had a small increase in skeletal elongation rate. This suggests that dietary CP has an effect on the endochondral ossification process of cattle, but the role of plasma IGF-1 is not clear, and larger changes in IGF1 may be required to elicit a robust increase in skeletal elongation rate.

Introduction

Insulin-like growth factor -1 (IGF-1) plays a leading role in controlling bone elongation and IGF-1 is affected by nutritional status (Gat-Yablonski and Phillip 2015). High protein diets maintained serum IGF-1 levels of caloric restricted humans (6-8% body weight loss in 14 days) to the same level prior to restriction (Musey et al. 1993). Feed restriction imposed by controlling intake of balanced diets consistently decreases the concentration of circulating IFG-1 in cattle (Hornick et al. 2000) although the effect of a high CP content diet during energy restriction is not known. Thus, we hypothesised that ME restricted steers fed high CP (LR) diet would have higher IGF-1 levels to the group fed low CP (MAL) and similar to LAL. The higher concentration of serum IGF-1 is expected to enhance endochondral ossification and thus the change in hip height or skeletal elongation rate (SER).

Materials and Methods

The experiment used 15 Brahman cross steers (B; 178 ± 3.4 kg) and 15 Holstein-friesians (HF; 230 ± 7.2 kg) which were individually allocated in pens and assigned to one of the three treatments: High CP-High ME [LAL, Lucerne chaff ad libitum (Medicago sativa); 896 g OM, 195 g CP, 359 g NDF, 3.3 g P and 11.9 g Ca/kg DM)], Low CP-Low ME [MAL, Mitchell grass hay ad libitum (Astrebla spp.; 901 g OM, 37 g CP, 630 g NDF, 1.8 g P and 4.7 g Ca/kg DM)] and High CP-Low ME [LR, Lucerne chaff restricted to equivalent ME intake as MAL]. The MAL treatment included 50 g of cottonseed meal (CSM; 924 g OM, 428 g CP, 237 g NDF, 14.6 g P and 2.5 g Ca/kg DM) per kg of Mitchell grass hay offered from d 49. The LR treatment included 84 g of mono-sodium phosphate (MSP; 240 g P/kg DM)/kg LW.day. The treatment diets were fed for 103 days. Liveweight (LW) and feed intake was measured weekly and hip height (HH) fortnightly.

Blood samples were taken on days 78 and 103 for plasma metabolites and hormone analysis, respectively. Samples were collected from the jugular vein of individual steers using lithium heparin coated vacutainers prior to feeding. The samples were centrifuged at 1,200 g for 10 min and stored at -20°C. Plasma IGF-1, Insulin, Thyroxine (T4) and leptin were analysed using commercial radioimmunoassay kits (Biocline 10IGF100; Siemens Coat-a-Count insulin TKIN; Beckman Coulter Total T4 IM1447; Millipore multi-species leptin XL-85K respectively) as per the manufacturer’s protocol, including extraction for IGF1. Plasma glucose, phosphate, total protein, calcium, urea (BUN) were measured using an enzymatic kinetic reaction on AU400 with Olympus reagents (Olympus America Inc., Melville, NY). Nonesterified fatty acid (NEFA) was analyzed using ACS-ACOD method and commercial kit (Wako Pure Chemical Industries, Japan).

Analysis of variance (ANOVA) was performed with main effects of diet and genotype. Shapiro-Wilk test was applied and IGF-1 data was detected as not normally distributed so a log-transformation was performed before ANOVA. A post-hoc Tukey test was used to examine differences within treatments groups. No breed effect was detected for any hormone. The interaction between diet and genotype was significant for T4, LWG and SER.

Results and Discussion

The animal production data [liveweight gain (LWG) and SER] were previously presented in Silva et al. (2014) and are repeated in Table 1.

Lower concentration of glucose, insulin and IGF-1 were observed in animals fed restricted diets independent of CP level (Fig 1 and Table 1). Glucose levels are positively correlated to energy intake and insulin concentration in the bloodstream. In situations of limiting ME intake, NEFA are used as a major energy substrate but there were no treatment differences in concentration of NEFA but a difference between breeds (Table 1). Interestingly, T4 was lower only in Holstein-Friesians fed Low ME-Low CP diet while no differences were found between diets in Brahman steers. BUN concentration is positively correlated with protein intake when energy is not a limiting factor (Preston et al. 1965) although, divergent results were found for restricted fed cattle (Yambayamba et al. 1996). We found a
significantly lower concentration of BUN in steers fed MAL than LR diet and no difference between LR and LAL.

Table 1. Performance and plasma metabolites concentration of Brahman cross steers (B) and Holstein-Friesians (HF) fed High CP-High ME (LAL), High CP-Low ME (LR) and Low CP-Low ME (MAL).

<table>
<thead>
<tr>
<th></th>
<th>LAL</th>
<th>LR</th>
<th>MAL</th>
<th>P</th>
<th>SEM</th>
<th>B</th>
<th>HF</th>
<th>P</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>LWG (kg/day)</td>
<td>1.27</td>
<td>0.16</td>
<td>0.14</td>
<td>***</td>
<td>0.04</td>
<td>0.47</td>
<td>0.58</td>
<td>**</td>
<td>0.03</td>
</tr>
<tr>
<td>SER (mm/100d)</td>
<td>104.8</td>
<td>41.7</td>
<td>30.2</td>
<td>***</td>
<td>4.38</td>
<td>54.8</td>
<td>63.0</td>
<td>*</td>
<td>3.5</td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>5.22</td>
<td>3.93</td>
<td>3.74</td>
<td>***</td>
<td>0.10</td>
<td>4.28</td>
<td>4.27</td>
<td>NS</td>
<td>0.08</td>
</tr>
<tr>
<td>Total Protein (g/L)</td>
<td>66.0</td>
<td>66.2</td>
<td>64.7</td>
<td>NS</td>
<td>1.3</td>
<td>64.0</td>
<td>67.0</td>
<td>NS</td>
<td>1.1</td>
</tr>
<tr>
<td>BUN (mmol/L)</td>
<td>7.13</td>
<td>7.49</td>
<td>1.21</td>
<td>***</td>
<td>0.29</td>
<td>5.49</td>
<td>4.82</td>
<td>**</td>
<td>0.22</td>
</tr>
<tr>
<td>Calcium (mmol/L)</td>
<td>2.39</td>
<td>2.19</td>
<td>2.18</td>
<td>***</td>
<td>0.03</td>
<td>2.25</td>
<td>2.25</td>
<td>NS</td>
<td>0.03</td>
</tr>
<tr>
<td>Phosphate (mmol/L)</td>
<td>2.39</td>
<td>2.15</td>
<td>2.31</td>
<td>NS</td>
<td>0.10</td>
<td>2.31</td>
<td>2.26</td>
<td>NS</td>
<td>0.07</td>
</tr>
<tr>
<td>NEFA (mmol/L)</td>
<td>0.19</td>
<td>0.16</td>
<td>0.12</td>
<td>NS</td>
<td>0.03</td>
<td>0.22</td>
<td>0.10</td>
<td>**</td>
<td>0.03</td>
</tr>
</tbody>
</table>

References


In conclusion we rejected our hypothesis that a High CP-Low ME diet (LR) would have elevated IGF-1 compared to a Low CP-Low ME diet (MAL) and similar to the High CP-High ME (LAL). Despite the lack of an effect on IGF-1, insulin and leptin the LR diet increased SER, but this was quantitatively small and well below what was achieved on the LAL diet. There was a small quantitative increase in IGF-1 with LR compared to MAL and this may have been sufficient for the small increase SER. Another possible explanation could be a local stimulation of IGF-1 acting in an autocrine/paracrine manner without an effect on plasma IGF-1 (Ohlsson et al. 2009). Overall the nutritional treatment LR was at the extreme of what could be increased in the dry season and it may be concluded that such a strategy would only have a small effect on skeletal elongation rate.

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Lamb growth and in vivo organic matter digestibility of arrowleaf clover and bladder clover hay

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Summary

Twenty-four Merino weather lambs were offered a diet of either arrowleaf clover, bladder clover or subterranean clover hay ad libitum for 51 d. Individual liveweight and body condition score was recorded weekly, whilst in vivo organic matter digestibility was measured over a 7 d collection period. Liveweight gain was greater in lambs offered bladder clover hay compared subterranean clover hay. Dry matter intake (g) did not differ between the diets; although, dry matter intake adjusted for liveweight (g/kg) was greater (P = 0.003) in bladder clover hay than subterranean clover hay. In vivo organic matter digestibility was higher (P<0.001) in the bladder clover hay than both the arrowleaf clover and subterranean clover hays.

Introduction

Subterranean clover (Trifolium subterraneum L.) and annual medic spp. (Medicago spp.) have been the foundation of pasture-based production systems in the mixed farming zone of southern Australia. In recent decades; however, their suitability for this role has decreased due to changes in climatic, biological and edaphic factors (Loi et al. 2005).

A second generation of annual, self-regenerating, hard-seeded pasture legumes, including arrowleaf clover (Trifolium vesiculosum Savi) and bladder clover (Trifolium spumosum L.), were introduced to Australian farming systems as a result of selection and breeding research undertaken from the mid 1980s through to mid 2000s. These species are generally more persistent than traditional species under adverse climatic conditions. Potential biomass production of arrowleaf clover (Thompson et al. 2010) and bladder clover (Hackney et al. 2012; Norman et al. 2013) is higher or comparable to subterranean clover, and of similar forage quality (Hackney et al. 2012). Their potential as a conserved fodder is unknown, however.

This paper reports lamb growth rates of lambs fed either arrowleaf clover (cv. Cefalu) (AC), bladder clover (cv. Bartolo) (BC) or subterranean clover (cv. Mt Barker) (SC) hay and in vivo digestibility of each hay. We hypothesised that the LWT gain and in vivo organic matter digestibility in lambs fed AC and BC hays would be similar to SC hay.

Materials and Methods

Twenty-four Merino wether lambs (34.7 ± 0.9 kg) aged 9 to 10 months were fed ad libitum a diet of either AC, BC or a SC hay (n=8 sheep/diet) for 51 d in individual pens in the animal facility at NSW Department of Primary Industries’ Wagga Wagga Agricultural Institute. Lambs were allocated to diets using a stratified randomisation based on liveweight basis. All lambs were drenched (Q-Drench; Ixoroxt) with an anthelmintic and vaccinated (Glucvac 6-in-1; Zoetis) against clostridial diseases prior to the experiment.

Lambs were fed daily at approximately 9:00 h and ors were collected 3 times per week on Monday, Wednesday and Friday. Samples of feed offered and ors were bulked for each week and dried in a fan-forced oven at 80°C to determine dry matter content (DM) to allow calculation of daily DM intake (DMI). Lambs were weighed weekly and body condition scored (BCS; Jefferies 1967) prior to feeding.

In two periods during the experiment twelve lambs (n=4/diet/period) were housed in metabolism crates designed to allow collection of faeces to determine organic matter digestibility (OMD). Diet OMD was determined for each lamb, hence there were eight OMD estimates per diet. The period of digestibility determination included a 6 d adaptation period followed by a 7 d collection period. Feed samples, orts and faeces were collected daily, and stored at -18°C. There was a 24 h lag phase after the 7 d feeding period for the 7 d faecal collection. Samples were thawed, mixed and dried at 80°C in a fan-forced oven for 24 h (feed, orts) or 48 h (faeces) to determine DM content. Dried samples were ground (1 mm) and organic matter (OM) content determined (AFIA 2014) to allow the calculation of OMD.

All results were analysed using a linear mixed model in R (R Core Team 2015) using the ASReml-R package. Results were reported as predicted means from the model with significant differences detected at a 5% significance level (P<0.05).

Results

Table 1. LWT, BCS, DMI and OMD values for AC, BC and SC

<table>
<thead>
<tr>
<th>Diets*</th>
<th>AC</th>
<th>BC</th>
<th>SC</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LWT and BCS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starting</td>
<td>34.7</td>
<td>34.8</td>
<td>34.6</td>
<td>0.425</td>
</tr>
<tr>
<td>LWT(kg)</td>
<td>± 0.8</td>
<td>± 0.9</td>
<td>± 0.8</td>
<td></td>
</tr>
<tr>
<td>LWT (kg)</td>
<td>10.4</td>
<td>12.7</td>
<td>9.3</td>
<td>0.01</td>
</tr>
<tr>
<td>change</td>
<td>± 0.6ab</td>
<td>± 0.7b</td>
<td>± 0.7a</td>
<td>0.504</td>
</tr>
<tr>
<td>Starting BCS</td>
<td>3.50</td>
<td>3.25</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>End BCS</td>
<td>± 0.13</td>
<td>± 0.13</td>
<td>± 0.13</td>
<td></td>
</tr>
<tr>
<td>± 0.14</td>
<td>± 0.06</td>
<td>± 0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DMI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI (g)</td>
<td>1341.11</td>
<td>1504.29</td>
<td>± 57.88</td>
<td>1310.00</td>
</tr>
<tr>
<td></td>
<td>± 54.33</td>
<td>± 54.33</td>
<td>± 0.01</td>
<td>± 0.01</td>
</tr>
<tr>
<td>DMI(g)/LWT (kg)</td>
<td>31.52</td>
<td>34.39</td>
<td>30.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>± 1.71ab</td>
<td>± 1.68b</td>
<td>± 1.68a</td>
<td></td>
</tr>
<tr>
<td>OMD (ratio)</td>
<td>0.676</td>
<td>0.729</td>
<td>0.653</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>± 0.020a</td>
<td>± 0.019b</td>
<td>± 0.019a</td>
<td></td>
</tr>
</tbody>
</table>

* Significant differences (P<0.05) indicated by differing superscripts.

ASAP Animal Production 2016, Adelaide
Lambs fed BC hay gained more (P<0.01) weight than lambs fed SC hay, whilst LWT change for AC hay was not significant to either diets (Table 1). BCS of lambs did not differ between diets over the experiment (Table 1).

DMI (g) did not differ between the diets; however, DMI adjusted to LWT (g/kg) was greater in lambs offered BC hay compared to SC hay (Table 1).

Apparent OMD for BC hay was significantly higher than for both the AC and SC hays (Table 1).

Discussion

The higher LWT gain (LWG) of the lambs fed the BC hay compared to the SC hay was related to the higher DMI of lambs fed BC and the higher OMD of the BC hay. This is expected given the known relationship between voluntary feed intake (FI) and diet digestibility (Blaxter et al. 1961; Minson et al. 1964; Thornton et al. 1973), with more digestible diets resulting in shorter feed retention time and higher rate of passage out of the gastrointestinal tract (Thornton et al. 1973).

Norman et al. (2013) also found higher in vitro dry matter digestibility (DMD) in BC pastures, compared to SC (cv. Dalkeith) pastures; although, this did not result in differing LWG. Despite Norman et al. (2013) identifying a difference in digestibility between the BC and SC pastures (approximately 5% DMD) in early-mid spring, both pastures showed high levels of digestibility (75-85% DMD), which is unlikely to result in a significant difference in DMI (Blaxter et al. 1961) between the pasture types and thus, animal production. Animal selectively on pastures is also a likely influence. A nutritive sample is only a representation of the likely diet of the animal and does not take into consideration the selectivity of individual animals to specific parts of the plant that may be more digestible (leaves and seed heads), compared to the least digestible components (stem). Thus, animals on the SC pasture in Norman et al. (2013) study may have been more selective than sheep on the BC pasture, affecting the apparent digestibility of the SC pasture and their subsequent FI and LWG. BC was also shown to lose quality less rapidly than SC in the late spring (Norman et al. 2013), which is advantageous if BC was to be cut for hay later in the season.

There were no differences in LWG, DMI or OMD between the AC and SC hays, which was expected and compares to results found in early-mid December by Thompson et al. (2010). Thompson et al. (2010) found that AC maintained a higher in vitro DMD than SC in the summer period. It would be expected that when harvesting AC and SC for hay at a later stage, the digestibility of AC hay would also be higher, resulting in a higher value for animal production.

Based on the results from this study, BC and AC appear to have high value as conserved forages, provided that they can be harvested at a time that captures their high levels of digestibility. Further studies are warranted to investigate the feeding value and LWG potential of these second-generation legumes at the varying stages of plant growth, from early through to late vegetative/early flowering. Furthermore, it is necessary to understand the underlying mechanisms involved in lamb production, including ruminal fluid passage rates and temporal changes in rumen parameters. This includes, fermentation by-products in animals fed these second-generation legumes that will allow us to better understand their advantages and disadvantages when fed as conserved forage.

Acknowledgement

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References


Position of sensing microchips for detecting core temperature changes in sheep.

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Summary

Eleven crossbred ewes were implanted with temperature sensing microchips positioned in the neck muscle and tail regions, sites potentially suitable for remote temperature monitoring. Temperature measurements were taken at regular intervals from the microchips and from vaginal (core) temperature using iButton and thermocouple sensors. Temperature change was recorded over baseline and treatment periods where sheep were exposed to challenges designed to increase (i.v. lipopolysaccharide) and decrease (cold water gavage tube) core temperature. The temperature changes caused by the cold challenge were not well correlated with microchip temperatures. However, there were highly significant correlations between neck microchip amplitude and thermocouple and iButton measures when body temperature was rising. These results indicate that the location of the microchip implant affects its ability to accurately reflect core temperature changes and microchips implanted in the neck may be of use in remotely identifying feverish sheep.

Introduction

The health and wellbeing of sheep in extensively managed production systems is of increasing concern to producers, and the capacity to remotely monitor the health and welfare of stock would be an invaluable tool in improving treatment and response times to illness and reducing labour costs.

Core body temperature may be a good indicator of health status of animals and being able to remotely record animals that deviate from normal could be of particular benefit in extensive systems where time and labour constraints are evident. The capacity to identify sick animals remotely facilitates the likelihood of timely and successful treatment.

This project aimed to investigate the accuracy of temperature sensing microchips in monitoring absolute and positive or negative change in body temperature of ewes. Two locations for the microchip implants were chosen in order to compare suitability of the sites for detecting body temperature changes.

Materials and Methods

Eleven crossbred ewes (6 tooth, tail docked as lambs) were introduced into the UNE animal house and fed a blend of oaten, lucerne and wheaten chaff at maintenance levels for the duration of the experiment. During the testing periods the sheep were housed in individual pens and companions were always in visual and auditory contact. There were two 48h experimental periods with the first 24h measuring baseline temperature change and the second 24h being the treatment period. The first experimental period assessed the ability of the sensors to record increases in temperature while the second assessed decreases in temperature.

Temperature sensing equipment was attached to the animals using various technologies. A controlled intravaginal drug release delivery device (CIDR) was inserted intravaginally and was in place for both the 48h experimental periods. Prior to insertion thermocouple (TC) and iButton temperature sensors were attached to the CIDR with the thermocouples wired to a PowerLab logging device (AD Instruments) to allow continuous monitoring of vaginal temperature. The iButton sensors (Thermodata) were configured to take temperature readings every 5-10 minutes depending on the treatment. Temperature sensing microchips (Destron Fearing) were implanted in two locations in each animal, the first in the sternocleidomastoid muscle (neck) and the second was implanted subcutaneously underneath the tail (tail). Implantation was performed several days prior to the experiment commencement in order to reduce the potential impact of any associated inflammation.

To cause an increase in core temperature and replicate a fever state, a lipopolysaccharide (LPS) derived from the bacterium Salmonella abortus equi was administered intravenously at a dose rate of 0.03μg/kg, resulting in an increase in core temperature for a short period (approximately 3-4 hours). During the treatment period temperature measurements were taken at 10 minute intervals for the first four hours, then at increasing intervals over the next 20 hours. On completion of the first 48h sampling period the CIDRs were removed and the sheep were given a 5 day recovery period. Following baseline temperature monitoring for the second experimental period a drop in core temperature was induced. This was done through the direct administration of 1-2L of ice cold water (0°C) into the rumen of each sheep by gavage. During the treatment period, temperature measurements were taken at 5 minute intervals for the first three hours, then at increasing intervals over the next 21 hours.

The data were analysed using JMP 12 (SAS Institute Inc, NC, USA 2015) and Pearson correlations were performed using the peak high or peak low temperature recorded for each sheep after treatment and also the amplitude of temperature change between basal temperature (prior to treatment) and peak values.

Results

Correlations between the thermocouple recorded core temperature (TC) and iButton, neck and tail temperatures...
are shown in Tables 1 and 2. With the baseline recordings of both cold and LPS treatments, the TC values were significantly correlated to the tail site recordings (P<0.05) but were not significantly correlated to either the neck or iButton recordings (P>0.05). The cold treatment resulted in neither the low temperature nor the amplitude of the temperature changes being significantly correlated to the TC at any of the recording sites (P>0.05). With the LPS treatment high temperatures were significantly correlated with TC at all sites, and the amplitude of these changes were also highly correlated with the neck and iButton recordings (P<0.05). However, the amplitude of the changes in TC were not significantly correlated with values recorded at the tail (P>0.05).

Table 1: Cold treatment correlations between thermocouples (TC) and iButtons, TC and microchips located in the neck, and TC and microchips located in the tail for baseline, lowest temperature (low) and temperature change (amplitude).

<table>
<thead>
<tr>
<th>Cold baseline</th>
<th>Correlation</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC vs iButton</td>
<td>0.523</td>
<td>0.115</td>
</tr>
<tr>
<td>TC vs Neck</td>
<td>-0.208</td>
<td>0.564</td>
</tr>
<tr>
<td>TC vs Tail</td>
<td>0.692</td>
<td>0.027</td>
</tr>
<tr>
<td>Cold low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC vs iButton</td>
<td>0.539</td>
<td>0.097</td>
</tr>
<tr>
<td>TC vs Neck</td>
<td>-0.204</td>
<td>0.572</td>
</tr>
<tr>
<td>TC vs Tail</td>
<td>0.516</td>
<td>0.127</td>
</tr>
<tr>
<td>Cold amplitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC vs iButton</td>
<td>0.567</td>
<td>0.087</td>
</tr>
<tr>
<td>TC vs Neck</td>
<td>-0.311</td>
<td>0.381</td>
</tr>
<tr>
<td>TC vs Tail</td>
<td>-0.374</td>
<td>0.409</td>
</tr>
</tbody>
</table>

Table 2: Lipopolysaccharide (LPS) treatment correlations between thermocouples (TC) and iButtons, TC and microchips located in the neck, and TC and microchips located in the tail for baseline, highest temperature (high) and temperature change (amplitude).

<table>
<thead>
<tr>
<th>LPS baseline</th>
<th>Correlation</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC vs iButton</td>
<td>0.449</td>
<td>0.225</td>
</tr>
<tr>
<td>TC vs Neck</td>
<td>0.262</td>
<td>0.496</td>
</tr>
<tr>
<td>TC vs Tail</td>
<td>0.816</td>
<td>0.013</td>
</tr>
<tr>
<td>LPS high</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC vs iButton</td>
<td>0.715</td>
<td>0.046</td>
</tr>
<tr>
<td>TC vs Neck</td>
<td>0.718</td>
<td>0.045</td>
</tr>
<tr>
<td>TC vs Tail</td>
<td>0.800</td>
<td>0.031</td>
</tr>
<tr>
<td>LPS amplitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC vs iButton</td>
<td>0.982</td>
<td>0.000</td>
</tr>
<tr>
<td>TC vs Neck</td>
<td>0.898</td>
<td>0.002</td>
</tr>
<tr>
<td>TC vs Tail</td>
<td>0.532</td>
<td>0.175</td>
</tr>
</tbody>
</table>

Discussion

A previous temperature microchip study by Abecia et al. (2015) compared several devices in sheep and concluded that a tail position was preferable to implantation in the nuchal ligament (top of neck). This outcome contrasts with the present findings where tail position temperature was only significantly correlated to baseline core temperature and core temperature change when core temperature was increased. It is not immediately apparent why the findings should contrast so markedly but it may relate to the depth of implantation and further examination of this variable is justified.

The poor correlations of neck microchip measures with the thermocouple and iButton basal temperature measurements was unexpected, particularly given the tail measures were significantly correlated. This disparity may be due to the small change in baseline measurements and the lack of sensitivity of the measurement devices when compared with TC. There are regional differences in skin blood flow that could contribute to differences between tail and neck in response to thermal challenge but this should be minimised for baseline recordings.

In contrast the tail temperature values were significantly correlated to core temperatures for basal and the LPS treatment. Why the cold treatment correlations were not significant may again relate to regional difference in blood flow; the cold challenge in the rumen resulting in very rapid changes in partitioning of blood flow from the surface tissues of the body (Hales et al. 1976). This may also explain the poor correlations for amplitude measures. In sheep, arterio-venous anastomoses (AVA) associated with the skin regulate blood flow through specific thermoregulatory reflexes, whereas cutaneous capillary blood flow is regulated by local temperature effects. Cold water introduced into the rumen would have no local effect on skin blood flow, but may well influence reflex control of AVAs (Hales et al. 1978) compared to exposure to cold ambient temperature. The distribution of blood flow control in the sites examined is unknown.

In contrast to the cold treatment, neck and iButton values obtained during LPS treatment were well correlated with TC. When animals were feverish, temperatures recorded by chips in the neck muscle accurately reflected both qualitative and quantitative changes in core temperature. If this is repeatable in a less controlled context then it is possible that a microchip positioned in the neck muscle could provide a reliable means to regularly/remotely monitor body temperature increases in sheep. However, further studies will be necessary to determine if the microchip readings can be remotely collected and interpreted to identify feverish animals.

Acknowledgement

This research was funded by the Sheep CRC. Many thanks to the technical assistance of Laura Kemmis and Michael Raue.

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Profit Drivers for the Sheep Industry across Climate and Land Class

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Summary

Beef and sheep enterprises are run across the most diverse landscapes and variable climates and consideration of profitable systems need to take this into account. Four case study farms were used to test a range of sheep enterprises and management options across farms and land types. Under constant commodity prices, the greater the supply and reliability of pasture production, the greater the reliance on sheep meat and live weight per hectare to increase profit. With more unimproved pastures and lower and more variable rainfall, the greater the contribution of wool to profit. The most profitable strategies for increasing live weight sometimes differed across sites, indicating that rainfall and associated pasture production influence the most profitable system.

Introduction

In Victoria, beef cattle and sheep are run across diverse land class and climate regions. Whilst many producers have abandoned wool merinos as the main enterprise, there is evidence that climate (and associated pasture production) may be a stronger driver of profitability than price for some commodities (Browne et al 2012). This study considered the relative attributes that contribute to profit for a range of sheep enterprises across locations with land class and rainfall variability.

Materials and methods

Twelve sheep enterprises were modelled in GrassGro™ on four case study farms in Victoria. Sheep enterprises included fine and superfine self-replacing merino flocks (SRW), fine and superfine wether flocks; dual purpose sheep (DP) and systems as merino ewes joined to terminal or maternal sires; first cross ewes joined to terminal sires (FX) and two self-replacing meat sheep enterprises (SRM). Three case study farms were selected with high land class and rainfall variability in north east and central Victoria (B, S and W) and one with low variability in south west Victoria (H). Each variable site (B, S and W) had two distinct land classes as fertile, improved pastures (Imp) and as non arable low fertile pastures with annual pasture species (Unimp). Each whole farms (WF) comprised varying proportions of Unimp and Imp pastures. Annual average rainfall and pasture production are summarised for each WF in Table 1 for each land class in Table 2. Commodity prices were averaged over the 2004-2009 period.

<table>
<thead>
<tr>
<th>W</th>
<th>B</th>
<th>S</th>
<th>H</th>
<th>W</th>
<th>B</th>
<th>S</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual average rainfall (mm/year)</td>
<td>772</td>
<td>661</td>
<td>612</td>
<td>1003</td>
<td>9079</td>
<td>7256</td>
<td>5676</td>
</tr>
<tr>
<td>Annual average pasture production kgDM/ha</td>
<td>11565</td>
<td>10,912</td>
<td>7915</td>
<td>12374</td>
<td>2864</td>
<td>5354</td>
<td>3438</td>
</tr>
<tr>
<td>Variability in annual pasture production CV%</td>
<td>29%</td>
<td>36%</td>
<td>27%</td>
<td>9%</td>
<td>28%</td>
<td>34%</td>
<td>27%</td>
</tr>
<tr>
<td>% Improved pasture</td>
<td>71%</td>
<td>45%</td>
<td>50%</td>
<td>100%</td>
<td>71%</td>
<td>45%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Table 1: Pasture and rainfall for four case studies farms (WF) from 1971 to 2010
Simulations were conducted between 1971 and 2010 on a whole farm basis and across each land class. Contribution of the enterprise to farm profit was estimated as net margin ($/ha) as enterprise gross margin minus labour costs allocated to the enterprise.

**Results and Discussion**

At low and unimproved pasture production and highly variable locations the wool enterprises were consistently the most profitable. At the lowest pasture production site (W Unimp), wool enterprises were the only enterprises with a positive return. Figure 1 shows wool production as clean fleece weight (CFW kg/ha) at each location and across each land class within location. At the highest rainfall site (H) there was no clear relationship between wool production and profit, and as pasture production improved (Imp) on the other sites, wool contribution to profit was reduced.

![Figure 1. Clean fleece weight (CFW kg/ha) against profit ($/ha) across 4 sites and 3 land types (WF, Imp and Unimp)](image1)

As pasture production increased due to rainfall (H), soil and pasture type (Imp), increasing live weight production per hectare clearly contributed to profit across all enterprises. (Figure 2).

![Figure 2. Live weight (LWT kg/ha) against profit ($/ha) across the 4 sites and 3 land types (WF, Imp and Unimp)](image2)

Keeping lambs beyond weaning to heavier weights tended to improve contribution to profit for the merino cross systems (DP and merinos joined to maternal sires), but not for prime lamb enterprises. Improving the profitability of prime lamb enterprises did not always involve increasing fecundity and higher weaning rates did not always produce more live weight per hectare. The best option for a SRM enterprise at W WF and B WF was to increase ewe fecundity, although whether this could be realistically achieved, without incurring higher costs, is questionable. At S, increasing fecundity was not more profitable but, joining ewes as lambs was. This was due to running less ewes, which reduced costs, and selling lambs at the end of spring. Length of growing season as well as total annual pasture production, which is influenced by climate and land class, can influence the most appropriate and profitable enterprise and system.

Unless producers have good perennial pastures and a reliable growing season, wool should not be dropped out of the system. Conversely with high, reliable rainfall and good perennial pastures, producers should consider maximising live weight production per hectare, and the strategy to do this will vary across enterprise and environment.

**References**

Are neonatal beef calves getting enough to drink in northern Australia?

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Summary

The incidence of low milk delivery was assessed in 14 Brahman neonatal calves in the dry tropics of northern Queensland. Calf measures included live weight (as growth is primarily a function of milk intake) and urea space (a measure of body water). Urea space data were inaccurate. One calf dehydrated due to the dam having larger teats. Each of the remaining calves was categorised as having early (n=7) or delayed growth pattern (n=6), depending on whether calf live weight versus day of life had higher adjusted R\textsuperscript{2} for linear or exponential regression, respectively. Delayed calves did not reach the average growth rate of early calves (0.97±0.09 kg/d) until 4.2±0.7 days of life (P<0.05); and gained 0.57±0.1 kg/d prior to reaching this age. The high incidence of delayed growth in neonatal Brahman calves appeared to be related to delayed lactation, which may potentiate calf mortality under more stressful conditions.

Introduction

Pre-weaning beef calf mortalities in northern Australia can be as high as 60\% (McGowan et al. 2014) and thus can have large impacts on live weight production. Less than half of occurring calf mortalities are explained by risk factors including predation, mis-mothering, large teats and infectious disease.

A detailed study on tropical cattle (Bunter et al. 2013) reported that most (67\%) pre-weaning mortalities occurred during the first week of life (neonatal life) and that most of these losses were unexplained. High environmental and nutritional stress prior to and around calving is associated with increased calf mortalities (McGowan et al. 2014). Tropically adapted calves in extensively managed herds are highly likely to die if they do not suckle within the first 2-3 days of life (Fordyce et al 15). Based on the above, high nutritional or environmental stresses may be leading to low or delayed lactation in dams, ultimately leading to limited milk for the neonate and dehydration-mediated mortality. This study investigated how hydration status varies in tropically adapted neonatal calves.

Materials and Methods

This study was conducted at Spyglass Beef Research Facility (100 km north of Charters Towers) situated in the dry tropics; early in the typical calving period for beef cattle of the region (late dry season). Live weight and urea space of 14 Brahman calves were measured daily in the first week of life. Urea space is the volume in which injected urea distributes through the animal’s body water (Hammond and Rumsey 1990) and has been used as a practical way to estimate calf total body water (Dalton 1964) and thus percentage body water. Visual assessments for evidence of milk intake included daily measurement of calf para-lumbar fossa distension (5 point scale) and udder distension (5 point scale). Cow body condition during the study was 2.8 ± 0.03 (5-point scale).

Analyses. Initial graphing of calf live weight over time indicated two distinct growth patterns: where calves grew rapidly from birth; and where calf growth was delayed for several days after birth. The latter was represented by an exponential curve. Calves were categorised as early or delayed growth if linear regression of live weight vs. day of life provided a higher or lower adjusted R\textsuperscript{2}, respectively, than exponential regression.

Data were initially tested for normality using the Shapiro-Wilk test (α = 0.05). The average growth rate of the early growth group was used as a reference to compare with delayed growth calves. The days taken for each delayed growth calf to reach this growth rate was calculated, as was the live weight gain to this point (‘target growth from birth’). Time taken for the delayed calf group to reach the target growth rate was compared to zero days using a one-way t-test. Birth weights of early and delayed calf groups were compared using a two-way t-test. Bartlett’s test was used to confirm equality of variances; α = 0.05. Within groups, time to reach ‘target growth from birth’ was tested against birth weight using simple linear regressions. Analyses excluded the one dehydrating calf.

To determine if evidence of sucking explained growth pattern within group, both calf para-lumbar fossa distension and dam udder distension were linearly regressed over calf day of life.

Results

All calves in the study appeared to be well-hydrated through neonatal life except one that dehydrated due to its dam having larger teats. Of the apparently well-hydrated calves, 7 were categorised as early growth and 6 were categorised as delayed growth.

Delayed growth calves took 4.2 ± 0.7 days to reach a growth rate of 0.97 ± 0.09 kg/d, i.e., the average growth rate of early growth calves from birth (P < 0.05). The daily growth rate of delayed calves before they commenced high growth was 0.57 ± 0.1 kg/d. Birth weight (30.1 ± 0.8 kg) did not differ between early growth and delayed growth groups (P = 0.8). There was limited relationship between time to reach target growth from birth and birth weight for either growth pattern, where simple linear regression approached significance (P = 0.06; adjusted R\textsuperscript{2} = 0.32).

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Evidence of milk consumption did not differ between early and delayed growth calves, as measured by rate of change in para-lumbar fossa distension \( (P = 0.16) \) or rate of change of dam udder distension \( (P = 0.54) \) over the first week following calving.

Excluding the extreme values that were above 210\% \( (n = 2) \) or below 55\% \( (n = 4) \); urea space was 85.5 ± 1\% \( (n = 61) \) of live weight over neonatal life.

Discussion

The study has shown that approximately half of a Brahman calf cohort experienced very little growth until an average of 4 days post-calving under well-managed conditions in the dry tropics. Calf growth is determined by solid and fluid accruing as tissue growth and is primarily a function of milk intake \( (\text{Totusek et al. 1973}; \text{Black 1982}; \text{Castells et al. 2014}) \). Birth weight did not differ between early and delayed growth calves. This suggests that a foetal nutritional restriction and consequent issues reported in calves including low muscle fibre development \( (\text{Funston et al. 2010}) \) and possibly calf metabolic ability to use milk was not limiting factor growth in this study.

Pre- and post-partum dam energy and protein nutrition has clear implications for early post-natal lactation yields as shown in dairy studies \( (\text{Coulon and Remon 1991}; \text{Bell et al. 2000}; \text{McCarthy et al. 2105}) \). Water is also important for milk production \( (\text{Meyer et al. 2004}) \). In Brahman cows, daily milk yield tended to be associated with body condition \( (\text{McBryde et al. 2013}) \). Trends of change in calf para-lumbar fossa-distension and cow udder distension did not differ between growth pattern groups, and this may be because that milk delivery was still occurring albeit at sub-optimal levels.

Considering the above, delayed growth in neonatal calves may be explained by low milk production in the first few days post-partum. The dams in this study were in extensive pasture conditions though were in fair condition and appeared not to be under any heat stress. It is hypothesised that neonatal calves of delayed growth would be prone to dehydration mediated mortality under higher levels of nutritional and/or environmental risk factors.

Detailed investigation into the impact of nutrition on lactation yields within the first few days post-partum may clarify potential nutritional interventions to reduce calf mortalities across northern Australia.

Urea space as a percentage of live weight values averaged around 85\%, which exceeds that of previous reports. Previous reports of average \% body water in young calves include: 73.6 ± 6.4\% as measured by urea space as a percentage of live weight \( (\text{Dalton 1964}) \) and 73.0 ± 12\% as measured by desiccation \( (\text{Haigh et al. 1920}) \). Therefore the urea space method was not useful in the circumstances of this study.

A high incidence of delayed growth in neonatal Brahman calves occurred; with evidence that this was related to delayed lactation.

Acknowledgement

The staff at Spyglass Beef Research Facility are gratefully acknowledged for their assistance.

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Nutrition and its influence on early-life programming in animals

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Summary

Early-life programming is an area of research that seeks to discern links between gestational and post-natal environmental influences and long-term health status. Of particular interest in both animals and humans is the influence of nutrition on early-life programming. Nutritional status during gestation has been shown to potentially alter fetal development, for example, decreasing skeletal muscle mass. Nutrition during the neo-natal or post-hatch period has been shown to have long-term effects on performance, health and nutrient transporter expression. By understanding how nutrition influences early-life programming, we can develop nutritional strategies to optimize the lifetime health and performance potential of animals before they are even born.

Introduction

Early-life programming is an emerging concept that links influences during fetal and post-natal development with health later in life. Over the past few decades, these influences have begun being recognized as key factors in the risk of disorders and diseases in adulthood. Early-life programming hinges on epigenetics, the study of changes in gene expression in the absence of changes to the DNA sequence (Simmons, 2008). Gene expression differences play a key role in normal cellular processes and explain why different types of cells are able to share the same DNA sequence. The regulation of gene expression, both by “turning on” and “turning off” genes, can be achieved by DNA methylation, histone modification, or RNA silencing. One key environmental influence affecting early-life programming is nutrition. Epigenetic mechanisms provide potential insights as to how nutritional status during important developmental periods can lead to long-term health effects in offspring.

Nutrition: Fetal Programming

Perhaps the best example of the influence of maternal nutrition on the health outcome of offspring was the Dutch Hunger Winter of 1944-1945 (Ravellis, 1999). Individuals who were conceived during this period and subject to maternal under-nutrition were prone to an increased incidence of metabolic disorders. Several generations later it was found that the descendants of these individuals showed epigenetic changes to insulin-like growth factor 2 (IGF2), a key gene in human growth and development (Heijmans et al., 2008).

In livestock, maternal nutrient restriction seems to have the greatest impact on skeletal muscle development. Zhu et al. (2006) found that lambs from nutrient-restricted ewes were heavier than those from adequately fed ewes, but had increased fat and decreased muscle mass. This reduction in muscle mass was linked to a reduction in the number of myofibers during fetal development and a decrease in the activation of the mTOR signaling pathway, a key regulator of protein synthesis (Zhu et al., 2006). Underwood et al. (2010) found that cows fed poor quality diets during mid to late gestation produced calves with lower weaning weights. When these calves were followed through the feedlot period, researchers found that they had lower ADG, total weight gain, and hot carcass weights. While more research is needed to thoroughly understand the epigenetics behind these effects of maternal nutrition, it is known that maternal diet can lead to differences in fetal DNA methylation and expression of DNA methyltransferases (Lan et al., 2013; Wang et al., 2014).

Nutrition: Neo-Natal Programming

Early-life programming can also occur during the neo-natal or post-hatch period and have long-term influences on animal productivity and health. In poultry, reducing protein levels in the post-hatch diet can actually improve growth and development later in life and can increase the expression of genes involved in protein translation initiation (Everaert et al., 2010). Ashwell and Angel, 2008 found that in chickens, a low-phosphorus diet fed for 90h post-hatch resulted in increased intestinal Na/P cotransporter mRNA levels and enhanced ability for phosphorus utilization. Feeding higher levels of trace minerals during the first 96h post-hatch in chickens can increase expression of genes such as cyclin D1, which play a key role in cell cycle regulation, a biological function essential for gut mucosal growth and repair, and of nutrient transporter proteins in the small intestine (Brennan et al., 2013). Similarly, long-term growth in fish is improved when an optimal diet of zooplankton, rather than enriched rotifers, is fed during the larval and juvenile periods (Koeduk et al., 2009).

Improvements resulting from post-natal or post-hatch nutrition are not limited to changes in performance or growth. Early-life nutrition can also affect an animal’s ability to respond to immunological challenge. For example, adult dogs had more severe clinical signs of atopic dermatitis after exposure to an allergen if they had been fed probiotics during the first 6 months of life rather than a control diet (Marsella et al., 2012). Also, feeding spray-dried plasma to piglets during the first two weeks post-weaning improved immunological responses and decreased intestinal injury after exposure to S. Typhimurium later in life (Boyer et al., 2015).

Conclusion

Nutrition is a key influence in early-life programming both during fetal development and during the neo-natal or post-hatch period. While more research is needed, we are beginning to understand the epigenetic changes that are triggered by nutritional programming. Further study will allow valuable contributions to the field of animal nutrition and the use of early-life programming to improve animal production and long-term health.

References

ASAP Animal Production 2016, Adelaide


Climate challenges for pastoral agriculture in Australia

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Summary

The Australian grazing industries will be affected by climate change, both through impacts on the animals and pastures, but also through imperatives to reduce livestock emissions. Livestock research has traditionally focused either on mitigation or options to adapt to a changing climate, but both need to be achieved. Recent attempts to reconcile emissions reductions with increased global food demand have shifted the emphasis towards emissions intensity (t CO2e/t product), or the carbon footprint, as a preferred mitigation metric. While a focus on emission intensity is more compatible with productivity gains, this may also lead to less resilience to climate shocks through increased intensification. Options for livestock producers to reduce absolute methane emissions are currently limited, as are options to cope with extreme climate events; both require further research. This paper will discuss these challenges, using case studies from a series of recent farm systems analyses conducted in the Australian grazing industries.

Introduction

Australia has the highest levels of naturally occurring, year-to-year, rainfall variability globally (Love 2005), being over 22% more variable than any other country. Climate change will add an additional challenge to this existing high variability.

The Australian grazing industries will be affected by climate change, through direct impacts on the feedbase (crop and pasture growth) and on the animals (e.g. heat stress). However, livestock can also have an impact on climate change, negatively through emissions of methane and nitrous oxide, but also positively through the storage of carbon in soils and vegetation.

This paper will discuss these challenges, using case studies from a series of recent farm systems analyses conducted in the Australian grazing industries.

Results and Discussion

Impact of climate challenges on livestock

A number of recent studies have modelled the likely impact of climate change on Australia’s grazing industries, both in the northern Australian tropical rangelands (Hall et al. 1998; McKeon et al. 2009b) and southern temperate pastures (Cullen et al. 2009; Cullen et al. 2012a). These studies showed that predicted changes in climate will affect both the animal feedbase, through changing the production and pattern of growth, and the animal directly through increased heat stress.

In southern Australia Cullen et al. (2009) showed an earlier onset of the drier summer reducing the growing season by up to 3 weeks in last spring, but potentially compensated for by an increase in winter pasture growth due to warmer temperatures by 2050. In the northern rangelands McKeon et al. (2009a) reported that a 3°C increase in temperature could reduce forage production by up to 21%. However, what may appear as minor impacts on pasture growth, can translate to far larger economic impacts (Ghahramani and Moore 2013), in the absence of appropriate adaptation (Moore and Ghahramani 2014).

While these studies concluded that ‘average’ climate change was largely manageable through to at least 2050, both McKeon et al. (2009a) and Cullen et al. (2012b) suggest that the real challenge lies in the frequency, severity and extent of extreme events associated with this change. Most ecosystems and farm system models lack skill in predicting the impact of these extreme rainfall or heat wave events, either on forage production or on the animal. Thus significant further research is required to understand the frequency, severity and duration of these events, plus provide livestock producers with management options and systems to cope with extreme climate events.

Impact of pastoral agriculture on climate change

The Australian livestock industries contribute an estimated 11% of national greenhouse gas emissions in Australia (Department of the Environment 2015), with the majority if the emissions being enteric methane. Cost-effective options to reduce these emissions are currently limited, particularly in the more extensive grazing regions (Eckard et al. 2010).

However, attempts to reconcile imperatives to reduce livestock emissions with the need to increase global food production by 50 to 70% by 2050 (FAO 2006), have resulted in a shift in the focus from net mitigation (t CO2e) to emissions intensity (t CO2e/t product) (Gerber et al. 2013). A focus on emissions intensity (i.e. the carbon footprint) also provides the grazing industries with more options to reduce emissions, relative to business as usual, while continuing to improve productivity and profitability.

A number of recent case studies have shown relatively limited potential for net mitigation, but significant potential for improvements in emissions intensity and profitability in Australian grazing systems. For example, Cullen et al. (2016) showed farm gross margins being $562K and $38K higher, from beef production systems at Longreach and Bouria, respectively, where the focus was on reducing emissions intensity compared to reducing net emissions (including carbon offset income). Likewise, Ho et al. (2014) modelled a prime lamb system in south eastern Australia producing $60K more whole-farm profit when focused on reducing emissions intensity, rather than net emissions. The study concluded that revenue from the sale of carbon credits was
small compared with revenue from the sale of livestock products (Ho et al. 2014), a conclusion common to numerous other recent studies.

A potential positive effect that livestock production can have on climate change is that permanent grassland systems have greater potential to build soil carbon than agricultural systems where soil is disturbed or annually cropped; both through more continuous root growth by perennial plants and through less disturbance of soil organic matter. While converting from a long-term cropping to pasture has been shown to increase soil organic matter, most long-term perennial pasture systems would have reached a new steady state in soil organic matter and therefore no longer provide additional sequestration benefits (Meyer et al. 2015). During this transition from a low to a higher soil organic matter steady state, there may be potential for the increased sequestration of carbon to offset livestock emissions, but with diminishing returns as the soil organic matter approaches a new steady state (Meyer et al. 2016).

Conclusions

While livestock research has traditionally focused either mitigation of greenhouse gas emissions or adaptation options to adapt to a changing climate, in reality both need to be achieved simultaneously; this is an imperative for future research, as there are both potential synergies to be captured and conflicts that need resolving.

The most obvious of potential conflict is that a focus on emissions intensity can lead to further intensification and therefore less resilience in the face of increasing climate challenges. Mixed farming systems are likely to be more resilient to climate shocks, through providing more than one source of income for farmers, and will become more important particularly in lower rainfall and highly variable climates.

Clearly there are some farming systems that will be able to intensify their production systems, and therefore reduce their emissions intensity, but these will be systems where rainfall is high, climate variability remains low, or where water security is high. Typically these would be dairy and prime lamb systems in coastal temperate southern Australia and perhaps beef systems in higher rainfall, northern tropical regions.

Livestock systems in lower rainfall regions, or more highly variable climate zones, may need to de-intensify or move to more mixed production systems, to ensure greater resilience of their farming system to climate challenges. In these systems, either economies of scale or a refocusing from volume to value-adding would be required to sustain profitability and manage the increasing challenges from a changing climate.

Acknowledgement

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References


Pastures from Space – a practical application

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Summary

Pastures from Space has been commercially available to producers for more than 12 years. The system provides estimates of pasture production during the growing season by means of remote sensing. Satellite data is used to estimate pasture biomass and combined with climate data to produce pasture growth rate estimates. Feedback from producers indicates that there is a general lack of understanding on how they can use the data available and the perceived benefits.

By using a simple spreadsheet and historical data collected from the past 10 years of satellite modelling and from farmer’s records, it is possible to remove the “noise” of seasonal variability and observe the impact of management.

By analysing the bigger picture farm system results, the impact of the management on the productivity of the pasture system and its capacity to cope with seasonal variability and the effectiveness of strategies adopted over the past 10 years can be analysed with little additional data collection on the part of the producer. However, producers will need on-going support and access to simple tools (beyond Pastures from Space) to assist them with the interpretation of the information.

Background

Pastures from Space provides estimates of pasture production during the growing season by means of remote sensing. Satellite data is used to estimate pasture biomass and combined with climate data to produce pasture growth rate estimates. District estimates are directly available from www.pasturesfromspace.csiro.au, whilst individual farm data is available by subscribing to a paid service. Pastures from Space was launched commercially in 2004 (Mata et al 2004) with 80 commercial subscribers in 2007 declining too many less in 2015. Feedback from producers indicates that there is a general lack of understanding on how they can use the data available and the perceived benefits (Eastwood et al 2013).

This paper provides details on the preliminary outcomes from working with a group of producers, introducing them to Pastures from Space (PfS) and using the data to benchmark their farm’s historical pasture performance across seasons.

Data from a single property has been presented to demonstrate the outcomes.

Method

Collaborating farmers subscribed to Pastures from Space (PfS) (beta version). Total dry matter (TDM) production data was taken from PfS for 5 paddocks across each property. A simple spreadsheet was developed to assist in using the data to benchmark each property – the key data included the week of break, growing season rainfall (GSR), total dry matter (TDM), water use efficiency (i.e. kg DM/mm GSR), potential stocking rate, potential total dry matter, unrealised TDM, and potential TDM/dry sheep equivalent (DSE).

Potential stocking rate (S/R) was calculated from TDM minus residue required at end of the season divided by 550 (the assumed kilograms DM consumed by a sheep) (Grimm 1998).

Potential TDM was calculated from GSR multiplied by 30 (the target kg DM/mm GSR) (Bolger & Turner 1999).

Figure 1. Potential and actual stocking rate
Discussion

Figure 1 is an analysis of data collected from one farm. It shows the property’s actual stocking rate (S/R) expressed as DSE/WGHa and the S/R that the TDM produced would support. When the actual S/R exceeds the potential from TDM, the deficit is filled with supplementary feed, overstocking will reduce the leaf area and hence the capacity of the pasture to grow. There has to be a balance between growing pasture and utilization and the best compromise is when actual stocking rate is slightly less than potential stocking rate. It shows the importance of being flexible with stocking rate to adapt to seasonal variability.

The impact of high stocking rates is reflected in the WUE, with the property only achieving 8 to 12 kg DM/mm GSR. Is the WUE of 30 kg DM/mm GSR too high? Having analysed a number of farms with this method, changes in management can result in significant increases in WUE. Wooldridge achieved a 180% increase over a 10 year period (from 10kg DM/mm GSR in 1994 to 28kg/mm in 2014 at same S/R).

The week of break drives TDM in some areas, but with the case study property it does not make a significantly reliable indicator. However, the season break reasonably consistently occurs around week 15, which makes planning practices such as pasture deferment easier. There are obviously other key seasonal indicator points and with local knowledge, breaking the season’s productivity into T periods (Grimm 1998) will allow implementation of management practices that target key seasonal components where the greatest response will be achieved. Thus the focus may become sub season rather than the individual season as a whole.

Although producers may not have been using Pastures from Space, the system has continued to collect information on farms – accumulating a wealth of useful data that is just waiting for producers to use.

By analysing the bigger picture farm system results using PFS data, the impact of the management on the productivity of the pasture system and its capacity to cope with seasonal variability and the effectiveness of strategies adopted over the past 10 years can be analysed with little additional data collection on the part of the producer.

Conclusion

A relatively simple exercise with a group of producers has demonstrated the value of the information that can be extracted from Pastures from Space, assisting producers to benchmark their pasture productivity and quantify the impacts of seasonal variation.

However, producers will need on-going support or access to simple tools (beyond Pastures from Space) to assist them with the interpretation of the information.

Further adoption of this technology will depend on this further support.

Acknowledgements

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References


Implementing the Australian Funded “On-The-Ground” Aid Program at the Holy Karbala Sheep Research Station in Iraq

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Summary

The Iraq On-The-Ground (OTG) Sheep Reproduction Technologies project was developed and implemented between 2010 and 2013 as a partnership between the Iraq Ministry of Agriculture and the Australian Government. The project was part of a larger OTG Program to assist Iraq to rebuild its agricultural expertise. A concurrent objective of the OTG methodology was to enable Australian agricultural capability, experience and support to be utilised in Iraq without exposing Australian professionals to the security risks posed by travel to Iraq. This was achieved by providing intensive training to Iraqi agriculturists in Australia, resources to establish on ground projects in Iraq, e-mentoring and online support, and bi-annual workshops in Jordan for ‘refresher’ training, program review, evaluation, and planning. This paper reports on the outcomes of the OTG project during its implementation at the Holy Karbala Sheep Research Station in the Karbala region of central Iraq.

Background

After the Iraq war in 2003, the local agriculture sector began a long period of rebuilding that continues to the present day. The new Iraqi government at the time planned to rebuild the agriculture sector by seeking developmental assistance from other countries, and particularly those with expertise in farming systems comparable to those in Iraq. Australia was one such country, and the Iraq Ministry of Agriculture (MoA) and the Australian Government, through AusAid, planned and implemented a number of agricultural assistance programs to address the country’s needs.

Most of the assistance programs provided to the Iraq Ministry of Agriculture were short-term training missions by Iraq’s agricultural professional to Australia to experience Australia’s agricultural technologies, and providing post-graduate education scholarships to Masters and Doctorate level. Although these programs were useful in providing exposure to Australia’s farming systems, they were unable to provide follow-up support to the participants following their training visits. To address this problem, a program called the On-The-Ground (OTG) program was developed in conjunction with AusAID and was implemented in 2011 to demonstrate a new methodology to provide lasting agricultural support that had the potential to deliver meaningful and lasting local outcomes for the Iraq agricultural sector (Al Moadhen and Miller 2015).

This paper reports the outcomes of the OTG Sheep Reproduction Technologies project. This project was focussed on training four Iraqi agricultural professionals to a high level of competency in all aspects of assisted reproduction technologies for sheep, including semen collection, preparation and storage, artificial insemination by cervical and laparoscopic methodologies, embryo collection and storage, and embryo transplant. In particular, the activities, outputs and outcomes of the work at the Holy Karbala Sheep Research Station are discussed below.

Strategy

The OTG program was developed to provide intensive training to selected Iraqi agricultural professionals in Australia with leading experts in the chosen field, and to subsequently provide a small quantity of essential equipment, a modest operating budget, real-time and ongoing e-mentoring and communication with the participants on their return to Iraq, and bi-annual face-to-face refresher training for the participants with the Australian training team in nearby Jordan throughout the project.

The program also included train-the-trainer processes for the participants to train more colleagues on their return to Iraq, and training in complementary technical areas such as project management (including planning, implementation, monitoring and evaluation), and participatory extension methods to engage producers and other stakeholders in Iraq.

With respect to the Karbala component of the OTG project, Karbala is located approximately 100 km south of Baghdad in the middle part of Iraq in an important area for the country’s sheep sector. The Karbala Sheep Research Station was built in 2007 and during that time has provided workshops, presentations, and training to sheep producers to demonstrate how to better manage their flocks. The addition of the OTG project to the Station’s operational activities was initially seen by the MoA and the Australian project team as a strategic and complementary benefit for local producers.

Progress and Outputs

The Australian-based intensive training program trained 4 individuals from the Iraq MoA staff in Australia during the period from May to August 2011, with the assistance of the expert staff of the South Australian Research and Development Institute’s (SARDI) reproduction technologies unit at Turretfield, South Australia. Following the training program, the 4 participants returned to Iraq with the goal to establish 4 assisted breeding technologies centres in the key sheep production regions of Iraq (Karbala, Diyala, Salah Al Din, and Erbil). Each of the group were responsible for establishing the centres and training other staff to build their team, and to implement the program, including extending the results to producers and other stakeholders in a targeted extension program.
An unforeseen delay in the arrival to Iraq of the containerised equipment required by the teams to establish the sheep reproduction centres caused a number of delays in commencing activities at the centres. However, at the Karbala Research Station, a program of training for local staff was able to be planned and implemented using a small quantity of essential equipment that was taken to Iraq separately from the containerised equipment, and which enabled some skill development to commence in the meantime. At Karbala, this training program was implemented with 4 staff and included:

1. Ram training for semen collection,
2. Synchronization methods for ewes,
3. Anatomy of the sheep reproduction system,
4. Theory of semen collection, preparation for insemination, and storage,
5. Artificial insemination (AI) methods, including mock training techniques (Figure 1), and
6. Embryo collection, storage and transfer methods.

Figure 1. Laparoscopic AI training methods used at Karbala while waiting for equipment to arrive from Australia.

The delay to the arrival of the equipment also allowed the Karbala team to engage with a range of local sheep producers and university students studying Veterinary Science and Livestock Science at the Karbala University. These activities provided an opportunity to explain the technical aspects of the sheep reproduction technologies learned in Australia, and also the opportunities and benefits that can be offered to develop the sheep industry by using the techniques in well targeted breeding programs. These activities generated significant interest amongst the group and there is positive hope that one or more may seek further training and experience to use these technologies in the future.

Following the arrival of the containerised equipment, steps were taken quickly to set up the sheep reproduction centre and to begin the hands-on work with local sheep. Along with being able to train colleagues more effectively by using the equipment, a program was established to demonstrate that the assisted breeding technologies could be applied successfully with local sheep breeds.

To achieve this, 2 local Awassi rams were trained for semen collection, and fresh semen was successfully collected for use in the demonstration project. This semen was then used to inseminate 12 Awassi ewes by cervical (n=7) or laparoscopic (n=5) methods. After 35 days, the pregnancy status of the ewes was determined by using a portable ultrasound scanner provided by the OTG project to the Karbala centre. At this time it was established that 11 of the 12 ewes were successfully inseminated and were carrying lambs as a result. All 11 of these ewes subsequently delivered viable lambs at the full term of their pregnancy: 8 lambs produced via cervical AI (includes 1 set of twins) and 4 lambs by laparoscopic AI. These lambs have been recognised locally as “the OTG lambs”.

At present the Karbala team are continuing to work with producers. The team now routinely provides on-farm pregnancy diagnosis services using ultrasound scanning, and are continuing to develop their skills and train others in the technologies (Figure 2). It is notable that one of the most successful extension engagement tools has been supplying synchronization devices (Eazi-Breed CIDR, Pfizer Animal Health) and providing instruction in their use. This is because synchronization is a widespread standard practice of sheep breeders; using vaginal sponges.

Figure 2. Karbala Sheep Research Centre staff trained by the author continue to provide services in Iraq.

Outcomes

The sheep OTG project has achieved many successful steps and has been acknowledged as one of the most successful projects to receive Australian aid assistance. Although the security situation in Iraq remains unstable, project activities are continuing in Karbala. Also, OTG colleagues at the Erbil centre have recently successfully crossbred local Karadi sheep using East Friesian semen imported from Australia. The OTG team continues to believe that the future is full of opportunities and that activities will resume quickly and successfully when the security situation improves.

Acknowledgement

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References

The case for digital livestock monitoring in the mixed farming region – is it possible to reduce management complexity without adding to it?

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Summary

In this study, we investigated the application of a digital livestock monitoring system for mixed farming enterprises. Our aim was to evaluate the practical use of a web-based interface to display monitoring information and to identify data metrics of priority for farmers. Grazing trials were conducted on mixed sheep and cropping farms in Western Australia, and accompanying survey data was collected from the participating farmers. Results of the survey indicated that monitoring sheep on crop stubbles and dual-purpose crops was a higher priority than sheep grazing annual pasture. Measuring daily distance travelled on several sentinel animals was considered useful to inform changes in feed supply, estimating energy balance and managing feedbase rotations. To be of most value to livestock managers, the priority metrics and context of summary data (guided through experience) should be considered carefully when monitoring products are developed.

Introduction

The cost of complexity in managing sheep enterprises in the mixed farming region of Western Australia is being closely scrutinised by farmers. Key pressure points for livestock enterprises include labour scarcity, increasing management demands in cropping, soil conservation, loss of livestock management skills by the younger generation, and unwillingness to allocate a higher proportion of labour to an enterprise considered to generate a lower proportion of farm profit (Kingwell 2011; Rose 2011). Digital livestock monitoring systems have the potential to support and simplify management, reduce labour requirements, and improve production efficiency. But there is a risk of the technology adding to management complexity (Watthes et al. 2008). The use of behavioural monitoring systems in livestock management has been considered for many decades (e.g. use of aerial photography to relate animal dispersion to rangeland condition, Dudzinski et al. 1978). The development of such systems is necessarily complex. Digital livestock monitoring requires the integration of biological information from sensor devices via suitable data analytics and software platforms in a manner that is adaptable to unique and varied businesses. The recent rapid expansion of digital technologies has meant that a range of livestock monitoring systems are becoming commercially feasible. In this paper we report a study to identify and evaluate applications of on-animal livestock monitoring for mixed farming and the level of interest by farmers. An analysis of the distance travelled by sheep grazing crop stubbles is described, and the practical use of GPS tracking data is discussed.

Materials and Methods

To evaluate a livestock monitoring system in the mixed farming region, we developed a web-based data visualisation tool and conducted a series of grazing trials using on-animal GPS tracking and activity sensors. We received 21 responses from farmers interested to participate in the livestock monitoring trials, following the distribution of an EOI call through the WA Grower Group Alliance. Grazing experiments (Floreat AEC ref. 1503), of 4 weeks duration, were carried out at 4 farms with the host farmers and other interested farmers provided access to log in and view the daily locations and movement of the sentinel sheep. The experiments were conducted in paddocks ranging from 72 – 310 ha in size at a stocking rate that was representative of district recommendations (between 2 and 6 mature ewes/ha). At each farm, 4 ewes were randomly selected from the flock and fitted with GPS tracking devices that transmitted their location at 5 minute intervals. Animal liveweight and condition score from a subset of 30 sheep in each flock was measured at days 0, 14 and 28 of the trial. The biomass of forage components of the wheat stubbles was measured immediately prior to grazing. A survey of farmers who were affiliated with the participating grower groups was conducted to provide supporting qualitative data.

Results and Discussion

Our evaluation of the livestock monitoring tool and the survey responses suggests that farmers are willing to use a livestock monitoring system to check the location of stock, integrate information on animal travel distance into their farm business and better understand the patterns of land use by sheep grazing on crop stubbles. Crop stubbles and vegetative crops (out of season feed) were seen as a higher priority for livestock monitoring compared with annual pastures (75% and 72% versus 17% of respondents expected high or very high value). Farmers selected lifting livestock productivity over summer (73%) and reducing supplementary feeding costs (64%) as the main reasons to improve management through livestock monitoring on their farm, while extra labour requirements (82%), the cost of infrastructure (55%) and uncertainty in economic return (35%) were considered the main barriers to improving stock monitoring.

Liveweight gain was generally higher during the first two weeks of stubble grazing compared with week 3 and 4 (+63 versus -60 g/head/day), and varied greatly among the experimental sites. The composition of feed components was highly variable, with paddocks containing from 15 to 120 kg/ha of spilt grain. Only one site (West Arthur Trials Group) had a notable quantity of edible green forage (25 kg DM/ha
germinated wheat). Figure 1 shows the daily distance travelled by the ewes over 4 weeks. There was a location x week interaction (P<0.001), where sheep in the smaller paddocks (●72 and ○ 94 ha) first increased travel distance before it decreased in the later part of the trial, whereas travel distance in the larger paddocks (+147 and * 310 ha) increase over the 4 weeks (Figure 1).

![Figure 1. Distance travelled daily (km) by ewes grazing crop stubbles at four sites in the mixed farming region of Western Australia.](image)

Enhanced livestock monitoring systems provide an opportunity both to increase the efficiency of livestock management and improve animal productivity, and to reduce the labour requirements for monitoring animals in extensive grazing systems. These were identified as important outcomes for livestock managers in the mixed farming region of Western Australia in considering whether to implement the technology. Our results demonstrate that understanding relationships between the composition of stubbles and the characteristics of the paddock will be important in using animal behaviour to inform feedbase management. Specifically, larger paddocks and access to ‘green pick’ may have contributed to greater daily travel distances and different patterns of travel over time. The project demonstrates the possibility of more basic applications of livestock monitoring (e.g. detecting predation and escaped animals, and water point monitoring). However, the cost of implementing the technology will vary depending on the type of information required and the level of development and refinement of the product so that it is fit for purpose. The proportion of sentinel animals that require sensors for the intended metrics is an important consideration. For farmers to install on-animal sensor-based monitoring systems in their sheep flocks the product would need to be cost effective, easy to use, and reliable and to provide high priority information for management.

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Responses of deficient breeder cows to additional diet phosphorus

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Summary
An experiment examined the responses of non-lactating breeder cows fed low phosphorus (P) or adequate P diets. Plasma inorganic P concentrations indicated that animals fed low P diets were in severe P deficiency. Adequate diet P increased (P<0.001) voluntary intake of DM and metabolisable energy (ME) and liveweight (LW) gain. These increases were greater (P<0.05) with a higher ME content diet. Rib cortical bone thickness (CBT) was increased (P<0.05) by adequate diet P. The experiment demonstrated that large responses occur when P-deficient cows are supplemented with P during mid-pregnancy.

Introduction
Nutritional deficiencies of phosphorus (P) in grazing cattle commonly occur in the seasonally dry tropical rangelands (Winks 1990). A study examined the responses of mature breeders in mid-pregnancy to additional P fed with P-deficient diets of moderate (ModE) or high (HighE) metabolisable energy (ME) concentration. These diets were designed to represent high quality pasture in the mid-late wet season, or moderate quality pasture in the early-mid dry season, respectively.

Materials and Methods
Forty recently-weaned Bos indicus cross cows (6-11 years, (mean ± SD) LW 430 ± 45 kg, body condition score 2.7 ± 0.35, foetal age 12 ± 1.2 weeks) were housed in individual pens. For 13 weeks the cows were fed ad libitum one of four diets with HighE or ModE ME content based on straw, wheat flour and sugar ± calcium phosphate (HP or LP; 1.61 and 0.66 g P/kg DM respectively) in a 2x2 factorial design (HighE-LP, HighE-HP, ModE-LP and ModE-HP). Digestibility was measured by total collection of faeces. Blood was sampled fortnightly and rib bone was obtained by biopsy at the commencement and end of the experiment.

Results and Discussion
Plasma inorganic P concentrations (Table 1) indicated that the cows given the low P diets (means 0.50 and 0.67 mmol/L in HighE-LP and ModE-LP respectively) were severely P-deficient. Voluntary intake of DM and ME were increased (P<0.001) by additional P in the high P diets, but the proportional increase was greater (P<0.001) with the high ME diet. Inclusion of additional diet P also increased LW gain (P<0.001) of cows fed the ModE diet (0.07 to 0.32 kg/day), but the increase in LW gain was much greater (0.29 to 1.05 kg/day) with the HighE diet. Higher diet P increased rib cortical bone thickness (CBT) (P<0.05), but did not affect (P>0.10) the specific gravity (SG) of cortical rib bone. Bone SG was reduced (P<0.01) by the HighE diet.

In conclusion, mature pregnant breeder cows fed a P-deficient diet post-weaning responded to additional diet P with substantial increases in intakes of DM and ME, and increased CBT of rib bone. The effects of additional diet P on intake and LW gain were much greater in cows given a diet of high ME content (HighE) than those given a diet of moderate ME (ModE) content.

Table 1. The responses of mature cows fed high ME (HighE) or moderate ME (ModE) content diets containing low (LP) or high (HP) concentrations of phosphorus (P) for 13 weeks during mid-pregnancy (n=8 to 10)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>HighE-LP</th>
<th>HighE-HP</th>
<th>ModE-LP</th>
<th>ModE-HP</th>
<th>s.e.d</th>
<th>E</th>
<th>P</th>
<th>E x P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake (g/kg LW.day)</td>
<td>16.1b</td>
<td>21.5a</td>
<td>13.5c</td>
<td>14.9bc</td>
<td>0.50</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>ME content (MJ/kg)</td>
<td>9.45b</td>
<td>10.02a</td>
<td>8.87c</td>
<td>8.36d</td>
<td>0.140</td>
<td>***</td>
<td>n.s.</td>
<td>***</td>
</tr>
<tr>
<td>ME intake (kJ ME/kg LW.day)</td>
<td>152b</td>
<td>216a</td>
<td>119c</td>
<td>124c</td>
<td>4.6</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>LW change (kg/day)</td>
<td>0.29b</td>
<td>1.05a</td>
<td>0.07c</td>
<td>0.32b</td>
<td>0.052</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Plasma inorganic P (mmol/L)</td>
<td>0.50a</td>
<td>1.95b</td>
<td>0.67a</td>
<td>1.91b</td>
<td>0.064</td>
<td>n.s.</td>
<td>***</td>
<td>n.s.</td>
</tr>
<tr>
<td>Plasma total Ca (mmol/L)</td>
<td>2.32b</td>
<td>2.06a</td>
<td>2.35b</td>
<td>2.05d</td>
<td>0.039</td>
<td>n.s.</td>
<td>***</td>
<td>n.s.</td>
</tr>
<tr>
<td>Bone CBT change (mm)</td>
<td>-0.46ab</td>
<td>+0.10b</td>
<td>-0.41abc</td>
<td>-0.13ab</td>
<td>0.188</td>
<td>n.s.</td>
<td>*</td>
<td>n.s.</td>
</tr>
<tr>
<td>Bone SG change (g/cc)</td>
<td>-0.053ab</td>
<td>-0.028ab</td>
<td>-0.001bc</td>
<td>+0.013c</td>
<td>0.014</td>
<td>**</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

Means with different superscripts are different at P<0.05, n.s., not significant P>0.05.

References

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Effects of time of sampling during the day on the concentration of phosphorus in faeces of cattle

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Summary

The concentration of total phosphorus (TotP) and acid insoluble phosphorus (AIP) in the faeces of steers held in metabolism crates was measured at five intervals during the 22 h after feeding. Steers were fed ad libitum once daily a semi-purified diet low in P (LowP), or the same diet with addition of calcium phosphate to provide sufficient P for high growth (HighP). There was no effect (P>0.10) of interval through the daily cycle on the concentration of TotP or AIP in faeces. It was concluded that the time of sampling of faeces after feeding does not affect the concentration of P in faeces of cattle ingesting diets with the P mixed through the diet. The results suggested that when faecal TotP is measured in grazing cattle no differences between treatments at P<0.05 are likely to be observed unless the actual difference in TotP is > 0.5 g P/kg DM.

Introduction

Since nutritional deficiencies of phosphorus (P) can occur in cattle grazing many regions in the seasonally dry tropical rangelands it is necessary for managers to be able to estimate their diet P intake (Winks 1990). The concentration of P in tropical forage diets ingested by cattle can be estimated with moderate accuracy (R² of P in tropical forage diets ingested by cattle can be estimated with moderate accuracy (R²=0.7) from measurements in faeces of P concentration together with diet attributes measured with near infrared spectroscopy of faeces (Dixon 2015). However any variation through the daily cycle in the concentration of P in faeces would lead to error in the estimation of dietary P concentration from faeces since the estimate would be partly dependent on the time of sampling. The present study measured the magnitude of the variation in faecal P concentration with time after feeding in cattle fed once per day on a low P diet, or the same diet mixed with sufficient calcium phosphate to provide for high growth. Samples were obtained from a major experiment with growing steers reported by Quigley et al. (2015).

Materials and Methods

Twelve Bos indicus crossbred steers (6 per diet treatment) were housed in metabolism crates and fed a semi-purified pelleted diets containing either 0.9 g P/kg DM (LowP) or 2.4 g P/kg DM (HighP). Dietary crude protein (CP) and metabolisable energy (ME) concentrations (109 g CP and 9.2 MJ ME/kg DM) represented the quality of the diet often ingested by grazing cattle in the early wet season. The pellets contained (g/kg as fed basis) barley straw 590 (15 mm chop length), sugar (230), gluten (80), wheat starch (80), urea (8) and a mineral mix containing monensin, with an inorganic P source (calcium phosphates, Biofos, Ridley Agri-products) included in the HighP pellet. All steers were also offered 0.5 kg/head.day of Mitchell grass (Astrebla spp) hay (39 g CP, 666 g NDF and 1 g P/kg DM). Except for short periods when the steers were in metabolism crates, the steers were housed in individual pens and had consumed these diets for an average of 145 days prior to collecting the faecal samples used for this study. The steers were moved to metabolism crates for 9 days for collection of faeces and urine. The steers were 228 ± 2 kg liveweight (mean ± s.e.m) at the commencement of the experiment and were 307 ± 3 kg (LowP diet) and 416 ± 9 kg (HighP diet) at entry to the metabolism crates. On day 7 in the metabolism crates faecal samples were collected approximately every 4 hours within a 24-hour period. One steer from the LowP treatment was withdrawn from the metabolism crates due to low voluntary intake of the feed.

The amount of feed offered and remaining at the end of each collection interval was measured. Faecal samples were oven dried (65°C) and then ground through a 1 mm screen in a laboratory mill. Total P (TotP) concentration was determined in these samples by inductively coupled plasma spectroscopy following perchloric/nitric acid digestion. In addition samples of the faeces were incubated in 0.4% hydrochloric acid for 1 h, centrifuged, and the P in the supernatant was determined directly as the acid-soluble fraction of P in the faeces. The acid-insoluble fraction (AIP) was calculated by difference. The differences between diets and between time of sampling of faeces were examined in repeated measures AOV of response variables. For percent intakes no comparison between diets was possible since each diet had an average of 20% over the intervals. To obtain a statistical comparison of percent intakes a between diets separate AOV was done at each interval.

Results and Discussion

The LowP steers had lower day 7 voluntary intakes than the HighP steers (on an as fed basis 3.69 kg and 12.0 g /kg LW, 7.81 kg, 18.8 g /kg LW, respectively). Ingestion of the feed followed a similar pattern in both the Low P and the High P steers with the majority of ingestion occurring in the first 8 hours (78 and 65%, respectively) and ≥ 90% in 16 h (Table 1). The LowP steers tended to consume a greater proportion of their diet earlier in the daily cycle, but this may have been associated simply with their lower voluntary feed intake.

The time of sampling of faeces through the daily cycle clearly did not significantly effect (P>0.10) the concentration of...
either total P or acid insoluble P in faeces. Presumably the mixing of ingested feed with digesta in the rumen, and the large inflow of endogenous P into the rumen in saliva, was sufficient to remove most of the variation in entry of P into the rumen which must have occurred with the ingestion of the majority of the daily intake during the 8-12 h after feeding. The implication is that in cattle ingesting a diet where the P is mixed through the diet as a constituent of the forage or concentrate, or as calcium phosphate, the time of 'spot' sampling of faeces is not likely to have a large and important effect on the faecal P concentration. However this conclusion, that faecal P concentration does not vary through the daily cycle, may not be correct in other feeding systems such as if a P supplement is ingested during a brief interval once each day, or once each several days, or if the P supplement is in a more soluble form than that used in the present study and which may be more readily absorbed from the gastrointestinal tract.

The sem = 0.19 (5% level least significant difference = 0.61) for g TotP/kg DM in faeces at a specific time interval and with 5 or 6 animals in each of the two diet treatments indicated that the 95% confidence interval for measurement of faecal total P was approximately ± 0.5 g P/kg DM units. To halve this confidence interval would require about 12 animals per diet treatment. In practice in most herds of grazing cattle the variation among animals in faecal P concentration is likely to be larger, possibly substantially so, than that observed in the present study when a homogeneous group of steers were fed specified diets for six intervals during the 22 hours after feeding. The implication is that in cattle ingesting a diet the P is mixed through the diet as a constituent of the forage or concentrate, or as calcium phosphate, the time of 'spot' sampling of faeces is not likely to have a large and important effect on the faecal P concentration. However this conclusion, that faecal P concentration does not vary through the daily cycle, may not be correct in other feeding systems such as if a P supplement is ingested during a brief interval once each day, or once each several days, or if the P supplement is in a more soluble form than that used in the present study and which may be more readily absorbed from the gastrointestinal tract.

The division of faecal total P into fractions soluble and insoluble in dilute hydrochloric acid has been used as a measure of the extent to which P in cattle faeces moves into groundwater, is present in water runoff, and contributes to eutrophication (Kebreab et al. 2005; Dou et al. 2007). This fraction of total P was examined in the present study as a rapid procedure to examine whether different P fractions in faeces may change through the daily cycle. However there was no evidence that these proportions changed through the daily cycle. The average concentration of total P in faeces was on average higher in the HighP than the LowP diet treatment (5.0 and 3.4 g P/kg DM, respectively, P<0.001) even though the diets differed only in calcium phosphate content. This suggests that a substantial proportion of the total P in faeces was comprised of undigested microbial debris, and the higher concentration was associated with more extensive microbial synthesis in the HighP than the LowP diet. However, the observation that the proportion of total P comprising AIP was similar in the faeces from LowP and HighP diets (0.57 and 0.60, respectively) suggested that the acid extraction procedure solubilized a substantial proportion of the P in microbial debris in the faeces.

### Table 1. The concentrations of total phosphorus (TotP) and acid insoluble P (AIP) in the faeces of steers fed a low P semi-purified diet (LowP) or of six steers fed the same diet with addition of calcium phosphate (HighP). Faeces were sampled during six intervals during the 22 hours after feeding

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Diet</th>
<th>Interval after feeding during the 24 hour cycle (h)</th>
<th>s.e.m. (DxT)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-4 4-8 8-12 12-16 16-22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of intake ingested during each interval^a</td>
<td>LowP</td>
<td>45 33± 13 5* 4</td>
<td>4.1</td>
<td>n.d. *** n.s.</td>
</tr>
<tr>
<td></td>
<td>HighP</td>
<td>38 27b 18 7b 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total P (g/kg DM)</td>
<td>LowP</td>
<td>3.35 3.38 3.36 3.31 3.43</td>
<td>0.19</td>
<td>*** n.s. n.s.</td>
</tr>
<tr>
<td></td>
<td>HighP</td>
<td>4.90 4.83 5.26 5.24 4.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid insoluble P (g/kg DM)</td>
<td>LowP</td>
<td>1.88 1.89 1.90 1.91 1.93</td>
<td>0.069</td>
<td>*** n.s. n.s.</td>
</tr>
<tr>
<td></td>
<td>HighP</td>
<td>2.39 2.24 2.27 2.32 2.28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^aPercent of total daily feed intake which was ingested during the interval indicated. D, diet; T, time interval. n.d., not determined; n.s., not significant; ***, P<0.001. s.e.m., standard error of the mean. Superscripts within columns indicate that the percent of intake ingested during interval was different between diets (P<0.05).

Acknowledgement

This research was supported by Meat and Livestock Australia and the Queensland Department of Agriculture and Fisheries. We thank Diogo Costa for assistance with faecal sample collections.

References


Crossbred ewes had blood samples taken which were then washed with sodium nitrite to convert haemoglobin to 100% methaemoglobin. Six treatment alternatives, including riboflavin, nicotinamide, lactate, formate, ascorbate and methylene blue were added to nitrite treated sheep erythrocytes and their methaemoglobin concentrations were measured every two hours over a ten hour period. Methaemoglobin levels reduced in all treatments over time. Methylene blue was the only treatment to significantly accelerate methaemoglobin reduction compared to the control. Ascorbate and lactate showed a trend in reducing methaemoglobin although at a much slower rate than methylene blue. It was concluded that methylene blue remains the most efficient treatment in reducing methaemoglobin back to haemoglobin.

Introduction

Feeding nitrate to ruminants is fraught with the possibility of nitrite poisoning when excess nitrite is produced in the rumen and absorbed into the bloodstream. Nitrite causes oxidation of the ferrous ion in haemoglobin resulting in the formation of methaemoglobin, which can no longer carry oxygen. The red cell has two enzyme systems that can reduce methaemoglobin back to haemoglobin. The first, NADH-methaemoglobin reductase is continually active keeping the normal level of methaemoglobin below 1%. It relies on the production of NADH from glycolysis. The second enzyme system, NADPH-methaemoglobin reductase is normally inactive, but much more efficient once activated. Classically methylene blue has been used as an activating agent for this enzyme and hence is the preferred antidote to nitrite poisoning. However, methylene blue is no longer registered for use in animals destined for the food chain. Hence alternative treatments were sought.

Materials and Methods

Blood was obtained from four crossbred ewes into heparinised containers and washed 3 times with cold isotonic saline, removing the buffy coat with each washing. The cells were incubated for 1 hour with 150mmol/L sodium nitrite to ensure 100% MetHb formation. The cells were then washed a further 5 times to remove all nitrite.

The cells were then placed in an Tris buffer (pH 7.4, Tris 50mmol/L, KCl 5mmol/L, MgCl₂ 1.2mmol/L, NaCl 158mmol/L Na₂HPO₄ 5mmol/L, glucose 20mmol/L) to produce haematocrits of approximately 30%. Therapeutic concentrations of nicotinamide (7.6mM), riboflavin (2.6mM), methylene blue (6.5mM), ascorbic acid (0.35mM), sodium lactate (18mM) and sodium formate (1.3mM) were added to the buffer and the suspension incubated at 38°C for 10 hours. The concentrations of methaemoglobin were measured every 2 hours for 10 hours, using a Radiometer ABL800 Flex Blood Gas Analyser.

Data were analysed using a one-way ANOVA with repeated measures.

Discussion

The normal levels of methaemoglobin are below 1% and are kept at this level by the action of NADH-Methaemoglobin reductase. Clinical signs of hypoxia are evident when levels are between 20 and 50% and levels above 60-70% are
considered lethal (Kinoshita 2007). The current antidote to nitrite poisoning, methylene blue, activates a secondary rescue pathway involving the enzyme NADPH-methaemoglobin reductase. In this pathway methylene blue is reduced to leukomethylene blue which then acts as an electron donor to stimulate the reduction of methaemoglobin. Methylene blue is not registered for use in food producing animals and some alternative treatments for methaemoglobinemia have been investigated in humans, particularly for those patients deficient in glucose-6-phosphate dehydrogenase. Ascorbic acid has been shown to enhance methaemoglobin reduction in both rats and humans, but was very slow in comparison to methylene blue (Hsieh and Jaffe 1975). A similar response was obtained in the present study.

Lactate was considered a treatment alternative as the addition of lactate to red blood cells increases the production of NADH when it is oxidised to pyruvate by lactate dehydrogenase (Godwin et al. 2015). Lactate showed a trend towards lowering methaemoglobin levels, but the effect was minimal compared to methylene blue.

Surprisingly riboflavin had no effect on the reduction of methaemoglobin. The vitamin acts as a precursor for flavin mononucleotide and the NADH-methaemoglobin reductase pathway has been demonstrated to be a flavin-mediated pathway (Yubisui et al. 1977). Indeed Dotsch et al. (2000), recorded a significant reduction of methaemoglobin in human erythrocytes with concentrations above 120µM riboflavin. Our study used concentrations about 15 times greater than Dotsch (close to the solubility limit) with no effect on methaemoglobin reduction.

Jaffe and Neumann (1968) reported that nicotinamide and nicotinic acid had the ability to reduce methaemoglobin in human red cells. Presumably the effect was due to providing more of the precursors NADH and NADPH. However, we found no effect with nicotinamide (or nicotinic acid which interfered with the methaemoglobin assay, data not presented).

Matthias (1956) suggested that formate may be involved in methaemoglobin reduction. We found no such effect of formate.

Methylene blue remains the “gold standard” for treating methaemoglobinemia. Ascorbic acid and lactate show some action in reducing methaemoglobin, but the magnitude and rate of the effects are likely to be of little clinical significance. Further studies are needed to find an efficacious alternative to methylene blue.

Acknowledgement

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References


It’s Ewe Time – a national productivity stimulation campaign

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Summary

The Australian sheep flock contracted by 31% between the late 1990’s and 2010. Concurrent industry restructuring caused a shift away from wethers towards a greater proportion of ewes in the flock. However strong demand for lamb resulted in prime lamb production increasing from a declining ewe base. The It’s Ewe Time campaign was initiated to create a timely sense of industry awareness, enthusiasm and urgency to improve on farm productivity gains and address declining ewe numbers. Seven forums were run during winter 2010 and nine forums during winter 2011 across Australia.

The forums were highly successful in engaging producers, reaffirming key productivity and profitability messages, increasing producer awareness and knowledge of practical, relevant on farm practices and demonstrating the business value for changing and modifying management practices. It’s Ewe Time reinforced Meat & Livestock Australia (MLA), Australian Wool Innovation (AWI) and Making More from Sheep (MMFS) as credible sources of science based, on-farm management information.

Background

The Australian sheep flock contracted by 31% between the late 1990’s and 2010 to approximately 71 million head (Australian Bureau of Statistics). Significant flock restructuring saw a fall in wether numbers resulting in a strongly ewe dominant flock. A concurrent shift from Merino-Merino matings towards Terminal – Merino matings, saw prime lamb supply defy the drop in national flock numbers (Figure 1).

Figure 1: Australian sheep flock and sheepmeat supply

While positive for building lamb supply to capture a growing market, a sustainable ewe base was required to sustain the lamb supply. Key industry outcomes required were to reverse the decline in ewe numbers, improve reproductive efficiency and increase carcase weight.

To address the declining sheep flock MLA initiated It’s Ewe Time forums in 2010 and were supported by AWI in 2011 to deliver forums throughout key sheep producing regions of Australia.

Strategy

It’s Ewe Time, a sheep industry productivity stimulation campaign, aimed to create a timely sense of industry awareness, enthusiasm and urgency to address declining industry productivity and create a vision of industry potential. The program directly linked to MLA and AWI’s delivery platform, Making More from Sheep (MMFS) (MMFS, 2016a) which offered producers follow up learning opportunities to develop knowledge, skills and confidence to encourage adoption of productivity and profitable on farm management practices. Each campaign aimed to provide technical information with clear take home and actionable messages, aligned to the learning modules of MMFS.

The 2010 It’s Ewe Time series targeted seven major sheep producing centres to maximise the number of sheep producers engaged. The 2011 series built on the previous year’s momentum, targeting regions with smaller flock sizes albeit representing a significant proportion of the national flock or regions that demonstrated signs of re-entry to the sheep industry. Nine forums were held during the winter 2011 period..

Partnerships were developed with agribusiness agencies, Sheep Cooperative Research Centre (CRC) and Department of Agriculture and Food, Western Australia, to support a targeted regional media campaign for producer engagement. Agribusiness partnerships at a local level were essential and provided value to both parties. Local agribusinesses valued the opportunity to partner as it gave their clients access to relevant, “hear today, take home and use tomorrow practices”. The strategic effect being an increase in the number and quality of stock presented for sale and, demand for input products. From MLA and AWI’s perspective local partners enabled leverage of networks, creation of promotional opportunities, event credibility through personal invitation, and coordinated local logistics and intelligence.

Quality speakers and content aligned to the key profit drivers of sheep businesses, a focus on proven science-based practical take home messages and actions was essential to producer engagement (MMFS, 2016b). A focus on continuous improvement as the forums rolled out contributed to maintaining a high standard of delivery and event quality across the series. Robust monitoring and
evaluation of producer engagement, content satisfaction, business value and intended practice change provided valuable feedback to the forum funders and partners on the value of the campaign and provided an evidence base to make refinements.

Evaluation results
Extensive evaluation was performed on both forums. The winter 2011 results are presented in this paper. Nine hundred and fifteen participants attended nine It’s Ewe Time forums held throughout Western Australia, South Australia, New South Wales, Victoria, Tasmania and Queensland. Average attendance was over 100 producers. The largest group of attendees considered themselves mixed farmers (46%) and 26% of attendees were in the under 35 age bracket. Forty two percent were aged over 50. The forums attracted producers with large flocks, as the median number of breeding ewes was 1,500. The average scores related to the business value of the content was 8.5 out of 10.

Producer feedback from the forum series highlighted the strengths of the campaign. In particular, speaker quality, content diversity, business relevance, the science grounding of messages and the focus on practical take home messages were noted. Interaction with speakers and networking was highly valued by some participants. However others preferred more content or potentially a facilitated debate amongst producers.

Seventy four percent of forum participants intended to implement a practice change to their sheep enterprise as a result of attending a forum. The majority of intended changes related to ewe management (28.6%) and genetics (23.5%) (Figure 2). Practices that producers intended to adopt included “analyse business production / structures to improve profitability”, “make decisions based on analysis and assessment”, “match paddock size to the stock”, “actually define our breeding objectives”, “Use ASBVs”, “Urge stud to adopt ASBVs”, “maintain ewe condition score 2-3 after lambing”, “join ewe lambs” and “wean and drench earlier” (Conway, 2011).

Value to industry
It’s Ewe Time achieved its aims of raising producer awareness and a sense of urgency to address declining industry productivity and created a positive vision of industry potential. The forums were highly successful in engaging producers and service providers, reaffirming key productivity and profitability messages, increasing producer awareness and knowledge of practical, relevant on farm practices and demonstrating the business value for changing and modifying management practices. Whether the campaign achieved its intended aim of feeding producers into MMFS delivery events is unclear from the data available.

The It’s Ewe Time collaboration with AWI presented a united approach to addressing key sheep industry issues and enabled MLA and AWI to showcase the value and relevance of their research, development and engagement to sheep producers.

Partnership arrangements with agribusiness and local merchandise outlets built on a strong value proposition for themselves and their clients, and in turn enabled a far greater reach to producers than MLA alone could have achieved. The local networks agribusiness was able to access, along with collateral and word of mouth support created significant additional promotion and enthusiasm for the events.

The professional approach to the It’s Ewe Time series, including a dedicated program development team, a scheduling and program development consultant, the engagement of a professional communications company, professional audio-visual services, high calibre speakers and quality, relevant content reinforced MLA, AWI and MMFS as credible sources of on-farm management information for sheep productivity.

Acknowledgements
It’s Ewe Time partners and sponsors for 2011 were Elders Pty Ltd, Landmark Pty Ltd, Ruralco Holdings Ltd, Sheep CRC, Department of Agriculture and Food WA, Sheepmeat Council of Australia (SCA), State Primary Industry Agencies, Private Livestock Consultants, Sheep Updates (WA).

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Meat Consumers Ignore Online Animal Welfare Activism

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Summary

Social media has become an integral part of everyday communication for many citizens across the globe. People access news on platforms such as Twitter and Facebook through shared links from news websites, and through images and videos shared by various organisations. The increased adoption of social media sites by organisations such as Animals Australia and People for the Ethical Treatment of Animals (PETA) has sparked concern within livestock production industries, who often claim that such organisations post false or misleading content in order to damage the industries’ reputation. Ongoing research suggests that content shared by animal welfare activists is considered by some to be extreme and hence does not impact on people’s choice to eat meat.

Introduction

The role of social media in the distribution of topical information is of increasing interest in areas such as communication during and after natural disasters (Mark and Semaan 2008; Sutton et al. 2008) and online campaigning or protest (Bonilla and Rosa 2015). Consumers frequently receive information about food production through the media (Hoban and Kendall 1994; Tonsor and Olynk 2011). The adoption of social media has changed the way in which people are exposed to such information because people can access, post and share content 24 hours of the day instantaneously and globally.

The 2011 ban on live-export of Australian cattle following a television expose and subsequent social media campaign is an example of the impact of the media on livestock production (Munro 2014, Schoenmaker and Alexander 2012, Tiplady et al. 2013). Concern about the impact of increased social media activity by animal welfare activist groups has led Australian livestock organisations to encourage producers to use social media to “help consumers get to the real story, and to have real conversation – one that is genuine and free from spin” (Meat and Livestock Australia 2014).

The aim of our research is to look at consumer attitudes to animal welfare activism online and whether such activism is having an impact on what people think about livestock production and ultimately changing their purchasing decision when it comes to meat products. This becomes important when considering the emphasis required from industry to provide opposing information on social media. Our preliminary research findings suggest that content being posted on social media may be viewed as too extreme and hence does not have impact on red meat consumers’ meat purchasing behaviours.

Materials and Methods

Consistent with qualitative approaches to research (Creswell 2013), focus groups and interviews were used to explore attitudes to animal welfare activism online. As of March 2016, 53 participants have been involved from Adelaide, Brisbane, Toowoomba and Melbourne. It is a requirement that participants are red meat consumers as this research is looking at attitudes of those involved in the meat value chain. In the context of a discussion about opinions of farm animal welfare in the Australian sheep and beef cattle industries, Australian meat consumers also were asked about their exposure and response to animal welfare activism online. All responses were audio recorded for transcription. All transcriptions were anonymised, coded, and analysed thematically (Creswell 2013).

Results and Discussion

While this research is still ongoing, there is early evidence that our participants often report ignoring the content being posted online by activist organisations due to the graphic and sensationalistic nature of the video or image.

Participants said their views on this content also depended on who posted the content, suggesting animal welfare activists are biased in that they only focus on the worst case or are targeting those who are failing to meet generally-accepted welfare standards:

I often disregard a lot of what I see on Facebook. I think … a lot of the original articles I see are often published or it seems to me that they are published by people who have the worst, worst possible view on it. So I think a lot of it is possibly exaggerated … I just disregard it because you know I think it is just one really bad case, it’s not the way everything is so why should I stop doing what I am doing because one really bad thing is happening? And that’s not the standard. Like we’re only seeing the worst of the worst.- Juan, Melbourne.

So if I know the source is an … animal welfare or animal liberation or animal activist group such as Animals Australia or PETA … I tend to take it with a grain of salt and [it] tends to make me agitated because I know that the people who they’re targeting are very, very of the minority. – Steve, Toowoomba.

Participants also stated that information had more credibility if posted by a personal friend due to people having greater trust in information from friends or relatives. However, if the friend engaged in a vegan lifestyle, the information was often dismissed due to the content being considered as unreasonable and “extreme”. Participants also said that those who share vegan activist literature online are less likely to be open to having a conversation about consuming meat and tend to share information about veganism to persuade people to change their lifestyles.
I have got one vegan friend who yeah, all the information she posts is all from the same source ... And it's like they aren't willing to have a conversation either, it's just there. – Katie, Adelaide.

Other participants believe that social media is influential because people are able to offer their experiences with a product. In relation to animal welfare, people with experience in animal production or have on farm experience are also able to offer their experiences:

I think social media is very influential, more than advertising, because when I studied design... we were saying whether social media or advertising is the more influential way of communicating. Social media definitely is...it exposes a lot of things and people are more inclined to believe what is on social media because in a sense, someone has sort of experienced it and you know, from word of mouth and you know it can be very influential. – Patrick, Melbourne.

Some of the participants expressed scepticism that social media is a site for activism, using the word “slacktivism” (Glenn 2015) to describe the sharing of content online. ‘Kony’ in 2012 is often used an example, where millions of social media users pledged to support the efforts to arrest Joseph Kony, the leader of an African cult and militia leader (Invisible Children 2012). Although the cause received great support online, it is an example of how online popularity and lack of offline mobilisation is changing norms and definitions of participation in a social cause (Glenn 2015):

Let’s not confuse activism with like slacktivism. Like posting on Facebook doesn’t actually do anything. – James, Adelaide.

Conclusion

Although our results are preliminary, they suggest that meat consumers’ perceptions of animal production are unlikely to be influenced by activist campaigns on social media. While social media has altered the way in which people access information, it could be argued that it is not resulting in a change of people’s choice to consume meat, but simply allows quicker and easier access to information to support their already held views, especially with regard to meat consumption.

While some people believe social media is extremely influential due to its ability to make content personal, social media should not be treated as unique or any more powerful than other forms of media. Further research is required to investigate whether content being broadcast by industry is also having an impact on what people think about animal agriculture to determine its effectiveness and whether it requires the current amount of emphasis so the broader public have access to multiple sources of information.

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References


Welfare issues facing the Australian Chicken Meat industry

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Summary

The most important consideration to ensure good animal welfare is that there is science/evidence base to determine and/or inform good welfare practice as opposed to practice based on perception and perceived welfare benefits of current practice. To this end, R&D for the Australian Chicken Meat industry currently, and into the future, aims to identify what constitutes best practice and how to ensure that this information can be translated into action at the human:animal interface. There is also the added difficulty of being able to communicate what constitutes best practice (based on scientific evidence) to the broader community, particularly when this may contradict long held perceptions. An example of this is the move towards free range which is being driven by perception before the R&D has been able to identify what is appropriate or not for this type of production system.

The Australian Chicken Meat industry

Australians consume around 46kg per head of chicken meat and this consumption is predicted to continue growing at around 2-4% per annum for the immediate future. The consumption of chicken meat exceeds the consumption of any other meat in Australia, with it expected to become the most consumed meat globally in the near future.

Science vs perception

Not all perception is inaccurate but it is important that when establishing best practice welfare in an intensive animal industry that all practices are evidence-based. One issue faced with the move to free range production is that the growth of this section of the industry has been significantly faster than completion of the R&D to support it. This has meant that current practices may not be best practice, so it is important that any R&D that is undertaken is designed to identify what constitutes best practice rather than perpetuating inaccurate perceptions. As free range production makes its way towards 20% of the meat chicken market in Australia, the R&D to support this sector is still working towards defining the positives and negatives of free range production and how to practically reduce the negatives and enhance the positives. There is a strong need to improve communication with the broader public regarding what actually constitutes best practice welfare in an era when intensive animal production is required to meet the nutritional demands of the growing population. This is difficult for R&D to address, beyond ensuring the science is robust and communicated widely and articulately.

Impediments to continual improvement

The industry is always striving for continual improvement in every aspect of production – including welfare, and it’s important that R&D underpins any move away from a current practice. To this end, there have been significant improvements to genetics (that focus on a number of factors, including health and welfare and feed-to-conversion ratio instead of growth rate), more efficient feed formulation, housing environment and health (new vaccines and preventative measures for disease) status and all of these improvements have a basis in quality science and have led to improvements for the overall welfare of the birds. There is not enough funding to undertake all areas requiring R&D at the same time, so processes need to be identified to ensure that issues are prioritised in a way that maximises the welfare improvements for the birds. This can only be truly effective when welfare assessment methods that are not subjective are used and where there are no vested interests that impede collaboration.

There is ongoing work on industry standards for animal welfare and the Chicken Meat industry is working towards universal uptake of these throughout sustainability and QA frameworks. However, where standards that have been developed at the national level are integrated into legislation it is important that they are implemented consistently at the jurisdictional level. If they are not, it can negatively impact on both the productivity of the industry and the industry’s ability to ensure consistent welfare for all meat chickens in an industry that operates cross-jurisdictionally. A further issue is
the time it takes for improvements and reviews to existing standards and guidelines to be agreed by all stakeholders (industry and non-industry) which delays implementation of improved welfare practices. Alongside this is the question of how to actually measure if there has been any progress in bird welfare through these extensive processes.

**The importance of applied practice**

The best science can underpin best welfare practice, but unless this is actually applied, then there can be no real improvements in animal welfare. One of the greatest challenges to animal welfare is identifying the most practical and effective ways to ensure best practice is actually applied, consistently, at the human:animal interface. In the Chicken Meat industry, the people who write the standards and guidelines are most often not the people actually looking after and handling the birds. So the issue then becomes how to filter appropriate welfare practice to the people that have a direct impact on the quality of the animal welfare. This is further complicated by the fact that some of these roles are transient in nature, meaning that there is a need for companies to be continually training new staff. Beyond the obvious, how stockmanship actually effects animal welfare is poorly understood.

**Collaboration with other industries**

Collaboration and communication between intensive animal industry sectors is critical to learn from successes and failures, and to identify areas of mutual importance and therefore, mutual, collaborative, R&D investment.

There are a number of national forums that want to discuss and try to address how to improve animal welfare, and while this has sharpened the focus on industry issues, it has also led to confusion and duplication of people and R&D resources, which is not ideal. A single national approach and coordination is required to promote strategic thinking, partnerships and shared investment rather than a patchwork of differing committees trying to address the same issues.

All intensive livestock industries have identified and are working towards improving the above issues. But it is important to note that improved communication between industries is drawing out these similarities so there are greater opportunities for collaboration between and within sectors in a non-threatening and productive environment.
Hormones, Stress and Animal Welfare

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Summary

There are numerous endocrine (hormonal) responses during stress and these are often complex. This complexity makes the study of endocrine stress responses challenging and the challenges are intensified when attempts are made to use measures of hormones to assess the welfare of animals because there are so many endocrine systems activated during stress and because there are countless stimuli that trigger these systems. Most research has concentrated on only a small number of these endocrine systems, particularly the hypothalamo-pituitary adrenal axis and the sympathoadrenal system and there is a need to broaden the scope of endocrine systems that are studied. Furthermore, systematic approaches are required to establish when the actions of hormones associated with stress responses result in physiological and/or behavioural consequences that will have negative or positive effects on the welfare of animals.

Introduction

Understanding the welfare of animals requires a comprehensive appreciation of their physiology and behavior. From a physiological perspective it is common to measure hormones that are released during stress and to try and correlate these with the welfare of an animal. This is a tenuous approach at best, not only because it is difficult to achieve a consensus on the definitions of stress and welfare, but also because stress responses are not necessarily associated with impacts on welfare. Welfare has been defined in a variety of ways, perhaps with the biological functioning and affective (emotional) states frameworks being the most commonly accepted (Hemsworth et al 2015). Definitions of stress usually refer to disruptions in homeostasis (Tilbrook and Clarke 2006). While this is reasonable, it is important to acknowledge that stress embodies a vast range of physiological responses, including endocrine (hormonal) responses, which are designed to ensure normal bodily function. Inappropriate endocrine responses during stress may have detrimental impacts on this function which may, in turn, negatively impact welfare. Nevertheless, this is not always the case and the endocrine effects may be neutral or even positive.

Currently, there is a poor understanding of the roles of hormones during stress in influencing the welfare of animals. This limits the usefulness of endocrine measures in the assessment of animal welfare. Here, we discuss the reasons for this and suggest an approach to fill this gap in knowledge.

Endocrine responses to stress: complex and varied

Hormonal responses to stress are numerous and complex. A corollary of this is that the discipline is challenging to understand. The challenge is magnified when trying to translate the science to the assessment of animal welfare.

The collective seminal work of Bernard, Cannon and Selye set the platform for our understanding of endocrine responses to stress (Ralph et al 2016a). The combined efforts of Bernard and Cannon clearly established that disrupting homeostasis induced a myriad of responses in the body to re-establish the balance. The work of Cannon and Selye identified the sympathoadrenal system and the hypothalamo-pituitary adrenal (HPA) axis, respectively, as frontline physiological systems activated during stress to confront challenges. The catecholamines of the sympathoadrenal system act as neurotransmitters, innervating target tissues, and as hormones, acting throughout the body. The glucocorticoids of the HPA axis are steroid hormones with multiple targets throughout the body. Catecholamines and glucocorticoids have numerous actions, many that stretch way beyond what might be considered the domain of stress hormones. Despite this, these are the most commonly studied hormones in the context of stress responses and, indeed, in the assessment of the welfare of animals.

In addition to the so-called classical stress systems mentioned above, there are numerous peptides that are involved in stress responses, sometimes as regulatory factors, sometimes with direct actions on target tissues. These include corticotrophic releasing hormone, vasopressin, adrenocorticotrophic hormone, the opioid peptides, oxytocin and a number of appetite regulating hormones such as orexin, neuropeptide Y, agouti-related peptide, cocaine and amphetamine regulated transcript, leptin and ghrelin, amongst others (Tilbrook 2007). Another family of peptides, the RF-amides have also been the subject of investigation during stress (Papargiris et al 2011) and, recently, we have added to the list by including the actions of the neuropeptides kisspeptin, dynorphin and neuropekin B (Ralph et al 2016b).

Coming to terms with such vast endocrine responses is in itself a challenge but the complexity is magnified because there are so many different stimuli that induce stress responses. These stimuli are called stressors and their initiation of the range of stress responses is influenced by the physiological and behavioural state of the animal, sex, experience and genetic and environmental factors (Tilbrook and Clarke 2006).

Acknowledging that endocrine responses are many and varied is important when trying to assess how these responses may impact normal bodily functioning and, further, how this may affect the welfare of an animal. The latter is key to this debate and to understand this we need to know the consequences of the actions of the hormones. We need to appreciate when these actions result in consequences that ensure normal and acceptable bodily function and, in contrast, when the outcomes are physiological and...
behavioural effects that are considered to influence the welfare of an animal. This can only be established by systematic research to determine the actions and consequences of the actions of hormones to particular stressors in particular conditions. Such research is lacking in animal welfare science but an example of this systematic approach exists in our research to determine the impact of the glucocorticoid cortisol in causing stress-induced suppression of reproduction in female sheep.

**Systematic determination of the impact of endocrine responses on physiology and behaviour: reproduction case study**

We undertook a series of systematic studies in ewes to establish the importance of cortisol in mediating the inhibitory effects of psychosocial stress on reproduction (Ralph et al 2016b). These studies determined the conditions under which cortisol has an impact, and the consequence of that impact, on each of the (i) tonic secretion of gonadotrophin releasing hormone (GnRH), the regulator of the synthesis and secretion of luteinising hormone (LH), which is necessary for follicular development, (ii) the surge secretion of GnRH and LH that are necessary for ovulation and (iii) sexual behaviour. Thus, we methodically partitioned the reproductive axis. Our strategy was to systematically establish whether cortisol is both sufficient and necessary to suppress reproductive hormone secretion and inhibit sexual behavior. A key innovation in the approach was establishing whether cortisol was necessary for stress-induced inhibition. In other words, were the effects of stress due to cortisol beyond doubt?

An essential element of this strategy was the use of an *in vivo* neuroendocrine model in the female sheep that allowed full quantification of reproductive hormone secretion from the brain to the gonad, the ability to map the specific neuronal populations and pathways that control neuroendocrine function, and to quantify sexual behavior.

This research showed that cortisol is necessary to inhibit some, but not all, aspects of reproduction in female sheep. For example, psychosocial stress inhibits sexual motivation and sexual receptiveness in ewes but cortisol is only responsible for the effect on receptiveness and not motivation. The actions of cortisol during stress vary with reproductive state and there are important interactions with gonadal steroids.

Our approach determined the critical concentrations of circulating cortisol needed to cause particular inhibitory effects, and the sites and mechanisms of action of cortisol to inhibit reproductive events. Thus, it is now possible to predict the conditions under which cortisol synthesis during stress will have an inhibitory impact on reproduction in ewes, what the inhibitory impact will be and, in contrast, when cortisol will not have an inhibitory effect.

We propose that a similar systematic approach to that used to establish the role of cortisol in stress-induced inhibition of reproduction in female sheep would be beneficial in animal welfare science. There needs to be development of models to assess when the actions of particular hormones that are associated with stress responses have consequences that impact the welfare of animals (Figure 1). The objective should be to take this research to a level where reasonable extrapolations can be made about how the measurement of hormones in certain conditions in response to particular challenges will affect the welfare of animals. The approach must be broad and must extend well beyond the classic stress hormones: the glucocorticoids and catecholamines.

**Figure 1.** Schematic cascade of events that need to be considered when determining if measuring hormones can assist in the assessment of animal welfare. A stressor will induce the synthesis of many hormones and the active secretion of a range of hormones that are proteins or amino acid derivatives. The hormones will have actions in target tissues and this will evoke physiological and behavioural outcomes. These consequences of the actions of hormones may or may not impact animal welfare. Research is required to unravel the last step.

**Conclusion**

It is common to measure hormones in studies of stress and welfare in animals, particularly the glucocorticoids and catecholamines. Much of this research has been inconclusive and this is largely due to the challenges associated with understanding the complexity of endocrine systems, the complexity of stress and the link, or otherwise, between endocrine stress responses and the welfare of animals. Furthermore, much research has been narrowly focused on the sympathoadrenal system and HPA axis with insufficient consideration of the other numerous endocrine and neuroendocrine systems that are involved in stress responses and the welfare of animals. Animal welfare science requires systematic research to establish the conditions under which stress results in endocrine actions that impact the welfare of animals. This promises to provide one of the most substantial advances in our understanding of stress and animal welfare.

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Productivity and phosphorus content of rib and tail bones in reproducing cows ingesting diets deficient or adequate in phosphorus

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Summary

During dietary deficiencies of phosphorus (P) cattle may mobilize bone P. Through an annual cycle of pregnancy and lactation Droughtmaster first-calf cows (initially c. 2.5 Y.O.) grazed as 6 paddock groups (each n 10) at a site in the seasonally dry tropics. From late pregnancy 3 paddock groups ingested P deficient diets, and the other 3 groups P adequate diets. Cow liveweight (LW), plasma inorganic P (PIP), milk production and calf growth indicated that herds were severely P deficient or P adequate. Rib bone and Cy9 tail bone were sampled at the end of the experiment. P deficiency reduced rib cortical bone thickness (CBT) by 31% (3.31 and 2.83 mm, P < 0.01), but there was little change in bone mineral density (BMD) of Cy9 tail bone (0.443 and 0.397 g/cc, P > 0.05). In conclusion during extended P deficiency of young cows mobilization of bone P was much greater from rib bone than from tail bone.

Introduction

Diagnosis of diet P deficiency and P status in grazing cattle is difficult. During diet deficiency substantial P may be mobilized from bone, and during LW loss, from soft tissues (Benzie et al. 1959; ARC 1991). The concentration of PIP is the most reliable method for diagnosing current diet P deficiency provided consideration is given to sampling procedures and the physiological status of the animal (Wadsworth et al. 1990; Coates 1994). The CBT of rib bone obtained by biopsy (Little 1984) is often used to assess bone P reserves in cattle. An alternative and less invasive approach has been to measure the BMD of tail bone using single photon absorptiometry (Coates and Murray 1994; Coates et al. 2015). The present study examined the effects of diet P deficiency on the productivity of first-calf cows in a seasonally dry tropical environment, and changes in PIP, rib bone and tail bone at the end of 9 months of P deficiency to evaluate diet P and skeletal P reserves.

Materials and Methods

In a grazing experiment at Springmount Station (17°13’S, 145°12’E), near Mareeba, Queensland, Bos indicus cross (Droughtmaster) first-calf cows (n 60), initially c. 2.5 years of age, grazed in six paddock groups for 12 months commencing in June 1993. The paddocks and pastures (Miller et al. 1997) encompassed a range of available P concentrations in the surface soil, pasture species and supplement regimes (P and/or non-protein N) to provide 3 paddocks with P deficient diets (P\(_{\text{defic}}\)) and 3 with P adequate diets (P\(_{\text{adeq}}\)). The P\(_{\text{defic}}\) cows grazed paddocks with soil very low in bicarbonate extractable P (P\(_b\), Colwell 1963), one paddock with 2 ppm and two paddocks with 3-4 ppm P\(_b\). Cows in one of the latter paddocks were supplemented with non-protein N. Two of the paddocks grazed by P\(_{\text{adeq}}\) cows also had low soil P (3-4 ppm) but were supplemented with 10 g P/hd.day (without or with non-protein N supplement) from late September 1993 until the end of the experiment in June 1994. The third P\(_{\text{adeq}}\) paddock had previously been fertilized with superfosphate for a number of years so that soil available P was elevated to 6-10 ppm. The cows calved during October-November 1993 in the late dry season; the seasonal break occurred in late January 1994; and calves were weaned in late March 1994.

Mean LW of cows and of calves was measured frequently and jugular blood was sampled for PIP in late pregnancy (September), in mid-lactation (February) and 2 months post-weaning (May). Milk production was measured by weigh-suckle-weigh in February. In June 1994 rib bone was biopsied (n = 4 per paddock; Little 1984). Also, tails were resected from all cows. Laboratory measurements of BMD of the entire Cy9 tail bones were made following dissection as described by Coates et al. (2015). Statistical analysis was conducted using GENSTAT with the 3 paddock groups in the P\(_{\text{defic}}\) and P\(_{\text{adeq}}\) treatments considered as replicates. Separate analyses were conducted for each sampling occasion and for each constituent.

Results and Discussion

The changes in cow LW during the annual cycle occurred in three distinct phases (Fig. 1). A first phase was the interval of late pregnancy (June to September 1993) which corresponded with the early- and mid-dry season and before P supplementation was commenced; the cows gained 14 kg during this interval. The second phase encompassed calving and early lactation (October1993 to January 1994) and corresponded with the late dry season. The cows in both the P\(_{\text{adeq}}\) and P\(_{\text{defic}}\) treatments underwent similar large LW losses (92 and 88 kg, respectively). The third phase (February to June 1994) was from mid-lactation to the end of the experiment, included a post-weaning interval of 11 weeks (calves were weaned in late March), and coincided with the wet season and early dry season. Cows in both treatments gained LW, but the gains were much greater (P < 0.05) in the P\(_{\text{adeq}}\) treatment (71 kg) than in the P\(_{\text{defic}}\) treatment (9 kg). By the end of the experiment in June 1994 the P\(_{\text{adeq}}\) cows were the same LW as at the commencement (~2 kg), whereas the P\(_{\text{defic}}\) cows were 69 kg lighter (P < 0.05). Milk production in February 1994 tended to be greater in P\(_{\text{adeq}}\) than P\(_{\text{defic}}\) cows.
Mean BMD of Cy9 tail bone (measured as ash density) in the P_{defic} cows was on average 10% lower than in the P_{adeq} cows (Table 1), but the difference was not significant (P > 0.10). The volumes of the Cy9 tail bones were similar. The absence of any change in dimensions of the Cy9 tail bone was presumably because these cows had largely completed their skeletal growth when the experiment commenced and the potential effect of P deficiency was to reduce the BMD of the tail bones. This is in contrast to growing cattle where P deficiency may reduce dimensional bone growth (i.e. the volume) as well as BMD. In contrast to the absence of a significant change in tail bone BMD, the rib bone CBT at the end of the experiment was 30% lower (P < 0.01, Table 1) in P_{defic} than P_{adeq} cows. This indicated that in these 2.5-3.5 Y.O. cows examined in the present experiment there was much greater net mobilization of P from rib bone than from the Cy9 tail bone.

The results of this study are in accord with the much lesser mobilization of bone mineral from Cy9 than from rib bone observed in a subsequent draft of mature breeder cows at the same experimental site (D. B. Coates, unpublished). They are also in accord with observed changes of only 10-15% in tail bone mineral content of dairy cows reported by Zetterholm (1978). However the present study is in contrast to large losses in tail bone BMD through an annual cycle measured with single photon absorptiometry in first-calf Droughtmaster cows grazing P adequate or P deficient pastures at Lansdown, another site in the seasonally dry tropics of north Queensland (D. B. Coates, unpublished). We cannot offer any explanation for the difference observed in the present study and that at Lansdown with first-calf cows. Regardless, the large change in CBT of rib bone in the present and other experiments indicates that during severe and extended dietary P deficiency breeder cows can mobilize substantial amounts of skeletal P, and measurement of the CBT of rib bone provides a sensitive measure of these changes. Change in rib CBT is a much more reliable indicator than tail bone BMD of skeletal P mobilization during prolonged diet P deficiency in reproducing breeder cows.

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References

Focus on food and food production practices has increased globally from both consumers and citizens. Parallel to this increase has been development of social media technology, along with capabilities to analyse online dialogue and engage in dynamic conversation across a global network in short timeframes. Insights from social media analytics can complement other sources to inform language and scope of policies and communications related to food production, to ensure that societal concerns are addressed and allow opportunities for stakeholders to be engaged. This is particularly important in relation to animal welfare, where science, policy, and societal values are inextricably connected. Organizations can also use insights from social media to monitor the perception of their brand, and reactions to their policies, in near to real-time, while using social media to positively engage stakeholders in discussion of their policies and manage concerns.

Background
Food is an integral part to life, not only through nutritional value, but also cultural and social value. As public interest in how food is produced increases, there is a seemingly parallel increase in food policy directed at agricultural practices. These policies can be reflected in private brand standards that communicate product or production practice attributes of specific brands (e.g. cage-free eggs, Meat Standards Australia), national standards of care (e.g. Canadian NFACC Codes of Practice, Australian Animal Welfare Standards and Guidelines), and/or in standards that are legally governed (e.g. maximum residue limits for veterinary medicines). Animal welfare is a specific example within agriculture where increased interest has heightened awareness of the inextricable connection between science and societal values (Fraser, 1995). Food policies, and subsequent products and practices, are heavily influenced from consumer and citizen interests increasingly mediated through public discourse (Stevens et al., 2016). As technological developments have progressed, mechanisms of social media have increasingly become an important space where perspectives on food are discussed (Stevens et al., 2016). Social media has changed how individuals digest information, with news often breaking on social media vs. broadcast in some instances. Social media presents multiple opportunities for utilizing analytics to inform policy considerations through understanding of societal perspective and communication efficacy, as well as facilitating two-way engagement (McGoveran, 2012; Rutsaert et al., 2014; Stevens et al., 2016).

Approach
There are multiple platforms for social media monitoring and analytics. Key features are breadth of social media platforms assessed, language capabilities, the granularity and accuracy of text analysis, speed of assessment capabilities, and the geographies included. A broad scoping of these factors should encompass social networks, social bookmarking, video sharing, news, and blogging sites. As with many activities that turn data into meaningful information, there is a necessity for the people engaged in this process to have a skill set that addresses not only the technical understanding of social media analytics, but also the “translation” into real-world relevant insights.

Summary
There are a variety of social media metrics that can convey an individual’s perspectives in relation to a topic, issue, industry, or specific business. Metrics can be comprehensive at issue level, or customized to understand specific nuances of a conversation.

Insights into Food Chain Issues
While there are many examples of the benefits of social media analytics, two examples with implications for global policy considerations will be presented based on the Elanco Pulse Institute™ insights.

1. Language use in agricultural policy can influence understanding, translation, and also the ability of individuals using search queries to find company’s policies online. As more and more consumers turn to their own searching mechanisms to find out about companies and brands, web publication of policies is an important factor in the transparency and responsibility of food companies (BBFAW, 2015). Comparison of the same search terms replacing “animal welfare” with “animal well-being” between June 1, 2014 and June 19, 2015 revealed that on multiple social media platforms, welfare was used 4,500 times more often in English-only conversations regarding farm animals with a broader range of influential individuals participating in the conversation. In combination with focus-groups and searching scientific publications, the results were used to inform language considerations for policies related to farm animal care.

2. Responsible use of antibiotics is a growing area of focus, given the increased understanding of antibiotic resistance and threats to the health of humans and other animals. Differences in food policies related to antibiotics are noticed in social media responses to announcements. For example, in 2014 a positive policy that advocated responsible use and connected the availability of animal-only antibiotics to ensuring good animal health elicited higher volumes of discussion, more engagement, and more positive responses than a policy that focused on complete elimination of all antibiotics from chicken production. In 2015, the growth of the
online discussion of antibiotics outpaced GMOs, and experienced a shift in the dynamics of the conversation from regulation-focused towards focus on food and food chain actions. The content of the conversations were dominated by sharing of research and statistics, expected given the scientific nature of antibiotics and resistance, although headlines focused on fear-evoking research. Agricultural supporters were 0.02% of the conversation, and had lower influence capabilities than other authors in the online dialogue. There was, however, a large increase in ag-supporters throughout 2015 compared to initial engagement. Social information can play a key role in shaping users’ opinions. As consumers rely more on online sources for information about food (CFI, 2015), it is important that accurate information is shared in ways that are easy to understand, readily amplified, and accessible. These factors are important to establishing honest transparency with consumers, which has been shown to be an effective strategy for managing social outrage (CFI, 2015).

Integrating Social Media into Food Policy Development and Communication

Proactive and science-based food policy requires consideration of a multitude of factors, including consideration of consumer interests, implementation capacity, regulatory requirements, and sustainability consequences. All of which can vary across different geographies, industries, and over time. Social media can operate as an emerging force in food governance through creating hypes and self-organizing movements that are typically concerned with social values in food production (Stevens et al., 2016). Social media analytics can be a powerful tool to understand the dynamics of public discourse on general topics, specific issues, and/ or brands. As with any information source, there are caveats to the data collection and analysis, such as the demographics of participants in relation to target populations, the accuracy of text mining technologies for refined metrics such as sentiment, as well as limitations in self-reporting locations used to determine geographic scope of conversations.

Understanding of online conversations, with consideration of the limitations, can be combined with additional sources of information to develop policies that address the social value of food and food production practices, increase transparency and communication, and create positive experiences with food that will facilitate increased trust with both consumers and citizens. Enhancing public trust and robust science-based agricultural policies will facilitate beneficial outcomes for agriculture and brand enhancement, as well as supporting a good life for the animals that support our lives.

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References


Serological responses to *Salmonella* Typhimurium infection in laying hens

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**Summary**

*Salmonella* detection by bacteriological culture along with serology is a common practice in the poultry industry. The present experiment was conducted to study the antibody response of laying hens to *Salmonella* Typhimurium infection using an Enzyme-linked immunosorbent assay (ELISA). At 14 weeks of age, hens were orally inoculated with $10^9$ colony forming units (CFU) of either *S*. Typhimurium Definitive Type 9 (DT9) or a combination of *S*. Mbandaka and DT9. Serum samples were collected at day 0 followed by 1, 2, 4, 6, 8, 10, 12 and 14 weeks post infection (wks p.i.). Serological analysis revealed a strong immune response to *S*. Typhimurium infection. IgG antibody titters started to rise from 1 wk p.i., peaked at 6 wks p.i., and persisted throughout the course of this study (14 wks p.i.) in both the infected groups. The results of this study suggest that serology can be used as a preliminary screening of *S*. Typhimurium infected birds for further bacteriological examination.

**Introduction**

Globally *Salmonella* is one of the major zoonotic foodborne pathogens. Amongst more than 2,500 serovars of *Salmonella*, serotypes, such as Enteritidis and Typhimurium, have been responsible for the majority of food-borne outbreaks in humans (Voetsch *et al.* 2004). In South Australia, *Salmonella* Typhimurium DT9 (*S*. Typhimurium) is an important food borne pathogen and has been reported from several food borne outbreaks following the consumption of contaminated egg and egg products (OzFoodNet 2015). Despite on-farm control strategies *S*. Typhimurium, is a major concern for the Australian egg industry. Therefore, detection and prevention of *Salmonella* infections within poultry flocks is important. Bacterial culture method is routinely used for the *Salmonella* identification (Hsu *et al.* 2011) however, low and intermittent shedding of *S*. Typhimurium in the faecal and or environmental samples can provide false positive results (Ishola 2009). Moreover, the faecal sample analysis by the culture method is laborious and time consuming. Monitoring birds for *S*. Typhimurium specific antibodies is an initial screening step used to identify flocks that have been exposed to this pathogen. To overcome false positive results by culture method, monitoring of antibody titters to *S*. Typhimurium could be a better alternative. The aim of the current experiment was to characterise the serological response to *S*. Typhimurium infections in hens from early to peak lay.

**Materials and Methods**

Fertile eggs were obtained from a commercial layer parent flock. Eggs were fumigated and incubated for 21 days at 37.7°C. A total of 32 birds were hatched and raised in pens in positive pressure rooms at Roseworthy campus, at the University of Adelaide. Strict biosecurity measures along with fortnightly testing of feed, water and faecal samples were followed to maintain birds Salmonella free until the start of the challenge experiment. At week 10, birds were divided in three groups and transferred in to cages in separate rooms. At 14 weeks of age, the C (control) group received only sterile Luria Bertani (LB) broth, other hens were orally inoculated with $10^9$ colony forming units (CFU) of either *S*. Typhimurium definitive type DT9 (T group) or a combined total of $10^9$ CFU of *S*. Typhimurium DT9 and *S*. Mbandaka (MT group) suspended in LB broth (Oxoid Australia). Blood samples were collected at day 0 followed by 1, 2, 4, 6, 8, 10, 12 and 14 wks p.i. Serum was separated by centrifuging the blood samples at 1500g for five minutes and samples were stored at -20°C until further analysis. Serum samples were analysed by the Chicken *S*. Typhimurium Antibody Kit LPS Group B (BioChek, Holland) titters were calculated, according to the manufacturer's instructions. Absorbance of controls and test samples was measured at 405 nm (Multiskan Ascent pathtech). All data generated in this study was analysed statistically using GraphPad Prism version 6 (Graph Pad inc, CA, USA) using two-way ANOVA or Student’s t-test to compare groups. $p < 0.05$ were considered statistically significant.

**Results and Discussion**

Specific antibody response to *S*. Typhimurium
None of the birds were seropositive prior to infection with *Salmonella*. Overall, the mean antilog of antibody titters in T group were higher (without any significant difference) than the MT group. Serum IgG antibody titters started to rise from wk 1 p.i. and peaked at the onset of lay (6 wks p.i.). The antibody titters persisted and birds were seropositive till the end of experiment i.e. 14 wks p.i. in both T and MT group (FIG. 1). These findings are in agreement with the previous finding (Hassan *et al*. 1991) in which four day old chickens infected with *S*. Typhimurium strain showed a strong IgG antibody response with peak titters at 4 wks p.i. Similar to our findings Gast and Beard (1990) reported a rapid and early antibody response in *Salmonella* infected birds and found that most birds were seropositive at 10 weeks p.i. There were a significantly (p < 0.05) higher antibody titters in T group at 6, 10, 12 and 14 wks p.i. in comparison to the MT group. It is difficult to compare our results to those obtained by other researchers because of the paucity of such reports in the literature.

FIG. 1. Antibody Titters for *S*. Typhimurium at different weeks of post infection in *S*. Typhimurium (T) and *S*. Typhimurium + S. Mbandaka (MT) groups.

Mean antilog of log$_{10}$ antibody titters ± standard error. Bars with the different lower case letters in the same wks p.i. are significantly different (p < 0.05).

The findings of the present study suggest persistent antibody response to *S*. Typhimurium infection in laying hens from early to peak period of lay. In conclusion, serology can be used as a preliminary screening for *S*. Typhimurium infected birds for further bacteriological screening.

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Pasture quality and pre-slaughter mob movements increase the incidence of dark cutting beef

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Summary

Dark cutting beef, defined as meat of pH >5.71 or colour >AUS meat colour score 3, is detrimental to meat quality and results in significant financial losses to both producer and processor. Meat colour and pH are a function of the animal’s muscle glycogen status, and the resultant levels of lactic acid produced as muscles contract post-slaughter. The incidence of dark cutting in pasture-finished cattle is seasonally variable and in particular, the Limestone Coast region of South Australia experiences greater overall incidence compared to the national average. This study aimed to identify on-and-off-farm risk factors for dark cutting within pasture finished cattle from the Limestone Coast. Data was collected on 39 mobs totalling 2241 animals, with farm management, pasture composition, blood parameters and carcass traits recorded.

Introduction

This study was motivated by the findings of McGilchrist et al. (2014), who characterised a significant variation in incidence of dark cutting (DC) beef between month and state. The analysis of 2010-13 Meat Standards Australia grading data revealed that South Australia had the greatest seasonal fluctuation in the rate of DC, with monthly mean values ranging from 1.53-12.44% of all cattle graded. Evaluation of data from the Limestone Coast region of South Australia revealed that the overall incidence was 18%. Such a high incidence of DC cattle, coupled with the fact that the region has 56% of the state’s cattle herd focused the attention of this study to this area.

Materials and Methods

Limestone Coast producers with historically high and low rates of DC incidence were selected and asked to be involved in the study. Consignments of cattle due to be slaughtered were identified in advance, and measurements recorded across four main areas.

On farm management

The pre-slaughter conditions and management operations were recorded and classified within groups as per Table 1.

Table 1: On-farm management practice classification matrix

<table>
<thead>
<tr>
<th>Management parameter</th>
<th>Description of categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of cattle on sale</td>
<td>2: &lt; 24 months; 4: &gt;24 months</td>
</tr>
<tr>
<td>Sex makeup of mob</td>
<td>2: Sex mix; 4: Sex either</td>
</tr>
<tr>
<td>Source of mob</td>
<td>2: Vender breed; 4: Not Vender breed</td>
</tr>
<tr>
<td>Breed</td>
<td>2: Angus; 4: Hereford</td>
</tr>
<tr>
<td>30 cattle were received from the mob</td>
<td>2: 1-2 weeks; 4: &gt;4 weeks</td>
</tr>
<tr>
<td>Share of beef introduced to the mob</td>
<td>2: 1-2 weeks; 4: &gt;4 weeks</td>
</tr>
<tr>
<td>30 cattle were placed from paddock to mob</td>
<td>2: 1-2 weeks; 4: &gt;4 weeks</td>
</tr>
<tr>
<td>Valnasc 112 inoculation</td>
<td>2: 0-6 months prior to slaughter; 4: &gt;6 months prior to slaughter</td>
</tr>
<tr>
<td>Mineral Supplement, zacapal, Oral Or Liver Licks</td>
<td>2: 0-6 months prior to slaughter; 4: &gt;6 months prior to slaughter</td>
</tr>
<tr>
<td>Parasite treatment</td>
<td>2: 0-6 months prior to slaughter; 4: &gt;6 months prior to slaughter</td>
</tr>
<tr>
<td>Distance from yards to shearing</td>
<td>2: &lt;100km; 4: &gt;100km</td>
</tr>
<tr>
<td>Transport type</td>
<td>2: Private; 4: Contact</td>
</tr>
<tr>
<td>Timing of transport</td>
<td>2: Day of slaughter; 4: Day prior to slaughter</td>
</tr>
<tr>
<td>Cooler practices</td>
<td>2: With feed and water; 4: No feed but water available</td>
</tr>
<tr>
<td>Ocean Crossing</td>
<td>2: Ocean crossing; 4: No ocean crossing</td>
</tr>
<tr>
<td>Media Patrick</td>
<td>2: No; 4: Yes</td>
</tr>
<tr>
<td>Pasture composition</td>
<td>2: Grass dominant; 4: Lucerne dominant</td>
</tr>
<tr>
<td>Feed On Offer</td>
<td>2: &lt;2500; 4: 2500-25000; 8: &gt;25000</td>
</tr>
</tbody>
</table>

Carcass assessment

All carcasses were processed at Teys Australia abattoir Naracoorte, South Australia as per standard practice. Carcasses were assessed in accordance with MSA guidelines by an MSA accredited grader (Polkinghorne et al. 2008).

Blood analysis

A blood sample was collected from each animal at sticking, centrifuged and the separated plasma removed. Plasma samples were pooled between DC cattle in each mob. A control pooled sample was obtained for each mob by randomly sampling an equal number of non-dark cutting cattle. Analysis of blood plasma constituents was undertaken using RADIOMETER ABL725 blood gas analyser for glucose, lactate concentrations and blood carbonate concentrations.

Statistical analysis

All traits were tested for correlations with DC and each other and then a number of linear mixed models were formed, with combinations of traits maintaining a significant effect on DC
% retained in the model. All analyses were conducted using Genstat 15th Edition (VSN International UK).

Results and Discussion
A total of 39 consignments of cattle (2241 head total) were sampled during this study. Mean DC percentage was 21±18%, with mob values ranging from 0-56%. Mean consignment size was 54 head.

Multiple models were fitted to the data to explain various components of DC incidence. This paper will focus on a singular model which explained 50.5% of the variance in DC (Table 2).

Table 2: Estimated effects and tests of significance for management and feed factors influencing the incidence of DC in pasture-finished cattle.

<table>
<thead>
<tr>
<th></th>
<th>Estimates</th>
<th>SE</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard structure change &lt; 1 week Prior to slaughter</td>
<td>+0.0090</td>
<td>0.0419</td>
<td>0.001</td>
</tr>
<tr>
<td>Blood HCO₃ concentration per 100ml</td>
<td>-0.0139</td>
<td>0.0106</td>
<td>0.040</td>
</tr>
<tr>
<td>Feed On Offer &gt; 3000 kg dry matter per hectare</td>
<td>-0.0026</td>
<td>0.0052</td>
<td>0.355</td>
</tr>
<tr>
<td>Neutral Detergent Fibre</td>
<td>+0.0118</td>
<td>0.0038</td>
<td>0.025</td>
</tr>
<tr>
<td>Pasture's Rumen degradable protein</td>
<td>+0.0172</td>
<td>0.0072</td>
<td>0.026</td>
</tr>
<tr>
<td>Crude Protein</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Changes in mob structure within one week of slaughter had the greatest effect on DC % (P=0.001), resulting in a 12% increase compared to those disrupted within 1-2, 2-4 or >4 weeks weeks pre-slaughter (Table 2). Changes in environment or hierarchal structure of the herd can invoke significant physiological stress (Tarrant 1989), leading to increased activity, decreased feed intake (Nakanishi et al. 1991), and ultimately limiting pre-slaughter glycogen accumulation (Lambert et al. 2000).

Higher blood carbonate levels were associated with lower DC incidence (P=0.04). Low blood carbonate levels are indicative of low rumen pH, and the occurrence of sub-acute ruminal acidosis (Dunshea et al. 2005). In this instance, animals that have undergone restricted feeding (Guo et al. 2013) or experienced a change in dietary composition (Morley 1968) may have been experiencing periods of low rumen pH, affecting their direct energy uptake as well as depressing intake. Affected individuals ability to accumulate muscle glycogen pre-slaughter would have been compromised.

The total availability of feed has a direct effect on the total energy intake potential (P=0.035) (Nicol et al. 1976), as well as the energy expenditure incurred harvesting it (Dumont et al. 2002). In addition to the gross availability of feed, increases in the indigestible fibre (NDF) content of pasture were associated with an increased incidence of DC (P=0.025). High NDF values can impair the intake capacity of cattle (Kay 1983), and thus their ability to accumulate muscle glycogen sufficiently.

Higher proportions of rumen degradable protein (RDP) in pasture were significantly associated with increased DC (P=0.026). High RDP levels will lead to increased rumen and in turn blood ammonia levels which depress intake, contribute to the occurrence of acidosis and therefore inhibit energy accumulation pre-slaughter.

This results of this study reiterate the importance of minimising stress during two weeks pre-slaughter as recommended under the MSA guidelines (Polkinghorne et al. 2008). In addition to these physical and psychological stressors, the quantity and quality of feed have a direct bearing on the ability of cattle to maintain a healthy rumen environment and consume sufficient energy. Cattle slaughtered from pasture finished systems are at much greater risk of having insufficient energy compared to their feedlot counterparts, and thus must be managed appropriately through thorough feed-budgeting and an understanding of pasture composition.

Acknowledgement
This research was primarily funded by Meat and Livestock Australia through the Southern Beef Compliance Project. Particular thanks go to Teys Naracoorte complex for providing access to data and facilities.

References
Towards a sustainable and effective model for extension and adoption investment in the red meat and livestock industries

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Summary

Significant changes in the extension delivery landscape have been occurring over the last 15 years, largely with the public sector withdrawing services and resources. Industry organisations such as Meat & Livestock Australia (MLA) have been heavily reliant on partnerships with the public sector for extension program delivery and with the changes across jurisdictions, MLA has needed to rethink our extension and adoption investment strategy. The review process has incorporated evaluations of existing programs, conducting a skills needs analysis of our producers and engaged industry stakeholders. The result of this process has defined a new model for extension and adoption investment to test with industry, that will support high impact of research and development (R&D) outcomes, while at the same time initiate a model that will enable resources to be self-sustaining for the long term. While this is a work in progress, emergent learning from the development process to date has revealed different tensions and challenges that will need to be overcome, to ensure the model is a success.

Background

As a research and development corporation (RDC), MLA is required under the statutory funding agreement with the federal government to demonstrate the impact of R&D investment for industry. Over time MLA has initiated a number of industry programs such as More Beef from Pastures (MBfP), co-invested in Making More from Sheep (MMfS) with Australian Wool Innovation (AWI) and also invested in a number of relevant co-operative research centres (CRCs) where R&D has been integrated with extension program efforts. All of these extension program investments have relied on long term strategic partnerships, largely with all state governments.

State governments have been withdrawing extension services dramatically over the last 15 years due to reallocation of funds in line with changed investment priorities. The Red Meat Co-investment Committee National Blueprint for Future Sheep and Beef Extension Co-investment project found that, since 2009, there has been a further 25% reduction in state agency resources and identified that the private sector has limited capacity to fill the void (Hogan et al., 2013).

With the public sector no longer able to significantly co-invest and be delivery partners, and the private sector limited to fill the gap, MLA has had to review the approach to extension and adoption strategy investment. Other imperatives that have emerged that also require consideration are the new Meat Industry Strategic Plan (2020) and the respective industry specific plans for sheepmeat and beef which have clear key performance targets set for industry impact.

Strategy

In response to the challenges the MLA took a systematic approach to identifying how a new approach for extension and adoption partnerships could be initiated.

The first step involved a comprehensive evaluation of previous and existing extension investments. Most of the programs MLA has delivered have been successful in achieving their objectives. For example, since 2004 the MBfP program engaged 35,432 beef producers in a variety of awareness events. From 2010-15, additional evaluation found 4,701 beef producers have participated in knowledge and skills building activities with 2,711 beef producers applying at least one practice change, from at least one module of the program. The economic benefit of $21.47m NPV for an investment of $3.7m (2010 – 2014), representing a BCA of 4.7:1 (Howard and Beattie, 2014).

More recently, Meat & Livestock Australia’s Farm300 project demonstrated the appropriateness of supported learning using a coaching methodology to assist livestock producers develop skills to achieve practice change on farm (Sobotta et al., 2016). The project focused on management of greenhouse gas (GHG) emissions from livestock production, with practice change resulting in private and public benefits. A supported learning methodology based on coaching was used to develop skills which enabled the achievement of significant reductions of GHG emissions from the production systems of participating producers. GHG emissions were reduced by over 31,000 t CO$_2$e, with an average reduction of 1,700 t CO$_2$e per participant. Based on the carbon price at the time (April 2014) of $13.95/t of CO$_2$e, this equates to a financial benefit of $437,000 (average of $24,000 per producer) that could be accrued by producers participating in the federal government Emissions Reduction Fund initiative (Doonan and Sheriff, 2014).

Using the legacies of these key programs, as well as other significant investments such as the Evergraze program (with the Future Farming Industries CRC), Grain and Graze (collaborative program with Grains Research and Development Corporation), and Sustainable Grazing Systems, there has been considerable resources and expertise available to formulate a revised model. An industry workshop with key stakeholders assisted in formulating a series of principles, to guide the development of a new adoption model. These guiding principles included that the program needed to:

ASAP Animal Production 2016, Adelaide
• Utilise best practice extension principles using proven approaches such as coaching and mentoring
• Consolidate MLA extension investment into one national program instead of multiple activities
• Target specific profit and production drivers as the focus for intervention on-farm rather than a generic, ad-hoc approach
• Target those producers who are willing to change and seriously seeking to improve their business performance rather than a broad engagement approach (quality engagement not quantity)
• Implement a user pays culture to ensure producers pay for the 'private good' elements of delivery so a sustainable, commercial delivery model can be initiated
• Utilise the new MLA consultation structure to tailor content specific to regional needs (e.g. case studies, utilisation of existing - and development of new - producer networks)
• Utilise/integrate ML tools from multiple business units e.g. Livestock Data Link, myMSA that provides individualised business data to identify areas for change on-farm in combination with producer demonstration sites
• Embed monitoring and evaluation at the commencement of the program to more effectively measure the impact of program investment
• Ensure there is clear branding and attribution towards MLA investment underpinning the program

In addition to the stakeholder workshop, a national skills needs analysis was conducted to determine what producers consider to be their priorities for skill development. MLA invested in social research and conducted phone surveys with 500 red meat producers to determine their skills and training requirements. The overall approach involved industry stakeholder interviews, phone surveys and focus groups to delve further into the phone findings. To date the results of the phone survey have been completed and, overwhelmingly, producers are most concerned with the challenge of business resilience from climate variability (67% respondents) and profitability from managing costs with limited return (18% respondents). The main opportunities identified for unmet training needs were in pasture improvement and grazing management, feeding and animal nutrition, meeting market requirements, knowing cost of production and using financial information to make decisions (RMCG, 2015).

The model that has been devised as a result of these various activities is presented in Figure 1. Ultimately the program is one that focusses on key profit driving modules, ensures data collection, with measuring and monitoring skill development at the centre of all activities, underpinned by the supported learning process of small coaching groups. Nationally these groups will be linked to create a producer network, and a strong monitoring and evaluation framework will be in place to measure impact at the individual, coach and program levels.

**Outcomes**

The pilot program has since commenced. By December 2016, a full business plan will be completed on the pilot program for the new industry adoption model. It is expected that the business plan will include a full economic evaluation and overall recommendations on how to successfully execute the new model for the long term.

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**Figure 1. The new MLA model for extension and adoption delivery**

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Howard, K., Beattie, L. (2014) Assessing the impact of MLA’s majority market programs. MLA project B.COM.0341


Drafting cattle for slaughter should not limit use for genetic evaluation

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Summary

Capturing data for genetic evaluation from commercial herds can be problematic. One of the limitations relative to research projects is that in commercial herds it is common for cattle to be drafted prior to slaughter based on carcass price grids. This paper generated an artificial draft factor based on carcass weight and then examined the effect of this on genetic analysis of carcass quality traits. Compared to fitting carcass weight as a covariate for carcass quality traits, the impact of drafting was negligible. Thus, this should provide confidence for greater use of commercial data for genetic evaluation. Even a small proportion of MSA graded carcasses utilised would increase the amount of carcass data in BREEDPLAN enormously.

Introduction

Increasingly applied livestock research is being conducted in commercial productions systems. This has advantages of working closely with those that will adopt the outcomes and for researchers to understand more fully commercial drivers of innovation adoption and farm profitability. With the exception of well designed progeny test programs, it can be difficult to capture data of sufficient quality for genetic evaluation.

The impact of genomics (Meuwissen et al. 2001) means that large numbers of single nucleotide polymorphism (SNP) markers can be tested on animals. A limitation for conducting genetics research and development on commercial properties used to be lack of pedigree. However, SNP chips can be used to effectively reconstruct pedigree on commercial animals. In addition, if the property has been using bulls with high genetic merit, then their animals will likely be genetically related to leading animals in the breed. Thus, commercial performance can be integrated into genetic evaluation programs like BREEDPLAN (Graser et al. 2005) and can provide valuable information which is currently difficult for studs to record. Examples of such traits are days to calving of heifers and cows where synchronising oestrus masks genetic variation and marbling of steers especially those for commercial animals. In addition, if the property has been using bulls with high genetic merit, then their animals will likely be genetically related to leading animals in the breed. Thus, commercial performance can be integrated into genetic evaluation programs like BREEDPLAN (Graser et al. 2005) and can provide valuable information which is currently difficult for studs to record. Examples of such traits are days to calving of heifers and cows where synchronising oestrus masks genetic variation and marbling of steers especially those for commercial productions systems. This has advantages of working closely with those that will adopt the outcomes and for researchers to understand more fully commercial drivers of innovation adoption and farm profitability. With the exception of well designed progeny test programs, it can be difficult to capture data of sufficient quality for genetic evaluation.

A problem often encountered with commercial data is maintenance of contemporary groups. However, increasingly cattle are grazed in large mobs (>100) and this is becoming less of an issue.

Another common problem is that of drafting cattle for sale where cattle are weighed and the heaviest potentially grazed in a separate mob for 1-4 weeks, then transported to a feedlot or abattoir for slaughter. The common number of cattle would be a semi-trailer or B-double load in southern Australia (e.g. 50 x 640kg) and a 6 deck road train in northern Australia. Thus, these cohorts are still quite large but the problem of drafting remains and is the subject of this paper.

Materials and Methods

The “Southern Crossbreeding Project” was conducted at Struan Research Centre, Naracoorte SA and various feedlots in southern Australia (Pitchford et al. 2006). Mature Hereford cows (637) were mated to 97 sires from 7 breeds: Jersey, Wagyu, Angus, Hereford, South Devon, Limousin and Belgian Blue. There were 1201 carcasses from heifer and steer calves born 1994-97. Cattle were slaughtered when the majority of heifer carcasses were >200 kg (average 16 months) and steer carcasses >300 kg (average 23 months) at various commercial abattoirs. With 4 years and 2 sexes, there were 8 slaughter groups. They were assessed for hot standard carcass weight (HSCW, kg), and carcass traits of eye muscle area (EMA, cm²) and P8 rump fat depth (mm). Chemical extraction of intramuscular fat (IMF, %) was conducted subsequently in the University laboratory.

The data was analysed with an animal model including fixed effects of management group and sire breed in all models (Gilmour et al. 2009). Management group was a function of year of birth (1994-97), birth location (Struan or Wandilo) and sex (heifer, steer) with a total of 16 combinations. Birth month (March or April) was not included because it was not significant for any of the four carcass traits herein.

There was no drafting of carcasses, but a factor was developed to simulate cattle being drafted on weight and slaughtered on different days. This was simply done by sorting carcasses by HSCW and then within each of the 8 year x sex cohorts assigning a 1 to the heaviest 50, 2 to the next 50 and P8 rump fat depth (mm). Chemical extraction of intramuscular fat (IMF, %) was conducted subsequently in the University laboratory.

The data was analysed with an animal model including fixed effects of management group and sire breed in all models (Gilmour et al. 2009). Management group was a function of year of birth (1994-97), birth location (Struan or Wandilo) and sex (heifer, steer) with a total of 16 combinations. Birth month (March or April) was not included because it was not significant for any of the four carcass traits herein.

Results and Discussion

Breed differences

While not the primary focus of this paper, the breed means do demonstrate the difference between the three models. There were large differences between breeds in carcass weight with the Jersey (12%) and Wagyu (9%) much lower than purebred Hereford and the other crossbreds were 3-8% heavier (Table 1). The Belgian Blue sired calves were 22% heavier than Jersey and the difference in eye muscle area (EMA) was even greater (32%). However, fitting carcass weight as a covariate had a big effect so that the difference in EMA between Belgian Blue and Jersey reduced to 19%. Given that carcasses were “drafted” on carcass weight, it is not
surprising that the means for the drafted model (3) were similar to fitting carcass weight as a covariate (Table 1).

Table 1. Sire breed means for carcass weight and eye muscle area.

<table>
<thead>
<tr>
<th>Sire breed</th>
<th>Carcass weight (kg)</th>
<th>EMA Unadjusted (cm²)</th>
<th>EMA Covariate (cm²)</th>
<th>EMA Drafted (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jersey</td>
<td>238</td>
<td>62.4</td>
<td>67.1</td>
<td>66.1</td>
</tr>
<tr>
<td>Wagyu</td>
<td>245</td>
<td>67.0</td>
<td>70.7</td>
<td>69.3</td>
</tr>
<tr>
<td>Angus</td>
<td>285</td>
<td>69.6</td>
<td>67.8</td>
<td>67.6</td>
</tr>
<tr>
<td>Hereford</td>
<td>270</td>
<td>66.8</td>
<td>67.1</td>
<td>66.9</td>
</tr>
<tr>
<td>Sth. Devon</td>
<td>286</td>
<td>74.1</td>
<td>72.3</td>
<td>72.4</td>
</tr>
<tr>
<td>Limousin</td>
<td>278</td>
<td>76.7</td>
<td>75.9</td>
<td>75.6</td>
</tr>
<tr>
<td>Bel. Blue</td>
<td>291</td>
<td>82.4</td>
<td>80.0</td>
<td>80.3</td>
</tr>
<tr>
<td>SED</td>
<td>4.6</td>
<td>1.36</td>
<td>1.23</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Table 2. Phenotypic variance for eye muscle area.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Unadjusted</th>
<th>Covariate</th>
<th>Drafted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass weight</td>
<td>712</td>
<td>-</td>
<td>193</td>
</tr>
<tr>
<td>Eye muscle area</td>
<td>76.4</td>
<td>63.6</td>
<td>63.4</td>
</tr>
<tr>
<td>P8 fat depth</td>
<td>17.0</td>
<td>15.3</td>
<td>15.7</td>
</tr>
<tr>
<td>Intramuscular fat</td>
<td>2.31</td>
<td>2.30</td>
<td>2.29</td>
</tr>
<tr>
<td>Carcass weight</td>
<td>50</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>Eye muscle area</td>
<td>32</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>P8 fat depth</td>
<td>20</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>Intramuscular fat</td>
<td>15</td>
<td>17</td>
<td>14</td>
</tr>
</tbody>
</table>

The variances of EMA, P8 fat and IMF from the drafted model environmental. The drop in with itself fitted as a covariate. The draft factor accounted for doesn’t make sense to report an analysis of carcass weight than that reported by Reverter et al. (2007) are similar to fitting carcass weight as a covariate (Table 1).

The heritabilities were also very similar and the results are similar to those reported by Reverter et al. (2003). This demonstrates that if drafting is done on weight alone, it should not affect genetic evaluation of carcass quality traits. Indeed, IMF is the trait most related to eating quality and MSA Index and the variance and heritability in IMF hardly changed at all (Table 2). Furthermore, the correlation between EBVs for IMF from the Covariate and Drafted models was 0.99. Thus, it is assumed the impact on MSA marbling score would also be negligible.

Table 3. Phenotypic (above diagonal) and genetic (below) correlations.

<table>
<thead>
<tr>
<th>Trait</th>
<th>HSCW</th>
<th>EMA</th>
<th>P8</th>
<th>IMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSCW</td>
<td>0.41</td>
<td>0.32</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>EMA</td>
<td>0.54</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>P8</td>
<td>0.30</td>
<td>-0.16</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>IMF</td>
<td>-0.33</td>
<td>-0.40</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Covariate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMA</td>
<td>-0.16</td>
<td>0.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P8</td>
<td>0.24</td>
<td>0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMF</td>
<td>0.34</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This paper has modelled drafting on carcass weight and demonstrated that the effect on genetic evaluation of carcass weight is substantial, but on carcass quality traits (EMA, P8, IMF) is negligible. In reality, commercial mobs would be drafted on live weight rather than carcass weight. Given that final weight is highly genetically correlated with carcass weight (Crews et al. 2004), this is almost equivalent to what was modelled herein. The results of Jopson et al. (2007) are encouraging in that even the effect on genetic evaluation of later weights of drafting on an earlier weight is not as severe as may be expected.

In addition to the drafting information herein, the effect of birth month was only just significant for carcass weight and not for any of the three traits when carcass weight was a covariate. Thus, it is concluded that genetic evaluation for weight can be conducted on the final liveweight before cohorts are drafted and that as long as cattle are drafted on weight alone (not including condition), there should be ample opportunity to conduct genetics projects with commercial collaborators. As stated in the introduction, the limitation for this work used to be lack of pedigree but genomic tests have overcome that and allow a new paradigm of livestock genetics research and development. Even a small proportion of MSA graded carcasses utilised would increase the amount of carcass data in BREEDPLAN enormously.

References

Size Matters – Heavier and carcasses with greater marbling have greater variation in traits affecting beef eating quality.

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Summary
The motivation behind the wider study is to examine the extent to which MSA Index of commercial animals is related to estimated breeding values (EBVs). MSA data from 23,128 lots containing 1.37M carcasses from southern Australia were analysed to determine the amount of variation between lots in the standard deviation of carcass traits within the lot. There was a moderate scale effect observed for carcass weight and marbling with the correlation coefficient between lot-mean values and the lot standard deviation 0.34 and 0.54 respectively. A 100 kg increase in the lot mean carcass weight resulted in an increase in the SD of marbling by 27 points. Therefore predicted gains in MSA Index at a given level of genetic improvement in IMF or carcass weight EBV will depend on the carcass end point for weight and marbling. The implication of this work is that the superiority of progeny from bulls with superior carcass trait EBVs depends on the weight at which steer progeny are finished.

Introduction
Since the development of Meat Standards Australia (MSA) and the MSA index there has been significant interest by beef cattle industry to improve eating quality through genetic selection and management. How eating quality traits respond to selection is a function of the selection intensity, heritability and the phenotypic variance of the traits. For carcass traits the additive genetic variance tends to increase with the trait mean. Reverter et al. (2003) reported a scale effect on the variance of hot standard carcass weight (HSCW, kg) with increased carcass weight endpoints for various markets (domestic, Korean, Japanese) in temperate cattle breeds. The genetic variance also increased proportionately so there was no change in heritability across the mean HSCW. The underlying genetic relationships between the MSA Index (and its components) with other traits is not clear. It is expected that increased lot mean HSCW will be associated with increased phenotypic variance of HSCW and that higher lot mean MSA marbling (marbling) and lot mean HSCW will be associated with increased phenotypic variance in marbling. Therefore, cattle with higher mean marbling could also have higher phenotypic variance at a given HSCW.

Currently producers can select for increased intramuscular fat (IMF) using BREEDPLAN estimated breeding values (EBVs) to improve marbling and in turn increase MSA Index. Differences in the phenotypic variance have the potential to change the magnitude of the regression coefficient for marbling on BREEDPLAN IMF EBV and therefore, of IMF EBV on the MSA Index. The regression coefficient is calculated as:

$$b_{\text{MSA,EBV}} = \frac{\sqrt{h^2} \times \sigma_P}{\sigma_{EBV}}$$

which is a function of the genetic correlation ($r_G$) between the traits (could be same trait at different endpoints), the heritability ($h^2$) of the trait, variation of the carcass trait ($\sigma_P$) and the variation ($\sigma_{EBV}$) in EBV. Since the genetic correlation between traits, the heritability and the variation in EBV are likely to remain constant any scale effect observed in the variation of carcass traits is likely to have the greatest effect on the regression coefficient estimate.

The aim of this paper was to determine the relationship between carcass endpoint (defined by lot mean HSCW) and phenotypic variation in a data set of MSA graded southern Australian beef carcasses.

Materials and Methods
Data from approximately 1.7 million animals from 37,637 lots (slaughter groups) from the MSA database were accessed for cattle from nine processing plants in southern Australia from 2010-2013. A lot was defined as a group of cattle delivered to a processor by a supplier, which were killed on the same day. Slaughter groups with less than 20 head and those from saleyards were excluded from the dataset. Carcass records were excluded where the mean lot ossification was greater than 250, which was considered indicative of including cull cows. The data set was also trimmed for lots where variation in carcass weight and ossification were extreme (suggestive of mixed lots comprising some prime stock and some cull stock). After data editing to remove extreme within lot variation for HSCW and ossification there 23,128 lots with 20 or more carcass records, from 1.37 M carcasses.

Summary statistics were generated using the Proc Means procedure in SAS. Pearson’s correlation coefficients were estimated between HSCW, marbling, ossification and the MSA Index for both lot means and standard deviations (SD), using Proc Corr in SAS. Carcass trait means and standard deviations were regressed on carcass weight using Proc Reg in SAS to determine the change in the mean and variation of carcass traits for a 100kg increase in carcass weight.

Results
After data editing to generate the best possible representation of management groups with sufficient numbers of animals in each lot, the average lot size was 59 ranging from 20 to 673 head (Table 1). Most (95%) lots had 125 head or less. Lot size was not correlated with the lot mean or variance for any carcass traits (not presented). The mean within lot SD for marbling was 62.2 with a standard deviation of 29.8. In some lots there was no variation in marbling (i.e. all carcasses within this lot were graded same for marbling), whereas other lots had substantial variation in marbling. For
HSCW there was less within lot variation than between lots (21.3 vs 44.0 kg).

Table 1. Summary statistics for lot size, carcass trait lot means (mean and SD of means) and lot standard deviations (mean and SD of SDs).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot size</td>
<td>59</td>
<td>51.1</td>
<td>20</td>
<td>673</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSCW</td>
<td>274</td>
<td>44.0</td>
<td>137</td>
<td>475</td>
</tr>
<tr>
<td>Marbling</td>
<td>344</td>
<td>62.5</td>
<td>125</td>
<td>1004</td>
</tr>
<tr>
<td>MSA Index</td>
<td>60</td>
<td>2.9</td>
<td>47</td>
<td>69</td>
</tr>
<tr>
<td>Ossification</td>
<td>145</td>
<td>13.5</td>
<td>100</td>
<td>228</td>
</tr>
<tr>
<td>Standard deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSCW-SD</td>
<td>21.3</td>
<td>8.0</td>
<td>4.7</td>
<td>50</td>
</tr>
<tr>
<td>Marbling-SD</td>
<td>62.2</td>
<td>29.8</td>
<td>0</td>
<td>257</td>
</tr>
<tr>
<td>MSA Index-SD</td>
<td>1.3</td>
<td>0.4</td>
<td>0.02</td>
<td>4.3</td>
</tr>
<tr>
<td>Ossification-SD</td>
<td>13.5</td>
<td>5.0</td>
<td>0</td>
<td>30</td>
</tr>
</tbody>
</table>

As expected, lots with heavier carcasses also had greater marbling ($r=0.47$) and ossification ($0.38$, Table 2). Lots with higher mean HSCW also tended to have more variation in carcass weight (HSCW-SD) and marbling (marbling-SD) and ossification but not the variation in ossification (Ossification-SD). Lot mean marbling was also positively correlated with marbling-SD ($0.54$).

Table 2. Correlations between slaughter group lots for carcass traits (lot mean) and variation (SD) in carcass traits within lot.

<table>
<thead>
<tr>
<th>Trait</th>
<th>HSCW</th>
<th>Marbling</th>
<th>MSA Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td>0.47</td>
<td>0.14</td>
</tr>
<tr>
<td>HSCW</td>
<td></td>
<td>0.47</td>
<td>0.34</td>
</tr>
<tr>
<td>Marbling</td>
<td>0.14</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>MSA Index</td>
<td>0.38</td>
<td>0.33</td>
<td>-0.31</td>
</tr>
<tr>
<td>Ossification</td>
<td>0.34</td>
<td>0.18</td>
<td>0.04</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td></td>
<td>0.40</td>
<td>0.54</td>
</tr>
<tr>
<td>HSCW-SD</td>
<td>0.40</td>
<td>0.54</td>
<td>0.23</td>
</tr>
<tr>
<td>Marbling-SD</td>
<td>0.04</td>
<td>0.11</td>
<td>-0.02</td>
</tr>
<tr>
<td>MSA Index-SD</td>
<td>0.11</td>
<td>0.24</td>
<td>0.16</td>
</tr>
</tbody>
</table>

A 100 kilogram increase in the lot mean carcass weight (e.g. from 250 to 350 kg) was associated with an increase in marbling by 67 points the standard deviation of marbling by 27 points (almost $\frac{1}{2}$ a standard deviation), and the standard deviation in carcass weight by 6.1 kg with little change in the SD in ossification (Table 3).

Table 3. The change in carcass traits (lot mean) and variation (SD) in carcass traits for 100 kg increase in carcass weight.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSCW</td>
<td>100</td>
<td>6.1 $\pm$ 0.1</td>
</tr>
<tr>
<td>Marbling</td>
<td>67 $\pm$ 8</td>
<td>27 $\pm$ 0.4</td>
</tr>
<tr>
<td>MSA Index</td>
<td>0.93 $\pm$ 0.04</td>
<td>0.11 $\pm$ 0.01</td>
</tr>
<tr>
<td>Ossification</td>
<td>11.6 $\pm$ 0.2</td>
<td>0.48 $\pm$ 0.07</td>
</tr>
</tbody>
</table>

Discussion

The positive correlation between lot mean HSCW and lot mean marbling, and between lot mean marbling and variation in marbling have important implications for the expected magnitude of the regression of carcass traits including MSA Index on BREEDPLAN EBVs. The scale effect observed on the variance for both HSCW and marbling indicates that lots with higher mean marbling and HSCW appear to be associated with increased phenotypic variance within the lot. If heritability remains constant across market end point or finishing regime but the phenotypic variance increases, then the regression coefficients for EBVs on key traits influencing the MSA Index will increase significantly.

Lots were defined as a concatenation of producer, processor, HGP use and kill date with some data editing to remove obvious outliers. It is possible that stock from varying backgrounds were grouped together resulting in increased variance relative that which would have been observed if animals had been maintained in contemporary groups throughout life. However, larger scale producers may manage and sell multiple lots through a season as animals reach target market specification, for example drafting off animals that have reached market specification for weight. This would reduce the variation within a lot compared to what might be expected if drafting had not occurred. Despite not being able to assign ‘true’ lifetime management groups to more accurately quantify the phenotypic variation, confidence can be gained from the estimates as the phenotypic SDs closely match those estimated in the literature for both feedlot and pasture fed cattle (Reverter et al. 2003).

In conclusion, carcass end point for weight and marbling is positively correlated with phenotypic variation in those traits (there is a scale effect). Therefore, expected gains in MSA index for a given level of genetic improvement in IMF or carcass weight is dependent on carcass endpoint for weight and marbling.

Acknowledgement

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References

Feeding frequency and rate of nitrate ingestion affect nitrite toxicity in sheep supplemented with dietary nitrate

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Summary

Three rumen cannulated sheep were fed 1 kg chaffed hay treated with 2% nitrate either once a day, twice a day or hourly during three periods according to a Latin square design. Frequent blood and rumen fluid samples were taken over the day and residual feed was weighed at each sampling time. Sheep on the hourly feeding regime had significantly lower average blood methaemoglobin (MetHb) levels and lower average plasma nitrate concentrations. There were no significant differences in MetHb concentration between groups fed once or twice daily. Rumen nitrate and nitrite concentrations were variable between sheep but were unaffected by feeding frequency and did not accurately predict MetHb levels in the blood. Frequency and size of meals affects the risks of methaemoglobinemia in sheep and is therefore important to consider when sheep are supplemented with nitrate. However, more explanations for the large variability between animals in average blood MetHb concentrations over time, which cannot be adequately explained by feed intake, are needed.

Introduction

Supplementing dietary nitrate to ruminants is a promising methane mitigation strategy, with nitrate reduction acting as a hydrogen sink in the rumen, competing with methanogenesis. However, when nitrate is fed in excessive amounts, nitrite, the intermediate product of nitrate reduction to ammonia, accumulates in the rumen. This nitrite can be absorbed into the blood stream, converting haemoglobin to methaemoglobin (MetHb) leading to methaemoglobinaemia. Large variations in blood MetHb levels have been observed between sheep fed the same diet (de Raphélis-Soissan et al. 2014). A recent meta-analysis showed that ruminants are more susceptible to methaemoglobinaemia when the intake of feed containing nitrate is restricted rather than ad libitum (Newbold et al. 2016). It is hypothesized that risks of methaemoglobinaemia are linked to the ingested quantities of feed and the frequency of meals, i.e. to the rate of nitrate and substrate intake. This study compared blood MetHb levels and nitrate-N metabolism in sheep offered nitrate containing feed at differing time intervals.

Materials and Methods

Three rumen-cannulated crossbred ewes (bodyweight 37.3 ± 3.2 kg) that had been adapted to dietary nitrate supplementation for over five weeks were randomly allocated to one of three treatments: hourly feeding, twice a day feeding, or once a day feeding in a randomized 3x3 Latin square design. Measurements were performed over six days divided into three periods, each lasting two days; during the first day of each period sheep were adapted to the feeding regime and measurements were taken on the second day. Sheep were fed a chaffed mixture of lucerne and cereal hays supplemented with nitrate (20g nitrate/kg diet dry matter). The feed was prepared by sprinkling a solution of calcium nitrate (500 g/l, 5Ca(NO3)2·NH4NO3·10H2O, Bolifor CNF, Yara, Oslo, Norway) onto the hay, while tossing in a rotary mixer. All sheep were fed 1 kg per day nitrate-treated air dried chaff. Sheep fed once a day were fed their entire daily portion at 08:00 h; sheep fed twice a day received half the daily ration at 08:00 h and the second half at 20:00 h. The hourly fed sheep were given 41.7 g meals every hour by an automatic feeding system. Prior to the experiment, polythene catheters (60 cm of length, OD 1.50 mm x ID 1.00 mm, Sterihealth) were inserted into the jugular vein of each sheep by a double-bevel introducer needle (14G, Surflo I.V. catheter, Terumo, Japan). Catheters were flushed with 2 mL heparinised saline (25 iu/mL) after each sampling and with a stronger solution (100 iu/mL) over night.

Blood and rumen fluid samples from each sheep were taken at 07:45, 09:00, 10:00, 11:00, 12:00, 13:00, 15:00 and 17:00 h. To determine feed intake between sampling times, residual feed was weighed at each sampling and then returned to each sheep. Blood (10 mL) was sampled with a heparinised 10 mL syringe through the jugular catheter after discarding the first 2 mL. Samples were immediately introduced into a blood gas analyser (ABL 800 Flex, Radiometer, Brønshøj, Denmark) to measure MetHb levels. The remaining blood (9 mL) was centrifuged (4470 x g, 10 min, 4°C) to separate the plasma. Rumen fluid (10 mL) was preserved with 2 mL 38% (v/v) formaldehyde. All samples were stored at -20°C until analysis. Concentrations of nitrate and nitrite in rumen fluid and blood were analysed after deproteinising the samples by a 1 : 1 inclusion of ethanol (95%). Ethanol treated samples were stored at -20°C overnight and then centrifuged (44,000g, 15 min, 4°C). The supernatant was analysed for NO3 and NO2 by a continuous-flow analyser (San++, Skalar, Breda, The Netherlands).

Results

Sheep ingesting meals every hour were more effectively protected against methaemoglobinaemia than those offered the same daily ration in one or two meals. Hourly fed sheep had lower average blood MetHb concentrations (1.1%±0.3, P<0.001), lower average plasma nitrate concentration (P<0.001) and tended (P=0.053) to have a lower average plasma nitrite concentration (Figure 1). Animals offered feed twice a day also tended (P=0.07) to have lower average MetHb concentration than sheep offered their ration once a day, but plasma nitrate or nitrite concentrations were unaffected. Rumen fluid nitrate and nitrite concentrations were unaffected by patterns of feed intake (data not shown). The rate of feed intake was positively correlated with MetHb (r=0.46), plasma nitrate (r=0.41) and plasma metabolism.
nitrite (r=0.76), but not with rumen nitrate or nitrite concentrations. Individual sheep had different responses to the same dietary nitrate intake. There was significant between-sheep variation in MetHb levels that was not explained by individual variation in feed and nitrate intake. One sheep seemed to be less susceptible to MetHb increases; its maximal MetHb level was 4% across all treatments while the other two sheep reached levels of 9 and 11.5%.

One meal was effective in reducing MetHb levels. A major difference between the studies was that MetHb levels were considerably lower in our study with sheep (averaging 2.6% and 11.5%) than for cattle that showed daily mean MetHb of 20% and a maximum MetHb concentration of 75%. Furthermore, feeding a lower dose of nitrate (30 g nitrate/steer versus 40 or 50 g nitrate/steer), reduced the difference between once and twice a day feeding. In our current study, the high variability between animals, the low er number of replicates and the lower levels of toxicity might explain the absence of differences between twice-a-day and once-a-day feeding. However, the fact that hourly feeding effectively reduced MetHb shows that feeding frequency and the rate of intake of nitrate do have an impact on nitrite toxicity. When the same daily amount of nitrate is ingested in more frequent, smaller meals, plasma nitrite concentration is lower and less MetHb is formed, presumably because less nitrite accumulates in rumen contents and less is absorbed into the bloodstream. In our study, rumen nitrate and nitrite concentrations did not differ significantly between treatments and were not good predictors of blood MetHb levels. In contrast, Kemp et al. (1977) found a strong correlation (r=0.92) between rumen nitrite and blood MetHb concentrations. We hypothesized that the accumulation of rumen nitrite increases absorption of nitrite and a rise in MetHb level. Our data do not show this, perhaps because of non-homogenous mixing of rumen nitrate and nitrite, especially when rumen samples were taken shortly after sheep ingested nitrate-treated feed. The variability in MetHb levels under the same conditions suggests that sheep had different tolerances to high nitrate doses either in the rumen or in tissues. Differences in rumen microbial composition might exist between sheep with different abilities to tolerate nitrate (Veneman et al. 2015) and differences in hepatic gene expression have been observed between ewes with a high or low tolerance to nitrate supplementation (Cockrum et al. 2010).

Acknowledgements
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References
The effect of maternal parity and birth weight on ovarian follicle population of female pigs (gilts).

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Summary

We hypothesized the in utero environment in which a female pig (gilt) developed would significantly affect ovarian development. We determined the effect of birth weight (high versus low), maternal parity (gilt versus sow) and the proportion of females in the litter (low; < 40% versus normal; 41 – 59% versus high; > 60%) on the characteristics of the antral follicle population at 21 weeks of age. Ovaries of light birth weight gilts contained more (P < 0.05) antral follicles than high birth weight gilts. The ovaries of gilts born from a first pregnancy contained a higher number and proportion of follicles ≥ 4 mm (P < 0.05). Being born in a litter with a low compared with a normal or high proportion of female litter mates resulted in ovaries with a higher proportion of follicles ≥ 4 mm (P < 0.05). These data support the hypothesis that in utero environment affects ovarian development.

Introduction

Traditionally the industry has focused on management of females after selection (16-21 weeks) to maximize production. However it is now understood that in many species it is important to consider not only the pre-pubertal environment of the animal but the maternal environment also. Banos et al (2007) reported that in dairy cows the age of the dam at first calving, milk yield and body condition score during gestation accounted for a significant proportion of the total phenotypic variance of calving interval and non-return rate of the daughter cows. Therefore there is growing evidence to suggest that the maternal environment plays an integral role in the subsequent productivity of a breeding animal.

Materials and Methods

This study was conducted at the University of Adelaide’s Roseworthy Piggery, South Australia. Litters were selected from both nulliparous and multiparous animals. At 24hrs post farrowing the number of piglets born, the number of male and female piglets, and individual piglet weights were recorded. Within litters, the heaviest and lightest female pigs (gilts) were individually identified. Gilts (n = 67) were weighed at 28 days and 21 weeks of age, and reproductive tracts collected post-slaughter at 21 weeks. Within 4 hours of collection, the surface antral follicles on both ovaries were counted and aspirated according to the following size classes, small (1 – 3.9 mm) and large (≥ 4 mm). An analysis of variance (ANOVA), with 21 week weight included as a covariate, was used to determine the effect of birth weight (Light versus Heavy), maternal parity (gilt versus sow), and the proportion of females in the litter (low; < 40% versus normal; 41 – 59% versus high; > 60%) on the total number of surface antral follicles, as well as the number and proportion of small and large follicles. Data are presented as Mean ± SEM.

Results

The ovaries of Light birth weight (BW) gilts contained more surface antral follicles (154.1 ± 11.6 versus 118.7 ± 12.3; P < 0.05) compared with those of Heavy BW gilts. The number of small and large follicles was similar for Light and Heavy BW gilts: 137.8 ± 11.8 and 105.3 ± 12.6; 16.0 ± 2.1 and 13.8 ± 2.2, respectively. There was no effect of maternal parity on the total number of antral follicles or small follicles present on the ovaries (Table 1); however, the ovaries of gilt progeny contained more (P < 0.05) large follicles than those of sow progeny (Table 1).

Table 1. Number and proportions of small (1 – 3.9 mm) and Large (≥ 4 mm) antral follicles present on the ovaries of 21 week old, gilt versus sow progeny

<table>
<thead>
<tr>
<th>Maternal Parity</th>
<th>Gilt</th>
<th>Sow</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of gilts</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>No. follicles:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 1 mm</td>
<td>146.3 ± 12.21</td>
<td>126.5 ± 13.72</td>
</tr>
<tr>
<td>1 to 3.9 mm</td>
<td>126.7 ± 12.50</td>
<td>117.4 ± 14.06</td>
</tr>
<tr>
<td>4 mm plus</td>
<td>19.4 ± 2.18⁴</td>
<td>9.8 ± 2.4⁴</td>
</tr>
<tr>
<td>Prop. follicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 3.9 mm</td>
<td>0.83 ± 0.02²</td>
<td>0.93 ± 0.03b</td>
</tr>
<tr>
<td>4 mm plus</td>
<td>0.17 ± 0.02²</td>
<td>0.07 ± 0.03b</td>
</tr>
</tbody>
</table>

* within row indicate differences; P < 0.05

The number of follicles present on the ovary was unaffected by the proportion of females present in the litter of birth. The total number of surface antral follicles was 116.8 ±19.2, 137.3 ± 13.6 and 136.4 ± 13.6 for gilts with a Low, Normal or High proportion of female litter mates. However, the gilts born in litters with a low proportion of female litter mates had a lower proportion of small follicles and a higher proportion of large follicles compared with those born in litters with a normal or high proportion of females litter mates (P < 0.05; Table 2).
Table 2. The proportion of small and large follicles present on the ovaries of gilts born in a litter with low (< 40%) versus normal (41 – 59%) versus high (> 60%) proportion of female littermates

<table>
<thead>
<tr>
<th>Prop. litter</th>
<th>1 - 3.9 mm (Small)</th>
<th>&gt; 4 mm (Large)</th>
</tr>
</thead>
<tbody>
<tr>
<td>female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 40%</td>
<td>0.75 ± 0.04</td>
<td>0.25 ± 0.04</td>
</tr>
<tr>
<td>41 - 59%</td>
<td>0.90 ± 0.03</td>
<td>0.10 ± 0.03</td>
</tr>
<tr>
<td>&gt; 60%</td>
<td>0.85 ± 0.03</td>
<td>0.15 ± 0.03</td>
</tr>
</tbody>
</table>

Discussion

It was hypothesized that animals in the lightweight category born to gilts would have the lowest antral follicle counts at week 21 of age, as it is arguable that body condition of the animal is more important than specific age in puberty attainment. However the lightweight animals were found to have a significantly higher antral follicle count. It is widely accepted that antral follicle counts in pigs and other species is indicative of higher oocyte quality, however these measures are generally used in cycling animals and may not be relevant to pre pubertal animals. Da Silva et al (2003) found that the morphological structure of the ovary collected from a light weight piglet at birth resembled that of a normal piglet several weeks prior to birth. As the ovarian development is delayed at this stage it is possible that these animals would reach puberty later than their heavier counterparts. During the pre-pubertal period ovarian follicle growth occurs in waves and is characterized by the gradual growth of a follicle pool, however in the absence of the luteinizing hormone release required to support the follicle through until ovulation these pools become atretic and are succeeded by the next wave of growing follicles (Bolamba et al. 1994; Foxcroft, 1991). It is therefore plausible that the high birth weight animals are reaching puberty around the time of slaughter and would potentially have less antral follicles, with oocytes of higher quality in comparison to the possibly atretic larger follicles found on the lightweight piglets, which are delayed in the onset of puberty. In this case the use of antral follicle counts alone may not be an accurate measure of follicle quality and therefore in vitro markers will be used in a further study to determine the developmental competency of the animal.

It was observed that gilts born into male biased litters show a significant increase in the proportion of larger (>4mm) antral follicles in comparison to normally distributed or female biased litters (Table 2). Generally this would be accepted as an indication of enhanced fertility of the animal, however studies of testosterone treated sheep prenatally indicate that increased levels of testosterone caused by the male biased litter can lead to the androgenization of the female, resulting in quantitative and structural alterations in the ovary. This androgenization has been found to culminate in a reduced ovarian reserve and the presence of a greater number of larger follicles (Steckler et al, 2005). As such it has been hypothesized that as the ovarian reserve cannot be replenished, this increased recruitment of the primordial follicle pool will result in early follicular exhaustion, therefore shortening the reproductive lifetime of the sow (Steckler et al. 2005, Forsdike et al. 2007, Clarke et al. 1977, Birch et al. 2003).

Acknowledgment

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References


Nitrate encapsulated with paraffin wax inhibits short term methane production in sheep and effectively reduces the risk of nitrite toxicity

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Summary

Two forms of encapsulated nitrate (coated with palm oil or paraffin wax) were administered intraruminally to sheep and nitrate metabolism was evaluated by determining blood methaemoglobin (MetHb) levels as well as nitrate and nitrite concentrations in plasma and rumen fluid. Methane production was also evaluated with sheep on urea diets used as negative controls. Whereas no significant effect of palm oil coating was observed, coating with paraffin wax lowered MetHb levels, rumen nitrate and plasma nitrate concentrations. When nitrate was supplied directly into the rumen, a large variation between animals in the response of blood MetHb was observed, suggesting that individuals differ in their ability to metabolise nitrate. During the first 6 h of measurement, methane was reduced by nitrate supplementation, without difference between encapsulated and unencapsulated nitrate treatments. Encapsulating dietary nitrate can effectively protect sheep against nitrite toxicity without adversely affecting methane mitigation.

Introduction

When nitrate (NO$_3^-$) is fed in excessive amounts to ruminants, nitrite (NO$_2^-$), the intermediate product of NO$_3^-$ reduction to ammonia (NH$_3$), accumulates in the rumen and can be absorbed into the blood stream, converting haemoglobin to methaemoglobin (MetHb). Decreasing the rate of NO$_3^-$ reduction in the rumen by coating NO$_3^-$ supplements with a slowly soluble or degradable material is a strategy that could reduce risks of methaemoglobinemia (Lee et al. 2015). The current study aimed to investigate if encapsulating NO$_3^-$ with paraffin wax reduces the risk of NO$_2^-$ toxicity without reducing its methane mitigation benefit. It was hypothesised that an encapsulated NO$_3^-$ product would reduce rumen NO$_3^-$ and NO$_2^-$ concentrations and thus blood MetHb levels, without adversely affecting methane mitigation.

Materials and Methods

Twelve rumen cannulated crossbred sheep (48.7 ±7.8 kg) were stratified by bodyweight, allocated by stratified randomization to two groups and fed chaffed oaten hay diets (1.5 kg air dried chaff/day) supplemented either with dietary NO$_3^-$ (1% per DM) or with urea (0.53% per DM). Nitrate or urea were added to the diets by sprinkling a solution of urea or calcium nitrate (BOL, 5Ca(NO$_3$)$_2$.2NH$_4$NO$_3$.10H$_2$O, Bolidor CNF, Yara, Oslo, Norway) onto the oaten hay, while tossing in a rotary mixer. Diets were iso-nitrogenous and delivered once daily (0800 h). Sheep were gradually adapted to treatments over one week and fed the diets for two additional weeks prior to the experiment. The six sheep on NO$_3^-$ diets were allocated to three treatment groups that were then administered intraruminally with nitrate, i.e. non-encapsulated BOL, BOL coated with 15% paraffin wax (PARA) and BOL coated with 15% palm oil (OIL). During methane measurements, the six sheep on the urea diets were fed as negative control. Nitrate or urea treated oaten hay was replaced by non-treated hay from the same batch on the days when NO$_3^-$ or urea was administered intraruminally. The paraffin coated product was manufactured by spraying melted paraffin wax onto BOL prills (Ø 4mm) in a cement mixer that was warmed with a propane gas burner to prevent the paraffin solidifying onto the mixer. After mixing, the material was emptied onto a cool stainless steel rack. The oil-coated product was supplied by Palital (Palital GMBH & Co. KG, Süldlohn-Oedling, Germany). Evaluation of the effect of NO$_3^-$ encapsulation on NO$_2^-$ toxicity and methane emissions was performed using a 3 x 3 Latin Square design with only the six sheep adapted to dietary NO$_3^-$ and NO$_2^-$ treatments. Between animals in the response of blood MetHb was observed, suggesting that individuals differ in their ability to metabolise nitrate. During the first 6 h of measurement, methane was reduced by nitrate supplementation, without difference between encapsulated and unencapsulated nitrate treatments. Encapsulating dietary nitrate can effectively protect sheep against nitrite toxicity without adversely affecting methane mitigation.

Results and Discussion

It was hypothesized that the encapsulated NO$_3^-$ treatments would reduce the rate of NO$_3^-$ release in the rumen, minimising accumulation of rumen NO$_3^-$ and absorption of...
NO₂ into the blood stream, therefore keeping MetHb levels low. Concentrations of NO₂ and NO₃ in rumen fluid and plasma, as well as MetHb levels in sheep supplemented with urea were at physiological levels and are therefore not further discussed.

Across NO₃ treatments, both NO₃ and NO₂ concentration in rumen fluid reached a peak about 30 min after NO₃ dosing. The Rumen NO₃ peak was lower for BOL than for OIL (P<0.001, data not shown). As calcium nitrate is highly soluble, the peak of rumen NO₃ might have been reached before the 30 min samples were taken. There was, however, no difference between PARA and BOL treatments (P>0.05). Rumen fluid NO₂ and NH₃ concentrations were not affected by treatments (P=0.16), suggesting that the form of supplied NO₃ did not affect NH₃ pools. However, there is no evidence that the amount of supplied NO₃ was large enough to significantly affect the NH₃ pool, as NH₃ concentration did not differ between pre- and post-dosing samples. Methaemoglobin levels were lower for sheep dosed with PARA (P<0.05, Figure 1) than for BOL, but OIL and BOL treatments did not differ (P>0.05).

Across treatments, the peak in plasma NO₂ preceded the peak in MetHb by approximately 30 min, suggesting a rapid, but not immediate response of the conversion of haemoglobin to MetHb by plasma NO₂. Overall, sheep on BOL diets had higher plasma NO₃ concentrations (P<0.001) and tended to have higher plasma NO₂ concentrations (P<0.1) than sheep on OIL or PARA treatments, suggesting that encapsulation of NO₃ reduces the absorption of both NO₂ and NO₃. However, only PARA caused a significant reduction of MetHb, showing that PARA is a more effective encapsulation form than OIL for protecting sheep from methaemoglobinemia.

There was a large variability in rumen and plasma NO₃ metabolites between sheep. One sheep in particular had a consistently lower mean MetHb level (a maximum of 1.5% MetHb), a higher average rumen fluid NO₃ concentration (over 10x higher than the average of rumen NO₃ of the five other sheep) and almost double the average NH₃ concentrations of the other sheep. The reason for such a different NO₃ metabolism is unknown. It is possible that the high rumen NH₃ concentration inhibited the reduction of NO₃ or that the rumen ecosystem in this sheep was unable to quickly reduce NO₃ due to its microbial population or environmental conditions.

Methane emissions from NO₃ supplemented sheep were lower (P<0.05) than for urea supplemented sheep in the first 6 h of the 22 h measurement period but did not differ (P>0.05) over the whole 22 h (data not shown). The stoichiometric potential of methane abatement by 5.09 g of NO₃N is less than 5% of the daily methane production, explaining the absence of effect of nitrate on daily methane production. However, over the first 6 h the given nitrate dose can stoichiometrically lower methane emission by 21% and the three nitrate treatments mitigated methane production by 22 to 30%, showing that methane was abated effectively by both unencapsulated and encapsulated nitrate. Methane produced over the first 6 h in the respiration chambers was not different between PARA, OIL and BOL treatments. It can therefore be concluded that both forms of encapsulated nitrate were effective in mitigating methane, but only PARA reduced levels of MetHb.

Acknowledgements

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References


Increasing sire breeding values for post weaning fat improves the condition score of their adult ewe progeny in late pregnancy.

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Summary

We examined the effect of sire breeding values for fat on the condition scores of their hogget and adult ewe progeny at joining and during pregnancy. Ewes from the Maternal Efficiency Flock (n=1628) were condition scored regularly over six years. Ewes from sires with higher breeding values for fat were in better condition during late pregnancy than those from lower fat sires, but these differences in condition score were not evident at other stages of the reproductive cycle. Across the range of sires tested, an extra 1 mm of sire fat at post-weaning age was associated with an extra 0.16 of a condition score in their ewe progeny in late pregnancy. The extra condition score prior to lambing could result in improvements in ewe and lamb survival and or reduce the need for supplementary feeding.

Introduction

Selection for increased fat has a positive association with reproductive performance of ewes, but the effects vary considerably between flocks and years (Ferguson et al. 2010; Brown and Swan 2015). Blumer et al. (2015) also reported that adult ewes from genetically fatter sires lost less live weight during summer and autumn, especially in environments where ewes lost a greater proportion of their live weight, and (Young et al. 2011) proposed that such ewes could be more profitable due to increased productivity per head at the same stocking rate, reduced requirements for supplementary feeding, and/or they could be managed at higher stocking rates for similar levels of productivity.

Few sheep producers weigh adult sheep but producers are increasingly monitoring the condition score of their ewes at key times during the reproductive cycle. Subjectively assessed condition score is positively related to fat and muscle tissue depth measured by ultrasound (van Burgel et al. 2011). We hypothesise that sire ASBVs for post weaning fat (PFAT) and post weaning eye muscle depth (PEMD) will be positively associated with the condition scores of their ewe progeny.

Materials and Methods

Ewes (n=1628) from the Maternal Efficiency Flock were joined with sires annually between 2010 and 2016 at Pingelly, Western Australia. All ewes were condition scored each year at joining, mid and late pregnancy by the same assessor. Birth type of lambs was determined by ultrasound scanning at approximately day 50 of pregnancy and verified by observations at lambing. All lambs born were weighed and identified to dam at birth and were parentage tested for sire. All sires used had ASBVs for fat at post weaning age, but the analysis only used data from sires with more than 10 progeny across multiple years.

The condition score of adult ewes at joining, mid pregnancy and late pregnancy was modelled with sire ASBVs for PFAT and for PEMD fitted as covariates. These models included year, parity group (hogget or adult) and previous rear type (lambs reared in the previous calendar year) as fixed effects. When condition score at mid- and late-pregnancy was the dependent variable the fixed effects also included birth type (lambs borne in the current year). Sire was included as a random term, but was also tested within the main models. All appropriate second order interactions were analysed and removed if not significant (P>0.05).

Results

A summary of fixed effects is shown in Table 1. Ewe condition score was significantly different between years and was lowest in 2011 (2.8 ± 0.15, 2.6 ± 0.20, 2.7 ± 0.12 for joining mid-pregnancy and late pregnancy respectively). Adults had a lower condition score than hoggets at joining (0.22 ±0.05) and in late pregnancy (0.15 ± 0.03).

Previously dry ewes were in better condition at the following joining than those that had raised singles or multiples in the previous year (3.4 ± 0.08 vs. 3.2 ± 0.07 and 3.1 ± 0.08), but these effects were not significant at late pregnancy. In late pregnancy, there was only a small difference in condition score between single (3.1 ± 0.03) and multiple bearing ewes (3.0 ± 0.03).

Table 1. Coefficients (±SE) for a general linear model that predicts ewe condition scores at joining, mid pregnancy and late pregnancy with the fixed effects of year, parity group, previous rearing type and current birth type. The coefficient for the effects of sire ASBV for post weaning fat (PFAT) is also shown.
Late pregnancy

<table>
<thead>
<tr>
<th></th>
<th>joining</th>
<th>Mid pregnancy</th>
<th>Late pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coefficient</td>
<td>P</td>
<td>coefficient</td>
</tr>
<tr>
<td>constant</td>
<td>3.02 (0.15)</td>
<td>***</td>
<td>2.69 (0.20)</td>
</tr>
<tr>
<td>year 2012</td>
<td>0.64 (0.13)</td>
<td>***</td>
<td>0.50 (0.20)</td>
</tr>
<tr>
<td>2013</td>
<td>0.61 (0.14)</td>
<td>***</td>
<td>0.29 (0.20)</td>
</tr>
<tr>
<td>2014</td>
<td>0.61 (0.16)</td>
<td>***</td>
<td>0.11 (0.19)</td>
</tr>
<tr>
<td>2015</td>
<td>0.46 (0.15)</td>
<td>**</td>
<td>0.94 (0.20)</td>
</tr>
<tr>
<td>2016</td>
<td>0.79 (0.16)</td>
<td>***</td>
<td>-</td>
</tr>
<tr>
<td>parity</td>
<td>adult</td>
<td>-0.22 (0.05)</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>previous rear type</td>
<td>single</td>
<td>-0.18 (0.06)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>multiple</td>
<td>-0.28 (0.07)</td>
</tr>
<tr>
<td>birth type</td>
<td>multiple</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

sire pfat | ns | ns | 0.16 (0.04) | ***  

The constant equates to a hogget ewe, dry in 2010, carrying a single lamb in the current year (2011).

Sire ASBVs for PFAT were significantly and positively associated with the condition score of their adult ewe progeny during late pregnancy (P<0.001; Fig. 1), but the effects of sire PFAT on ewe condition score was not significant at joining or mid-pregnancy. In late pregnancy, ewe condition score increased by 0.16 ±0.038 for each 1-mm increase in their sires ASBV for PFAT.

The effects of sire ASBVs for PFAT on ewe condition score were not evident at joining or mid-pregnancy. It appears that while selecting for higher genetic fat can allow ewes to maintain a higher level of body condition these effects were most expressed during periods of peak energy demand. This differs to Walkom et al. (2016) who reported that sire fat was positively related to the condition score of maternal composite ewes in mid-pregnancy. These authors proposed that differences in condition score between genetically fatter and leaners ewes will actually be less during periods of feed deficit, but Walkom and Brown (2016) also reported that adult body condition was highly genetically correlated (0.92–1.00) across stages of the reproductive cycle. The biological mechanisms responsible for the sire fat effects on condition score during late pregnancy in our study are not known, but could be due to an association with higher intake or intake efficiency. There are some reported benefits of whole body fatness on feed efficiency in dry ewes (Blumer et al. 2016) and it seems from this study that these benefits could be amplified in pregnant and lactating ewes.

**Acknowledgement**

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**References**


Paganoni, BL, Blumer, SE, Hancock, S, Inglis, L, Macleay, CA, Thompson, AN (2016) *this issue*.


**Discussion**

In agreement with our hypothesis there was a positive relationship between sire ASBVs for post weaning fat and the condition score of their adult ewe progeny in late pregnancy. A higher condition score at lambing resulting from selecting for higher genetic fat would be expected to improve lamb survival (Oldham et al. 2011) and ewe survival (Morgan-Davies et al. 2007). The average condition score at lambing of ewes in the Maternal Efficiency Flock was about 3.1, and the lamb survival responses to varying condition score were reported by Paganoni et al. *(this edition)*. An extra 0.16 of a condition score at lambing associated with using sires with an extra mm of PFAT would have a minimal effect on improving lamb survival in this flock. Sire fat is also known to influence the number of lambs born (Ferguson et al. 2010), but either way it is clear that many factors other than sire fat influence reproductive performance in the Maternal Efficiency Flock. More significant benefits of genetically fatter ewes are likely to be that they require less supplementary feeding to maintain condition score above minimum threshold values and/or they can be run at higher stocking rates.

**Figure 1. The relationship between sire Australian Sheep Breeding Values for post weaning fat depth (mm) and the condition score during late pregnancy of their adult ewe progeny. Dashed lines represent the standard error.**
A preliminary investigation to determine the potential for a Raman spectroscopic hand held device to predict sensory traits for 45 beef loins was conducted. Partial least squares regression models using Raman spectra to predict the sensory scores determined by an untrained consumer panel indicated that there was an ability to predict juiciness ($R^2 = 0.41, R^2_{cv} = 0.17$) and tenderness ($R^2 = 0.36, R^2_{cv} = 0.22$). However, further research is needed to determine the repeatability and robustness of these models.

Introduction

Despite the importance of eating quality to the consumer’s acceptance of red meat, eating quality traits including tenderness, juiciness, flavour and overall liking are not routinely measured in commercial situations. This is due to the amount of labour and resources required to complete sensory testing which is also destructive of the samples.

Raman spectroscopy (RS) is a method which has potential to measure eating quality traits in commercial situations as a rapid, non-destructive method. This is because it is an optic technology which uses in-elastic scattering to provide a chemical finger-print of the sample and no sample preparation is required (McCreery, 2005).

Therefore, the aim of this study was to examine the potential of a hand held RS device to predict eating quality traits of beef loin with a view towards online situations.

Materials and Methods

Fifty (50) beef loins (m. longissimus thoracis) were collected at 24 h post mortem (PM) from randomly selected carcases weighing between 250 – 450 kg with 0 – 4 teeth.

Measurements with the RS device were conducted perpendicular to the muscle fibre on the medial portion of the muscle at 3 d PM after chilled storage at 1°C using a 671 nM hand held device (Schmidt et al., 2009). Sections were then aged until 21 d PM when they were cut into 5 slices and frozen for sensory analysis.

Sensory analysis was conducted as previously described (Watson et al., 2008). Two hundred and twenty five (225) slices were eaten by 58 untrained consumer panelists, allocated so that each loin was consumed by 10 different consumers.

The tenderness, juiciness, flavour and overall liking scores were averaged for each loin before Partial Least Squares (PLS) regression, cross validated with Leave One Out was conducted using the PLS toolbox with MatLab software (The Mathworks Inc., 2013). Background correction of spectra was completed by fitting a 6th order polynomial.

Results and Discussion

The models for the prediction of eating quality traits indicate that there is a potential to predict juiciness ($R^2 = 0.41, R^2_{cv} = 0.17$, RMSECV = 11.21 using 5 LV; Fig 1) and tenderness ($R^2 = 0.36, R^2_{cv} = 0.22$, RMSECV = 10.43 using 3 LV). However, there was a limited ability to predict flavour ($R^2 = 0.14$, $R^2_{cv} = 0.01$, RMSECV = 9.53 using 3 LV) and no ability to predict overall liking.
Although there is no research to directly compare these findings to, one other study (Beattie et al., 2004) has conducted RS measurements on cooked beef silverside immediately prior to assessment by a trained sensory panel. This study (Beattie et al., 2004) yielded higher correlation coefficients between the spectra and the sensory traits tenderness juiciness and flavour ($R^2 = 0.65$, 0.62 and 0.26, respectively) yet, this methodology is not suitable for application in commercial situations.

Overall this research demonstrates that RS may be a better indicator of consumer tenderness scores in comparison to mechanical measures of shear force, which has a weak relationship to sensory tenderness (Van Wezemael et al., 2014). Consequently, further research is required to validate these finding on a larger independent data set as the sample numbers for this study may limit the transference of the models.

**Conclusion**

This preliminary investigation demonstrated that there is a potential to predict the juiciness and tenderness scores of beef loin determined by an untrained consumer panel using a Raman spectroscopic hand held device. Given the limiting sample numbers used for this preliminary study, further research needs to be conducted to determine whether these models can be repeated over time and validated with independent samples.

**Acknowledgements**

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**References**


Nitrate and canola oil are synergistic in reducing methanogenesis in cattle

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Summary

The effects of canola oil and nitrate (NO3), added to diets alone or in combination, on methane (CH4) emissions and rumen volatile fatty acid (VFA) concentrations were evaluated. The experiment was designed as a 4x4 Latin square using 4 cannulated steers over 4 x 15-day experimental periods. Dietary treatments were: control (CON: 40% lucerne chaff and 60% barley grain), OIL (CON + 5% canola oil), NO3 (CON + 2% nitrate) and NO3+OIL (CON + 5% canola oil plus 2% nitrate supplied as calcium nitrate). Total VFA concentration did not differ (P > 0.05) between diets, but NO3 increased acetate proportion and the acetate:propionate ratio, while OIL reduced it (P < 0.01). Compared with CON, NO3+OIL reduced (P < 0.01) methane yield (g CH₄/kg DMI) by 29%. Methane-mitigating effects of nitrate and oil are more than additive and CH₄ emissions were reduced without compromising feed intake or VFA concentration.

Introduction

Enteric methane is produced by ruminants during the microbial fermentation of feed and is an important source of greenhouse gas emitted from the livestock sector (Gerber et al., 2013). Strategies that reduce enteric CH₄ emissions are required to minimize agricultural greenhouse gas emissions. Nitrate and lipids have been evaluated and recognized as effective dietary additives to reduce methane emissions from ruminant livestock (Beauchemin and McGinn, 2006; Guyader et al., 2015). The objective of this study was to evaluate the effect of nitrate and canola oil fed alone or in combination on rumen fermentation and methane emission from beef cattle.

Materials and Methods

The experiment was conducted between October 2015 and February 2016. Animals were handled in accordance with the University of New England Animal Ethics Committee.

Four mature crossbreed cannulated steers (713 ± 20.5 kg liveweight) were used in a Latin square, with 4 diet treatments offered over 4 periods and each steer fed one of the four dietary treatments in each period.

Animals were housed individually in pens equipped with a feeder and water and were offered 7.5 kg of their experimental diet in 2 equal feeds/d. The basal diet was a blended chaff mixture (40% lucerne chaff; 60% rolled barley grain) fed alone (control; CON) or with inclusion of 2% nitrate (NO3; provided as 3.14% calcium nitrate, 5Ca(NO3)2·NH4NO3·10H2O, Bolifor CNF, Yara, Oslo, Norway). The third treatment (OIL) consisted of 5% canola oil inclusion in the chaff and the final treatment (NO3+OIL) contained 2% nitrate and 5% oil in combination, with all inclusions expressed as g/100g as fed.

Filtered rumen fluid samples (14 per animal) were collected for volatile fatty acid (VFA) determination via the rumen cannula after 14 d of diet adaptation. Each 10 ml sample was

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatments</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI (kg)</td>
<td>CON   NO3 OIL NO3+OIL</td>
<td>SEM  P-value</td>
</tr>
<tr>
<td>Methane Yield (g/kg DMI)</td>
<td>23.6a 20.1b 22.4ab 16.8c</td>
<td>0.72  &lt; 0.01</td>
</tr>
<tr>
<td>pH</td>
<td>6.24a 6.27a 5.97b 6.40b</td>
<td>0.03  &lt; 0.01</td>
</tr>
<tr>
<td>Total VFA (mmol/l)</td>
<td>104 99.5 106.5 100.1</td>
<td>1.61  0.30</td>
</tr>
<tr>
<td>VFA (molar %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetate</td>
<td>62.3a 67.4b 59.1c 64.1c</td>
<td>0.42  &lt; 0.01</td>
</tr>
<tr>
<td>Propionate</td>
<td>16.6a 15.2b 19.6b 15.8b</td>
<td>0.46  &lt; 0.01</td>
</tr>
<tr>
<td>Butyrate</td>
<td>17.1a 13.4b 17.0b 16.3b</td>
<td>0.39  &lt; 0.01</td>
</tr>
<tr>
<td>Acetate:Propionate ratio</td>
<td>3.77a 4.43b 3.00c 4.04d</td>
<td>0.09  &lt; 0.01</td>
</tr>
</tbody>
</table>

Table 1: Dry matter intake (DMI), methane yield, total VFA concentration and VFA molar percentages in rumen fluid of cannulated steers fed: 1) a control diet (CON: 7.5 kg air dry; 40% of lucerne chaff and 60% barley grain; 2) nitrate diet (NO3: CON + 2% nitrate; 3) oil diet (OIL: CON+5% canola oil) and 4) nitrate plus oil diet (NO3+OIL: CON with 2% nitrate plus 5% canola oil)

*a, b, c Within a row, means without a common superscript letter differ, P < 0.05

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taken and acidified with 0.3 mL (18M) H$_2$SO$_4$ and then frozen at -20°C. Volatile fatty acid concentrations were determined by gas chromatography using a Varian CP-3800 chromatograph.

Methane production (24 h) was measured by open circuit respiration chambers approximately after 13 d (except period 1) and again after 19 d of diet adaption, with data averaged for the 2 measures per animal per period.

**Results and Discussion**

Although NO3 and NO3+OIL diets were eaten more slowly (data not shown), there was no difference in daily DMI between treatments ($P = 0.51$; Table 1). This was probably because feed availability was restricted in this study in contrast to *ad libitum* feeding situations in which a suppressive effect of nitrate on feed intake has often been observed (Weichenthal *et al*., 1963).

The lack of effect of treatment on DMI was consistent with there being no treatment difference in total VFA concentration, but in all treatments the butyrate percentage was high (13-17 mol%). The OIL treatment caused a significantly lower rumen pH and this was associated with a higher propionate percentage. Molar percentage of acetate in total rumen VFA was higher in NO3 treatment ($P < 0.01$). Microbial reduction of dietary nitrate utilises H$_2$ and stimulates acetate proportion (Nolan *et al*., 2010). The acetate:propionate ratio was higher than the control when NO3 was fed alone but lower than in the control when oil was fed alone ($P < 0.01$). In combination NO3 and oil did not have a net effect on acetate:propionate ratio.

These effects on DMI, total VFA concentration and molar proportions of individual acids do not completely explain the differential effects of treatment ($P < 0.01$) on methane yield (MY: g CH$_4$/kg DMI). Stoichiometrically, 1 mole of nitrate can be expected to reduce methanogenesis by 1 mol, so the inclusion of 20 g of NO$_3$/kg feed should have reduced methanogenesis by 0.323 mol or 5.17 g/kg intake in this study whereas the observed mitigation was 3.54 g or 68% of that expected. Similarly, dietary oil has been shown to reduce MY by approximately 1.02 g CH$_4$/kg DMI per 1% oil added (Grainger and Beauchemin 2011), so the 1.25 g CH$_4$/kg reduction in MY with oil alone is less than that predicted from including 5% canola oil.

In combination however, NO$_3$ and oil caused a larger reduction in MY (6.82 g/kg DMI) than the sum of their individual contributions without compromising DMI or total VFA concentration. These findings show that combination of NO$_3$ and dietary oils as simple fed additives offers a promising means of reducing ruminant enteric emissions. Similar results of additive effects between nitrate and oil were reported by Guyader *et al.* (2015) with nitrate and linseed oil.

**Acknowledgements**

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**References**


Programming lambs to improve utilisation of novel forages.

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² Revell Science

Introduction

Rapid dietary transitions are common for ruminants in Mediterranean-climate production systems. In their first eight months of life, lambs may transition from annual pastures to crop stubbles and native shrubs and be offered assorted supplementary feeds. Lags in production are common as young animals learn to eat novel feeds and select an appropriate diet. In this study, we explored the role of the ewe as a transgenerational link in familiarising lambs to locally available foods (see Provenza et al. 2003). The aim was to influence diet selection and productivity of lambs offered saltbush-based pastures in autumn. We tested the hypothesis that exposure to saltbush either (a) in utero or (b) pre-weaning with their mother or (c) a combination of both will result in less variation in saltbush intake and better growth than (d) lambs that have had no exposure to saltbush.

Method

This work was conducted on a commercial farm in Tammin, Western Australia. Ewes (who had all grazed saltbush previously) were scanned mid pregnancy and 280 single lamb bearing ewes were selected for the study. The ewes were randomly split into four treatment groups. For the last third of pregnancy (approximate as the ewes were not synchronised), two groups of ewes grazed annual legume and grass based pastures (with lupin supplements) while the other two groups grazed old man saltbush with cereal hay and a lupin supplement. After lambing, one group of ewes from each treatment and lambs were shifted to the other pasture system, resulting in a factorial design of; +/- saltbush exposure in utero (during the last 1/3 of pregnancy) and +/- saltbush exposure as a lamb with its mother (birth to weaning). After weaning, the lambs were managed as a single flock, grazing a cereal crop stubble. When the animals were ~8 months old they were allocated to 4 groups, each containing 4 lambs originating from each of the 4 maternal treatments. Lambs were weighed, condition scored and each group was placed into 4 replicated saltbush plots (2 ha each) and offered a 500 kg bale of cereal hay of moderate nutritional value. Lambs remained on the plots for 4 weeks and were reweighed. Every week during grazing the lambs were mustered and faecal samples were collected (per rectum). The faeces was used to estimate saltbush as a proportion of the total diet selected using the carbon isotope method, this allows a prediction of saltbush intake with an error of less than 2.7% (Norman et al. 2007). Data were analysed by ANOVA.

Results

Mean live weight change over 4 weeks of grazing and saltbush as a proportion of the total diet during the latter part of the first week of grazing are presented in Table 1. The groups of lambs originating from each of the treatment groups selected the same mean amount of saltbush in their diet during the first week of grazing. There was no significant differences associated with in utero exposure or early life experience with mum. However there were considerable differences in the variances within treatments. Lambs that had been exposed to saltbush with mum had almost half the variation in saltbush intake than those who had no exposure at all. The range for lambs with no previous exposure was 26 to 68% saltbush in the diet whereas lambs with exposure in utero and with mum ranged from 38 to 54% saltbush in the diet.
Table 1. Mean daily live weight change (g) of 8 month old lambs grazing saltbush and cereal hay over 4 weeks and saltbush selection during the first week of grazing.

<table>
<thead>
<tr>
<th></th>
<th>P:P</th>
<th>P:SB</th>
<th>SB:P</th>
<th>SB:SB</th>
<th>LSD (5%)</th>
<th>Significance of differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>cv</td>
<td>mean</td>
<td>cv</td>
<td>mean</td>
<td>mum</td>
</tr>
<tr>
<td>Daily wt change (g)</td>
<td>127</td>
<td>52</td>
<td>175</td>
<td>30</td>
<td>154</td>
<td>33</td>
</tr>
<tr>
<td>Saltbush in diet (%)</td>
<td>45</td>
<td>22</td>
<td>42</td>
<td>13</td>
<td>47</td>
<td>18</td>
</tr>
</tbody>
</table>

P = pasture system and SB = old man saltbush and hay. The first refers to in utero exposure, the second is with mum (ie P:SB lambs were born to ewes grazing pasture and then shifted to saltbush after lambing and prior to weaning).

Conclusions & implications

There is clearly an opportunity to improve productivity of lambs grazing saltbush through the use of transgenerational tools. Exposure to saltbush, both in utero and with mum during lactation, led to lambs having higher growth rates when they grazed saltbush in conjunction with cereal hay after weaning. Lambs that had been exposed both in utero and with mum grew 60% faster than lambs that had not had prior exposure to saltbush. This finding is not unexpected as Chadwick et al. (2009a) found that lambs exposed to saltbush (in utero and with mum during early lactation) were able to maintain live weight when grazing saltbush while lambs that had not been exposed lost weight. The same authors found that the lambs that had been exposed to saltbush had 8% higher fleece weights in later life than the control group (Chadwick et al. 2009a). Some of the physiological mechanisms that may be linked to improved productivity include altered hormones relating to salt and water balance (Digby et al 2009; Chadwick et al 2009b) and differences in kidney size and structure (Tay et al 20XX).

Diet selection would also impact on the growth rates of the lambs. Familiarity after exposure to saltbush with mum appeared to help the animals to select an appropriate diet. While there were no differences in mean saltbush intake between treatment groups, lambs subject to exposure with mum had almost half the variation in saltbush as a proportion of the diet, compared to lambs with no exposure. Saltbush has excessively high levels of salt, sulphur and oxalate so eating too much would be disadvantageous for growth. Equally the hay was only of moderate digestibility and crude protein, so selecting a balanced diet would optimise both voluntary intake and growth. There are a number of studies that document an animal’s ability to choose an appropriate diet based on learning from its mother.

Acknowledgements

This work was funded by CSIRO Agriculture and CRC Future Farm Industries. Thanks to Tony and Simon York at Tammin in Western Australia for hosting the research. Thanks to Elizabeth Hulm, Andrew Toovey and Paul Young for technical assistance.

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4- Nonylphenol induced Genotoxicity assessment in blood cells of fish

*Channa punctatus* using Comet Assay

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Summary

The present study has been undertaken to study genotoxic effects of endocrine disrupting compound nonylphenol (NP) on *Channa punctatus* after acute exposure using comet assay. Blood cells were used for the study and percent tail DNA was used as biological indicator. Fish were exposed to three sublethal concentrations (0.15 mg/l, 0.31 mg/l and 0.63 mg/l) of 4-NP for 24, 48, 72 and 96 hrs. Blood cell was found to show genotoxic effect and highest genotoxicity was found at 24 hrs of exposure followed by decrease in the value but at later hrs value again increases. So the present study is intended to shed light on the genotoxic potential of 4-NP in fish, *Channa punctatus* and to find the time for maximum induction of genotoxicity.

Introduction

Nonylphenol ethoxylates (NPE) are cost effective surfactants used in commercial and household applications such as detergents, dispersing agents and solubilisers (Soares *et al.* 2008). Due to extensive use of NPE, they reach sewage treatment works in substantial amounts where they are incompletely degraded to NP due to microbial action. NP has attracted the attention due to its perserviveness in the environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment can disrupt endocrine and reproductive systems. The investigation of the genotoxic potential of various aquatic pollutants has become a major task in the monitoring of environmental pollution. A number of techniques have been developed to test DNA alterations in aquatic organisms. Comet assay has advantage over other tests as these are easy technique, less time and resource consuming.

Blood is highly susceptible to changes in the environment and is a good indicator of environmental toxicity and is used for various genotoxicity studies in the case of fish as is easy to collect and no cellular dissociation is required. So keeping all these things in mind, this paper aimed at increasing the knowledge and understanding the toxic effects of 4-NP towards an aquatic vertebrates model *Channa punctatus*. *C. punctatus* is distributed throughout India. Such a species is of commercial importance due to its easy maintenance, high food value and availability throughout the year. Moreover *C. punctatus* has been used in fundamental research and considered as an excellent model for toxicological studies.

Materials and Methods

Freshwater fish (*C. punctatus*) of an average weight and length of 16.50± 2.14 g and 11.40 ± 2.01 cm respectively, were procured from the local fish market and acclimatized for two weeks under laboratory conditions in glass aquaria of 200 liters capacity. They were fed with boiled eggs and other waste materials were siphoned off daily to reduce the ammonia content in water. The 96 hrs LC_{50} value of 4-NP was determined as 1.27 mg/l^{1} for *C. punctatus* following the probit analysis method as described by Finney (1971). Based on the 96 hrs LC_{50} value, the three test concentrations of NP viz; SL-I; 1/8th of LC_{50} = 0.158mg/l, SL-II; 1/4th of LC_{50} =0.317mg/l and SL-III; 1/2nd of LC_{50} =0. 635mg/l were estimated and used for the in vivo experiment.

The blood sample was taken at the intervals of 24, 48, 72 and 96 hour at the rate of five fish per interval. The specimens maintained in tap water are considered as negative control while in ethanol as positive control.

Comet assay using blood cells were analyzed as per the protocol given by Ahuja and Saran, 1999. DNA damage was assessed using parameter percent tail DNA (TI) using Casplab software.

The results are expressed as Mean ± S. E. The data was analysed using Assistat version 7.7 beta (en) using one-way analysis of variance (ANOVA) to assess the effect of concentration and time using. The Tukey-HSD test was considered for multiple comparisons and signify the effect of concentration and time duration.

Results and Discussion

Table-1. showed the effect of different concentrations of 4-NP (0.51 mg/l, 0.31 mg/l and 0.63 mg/l) at different hrs of exposure on the blood cells. Treatment with 4-NP induced significant change (p ≤ 0.05) in TI when compared to both control groups. High DNA damage was observed at 24 hrs post treatment (p.t.) followed by a decrease in the TI value at 48 and 72 hrs. But at 96 hrs again the value increased. This might be due to repair of damaged DNA or replacement of highly damaged cells or both. Other reason may be gene activation like cytochrome p450 which activate the metabolizing enzymes which provide a defensive mechanism against genotoxicants. Similarly, Gulsoy *et al.* (2015) reported that when Zebra fish (*D. rerio*) were exposed to borax, the highest DNA damage was observed at 24 hrs, followed by a decrease at 48 and 72 hrs and again increase in the value was observed at 96 hrs, while treatment with boric acid induced highest effect at 96 hrs of exposure.

Highest DNA damage was seen at 96 hrs after treatment (p.t.) followed by a decrease in the TI value at 48 and 72 hrs. But at 96 hrs again the value increased. This might be due to repair of damaged DNA or replacement of highly damaged cells or both. Other reason may be gene activation like cytochrome p450 which activate the metabolizing enzymes which provide a defensive mechanism against genotoxicants. Similarly, Gulsoy *et al.* (2015) reported that when Zebra fish (*D. rerio*) were exposed to borax, the highest DNA damage was observed at 24 hrs, followed by a decrease at 48 and 72 hrs and again increase in the value was observed at 96 hrs, while treatment with boric acid induced highest effect at 96 hrs of exposure.

Highest DNA damage was seen at 96 hrs after treatment with 0.31 mg/l concentration. Decline in the value at highest concentration might be due to threshold repair theory according to which repair enzyme gets activated only when tissue accumulates the toxicant above a threshold level.

NP is reported to induce DNA adduct formation and mutation or genomic rearrangements (Vazquez-Duhalt *et al.*, 2008). Due to extensive use of NPE, they reach sewage treatment works in substantial amounts where they are incompletely degraded to NP due to microbial action. NP has attracted the attention due to its pervasiveness in the environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment. Concerns have increased recently as it can mimic natural hormones and its copious level in environment.
Increased DNA damage may also lead to apoptosis and apoptosis was observed in fish sertoli cells when exposed to NP. The finding of present study suggests that 4-NP is having genotoxic effect to fish C. punctatus and 24 hrs show maximum DNA damage at all the three concentrations.

Table 1. Percent tail DNA in blood cells of fish C. punctatus after exposure to different concentrations of 4-NP for different time intervals.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Time duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 hrs</td>
</tr>
<tr>
<td>Control</td>
<td>0.11±0.69&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethanol</td>
<td>0.37±0.16&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.15 mg/l</td>
<td>12.67±5.87&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.31 mg/l</td>
<td>11.3±0.80&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.63 mg/l</td>
<td>5.68±0.44&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

The values given as mean ± standard error. Different letters a, b, c, d and p, q, r, s are significantly different (Tukey’s test) and signify the effects concentrations and time duration.

Acknowledgement

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References


Major welfare issues facing the red meat industries in Australia

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Summary
The red meat industry has recently released a strategic plan which emphasises the importance of gaining and maintaining consumer and community support for the industry. This includes demonstrating continuous improvement in animal welfare, and minimising the impact of endemic diseases and the risk of exotic diseases. The key in doing this is how to put producers at the centre of improving welfare practices on their farm, giving them the tools to know what to tackle and how, helping them assess improvement and rewarding them for improvement, with a premium on assured labelled high welfare products.

Introduction, MISP 2020 analysis
In 2015 the red meat industry released the Meat Industry Strategic Plan MISP 2020. It makes some very telling and important observations about the importance of the industry and where it’s headed and how continuous improvement in animal welfare is essential, that are worth recapping.

“Globally, real per capita incomes will increase by 60% to 2030. With red meat consumption and per capita income being closely related, this translates to an increase in red meat demand of 25% over that period, as well as an increase in demand from markets specifically seeking high quality red meat and livestock products. Growth in consumption of chicken (29% to 2030) and pork (27%) will continue to outpace growth in consumption of red meats (16%). South American countries will be significant competitors to Australia in a number of beef markets expected to expand over the next 15 years. It will be critical to maintain our reputation for premium integrity and quality for Australian red meat in these markets, with this reputation continuing to be underpinned by robust integrity systems that engender complete confidence.

Of increasing importance is our ability to ensure these elements are used to actively align our practices with consumer and community expectations. Such alignment must flow both ways, and necessitates an on-going commitment to objectivity and transparency in communicating – and building understanding around – our industry’s activities and performance.

We must acknowledge that the biggest non-economic challenge facing our industry is cultural change – this is a far greater task than delivering any related technologies. Our enterprises, supply chains and industry as a whole must engender, support and reward a business and customer focus. Industry organisations must lead by example in promoting collaboration and transparency across our industry. The MISP highlights that the future of the red meat and livestock industry is one of valuable opportunities and significant threats. There is almost a 50/50 split between the benefits associated with capitalising on upside opportunities and those associated with mitigating downside risks. – Figure 9, 14 risk and benefits by 2030 relative to a net industry income of $488.
A key pillar for the red meat industry into the future is ‘Consumer and community support for the industry’s products and practices’. This requires improving the way we operate to gain ongoing consumer and community support for our industry, our activities and our products. It includes the priority area of ‘Welfare of the animals within our care’ with the following imperatives:

1. Continuous improvement of animal welfare
2. Minimising risk and impact of emergency disease
3. Minimising the impact of endemic disease

All the strategic scene setting translates into a need to continuously improve welfare across the value chain, to be transparent and to be able to verify such improvement, compliance with standards and assure consumers and community.

The way forward

There is a growing willingness and recognition of the necessity, among producers, to publicly champion and measure animal welfare and it is now a matter of how we put measures in place and report on this, back to our community. The issue is to find a practical way that gets the farmer into the middle of the improvement process.

“Schemes for the assessment of farm animal welfare and assurance of welfare standards have proliferated in recent years. An acknowledged short-coming has been the lack of impact of these schemes on the welfare standards achieved on farm due in part to sociological factors concerning their implementation” (Colditz et al. 2014). “In the UK, the various QA systems differ in the drivers and standards, and in the processes for inspection, assessment and audit. Moreover, to date, they have focused on inputs in animal management (eg, housing standards) rather than outcomes (the welfare of the animals) and none of them have been successful in capturing the red meat industries” (Martin and Blache, 2014; B.AWW.0236). Therefore no scheme exists, suitable for adoption in Australia that works and improves the welfare of ruminants on farm. I think this is what Professor John Webster is getting at with his “virtuous bicycle” where he puts the producer and the retailer at the centre of two joined wheels (Webster J, 2012).

We have already been working across a number of welfare areas in our industry for several years now and while we are making some gains, continuous improvement is essential. Areas include: land transport – journey and rest times, aversive husbandry practices, perinatal and cull female mortality and live export. The main game is to find ways to put producers at the centre of improving welfare practices on their farm, giving them the tools to know what to tackle, helping them assess improvement and rewarding them for improvement with a premium on assured labelled high welfare products.

References


Animal nutrition: past, present and future - value of thinking across species and across disciplines

The Eric Underwood Memorial Lecture

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Introduction

Eric Underwood was renowned for his ability to think through problems, as exemplified in solving Denmark Wasting Disease. Sheep and cattle introduced into coastal regions like Denmark in southern Western Australia would, after around three months, start losing weight, become anaemic and frequently die. Anaemia and low haemoglobin concentrations had been associated with iron deficiencies. Working with J.F. Filmer in the early 1930s, Underwood showed that feeding limonite, a hydrated iron oxide compound, or liver from unaffected animals, alleviated the disease. Although the hypothesis that dietary iron cured the problem seemed credible, the iron concentration in liver and spleen from affected animals was 3—6 times higher than from healthy animals. Underwood speculated that another compound must be required for effective iron metabolism (Underwood and Filmer 1935).

Underwood proceeded with a series of extractions from limonite and found the disease was cured by two iron-free extracts, but not a high copper extract. One extract was high in chromium and aluminium and the other in zinc and nickel. Further research with zinc and nickel compounds showed a positive response in sheep to nickel oxide but not to nickel chloride. Underwood speculated that a trace contaminant in compounds used must be responsible and proceeded to include manganese and cobalt in the diets. Cobalt at concentrations as low as 0.1 mg/day cured the disease. This finding raised a conundrum because, liver but not liver ash, from unaffected animals cured the disease. Hence, Underwood presumed that cobalt must be incorporated into an organic compound to be metabolically active; a thought that was subsequently verified with the discovery of cobalamin, or vitamin B12.

This example of the logical approach Underwood took to solve Denmark Wasting Disease provides a great stimulus for creative thinking about the research process and where new advances in animal nutrition and productivity may be derived. Black (2016) concludes that advancement in productivity in any industry or human endeavour comes from new technologies. These novel technologies are commonly derived from curiosity research or research targeted to provide a major change to an industry. This paper outlines how cross species and cross discipline thinking has advanced animal nutrition science in the past and may do in the future.

Past examples

Estimates of protein requirements of growing lambs in the early 1960s ranged from 9.5 to 20% of the diet. The wide range was caused primarily by differences between experiments in the extent dietary protein was degraded in the rumen and energy content of the diets. Research over preceding years with rats had shown that utilisation of protein depended on the essential and non-essential amino acids content of the protein, energy from the diet available for metabolism and weight of rat. Findings from these rat studies led to the conclusion that protein requirements of lambs should be considered in two steps: i) requirements for amino acids of the combined animal tissues in relation to the energy available for metabolism; and ii) modification of dietary ingredients by rumen microorganisms and the resulting supply of amino acids and energy sources for absorption and metabolism (Black 1970). Consequently, my PhD research determined the protein and energy requirements of lambs by infusing complete diets into the abomasum of animals ranging from 10 to 30 kg. Subsequently, these results were incorporated into simulation models which predicted the effects of rumen microbes on amino acid and energy absorption by sheep and their utilisation for body functions including muscle and visceral growth, wool production and fat deposition. These models could then be used to identify amino acid and energy requirements for sheep under a wide range of situations and predict rates of change in growth, body composition and wool production (Graham et al. 1976).

Low nutritional status of honey bees reduces productivity and industry profitability through shorter longevity, smaller foraging distances, poorer brood rearing and increased susceptibility to disease. Commercial honey bees were introduced into Australia from Europe. Low nutritional status of bees, or the 'skinny bee syndrome', is common in Australia because of the dominant flora. Australian eucalyptus species produce large amounts of nectar, small amounts of pollen on stamens distant from the nectar and are typically fertilised by small mammals and birds. Honeybees working eucalyptus flows fly to the nectar without touching the stamen and produce large amounts of honey. However, the number of bees in colonies declines rapidly due to lack of nutrients from pollen. An artificial pollen would be valuable and, if combined with a sugar supplement, assist expansion of colonies following winter and during periods of floral dearth. However, there was little knowledge on nutrient requirements of honey bees. Consequently, a factorial
approach used for domestic livestock to assess nutrient requirements was adopted (Black 2006). The amount of each nutrient deposited in the body of bees during growth to maturity plus an estimate of endogenous losses were used to predict the protein, amino acid, fatty acid and mineral requirements. Energy requirements were calculated based on needs for metabolism, flight and brood-temperature control. The estimated requirements have been used to develop a pollen supplement (Manning 2016) and a simulation model to predict pollen and sugar needs for individual colonies (Black 2006).

Possible future applications

A concept could be that, through evolutionary development, a mismatch occurred between microbes optimising their growth and reproduction in the rumen and the animal optimising its performance with the nutrients supplied from the rumen. The consequence of these two partially independent evolutionary outcomes is that the supply of nutrients to the animal from feed and existence of a large microbial population in the gut is not optimised for animal productivity. An example is the production of methane, where 3—12% of the digested energy is converted to methane and lost from the animal for productive purposes. Recent research has shown methane emissions can be substantially reduced, and provide an increase in energy for animal productivity (McSweeney 2016). Methane may not be the only inefficiency for the animal resulting from microbes residing in the rumen. Evidence from monogastric species could be used to develop hypotheses about ways to improve ruminant productivity.

Ruminants are more resistant to infection following surgery than monogastric species. The heightened immune response in ruminants is likely to come at a cost to performance. Large populations of viable non-pathogenic bacteria in pig environments are known to reduce performance by at least 10% due to stimulation of the immune response (Lee et al. 2005). Pro-inflammatory cytokines stimulate the production of prostaglandin E2 (PGE₂), which is largely responsible for reduction in feed intake and decreased protein synthesis causing depressed growth. PGE₂ synthesis can be greatly reduced by the use of compounds like aspirin and the COX₂ inhibitor, meloxicam, in diets fed to pigs. Would similar anti-inflammatory drugs improve productivity of ruminants?

Rumen microorganisms hydrogenate unsaturated dietary fatty acids and increase n6:n3 fatty acid supply to the animal. Strong evidence from monogastric species shows that high n6:n3 ratios in fatty acid consumption reduce disease resistance and performance. High n6:n3 fatty acid increases production of pro-inflammatory cytokines, stimulates the immune system and changes the function of cell membranes (Harbige 2003). These changes are associated with increased cardiovascular disease, cancer, mental disorders in humans and energy metabolism through alterations to cell sodium and calcium pumps (Ibarguren et al. 2013). Recent research has shown that feeding small quantities of poly-unsaturated natural and designed synthetic fatty acids to monogastric animals markedly changes cell membrane composition and function, with positive effects on human health. The impact on animal performance of feeding natural or synthetic n3 fatty acids protected from rumen hydrogenation may result in improved ruminant productivity.

Viral diseases have major consequences for animal production and human health. Outbreaks of Nipah, Hendra, Menangle, Lyssa, Ebola viruses and Rabies in animals and man have been traced to flying foxes, but these mammals show no clinical symptoms of the diseases. Recent research suggests that bats coexist with viruses through rapid control of viral replication resulting from major differences in the interferon, IFN-α, genes compared with other mammals (Zhou et al. 2013). Only one IFN-α gene has been identified in bats compared with 13 in humans. The three interferon regulatory factor binding molecules on this one bat gene are totally disrupted compared to human or mouse genes, which makes it unresponsive to stimulation with challenge viruses, such as Sendai virus. Could disruption of the more abundant IFN-α genes in domestic animals eliminate viral diseases?

Conclusions

These few examples suggest that major advances in the understanding of nutrition and improvements in animal productivity can come from transfer of knowledge across species and scientific disciplines.

References


ASAP Animal Production 2016, Adelaide
Preparing the neonate for the transition from intra- to extra-uterine life

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Summary
Offspring mortality limits reproduction as well as animal welfare in livestock industries. A new focus on the neonate itself could improve survival beyond the static 80 to 90% that is commonly cited in both the sheep and pork industries. Neuropeptactants limit the CNS damage caused by oxygen deprivation during the birth process, an issue that has both direct and indirect consequences for survival. We have demonstrated that two compounds, MgSO4 and creatine monohydrate, improve the behavioural and physiological responses of the pig neonate after birth, suggesting they may be suitable for use in livestock species. Similarly, increasing the physiological maturity of the neonate at birth could improve survival, as we have linked maturity with improved behavioural and thermoregulatory outcomes. Development of novel means of enhancing physiological maturity are needed and will be facilitated by applying lessons learnt from one species to others.

Introduction
Neonatal mortality is a major constraint to the reproductive output of large animal livestock industries. The morbidity and mortality of young animals can also impede welfare. Trauma caused by the birth process, hunger, hypothermia, distress from maternal separation, and disease resulting from insufficient colostrum ingestion, have all been identified as factors that impair the welfare of the neonate (Dwyer 2008). Mortality of lambs and piglets ranges between 10-20% (Brien et al. 2010; APL 2013), a figure that is unacceptably high. Interestingly, the causes of mortality in lambs and piglets are surprisingly similar. Intra-partum death (stillbirths in piglets and dystocia in lambs) is a significant, direct contributor to mortality, but hypoxia during birth can also increase the likelihood of other causes of mortality. These include starvation, chilling and mismothering.

For both species, little improvement in survival has been reported, and in fact, may actually be declining as fecundity increases, and as changes in birth weight are observed. These two points can be inter-related, for example as the number piglets born within a litter increases, birth weight declines (Damgaard et al. 2003). Or they can be independent of one another, with the increasing use of inappropriate sires resulting in heavier lambs, feto-pelvic disproportions, and so risk of dystocia and associated issues (Hinch and Brien 2014). Neonatal survival is dependent on many factors including the physical environment the offspring is born into, as well as the environment the mother creates. The direct impact of the neonate itself on its ability to survive has received less scientific attention. Protection from neural damage that can occur during the birth process, and the improved transition from intra to extra-uterine life could improve the survival of neonates.

Fetal neuroprotection
Extended labour, or compression or rupture of the umbilical cord can result in a hypoxic event. If severe, this hypoxia is lethal and the offspring is born dead. In lambs, this represents 30% of total mortality (Refshauge et al. 2016) and in piglets 40% of those that perish are born dead (APL 2013). In addition to anoxia, non-lethal hypoxic damage caused during labour contributes to mortality indirectly. In piglets, reduced vitality and thermoregulatory ability in hypoxic individuals has been reported (Herpin et al. 1996). Similarly, increased latency to suck is associated with decreased pO2 levels at birth in lambs (Dutra and Banchero 2011).

Strategies that prevent, limit or slow neuronal damage, which occurs during hypoxia, have been termed neuroprotectants, and are widely studied in human medicine for the prevention and treatment of central nervous system disease. Magnesium acts to limit cell apoptosis through the reduced production of pro-inflammatory cytokines and free radicals after hypoxia-ischemia (Marret et al. 2007). Our studies in pigs have shown that MgSO4 administered orally to sows at 21g/sow/day prior to farrowing tended to improve the vitality and blood glucose levels of newborn piglets. Colostrum ingestion (24h weight gain) was higher in hypoxic piglets (high meconium stain score) than those from the control group ((Plush et al. 2015); Figure 1).

We also observed significant increases in the thermoregulatory ability of piglets from MgSO4-treated sows 15 minutes after birth, and at 24h of age in piglets classed as low birth weight (unpublished results).

Inclusion of creatine monohydrate has been shown to protect the neonatal brain from the consequences of oxygen deprivation in spiny mice (Dickinson et al. 2014). We were
able to show that maternal supplementation of 5% creatine to sows prior to farrowing improved postnatal behaviour, with a reduced latency to contact udder and suck observed in piglets from treated sows (van Wettere et al. 2015). Given these improvements in behaviour, colostrum ingestion and thermoregulation, it would be expected that these promising neuroprotectants will improve the survival of neonates, and experiments to determine whether this is indeed the case are currently underway.

Physiological maturity at birth

‘Physiological maturity’ of the newborn has been implicated as an important contributor to mortality (Thompson et al. 2006). The term refers to the neonate’s ability to adapt to the changes between intra-uterine and extra-uterine life. In particular, this means the capacity to adapt to an abrupt change in energy metabolism (Greenwood et al. 2002), to adjust to independent oxidative metabolism, and to regulate homeothermy autonomously (Bassett 1989).

We hypothesised that neonatal vigour is an indication of physiological maturity at birth (Plush et al. 2016a), and were able to demonstrate that lambs exhibiting rapid behavioural progression also show improvements in markers of physiological maturity (unpublished results). Lambs that were fast to stand (top quartile) displayed increased rectal temperature at birth (fast: 39.4 ± 0.1°C and slow: 38.3 ± 0.2°C, P < 0.05) and tended to resist hypothermia for longer at 24h of age (fast: 55.2 ± 2.0 min and slow: 48.0 ± 2.8 min, P = 0.08) than those that were slow to stand (bottom quartile). Additionally, endocrine markers of maturity were also affected by behavioural progression, as ‘fast’ lambs tended to display higher cortisol levels 30min into a cold challenge than ‘slow’ lambs (fast: 199.4 ± 16.9 nmol/mL and slow: 127.4 ± 38.2 nmol/mL, P = 0.1), and higher leptin concentrations after the cold challenge (fast: 1.24 ± 0.06 ng/mL and slow: 0.96 ± 0.06 ng/mL, P < 0.01) than slow to stand lambs (for methodology see Plush et al. (2016b)).

Nutritional restriction around the time of conception could increase neonatal maturity as it reduces gestation length in sheep (Bloomfield et al. 2003), explained by an accelerated maturation of the hypothalamic-pituitary-adrenal axis in the fetus (Bloomfield et al. 2004). Given the important role of cortisol in preparing the fetus for the transition from fetal to postnatal life, we hypothesised that peri-conceptional restriction of nutrition (low PCN) would improve the physiological maturity of lambs, and therefore increase survival rates. Lambs from low PCN ewes returned faster to their mothers after release and contacted the udder in the shortest time at approximately 12h of age (Kleemann et al. 2015). This improvement in behaviour failed to translate to an increase in survival, most likely attributed to favourable weather conditions. However, others have been successful in improving lamb survival rates by restricting ewe nutrition in early gestation (Munoz et al. 2007).

Conclusions

The survival of neonates has shown little improvement in recent years both within the sheep and pork industries. A shift in focus from the environment in which the offspring is born into, to the offspring itself could prove useful in reducing mortality. Two novel fields of research; the use of neuroprotectants, and increasing physiological maturity at birth, have been linked to improvements in behavioural progression and thermoregulation. Both appear to be suitable targets for increasing neonatal survival, and so could ultimately improve the reproductive output and welfare standards of large animal livestock industries.

Acknowledgements

We wish to thank all co-authors on cited publications for their contributions, and the CRC for Sheep Industry Innovation, and Australian Pork Limited for funding the experiments presented.

References


Although dehorning and castration are recognized as requisite practices in modern livestock systems, producers would like to avoid animal welfare issues that arise from current management methods. Increased criticism and scrutiny of both producers and the food industry emanates from a growing number of concerned citizens and NGOs with animal rights/animal welfare agendas. The optimal and simple solution for dehorning cattle is to breed for polled animals, but crossbreeding devalues animals when considering the cost of recovery to re-establish elite performance for production. Similarly, solutions for genetic castration would seem impractical due to obstacles for propagating sterile lines. In this study, we report the efficacy of precision cross-breeding, also known as gene-editing, as a means for elimination of dehorning and surgical castration.

Introduction

Since the first livestock domestication events approximately 10,000 years ago, the efficiency of animal production in the developed world has continued to improve through selection for desirable traits related to protein yield. More recent advances in animal breeding theory (i.e. genomics), advanced reproductive technology, housing, feed and forages, and vaccine and drug treatments have allowed for intensification of production. However, none of these husbandry tools directly addresses some of the most common yet controversial management practices of livestock production, dehorning and surgical castration.

In the United States, an estimated 80% of all dairy calves (7.2 million per year) and 25% (7.5 million animals) of beef cattle are physically dehorned every year (Bouie 2002) to protect animals and producers from accidental injury. Because animal advocacy groups have campaigned for mandated anesthesia during dehorning or complete cessation, global corporate food retailers have prioritized use of humane management alternatives to dehorning in their animal welfare policies (Swanson 2015).

Solutions based on animal breeding are intuitively the most likely method to solve this problem; however, full implementation is hampered by generation interval times, economic feasibility and practicality for low input production systems. For example, the use of existing polled dairy genetics carries a substantial value difference of $252 USD per lactation cycle between horned and polled dairy cows (Dorshurst 2015).

Like dehorning, surgical castration has been practiced for centuries in swine production; now affecting hundreds of millions animals annually. The main purposes are to reduce aggressive behaviour of males and remove ‘boar taint’ from pork. Research has proven that castration inflicts pain, even on very young pigs under anaesthesia or analgesia. Recently, European swine industry leaders voluntarily signed a declaration to abandon all forms of surgical castration by Jan., 2018. DNA-based selection tools have been used to reduce boar taint genetics down to between 0-13% across populations, but this reduction appears associated with reduced libido. Alternatives, like vaccinations against boar taint, possibly have negative effects on carcass yield (Aluwe et al., 2015).

Based on the welfare issues surrounding both dehorning and castration, we set out to demonstrate that advanced breeding techniques, like non-meiotic allele introgression (Tan et al., 2013), offer an alternative non-GMO method for rapid genetic change in a single generation. Furthermore, we show these methods are precise, sustainable, and directly applicable to improved animal well-being.

Materials and Methods

Experimental procedures involving animals were done according to established standard procedures and protocols approved by Integra, MOFA and Trans Ova’s Institutional Animal Care and Use Committees.

Bovine fibroblasts derived from crossbred dairy bull calves were used for somatic cell nuclear transfer (SCNT) and genome analysis as previously described (Tan, 2013). All methods to create and identify properly edited clonal cells, other than HP-24.8 (Carlson, et al., 2016), were described previously (Tan, 2013). Individual colonies were evaluated for introgression of the Pc (polled locus of Celtic origin). Nuclear and embryo transfers were done by Trans Ova Genetics (Sioux Center, IA). Genetic analysis of cloned offspring for both the Pc locus and genome-wide off-target editing events are described Carlson and colleagues (2016). Skull palpations were done by a non-blinded licensed veterinarian at birth, 3, 6 and 10 months of age.

All porcine studies were done at Minitube of America (Verona, WI). Porcine somatic cells and TALen gene knock-out (KO) techniques used for SCNT of gene edited cell lines were previously described (Carlson, 2012). The TALen for genetic castration was designed to break the KISSR gene in the third exon. Individual colonies were propagated and evaluated for KISSR KO as previously reported (Tan 2013).

Puberty induction studies was set up with three groups of KISSR KO cloned male pigs (each N=4): 1) control/sham injected, 2) FSH/slow release treatment and 3) GnRH treatment. FSH was administered using Pluset H, which
includes 5.2 IU of FSH and 17.5 IU of LH per mL. Doses were given as intramuscular injections (i.m.) with a mixture of 150-225 IU of Folltropin to slow release formulation and reduce treatment to a dose every 2d. GnRH treatment consisted of i.m. injections of Cystorelin at 50 μg/injection daily for 4 wks, 2 times/d for 4 wks, and then 4 times/d for 4 wks. The GnRH protocol was not expected to induce puberty; but testosterone, LH, and FSH levels could be determined, to support future testing of hormone treatments. All animals were euthanized humanely for subsequent histology and gene expression studies.

Results and Discussion

For the genetic dehorning, five clonal cell lines with the correct 212 bp insertion/10 bp deletion to replicate the Pc allele were identified after Talen editing of fibroblasts from two “horned” male animals. After seven rounds of SCNT, 26 of the 70 surviving blastocysts were placed into recipients to yield five live polled animals. Three of these animals were humanely euthanized shortly after birth due to known complications from cloning. The polled phenotype was also confirmed in the remaining two homozygous polled animals at 3, 6 and 10 m of age. These yearling bulls are at UC-Davis for further evaluation of unintended effects from the gene editing process. However, diagnostic sequencing of Pc and whole genome sequence comparison between the two parental cell lines and representative cloned animals revealed no unintended changes caused by the editing process.

Our results appear to provide the first empirical validation of a putative causative allele in livestock, which in this case is a sequence variant duplication in a genomic region with no known function or predicted coding or noncoding genes. The polled bulls created by precision crossbreeding demonstrate that introgression of Pc into elite animals could eliminate the need for dehorning. This solution would be more economically viable than traditional crossbreeding; and if implemented across the industry, should improve the welfare of cattle globally.

For genetic castration of swine, a single edited cell line (Kissr +/-) derived from a White Composite male pig was used for SCNT. Blastocysts were transferred into three recipients, which resulted in two successful pregnancies yielding 19 piglets (2 stillborn). The 17 remaining animals were raised to 200-225 lbs. The Kissr KO edit was diagnostically confirmed as was lack of testicular development. The animals looked and acted (low aggression) like barrows in good health, and were phenocopies of humans with hypogonadotropic hypogonadism.

We attempted to initiate testicular development in these pigs using hormone therapy as a potential method to rescue reproductive competency (Fig. 1). The hormone treated testes increased mass and structural histology strongly supported the potential for recovery of sperm production with a more efficacious treatment even though sperm were not detected in any group. Current studies are underway to compare growth efficiencies between normal, castrated, and Kissr KO pigs. These results are needed to validate the market value of genetic castration.

Genetic improvement of livestock using precision crossbreeding (genome-editing methods), establishes an alternative to GMO-based (transgenic) methods for genetic improvement of livestock. Making these changes using natural occurring alleles would be consistent with non-GMO breeding principles and would provide rapid change without admixture-derived devaluation common to traditional crossbreeding. Furthermore, we demonstrated genome editing can be used to benefit animal health and welfare by eliminating stressful management practices in a single generation.

Figure 1. Comparison of testes mass between control and hormone treated pigs with Kissr knock-out.

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References


Consumer valuation and attitudes towards farm animal welfare claims

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Summary

A representative (n=1009) sample of Australian meat consumers completed a comprehensive online survey in 2015. A discrete choice experiment (DCE) was used to determine the relative importance of farm animal welfare status versus other credence attributes, and the trade-offs meat consumers make between credence attributes when purchasing four types of fresh meat (beef, pork, chicken, lamb) products. Credence claims have a significant impact on purchase decisions for all meat types investigated. Overall, meat buyers value the No-Added Hormones claim more than claims relating to animal welfare status, including ‘Certified Humane’ claims and Free-Range or Pasture-Raised claims, as well as other credence claims (Organic and Antibiotic-Free). There is relatively little difference in consumers’ willingness to pay (WTP) for different claims across meat types; preferences for the credence claims are relatively independent of meat cut; and there are few significant interactions between socio-demographic characteristics and credence claims.

Introduction

Globally, there is increasing consumer concern about animal welfare across all livestock sectors. Recent media reports focusing on cases of unethical treatment of farm animals have impacted meat markets and public opinion. For example, in 2011, Australia banned the live export of beef cattle to Indonesia after media reports suggested animals were being treated unethically. Concern about adverse impacts on the livestock industry as well as consumers in Australia and Indonesia have driven livestock industries to implement new management (e.g. production and transport standards) and marketing strategies, including labelling, to both ensure and communicate their animal welfare values and standards to consumers. However, it remains to be established whether these strategies alleviate or exacerbate consumer concerns, or if Australian consumers understand and use the additional information when purchasing meat products.

This study used a discrete choice experiment (DCE) to determine the relative importance and the trade-offs Australian meat consumers make between credence attributes, including farm animal welfare status, when purchasing fresh meat (beef, pork, chicken, lamb).

Methods

The DCE was part of a national online survey of a representative sample of 1009 Australian meat consumers conducted in 2015. Respondents answered questions regarding socio-demographic variables; meat purchase and consumption behaviour; understanding of existing meat product labels; and experience, knowledge and attitudes related to livestock management practices.

For the DCE, respondents were asked to imagine they were shopping for fresh meat to be prepared and consumed at home for a typical main meal. Each respondent completed four choice sets, specific to one type of meat. Respondents indicated their most likely choice in each choice set, out of the five options presented (including a no-choice option). The meat options shown in each choice set were described in terms of seven attributes: Price (four); meat cut (two) and the five credence claims (two levels) shown in Table 1.

Table 1. Meat claim attributes

<table>
<thead>
<tr>
<th>Production method</th>
<th>Organic status</th>
<th>Farm Animal Welfare status</th>
<th>Other claims</th>
<th>Other claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef &amp; Lamb:</td>
<td>Certified</td>
<td>Certified Humane</td>
<td>Antibiotic</td>
<td>No Added</td>
</tr>
<tr>
<td>Pasture-raised</td>
<td>Organic</td>
<td></td>
<td>Free</td>
<td>Hormones</td>
</tr>
<tr>
<td>Chicken &amp; Pork:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

The DCE used a Bayesian design resulting in 24 choice sets in total for each of the four meat types. To avoid respondent fatigue, respondents were randomly allocated to one of six different versions of four choice sets. Respondents’ choices were analysed using error component random parameter models, which were meat-specific and accounted for heterogeneity between alternative options (meat cuts).

The error component random parameter logit (ECL) model is a variant of the mixed logit model (Train, 2003), which can be specified as:

\[ L_{ij}(\theta) = \frac{\exp \left( \beta X_{ijk} + \theta_j E_{ij} \right)}{\sum_q \exp \left( \beta X_{qjk} + \theta_q E_{qj} \right)} \]

where \( X_{ijk} \) are the attributes for individual \( i \) making choice \( j \) from a set of \( k \) choices, \( \beta \) represents the density function explaining choice variation, \( E_{ij} \) are alternate specific random individual effects, \( \theta \) is a parameter, and \( q \) are alternate choices to \( j \). The density function varies with heteroscedasticity (Train 2003). Socio-demographics were
included in the choice models in an attempt to link choices with observable covariates and better understand preferences.

Results and Discussion

Overall, 70% of meat consumers indicated that they were somewhat concerned about or interested in FAW issues, suggesting that meat consumers might consider FAW claims in their purchase decisions. While 34% agreed to some extent that ‘FAW in Australia concerns me so much that it influences my food purchases’, 28% agreed that ‘use of hormones in meat production concerns me so much that it influences my food purchases’. There were significant preferences for all five credence claims across the different meat types.

Willingness to pay (WTP) was estimated for the different claims (Table 2) and these values can be compared across meat types as they account for scale heterogeneity across the separate models.

Poe et al. (2005) tests showed that WTP for ‘No Added Hormone’ meat was significantly higher (P<0.01) than the WTP for all other claims, including those related to FAW (Production method and Certified Humane). WTP for the Certified Humane claim was significantly higher (P<0.10) than the Antibiotic-free claim, while WTP for Production Method and the Organic claim was not significantly different to other claims apart from the ‘No Added Hormone’ claim. These findings suggest that consumers value the hormone status of their meat more than the welfare status of animals raised for meat. This may reflect both a greater concern for personal wellbeing rather than the wellbeing of farm animals, and a belief that hormone status of meat has a greater effect on consumers’ health and safety than animal welfare status. Compared with ‘Certified Humane’, a larger share of meat consumers believed ‘No-Added Hormones’ is ‘a healthier choice’ (36% vs. 16%) and ‘safer- less likely to make me or my family sick’ (35% vs 12%).

Few significant interactions were found for credence claims and meat cut, indicating that preferences for the credence claims are relatively independent of the meat cut. Similarly, few significant interactions were found for credence claims and frequency of consumption. There were only three significant interactions between socio-demographic factors and credence claims: males were less likely than females to select the ‘Certified Humane’ claim; respondents aged 60 years and over were less likely than younger respondents to select the ‘No Added Hormones’ claim; and those with a higher than average household income were more likely than those with a lower income to select the ‘Organic’ claim.

No known studies have explored the relative importance of such a wide variety of credence attributes for different meat types. This is also the first national study of Australian meat consumers, which provides insight into the understanding of existing meat product labelling and concerns regarding livestock management practices. Further analyses are needed to investigate interactions between credence claims and to explore how attitudes towards FAW influence preferences. This information will help to frame and target consumer information about FAW labelling. Findings from this research are well positioned to inform policy makers and stakeholders in meat markets tasked with labelling and information policies aimed at maintaining Australian consumers’ trust in the livestock industry.

References


Table 2. WTP estimates for credence claims and 95% confidence intervals

<table>
<thead>
<tr>
<th></th>
<th>Beef</th>
<th>Chicken</th>
<th>Pork</th>
<th>Lamb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>$1.49</td>
<td>$1.45</td>
<td>$1.12</td>
<td>$0.80</td>
</tr>
<tr>
<td></td>
<td>($0.70 -</td>
<td>($0.88 -</td>
<td>($0.32 -</td>
<td>($0.22 -</td>
</tr>
<tr>
<td></td>
<td>2.54)</td>
<td>2.28)</td>
<td>2.40)</td>
<td>1.70)</td>
</tr>
<tr>
<td>Organic</td>
<td>$1.76</td>
<td>$1.03</td>
<td>$0.75</td>
<td>$0.52</td>
</tr>
<tr>
<td></td>
<td>($0.96 -</td>
<td>($0.45 -</td>
<td>($0.10 -</td>
<td>(-0.13 -</td>
</tr>
<tr>
<td></td>
<td>2.84)</td>
<td>1.86)</td>
<td>1.80)</td>
<td>1.51)</td>
</tr>
<tr>
<td>Humane</td>
<td>$1.53</td>
<td>$0.98</td>
<td>$2.01</td>
<td>$1.09</td>
</tr>
<tr>
<td></td>
<td>($0.68 -</td>
<td>($0.44 -</td>
<td>($1.03 -</td>
<td>($0.39 -</td>
</tr>
<tr>
<td></td>
<td>2.66)</td>
<td>1.77)</td>
<td>3.58)</td>
<td>2.16)</td>
</tr>
<tr>
<td>Antibiotic</td>
<td>$1.49</td>
<td>$0.99</td>
<td>$1.35</td>
<td>$0.52</td>
</tr>
<tr>
<td></td>
<td>($0.68 -</td>
<td>($0.44 -</td>
<td>($0.54 -</td>
<td>(-0.10 -</td>
</tr>
<tr>
<td></td>
<td>2.57)</td>
<td>1.79)</td>
<td>2.64)</td>
<td>1.48)</td>
</tr>
<tr>
<td>Hormone</td>
<td>$2.47</td>
<td>$1.79</td>
<td>$2.52</td>
<td>$1.72</td>
</tr>
<tr>
<td></td>
<td>($1.46 -</td>
<td>($1.10 -</td>
<td>($1.46 -</td>
<td>($0.96 -</td>
</tr>
<tr>
<td></td>
<td>3.83)</td>
<td>2.81)</td>
<td>4.23)</td>
<td>2.91)</td>
</tr>
</tbody>
</table>

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Consumers link ‘better’ farm animal welfare with better quality products

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Summary

Current consumer concern with farm animal welfare is part of ethical consumerism where consumers seek to reduce the impact of their choices on “moral others”. We have been examining consumers’ motivations to purchase food with animal welfare claims across two projects using qualitative approaches. Results suggest that consumers strongly link animal welfare claims with superior product quality. Consumer perceive that red meat production is extensive, in contrast to eggs, chicken meat and pork production. However concerns about “unnatural” diets and confinement during transport in red meat production mirror concerns about intensive production systems. Understanding how consumers think about farm animal welfare and the role it plays in purchasing decisions is key to engaging both consumers and producers in discussions about how to develop animal products that are affordable, safe, nutritious, sustainably produced, and humanely produced.

Introduction

Increasing sales of animal products with welfare claims and recent campaigns by animal advocacy groups have been linked to increased public concern with farm animal welfare. While community/citizen concern for farm animal welfare arguably began in the 1960s (Woods 2011), current consumer concern for farm animal welfare can be considered as part of growing and more widespread interest in so-called ethical food production, in which consumers make choices that have reduced impact on ‘moral others’ such as communities of people, animals or the environment, and may seek to influence food production systems (Ankeny 2012).

Our initial project (ARC Discovery Project DP110105062) aimed to understand why Australians make what they consider to be ethical choices when purchasing food. When discussing purchases of animal products with our participants (described further below) conversations were predominantly about eggs, with little discussion of meat, and dairy. Participants mentioned recent advertisements by activist groups as well as documentaries and the activities of celebrity chefs as sources of information. Participants mentioned clear labelling and prominent positioning of free-range eggs within the supermarket to be healthier and safer in contrast to eggs produced in intensive systems. Participants perceived risk in the ‘more natural’ diet. Quality was mentioned much more readily as a motivating factor for purchase than concerns about animal welfare. Free-range eggs also were thought to be healthier and safer in contrast to eggs produced in intensive systems. Participants perceived risk in the ‘unknown’ composition and use of ‘chemicals’ in hen diets.

Four key factors emerged from the data to explain the reasoning behind their answers in dialogue with the interviewer. Qualitative data collection focuses on the range of opinions and representations of an issue rather than counting opinions or people, and sampling is considered adequate when no new themes emerge from the data (Gaskell 2000). DP110105062 involved 73 participants from Adelaide. LP130100149 involved 53 participants in Adelaide, Toowoomba and Melbourne.

Focus groups and interviews were recorded, transcribed, anonymised, and checked for accuracy against hand-recorded notes. Analysis was performed by one researcher coding the transcripts for major themes emerging from the data, similar to the “open coding” method described by Corbin and Strauss (1990) using a general inductive approach. Validity was checked by a second researcher by comparing these themes to those identified independently by her in the transcripts.

Results and Discussion

1. Free-range and cage-free eggs (DP110105062)
Free-range or cage-free designators on labels serve as proxies for quality. Participants explained that, in comparison to intensively-produced eggs, free-range eggs had superior sensory characteristics (in particular their taste and yolk colour), and attributed these characteristics to the animal’s ‘more natural’ diet. Quality was mentioned much more readily as a motivating factor for purchase than concerns about animal welfare. Free-range eggs also were thought to be healthier and safer in contrast to eggs produced in intensive systems. Participants perceived risk in the ‘unknown’ composition and use of ‘chemicals’ in hen diets.

Four key factors emerged from the data to explain the dominance of free-range eggs over other products with animal welfare claims:

a) High levels of awareness about the use of cages in egg production. Participants mentioned recent advertisements by activist groups as well as documentaries and the activities of celebrity chefs as sources of information.

b) Participants mentioned clear labelling and prominent positioning of free-range eggs within the supermarket compared with other welfare products with welfare claims.
consumers such as confinement did not arise as a typical farm animal welfare issue perceived by meat, and pigs. Sheep and cattle are raised ‘out in a paddock’ production particularly when compared to eggs, chicken and red meat production is associated with extensive campaigns, and if these are the only sources of information, awareness of caged egg production existed before these prominent influences, but it is difficult to estimate what levels of product quality and safety were more readily spoken of as a motivation to purchase free range pork, chicken and eggs than red meat. Grazing production systems were described by participants in connection to the production of beef and sheep meat, were seen as preferable, and enabled the animals engage in natural behaviours. Some participants were unaware about sheep and beef production methods. There was little mention of feedlots or other intensive production methods in relation to sheep and beef cattle, and these were mostly mentioned in connection with experiences overseas, such as in the USA or Europe.

Similar to the previous project however, themes relating to a ‘natural diet’ and confinement emerged from participant responses. ‘Grass-fed’ beef was linked to a ‘natural diet’ by consumers of that product, the corollary of which is that grain based diets are unnatural and have negative impacts on both meat quality and animal welfare. The use of agricultural chemicals in grain production contributed to this perception. Confinement during transportation was problematic for many participants, despite transportation standards to limit movement and minimise bruising. Animal stress was perceived as having a negative impact on meat quality. Overall, red meat purchasing decisions were motivated by price, with some participants commenting that organic and grass-fed products were more expensive. There was a strong preference for Australian product. In addition, consumers did not understand some of the claims currently made on meat labels and so bought from sources they trusted.

2. Red meat
Participants in LP130100419 contrasted the extensive nature of sheep and beef cattle production with intensive productions systems used in poultry and pigs, both in terms of product quality and animal welfare. Concerns about intensive production and perceived negative impacts on product quality and safety were more readily spoken of as a motivation to purchase free range pork, chicken and eggs than red meat. Grazing production systems were described by participants in connection to the production of beef and sheep meat, were seen as preferable, and enabled the animals engage in natural behaviours. Some participants were unaware about sheep and beef production methods. There was little mention of feedlots or other intensive production methods in relation to sheep and beef cattle, and these were mostly mentioned in connection with experiences overseas, such as in the USA or Europe.

Our findings suggest that for most consumers, good animal welfare is closely associated with higher product quality including sensory characteristics such as taste and colour, nutritional quality, and food safety, and that these latter aspects are stronger drivers for consumers’ purchasing decisions than issues relating directly to concerns about the animals. This is not to say that consumers do not care about farm animal welfare, or more explicitly, farm animal suffering, but more that in general these issues are not considered in isolation when choosing what food to purchase. Natural behaviours and in particular a natural diet are seen to be linked to extensive and ‘free-range’ systems that have direct and desirable consequences for consumers as well as being perceived as having better animal welfare generally. Understanding how consumers think about farm animal welfare and the role it plays in purchasing decisions is key to engaging both consumers and producers in discussions about how to develop animal products that are affordable, safe, nutritious, sustainably produced, and humanely produced.

Acknowledgement
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References
Not all Australian families find it easy to talk about where meat comes from

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Summary
The contexts in which Australian families discuss animal production remains largely unexplored, hence we sought to understand how children learn about the origins of meat. Responding to an online survey, 225 primary carers, mostly parents, identified meal preparation as the context where most conversations about meat origins occur. A preference was expressed for having conversations about meat production before children were 5 years of age. Urban parents were more likely to say that they were conflicted about eating meat and to be more empathetic to children who chose to stop eating meat. In contrast, rural parents were more likely to feel that children should eat what they are given and that talking about meat origins is not a major issue. Children’s knowledge about where food comes from was important to both groups. Our findings suggest parental values and attitudes to meat production and consumption influence conversations about meat origins with their children.

This paper is a summary of Bray et al. 2016.

Introduction
The process of urbanisation has been associated with changes in attitudes towards food production and a decrease in food and agricultural literacy in Australia (Worsley et al. 2015; Meyer et al. 2012). Opportunities for specific discussions about the origins of food and its relationship to agriculture with children are scarce and the discussion of slaughter in most western societies, particularly in front of children, is considered taboo (Heinz & Lee 1998). Psychological studies have found that some meat consumers experience “cognitive dissonance”, or in other words, psychological discomfort, knowing that harm has been caused to a sentient being (a thinking, feeling creature) (Bastian et al. 2012). Some parents may feel uncomfortable, guilty, or ill equipped when initiating discussions or when answering children’s questions about where meat comes from.

This study aimed to explore attitudes surrounding family conversations with children about the origins of meat and potential challenges experienced by parents, or other primary carers, when having these discussions.

Materials and Methods
Primary carers of children who resided in Australia and who lived in households where meat was consumed, independent of the participant’s own eating preferences, were invited to complete an online survey. Participants were recruited through social media websites, local media announcements and interviews, or via passive snowballing (a participant passing the survey on to another person or group). Data were collected between October and December 2013.

We collected demographic data, information on eating habits, food purchasing practices, attitudes to having conversations or when answering children’s questions about the origins of meat with their children. Discussions were mostly triggered by preparing a meal at home (67%) or eating at home (65%). The majority (60%) of participants who had discussed meat origins with their children said that it was appropriate to do so at 5 years old or earlier, and were more likely to agree that it was their role to openly discuss meat origins, that children should know, and that knowledge of where food comes from is important for healthy life choices.

Data were analysed using Mann-Whitney U and Kruskal-Wallis tests. Significant results from Kruskal-Wallis tests were explored through pairwise comparisons.

Results and Discussion
Of the 225 participants, 64% of were women and 53% were from a major city. Almost all (93%) participants had discussed the origins of meat with their children. Discussions were mostly triggered by preparing a meal at home (67%) or eating at home (65%). The majority (60%) of participants who had discussed meat origins with their children said that it was appropriate to do so at 5 years old or earlier, and were more likely to agree that it was their role to openly discuss meat origins, that children should know, and that knowledge of where food comes from is important for healthy life choices.

Women agreed more than men with the idea that children should make conscious decisions about eating meat, were more likely than men to be supportive of their children if they stopped eating meat, were more likely to discuss healthy eating habits with their children, were more likely to feel conflicted about eating meat themselves, and would have preferred to avoid having these conversations with their children. Men were more likely to agree that it’s not a “big deal” to tell children where meat comes from, that children should eat what they are given, that meat should be eaten as part of a healthy diet, and they were more likely to be surprised at the compassion of their children towards animals.

Urban parents were more likely than rural parents to have been honest but vague, to have thought that their children may not have understood, and would have preferred to avoid the conversations. They were more likely than rural parents to understand if their children stopped eating meat, were more likely to feel conflicted about eating meat themselves, and they were more likely to feel that they lacked knowledge compared to parents from rural areas. Participants in rural areas (compared with those in the cities) did not perceive these conversations as difficult, believed that children should be shown aspects of animal production, that conversations should not be avoided, and that there is no reason to hide this information from children. They were also more likely to agree that their openness allowed their children to become
more conscious of the food they ate and more appreciative of the fact an animal died for them to have food.

Our results suggest that gender and location of residence influence whether parents find it challenging to tell children where meat comes from. Although there may be considerable within-group variation, women tend to be more empathic towards animals and more concerned about their welfare than men (Herzog 2007), are more likely to be vegetarians than men, and are more likely to endorse vegetarianism on the grounds that it reduces cruelty to and minimises the suffering of farm animals (Ruby 2012).

It is difficult to separate living in a rural location from involvement in, or proximity to, food production practices. Although we could not determine whether rural parents experience cognitive dissonance when talking to their children about meat production, our findings that rural parents are more likely to expect their children to eat meat than rural parents is consistent with the idea that the ‘meat and three veg’ meal is more persistent in rural areas than in urban areas (Lupton, 2000).

We acknowledge some limitations to our findings. Our sampling strategy, namely snowballing and using social media, may have biased participant recruitment. It may be that one view or another is evident in our findings because of sampling problems rather than a true representation of overall community views. Despite the potential self-selection bias, our sample was varied in many demographic variables such as gender, age, and place of residence, though it may not have been representative of Australia’s highly multicultural population. However, we assert that the findings have face validity – they resonate and make intuitive sense.

This study shows that the processes relating to learning about the origins of meat for Australian children relates to familial attitudes to animal production and thus reflects the underlying social and cultural values of families. Living in a rural locale does seem to influence the attitudes of parents to meat consumption as well as the likelihood that children participate in activities involved in meat production, both leading to higher likelihood of discussions about the origins of meat.

The finding that parents prefer to have conversations with children before the age of 5 is interesting given that children are unlikely to fully understand the concept of death at that stage. We hypothesize that it is precisely because children do not fully understand the underlying concepts that conversations may be perceived by parents as being easier, and some children may become socialised to the origins of meat over time without questioning or feeling the need to change behaviours and food choices.

Our findings show cognitive dissonance is experienced by some parents, when telling children where meat comes from especially those from urban areas.

Further work is needed to understand the motivations of those who have not spoken to their children, and in particular to understand whether meat consumption is a ‘mindless’ act for the majority of Australian parents or one that takes some psychological effort to reduce dissonance associated with eating meat and using other animal products. Exploring these issues further is an important step in engaging the community in constructive conversations about farm animal welfare in Australia.

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References
Translating animal welfare science into animal care standards

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Summary

Public policy for farm animal welfare is continuously evolving through science-based standards and codes of practice. Developing science-based standards is complex because scientific assessment of animal welfare involves multiple measures that capture different viewpoints on what constitutes a good quality of life for animals. Standards for space requirements, for example, can be based on measures of biological function, such as production performance, mortality or stress response or they can be based on the amount of space required to accommodate physical body size or activity patterns. Setting standards for different housing systems is even more difficult because of wide variations across systems and because different measures often lead to different conclusions about the welfare of animal in those systems. Systems that offer greater freedom of movement also generally increase risks for injury, disease and mortality. Future science-based standards for specific aspects of system designs will be important for mitigating these problems.

Introduction

Public policy for the care of farm animals is continuously evolving in the form of nationally- or internationally-developed animal welfare standards, codes of practice and animal care guidelines. Most public standards for farm animals are based on a foundation of scientific information about the effect of housing and management practices on well-being in order to define ethically acceptable levels of animal welfare on farms (Mellor, 2014). However, developing science- or evidence-based standards is a complex venture. The scientific assessment of animal welfare involves multiple measures that capture different viewpoints on what constitutes a good quality of life for animals including measures of health and biological fitness, the emotional or subjective experiences of animals and aspects of their natural lives (Fraser, 2008). Moreover, conceptual frameworks for animal welfare have also evolved considerably. Previously the focus was mainly on identification and alleviation of negative welfare states, but more contemporary frameworks increasingly emphasize the promotion of positive ones (Mellor and Beausoleil, 2015). Thus, different scientific measures of animal welfare can lead to different conclusions about where a standard should be set. Additionally, scientific data concerning other factors such as economic and environmental sustainability may be important (Thornber, 2010). This paper addresses how different types of scientific measures can be used to inform decision-making for animal welfare standards and how values of the broader community play an increasing role in determining which types of scientific measures are used.

Scientific measures used for determining space requirements

The setting of recommended or required space allowances for farm animals would seem to be relatively straightforward. Space requirements for farm animals kept in confinement systems can be derived empirically from measures of biological function, such as production performance, mortality or stress response, and these measures also have economic implications for producers. However, consumers and members of the broader community are demanding that more value be placed on behavioural opportunities for animals (Swanson et al 2011), and thus the minimum space allowances can alternatively be based on sufficient room to accommodate physical body size in different postures, basic movement for changing body postures (e.g. turning around or moving from lying to standing) or the minimum amount of space needed to engage in simple activity patterns such as locomotion. These values can also be derived empirically. In most cases the different sets of measures do not align. For example, Gonyou et al (2006) estimated a threshold for space allowance of pigs at different body weights using a broken line analysis on data from 21 studies on the average daily gain of nursery and growing pigs. Below this threshold the growth rates of pigs were compromised. Alverós et al (2010) used a meta-analytical approach to determine the threshold space allowance for growing pigs to all lie down at the same time. Their values indicated that ability to rest was compromised at a higher threshold of space allowance than that affecting production performance. For group housed sows, indicators of stress together with levels of aggression and injury are generally used for determining space allowance (Hemsworth et al 2015).

Different measures have also been used to determine the minimum space requirements for laying hens (Widowski, et al 2016). For hens housed in cages, space allowances below the range of 432 cm² to 554 cm² per hen generally result in reduced egg production, higher levels of stress response and increased mortality. At or just above the upper end of this range, egg production and stress response may not be affected but feather condition, foot health, keel deformities may be poorer compared to hens given more space. Many basic body postures and activities, however, require a larger space envelope. For example, the amount of space required for standing, turning and wing flapping was determined from kinematic analyses to be 475, 1272 and 1876 cm², respectively, for medium hybrid birds (Dawkins and Hardie, 1989) and 563,

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1316, and 1693 cm² for light hybrids (Mench and Blatchford, 2014).

Determining space allowance based on behaviour is complicated by the fact that at any given space allowance, increasing group size alters the dynamics of space use resulting in changes in the amount of space afforded to individual hens (Appleby, 2004). First, the total amount of space increases thereby affording more overall area for locomotion. Additionally, the amount of free space available to individual birds increases at different times of day, as hens cluster together when performing some types of behaviour. This results in higher densities in some areas while leaving other areas largely unoccupied. For intermediate group sizes, for example those in enriched colony cages, theoretical models have indicated that individual space allowance required for hens to perform some behaviours (i.e. wing-flapping) decreases as group size increases. In non-cage systems where groups sizes are in the thousands, it is much more difficult to determine individual space requirements for birds as spatial distribution around resources such as feeders, perches, nests or litter areas varies considerably over the day. System design, as it effects distribution of birds has a greater effect on measures of bird welfare than individual space allowance.

Scientific measures used for setting standards on housing systems

For laying hens, a large body of scientific evidence on the effects of housing system on welfare has been gathered from a combination of focused laboratory studies to large field trials on commercial farms (see Lay et al, 2011; Widowski et al, 2013). Scientific approaches range from measuring hen preferences and motivation to perform specific behaviours to assessing health, mortality, and indicators of stress response. Comparisons of the effects of different housing systems on animal welfare are extremely complex because of wide variations across systems. Often specific designs and management within systems have greater effects on welfare than difference between systems.

There is general consensus in the literature that all housing systems have both costs and benefits for hen welfare (Widowski et al, 2013). Laboratory studies indicate that hens are highly motivated to perform nesting, perching, foraging and dust bathing. These behaviour patterns are significantly constrained in conventional cages, and generally well-supported in non-cage and free-range systems. However, the risks for infectious diseases, parasites, injuries and bone fractures are significantly greater in non-cage and free-range systems. The general trend in the literature is that risks for higher mortality increase in the order of cages (conventional and furnished), indoor non-cage systems and free-range systems. A recent study using data from over 3500 commercial flocks in the European Union confirmed these previous reports and also calculated considerable costs in terms of environmental sustainability resulting from these high levels of mortality (Weeks et al, 2016).

Furnished cages and the larger enriched colony cages fitted with nests, perches and scratch mats do appear to maintain the health and hygiene benefits of conventional cages while supporting the expression of some of the hens’ motivated behaviour patterns. Furnished cages have also been shown to have less environmental impact and lower dust and ammonia emissions than non-cage systems (Shepherd et al 2015). However, public perception is driving private sector decisions to require cage free housing for laying hens. To date, there have been few standards developed for specific design features of non-cage and free-range systems (e.g. perch design, ramps and ladders for reducing falls and injury) but new data are emerging. Future science-based standards for specific aspects of system designs will be important for mitigating welfare problems in non-cage and free-range systems. Whether significant improvements can also be made in terms of economic and environmental sustainability is yet to be determined.

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Systems impacts of introducing crop grazing into pasture-based systems

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Introduction

Many Australian farms involve a mixture of livestock and cropping enterprises, with considerable variability in the extent to which these two enterprises interact. Each enterprise is a ‘system’ in its own right, but the introduction of crop grazing into a previously ‘pasture-only’ grazing enterprise increases the complexity of the system, to the extent that a systems approach is probably the only route toward a better understanding of the crop-pasture grazing system.

A major component of an understanding of a system is a clear appreciation of what the system actually entails. This is certainly the case when dual-purpose crops are introduced into a grazing system. The current interest in dual-purpose crops in Australia focusses on long-season or true ‘winter’ crops, especially winter wheats, which have a marked vernalisation requirement and do not flower until this requirement has been satisfied. Such crops can thus be sown early, so that they can provide a late autumn/winter feed bank, and can then be grazed in winter and subsequently go on to provide a grain/seed crop. The lecture and full paper will discuss how grazing can be achieved with minimal effects on grain production. One must also consider the dual-purpose crop in terms of what part of the system it is replacing. For example, in the cereal-livestock zone, crops are already grown within the mixed farm and dual-purpose crops may simply replace an area that was previously grain-only crop. By contrast, in the high-rainfall zone, dual-purpose crops will more likely replace grazed pasture. This means that the grazing/grain provided by the crop must at least make up for the pasture grazing foregone during crop preparation and growth.

The full paper will also discuss the grazing of long-season brassica crops such as canola. These can be grazed in a manner analogous to dual-purpose cereals, but can also confer major system benefits. For example, introduction of dual-purpose canola provides a break crop to assist disease control in dual-purpose wheat.

Dual-purpose wheat in grazing systems

The impacts of dual-purpose wheat grazing can conveniently be discussed in terms of the effects of the grazing on the crop, and the effects on the grazing animals of the availability of crop forage.

Effect of grazing on the crop

A key component of the use of dual-purpose crops is their early sowing, so that they have time to produce a feed bank for animals by late autumn/winter. Early sowing exposes the crop to greater competition from weeds and fungal disease, which may require greater pre-emergent herbicide or fungicide use. Grazing management of the crop needs to accommodate the withholding periods for these chemicals.

One of the main concerns about the grazing of the developing crop is that grazing might jeopardise subsequent grain yield. Recent data indicate that with appropriate grazing management, this should not be a major concern. Harrison et al. (2011) reviewed the effect of grazing on grain yield and reported that grazing caused a reduction in grain yield of 7±25%. The standard error of 25% implies that in some cases, grazing resulted in an increase in grain yield. Such increases are real and arise from reduced soil-water usage by the crop in winter (due to reduction in canopy mass), which conserves soil water until the grain-ripening stage.

Another system impact of grazing on crop production is that grazing often delays flowering in the crop, such that the possible impact of frosts on grain production are minimised.

In order to achieve rapid early forage production from the early-sown crop, nitrogen supply to the crop is crucial but at the system level, nitrogen management must avoid high nitrate content in crop forage because of the possible risk of nitrite toxicity in grazing stock. This is of particular concern with canola. Nitrogen should not be applied to canola if canola grazing is imminent.

Effect of crop grazing on the animals

To accommodate the ‘winter feed gap’ which often occurs in pasture-only systems, producers must either reduce winter stocking densities or provide supplementary feed or forage. Dual-purpose wheats (and canola) can help fill this feed gap in a cost-effective way, provided they are sown early. The full paper will discuss this in relation to three key questions:

1. When should the crop be sown?
2. When should the crop be grazed, and with what?
3. What stocking rate to use and when to remove stock?

Of all these questions, the decision of when to remove stock is probably the key question in relation to minimising the effects of grazing on crop grain yield.

The forage of dual-purpose wheat is of high nutritive value for grazing livestock, but recent studies have shown that the introduction of such wheats into grazing systems will require producers to pay more attention to the mineral nutrition of livestock grazing the wheat (see Dove et al. 2016), especially in relation to magnesium and sodium. This work will be discussed in more detail in the full paper. Wheat forage is not markedly deficient in magnesium, but often has very high potassium content and very low sodium content, relative to animal requirements. The resultant high forage ratios of potassium:sodium can reduce gut absorption of magnesium (see Dove et al. 2016), and the wheat forage can also be
considered to be frankly deficient in sodium. As a result, liveweight gain responses of at least 15-25% have been found when livestock grazing wheat are supplemented with either magnesium (MgO) or sodium (NaCl), with somewhat higher responses when both minerals are given (see Dove et al. 2016). There have not been significant liveweight gain responses to these minerals in livestock grazing barley or oats.

Dual-purpose canola in grazing systems

The issues which arise when grazing dual-purpose canola are generally similar to those for cereals. In the high-rainfall zone, early-sown winter canola varieties can provide feed of high nutritive value, with high forage yield and little impact of grazing on seed production. Measurements of diet selection and intake in sheep grazing canola have shown that, contrary to frequent producer perceptions, animals spend >85% of their time grazing the canola, which constitutes >85% of their total DM intake.

In relation to mineral supplementation of sheep grazing canola, magnesium/sodium supplementation is not required and may even be contra-indicated. This will be discussed in more detail in the full paper.

Further impacts of dual-purpose crops in the whole-farm system

Dual-purpose crops such as long-season wheat or canola can be grazed separately or in sequence, and provided stock are removed before critical growth stages, these crops can be grazed more than once in a season. If the crops are managed so as to minimise reductions in grain yield arising from grazing, increased profits can accrue. However, there are even greater benefits for the whole-farm system, resulting from complementarities between the cereal and the canola, and from the spelling of pasture which occurs in winter, when livestock are grazing the crops. Dove and Kirkegaard (2014) identified the following benefits, which will be discussed in detail in the full paper.

Impact on crop disease

Early-sown winter wheat is at greater risk of wheat-streak mosaic virus (WSMV), which can severely reduce yields. Producer perception was that this was due to the virus being spread by grazing. However, the increased WSMV infection is actually related more to crop/weed hygiene over the previous summer. As part of the whole cropping/grazing system, producers in areas prone to WSMV will have to pay more attention to crop/weed hygiene, or must consider sowing the wheat after canola; both approaches can avoid or greatly reduce the virus problem. At the systems level, the dual-purpose canola thus not only provides useful winter forage in its own right, but it also functions as a break crop to reduce the chance of WSMV infection in a subsequent wheat crop.

Canola itself is at risk of the fungal disease ‘blackleg’. Using canola as a grazing resource can increase the severity of blackleg infection, but much less so in canola cultivars which are blackleg resistant. A cropping/grazing system involving canola should thus be based on canola cultivars which are already highly resistant to blackleg.

Weed management

Producers have recognised that the incorporation of dual-purpose crops into a grazing system can be a key component of an integrated weed management system on-farm. However, this aspect has not received the research attention it deserves. Examples of the impact of crop grazing on whole-farm weed management will be discussed. In general, careful attention to the management of weeds in dual-purpose crops will be needed to ensure that weed infestations do not arise from the introduction of crops into the grazing system. Rather, the aim should be to use the cropping phase as part of the whole-farm weed management plan.

Pasture spelling

When livestock are removed from pasture to graze one or more crops as part of winter pasture management, the pastures are ‘spelled’ and theoretically should provide increased pasture production in late winter. This is especially the case if different crops are grazed in sequence, and/or grazed more than once. Under these circumstances, the livestock may be off pasture for an extended period. Dove and Kirkegaard (2014) showed that, relative to pasture grazing only, the grazing of a single crop (either wheat or canola) could provide 800-1200 extra sheep grazing days, while the grazing of both crops in sequence provided over 2000 extra sheep grazing days. However, taking the crop and pasture components together, the grazing of crops resulted in about 1600 (one crop) or 3500 (both crops grazed) extra sheep grazing days. Hence, of the total extra sheep grazing days accruing from the introduction of crops into the grazing system, no less than 30-40% of the benefit arose from the extra pasture which accumulated during crop grazing. Further work is needed with other pasture-based systems and with cattle grazing, to fully quantify the ‘pasture-spelling’ benefits arising from the used of grazed crops.

Crop residue management

Since grazing usually delays crop flowering and thus grain harvest, and since an early sowing is required to make best use of dual-purpose crops in the following year, there is a limited period in which to utilise/dispose of crop residues. There is a need for much more research on this aspect, to optimise crop utilisation in grazing systems.

Increased farm carrying capacity

The extra grazing provided by crop grazing and by pasture spelled during crop grazing means that winter carrying capacities can be increased. Such increases, while real, will decline once the winter stocking rate exceeds that which can be maintained over summer. This is a major issue for the design and management of pasture/crop grazing systems, and much more work needs done in this area. The modelling of grazing systems would seem an ideal approach to explore this aspect, and extend it to other systems and regions.

References

Good animal welfare practices are integral to the sustainability and productivity of the Australian pork industry. Australian Pork Limited (APL) is committed to investing in animal welfare research, and the knowledge and outcomes produced all feed into a system of continuous animal welfare improvement.

Introduction
The Australian pork industry has been scrutinised from an animal welfare standpoint. Issues can include housing (gestation and lactation housing), husbandry practices such as tail docking and teeth clipping, and euthanasia and stunning management. Often anthropomorphic views can complicate how we perceive the welfare of our pigs and will detract from any robust scientific investigations. The Australian pork industry has taken a proactive approach to animal welfare through our continuous welfare improvement programs. Australia’s pork industry and researchers have shown global leadership in the research conducted to assist in the transition from gestation stalls to group housing. Through the program ‘Shaping Our Future’ we aim to phase out gestation stalls by 2017.

Shaping Our Future
Both APL and the Cooperative Research Centre for High Integrity Australian Pork (Pork CRC) have made significant investments into animal welfare research towards the goal of the ‘Shaping Our Future’ program to phase out gestation stalls by 2017.

A gestation stall confines the sow, allowing her to get up and down but not turn around. Sows were placed in gestation stalls for either the entirety of gestation or until pregnancy was confirmed (about 28 days post-mating). Gestation stalls were used to protect the sow from aggression from other sows thus avoiding injury and stress. Stalls can be likened to separate pens allowing the sow to be individually fed, watered and assisting individual sow care. In 2010, the Australian pork industry voted to voluntarily phase out gestation stalls by 2017. This decision was underpinned by decades of industry funded research into sow loose housing, with the change providing freedom of movement, from five days after mating, until one week before they are due to farrow.

Currently, our significant investment into R&D to investigate group housing management and, championed by the Australian Pork Industry Quality Assurance Program (APIQ®): Gestation Stall Free classification, has led to 68% of the breeding sows currently in Australia classified as gestation stall free with the majority of other producers planning to be gestation stall free by 2017.

Welfare R&D
The Australian pork industry is assisted in maintaining high welfare standards through the implementation of research outcomes that address the needs of the animals and are in keeping with the expectations of the community. Over the past 5 years APL has invested in excess of $1M in welfare to be at the forefront of innovative research.

APL’s welfare R&D program, Welfare Interventions, includes the following key projects:
- Reducing and assessing the pain response associated with routine husbandry practices
- CO₂ stunning standards
- On-farm welfare assessment
- Environmental enrichment
- Development of welfare biomarkers and;
- Providing environments conducive to positive affective states

Husbandry procedures such as tail docking cause a transitory pain response which may lead to welfare consequences. Through this project we are investigating methods to reduce and assess the acute pain of tail docking and, to understand the causative factors leading to tail biting to then be able to reduce the need to tail dock.

Humane methods of slaughter, to satisfy both meat quality standards and also consumer expectations, is a nationwide project working with key industry partners. Carbon dioxide stunning is the most common method of slaughter for pigs in Australia and Europe and there is a need to develop standard operating procedures associated with CO₂ stunning that safeguard animal welfare outcomes. The humane euthanasia of pigs is a required practice from birth to
sale. Farm euthanasia protocols must ensure that selected procedures are able to be conducted as soon as possible, to reduce any undue welfare impacts. Therefore, to assist stock people we are developing Standards for Humane Euthanasia and Stunning of pigs, from birth to sale.

On-farm welfare assessments for producers to be able to assess a pig’s welfare and to be able to readily identify when a pig is experiencing compromised welfare is being developed with producers nationwide.

The environment of a pig pen can be considered to be lacking in stimulation and through the provision of environmental enrichment we can possibly maximize the number of positive experiences for our pigs. However, what constitutes enrichment for pigs and leads to long-term positives experiences over the lifetime of a pig, needs to be investigated.

To be able to quantifiably assess the welfare of our pigs and whether they are in a positive or negative affective state has the ability to transform our Australian pork industry. This is why we are investigating the use of multiple welfare biomarkers to assess pain or stress and, identifying practices and environments which are conducive to a positive affective state, over the lifetime of the pig.

**Extension Priorities**

The industry has a duty of care to the animals we are raising and expects that APL will provide research outcomes that assist producers to continue to improve animal welfare on farm. ProHand Pigs for a long time provided the means to train staff and inform them about pig welfare and the impact that their behaviour has on pigs. The ProHand Pigs program and delivery platform has been upgraded with ProHand Pigs 2.0 ensuring that training and assessment can now occur on farm.

One of the biggest issues that affect the agriculture sector in general is the continued and growing gap between the consumer and the producer. Alarming statistics were found that Australia’s youth did not know where their food and fibre came from. APL took the initiative to develop educational units that can be used from junior primary to high school level, informing and educating the youth of Australia on the practices and sustainable initiatives of the Australian pork industry. Industry educational resources are now being used in greater than five hundred schools across Australia.
Animal Handling and Welfare

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Summary

Assessing animal welfare during handling is simpler than assessing welfare in housing. The first step is preventing acts of abuse that everybody interested in animal welfare would want stopped. Acts of abuse include beating animals, poking sensitive areas, dragging downed animals, deliberate slamming of gates on animals and deliberate driving animals over the top of downed animals. The next step is to implement objective scoring of animal handling. The outcome measures that should be used are percentage of animals that fall, strike fences or gates, vocalize during restraint or moved with electric goads. These measures will bring handling up to an acceptable level. Further improvements in handling can be obtained with stockmanship training. Physiological measures of stress such as cortisol, lactate or glucose are useful for assessing handling methods because handling is a short-term stressor.

Introduction

Animal welfare assessments for use in commercial animal production units need to be simpler than assessment tools used in research. Some tools that work well for research are too complex for use by producers or commercial auditing companies. The author has trained many auditors from commercial companies and inspectors to evaluate animal handling at slaughter plants. The commercial reality is that it has to be possible to train people in a one-to-two day workshop. Standards must provide clear guidance for acceptable and not acceptable methods. They must never be vague, because vague standards will be interpreted differently by different people.

Steps to Improve Handling Practices

The first step managers must take to improve animal welfare is to prevent acts of abuse during animal handling. This requires both management supervision and training of employees. Acts of abuse are never acceptable. Examples of acts of abuse that should never be tolerated are: dragging downed animals, throwing animals, beating, poking sensitive areas to move animals, deliberate slamming of gate on animals or deliberate running animals over the top of downed animals. There have been discussions about when tapping an animal with a driving aid becomes beating. To train auditors and inspectors, a video has been produced titled Proper Use of Livestock Driving Tools. Access by typing the title into a search engine. An empty cardboard box is whacked with a plastic paddle. When the box starts crushing, tapping has progressed to beating.

People manage the things that they measure. The use of simple outcome based measurements has been effective in improving animal handling at slaughter plants (Grandin, 2005). During handling in both slaughter plants and feedlots, the percentage of cattle that fell during handling was under 1% (Grandin, 2006; Woiwode 2015). Electric goad use in 28 feedlots averaged at 5% of the animals and some feedyards never used them (Woiwode, 2015). The percentage of cattle that vocalized in the squeeze chute before a procedure was performed or in a stun box can be easily kept at 5% or less (Grandin, 2012 and Woiwode, 2015). Numerical scoring is recommended for evaluating handling and it makes possible to determine if handling has improved or become worse. Scoring also makes it possible to compare practices between different facilities. This may help motivate people to improve because they want recognition for being better than the other places.

Animal Handling Outcome Measures for Use on Farms, Feedlots and Stockyards

- Percentage of animals that fall during handling.
- Percentage of cattle or pigs that vocalized (moo, bellow, or squeal) during handling and restraint. Do not use vocalization scoring for sheep.
- Percentage of animals moved with an electric goad.
- Percentage of animals that strike gates or fences
- Percentage of animals running when they exit the squeeze chute

These measures will establish a baseline for acceptable handling practices. The author recently visited a feedlot where cattle were handled for vaccinations with 0% electric goads and 0% of the cattle falling. The employees were silent and never yelled at cattle. The handling was definitely acceptable. Stockmanship training further improved handling. Re-positioning of one employee in a different position alongside the race and stopping constant waving of his flag driving aid resulted in quieter cattle. Animal agitation and banging and clanging of the squeeze chute became noticeably quieter.

Australian researcher Paul Hemsworth has found that animals with a large flight zones and fearful of people are less productive (Hemsworth et al., 2000). Further studies have shown that animals are also more productive when stockpeople have positive attitudes towards animals. Training stockpeople on how to use behavioral principles of animal handling is really important. When people learn more about animal behavior, it helps promote a positive attitude.

Video Cameras

Two large beef and pig slaughter companies in the U.S. have installed video cameras that are remotely accessed by an auditing company. This keeps handling standards high when management is not watching. Today many mobile phones are video cameras and everybody who handles animals must stop and think. If I did this, how would it look posted online?
Use of Physiological Measures to Evaluate Handling Practices

Assessing animal welfare during handling is easier and more straightforward than assessing welfare under different housing conditions. Handling procedures, such as vaccinations, loading trucks, and movement through a slaughter plant, take a short period of time. For short-term stressors such as handling, physiological measures of stress may be really useful. Physiological measures such as cortisol, lactate and glucose can easily show differences between low stress and high stress handling methods. For example, when pigs are moved with electric prods or jammed in a race, lactate and glucose levels are higher (Edwards et al., 2010; Benjamin et al., 2001, and Gruber et al., 2010). In cattle, vocalization (moo or bellow) during handling and restraint is associated with higher cortisol (Dunn, 1990; Hemsworth, et al., 2011). Vocalization is also associated with excessive pressure from a restraint device and electric goad use (Grandin, 1998 and Bourquet et al., 2011). For long-term stressors such as comparing the effects of different housing system, physiological measures may be less useful.

Effects of Previous Experience in Stress

An animal’s previous experience with handling and restraint will also have an effect on stress levels (Grandin, 1997; Grandin and Shivley, 2015). Numerous studies have shown that animals can be acclimated to handling or transport. The first trip on a truck was more stressful than subsequent trips (Stockman et al., 2012). Beef heifers that were carefully acclimated to being moved through a race had better conception rates after artificial insemination (Cooke et al., 2009, 2012). Animals can be acclimated to the point where they will voluntarily enter a restraint device for a feed rewards (Grandin, 1989). Acclimated animals will have lower cortisol levels (Petherick et al., 2002).

References


Sex selection in layer chickens

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Summary

Differentiating between males and females pre-hatch, by adding a biological marker to the sex chromosome, is a new gene technology set to impact the poultry industry.

A new approach to sex selection

Recognising the potential of gene editing technology for selecting female layer chicks pre-hatch by removing male eggs carrying a marker gene was certainly one of those eureka moments. Thanks to recent advancements in gene technology, it is now possible for scientists to specifically place a biological marker on the sex determining chromosome of the chicken. This discovery provides a simple solution to meet a pressing need for the industry and a leading opportunity for the adoption of biotechnology in animal agriculture. Being male or female is determined by sex chromosomes, both in humans and in chickens. By harnessing technology to mark the sex determining chromosome in chickens, the males can be identified before hatching and removed during the incubation. The process uses a gene that marks only the chromosome that says "become male", resulting in only the male chickens being marked and the females not. The unmarked females go on to lay eggs for our plate.

How does it work?

The technology used for the sex selection process builds on ten years of experience with chicken genome engineering and gene editing. The skills for the job were developed in collaboration with industry and university partners. The process of marking the sex chromosome starts by carefully opening the shell of a fertilised egg to expose the embryo. A snippet of DNA that encodes for the marker gene, known as green fluorescent protein (GFP), is then microinjected into the bloodstream and taken up by germ cells that go on to become the ovum and the sperm of the adult chicken. Once in these cells the DNA homes in on the sex chromosome and uses a precise ‘cut and paste’ process to lock into this specific target. Male eggs that carry the marker gene make the GFP which can be seen and then detected through the shell using UV light.

Opportunity for industry

The ability to detect and remove male chicks pre-hatch would be a big step forward for the egg laying and related industries. Currently culling male chicks post-hatch creates a major ethical dilemma for some countries. As a result the poultry industry has invested in developing solutions for this issue. In some European countries the need is becoming urgent with governments developing legislation to ban the culling practise. Growing male layer chicks is not a sustainable option for farmers. Sex selection effectively negates the need to cull or grow out male chickens and contributes to a more sustainable industry with a view to future food security. An added benefit is the potential to direct the marked male eggs for other valuable applications such as human influenza vaccine production. This new technology can be automated and integrated into existing farming practises potentially making it easy for industry to adopt.
What does genomics mean for animal production?

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Summary

“Genomics” is transforming many fields of human understanding and endeavour, the agricultural sciences being no exception. The transformations include identifying the DNA responsible for particular conditions, and potential ways to modify such effects, through to ways of identifying individuals’ genetic merit. The latter is particularly relevant to animal production, but both research and implementation carry involve challenges. The idea of genes being “for” something for the majority of attributes of interest is continually being eroded by genomic discovery. At the same time, an ever-expanding array of experimental tools provide increasing scope for understanding the biology of such attributes, which can enrich animal production research and understanding. “Genomics” demands large volumes of phenotypic data for both estimation of genetic merit and reliable elucidation of biological mechanisms. This means that animal production scientists and geneticists will need to collaborate in large-scale programs to exploit the full potential of genomics.

Introduction

We are living in a time of exploding discovery about the workings of the information system that is the foundation of all life, through the field of research known as genomics. Genomics is built on the ability to detect the molecular structure of DNA in essentially any life form – this ability has grown exponentially during the last 30 years, with the pace of discovery showing no signs of slowing.

How is this affecting animal production? How might it do so in future? This paper provides some examples and discusses some important considerations for livestock producers, industries and researchers.

What is “genomics”?

In its broadest sense, genomics is everything that flows from the ability to detect or read DNA sequence, at varying levels of precision. At its heart is the construction of maps of DNA, that allow us to locate particular segments of chromosomes, which in turn provides the basis of associating such segments with some aspect of how the life form functions.

Before discussing some challenges involved in that last point, we can list examples of how that might be useful:

- By providing a basis for determining the relationships amongst individuals. This can be useful for simple applications such as assigning parentage, through to determining the level of similarity between populations such as breeds. This latter is the basis of constructing ancestry trees, which can help us understand the history of populations, over timelines from the very short to the entire history of life.
- By allowing detection and identification of genetic material associated with specific conditions – finding “the gene for something”. While such searches can often be misguided or fruitless, there is a growing number of conditions for which DNA tests are available across many species. Very recently, this has underpinned the technique known as gene editing – the removal of specific segments of DNA, to remove a specific trait or version of a trait from the population.
- By providing a basis for understanding how “genes work” – examples being gene expression studies, in which sequential analysis of the expression of genes provides steps to understanding the complex control and feedback systems which lie between the underlying code and the function of the animal or plant.
- By building on knowledge of relationships between individuals, providing the basis for estimating the genetic or phenotypic merit of individuals on the basis of a DNA test alone. This approach, which is known as genomic selection, goes far beyond identifying genes “for” specific things, to use a statistical approach to prediction of genetic merit. This application has completely transformed dairy cattle breeding in the last decade, and is now being introduced to all major livestock species and to some plants.
- By “mapping” populations or communities, such as the rumen microflora, and investigating how patterns in such populations are related to outcomes (and in the case of the rumen microflora, how those patterns interact with genomic patterns in the host organisms).
- Finally, the fact that DNA can be read at birth, or even in utero or at the point of conception, provides the opportunity to screen individuals very young, allowing potentially faster genetic progress, and removal of sub-optimal individuals before much has been invested in them.

This brief list belies the fact that there is really no single science or area of work that defines “genomics” – it is more accurate to simply talk about using methods to detect genetic...
Some Challenges

The most significant challenge that has become apparent in the brief period of “genomics” is that genes “for” something are the exception, with the rule being large numbers of genes acting additively and interactively to produce observed performance. This is frustrating, particularly as in those cases where a detectable gene can be identified, simple tests can be made available very simply, and provide scope for rapid response, whether that be culling or some form of remedial treatment.

Extending this point, it has become clear that associations between genotype and phenotype found in one population may not hold up in others. Population genetics theory suggests that this should be no surprise, there being two potential contributing factors:

- Individual alleles (forms of genes) may not have the same effect in different populations, either through having different regulators or through different interactions with other genes
- Particular alleles may be at very different frequency in different populations

Neither of these factors should stop us using information about the location of particular genes (or SNPs) across populations, but will usually mean that we need to estimate associations within each population, potentially using data from other populations in the investigation.

This point about statistical associations will apply equally to underlying genetic (or bio-chemical or metabolic) pathways: it should not be automatically assumed that something “discovered” in one population will work the same way in another.

More generally, we need considerable volumes of performance data of some form – medical records, production data such as milk records, etc. – to enable estimation of the relationships between patterns across many genes and performance. Even then, the answers are usually only temporary and need continual updating with new data. In addition, the volume of data needing to be handled can be enormous – potentially thousands of DNA data points on thousands of individuals. This aspect of genomics is making it very clear that collection and use of data will be the most significant aspect of most applications of genomics.

This point suggests that researchers should take a lead in encouraging data-sharing wherever possible. Following the point about statistical associations, by definition the only circumstance in which data from some other population(s) will not be helpful in a particular project is where the association is zero, which can almost only be the case for where particular alleles are fixed in one population but not in others.

Such sharing will also have commercial significance, since a widespread problem will be validation of genomic tests, or biological insights. Making research data both widely available and included in any commercial applications has important ramifications for research organisations and the community, and warrants considerable careful consideration at community level.

Finally, the fact that most aspects of living things are influenced by hundreds or thousands of “genes” makes it questionable what exactly we can expect to learn from investigation of the pathways “from gene to performance”. Indeed, some authors have suggested that the concept of genes themselves is questionable. This is not to say that examining such pathways is not worth doing, but that it may need to be done using very large datasets, and with an appreciation that manipulations or interventions may not be as widely effective as we imagine from a simple “gene for something” perspective.

The clearest implication that can be drawn from genomics to date is that data is absolutely fundamental. This need will surely transform how much biological research is conducted, in particular in livestock production. It is likely that statistical interpretation of data and data patterns will become more and more important, and that exploiting insights into animal production will need a more “designed” approach.

For livestock producers, commercial populations are likely to become ever more precisely specified genomically, but this will require integrated and coordinated systems of large-scale data collection and analysis.

References

This paper has drawn on many reviews and specific articles, but two references which provide useful entry are:

Animal Frontiers (2016) 5 (4):4-85 This issue is devoted to “Animal Breeding in the Genomics Era”

Livestock Science (2014) 166:1-248. This issue is devoted to “Genomics Applied to Livestock Production”
Balancing efficiency of production and product quality with new tools – the example of lamb

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Summary
The Australian lamb industry has been transformed since the late 1980s through a coordinated combination of RD&E, marketing, and implementation of new technologies, particularly around genetic improvement. On-farm, the changes have focussed on developing lambs that will grow to heavier weights without becoming over-fat. Throughout the transformation, the risk of reducing fatness too much has been understood, but industry has had limited tools with which to manage this risk. Over the last 7 years, this gap has been addressed, again by a combination of R&D and implementation, this time focussed on development of genomic tools that allow direct simultaneous improvement of lean meat yield and traits associated with eating quality. This paper outlines those tools, and explores possible lessons for R&D and industry from the experience over the last 30 years.

Introduction
The Australian lamb industry has been transformed over the past 25 years from a declining by-product offshoot of the wool industry, to a strong contributor to the rural and national economies. This has been achieved through a combination of changes in genetics, production systems, and processing and retailing innovation.

These changes grew out of a coordinated program of RD&E involving all the lamb-producing states and the relevant RDE service providers, as well as steady improvement in communication and coordination between the on- and off-farm sectors, and between production and marketing.

At the heart of these changes as been the breeding of animals that produce more lean meat for essentially the same amount of bone and fat tissue as the lamb of the mid-1980s. This has been in response to market research in the 1970s and 80s, and has produced approximately 33% higher carcase weight, with much of the increase being lean tissue.

Such animals “break the correlation” between growth rate and fatness which reflects or expresses the underlying biology of growth, but which constrained our ability to produce heavier lambs (more meat) without more fat.

During the period since the 1980s, R&D has included investigation of patterns of muscle development in lambs, including evidence for genes with large effect. These are of concern because of potential compositional change in muscle tissue, with higher proportions of anaerobic fibres likely to have higher shear force, leading to increased toughness of the meat, and lower intra-muscular fat levels, leading to reduced juiciness and flavour.

Within the last 10 years, it has become apparent that some such changes have occurred (not necessarily involving genes of large effect), with progeny of terminal sire breed rams showing elevated shear force and reduced intra-muscular fat. These breeds have made the most change in lamb growth rate, reduced subcutaneous fat levels, and increased muscling.

So on the one hand, there has been significant improvement in efficiency of production through faster growth, more lean tissue and less fat, and therefore better feed efficiency, while on the other hand there are signs of some decline in product quality.

Is this trade-off inevitable? Do we have any tools to manage it?

At the heart of this question is the genetic relationship between the efficiency traits and the product quality traits – the genetic correlations amongst the traits:

- There are positive relationships between growth, the amount of fat deposited subcutaneously, and the depth of muscle tissue such as the Longissimus dorsi,
- There are positive relationships between muscle depth and the shear force, or toughness,
- And at the same time, there are negative (in this case unfavourable) relationships between depth of muscling and the amount of intra-muscular fat, which is important for juiciness and flavour

If we simply select for faster growth, less subcutaneous fat and deeper muscles, we get those outcomes, but at the expense of increased toughness and reduced intra-muscular fat. Until recently, this is essentially all we could do – it was simply too expensive to collect enough data on toughness and intramuscular fat to be able to include these traits in selection.

Tackling the trade-offs
The significance or extent of the trade-off between improved efficiency of production (growth rate, leanness, muscling) on
the one hand and eating quality (shear force, intra-muscular fat) on the other, is determined by two factors:

- The underlying genetic and phenotypic correlations amongst the traits
- The tools available to manage individual traits or sets of traits

Up until about 2010, industry had a simple set of tools for managing genetic choices about these traits – the Estimated Breeding Values (EBVs) for growth, fat and muscle. The EBV for fat was (and is) built on measuring sub-cutaneous fat, but is correlated to intramuscular fat, so that selecting against fat meant indirectly selecting for lower intra-muscular fat. Similarly, muscle depth and toughness are correlated, so that selecting using the Eye Muscle Depth EBV meant indirectly selecting for tougher meat.

To overcome these inherent constraints, industry invested in 3 steps:

- Collecting phenotypes and genotypes on large numbers of lambs, including for growth, subcutaneous fat, muscle depth, as well as for lean meat yield, intra-muscular fat, shear force and taste panel scores, through the Information Nucleus (Fogarty et al, 2007).
- Developing the tools to analyse all this data simultaneously, to produce EBVs for animals not measured for the eating quality traits using their genotypes alone
- Developing selection indexes that balance expected change in growth, carcase yield and muscling, with the changes in the eating quality traits (Sheep Genetics, 2016)

Together, the results of this R&D mean that breeders can now steer breeding programs in more balanced way, and producers can choose rams that will improve production efficiency without detrimental effects on eating quality.

Thus over the period since the 1980s, the lamb industry has made 2 significant improvements in its ability to manage lamb growth:

- From manipulating size at kill alone, with limited power to manage fatness levels, to using EBVs to change the weight:fat outcome
- Adding the ability to manage eating quality traits, meaning that we can now manage growth, subcutaneous fat (and hence yield), eating quality more independently.

A simple way to picture this development is that in the 1990s, we developed a “lever” with which to change efficiency and quality, and that lever had a large effect on efficiency, but at the same time, an unfavourable effect on quality. Now, we have two levers, one for changing efficiency, and the other for directly changing, or at least managing, quality. Accordingly, we have more choice about the balance of these two dimensions of change.

How these two levers are used in industry will depend on price signals received by producers and breeders for the quality traits, but even if these are not completely clear, there is scope to manage the balance in real-time to a much greater extent than previously. Encouraging and supporting industry appreciation of this is being lead by the Lamb Supply Chain Group, an initiative of Sheep CRC and MLA.

General Principles

All livestock breeding, and through breeding, production, depends on managing the relationships between traits. If we seek faster growing animals, they will tend to be larger at all ages – good for weight turned off, not so good for size and hence maintenance cost of the breeding female. We have just explored the relationship between production efficiency and product quality, and other examples could be provided. The more general point is that trade-offs, or combinations of favourable and unfavourable relationships are the rule, not the exception.

How well we are able to manage those trade-offs depends on the tools (or levers) we have at our disposal. For the genetic levers, that means what information we have. The important development that is taking place is that as DNA technologies become cheaper, it becomes more and more feasible to collect data on all relevant traits in a reference population, and then use that data as the basis of tests to inform us about all traits in our target population, in turn allowing more precise identification of the animals with the best balance of traits, whether for breeding or for production. And the greater precision increases our ability to minimise the unfavourable trade-offs.

There is an important underlying message here – with the right data, we can manage the balance among traits with much more power and precision than previously. At the same time, it will become clearer when other approaches, such as developing specific lines for crossbreeding, are more appropriate. Data is information, and information means greater choice and precision.

References

Summary

The Australian egg industry has adopted a hen centric approach to welfare and needs tools to assist in demonstrating continuous improvement in achieving best practice. To this end, the Hen Welfare RD&E Strategy was initiated by AECL to inform the welfare debate through the provision of robust scientific knowledge and industry research priorities via a consultative process. The main focus is to provide innovative on-farm solutions through research projects that produce data, information and outputs that generate research outcomes and feed back into skills and knowledge development and quality assurance programs.

There are three key areas of activity necessary to rationally address animal welfare; consumer expectations, robust science and commercial reality. The challenge for R&D is to attempt to resolve some of the unanswered questions surrounding hen welfare, welfare research methodologies and consumer beliefs while factoring in the long term nature of science.

Welfare RD&E Considerations

There are three key areas of activity necessary to rationally address animal welfare; consumer expectations, robust science and commercial reality.

There is increasing concern among the community regarding the treatment of animals which strongly influences the views of society on the acceptability of various animal management practices. Consumer and public attitudes to animal welfare have the potential to dramatically affect the use of animals in society, influencing the operations of livestock industries.

While consumer attitudes are important, science has a critical role in underpinning society’s decisions on animal use and the attendant conditions and compromises. Lack of awareness of factual information means that many people may be unaware of the conditions under which domestic animals live, how they are treated and their species-specific requirements. It is important that the community is well informed, including the scientific perspective.

While research can be utilised to underpin the establishment, amendment or validation of industry welfare standards and practices, to actually achieve these welfare standards and ensure industry best practice, it is critical to deliver industry education through training strategies (skills and knowledge development) and modify legislation, codes of practice and/or welfare components of Quality Assurance (QA) programs.

AECL Operating Environment

AECL invests in RD&E on behalf of producers and the Commonwealth Government. The main focus is to provide innovative on-farm solutions through research projects that produce data, information and outputs that are used to generate research outcomes. RD&E can be thought of as a continuum—a succession of steps from research to development and then on to extension. The continuum produces information and tools that are provided as resources to producers to enhance the skills and knowledge of egg producers to ensure continuous improvements to on-farm management.

AECL prioritises RD&E into four major programs to more effectively focus our support for the benefit of the industry. These four programs cover the key scientific research and development disciplines relating to hen health and welfare, disease management, bird nutrition, uniformity, feed availability, environmental stewardship, egg quality, human nutrition, food safety and supply chain management. They also cover capacity building through extension, training, QA and communication of R&D outcomes to ensure best practice egg production. A more targeted approach is being taken in the short to medium term, with greater focus on welfare and food safety.

The Complexity of Consumer Expectations

As animal welfare awareness continues to develop, there is increased public pressure related to the
housing systems of laying hens. The Australian egg industry broadly uses three different systems; cage, barn and free range. There is public pressure against cages which seems to be mainly related to the confinement of hens and their inability to express some natural behaviours, although, cage egg sales still represent over 50% of the retail market share by volume, with free range at 41% and barn at 7%. Free range systems allow for hens to move around freely and engage in natural behaviours, such as foraging, dust bathing and flapping their wings. However, the question of whether or not the move away from cages will actually improve the welfare of the hens remains unanswered. Hens with access to the outdoors are more vulnerable to certain diseases and infections that cause them suffering, including avian influenza. This may mean more medication needs to be used on these birds but there is also consumer pressure to remove antibiotics from poultry production, limiting vets’ options for treatment. Free-range hens also tend to engage more in feather pecking, with adverse consequences for bird welfare.

As certain animal production and management practices are highlighted from time to time by community groups, with their viewpoints promoted to the wider community, it is important to ensure that the community is well informed, including the scientific perspective. The challenge for R&D is to attempt to resolve some of the unanswered questions such as; what is the best type of housing to provide and on what basis?, is outdoor housing better than indoor housing?, what are the space allowance requirements of laying hens? and so on. However, there is considerable variation within science when it comes to methodologies used to study animal welfare and the interpretation of these methodologies in terms of animal welfare implications. Another factor to consider is the long term nature of robust science – it may take years to address a welfare issue (time required to do the research and implement it in the field) by which time community attitudes may have moved on.

The Australian egg industry is moving towards greater clarity with respect to free range labelling after significant public debate. Recently, consumer Affairs Ministers agreed to the introduction of an information standard requiring eggs labelled as ‘free range’ to have been laid by hens with meaningful and regular access to the outdoors and with an outdoor stocking density of 10,000 hens per hectare or fewer. This national outcome is a positive step for both the industry and consumers. Running in parallel is the transition of the Model Code of Practice 4th ed. (MCoP) into Standards and Guidelines (S&G). One of the key objectives of the S&Gs is to facilitate consistency of legislation across states for improved welfare outcomes. Through a public consultation process, (mandatory) standards will be will aim to reflect contemporary scientific knowledge and mainstream community expectations.

**AECL’s Hen Welfare RD&E Strategy**

The Hen Welfare RD&E Strategy was initiated by AECL in order to inform any review of the MCoP and assist in the transition to S&G through the provision of robust scientific knowledge. AECL facilitated a strategy of civil engagement to identify a Hen Welfare RD&E Strategy via a consultative process, through a series of structured workshops for representatives from a wide range of industry stakeholders including egg producers, animal advocacy organisations, State and Federal Government regulators, and scientists. Three Stakeholder Workshops and one Regulators’ Workshop were convened where research priorities were identified. At the final workshop participants were asked to generate research questions within their highest priority hen welfare themes, to give further specific guidance to the ongoing hen welfare RD&E process. A Hen Welfare RD&E Plan has been developed in collaboration with these stakeholders, which will guide AECL’s investment in RD&E.

**Top Five Hen Welfare RD&E Priorities Identified**

- Hygiene, parasites and disease – non-caged systems
- Range design - requirements for free range systems
- Optimal stocking density research – in all production systems
- Stockmanship for each production system
- Feather pecking and cannibalism – alternatives to beak trim

**RD&E Continuum**

Research questions have been developed within the priority areas identified and are being put out to tender in the research community. The Australian egg industry has adopted a hen centric approach to welfare and needs tools to assist in demonstrating continuous improvement in achieving not just minimum standards but best practice with respect to hen welfare. To ensure that best practice is adopted, research results feed into AECL’s Skills and Knowledge and QA Programs.
Breeding for better health and welfare in sheep – what is compromised if we do?

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Summary

Incorporating broader breeding goals into meat sheep breeding programmes such as traits that are important for health, welfare and maternal efficiency are important because they are often antagonistic to other breeding goals at a genetic level. This means that selection for higher productivity alone (e.g. lamb growth and litter size reared) can compromise animal welfare in the longer term particularly if new constraints (e.g. legislative) on farmers to control disease are introduced such as restrictions on the use of antimicrobials. Having key welfare indicators as new breeding goal traits, accurately recorded at birth and measured on animals of strategic importance in the population under selection, and under commercially-relevant rearing conditions widens the opportunity to select higher–performing sheep also with better innate ability to withstand disease in the future.

Introduction

Breeding programmes for sheep bred for meat production typically are geared towards maximising the weight of lamb reared either per hectare or per ewe, per annum. As most of our systems are largely grass-based in extensive rearing systems, unlike other livestock species, they have rarely been the subject of scrutiny from a health and welfare perspective. However as many sheep in extensive rearing conditions often graze poor quality pastures in marginal land areas, aspects of poor welfare are often overlooked, such as sub-optimal nutrition and low body condition score, exposure to climatic extremes of rainfall or temperature and high mortality rates. Also, in some sheep systems, farmers’ ability to identify and individually treat animals for diseases such as mastitis and footrot are limited by the very nature of the extensive grazing systems and lack of access to animal handling facilities in remote rangelands. With the drive to reduce reliance and use of antimicrobials and other pharmaceuticals in farmed livestock, it is logical that breeding more disease-resistant sheep will result in a ‘win-win’ scenario for both sheep and farmers alike. It will also reduce the rate of involuntary culling of ewes, thereby extending productive ewe longevity and lowering ewe replacement rate. However, older ewes tend to have higher litter sizes, which in turn have higher rates of lamb mortality and they also tend to have higher levels of footrot and mastitis. Having a lower annual ewe replacement rate by keeping an older flock age structure increases the generation interval and affects (lowers) the rate of genetic improvement possible in the flock(s). Similarly, we take it for granted that ewes will utilise their body reserves to fuel lactation for lamb growth but our research suggests that this may be at the expense of their own longevity. Such trade-offs – or compromises – that are made by flockmasters across the globe, will differ greatly according to the different sheep systems, yet all of them share the same solution to addressing them within the context of genetic selection index methodology. Combining new breeding goals for aspects of health and welfare into selection indices for sheep and weighting them appropriately, will both enable more profitable sheep farming, whilst halting the deterioration of these traits in the longer term. Four key aspects of sheep breeding systems are considered in the presentation.

Ewe Longevity

The definition of ewe longevity as a breeding goal has been the subject of previous and more recent industry-funded research to define productive longevity and to investigate the relationships with lifetime reproduction (Conington et al 2004). Ewe longevity can be considered as a relatively ‘blunt tool’ to improve ewe welfare because essentially it is the end result of ewes surviving several annual cycles of exposure to disease, tooth loss, pregnancy and parturition. It is a trait that is only expressed once in the lifetime of a ewe, and compared to other breeding goals, the economic value of improving ewe longevity is relatively low. On the positive side, ewe longevity can be automatically recorded within a performance recording scheme without relying on separate, additional recording undertaken by farmers. Our research shows that ewe longevity is under low genetic control, but for some breeds is antagonistically genetically correlated with lifetime productivity, indicating that high levels of performance leads to premature culling and lower longevity EBVs.

Disease resistance

It is usual that purebred rams are bought for use in more challenging environments compared to that of the purebred sector. Having good phenotypes on daughter disease status from these commercial flocks
is a powerful tool to generate genetic and genomic information and to reduce the impact of Genotype by Environment (GxE) interactions if that information is built into selection programmes. Detailed health screening in genetically-linked networks of purebred and commercial phenotype farms is a means to deliver a solution for endemic diseases of economic importance to the sheep industry; mastitis and footrot are examples of such diseases. The UK Texel Sheep Society is currently using this methodology to work towards the delivery of genomic breeding values (GEBV) for resistance/susceptibility to these diseases (Mucha et al., 2015). New, on-farm phenotypes for subclinical mastitis, that are cheap and easy to collect, are highly correlated with somatic cell count, both genetically and phenotypically, and routine screening has been put in place for udder and teat conformation alongside established hoof lesion phenotypes to continue selection for these traits in the future. The first genomic breeding vales for such ‘hard to measure’ traits will be estimated this year in the UK.

**Lamb survival**

Lamb survival is the cornerstone of flock profitability and keeping lambs alive after birth is more profitable and better for welfare, rather than focussing on increasing the litter size of ewes to achieve a higher number of lambs weaned. Industry data from 4 major breeds (Scottish Blackface, Texel, Lleyn and Dorset) were used to estimate heritabilities for lamb survival as a direct trait of the lamb, which were all low (0.05-0.09) but significantly different from zero. Again, this is another ‘blunt’ tool that masks subtle differences in lambs and their behaviour that are indicative of greater ability to survive such as aspects of lamb vigour (Matheson et al. 2012; Dwyer et al., 2015). As with ewe longevity, there is a large amount of information available from records currently collected within existing breeding programmes that can be used to estimate lamb survival, so there is not a requirement for additional farmer-dependent recording. Finding new proxy traits indicative of lamb survival and with higher heritabilities, measured quickly on a large number of animals in the recorded population is still needed, despite extensive research on the components of lamb survival behaviours described by Dwyer and Lawrence (2005). Survival rates differ significantly according to gender, litter size and dam age. Lamb survival and litter size born are antagonistically correlated, yet including them together in a breeding programme will enable both selection of sires and dams with higher propensity for survival without compromising greatly on genetic gain in litter size reared.

**Body tissue mobilisation**

Body condition score (BCS) is indicative of subcutaneous body tissue (fat and muscle) cover over the loin region of sheep (Russel et al., 1969). It reflects previous nutrition and is an indicator of future performance ability of ewes, and carcass attribute of lambs. Despite being widely accepted as a management tool, to date, BCS in ewes has not been included into sheep breeding programmes, yet it is a relatively simple measure that can be taken quickly and cheaply on a large number of animals. The genetic correlations among BCS and ultrasound fat and muscle depths measured from pre-mating through to 2nd weaning are positive and high (between 0.5 and 0.8; Anang 1995) and body tissue depletion and repletion of different fat and muscle depots, as measured by ultrasound and Computer Tomography (CT), has been shown to be under moderate genetic control (Lambe et al., 2004; 2005). The ability to mobilise body tissues is largely positively linked to offspring performance (Lambe et al. 2007) and survival, but in part, antagonistically correlated to ewe longevity (unpublished results). Integrating BCS into sheep breeding programmes will enable both selection for ewes that maintain body condition throughout the year as well as supply enough milk without compromising lamb performance.

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The Changing Drivers for Pork Production – Metabolic Modifiers

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Summary
Australia has been at the forefront of the development and adoption of technologies to improve the efficiency of pork production. However, there is now a strong tension between the use of these technologies that can have profound effects on improving the efficiency of livestock production and reducing environmental impact and the retailers and consumer groups. Never before has the environmental imperative been so important and yet there is increasing pressure to stop using technologies based on ill-informed perceptions about the environmental impact of farm practices. While these technologies do decrease eating quality these effects can be ameliorated through post-slaughter processes. Uncertainty around whether future technology will be adopted discourages investment in developing new approaches to improving feed efficiency. In conclusion, there is overwhelming evidence for the continued use and development of new technologies but retailers and consumer groups as well as trade barriers may prove to be too disruptive.

With the current and predicted increase in world population, growing global demand and consumption of food will result in increasing competition for land, water and energy. In turn, this will severely affect our ability to produce food, as will the urgent requirement to reduce the impact of food systems on the environment. Globalization has boosted trade in livestock inputs and products and resulted in industry growth, and concurrently livestock production, including pork production, has undergone a complex process of technical and geographical change. This has resulted in a challenge to livestock producers; growing demand for their produce with a dwindling supply of resources, with the only solution being a significant increase in efficiency. Also, as incomes increases in the burgeoning economies, so does the demand for high-quality animal proteins such as meat, milk and eggs, thus the Food and Agriculture Organization of the United Nations (FAO) suggests that food requirements will increase by 70% by 2050.

The improvements in efficiency in pork production has been largely driven by improved nutrition, genetics and the development and adoption of technologies such as metabolic modifiers. In Australia, the focus on efficiency also resulted in the cessation of castration of boars almost half a century ago whereas other countries are only just limiting castration now, albeit for different reasons such as animal welfare concerns. The drive to efficiency resulted in faster growing and leaner animals with undoubted negative impacts on eating quality as intramuscular fat levels were driven down to below 1%. Since a major proportion of pork ended up as processed products most pork producer paid scant regard to eating quality. Australia was also a major player in the development and adoption of growth promoting metabolic modifiers such as porcine somatotropin (pST), ractopamine and immunocastration through immunization against gonatotrophin releasing factor (GnRF). However, when the perfect storm in the form of a strong Australian dollar, decade long drought, high feed costs and increased global trading of pork hit during the late 2000’s the manufacturing market for Australian pork largely disappeared. As a consequence, local producers became more focused on fresh pork and the focus returned to eating quality. Of course, lowering cost of production and continued improvement in efficiency were still major drivers for the pork industry and so production systems were based on using metabolic modifiers while the uptake of immunocastration increased to ensure pork was free of boar taint.

The recent success in these developed and emerging technologies suggests that the animal industries are well placed to prosper through these new challenges. To ensure these technologies can be effectively utilized throughout the animal industries, further emphasis is required on their acceptance and development. As a result of these technological advancements, producers have benefited because of improved production efficiencies while meat packers have improved processing efficiencies because of increased lean meat yield. Ostensibly, the consumer has also benefited because meat is leaner and less expensive to purchase. However, as mentioned above there have been some concerns that the focus on increasing production efficiency and lean meat yield has been to the detriment of meat quality. It is also interesting, that at a time of apparently greater need for these technologies, there are external influences such as market differentiation and trade barriers as well as consumer resistance that challenge the use of technologies. Much of this is based on strong retailer or consumer beliefs about what constitutes a sustainable production system.

Sustainability can be defined as “meeting society’s present needs without compromising the ability of future generations to meet their own needs” and comprises three connected themes: environmental responsibility, economic viability and social acceptability. Too often, the focus on sustainability is hijacked by ill-informed impacts of livestock production on the environment with a common public perception that extensive production systems have a lower environmental impact than intensive systems and this unfortunate perception also applies to views of nutrition and quality of agricultural products. Also, too little credence is given to economic viability that, in an
entire sectorial sense, generally only comes with improved efficiency. The reality is that the use of technologies that improve efficiency of livestock productivity reduce environmental impact and improve economic viability but this may be at loggerheads with consumer expectations in some communities, particularly those with a high disposable income.

Presently, the consumer is readily able to access vast amounts of information (and misinformation) on the merits/demerits of how their food is being produced. The term ‘factory farming’ conjures up all manner of negative aspects of food production, whilst food production systems that hark back to the purported clean and green images of how food used to be produced, are seen as the gold standard. This has manifested itself where the retailer has opportunistically become a consumer educator through their marketing strategies. As a consequence, these retailer strategies have limited, and in some instances banned, the use of some very viable technologies, with little or no supporting evidence. In the case of Australia, these retailer strategies seem to have focused on the mantra of “don’t mess with my food” with the supposed aim of improving food safety and animal welfare; two issues that seem to resonate very well with modern consumers. These retailer strategies have had significant productivity impacts on livestock production systems as supermarkets attempt to differentiate themselves from each other on different credence values. This is exacerbated in settings such as Australia where 2 supermarket chains control over 70% of the market and where the livestock industries has been an early adopter of the growth promoting technologies. One supermarket chain has insisted on “hormone free meat” and doesn’t allow the use of pST, ractopamine, hormone growth promotants or the immunocastration vaccine in any of its fresh pork or beef and so has removed a range of tools that reduce environmental impact and increase the cost of production. While the other supermarkets have not made a similar decision, the fact that one of the major retailers has then limits the commercial outlets for an individual farmer. It also creates logistical issues on farm if a producer did choose to sell to the different suppliers as they would need to operate clearly differentiated production. Today’s pork producer is clearly operating in a different commercial environment.

A tenet of this paper is that if we are to meet the increased global demand for meat and dairy products then we must continue to develop and adopt technologies to improve livestock efficiency but we must be cognizant of the barriers to adoption. Australia has been at the forefront of the development and adoption of many of the growth promoting technologies, but in the short to medium term at least their continued use is threatened. A future worry is that this lack of surety means that there is little incentive for companies to invest in developing new technologies.
Off to the right start – how pregnancy and early life can determine future animal health and production

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Summary

Animal producers are well aware that a runt animal is more likely to die in the first few days of life, and if it survives is likely to perform poorly. We are now coming to appreciate that early life events can permanently change an animal’s developmental trajectory. This is an area of current interest in biomedicine, where the concept is known as the “developmental origins of health and disease” (DOHaD). Current gaps in understanding include many of the underlying mechanisms, and whether and how we might intervene and restore the potential for healthy and productive development. This brief communication introduces the biomedical perspective of DOHaD, reviews some of the evidence for long-term effects of prenatal growth and other early life exposures on welfare and productivity in animal production, and discusses options for intervening to improve long-term outcomes.

It’s more than just birth weight – evolution and understanding of DOHaD from studies in humans

The idea that events in early life might affect health decades later arose initially from David Barker’s studies of regional disease rates in England and Wales, where neonatal mortality rates were initially used as a marker for early life nutrition. Regional patterns of cardiovascular mortality in older adults mapped much more closely to those for neonatal mortality 55-70 y previously than to present day patterns, suggesting that events in early life, including fetal growth, were permanently altering or “programming” development in ways that made the individual more susceptible to heart disease (Barker 1998). Subsequent epidemiological studies linking individual birth and death records, confirmed that individual low birth weight was correlated with increased risk of death from coronary heart disease. Later, associations between individual birth weights and metabolic and cardiovascular health were confirmed in living individuals. Not only were rates of diseases such as diabetes increased in both low and the highest birth weight groups, it was evident that relationships between size at birth and adult disease exist across the whole birth weight range. The initial hypotheses arising from these studies have evolved to become the “Developmental origins of adult health and disease” hypothesis, recognising that the future development and potential of an individual continues to be shaped by its environment throughout life (Hanson and Gluckman 2014).

Birth weight itself, although fairly easy to measure, is a very crude measure of fetal environment. Low birth weight may reflect preterm birth, genetics or exposure to a restrictive fetal environment. Animal studies have been critical in providing direct proof that events before birth program the individual and alter subsequent development and health. These and studies of human cohorts who were subjected to defined exposures in early life, such as the Dutch Hunger Winter, have provided evidence supporting three more key ideas. Firstly, factors other than prenatal nutrition also program development. Secondly, even exposures that do not alter birth weight can program later health and development. Finally, there are critical periods of development where specific tissues and organs are more susceptible to effects of early exposures, and the effects of a given exposure therefore depend on timing. An example of this is differing impact of maternal rubella at different stages in pregnancy. Given these findings in humans, what is the evidence that early life exposures impact long-term welfare and productivity in animal production?

Poor prenatal growth and its impact on animal welfare and production

Poor prenatal growth is an exposure that is relatively easy to (indirectly) measure through size at birth. A species where there is particularly strong evidence that this marker of growth before birth predicts later animal well-being and productivity is the pig, where fetal growth is often variable between litter mates and/or constrained by maternal factors. Low birth weight consistently predicts poorer neonatal survival in the pig – like the human DOHaD studies this relationship is observed across a range of birth weights, without a magic “cut-off” for piglet viability. “Runt” piglets that are born substantially lighter than their litter mates present a particular welfare problem. The initial lack of vigour of small piglets may be compounded by competition between littermates, limiting access to milk supply. There is also evidence for impaired and/or delayed gut and immune development in the growth restricted piglet in early life, which may further increase their susceptibility to disease and impair adaptation to solid feeding. Supplementation with colostrum in the first day of life may improve survival, and cross-fostering is widely used within the industry to reduce variation of piglet weights within litters.

Restricted growth before birth also impacts later growth, efficiency and carcass quality of the pig. Piglet growth rates both before and after weaning are faster in littermates who were larger at birth (Dwyer et al. 1993). Slower growth in runt and small piglets than in their heavier littermates appears to be due in part because they are born with fewer muscle fibres. Muscle fibre development is largely complete by birth in the pig, so reduced muscle fibre number at birth has long-term consequences, including over-growth of existing fibres and poor meat quality (Rehfeldt and Kuhn 2006). Findings from studies in which maternal nutrition was manipulated during pregnancy in the pig suggest that the period from d25 to 50 of gestation may be particularly important for muscle

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development and increased maternal nutrition during this period can increase muscle fibre number and/or density in muscle of mature progeny (Dwyer et al. 1994; Gatford et al. 2003). This corresponds to development of the primary muscle fibres; although these form a relatively low proportion of the total muscle fibres in later life, it is possible that the primary fibres act as a scaffold and hence limit the capacity for secondary fibre development. These findings in pigs are supported by others in sheep, where maternal undernutrition during proliferation of muscle cells and before formation of muscle fibres, altered the proportions and numbers of muscle fibres in their newborn lambs (Fahey et al. 2005). This largely prenatal pattern of muscle development may mean that strategies to promote fetal growth and reduce variation between littersmates will be needed to improve later outcomes for animal production; it is probably too late to intervene after birth. In fact, over-feeding these small piglets to accelerate growth may worsen outcomes. Low muscle fibre numbers likely limit capacity for lean growth and contribute to the increased body fat seen after the first few months of life in pigs born at low birth weight. This effect is similar to the increased deposition of fat during catch-up growth after postnatal restriction, and in other species where catch-up growth in early postnatal life is also typical after restricted growth before birth.

Poor growth before birth may also impair the individual’s resilience and alter responses to stress and other environmental challenges. This may have welfare implications, although here limited data exists for animals in a production context and much of the underlying data comes from studies in humans and animal models of experimental restricted growth before birth. For example, basal (girls) or task-induced (boys) stress hormone levels in children are negatively correlated with their birth weight. There is also evidence that effects of the prenatal environment on cognition and on behaviour including stress responses are sex-specific, meaning that any studies in animal production systems need to include male and female offspring.

What other exposures are likely to be important?

Another exposure that impacts later welfare and production is prenatal exposure to elevated stress hormones. This is important for the pork industry in designing the best practices for group housing of sows during pregnancy in order to minimise stress levels. Inducing maternal stress in pigs by mixing unfamiliar animals and direct maternal administration of stress hormones each adversely affect progeny immune function, growth and behaviour, and effects may also impact the next generation through impaired reproductive development (Ashworth et al. 2011). Some effects of early life events may be indirect; for example maternal stress in experimental animal models may impact progeny through changes in maternal behaviours such as mothering. Recent research in poultry indicates that when progeny are fed diets markedly different from that of their mothers, the progeny grow slower and are more prone to disease and mortality than those fed diets similar to the maternal diet (Hynd et al. 2016). These researchers have also demonstrated that stress in the breeder hen results in progeny that differ in response to immune challenges (Hynd et al. 2016). These maternal effects in poultry have far-reaching industry relevance given the large animal numbers and the economic significance of small changes in feed efficiency and health.

Can we intervene?

Interventions to improve long-term outcomes require either reducing adverse exposures, or attempting to intervene later to restore developmental potential. As discussed above, improved practice and systems may reduce some adverse exposures such as stress. Birth weight may be able to be increased to some extent through management of nutrition and genetic selection, but variation between litter mates in litter-bearing species is likely to remain a challenge. A general principle from studies in humans and experimental animals appears to be that the plasticity of development decreases with age (Hanson and Gluckman 2014). Thus, not only is developmental potential likely most susceptible to events that occur earlier in development, but the greatest potential for benefits from interventions are likely to be when interventions are applied as early as possible.

Conclusions

Developmental potential is continuously altered by environmental exposures throughout life. DOHaD concepts can be applied in animal production systems to reduce exposures and/or reverse their effects to improve animal welfare and production outcomes.

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