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Factors affecting liveweight gain in red deer calves from birth to weaning

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Abstract The pre-weaning growth of two groups of red deer (*Cervus elaphus* L.) calves born at Invermay in the 1984 and 1985 seasons was studied to examine factors influencing gain and to provide estimates of correction values for estimating calf breeding values. Growth patterns were similar for both years. Male calves were on average 0.9 (SED ± 0.2) kg (10%) heavier than female calves at birth and 4.8 (± 0.8) kg (13%) heavier at weaning, with average growth rates of 384 g per day and 336 g per day, respectively. The growth rate from birth to mid lactation was 63 g per day greater than that from mid lactation to weaning. Birth weight was positively related to dam mating weight with a 0.33 kg increase in birth weight corresponding to a 10 kg increase in dam weight. The square of the metatarsus length at birth and birth weight were strongly related (R^2(adj) = 63%). Least squares models are given between early, later, and overall growth rates to weaning adjusted for sex and dam weight, and either metatarsus length squared or birth weight. In all instances, the square of metatarsus length explained more of the variation in growth rate than birth weight. Coefficients derived from the models including birth weight suggest a 1 kg increase in birth weight corresponded to an increase of 19 ± 3 g per day in early calf growth, to only 6 ± 5 g per day for later growth, and 14 g per day over the whole period. Dam liveweight made a smaller contribution to variation in calf growth rate with a 10 kg increase in dam mating weight corresponding to a 10 g per day increase in growth rate from birth to weaning.

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INTRODUCTION

Factors influencing liveweight gain of red deer (*Cervus elaphus* L.) calves during lactation are important in improving the weight of weaners produced both per hectare and per hind. Weaning weight is an important determinant in improving 15-month liveweight, which for stags is strongly related to later velvet antler yield (Moore et al. 1988). For hind calves good weaning weights are important in attaining breeding weight at 16 months. In this paper, the dependence of growth rate during lactation on birth weight, metatarsus length at birth as a measure of skeletal size, dam mating weight, and sex is analysed for two groups of red deer calves born in the 1984 ($n = 76$) and 1985 ($n = 67$) seasons at Invermay. This analysis provides some estimates of correction values to rank calves on early growth.

MATERIALS AND METHODS

Mating liveweights of the dams were recorded in March. All hinds were aged 2 years or older and had been weaned. Calves were weighed 12–36 h after birth with birth weight recorded to the nearest 0.1 kg. As an indicator of skeletal size, one metatarsus of the newborn calf was measured by tape to the nearest 0.1 cm as the distance from the hock to the distal end of the metatarsus bone. The 1984-born group (49 males, 27 females) was weighed at mid lactation, when the average age was 6 weeks and again at weaning, when the average age was 12 weeks. Corresponding weighings for the 1985-born calves (36 males, 31 females) were at average ages of 8 and 13 weeks, respectively. In this paper growth rate from birth to the mid lactation weighing will be referred to as early growth rate and growth rate from mid lactation to weaning as later growth rate. Liveweights of the hinds and calves were recorded to the nearest 0.5 kg. The animals were run on good quality ryegrass–clover pasture from the onset of calving through to weaning.

Statistical analysis

Since variation was homogeneous over year and sex, the variables of interest were meaned over year and sex and the pooled standard deviations were calculated. Adjusted 12-week weight was calculated assuming linear individual growth between mid lactation and weaning. The relationships among these variables were then investigated by stepwise regression; differences between years (which were in no instance significant) were corrected for and averaged, differences in intercept between sexes were calculated, and differences in slope between sexes were tested and found not to be significant so the common slope was used. In this context the allometric relationship between birth weight (BW) and metatarsus length (ML) was analysed by regressing the logs of these variables. Tests were then carried out to assess whether BW or the square of ML was better at predicting early (GR1), later (GR2), and overall growth rate (GR), once appropriate covariate adjustments had been made to mean birth date, mid lactation at 6 weeks, and weaning at 12 weeks. In both instances dam weight (DW) was then added to the model, to examine the extent to which the influence of DW on growth rate was mediated by birth characteristics. Except where otherwise stated, statistical significance was assessed at the 5% level using two-tailed tests.

RESULTS

Dam weight, birth date, and weaning age

Table 1 gives the mean value of dam mating liveweight, birth date, and weaning age over sex and year, with pooled estimates of standard deviation. Calves were born around 20 November in both years but 1985-born calves were on average 10 days older at weaning than 1984-born calves.

Calf weights

Table 2 shows mean birth weights, weaning weights, and adjusted liveweights at 12 weeks over sex and year. Male calves were on average 9.7 kg at birth, which was 0.9 (SED ± 0.2) kg heavier than females, and were also significantly heavier at weaning. There was also a significant main effect of year on weaning weight with the 1985-born calves weaned at an older age, but there was no year effect for adjusted 12-week liveweight, although there was a sex effect, with males on average 42 kg, 4.8 (±0.8) kg heavier than females.

Calf growth rates

Table 3 gives early, later, and overall growth rate to weaning over sex and year, which were significantly greater for male than for female calves by 51 (±8), 43 (±11), and 47(±8) g per day, respectively, with no year effect. Early growth rates were on average 63 (±5) g per day greater than later growth rates, uniformly over sex and year.

Table 1 Means and pooled standard deviations of dam weight, birth date, and weaning age for male and female red deer calves born in 1984 and 1985.

Calf sex and year of birth	*n*	Dam weight (kg)	Birth date	Weaning age (days)
Males				
1984	49	100	24 Nov	77
1985	36	99	18 Nov	90
Females				
1984	27	104	20 Nov	83
1985	31	100	18 Nov	91
SD		8	9	9

Table 2 Means and pooled standard deviations of birth weight, weaning weight, and adjusted liveweight at 12 weeks for male and female red deer calves born in 1984 and 1985.

Calf sex and year of birth	Birth weight (kg)	Weaning weight (kg)	Weight at 12 weeks (kg)
Males			
1984	9.8	39.5	41.7
1985	9.6	44.1	42.2
Females			
1984	8.9	37.3	37.5
1985	8.7	38.6	36.8
SD	1.1	6.0	4.4

Table 3 Means and pooled standard deviations of early, later, and overall calf gain to weaning.

Calf sex and year of birth	Gain rates (g/day)		
	Early	Later	Overall
Males			
1984	415	350	384
1985	406	337	383
Females			
1984	372	307	341
1985	348	295	330
SD	46	65	46

Regression relationships

Birth weight

There was a significant regression of BW on DW (Table 4), with a 0.33 (±0.12) kg increase in BW

Table 4 Regression coefficients for birth weight on dam weight and for the log of birth weight on the log of metatarsus length together with the sex effect on intercept.

y variate	Intercept Male	Female	Slope	SE (slope)	*x* variate	R^2(adj)%
BW	6.42	5.44	0.033	0.012	DW	19.1
log BW	−4.67	−4.72	2.17	0.16	log ML	62.6

Table 5 Multiple regression coefficients for early, later, and overall calf growth rates to weaning and metatarsus length squared plus dam weight and on birth weight plus dam weight together with the sex effect on intercept.

y variate	Intercept Male	Female	Slope	SE (slope)	*x* variate	R^2(adj)%
GR1	85	42	0.470	(0.074)	ML^2	
			0.83	(0.45)	DW	46.8
GR1	184	146	19.1	(3.3)	BW	
			0.80	(0.46)	DW	44.7
GR2	172	125	0.279	(0.115)	ML^2	
			1.34	(0.70)	DW	23.2
GR2	274	224	5.8	(5.1)	BW	
			1.52	(0.72)	DW	20.6
GR	41	−6	0.406	(0.072)	ML^2	
			1.00	(0.44)	DW	46.5
GR	141	96	14.4	(3.2)	BW	
			1.05	(0.45)	DW	42.3

corresponding to a 10 kg increase in DW. There was no evidence that date of birth influenced birth weight. The square of the metatarsus length at birth and birth weight were strongly related.

Growth rates

Table 5 gives the multiple regression coefficients for early, later, and overall growth rates to weaning on ML^2 plus DW and on BW plus DW after covariate adjustments, together with the sex effect on intercept. In all instances ML^2 explained more of the variation in growth rate than BW and BW did not contribute significantly to the model for later growth. Also, when fitted after ML^2, the effect of BW was not significant, whereas the effect of ML^2 when fitted after BW was significant. The contribution of DW after both ML^2 and BW had been fitted was significant at the 10% level for early and later growth rate and at the 5% level for overall growth rate.

The equations in Table 5 indicate that a 1 kg increase in birth weight corresponds to increases in early growth rate of 19 g per day, later growth rate of 6 g per day, and overall growth rate of 14 g per day. A 10 kg increase in dam mating weight corresponds to increases of 8 g per day in early gain, 15 g per day in later gain, and 10.5 g per day in overall gain, after its influence on birth weight has been adjusted for.

Neither the intercept, nor the slope, of the regression of later growth rate on early growth rate was influenced by calf sex, and the intercept was not significantly different from zero, giving the equation:

GR2 = 0.835 (0.012) GR1
R^2(adj) = 28.0%.

DISCUSSION

Stag calves weighed 10% more than hind calves at birth and 19% of the variation in birth weight was accounted for by calf sex and dam weight at mating. This agrees with the results of Blaxter & Hamilton (1980) and Asher & Adam (1985), who found that 10 kg increases in dam weight corresponded to 0.53 and 0.36 kg increases in calf birth weight, respectively, compared to 0.33 kg in our study. There was no effect of dam age on calf birth weight in their studies.

Liveweight gains of the calves in our study were similar for both years within sex. Males gained liveweight faster than females, which contributed to the males being 4.8 kg (13%) heavier at 12 weeks.

Blaxter & Hamilton (1980) and Asher & Adam (1985) reported similar findings. The latter found male calves were 2.7 kg (7%) heavier than females when weaned at 42 kg, the same average male weight as the adjusted 12-week weight in our study.

This indicates that male calves place a greater lactational demand on their dams and that the rearing of male calves therefore more fully utilises the lactational ability of hinds than the rearing of female calves. In Scottish deer, which live in a relatively harsher environment, it has been reported that hinds which have male calves are more likely to be barren the following season (Clutton-Brock et al. 1982). Underfeeding of lactating hinds on farms in New Zealand is unlikely to occur except perhaps during summer droughts. In this instance earlier weaning of male calves and/or supplementary feeding could safeguard the dams' subsequent reproductive performance.

There was a highly significant allometric relationship between calf birth weight and the square of metatarsus length at birth (Table 4), which can be used to estimate the birth weight of dead calves which have become dehydrated or partially decomposed. This could be of particular importance in assessing whether dead calves were over- or under-sized at birth in studies on causes of perinatal mortality. Metatarsus length squared was significantly related to early and later gain in calves whereas later gain was not significantly related to birth weight. Birth weights were recorded up to 36 h after birth and subject to variation because of milk intake and how dry the calf's coat was. Change in metatarsus length within 36 h of birth are not subject to these sources of variation and our evidence suggests it provides a better indicator of calf body size at birth.

In this study, where all hinds were fed very well over lactation, stepwise multiple regression analysis indicated that although body size at birth and sex of calf were the major factors accounting for variability in gain, dam weight made a secondary contribution. The main effect of dam mating weight on calf gain is apparently through calf body size at birth and secondarily through rearing ability.

In the survey of red deer farms in the northern North Island by Asher & Adam (1985), liveweight gain of calves from birth to weaning was significantly related to dam weight and birth weight. Overall gain of calves to 3 months of age was 334 g per day for males and 309 g per day for females, which was less than the average of 384 g per day for males and 337 g per day for females recorded in the present study at Invermay. A 10 kg increase in dam weight corresponded to increased gains of 6 g per day compared to 10.5 g per day in our study. It was the subjective assessment of Asher & Adam that nutritional effects on weaning weights in their study were more obvious than any genetic effects.

Blaxter & Hamilton (1980) found that liveweight gain of Scottish red deer calves was related to birth weight and to dam weight in a year when growth was good but not in a year when growth was poor. Again growth rates of calves were less than those reported here and the relationships were significant for both male and female calves. A 10 kg increase in hind mating weight corresponded to a 17 g per day increase in gain.

Growth rates of Scottish calves have been shown to increase considerably with the quality and quantity of pasture on offer over lactation (Loudon et al. 1984). In their study, three groups of lactating hinds with their calves were grazed on either an indigenous hill pasture, an improved grass sward maintained at <1500 kg dry matter (DM)/ha, or an improved pasture maintained at 2000 kg DM/ha. Calves on these pastures gained 257, 324, and 369 g per day, respectively, considerably greater differences than could be effected by realistic improvements in birth weight or in dam weight. Milk yield from the hinds grazed on the best pasture was found to be 60% higher on average over the lactation period than in the hinds grazed on the poorer quality indigenous hill pasture. Milk consumption of these calves decreased after about 50 - 60 days, indicating a decline in milk production by the hinds (Loudon et al. 1984). Arman et al. (1978) found that milk yield from penned Scottish red deer hinds declines from about 8 weeks after calving. Hence growth rate of calves from 8 weeks of age will increasingly become dependent on the quality of pasture in late summer.

The growth rates during later lactation were 63 g per day less than (84% of) those of early lactation. The period from 6 to 12 weeks of age is the time when hind milk production starts to decline and calves are adapting to digesting pasture.

Early calf growth will probably depend on hind milking ability as well as hind nutrition. Milking ability of hinds is likely to vary considerably and selection of hinds for this trait would be more accurate by ranking them on the growth rate of calves to 6 or 8 weeks of age for each sex rather than on calf growth rate to weaning at about 12 - 15 weeks of age or on hind weight alone.

Thus for farmed adult red deer hinds in good physical condition fed well over lactation as in this study, improved calf growth rates are most likely to be gained through maximising birth weights of calves through appropriate nutrition over pregnancy and by selecting hinds on the growth rate of their calves.

The data presented in this paper can be used as estimates of correction values for estimating a calf's breeding value for growth over the birth to weaning period.

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