Effects of melatonin on seasonal physiology of red deer

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ABSTRACT

Aspects of seasonal physiology were monitored in red deer either untreated or treated with melatonin designed to advance the onset of the natural breeding season. Treated animals were implanted with melatonin at monthly intervals during December, January and February (adult stags and yearling hinds) or January and February (lactating hinds).

Rutting behaviour, antler casting and velvet antler regrowth occurred up to 2 months earlier in melatonin-treated stags, while mean calving dates were advanced by 11 d in both groups of treated hinds.

In yearling hinds, melatonin treatment advanced by about 1 month the phase of low growth which occurred in control hinds in autumn. However, treatment had little overall effect on live weight of yearling hinds or lactating hinds. Treated hinds moulted their red summer coats and grew lighter winter-like coats about 1 month earlier than untreated hinds. The growth rates of calves sucking melatonin-treated and untreated hinds were virtually identical.

These results indicate that melatonin treatment can advance several aspects of seasonal physiology in deer.

Keywords Melatonin, red deer, early breeding, antlers, live weight, coats, calf growth.

INTRODUCTION

The reproductive seasonality of red deer (*Cervus elaphus*) and its modification by photoperiodic cues has been known for some time (Marshall, 1937). The secretion of melatonin from the pineal gland during the hours of darkness enables seasonal reproductive rhythms to be entrained with annual photoperiodic changes (Bittman *et al.*, 1983). Not surprisingly then, exogenous melatonin designed to mimic autumn photoperiodic changes has been used experimentally to advance the timing of the breeding and subsequent calving seasons in farmed red deer to enable better utilisation of seasonal pasture production (Adam and Atkinson, 1984; Webster and Barrell, 1985; Webster *et al.*, 1986). However, in addition to modifying reproductive activity, melatonin administration may also alter other aspects of seasonal physiology. Therefore we have monitored the effects of melatonin treatments designed to advance the onset of the breeding season on stag behaviour, antler status, hind live weight and coat changes. In addition, since treatment of adult hinds was imposed upon lactation, calf growth was also monitored.

MATERIALS AND METHODS

Animals and Treatments

Three groups of red deer comprising adult stags (n = 24), yearling hinds (n = 18) and lactating 3-year-old hinds (n = 36) were used. Half were treated with melatonin and half untreated. All melatonin-treated deer except the lactating hinds received 2 subcutaneous implants (each containing 18 mg melatonin; Regulin®; Regulin Ltd, Melbourne, Australia) on each of 3 occasions at 30 d intervals beginning on 16 December. Since they were calving during December, the lactating hinds each received 2 sub-cutaneous melatonin implants on only 2 occasions beginning on 15 January.

Melatonin-treated or untreated stags were joined with the hinds in single-sire mating groups on 13 February (yearling hinds) or 3 March (lactating hinds) and removed on 15 and 12 May respectively.

Measurements and Records

General observations of rutting and mating behaviour were made on several mating groups containing either treated or untreated stags during February and March prior to the normal mating season. Stag hard antler casting date and velvet antler cutting date and weight were recorded.

Calving date was monitored by observing all hinds daily. Live weights of hinds and calves were recorded at least monthly from the beginning of treatment until the calves were weaned (23 April) or the hinds were set-stocked in preparation for calving (16 October). Changes in coat growth were monitored on samples taken from hinds at monthly intervals by using curved scissors to remove to skin level a small amount of hair from a mid-side position in the region of the last rib. Coat length was measured with a ruler and coat colour appraised by eye as either reddish-brown (summer) or greyish-brown (winter), as reported by Ryder and Kay (1973). Fibre diameter was measured on a representative number of samples taken from the yearling hinds during winter (15 July) using the projection microscope method described by Andrews *et al.* (1987) except that a microtome was used to cut the fibres and a sample of 100 fibres was measured.

Statistical Analysis

All data is expressed as the mean ± standard error of the mean and differences between means tested with Student's *t*-tests.

RESULTS

Stags

Melatonin-treated stags tended to roar and herd their hinds more actively than untreated stags following joining. Extensive observations in early March on 2 animals, 1 treated and 1 untreated, suggested both animals could apparently copulate normally. Melatonin treatment induced earlier antler casting and velvet antler growth. This was most pronounced in the older stags (Table 1). The period from antler casting to velvet antler harvesting and velvet antler weight was identical in both treated and untreated groups (63 d and 2.69 kg respectively).

TABLE 1 Mean date of antler casting in control and melatonin-treated stags.

Age (years)	Treatment				Significance of difference
	Control		Melatonin		
	Date	Number	Date	Number	
5+	23 August	4	21 June	5	***
4	30 August	2	28 July	3	NS
3	2 September	2	21 August	3	NS

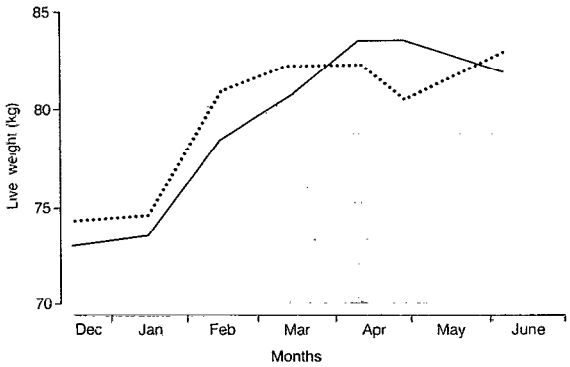

FIG. 1 Mean liveweight change in control (——) and melatonin-treated (. . . . .) yearling hinds.

Yearling Hinds

Melatonin treatment significantly advanced the mean date of calving by 11 d (13 November ± 3.44 d in melatonin-treated hinds *v* 24 November ± 1.25 d in control hinds; $P<0.05$).

All yearling hinds gained weight during summer (Fig. 1). This was then followed by a period of little growth during autumn in control hinds, while melatonin-treated hinds displayed this phase about a month earlier beginning in March (Fig. 1). Melatonin-treated hinds began growing again in late autumn, earlier than the control hinds which resumed growth during winter. Consequently there was no overall effect of melatonin treatment on live weight as indicated by mean hind live weight during winter (20 August; 87.2 ± 2.1 kg in control and 90.8 ± 2.8 kg in melatonin-treated hinds) and the following summer (18 January; 91.3 ± 1.7 kg in control and 96.6 ± 2.7 kg in melatonin-treated hinds).

The mean coat length of untreated and treated hinds was similar in mid-summer (Table 2). However, by late summer (12 March) the melatonin-treated animals had moulted and grown new, shorter-length coats. This moulting and regrowth occurred about a month later, during autumn, in the control hinds. By winter (20 August) both groups had similar length coats. Coat colour followed a similar trend changing from the reddish-brown colour of summer to the lighter greyish-brown colour of winter about a month earlier in melatonin-treated than in control hinds. Diameters of the outer coat hairs and the inner down, measured on a representative number of samples taken from hinds during winter, were similar. Mean values for the treated and untreated hinds were 316.7 ± 9.0 and 311.8 ± 13.4 μm for the outer coat hairs and 14.7 ± 0.6 and 14.6 ± 0.6 μm for the inner down respectively. Although coat changes were not accurately monitored through spring and early summer when the animals were calving, melatonin-treated hinds tended to moult their winter coats earlier. For example, on 25 September 8 of the 9 melatonin-treated hinds had begun moulting their winter coats compared with only 2 of the 9 control hinds.

TABLE 2 Mean (± SE) coat length (cm) in control and melatonin-treated yearling hinds.

Season	Date	Treatment		Significance of difference
		Control	Melatonin	
Summer	15 January	4.44±0.24	4.56±0.23	NS
	12 March	4.14±0.30	2.83±0.26	*
Autumn	9 April	2.22±0.19	4.67±0.08	***
	4 June	3.83±0.33	4.00±0.38	NS
Winter	20 August	5.28±0.40	5.17±0.24	NS

Lactating Hinds

Melatonin-treated hinds had a significantly earlier mean calving date (17 November ± 2.1 d in melatonin-treated hinds *v* 28 November ± 3.0 d in control hinds; $P<0.01$).

Both treated and control hinds lost weight from the beginning of treatment till weaning (Table 3) with no effect of melatonin treatment during the period of weight loss or the following summer (Table 3).

TABLE 3 Mean(± SE) live weight (kg) of control and melatonin treated lactating hinds.

Time	Date	Treatment	
		Control	Melatonin
Start of treatment	15 January	109.2±2.1	108.6±2.4
Weaning	23 April	107.9±2.3	106.2±2.3
Winter	19 August	103.2±2.0	102.3±2.5
Summer	18 January	110.6±2.1	109.8±2.3

Shedding of the summer coat and the subsequent growth of a winter coat as indicated by changes in coat length (Table 4) and colour (reddish-brown to greyish-brown) occurred approximately 1 month earlier in melatonin-treated hinds than in control hinds.

The growth rates of calves sucking melatonin-treated and control hinds from beginning of treatment to weaning were similar (324 and 328 g/d, respectively) with mean weaning weights on 23 April of 55.0 ± 1.2 kg and 55.7 ± 1.1 kg respectively.

DISCUSSION

The results indicate that exposing red deer to exogenous melatonin during summer advances the onset of the breeding season. Stags which normally rut in autumn were induced to rut in late summer and although not measured in the present experiment, seasonal changes in live weight, neck musculature and testes size also occur earlier in melatonin-treated stags (J.R. Webster, unpublished data). The seasonal antler cycle of casting and commercial velvet harvesting was also advanced in treated stags with the effect being more pronounced in mature stags. However, neither the amount of velvet produced nor the interval from casting to harvesting was affected.

Melatonin treatment of young, yearling hinds advanced the mean calving date by 11 d. However, the mean calving date of the control hinds in the present experiment (24 November) was considerably earlier than that previously recorded at Invermay (10 December; Fisher *et al.*, 1986). The reason for this difference is unknown but hinds in the present experiment were run with melatonin-treated stags, unlike those in the earlier experiment, suggesting the seasonal reproductive status of the stag might influence the onset of the breeding season.

In addition to advancing the onset of the breeding season, melatonin administration altered the seasonal pattern of liveweight change in young growing hinds although it had no overall effect on live weight.

In the present study the shortest time from the beginning of treatment to conception (calculated as calving date minus 233 d) was 55 d. Consequently, because of this considerable lag period, any treatment of adult animals would have to be imposed upon lactation. In the present study, treatment which began approximately 30 d after calving, advanced the following season's mean calving date by 11 d. Neither hind live weight, nor lactation, measured indirectly as calf growth, were affected by melatonin treatment. However, the possible effect of melatonin administered earlier in lactation needs to be examined as administration prior to the initiation of lactation may inhibit milk production (G.W. Asher, pers. comm.).

The seasonal coat changes comprising moulting of the summer coat and growth of the winter coat previously reported in red deer (Ryder and Kay, 1973; Ryder, 1977) were similar to those noted in the present experiment. Melatonin treatment merely advanced by about a month the timing of the summer moult and winter coat regrowth as indicated by monthly estimates of coat length and colour.

Collectively these results suggest that exposure to melatonin during summer acts to shift aspects of seasonal physiology so that antler growth, mating and subsequent calving, summer coat moult and winter regrowth and the growth of young hinds occur

TABLE 4 Mean (± SE) coat length in control and melatonin-treated lactating hinds.

Season	Date	Treatment		Significance of difference
		Control	Melatonin	
Summer	15 January	3.81±0.09	3.78±0.09	NS
	12 March	4.00±0.16	3.08±0.28	*
Autumn	6 April	3.94±0.21	1.83±0.17	***
	6 May	2.64±0.14	3.33±0.12	**
Winter	19 August	3.94±0.13	3.92±0.49	NS

about a month earlier. While these effects are still evident for some considerable time following treatment it is likely that there are few long-term detrimental effects on growth of hinds, their progeny or on winter coat growth with melatonin treatment regimes similar to those imposed in the present study.

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