

Animal Science Education in Australia - Current Situation and Future Needs. Are Current Training and Education Programs Appropriate for the Animal Industry Needs Over the Next 10-15 Years?

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Introduction

The global landscape in which animal production operates is changing so rapidly it is not unreasonable to label it a 'livestock revolution'. Indeed the comparison engendered by this term with the 'green revolution', applied largely to cropping developments of the mid-1900's, is deliberate (Delgado et al 1999), but the causes are entirely different. While the green revolution was driven by developments in plant breeding, cropping practices and fertiliser use (ie supply factors), the livestock revolution is being driven by an extraordinary increase in global demand for animal products driven largely by increasing per capita wealth in developing countries (Delgado et al 1999, 2002). The ability of the world's livestock producers to meet this demand over the next decade will depend on the availability of cereal and other grains; changes in water allocations; community attitudes to animal consumption; the net effects of climate change on production environments, and; whether agriculture is included in carbon pricing schemes. Some pressures are pushing animal production systems towards increasing intensification e.g. efficiency, product quality and consistency. Others favour extensive, low input systems of production with a strong emphasis on animal welfare, utilisation of low-quality roughages for high quality animal protein production, integration of animals with cropping enterprises, and perceptions that low input equates to sustainability. In this changing world Australia is well placed to supply animal products for developing markets. However to do this it will be vital that the industries are served by graduates with a sound knowledge of animal physiology, nutrition, genetics, reproduction, welfare, pasture management and agronomy, and economics and business management.

Over the past few years there has been an increase in the number of degree programs in Australian universities producing graduates trained in the 'animal sciences'. At the same time there has been a steady decrease in graduate completions in agriculture and related disciplines (Pratley and Copeland 2008). This paper examines trends in education in the animal sciences in Australia, with an emphasis on the provision of graduates with the expertise likely to be needed over the next decade, to service the 'livestock revolution' and other aspects of animal-related activities. The relatively recent inception of named animal science degrees in Australia makes it difficult to gather reliable national data related to student attributes, progression and careers. Where possible we have collated data from a number of universities. More detailed data were collected from student cohorts at The University of Adelaide.

Establishment of animal science programmes in Australia

The Frawley report into Rural Veterinary Services (Frawley 2003) concluded that there was no immediate need for a fifth veterinary school but that "there is scope for rural based universities to move further into the provision of production animal, equine and wildlife animal science courses". The report stated opportunities to develop:

- “(i) special courses aimed at producers and focussed on production systems with components in animal health; and
- (ii) a degree combining elements of veterinary and agricultural sciences”.

Since that report was released, three new veterinary schools have opened in Australia, and animal science programmes, as recommended, have proliferated (Table 1). If the supply of veterinary graduates exceeds their traditional job placements, it is likely that competition for jobs with animal scientists will ensue over the coming decade. Institutions may then distinguish animal science from veterinary science on the basis of depth of coverage (ie animal science as a pre-veterinary programme), focus (eg livestock production), or breadth of training (eg animal production systems in the context of sustainable environments- see below).

The proliferation of animal science degrees has coincided with a general and sustained decline in the number of agriculture graduates (Pratley and Copeland 2008). Provided the animal science graduates have a strong background in the broader themes of feedbase utilisation (pasture production, grazing and fodder management), natural resource management, drivers of profitability in animal businesses, and principles of supply-chain management, they will be well-suited to filling roles in animal agriculture. Encouragingly, in this regard, the advent of animal science programmes is attracting a different cohort of students into animal agriculture: namely urban-based females with high tertiary entrance scores (Buchanan 2008 and Table 2).

Degrees in animal science and related disciplines in Australia

The current degree programs producing graduates in the animal sciences in Australia are listed in Table 1. Animal science programs are offered at nine Australian universities as three or four year programs. Some offer a 4th year as an Honour's year (UA, UQ, UWA). Others include honours within a four year program (UNE, CSU). Most of the programs cover the broad spectrum of animal science including wildlife, domestic/companion and livestock (UA, UWA, UM, UQ) while others focus on production animals only (Murdoch, UNE). The tertiary entrance levels range from approx 70 to 85%. Entry into animal science programs is more competitive overall than entry into general science programmes, with cut-off scores approximately 10% units higher. This reflects greater demand for named animal science degrees than for other science or agriculture programs. A similar preference is apparent in the USA where animal science is the largest major in colleges of agriculture (Britt et al. 2008). In this US survey almost 30% of total graduates in the sciences were in 'animal science'. Agriculture graduates comprised 10%, horticulture 8%, plant science 6%, food science 5% and soil science 2%.

Table 1. Summary of 'animal science' degree programmes in Australian universities. Note, agriculture programmes with specialisation in animal sciences are not included.

Institution	Program	scope	years	Graduate numbers*	Web site careers specs
University of Adelaide	BSc (An Sc) (TER 80)	Domestic; production; wildlife	3 (+1 Hons)	60	"Pathway to Veterinary Science, Pest Control, Animal Breeding, Animal Welfare, Laboratory Technician, Land Resources and Land Care, Animal Behaviouralist, Livestock Production, Management Consultant, Manager / Business Management, Marketing - Agriculture, Food & Wine, Bioinformatics, National Parks / Ranger, Natural Resource Manager, Natural Resource Planner, Parks Management, Quarantine Officer, Environmental Scientist, Field Technician, Scientific Data Analyst, Government officer, Government or Corporate Policy Adviser"
Murdoch University	B An Sci (TER 70)	Livestock production (food and fibre)	4	n/a	"all areas of agriculture from Government Departments of Agriculture, rural supply and stock companies, in research funded by industry agencies such as Meat & Livestock Australia (MLA) and Australian Wool Innovation (AWI), as farm advisors, managers in the stud industry, in biosecurity and quarantine, and not least in universities as academics
University of New England	B Livestock Sci (UAI 75)	Livestock	4 years (incl Hons)	15	"advisory, regulatory and research positions in all agricultural fields in both the private and public sectors, particularly in breeding, management and consultancy for the livestock industries and agribusiness. Potential careers range from extensive rangeland production to high input grazing and feedlotting"

Institution	Program	scope	years	Graduate numbers*	Web site careers specs
University of Western Australia	B AgSci/An Sc (TER 80)	Livestock and wildlife	3 +1 (hons)	35	“fibre, agricultural, food, biomedical science, fisheries and pastoral industries. Examples include positions with animal and wildlife conservation and welfare groups, natural resource management organisations, wildlife parks or zoos, research institutions such as CSIRO, universities and colleges of advanced education, agricultural, stock or chemical companies and biotechnology companies”
Charles Sturt University	B An Sc		4 (incl hons)	25	research, teaching, commerce, government advisory or regulatory roles, and industries allied to animal health, welfare, nutrition, and the management of populations of free-living or captive wild animals.
University of Western Sydney	BSc(An Sc) (ATAR 73)		3	50	“animal nutrition; animal reproduction technology; animal genetics; animal behaviour; animal health product developers; and zoo animal science.”
Melbourne University	BSc (domestic animal science; animal health and disease; zoology) (ENTER 85)	Domestic, companion, wildlife	3		“research, animal production industries, disease surveillance and bio-security, and animal welfare”; “conservation and wildlife management, or the biotechnology, biomedical and bioinformatics industries”
La Trobe University	BAnim and Vet Biosciences (ENTER 72.6)		3		“veterinary and animal research, agricultural and environmental industries, animal care and welfare, biotechnology and the animal health industry. Potential employers include zoos, the RSPCA, animal welfare agencies, university and commercial animal houses, government departments, and veterinary, chemical and biotechnology companies”
University of Queensland	BAppl Sc (production animal sc; wildlife sc; equine sci; vet tech)	Livestock science; wildlife science; vet tech; equine science; animal science	3 (+1)	90	“Animal Scientists research and distribute newly discovered information regarding the biology and management of production animals. Animal Scientists also work to apply their knowledge to benefit the general public through the efficient, humane and environmentally responsible use of animals for food, companionship and recreation”

Data were gleaned from personal communications with programme convenors and from information available on the websites for each university. * Tertiary entrance values and student numbers are approximate only and vary significantly from year to year.

The number of graduates from named ‘animal science’ programs has increased dramatically over the past ten years. There were approximately 220 graduates per annum from animal science programmes between 2001 and 2006 (Pratley and Copeland 2008). Since then new courses at The University of Adelaide, Murdoch University, University of New England, Charles Sturt University and University of Western Sydney have increased the number of animal science graduates to in excess of 400/annum. The wide variety of potential career opportunities listed by the institutions (Table 1) suggests the programmes are aimed at producing generalists with an amalgam of agricultural, environmental and animal sciences. Relative to traditional agricultural scientists, animal science graduates are relatively deficient in soil sciences and agronomy.

The majority of animal science programs in Australia have emerged from existing food animal production courses, to include companion and laboratory animals. McNamara (2009) argues strongly that this development is well-founded given that in the USA alone pets number 72mill dogs, 82 mill cats, 11mill birds, 14 mill horses, 150mill fish, 6 mill rabbits, and 1 mill guinea pigs, with a total value of over \$41bill per annum. He argues that if animal science programs wish to remain relevant they must extend to domesticated species including horses, cats, dogs, as well as rodents, birds, fish, reptiles and camelids. Furthermore the number of rodents alone used in research in animal science departments usually exceeds the number of food animals used. The field of laboratory animal management presents an opportunity for careers for animal scientists (Mellor et al 2009).

Characteristics of students attracted to animal science programmes

In the USA a high proportion of animal science students is female (70%), and most nominate horses, companion and exotic animals as their preferred species of interest, reflecting their predominantly urban backgrounds (Britt et al. 2008; Buchanan 2008). A recent survey of 1st and 3rd year students enrolled in the animal science degree at The University of Adelaide confirms a similar situation (Table 2). A high proportion of the students in animal science are female (78%), have had or currently own pets (84-100%), and are employed during their degree (>70%). The species they nominate as their preference to work with are horses, companion animals and wildlife (>60%). Livestock interested about 46% of the year 1 cohort but this had risen to 72% in the year 3 cohort. This may simply reflect cohort differences, but is consistent with our experience that interest in production animals increases as students are exposed to them, and as career opportunities in livestock become apparent. Laboratory animals and pigs/poultry were the least preferred species (<30%). Interestingly the cohorts contained a significant number of vegetarians/vegans (11 and 19%).

Table 2. Survey data from two cohorts (years 1 and 3) of the Bachelor of Animal Science at The University of Adelaide in 2008.

Cohort	1 st year	3 rd year
Number of students	61	32
Gender (% females)	79	78
Age (range)	21 (17-48)	21 (19-33)
Current animal ownership (%)	92	84
Animal ownership as child (%)	97	100
Vegetarian or vegan (%)	11	19
Employed (%)	71	78
Species you would work with (%)		
Wildlife	74	78
Horses	61	63
Companion	67	63
Livestock	46	72
Pigs/poultry	16	28
Laboratory	10	22

A survey of animal science admissions statistics at The University of Adelaide (n=819 over the period 2004 to 2010) revealed that 74% of students offered places in animal sciences were urban-based and 26% rural-based. The socioeconomic split was: 35% high, 51% medium and 14% low.

Global trends in animal science and production

The animal sciences, perhaps more than any other endeavour, are at the forefront of a number of major challenges in societal, environmental, technological and economic areas. Concerns over the impact of animal production systems include: greenhouse gas production; animal welfare issues related to housing and husbandry (eg mulesing, castration, de-beaking, dehorning); health issues related to intensive production; antibiotic resistance, and; energy and water consumption by animal production systems. These are considered below with the objective of seeing if the curricula of current animal science programmes align with future requirements of global animal production systems.

Livestock support more than one billion people globally and contribute 40% of total agricultural output (FAO 2009). Future global animal production systems face diametrically opposing pressures (Fig. 1). On the one hand there is a growing trend, at least in developed economies, towards demands for production systems which could

be described as ‘low input, organic, animal welfare-friendly, environmentally-sustainable’ and in which the consumer has detailed knowledge of the production system. Increasingly animal products are marketed with these concerns in mind (free-range poultry, barn-laid eggs, ‘slow’ foods, organic beef, mules-free wool etc). On the other hand there are demands for animal products that might be deemed ‘technological, high input, and intensive’. The demand here is for inexpensive, consistent high quality, specified quality, and health-enhancing properties (eg trace element-enhanced meat, minimum fat, maximum fat, A2 milk, omega-3 eggs). Internationally this is reflected in the intensification of livestock production, with feedlot beef and sheep, high-intensity poultry and pig systems, and intervention in breeding and feeding systems with potential utilisation of genetic engineering and fetal programming to control production.

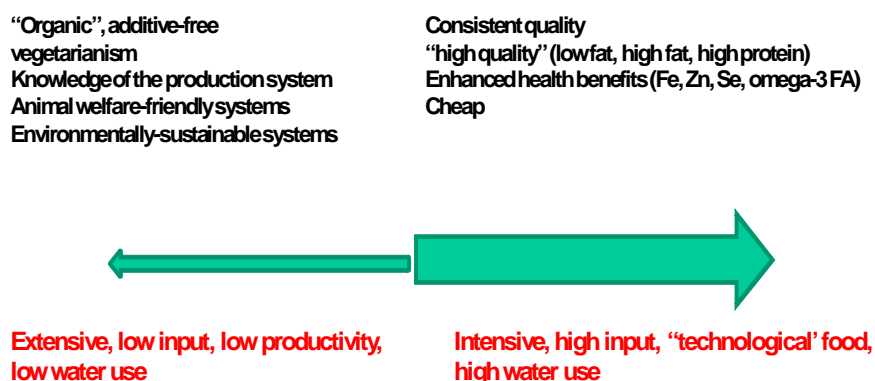


Figure 1. Hypothetical factors affecting the demand for animal products. The size of the demand arrows depends on economic, social, and cultural factors (nationality, age cohort, socioeconomic group).

In Australia this trend is exemplified by the dairy industry where there are fewer farms, greater animal numbers/farm and greater production/animal (Table 2).

Table 2. Dairy cow numbers/farm, number of farms and milk yield/cow in Australia from 1980 to 2010.

Year	No. of dairy farms	Dairy cow numbers/farm	Milk yield (L/cow)
1980	21,994	85	2882
1990	12,896	128	3807
2000	11,839	183	4847
2010	7,924	202	5707

Data from Dairy Australia (<http://www.dairyaustralia.com.au>)

Emerging issues in global animal production

Increasing demand for animal products.

Since 1960 global meat production has trebled, milk production doubled and egg production quadrupled (Delgado et al 1999) and this growth is expected to continue. Total consumption in the developed and developing world is expected to rise between 1993 and 2020 (%) respectively as follows: beef (0.4, 2.8), pork (0.3, 2.8), poultry (1.0, 3.1), meat (0.6, 2.8) and milk (0.2, 3.3) (Delgado et al 1999). The majority of the increased demand will be in the developing world (FAO 2009). The per capita consumption of eggs and meat in developing countries increased by 500 and 300% respectively between 1961 and 2005. In that period the consumption of milk almost doubled per capita while cereal and root crop consumption was virtually unchanged. Growth in demand for animal products reflects both an increase in population and affluence, there being a close relationship between per capita income and meat consumption (Delgado et al 1999). The greatest increase in animal production will be of pigs, poultry, eggs and milk (Speedy 2003).

Greenhouse gas abatement and climate change

The contribution of livestock to annual anthropogenic greenhouse gas emissions is disputed, with calculations from 7% (Smith et al 2007) to 18% (FAO 2006). In the latter report the contribution of intensive

systems (feedlots, pork and poultry production) was 5% and extensive grazing systems 13%. The impacts of climate change on animal production systems will include changes in 1) seasonal pasture growth, 2) pasture species (eg perennial versus annual; C₄ versus C₃; grasses versus legumes), 3) species of animals that are 'farmed' (eg macropods versus ruminants), 4) parasite and disease profiles, 5) disease vector populations, and 6) seasonal production cycles, to name a few.

Animal health and welfare

As educational levels increase, consumers become increasingly concerned about the origins and processing of their foods (Hughes 1995). This is particularly the case for females. Hughes (1995) describes the phenomenon well: "In general, better-educated food consumers not only want to be assured about the safety of their food but also seek to remove or assuage guilt about how food is produced and prepared for the table". The importance of animal welfare in Australia is illustrated by the support given to the Australian Animal Welfare Strategy, a national program aimed at promoting animal welfare in Australia (<http://www.daff.gov.au/animal-plant-health/welfare/aaws/online>). "Animal welfare" is difficult to define and measure, and includes consideration of the physical and psychological state of the animal, plus whether or not it is living in a 'natural' state (Fraser 2008). Dawkins (2008) provides a succinct definition as "animals that are healthy and have what they want". The challenge for animal scientists in the future will be to apply this caveat to practical solutions to animal transportation, intensive pig and poultry production, dairy production, and feedlot beef and sheep systems. In the past it has been the role of animal scientists to develop economically- and biologically-efficient systems, and clearly they have succeeded. In the future their task will be to produce 'animals that are healthy and have what they want' in economically-viable businesses. Dissecting the molecular, behavioural and physiological determinants of 'what animals want' will be a fascinating challenge in the next decade.

From an animal health perspective the emphasis in the future will be to utilise genetic solutions to health problems, and to reduce reliance on drugs and antibiotics to maintain good health and safe foods. The complete sequencing of the genome of many of the major animal species and the application of single nucleotide polymorphism technology to identify disease- and parasite-resistant animals will facilitate this task.

Competition for resources

Animals will need to compete for a number of limiting resources as the global population approaches 9 billion people by 2050. The limiting resources will include grazing land; land available for feed grain consumption; grains diverted to biofuel production; grains diverted to human consumption, and; water for pasture irrigation, drinking and effluent management.

New or re-emergent exotic and zoonotic diseases *Outbreaks of swine flu*

A(H1N1), highly-pathogenic avian influenza, BSE, and two recent deaths due to Hendra virus, have raised the public profile of zoonotic diseases in Australia. Several trends are producing an increasing risk of human and animal disease. Geographic clustering of intensive animal production in heavily-populated, peri-urban areas, the global movement of people and animals and changes in pathogen and vector distributions with climate change, increase the risk of new and re-emerging diseases. Frawley (2003) recommended the development of animal science degrees in which disease surveillance was undertaken by field-based animal scientists, rather than proliferating veterinary science degrees.

Changes in the scale and focus of animal production

The major issues facing animal production systems of the future will be complex and shift from incremental improvements in production efficiency, to interactions between production, societal demands and environmental sustainability. Marketing of animal products will increasingly include aspects of welfare, organic production, "food miles", health-promoting benefits (functional foods), food safety, carbon neutrality, water efficiency, and defined quality. The trend away from the family farm to large-scale, vertically-integrated production is likely to continue. In many developing countries there is an urgent need for implementation of basic systems to maximise animal welfare, health and production.

Changes in interactions with animal species

Pet ownership in Australia is amongst the highest in the world, with 38 million pets, including 3.7mill dogs, 2.2mill cats, 20mill fish, 7.8mill birds and 3mill other (horses, rabbits, guinea pigs and pocket pets) (ACAC 2009). Owning a pet is linked to a variety of health benefits, including reduced risk of heart attack, increased

social capital, fewer visits to the doctor, and reduced childhood risk of asthma and obesity (ACAC 2009). Pets are members of the family and can contribute to the learning of nurturing and social skills. Whilst the number of food animals far outnumbers pets (75mill sheep, 28mill beef cattle, 1.8mill dairy cattle, 5.5mill pigs), the number of people involved in food animal production is declining. The proportion of urban living Australians has increased to >80%, meaning most people have no direct exposure to food animals. Animal science departments of the future will have to take such shifts in societal and demographic trends into account if they are to remain relevant and productive.

Animal science programmes that will meet the future needs of the global livestock and companion animal industries

The skill sets needed to meet the challenges of future livestock production systems will include knowledge of: business management, international animal production systems, animal health, animal welfare, animal reproduction, animal biotechnology, animal breeding and genetics, ecology and management of landscapes and wildlife, sociology and cultural awareness, grazing animal nutrition and management (pasture management), and understanding of the production of feedbases available to animals.

One component of animal science programmes in Australia, which does not seem to have been addressed, is that of internationalisation. A survey of USA animal science faculties noted a similar failure to embrace international programmes despite strong rhetoric supporting the concept (Forsberg et al. 2003). The authors concluded “that few departments have incorporated internationalization into their mission statements or developed a specific international-themed class, scholarships devoted to international activities or roles for international students”. Given the trends in global animal protein demand described previously, it is somewhat surprising that internationalisation has not been adopted as a major theme into the core curricula. Internationalisation could take the form of shared resources, seamless credit transfers, alignment of courses, internships in other universities, audio/visual contacts and academic transfers. The value of creating an international animal science network is significant and would provide educational as well as cultural benefits to students (and academics). The formation of such a network would greatly expand the student’s learning in generic skills, cultural awareness and understanding of climatic, seasonal, cultural, production, management, and disease issues affecting animal production in different countries and for different species. Perhaps the initiation of an Australian network of animal scientists would be a useful way of initiating this proposal.

Schillo (1997) argues that traditional animal science curricula, which ignore sociological aspects and do not encourage analytical and critical thinking, will not serve the future needs of animal science. Perhaps this is best illustrated by the application of science to animal welfare issues. Quantitative, scientific assessment of pain, assessment of well-being in animals and provision of “what animals want” (Dawkins 2008) will require the application of high-level science including molecular, cellular, physiological, and behavioural approaches. However at some point ‘value’ judgements will be required and these will be greatly influenced by rapidly-changing cultural norms. Students of animal science should be exposed to critical thinking exercises which develop their ability to integrate science with social, cultural and ethical factors.

The greatest challenge facing animal science programs is to differentiate them from veterinary science so that they develop a clear vocational niche and are not perceived as second rate veterinary programs. Historically animal science programs developed out of agricultural science programs allowing, to date, a distinction on the grounds that veterinary science (animal health) is but one component of the generic animal sciences, alongside nutrition, reproduction, genetics, housing, lactation, growth, meat and fibre production (Mellor et al 2009). Such a schema saw animal scientists as potential managers of animal production enterprises which would include animal health as but one component. However the trend for veterinarians to expand their interests to more holistic approaches to animal health (Mellor et al 2009) and to whole animal enterprise consultancies, will increasingly make this distinction invalid. We see the future of animal scientists as developing a strong science base upon which one can build a wide range of career opportunities (research, veterinary technologies, species of interest, laboratory animal management, development aid and so on) with work-place experience and postgraduate specialisations.

Conclusions

The number of graduates in “animal sciences” in Australia is growing rapidly. This growth coincides with a time of increasing demands for animal protein in developing countries and changing demands and pressures on animal use. The on-going employment prospects for students will depend on receiving programs delivering high-quality science, critical thinking, and an understanding of the role of animals within a social, economic and

environmental context. Animal science programs should include companion and laboratory animals in addition to food animal species. It is vital that animal science programs distinguish themselves clearly from veterinary science. This can best be achieved by maintaining a broad-based program including economics, animal management, feedbase utilisation, research, statistics, and natural resource management, in addition to the basic animal sciences. A difficulty, of course, is achieving this depth and breadth of knowledge within a 3 or 4 year program. One way may be through the formation of an international network of providers of animal science education, which would provide opportunities for student exchange. The aim will be to produce graduates with a solid foundation in animal sciences, but sufficient flexibility to move into the new and expanding career paths resulting from an ever-changing world.

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