Advancing calving in red deer: The effects on growth and sexual development

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ABSTRACT

The growth and sexual development of red deer calves born early (12 male, 12 female), with an average birth date of 22 October 1990 ± 3.8 d (SD) were compared with control calves (12 male, 6 female) born 6 weeks later (2 December ± 2.4 d).

From birth to 16 months of age, the pattern of liveweight gain in the early-born and control calves was similar, but because of the 6 week advance in calving, early males and females were on average 11 to 13 kg heavier at weaning on February 22, and 10 kg heavier than their control counterparts one year later.

Pedicle initiation in males and plasma progesterone patterns in females were monitored to determine the stage of sexual development. Early-born male calves attained a pedicle height of 1.5 cm on 30 June at 250 d of age and an average liveweight of 71.1 kg. The control calves initiated pedicles 55 d later (24 August, SED ± 12.6 d, P<0.01) at a similar age (264 d, SED ± 12.4 d, NS) but at a significantly lower liveweight (66.1, SED ± 1.6 kg, P<0.05). No female calves (early-born or control) showed signs of ovarian cyclicity in plasma progesterone during the normal breeding season for adult hinds. Average liveweights on 23 April were 61.6 ± 4.5 and 49.2 ± 0.4 kg for the early and control female calves respectively.

Although early calving resulted in enhanced liveweights, only 2 of the hind calves reached 65 kg, the lower threshold liveweight required for the attainment of puberty in yearling hinds, and none displayed ovarian activity indicative of puberty. In contrast to the situation with the hind calves where there was no evidence of precocious puberty, the early-born stag calves initiated pedicles earlier than the controls and two of them had developed hard antlers (evidence of precocious puberty) by October 1.

Keywords Red deer, *Cervus elaphus*, birth, growth, liveweight, puberty, antler pedicle.

INTRODUCTION

The highly seasonal reproductive cycle of farmed red deer *(Cervus elaphus)* results in calving over the late spring and early summer period (Kelly & Moore, 1977; Hamilton and Blaxter, 1980). There has been considerable interest in advancing the present calving dates to better align the supply of high quality pasture available in early spring with the high nutritional requirement of the lactating hind with her newly-born calf (Adam & Atkinson, 1984; Adam *et al.*, 1986; Webster & Barrell, 1985; Fisher and Fennessy, 1990). While much research has been undertaken to achieve successful matings prior to the normal season, the consequent effect on calf development has not been so well documented. The objective of this study was to investigate the effects of an advanced date of birth on subsequent growth and sexual development in red deer calves.

MATERIALS AND METHODS

Generation of Calves

As part of an experiment to induce multiple ovulations and twin pregnancies in red deer (Fennessy *et al.*, 1991a), 70 rising 4 year old hinds were artificially inseminated either prior to the breeding season on 1 March 1990 (n=35) thereby generating early-born calves, or during the normal breeding season on 12 April 1990 (n=35) generating calves born within the normal calving period (controls). Synchronisation of oestrus was achieved by a 12 d exposure to progesterone via an intravaginal *CIDR* device (*CIDR* [Controlled Internal Drug Release]-type G, containing 9% w/w progesterone; AHI Plastic Moulding Co; Hamilton, New Zealand), replaced after 8 d, and a 420 I.U. i.m. injection of pregnant mare serum gonadotrophin (PMSG; *Folligon*, Intervet (Aust) Pty Ltd, Lane Cove, NSW, Australia) at the time of *CIDR* withdrawal. Intrauterine artificial insemination (AI) was performed per laparoscopy 52-54 hours later under general anaesthesia (Fennessy *et al.*, 1990a). Frozen semen from the same three stags collected during a previous breeding season was used on both March 1 and April 12. Full details are given by Fennessy *et al.* (1991a). Hinds pregnant to AI, determined by rectal ultrasound scanning at day 35-40 after AI, were maintained as one group until February 1991 except for the period over calving from mid-October to mid-December. All calves were weaned on 22 February and maintained as one group until 11 December when they were split according to sex.

All calves were managed under a normal farm health programme which included Ivermectin plus selenium (*Ivomec*, oral solution for cattle; Merck Sharp and Dohme, NZ Ltd) at monthly intervals from February to July 1991, copper (1 x 4 g *Copper Needles*; Bayer NZ Ltd) in April and October, iodine (1 ml *Lipiodol*; Rhone Merieux Wellington, NZ) in July and 5-in-1 Clostridial vaccine (*Coopers Multine*; Pitman-Moore NZ Ltd) in February and April 1991. The calves grazed high quality ryegrass-white clover dominant pasture along with a group of 16 Père David X red deer hybrids. Throughout winter, the calves grazed pasture and were supplemented at a rate of 1 kg barley and 0.8 kg lucerne hay per head per day.

Measurements

Hinds were weighed at the time of *CIDR* insertion. Over the calving period, the hinds were observed daily and the new born calves were tagged and weighed (to the nearest 0.1 kg) and the dam identified. Twins were excluded from the experiment although the animals continued to run with the group until weaning.

Sucking calves were weighed at 2 weekly intervals from 18 December until weaning (22 February) and thereafter at monthly intervals. The male calves were observed at fortnightly intervals for pedicle development. Once pedicles had appeared, pedicle lengths were recorded at two-weekly intervals. The date of pedicle initiation (PI) was defined as the date on which pedicles reached a height of 1.5 cm above the skull (medial aspect of the pedicle). To determine ovarian status in the female calves, twice-weekly blood samples were taken via jugular venepuncture over the period from 10 April to 24 May 1991 (the time of the normal breeding season in adult and pubertal hinds at Invermay) and plasma progesterone concentrations were analysed by solid-phase radioimmunoassay (Diagnostic Products Corporation, Los Angeles, USA; Jopson *et al.*, 1990). The intra-assay coefficient of variation calculated on 20 duplicate pairs in 2 assays was 8.7%. Assay sensitivity was 0.08 ng/ml. The onset of ovarian cyclicity was defined as the date when plasma progesterone concentrations were elevated above 0.5 ng/ml for 2 successive samples.

Statistical Analysis

The birth and liveweight data were analysed by analysis of variance. Means are expressed ± standard deviation (SD). The pedicle initiation data were analysed using REML implemented in GENSTAT, with time of birth (early or late) as a fixed effect and sire as a random effect.

RESULTS

Twelve single-born calves of each sex were weaned in the early calving group and 12 single male and 6 single female calves were weaned in the control group. Six sets of twins were excluded from this trial. Early calves were born over 15 days with a mean date of October 22 ± 3.8 days (SD). The control calves were born 6 weeks later (41.1 d; $P<0.01$) within an 8 day spread (2 December ± 2.4 d).

Hind mating liveweight, time of AI, sire or sex of the calf had no significant effects on gestation length or calf birthweight (Table 1). Within the sexes there was little difference between the early-born and control groups in the rate of growth of calves (Figure 1). At an average age of 80 days, all groups had reached a similar mean liveweight of 40.5 ± 3.2 kg and 38.9 ± 2.7 kg in the early-born males and females and 39.2 ± 2.7 kg and 36.8 ± 3.1 kg in the control males and females respectively. However, at weaning the early-born calves, now 123 days of age, weighed significantly more (52.0 ± 3.9 kg males and 48.0 ± 3.8 kg females; $P<0.01$) than their younger, 81 day old counterparts of the same sex (39.2 ± 2.7 kg males and 36.8 ± 3.1 kg females), by an average difference of 12.8 kg and 11.2 kg for male and female calves respectively. All animals continued to gain weight at similar, though reduced rates during late autumn and winter (late April to early September). The differences in liveweight were virtually maintained over the 11 months after weaning to 31 January 1992, at which time the early calves were 10.0 kg heavier ($P<0.05$) than their control counterparts, and male calves were 17.9 kg heavier ($P<0.01$) than the female calves born at the same time.

Over the 6-7 week period in which the hind calves were blood sampled, the early-born calves weighed an average of 60.8 kg (2 being heavier than 65 kg) and the controls, an average of 48.5 kg (all under 51 kg). During this time mean plasma progesterone concentrations were generally less than 0.18 and 0.12 ng/ml in the early and control hinds respectively and rose no higher than 0.31 ng/ml at any time, in any animal.

TABLE 1 Mean values (± SD) for dam liveweight, gestation length and birthweight for single-born calves

Calf Group	Dam mating liveweight (kg)	Gestation length (d)	No of calves	Birth wt (kg)
Early males	100.3 ± 7.8	235.7 ± 3.6	12	9.07 ± 1.33
Early females	105.4 ± 7.8	233.5 ± 3.9	12	8.23 ± 0.92
Control males	99.8 ± 10.2	237.2 ± 2.6	12	9.15 ± 0.73
Control females	101.0 ± 5.6	235.8 ± 1.9	6	9.01 ± 0.99

The early born stags attained a pedicle height of 1.5 cm (pedicle initiation, PI) on 30 June, an average of 55 d earlier ($P<0.01$) than the control stags who attained 1.5 cm pedicles on 24 August. Although both groups were of a similar age at PI (250 d in the early and 264 d in the control stags; SED ± 12.4, NS), the early born stags were 5.0 kg heavier (71.1 and 66.1 kg; SED ± 1.65, $P<0.05$) than the control stags at this time. When the data in the present experiment were compared with earlier Invermay data (Table 2), they indicate that the stags in this study exhibited PI at significantly higher liveweights than in 1977- and 1978-born stags. Of the 12 early-born stags, 2 had cleaned their antlers by October 1, while none of the controls had done so.

TABLE 2 Comparison of the mean date and mean liveweight at pedicle initiation (PI, height of 1.5 cm) in December-born red deer calves born at Invermay in 1977 and 1978 with 1990.[1]

Group	n	Mean at pedicle initiation Date	Liveweight
1977 born: winter diet comparison[2]			
Complete pelleted	5	7 Aug	52.4
Meadow hay	5	23 Sep	50.5
	SED	10.8	2.11
1978 born: winter diet comparison[2]			
Complete pelleted	6	6 Sep	59.1
Lucerne hay	6	26 Sep	58.8
Meadow hay	6	6 Oct	54.2
	SED	8.0	1.39
1990 born: birth date comparison			
Early	12	30 Jun	71.1
Control	12	24 Aug	66.1
	SED	12.6	1.65

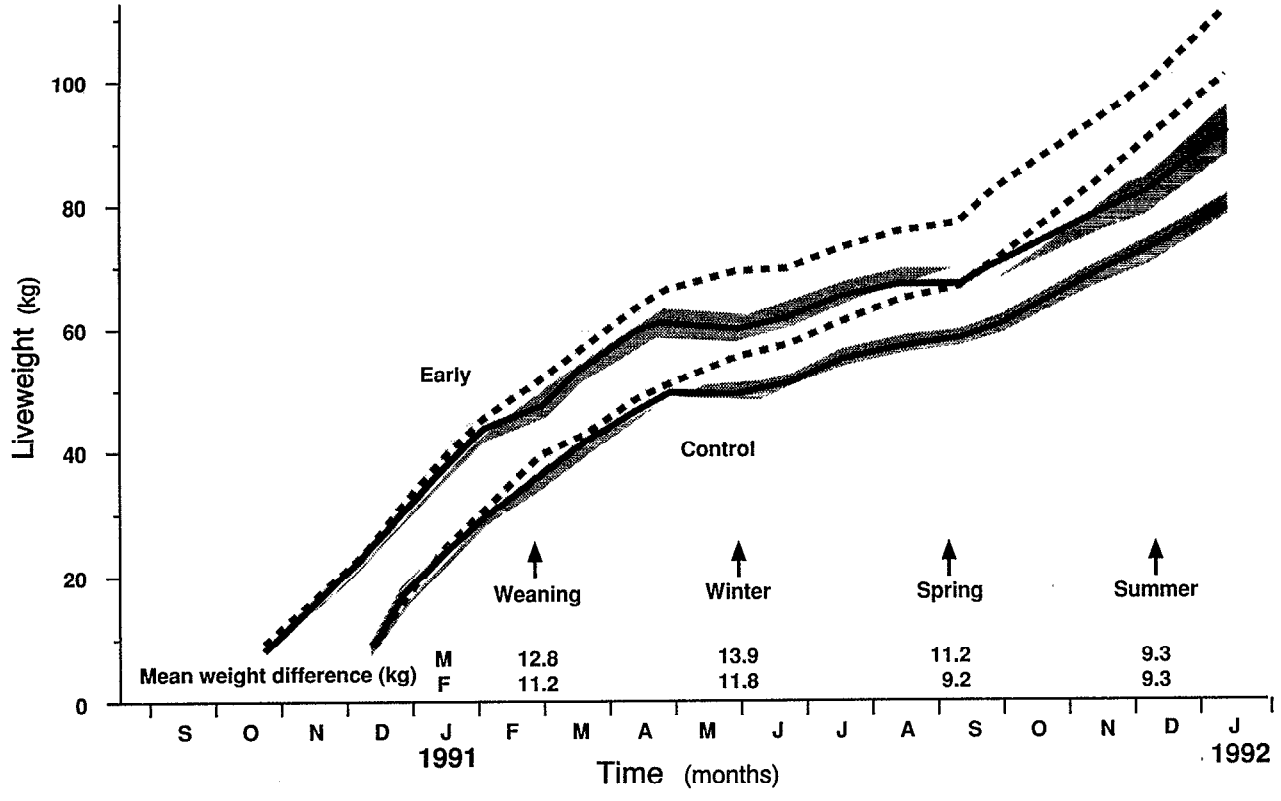
[1] All experiments were analysed using the version of REML implemented in GENSTAT with diet or time of birth as a fixed effect and sire as a random effect.

[2] P.F. Fennessy, I.D. Corson and G.J. Greer, unpublished data; the different diets were fed *ad libitum* to stags in individual pens (1977 born) or in groups of 6 (1978 born) from early June until late August; thereafter all stags were switched to the complete pelleted diet (barley-lucerne-linseed).

DISCUSSION

The male and female calves, whether born prior to or during the normal calving period, exhibited similar patterns of growth to those seen in previous studies over the first 16 months of life (Adam & Moir 1987; Suttie 1987). Changes in the rate of growth in all calves appeared to be governed by seasonal patterns, with the growth rates declining into, and increasing out of the winter period at about the same time and at about the same rate in each

FIGURE 1 Pattern of mean liveweight gain (± SD) in early-born (22 October ± 3.8 d, n = 23M + 12F) and control-born (2 December ± 2.4 d, n = 12M + 6F) male (— — —) and female (———) red deer calves.



group. Because of this, the 11 to 13 kg liveweight advantage gained in the early calves by advancing the average date of birth by 6 weeks was virtually maintained.

By 13 months of age, the difference in weaning weight between early-born and control calves had been reduced by only 13%. This contrasts with the situation observed in female calves with similar calving dates born in the previous year. The liveweight difference between the early and late groups was reduced by 67%, 11 months after weaning (P.F. Fennessy, unpublished data). The contrast between the two years raises interesting questions about possible interactions between the sexes and individual animals within the groups.

The uniformity of growth rates, and therefore mean liveweights, of early-born and control, male and female calves up until approximately 80 days of age suggests that there was little, if any, difference in early development between the groups. Any possible lactational advantage gained by the availability of higher quality pasture for the dams of the early-born group was not expressed by higher pre-weaning growth rates. A mild spring, and warm, wet summer such as experienced in the year the study was undertaken, may have influenced these factors. During a normal season we would expect the high quality feed supply to be available for a shorter period of time.

Puberty in farmed red deer hinds commonly occurs between 15 and 16 months of age (Bray and Kelly, 1979; Asher and Adam, 1985) at approximately 70% of their mature bodyweight or between 65 to 70 kg (Fisher and Fennessy, 1985). Even though a 11 to 13 kg advantage was gained by the calves born 6 weeks early, this was not sufficient to enable the female calves to attain the target weight needed to reach puberty during their first autumn. Although 2 early calves were heavier than 65 kg, the group average did not reach 65 kg until mid-July, and 13 weeks later (mid-October) in the controls. Oestrous cyclicity, indicated by plasma progesterone concentrations > 2 ng/ml, has been demonstrated in 3 of 5, 9-month-old, female calves that had been born 5 months prior to the normal breeding season (Adam *et al.*, 1991). These results suggest that if female calves can be born early enough to be exposed to the appropriate photoperiod cues and/or to reach appropriate liveweights prior to their first winter, precocious puberty may occur.

In the stag, pedicle development is a secondary sexual character. Its initiation is dependent on the elevation in testosterone production (Suttie *et al.*, 1984; 1991) and consequently it is an indicator of pubertal development. In the present study, the control males initiated their pedicles at a lighter weight, but at a similar age to the early-born males. Within each group the timing of pedicle initiation was highly correlated with body weight (Fennessy and Suttie, 1985). Further evidence of precocious puberty was observed in 2 early-born stags who cleaned their antlers prior to October 1, more than 4 months earlier than would normally be expected for stags born at the normal time (Fennessy *et al.*, 1992). This suggests that the rising plane of nutrition associated with increasing daylength in spring, may accelerate the onset of the pubertal changes in the stag. Interestingly, the liveweight at PI was significantly greater than that recorded in early December-born calves at Invermay 12 and 13 years earlier (Table 2). Comparisons with other Invermay data (Moore *et al.*, 1988a) indicate that the liveweights at PI for the pen-fed 1978-born stags (57.4 kg) were similar to those recorded for pasture-reared stags from the same cohort (59.5 kg; note: a 3.5 kg

adjustment has been made for the pasture-reared stags to account for the difference in the definition of PI). In addition, 1980- and 1982-born, pasture-reared stags initiated their pedicles at liveweights which were 3 and 7 kg greater than the 1978-born stags (Moore *et al.*, 1988a), with the liveweights at PI for the 1982-born stags and the 1990-born control stags being similar. Taken overall this would suggest that the increase in liveweight at PI in Invermay stags largely occurred prior to 1982. These early increases in liveweight at PI are not readily explicable but improvements in deer management and in genetic merit of the animals may have been involved. In this respect, Moore *et al.*, (1988a) reported that the 1980- and 1982-born stags were 8 to 12 kg heavier at 3.3 years of age than the 1978-born stags. Similarly, the rising 4-year-old hinds born in the mid-1970's averaged 94 kg (Moore *et al.*, 1988b) whereas those in the present study averaged over 100 kg.

Based on the results from this particular experiment, advancing the date of calving would appear to have long-term beneficial effects on calf growth. The average weaning weight was 12 kg higher for the early-born calves, an average advantage of 2 kg per week birth date was advanced, much of which was still evident at 12 months of age. However, the possible effects of social groupings and between animal interactions on the ability of the animals to exhibit catch-up growth should be considered in any future work. Although puberty was not attained in the female calves in this study, the possibility of precocious puberty occurring in early-born hinds cannot be dismissed, thus introducing a further problem to be negotiated in commercial farming. Pedicles, while not initiated at an earlier age, were initiated at a heavier weight. Further monitoring of this group of deer will determine long-term effects on liveweights, reproductive development in the hinds and velvet production in the stags. The potential impact, if any, of precocious puberty on ultimate body weight is also an important consideration.

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