PHOTOPERIOD AND SEASONAL INFERTILITY IN THE PIG AND THE POTENTIAL OF EXOGENOUS MELATONIN AS A PREVENTIVE: A REVIEW

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SUMMARY

Photoperiod, and not high ambient temperature, appears to be the major cause of seasonal infertility in pigs. Attempts to counter depressed fertility during summer by cooling sows are often unsuccessful. In contrast, artificially reducing daylength during summer shortened the wean-to-oestrus interval of a commercial sow herd by 18d to 5.7d. A similar programme also improved boar fertility. However, there are likely to be practical difficulties in manipulating daylength in the normal Australian style of housing for breeding pigs. It is suggested that parenteral or oral administration of the "daylength" hormone, melatonin, may have potential as a counter to seasonal infertility.

(Keywords: sows, infertility, temperature, photoperiod, melatonin)

INTRODUCTION

Seasonal infertility (SI), a decline in reproductive efficiency during the period from late spring to mid autumn (Love 1981), is a major constraint to profitability of the Australian pig herd. The value of lost production has been estimated at over $6m./yr (Greer 1983).

HEAT STRESS AND SEASONAL INFERTILITY

Since the drop in fertility occurs mainly during the summer months, the stress imposed by high ambient temperatures was thought to be the immediate cause. Experimental heat stress undoubtedly reduces reproductive performance (Greer 1983). Positive correlations between summer temperatures and lowered fertility have been reported from some field studies in Australia (Stone 1977; Love 1978; Paterson et al. 1978; Hennessy and Williamson 1984) and overseas (Greer 1983). Other workers, however, have not been able to demonstrate any such association (Benjaminsen and Karlberg 1981, Claus et al. 1984; Greer and Gilmour, unpublished data). Even under laboratory conditions it can be difficult to produce adverse effects of temperature on reproduction. Mercy and Godfrey (1985) imposed very high temperatures (38°C for 17h, 32°C for 7h) to induce only minor and variable effects on the fertility of gilts.

Various cooling methods have failed to reduce the effects of SI in many instances (Hurtgen et al. 1980; Hurtgen and Leman 1980, 1981; Kornegay and Thomas 1983). For example, BeVier and Backstrom (1980) maintained shed temperatures below 27°C by evaporative cooling, yet were not successful in preventing the decline in fertility during summer. Such results suggest that high temperatures are not solely responsible for the infertility. It may be that SI is due to the sum of a number of cumulative stressors acting on the animal, many of which are present all year (Greer 1980; Williamson et al. 1980). When the stress threshold is exceeded as a result of the additional stress due to high summer temperatures, SI occurs. Evidence for this multifactorial involvement has been provided by Hennessy and Williamson (1984).

SI is recorded in countries with hot and with mild summers (Greer 1983). Australian summers can be quite mild and yet SI still occurs (e.g. 1984/85, R.J. Love, G.J. Roosé, Pers. Comm. 1985). This suggests that the effect of summer temperatures on reproductive performance is relative to those in the cooler months or that their association with SI may simply be coincidental to changes in daylength, the other environmental factor which exhibits major and reliable cyclic changes.

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Photoperiod and Seasonal Infertility

The domestic pig is considered to be polyoestrous and capable of breeding throughout the year. By contrast, reproductive activity in the European wild pig is at its peak in winter while for much of the summer and autumn there is complete sexual inactivity. In the wild sow, ovarian inactivity commences in mid spring when daylength is increasing but when environmental temperatures are still low (Mauget 1982). The onset of mating in mid autumn is probably controlled by decreasing daylength as it is in sheep (Barrell 1983) and deer (Lincoln 1984). SI may be a relic of the annual photoperiodic rhythm inherited by the domestic pig from its wild ancestors. Or it may act by predisposing sows to the effects of heat and other stressors i.e. the stressors which trigger the syndrome may be acting on an animal with a vestigial propensity towards a "reproductive rest period" (Greer 1983). Data on plasma prolactin levels reviewed by Mauget (1982) support both theories.

A number of authors indicate photoperiod may be a significant factor in SI. Hurtgen et al. (1980) noted the frequency of post-weaning oestrus began to decline as daylight increased and prior to the onset of hot weather while data presented by Hennessy and Williamson (1984) shows a comparable effect with farrowing rate. Egbunike and Steinbach (1980) made similar conclusions about other fertility traits and Benjaminsen and Karlberg (1981) focused on changing daylength in spring and autumn. Unfortunately, laboratory data on the influence of photoperiod on boars and sows is equivocal (Greer 1983). In sheep, the timing of the seasonal reproductive cycle can be reversed by reversing daylength (i.e. artificial short days during natural long days and vice versa) but not by reversing natural temperature patterns (Karsch et al. 1984).

Improvement of Pig Fertility in Summer by Reduction of Daylength

Recent reports from Germany (Claus et al. 1984) reveal a major involvement of photoperiod in SI under practical conditions. Subjecting boars to simulated long summer days in winter and short winter days in summer resulted in a fertility pattern the opposite of that of boars under normal daylight regimes. Of greater interest is the effect of a lighting programme during summer on the reproductive performance of sows.

The windows of a sow shed on an 80-sow commercial piggery were blacked out during summer and artificial light provided: from the beginning of May until the end of August 1983, daylength was reduced by 20 min per week. The average wean-to-oestrus interval for June-August 1983 was reduced (P < 0.001) by 18d compared to the same months of 1982 (5.7d vs 23.6d), during which year the sows were exposed to natural photoperiod at all times. For the remaining months, apart from September, there was no difference between the two years. On an annual basis, reduction of daylength during summer reduced the average wean-to-oestrus interval by 4d. In a 100 sow piggery this is equivalent to an extra 3.5 litters or about 35 pigs farrowed per year.

This experiment lacks contemporaneous control and treatment groups. However, the differences in wean-to-oestrus interval between years for June-August are so clear and the pattern for the remaining months so similar as to minimise this criticism.

Application of the Results to Australia

In assessing the potential application of these results to Australia, the shorter summer daylength in Australia is an obvious divergent factor. At the summer solstice, daylength in the Central West of N.S.W. (33°20'S) is 15h 20m vs 17h for Germany (48°43'N). The change in daylength from winter to summer is 4.5h.
in the Central West and 8.5h in Germany. While a smaller response to a light program in Australia might be anticipated from the smaller change, Claus et al. (1984) found an increase in daylength of 3.5h at the end of August (when the sows were returned to natural photoperiod) increased the wean-to-oestrus interval in September by 10d compared to September the previous year. In fact, responses were seen in June 1983 when daylength had been reduced by only about 1.5h. Nonetheless, the results require confirmation under Australian conditions and this is tentatively provided by Greer and Gilmour (unpublished data). Sow fertility from November to April on N.S.W. piggeries was related to daylength 6 weeks prior to mating (there is a 4 to 7 week latency to changed photoperiod in pigs and sheep - Claus et al. 1984; Karsch et al. 1984) but not to daylength or maximum or minimum temperature in the week of mating.

REDDING DAYLENGTH IN AUSTRALIAN PIGGERIES

The design of Australian sheds for breeding pigs, with ventilation ridges and shutters or plastic blinds in the walls, would create practical difficulties in achieving an effective blackout. Even if it could be achieved, an effective blackout is likely to cause other problems. With ventilation restricted, internal shed temperatures would rise and may lead to heat stress per se. Reducing daylength by blacking out the shed in the cool of the morning does not appear to be a solution as the shed would need to be closed until about 1000h. Even at this early hour temperatures can be quite high. It would also lead to practical difficulties with husbandry/management.

MELATONIN AS A POTENTIAL PREVENTIVE

Using the same technique of artificially reducing summer daylength, breeding activity can be induced in seasonally anoestrous ewes by confining them in darkened sheds from mid-afternoon each day (Dunstan 1977). The mechanism by which changing daylength produces these effects involves the generation of hormonal signals within the brain. These endocrine responses occur in the pineal gland which is stimulated by the cranial cervical ganglia of the sympathetic nervous system. The ganglia are in turn regulated by the suprachiasmatic nuclei which directly receive lighting stimuli from the eye by a retinohypothalamic tract. The pineal gland secretes melatonin only during the night, and the duration of exposure to melatonin provides the brain with an index of night length and thus daylength. The long duration melatonin secretion in autumn and winter indicates a 'short day' and leads to activation of the reproductive system. This activation is thought to occur via an effect on hypothalamic activity and/or on the hypothalamic-pituitary-gonadal axis (Barrell 1983; Karsch et al. 1984; Lincoln 1984; Turek et al. 1984).

Administration of small amounts of melatonin in the late afternoon to sheep and deer advanced the onset of breeding activity. The hormone can be supplied orally as a feed supplement, by injection or as an implant either subcutaneously or intravaginally (Kennaway and Seamount 1980; Lincoln 1984; Nowak and Rodway 1984).

If, as the results of Claus et al. (1984) and Greer and Gilmour (unpublished data) strongly indicate, photoperiod is a major determinant of SI in the pig, then I suggest that the inclusion of small amounts of synthetic melatonin in the daily feed may offer a simple, convenient and effective means of mimicking short daylength during the summer/early autumn and thus reducing, if not preventing, SI.

Because of the need to maintain a prolonged period of uninterrupted high levels of circulating melatonin, the feed supplement would need to be given before dawn if morning feeding was to be practised (C. Earl, pers. comm. 1985). Feeding sows at the traditional time, with a period of daylight between dawn and feeding, may result in the 'light pulse effect' (Barrell 1983; Turek et al. 1984) in which a short period of light during an otherwise long dark period (i.e. short days)
reproduces the effects of long days. The practical alternatives to pre-dawn feeding are late afternoon feeding or feeding the major portion of the daily allowance at the normal time followed in the late afternoon by a small quantity of melatonin-supplemented feed. The afternoon feed would be timed such that circulating levels of exogenous melatonin would remain elevated until after dark when endogenous synthesis would assume the task.

CONCLUSIONS

The limited information available suggests that photoperiod, and not high ambient temperature, is the major cause of SI in pigs. As well as confirming the German results in Australia, information is needed on the actual cause. Is the response due to the stepped reduction in daylength, or can it be reproduced by short daylength per se? Determination of basal levels of circulating melatonin in the sow would be the initial task in an investigation of the exogenous use of the hormone.

REFERENCES


