Animal Science 1997, **64**: 171-176

1357-7298/97/

The effect of housing and food restriction during winter on growth of male red deer calves

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Abstract

Low winter growth is a characteristic of male red deer and is caused, in part by a combination of reduced appetite and higher energy expenditure due to cold weather. This study aimed to determine whether housing during winter would reduce energy expenditure and increase the growth rate of male red deer calves. An additional aim was to investigate whether food restriction in winter would be compensated for by increased spring growth. In each of two consecutive years, 80 calves were randomly allocated to eight groups (no. = 10) comprising two replicates of four treatments during winter. Groups were housed inside (I) or outside (O) and given food either ad libitum *(AL) or restricted (R) to maintain live weight. Winter treatments (southern hemisphere) ran from 12 May to 25 August (year 1) and from 5 June to 5 September (year 2). During these periods, animals were weighed weekly and group food intake recorded daily. At the end of winter animals were moved outside onto pasture and weighed monthly until the end of spring (27 November, year 1 and 7 December, year 2). In year 2 weighing continued during summer, until 4 April. The animals were slaughtered on 28 November and 18 January (year 1) and 5 April (year 2). The effect of housing on live-weight gain (LWG) and dry-matter intake (DMI) in AL groups was not significant in either year. However in R groups, O had a higher DMI than I in both years ($P < 0.05$) and a higher LWG than I in year 1 ($P < 0.05$). LWG was lower in R than in AL groups in winter in year 1 ($P < 0.05$) and year 2 ($P < 0.001$) and live weight was lower in R than in AL groups at the end of winter in both years. Live weight was still lower in R than in AL groups at the end of spring in both years ($P < 0.01$). In year 2, this live-weight difference was not significant by the end of summer. Hot carcass weight (HCW) was greater in AL animals than R animals ($P < 0.05$) and dressing proportion was higher in R than in AL ($P < 0.05$) in year 1. GR (an index of body fatness) was greater ($P < 0.05$) in O than I in year 1 and was greater ($P < 0.05$) in AL than in R animals in year 2. Differences in GR between treatments were not significant in either year, with HCW as a covariate.*

In conclusion, housing calves given food ad libitum *during winter did not reduce DMI or increase growth rate. When normal growth rates were prevented by restricting food intake, housing lowered DMI requirement, although such a situation is unlikely to be a useful farm management practice as recovery from the growth check was slow. Annual variations in climate may determine both the food savings made by housing and the extent of compensatory growth of food-restricted animals in spring.*

Keywords: *food intake, growth rate, housing, red deer, winter.*

Introduction

Red deer (*Cervus elaphus*) have a seasonal pattern of growth and food intake characterized by slow growth during autumn and winter and high growth during spring and summer (Kay, 1979; Fennessy, 1982; Suttie *et al.*, 1983). If maintained throughout the year on pasture supplemented over winter with hay, silage and/or barley, farmed male red deer calves at Invermay had growth rates of 72 g/day during winter and 242 g/day or more during spring and summer (Moore *et al.*, 1988). This low winter growth rate is not necessarily caused by the unavailability of food but rather by seasonal changes in appetite and energy requirements (Fennessy, 1982). We have focused on manipulating these two factors as a means of increasing winter growth rate and thereby achieving heavier animals at the end of the spring. Appetite follows a strong seasonal cycle that can be altered by artificial photoperiod (Simpson *et al.*, 1984; Suttie *et al.*, 1984; Suttie and Simpson, 1985). Energy requirement appears to be affected by climate as stags during winter had a much higher maintenance energy requirement of 0·85 MJ metabolizable energy (ME) per kg $M^{0.75}$ per day compared with only 0·57 MJ ME per kg $M^{0.75}$ per day for stags indoors (Fennessy *et al.*, 1981). In the present study we aimed to determine if such a difference in energy requirement due to environment would lead to higher growth rates in calves housed indoors during winter compared with those kept on a similar diet outside. Red deer calves that undergo a period of food restriction during winter, undergo compensatory growth during summer when given an *ad-libitum* diet (Suttie *et al.*, 1983). Restricting food intake during winter would therefore reduce the costs of housing, with no detrimental effects on slaughter time or weight, if animals compensated for the growth check during spring when released onto *ad-libitum* pasture. However other studies have indicated that full compensation may or may not be achieved by 16 months of age depending on the severity of the restriction and pasture quality during realimentation (Adam and Moir, 1985; Milne *et al.*, 1987). Consequently, in this study we additionally investigated the capacity for red deer calves to compensate on pasture during spring following a growth restriction during housing in winter.

Material and methods

Experimental design

In each of two consecutive years, 80 4-month-old male red deer calves were randomly allocated to eight groups (no. = 10) and exposed to four replicated treatments during winter. Animals were confined either inside (I) or outside (O) and were given food either *ad libitum* (AL) or restricted (R) to maintain a constant live weight. In year 1, treatments began 12 May and ended 25 August (southern hemisphere winter). In year 2, treatments extended from 5 June until 5 September. In both years, I animals were housed on a deep litter of sawdust in pens measuring 7·5 m by 4·5 m and O animals confined in a gravelled enclosure measuring 25 m × 15 m. At the conclusion of the winter treatments in each year, all animals were combined into one group and maintained on pasture until slaughter. In year 1, on 28 November all animals that had reached the live-weight range 95 to 100 kg were slaughtered and the remainder were slaughtered on 18 January. In year 2 all animals were slaughtered at about 16 months of age (5 April).

Diets

In year 1, animals were given over winter a mixed diet of whole-grain barley and lucerne hay cubes with an energy content of 12·8 and 9·6 MJ ME per kg dry matter (DM) respectively. In year 2, animals were given pellets containing 160 g protein and 11·0 MJ ME per kg DM. A small amount of lucerne hay (100 to 200 g per animal per day) was also offered. Fresh water was available at all times. Following turn-out, animals grazed winter-saved ryegrass/white clover pasture or fresh spring pasture down to a level that was always above 1500 kg DM per ha.

Measurements

During the winter feeding periods, all animals were weighed weekly and food intake of each group was recorded daily. In AL groups, daily food refusals were maintained at proportionately about 0·10 of food offered. In R groups, the food allowance offered for each day of the coming week was determined by using any change in the group mean live weight as a guide for increasing or decreasing the group allowance so that live weight would remain unchanged. Following release from winter housing onto pasture, animals were weighed at 4-week intervals. At slaughter, hot carcass weight (HCW) and the depth of tissue over the 12th rib, 16 cm from mid line (GR), were measured.

Data analysis

The winter feeding and spring pasture periods were analysed separately for each year. These were: year 1, winter = 12 May to 25 August, spring = 25 August to 27 November; year 2, winter = 5 June to 5 September, spring = 5 September to 7 December. In year 2 an additional period termed summer from 7 December to 5 April was also analysed. The mean daily live-weight gain (LWG) over each period was calculated by subtracting the initial live weight from the final live weight for each period and dividing by the number of days. GR was analysed both with and without HCW as a covariate. Dressing proportion (D) was calculated as HCW/fasted pre-slaughter live weight. Differences between treatments were estimated using ANOVA.

Results

As expected, food restriction during winter significantly reduced DM intake (DMI; $P < 0.001$, both years; Table 1) and LWG in year 1 ($P < 0.001$) and year 2 ($P < 0.05$). Live weight was lower in R groups than in AL groups by the end of the winter period in year 1 (52·9 *v.* 68·4 (s.e.d. = 0·87) kg; $P < 0.001$) (Figure 1) and year 2 (52·3 *v.* 64·7 (s.e.d. = 1·83) kg; $P < 0.01$) (Figure 2).

The effect of housing on DMI and LWG was not significant ($P > 0.05$) in AL groups in either year. There were significant differences between inside and outside within the R groups. DMI of OR was higher than of IR in both years ($P < 0.05$) and LWG ($P < 0.05$) and live weight at the end of winter (55·7 *v.*

Table 1 *Mean food intake (kg dry matter per day) and live weight gain (g/day) of male red deer calves housed inside or outside and given food either* ad libitum *or restricted during winter in year 1 and year 2 with the pooled standard error of the difference (s.e.d.) for each period. Mean daily maximum and minimum temperature, total rainfall, total solar radiation, and mean wind speed of the 2 years are also included.*

		Ad libitum		Restricted		
		Inside	Outside	Inside	Outside	s.e.d.
Food intake						
Year 1	Winter	1·61	1·71	0·84	1·17	0·04
Year 2	Winter	1·52	1·58	0·80	0·96	0·04
Live-weight gain						
Year 1	Winter	151	155	−12	48	6·3
	Spring	287	291	345	351	19·4
Year 2	Winter	196	189	27	50	16·1
	Spring	319	359	372	381	6·1
	Summer	148	148	205	189	18·8

Climate	Maximum (°C)	Minimum (°C)	Rainfall (mm)	Radiation (MJ/m^2)	Wind (m/s)
Year 1	10·7	1·1	217	465	2·2
Year 2	10·7	1·1	131	513	1·4

50·1 (s.e.d. = 1·23) kg; $P < 0{\cdot}05$) were higher in OR than in IR in year 1. The DMI (corrected for LWG) of OR during winter was proportionately 0·17 higher than that of IR in year 1 and 0·12 higher in year 2. Corresponding values for AL animals were 0·06 in year 1 and 0·05 in year 2.

Following turn-out onto pasture, LWG was higher in R than in AL groups in year 2 only, during spring ($P < 0{\cdot}001$) and summer ($P < 0{\cdot}05$). Live weight was significantly lower in R than in AL groups at the end of spring in year 1 (85·7 *v.* 95·6 (s.e.d. = 1·22) kg; $P < 0{\cdot}01$) and year 2 (87·3 *v.* 96·3 (s.e.d. = 1·81) kg; $P < 0{\cdot}01$). In year 2, the live weight of R groups had almost caught up with that of AL groups by the end of summer (110·5 *v.* 113·7 (s.e.d. = 1·7) kg; $P > 0{\cdot}05$). O groups grew faster than I groups during spring only in the AL state in year 2 ($P < 0{\cdot}05$). Live weight was not significantly different ($P > 0{\cdot}05$) between the O and I groups at the end of spring or summer periods.

In year 1, 59% and 39% of AL animals and 12% and 11% of R animals (I and O respectively) were slaughtered on 28 November. The remainder were slaughtered on 18 January. HCW was greater in AL animals than in R animals ($P < 0{\cdot}05$) and conversely D was higher in R than in AL ($P < 0{\cdot}05$; Table 2). GR was larger ($P < 0{\cdot}05$) in O than I in year 1 and was larger ($P < 0{\cdot}05$) in AL than in R animals in year 2. The increase in GR per kg HCW was 0·26 (s.e. 0·06) and 0·27 (s.e. 0·02) in year 1 and year 2, respectively. There were no differences ($P > 0{\cdot}05$) between treatments when HCW was used as a covariate for GR in either year 1 or year 2 .

Discussion

Housing of red deer calves during winter on *ad-libitum* food intake did not result in enhanced growth rates or savings in food requirements in comparison with animals outdoors. Housing reduced food intake when growth was prevented thus reducing the costs of housing, but animals failed to compensate fully during spring for the winter growth check.

Comparisons of winter growth rates of animals given food *ad libitum* in this study with others must be made carefully with regard to the period during which the growth rates are calculated, due to the seasonally changing growth rate in red deer. However, the winter growth rates during both years were higher than those reported for red deer calves given either lucerne or concentrates indoors (Fennessy, 1982) or maintained on pasture outdoors (Moore *et al.*, 1988) from June to August. Furthermore, the growth rates during year 2 were higher than those in year 1 when a lower quality diet was given and higher than the growth rates reported for stags given a silage and compound diet during mid winter at Rosemaund (Davies, 1991). Overall, this suggests that the animals grew well in both years, and that a high quality diet is required to achieve high growth rates during winter. The aim of the dietary restriction was to maintain a constant live weight and therefore the higher growth rates of the outside groups reflects a greater degree of difficulty in achieving this in that situation.

The benefits of housing during winter were only apparent in the R groups in which I animals required

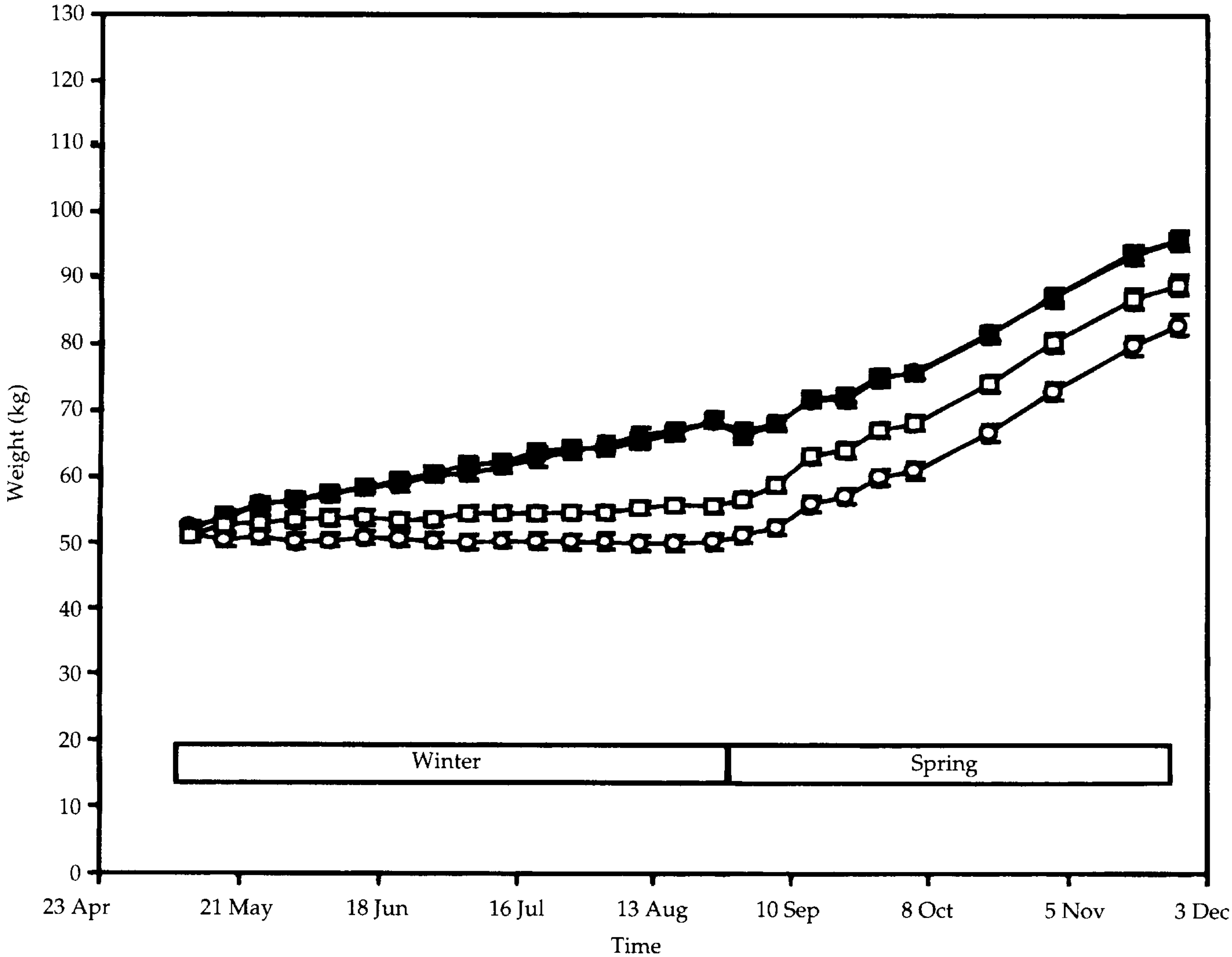

Figure 1 Live weight of male red deer calves maintained inside on *ad-libitum* (●) or restricted (○) diets and outside on *ad-libitum* (■) or restricted (□) diets in year 1 (s.e. for each sampling point is represented by the vertical bars).

a lower DMI to achieve equivalent growth rates of O animals. This difference was much reduced in AL groups which reflects the fact that body temperature is maintained at less extra energy cost when thermoneutral heat production is greater. In contrast, animals restricted to near zero growth must eat extra to counteract the effects of a colder environment. The smaller difference in DMI between IR and OR in year 2 may indicate that O animals in year 2 were under less environmental stress than in

Table 2 *Mean hot carcass weight (HCW), in kg depth of tissue, over the 12th rib, 16 cm from mid line (GR) in mm, and dressing proportion (D), calculated as HCW/fasted pre-slaughter live weight, of male red deer calves housed inside or outside and given food either* ad libitum *or restricted during winter in year 1 and year 2 with pooled standard error of the difference (s.e.d.) for each year*

		Ad libitum		Restricted		
		Inside	Outside	Inside	Outside	s.e.d.
Year 1	HCW	54·2	56·7	51·1	53·2	1·6
	GR	6·4	7·8	5·5	7·6	0·61
	D	0·569	0·594	0·617	0·611	0·005
Year 2	HCW	60·7	62·4	58·4	58·8	1·7
	GR	7·5	8·8	7·1	7·3	0·34
	D	0·541	0·541	0·530	0·530	0·043

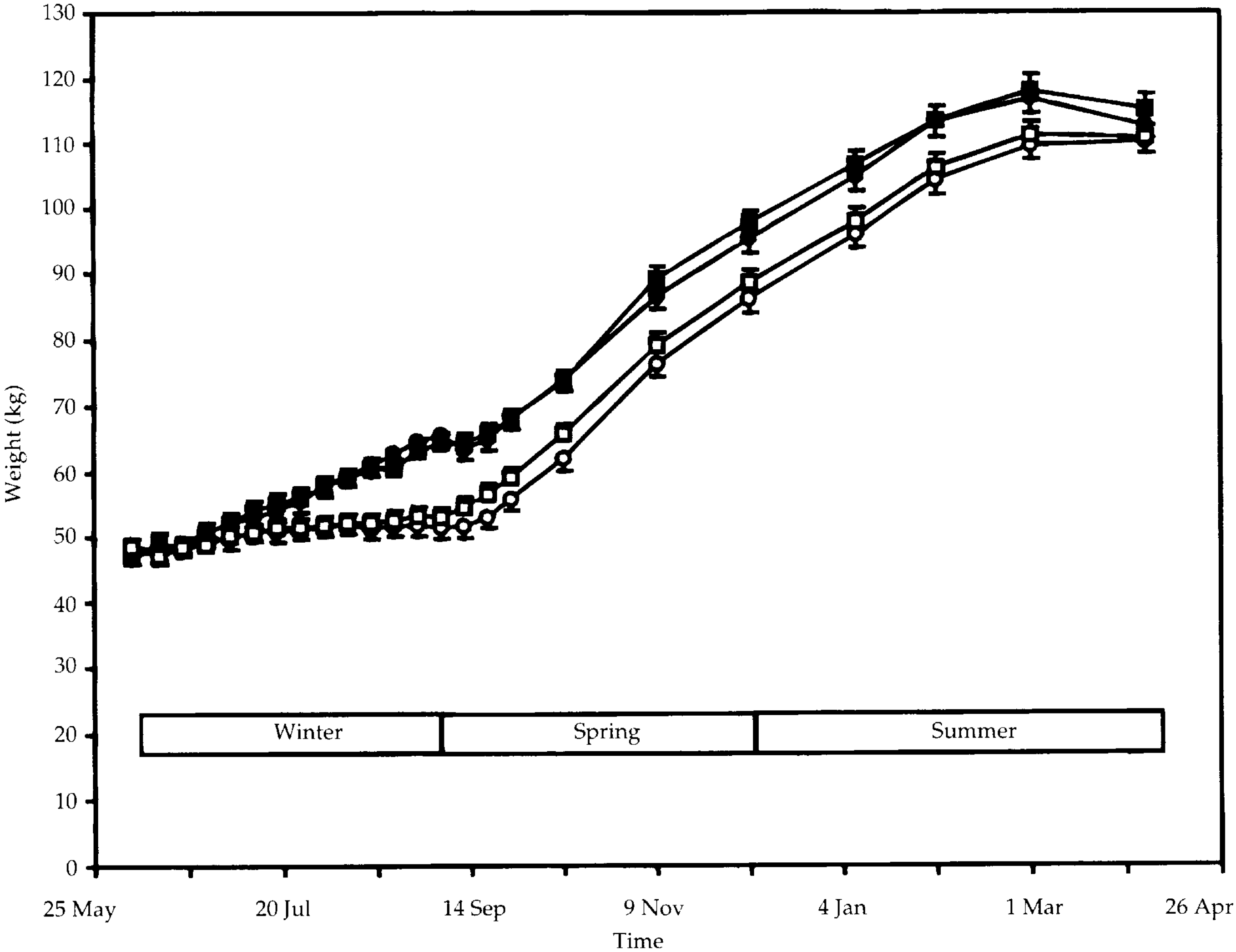

Figure 2 Live weight of male red deer calves maintained inside on *ad-libitum* (●) or restricted (○) diets and outside on *ad-libitum* (■) or restricted (□) diets in year 2 (s.e. for each sampling point is represented by the vertical bars).

year 1. Supporting this, climate records collected at Invermay by the National Institute of Water and Atmospherics show that although the mean daily maximum and minimum temperatures (10·7 and 1·1 degrees) over the winter period were the same in 1988 and 1989 there was a lower rainfall (131 *v.* 217 mm), more sun (513 *v.* 465 MJ/m^2) and less wind (1·4 *v.* 2.·2 m/s) in year 2 than year 1. It appears that although deer are less able to tolerate cold stress than sheep or cattle, heat production is only stimulated to maintain body temperature below 5°C in a sheltered environment (Simpson *et al.*, 1978). The mean daily temperature seldom falls below 5°C at Invermay in the coldest month (July). In addition, the gravelled enclosures outside were sheltered from prevailing winds by a large hedge which may have reduced heat loss from the O animals (Grace and Easterbee, 1979).

Deer maintained on a restricted diet during winter underwent compensatory growth when turned out onto an *ad-libitum* pasture diet in spring, evidenced by the faster growth rates during spring in R groups in year 2. That this compensatory growth was only significant in year 2, despite the dietary restriction resulting in a lower live weight at the end of winter in both years, suggests that compensatory growth may be dependent on factors that vary between years such as food availability and climate. Thus, in an earlier study, (Loudon and Milne, 1985) a lack of significant catch-up growth following winter food restriction was attributed to a low herbage mass at turn-out. Even in year 2, when there was significant compensatory growth, by the end of spring (7 December) AL animals had reached a mean weight of 96 kg while R animals were 87 kg. (In New Zealand a live weight of 96 kg is an acceptable slaughter weight whereas 87 kg is not.) Factors such as the severity of the restriction and stage of development of the animal that the restriction was applied are also likely to affect the extent of compensatory growth (Wilson and Osbourn, 1960). In addition, the faster maturing the animal, the more severe are the effects of a dietary restriction (Wilson and Osbourn, 1960). This latter factor is likely to be important to venison production systems in New Zealand in which selection and feeding are aimed to produce rapid growth and a 95-kg animal by 11 months of age or earlier. With higher growth rates being maintained during winter, followed by near maximum growth in spring, there is simply neither the time nor the capacity for an animal that has been restricted to catch up within the constraints of the production system.

The lack of compensatory growth in year 1 was reflected both in the slaughter dates, in which far fewer R animals reached slaughter weight by 28 November, and in the slaughter analysis, which showed a lower HCW in R groups despite the higher D of these animals. In year 2, when the live-weight difference between AL and R groups was reduced by the end of summer, there were no significant differences in HCW or D at slaughter.

In conclusion, winter housing of male red deer calves did not reduce food intake or increase growth rate. Techniques that increase the appetite of animals given food *ad libitum* during winter may therefore have greater potential to increase winter growth. Under conditions in which food intake is restricted to maintain live weight during winter, housing reduced the food requirement compared with animals outdoors. However, annual climatic differences may affect both the extent of any saving made by housing and the recovery from winter food restriction during spring.

Acknowledgements

We would like to thank Dr R. P. Littlejohn for help with statistical analysis.

References

Adam, C. L. and Moir, C. E. 1985. Effect of winter nutrition of young farmed red deer on their subsequent growth at pasture. *Animal Production* **40:** 135-141.

Davies, M. 1991. Rosemaund update on finishing stags. *Deer Farming* **35:** 9-11.

Fennessy, P. F. 1982. Growth and nutrition. In *The farming of deer. World trends and modern techniques* (ed. D. Yerex), pp. 105-114. Agricultural Promotion Associates Ltd, Wellington, New Zealand.

Fennessy, P. F., Moore, G. H. and Corson, I. D. 1981. Energy requirements of red deer. *Proceedings of the New Zealand Society of Animal Production* **41:** 167-173.

Grace, J. and Easterbee, N. 1979. The natural shelter for red deer (*Cervus elaphus*) in a Scottish glen. *Journal of Applied Ecology* **16:** 37-48.

Kay, R. N. B. 1979. Seasonal changes of appetite in deer and sheep. *Agricultural Research Council research reviews, vol. 5,* pp. 13-15.

Loudon, A. S. I. and Milne, J. A. 1985. Nutrition and growth of young red deer. In *Biology of deer production*, pp. 423-427. The Royal Society of New Zealand, Wellington.

Milne, J. A., Sibbald, A. M., McCormack, H. A. and Loudon, A. S. I. 1987. The influences of nutrition and management on the growth of red deer calves from weaning to 16 months of age. *Animal Production* **45:** 511-522.

Moore, G. H., Littlejohn, R. P. and Cowie, G. M. 1988. Liveweights, growth rates, and mortality of farmed red deer at Invermay. *New Zealand Journal of Agricultural Research* **31:** 293-300.

Simpson, A. M., Suttie, J. M. and Kay, R. N. B. 1984. The influence of artificial photoperiod on the growth, appetite and reproductive status of male red deer and sheep. *Animal Reproduction Science* **6:** 291-299.

Simpson, A. M., Webster, A. J. F., Smith, J. S. and Simpson, C. A. 1978. Energy and nitrogen metabolism of red deer (*Cervus elaphus*) in cold environments; a comparison with cattle and sheep. *Comparative Biochemistry and Physiology, A: Comparative Physiology* **60:** 251-256.

Suttie, J. M., Corson, I. D. and Fennessy, P. F. 1984. Voluntary intake, testis development and antler growth patterns of male red deer under a manipulated photoperiod. *Proceedings of the New Zealand Society of Animal Production* **44:** 167-170.

Suttie, J. M., Goodall, E. D., Pennie, K. and Kay, R. N. B. 1983. Winter food restriction and summer compensation in red deer stags (*Cervus elaphus*). *British Journal of Nutrition* **50:** 737-747.

Suttie, J. M. and Simpson, A. M. 1985. Photoperiodic control of appetite, growth, antlers and endocrine status of red deer. In *Biology of deer production* (ed. P. F. Fennessy and K. R. Drew), pp. 429-432. The Royal Society of New Zealand, Wellington.

Wilson, P. N. and Osbourn, D. F. 1960. Compensatory growth after undernutrition in mammals and birds. *Biological Review* **35:** 324-363.

(*Received* 1 *April* 1996—*Accepted* 12 *August* 1996)