MANIPULATION OF REPRODUCTION IN FEMALE DEER

M.W. Fisher & P.F. Fennessy
MAFTech, Invermay Agricultural Centre, Private Bag, Mosgiel

It has been envisaged that some of the largest changes in the farming of deer in the near future will be in reproduction, namely altering calving date, artificial insemination and twinning (Fennessy, 1987). While artificial insemination is reviewed elsewhere in this proceedings (Fennessy et al., 1987), this paper will review aspects of the induction of early breeding, synchronisation of the oestrous cycle and superovulation.

INDUCTION OF EARLY BREEDING

Progesterone/PMSG and GnRH treatments

There have been several studies using progesterone/PMSG treatment in red hinds (Adam et al., 1985; Fisher et al., 1986a,b; Moore & Cowie, 1986). Although there is little known of the hind, evidence in the ewe suggests that the period of progesterone pretreatment is required to ensure that oestrus accompanies ovulation (Robinson, 1954), and ensure normal corpus luteum formation (McLeod & Haresign, 1984) and embryo viability (Moore & Miller, 1984). At progesterone withdrawal, an injection of PMSG is given which will induce oestrus and ovulation in the majority of animals. However, the use of PMSG may result in variable responses with the possibility of excessive superovulation with higher doses an important consideration. This treatment synchronises mating so that nearly all hinds are mated within several days of progesterone withdrawal. However, low fertility has been frequently reported and this may in part be due to the use of stags which are likely to be subfertile prior to the onset of the normal mating season as the effectiveness of this treatment improves with proximity to the normal mating season (Moore & Cowie, 1986). Further evidence of this is seen in the vastly improved calving rates obtained when seasonally advanced stags (melatonin-treated) have been used. In 1986, 33/56 (59%) of progesterone/PMSG treated hinds run with melatonin-treated stags (Regulin, Genelink Australia) calved early in October (G H Moore, unpublished data) compared to 6/48 (13%) the previous season using similarly treated hinds but untreated stags (Moore and Cowie, 1986). Prior to the normal breeding season, red deer stags appear to have the capability to copulate normally but show a reduced tendency to roar and herd hinds compared with melatonin-treated stags (M. Quentin-Baxter, unpublished data).

A similar form of treatment utilises a period of gonadotrophin stimulation with GnRH following progesterone withdrawal (Fisher et al., 1986a,b; Asher & Macmillan, 1986) and although possibly not as effective as PMSG in inducing ovulation or as practical to administer it may be of benefit because multiple ovulations apparently do not occur.

Some PMSG and GnRH treated hinds calve corresponding to conception about 18 days after the induced ovulation suggestive of a second post-treatment ovulation, while the remainder calve at the same time as the untreated controls, indicating that they probably revert to anoestrus until the onset of the normal breeding season. This may result in a large calving spread in any group of treated hinds.

The pineal gland, photoperiod and melatonin treatments

The pineal gland, described by Descartes as the "seat of the soul", is located in the brain above the third ventricle and between the cerebral hemispheres. Melatonin, an indoleamine, was first isolated from bovine pineals 30 years ago (Lerner et al., 1958). Environmental lighting suppresses pineal function so that melatonin synthesis varies rhythmically with the light:dark cycle. In the ewe an estimated 1.5-5.0 mg melatonin per 14 hour night is secreted mainly into the blood but also into the third ventricle (Rollag et al., 1978). Photoperiodic changes mean that during summer plasma melatonin concentrations are elevated for a shorter period than during autumn when the hours of darkness are longer (Bittman et al., 1983). In this way, seasonal photoperiodic changes act via the pineal gland to entrain the animals inherent annual reproductive rhythms with the environment, enabling breeding to occur at a time that subsequently results in the birth of offspring during favourable environmental conditions, at least in the wild.

Not surprisingly then, manipulation of photoperiod or administration of melatonin (either orally, subcutaneously, intramuscularly or intravaginally), designed to mimic photoperiodic changes, have been used to experimentally modify the timing of the breeding season and the results for red deer are summarised in Table 1. Barrell & Staples (1987) found that the degree of advancement of seasonal reproductive activity was largely dependent on the date of commencement of treatment with melatonin. They found that when treatment began in December the mean calving date was advanced by 16 days whereas when treatment began in January the mean calving date was advanced by only 8 days.

TABLE 1: The effects of manipulating photoperiod or administering melatonin on the mating and calving seasons of red deer.

Treatment	Number and reproductive state of the hinds	Advancement of the mean mating (m) or calving (c) date (days)	Reference
Artificial darkness	3 prepubertal	32 m	Webster & Barrell, 1985
Intramuscular melatonin	4 prepubertal	26 m	Webster & Barrell, 1985
Oral melatonin	4 non-lactating	34 m	Adam & Atkinson, 1984
Oral melatonin	12 non-lactating	35 m	Adam et al., 1986
Oral Melatonin	12 lactating	32 m	Adam et al., 1986
Subcutaneous melatonin[1]	12 lactating	6 c	Barrell & Staples, 1987
Subcutaneous melatonin[2]	16 lactating	12 c	Barrell & Staples, 1987

[1] silicone rubber implant
[2] Regulin (Genelink, Australia)

However, there is probably a limit as to how early mating and subsequent calving can be induced. Studies in ewe lambs (Yellon & Foster, 1985) and rams (Lincoln & Ebling, 1985) suggest the animal may require exposure to increasing photoperiods (spring and summer) before exposure to shorter periods (autumn) or exogenous melatonin are able to induce breeding. Similarly, work in adult ewes indicated that melatonin implanted one or two months prior to the summer solstice while inducing early breeding in some animals resulted in normal or late breeding in others (English et al., 1986). The duration, timing and magnitude of exposure to exogenous

melatonin requires thorough investigation in deer and some of these aspects are currently being investigated at Invermay.

Melatonin-treated hinds which failed to conceive at their first oestrus and ovulation returned to oestrus 18 days later and mated successfully (Adam et al., 1986) while such treatment may even reduce the calving spread (Barrell & Staples, 1987).

In addition to clearly modifying reproductive activity, photoperiod or melatonin treatments can alter or at least have the potential to alter other parameters of seasonal physiology in deer namely antler growth, appetite and liveweight, coat growth and lactation. Melatonin treatments designed to advance reproductive activity in hinds have resulted in earlier moulting of the summer coat (Webster & Barrell, 1985; Adam et al., 1986) and possibly slightly reduced bodyweights of both yearling and lactating adult animals, although lactation, as assessed from calf growth, appears unaltered (Table 2; Adam et al., 1986). Liveweights and coat growths of treated animals continue to be monitored as Lincoln & Ebling (1985) found that some melatonin-treated rams were in poor condition and more vulnerable to cold weather.

Melatonin treatment (currently not licensed in New Zealand) is likely to gain commercial acceptance with the development of slow release implants which will deliver melatonin for periods of up to 60 days (e.g. Staples et al., 1986; Rodway et al., 1987).

TABLE 2: Liveweights of untreated and melatonin-treated yearling hinds and adult hinds and their calves (M W Fisher & P F Fennessy, unpublished data).

	Liveweight (kg)			
	Beginning of treatment	End of treatment (12 March)	Winter (4 June)	Gain (beginning of treatment to 4 June)
1. Yearling hinds				
control	72.2	79.0	81.9	9.7
treated[1]	74.3	82.2	82.8	8.5
2. Lactating hinds				
control	109.2	106.8	108.5	-0.7
treated[2]	108.6	108.5	106.6	-2.0
3. Calves belonging to the hinds in (2)			Weaning (23 April)	
control	23.3	42.9	55.6	
treated	23.7	43.9	56.1	

[1] 30-day melatonin implants (Regulin, Genelink, Australia) administered in December, January and February

[2] 30-day melatonin implants (Regulin, Genelink, Australia) administered in January and February

Hind/Stag Interactions

In sheep the breeding season can be advanced and synchronized using the "ram effect" - the mere introduction of rams to anoestrous ewes preconditioned by a period of isolation from the rams suffice to induce ovulation (Underwood et al., 1948; Knight, 1983, Martin et al., 1986). This induced ovulation is not accompanied by oestrus but is followed by either normal luteal function and subsequently oestrus or by premature corpus luteum regression, and a second silent ovulation, followed by normal luteal activity and subsequently oestrus. These events result in two peaks in mating activity in a flock of sheep, 18 and 24 days after ram introduction. Interestingly, the ram may be more effective if also exposed to oestrous ewes (Knight, 1985). Consequently, there has been considerable interest in applying these results to deer. Moore and Cowie (1986) found that untreated control hinds run in a mating group with hinds treated with progesterone/PMSG to advance breeding have subsequently calved approximately 18 days later than treated hinds (but still prior to the calving season) as would be expected if a "stag effect" occurred similar to the "ram effect". In another experiment, two groups of hinds were isolated from the stag from January and then one group was run with vasectomised stags for two weeks prior to when both groups were mated to entire stags. 20/42 (48%) hinds previously run with vasectomised stags calved corresponding to conception at a time consistent with the "stag effect" occurring compared with 5/39 (13%) controls (Moore and Cowie, 1986). In the ram at least, pheromones are the likely major component of the "ram effect" (Knight & Lynch, 1980). However, the possibility of visual and auditory components being important cannot be ignored. The auditory component was recently studied in deer by playing vocalisations of stags recorded during the roar, to hinds otherwise isolated from stags (K McComb, pers. comm.). Hinds which had been exposed to stag vocalizations for 2 weeks prior to joining with entire stags, tended to calve earlier than control hinds indicating that stag vocalisations alone may affect the timing of ovulation in hinds.

SYNCHRONISATION OF OESTRUS

Traditional methods of synchronizing the oestrous cycle, namely those involving progesterone or prostaglandin administration developed for use in other domestic animals appear to be similarly effective in deer (see Fennessy et al., 1986). With the increase in artificial insemination programmes in deer, PMSG has been administered at the time of progesterone withdrawal to ensure that the synchronisation of ovulation is precise and predictable. Mating was first noted in synchronized red hinds 28.5 hours after progesterone withdrawal/PMSG injection (250 IU) with 9/28 (32%) being mated by 35 hours (M W Fisher, et al unpublished data). Although there is little data available on the hind, work with sheep indicates an inverse relationship between the dose of PMSG used and the interval to oestrus and ovulation (Table 3). If hinds behave similarly then the optimum time for artificial insemination after progesterone withdrawal is likely to vary with the dose of PMSG.

TABLE 3: The effect of dose of PMSG on the interval from progesterone withdrawal to oestrus and ovulation in ewes (Boshoff et al., 1973).

	Time (hours) from		
Dose PMSG (IU)	progesterone withdrawal to oestrus	progesterone withdrawal to ovulation	beginning of oestrus to ovulation
0	48.9	96.7	47.8
250	33.8	71.9	38.1
500	27.1	59.7	32.6
750	25.1	51.6	26.5

SUPEROVULATION

There has been considerable interest in multiple births in deer following the birth of both natural and induced twins and triplets last calving season. Induced multiple births have so far been a consequence of progesterone/PMSG stimulated early breeding (Adam et al., 1985; Moore and Cowie, 1986; G H Moore, unpublished data) and attempts to induce twinning with PMSG during the normal breeding season generally have been unsuccessful (M W Fisher & P F Fennessy, unpublished data). There is normally wide variation in the response to PMSG (e.g. 1-12 ovulations were reported by Kelly et al. in 1982 with a single dose of 1000 IU) and excessive superovulation (3 or more) can lead to foetal wastage or non-viable, low birthweight calves (Adam et al., 1985). The induction of twinning and the subsequent growth of the offspring have yet to be fully evaluated in red deer.

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