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& DEVELOPMENT CORPORATION

Performance of Red Deer Calves after Early Weaning

**A report for the Rural Industries Research
and Development Corporation**

by G.McL. Dryden

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Foreword

The Australian deer industry recognises the importance of increasing the size of the national deer herd. The present small size of the industry constrains the establishment of dedicated deer processing facilities and research and extension services.

Reliable feeding management options will help the industry to expand deer numbers.

Early weaning/artificial rearing is an intensive feeding system which could give deer farmers additional control over their enterprise. It should be useful in normal management, because rapid weaner growth gives more flexibility to meet seasonal demands for venison. It may help to reduce predation and mismothering. It is especially relevant to the management of deer herds in droughts.

Red deer hinds naturally wean their calves at three to four months. There are limited reports of the performance of red deer calves weaned at two or more months, and of the performance as yearlings and adults of calves which have been given harsher than normal nutritional treatment during their weaner life. However, there have been no studies to determine if very early weaning (e.g. earlier than 2 months) is feasible or if it has permanent effects on mature animals. Further, none of these studies has been done under Australian conditions.

This publication reports an investigation into the effects of the artificial rearing of early-weaned female red deer (*Cervus elaphus*) calves. Calves were weaned at either seven or nine weeks of age, and their immediate responses to early weaning, i.e. their acceptance and consumption of solid food, occurrence of ill-health (such as diarrhoea, dehydration, and laminitis), their growth during the period of artificial rearing and throughout the subsequent year, and their abilities to digest solid food constituents, were monitored.

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This report, a new addition to RIRDC's diverse range of over 800 research publications, forms part of our Deer R&D program, which aims to foster an Australian deer industry as a profitable and efficient mainstream agricultural enterprise.

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Executive Summary

Red deer (*Cervus elaphus*) calves were weaned, i.e. separated from their dams and given solid food, in January when they were either seven or nine weeks old. They were held in pairs in small pens. They were given, as much as they would eat, a good quality lucerne hay, and a pelleted concentrate. These ingredients were fed in separate containers. Animals of both ages grew at approximately the same rate, but the younger calves were smaller at the end of the experiment in March (40.2 v. 46.1 kg; $P=0.023$). This reflected their differing liveweights at the start of the experiment. After nine months of grazing, through a typically dry Queensland winter and the following spring, the liveweights of the two groups were similar.

The calves tolerated well the intensive management during the artificial rearing period. They accepted solid food immediately, and there were few incidences of dominant behaviour between the paired calves. There were no cases of diarrhoea or laminitis (two conditions which may occur in ruminants which have been allowed free-choice access to concentrate-rich foods), or any other adverse effects on animal health.

It is concluded that (1) weaning at seven weeks is feasible, if a high-quality weaning ration is used, (2) early-weaned calves will show the effects of a growth check at weaning, and may be smaller than their normally-weaned counterparts for several months, (3) these effects will be largely overcome during the next season of good pasture growth (e.g. summer in Queensland).

1. Introduction

“Early weaning” is the separation of calves from hinds earlier than three to four months, when these animals are naturally weaned (Moore, *et al* 1988a,c). Methods for successful early-weaning to solid foods would help deer farmers manage pasture shortages (e.g. in droughts) when it may be necessary to wean fawns to conserve hind body condition or prevent deaths, manage calves so as to reduce losses through mismothering and predation, and reduce the cost and labour requirements of feeding orphaned or abandoned calves.

The Australian deer industry recognises the importance of increasing the national deer herd size. One of the weaknesses/threats to the Queensland deer industry identified by the Queensland Deer Industry Liaison Committee (Deer Industry Development Plan for Queensland 1997-1999) was the “current small herd size ...”, and the Plan recommended investigating supplementary feeding options and evaluating the nutritional implications of intensive *v.* extensive production systems to help resolve this problem. Artificial rearing is an intensive farming technique which could have a place in deer farming, but very little is known about how this might be best accomplished under Australian conditions.

Early weaning could give deer farmers additional control over their enterprise. It should be useful in normal management, because rapid weaner growth, which can be achieved by weaning to concentrate-based foods (Puttoo, *et al* 1998), gives more flexibility to meet seasonal demands for venison. Limited farmer experience of weaning red deer calves in Queensland at 14 weeks (C. McGhie, *personal communication*) suggests that it can reduce predation and mismothering. It is especially relevant to the management of herds in droughts, which commonly occur in deer farming regions. For example, in southeast Queensland (where most of the deer industry is concentrated in that state; Sinclair 1997) a drought will be declared in five to 30 % of years (Daly 1994). The Queensland deer industry looks to expansion into western Queensland (J. White, *personal communication*), where drought mitigation strategies will be needed to ensure enterprise sustainability. Early weaning is a recommended drought mitigation strategy in the beef industry (Clarke 1992) because it reduces the nutritional stress on cows, thus enhancing their survival and later breeding success (e.g. Holroyd, *et al* 1988). Early weaning may alleviate pasture degradation, which may arise from failure to reduce stock numbers at the beginning of droughts or during dry periods. Early weaning reduces the nutrient requirements of hinds and gives greater flexibility in managing the deer herd, and thus can help to minimise grazing pressure on susceptible pastures.

Although the effects of early weaning appear to have not been examined in red deer, in other farmed animals weaning generally results in a growth check which is more severe the earlier it occurs. Clearly, the influence of weaning age on growth following weaning, and the effect of early weaning on adult performance, should be examined.

There are two major gaps in our knowledge of early weaning: (1) how young can red deer calves be successfully weaned under Australian conditions, and (2) what is the effect of early weaning on the performance of these calves as adults?

2. Objectives

To improve the ability of deer farmers to control the growth and survival of young deer by investigating the feasibility and effects of weaning at various ages and recommending a practicable early-weaning strategy.

3. Methodology

3.1. Animals

Sixteen female red deer (*C. elaphus*) calves from the September/October 1998 calving season.

3.2. Management and diets

Artificial rearing period

The calves were weighed shortly after birth and ear-tagged. They were separated from their dams on 18 January, 1999, when they were either seven or nine weeks of age, brought as a group into the rearing unit and offered the diet described below. On 23 January the calves (eight in each treatment) were allocated, within weaning age groups, into pairs so that the paired animals were of similar liveweight, and introduced to the rearing pens. During the artificial rearing period they were given, *ad lib.* (except during the digestibility measurement periods) and in separate containers, a pelleted concentrate and a good-quality chopped lucerne hay. The calves were given lucerne hay only from 12 March, and this phase of the experiment concluded on 20 March.

The pelleted concentrate contained (% as fed basis) 54 wheat grain, 23.9 barley grain, 15 soybean meal, 5 molasses, 0.5 synthetic lysine, 0.3 vegetable oil, 0.9 limestone, 0.3 salt, and 0.1 mineral/vitamin premix. Calculated nutrient contents of the concentrate mix (as-fed basis) were metabolisable energy 12.3 MJ/kg, Ca 0.5%, P 0.4%, Na 0.2%, Cu 13 mg/kg, Se 0.08 mg/kg, vitamin A 8000 i.u./kg, vitamin D3 1600 i.u./kg, vitamin E 24 i.u./kg. The concentrate and lucerne hay used in the artificial rearing phase of this experiment contained on a DM basis, respectively, 22 and 20% protein, and 18 and 46% NDF.

Grazing period

The deer were maintained as a single group on a mixed kikuyu/green couch pasture from March to December.

3.3. Measurements

Artificial rearing period

The animals were monitored continuously for ill-health, especially for any occurrence of dehydration, diarrhoea and laminitis.

Air-dry concentrate and lucerne hay intakes were measured each day by total collection. Intakes of feed DM were measured during the digestibility collection period.

Digestibilities of dry matter (DM), neutral detergent fibre (NDF, cell wall constituents) neutral detergent solubles (NDS, cell contents) and total nitrogen (N) in the hay/concentrate diets as eaten, were calculated from data collected for 5 days beginning (in digestibility trial 1) on 31 January and (in digestibility trial 2) on 7 March. It was assumed that undigested food took 24 hours to pass through the digestive tract. Faeces could not be collected quantitatively. Digestibilities were therefore calculated by reference to the lignin concentrations in the consumed feed (values calculated from the

measured lignin contents of feed ingredients offered and refused) and in faeces. During digestibility trial 1, calves weaned at 7 weeks were offered (per pen) 1500 g air-dry concentrate/day and 1000 g air-dry lucerne hay/day. Calves weaned at 9 weeks of age were offered 1800 g concentrate and 1200 g hay. In digestibility trial 2, each pair of calves was offered 1200 g hay/day; the 7- and 9-week pairs were offered 2700 and 3100 g concentrate/day, respectively.

Growth (increase in body weight) was calculated by regression of weekly liveweights against time. Measurements of neck (immediately in front of the shoulder) and chest (immediately behind the front legs) circumferences (Sharples and Dumelow 1990) and the length of the lower hind leg (from the calcaneal tuber to the junction between the fused metatarsi and the phalanges; Suttie, *et al* 1983) were made on 3 occasions to determine increase in frame size.

Grazing period

Liveweights were measured on 28 April, 5 August, 23 September, and 27 December. A final set of frame size measurements was made on 5 August.

3.4. Chemical analyses

Feed, feed refusals and faeces samples were collected during the digestibility measurement periods. Feed and refusals samples were dried (100 °C in a forced draught oven until constant weight) in their as-received state for the calculation of food constituent intakes. Further air-dry samples were collected and stored at ambient temperature until analysis. Faeces were collected and subsampled, and stored frozen (–15 °C) until analysis. Faeces samples were thawed (3 °C), dried at 55 °C in a forced-draught oven, and these and the air-dry feed and refusals samples were then ground through a 1 mm screen and analysed for DM in a forced-draught oven at 105 °C, NDF and H₂SO₄ lignin by the methods of Goering and Van Soest (1970), using a Fibertec apparatus (Tecator Inc., Sweden), and total N by the semi-micro Kjeldahl method.

3.5. Statistical analysis

The experiment was a one-way treatment design (calves weaned at seven weeks v. nine weeks) imposed in a completely randomised experiment design. There were four pens of two animals for each weaning age, giving eight replicates per treatment group for growth and four replicates for food consumption and food constituent digestibilities. Means of groups weaned at different ages were compared by *t* test, assuming unequal variances. Comparisons of groups of the same weaning age between different digestibility trials were made by paired *t* test. Significance was declared at $P < 0.05$.

4. Results

4.1. Animal health

No failure to eat, dehydration, digestive dysfunction or laminitis was observed.

4.2. Growth

The mean (\pm standard deviation, SD) birth weights of the calves from the 7-week and 9-week old groups were, respectively, 8.4 ± 1.10 and 9.3 ± 0.93 kg ($P = 0.113$). The younger calves were smaller on entry to the artificial rearing period (24.0 ± 2.22 v. 28.7 ± 2.76 kg; $P = 0.002$) and at the completion of this phase in March (40.2 ± 4.29 v. 46.1 ± 4.06 kg; $P = 0.023$). There were losses of liveweight equivalent to approximately 3% of the initial liveweight immediately after the calves were weaned. These data are in Table 1.

The mean growth rates of the 7- and 9-week groups during the artificial rearing period were, respectively, 0.272 and 0.295 kg/d ($P = 0.160$). Liveweight differences had disappeared by 27 December (62.7 ± 3.95 v. 67.8 ± 7.93 kg; $P = 0.133$). Liveweight changes over the experimental period are illustrated in Fig. 1.

Table 1. Growth of red deer calves weaned at either 7 or 9 weeks of age.

	Weaned at 7 weeks	Weaned at 9 weeks	P =
Liveweights (kg)			
At birth	8.5	9.3	0.113
At weaning	24.0	28.7	0.002
At 8 March, 1999	37.7	43.3	0.009
At 27 Dec., 1999	62.7	67.8	0.133
Liveweight loss at weaning (kg)	0.60	0.76	0.647
Growth rate 18 Jan. to 8 Mar. (g/d)	289	323	0.066

There were no differences between the age groups in neck circumferences (Table 2) at any of the three measurement times. Animals weaned at 9 weeks had larger chest circumferences than the 7-week old calves at 25 January, (70.1 ± 2.85 and 74.6 ± 4.72 cm respectively, mean \pm SD; $P = 0.039$). There were no between-treatment group differences in chest girth at the other measurement times. Calves in the older group had longer lower hind legs than the 7-week animals at the first three measurement times (until 20 March, when the calves were approximately 15 and 17 weeks old). The 7-week group calves had similar neck, chest and lower hind leg sizes on 8 February (when they were 9 weeks old) as the calves in the older group had on entry to the artificial rearing program.

Table 2. Changes in frame size in red deer calves weaned at either 7 or 9 weeks of age.

	Weaned at 7 weeks			Weaned at 9 weeks		
	Neck	Girth	Leg	Neck	Girth	Leg
25 January	31.8	70.1	30.3	32.5	74.6	31.1
8 February	34.5	73.3	31.6	-- ^a	--	--
20 March	40.5	82.1	32.9	43.1	84.1	33.5
5 August	34.9	89.1	34.8	35.8	91.6	35.6

^a not measured

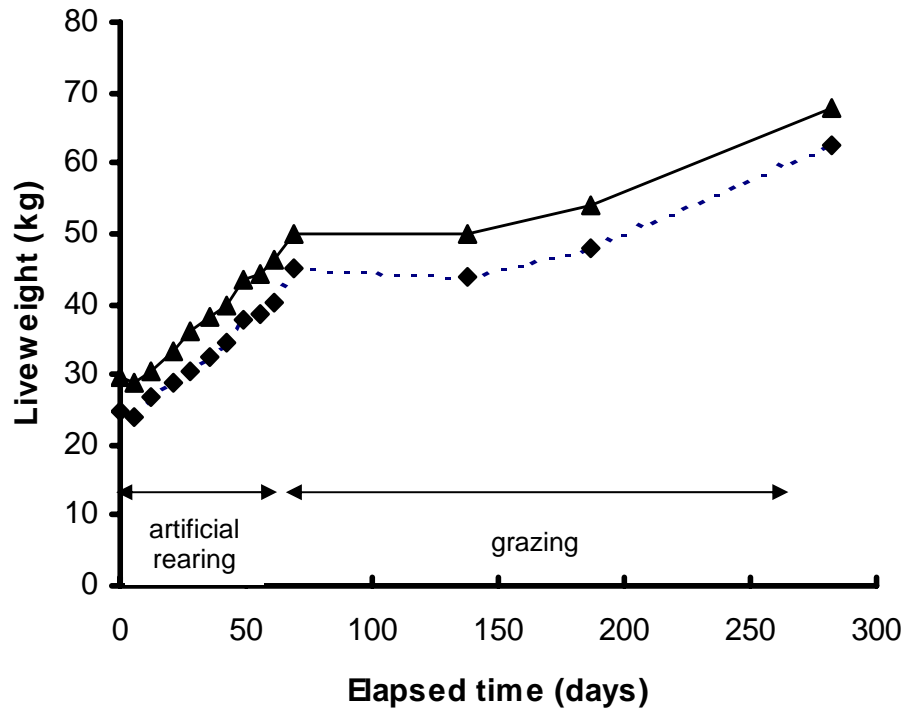


Fig. 1. Change in liveweight of female red deer calves weaned at 7 weeks (σ σ) or 9 weeks (\triangleright — \triangleright) of age.

4.3. Food intake and digestion

By the end of the artificial rearing period the 9-week calves were eating more concentrate than the younger animals (Table 3, Fig. 2). Air-dry concentrate intake (y , g/pair.d⁻¹) increased curvilinearly with time (x , days), but at different rates for the 7-week and 9-week weaned groups:

$$y = 549.44 \ln(x) + 215.69, \quad R^2 = 0.937 \quad (\text{weaned at 7 weeks})$$

$$y = 685.02 \ln(x) + 178.07, \quad R^2 = 0.959 \quad (\text{weaned at 9 weeks})$$

The calves weaned at 7 weeks of age had no consistent changes in lucerne hay intake (y , g/pair.d⁻¹) with time (x , days) after weaning (Fig. 3), but the hay intake of the older calves trended downwards during the artificial rearing period. Linear regression equations were:

$$y = 1.1(x) + 556.3, \quad R^2 = 0.021, \quad P = 0.325 \quad (\text{weaned at 7 weeks})$$

$$y = -3.9(x) + 683.6, \quad R^2 = 0.171, \quad P = 0.0035 \quad (\text{weaned at 9 weeks})$$

Table 3. Air-dry food intakes of pairs of red deer calves weaned at either 7 or 9 weeks of age.

Food intake (g/d)	Weaned at 7 weeks	Weaned at 9 weeks	P =
Days 1 to 7			
Concentrate	882	980	0.626
Lucerne hay	534	713	0.270
Days 35 to 48			
Concentrate	2303	2730	0.017
Lucerne hay	599	549	0.490
Concentrate : hay ratio	3.9	5.1	0.078

DM intakes measured during the digestibility trials showed that although the older calves ate more food, especially more concentrate, the total DM intakes were similar when they were adjusted for differences in metabolic size (Table 4).

Food constituent digestibilities are reported in Table 4. Fibre (NDF) was digested poorly, but digestibilities of NDS, i.e. starch and other cell content constituents, were high. Digestibilities of DM, NDF and NDS increased with age, but only in the 9-week group ($P < 0.05$) and these changes were small.

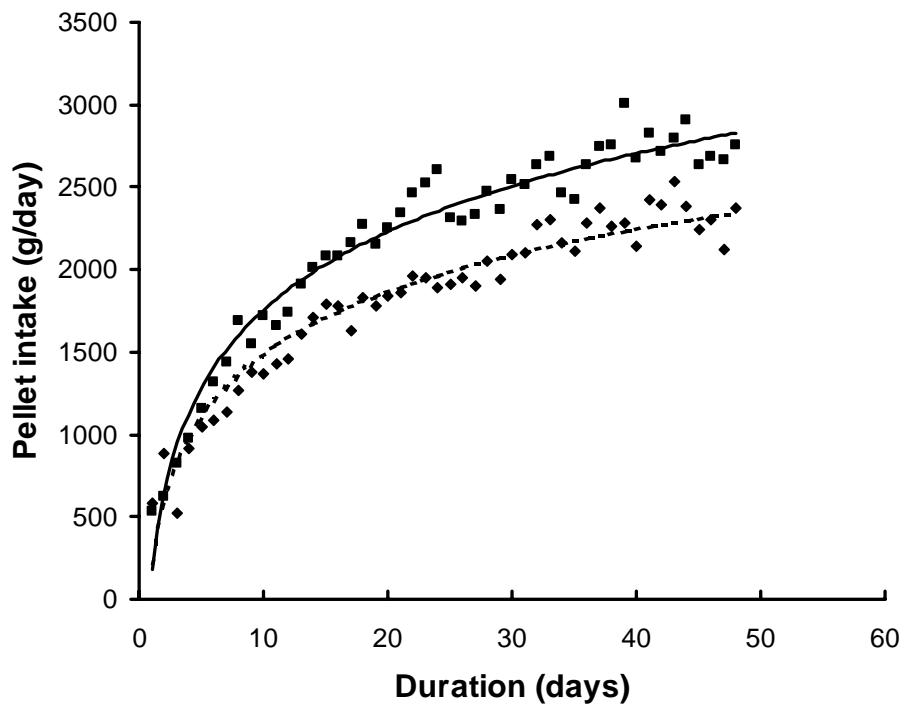


Fig. 2. Consumption of air-dry pelleted concentrate by red deer calves weaned at 7 (v —v) and 9 (v —v) weeks of age.

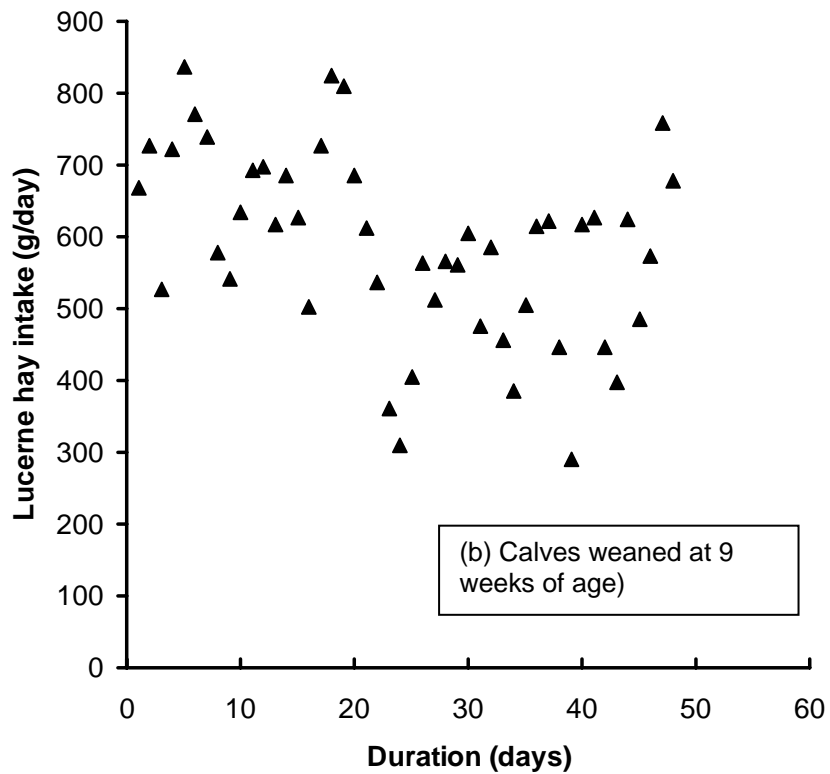
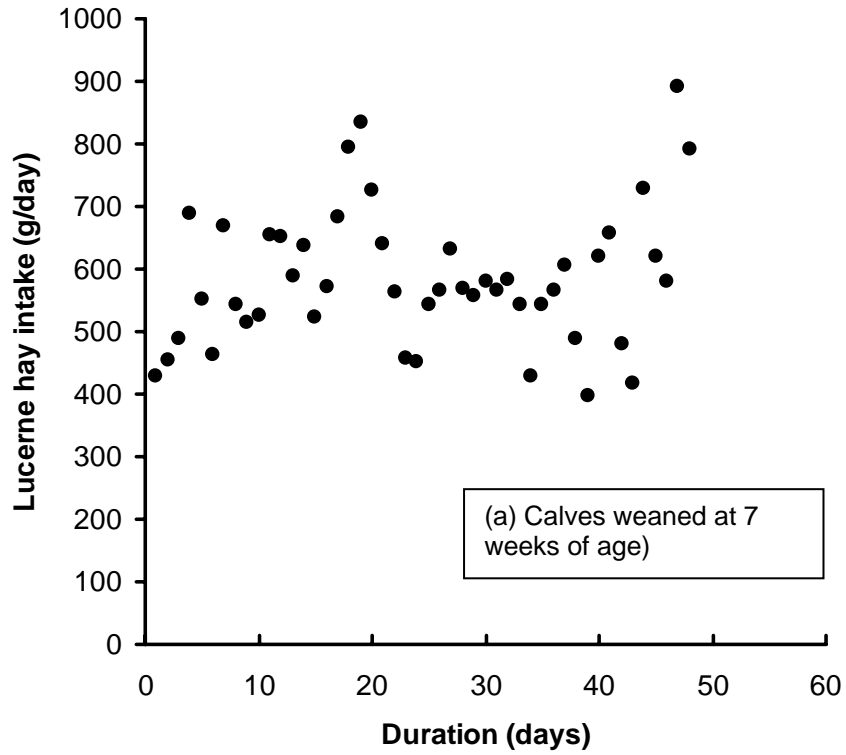


Fig. 3. Air-dry lucerne intakes during the artificial rearing period, of red deer calves weaned at either 7 or 9 weeks of age.

Table 4. Food DM intake and constituent digestibilities, measured between 7 and 12 days (digestibility trial 1) or 44 and 48 days (digestibility trial 2) after the start of the artificial rearing period, by red deer calves weaned at either 7 or 9 weeks of age.

Attribute	Weaned at 7 weeks	Weaned at 9 weeks	P =
DM intakes			
Digestibility trial 1			
Total (kg/head.d ⁻¹) ^a	870	1032	0.012
Total (kg/W ^{0.75} .d ⁻¹) ^{a,b}	76.1	79.5	0.155
Digestibility trial 2			
Total (kg/head.d ⁻¹) ^a	1336	1492	0.082
Total (kg/W ^{0.75} .d ⁻¹) ^{a,b}	87.9	88.4	0.835
Digestibility trial 1			
Concentrate (g/head.d ⁻¹)	617	747	0.019
Lucerne hay (g/head.d ⁻¹)	253	286	0.372
Concentrate : hay ratio	2.49	2.70	0.618
Digestibility trial 2			
Concentrate (g/head.d ⁻¹)	1017	1216	0.014
Lucerne hay (g/head.d ⁻¹)	319	276	0.332
Concentrate : hay ratio	3.24	4.65	0.116
Constituent digestibilities			
Digestibility trial 1			
DM	0.654	0.572	0.029
NDF	0.187	0.046	0.010
NDS	0.808	0.755	0.016
N	0.726	0.602	0.029
Digestibility trial 2			
DM	0.693	0.737	0.290
NDF	0.213	0.269	0.435
NDS	0.828	0.858	0.312
N	0.696	0.622	0.140

^a amounts per head daily are calculated by dividing the total amount consumed by each pair of calves over 5 days, by 10.

^b metabolic size (W^{0.75} kg) is the mean liveweight of each pair as measured on 30 January (trial 1) or 7 March (trial 2), raised to the 0.75 power.

5. Discussion

“Early weaning” is defined as separation of calves from hinds at any age earlier than 3 months, as natural weaning occurs from 11 to 16 weeks in red deer (Moore, *et al* 1988a,c). There is evidence that cervid calves may tolerate weaning earlier than this. Fennessey, *et al* (1981) weaned artificially-reared red calves at 9 to 12 weeks. At 9 weeks of age, artificially-reared rusa (*Cervus timorensis*) calves began to eat forage and their milk intake began to decline (Sookhareea and Dryden 1993) while a rusa calf reared by van Mourik (1983) began to eat forage at 12 days. The milk intake of artificially reared sambar (*Cervus unicolor*) calves (Semiadi, *et al* 1993) was less than 250 g/day by 10 weeks of age, and in this study both red and sambar calves began nibbling forage at 20 days, and began ruminating at 32 days (red) and 35 days (sambar). Brüggemann, *et al* (1973) considered that weaning of red calves was feasible from 60 days; they noted that growth was not improved by giving milk for 100 days or more.

The success of early weaning will depend on the diet used. Several North American weaning studies have used a diet which incorporates maize grain, soybean meal and minerals, and which provides sufficient Se and vitamin E (Ullrey, *et al* 1971). The concentrate mixture used was similar to that described by Ullrey, *et al* (1971), modified to ensure 16% protein (Puttoo, *et al* 1998). Semiadi, *et al* (1995) and Puttoo, *et al* (1998) have used similar diets (but based on barley) for red, sambar and rusa weaners. Roughage may not be needed in large amounts as rusa weaners self-selected a diet of 88% concentrate (Puttoo, *et al* 1998).

The weaner ration must also be palatable, and have no adverse effects on animal health. The data show that red deer calves will readily consume concentrates and good quality lucerne hay. The DM intakes recorded in this experiment (76 to 80, and 88 g/W^{0.75}.d⁻¹) intakes were similar to those reported by Domingue, *et al* (1991a,b) for adult red stags (68 and 63 g DM/W^{0.75}.d⁻¹). That the young calves in this experiment ate amounts of dry food similar to those expected of mature red deer is further evidence for the acceptability of this weaning ration and the ability of these young calves to adapt to early weaning. Like the rusa calves in the study of Puttoo, *et al* (1998), these red deer calves selected a diet rich in concentrate – the concentrate roughage ratios varied from about 1 : 1 immediately after introduction to the weaner diet, and were up to 4 and 5 : 1 at the end of the artificial rearing period. Even though the diets had high concentrate contents, there were no incidences of diarrhoea or the diseases associated with concentrate-rich rations which are often found in other domestic ruminants, e.g. rumen acidosis and laminitis.

The diets were digested acceptably well from the beginning of the artificial rearing period. Mean DM and NDS digestibilities were 0.613 and 0.781, respectively, in the first digestibility trial, when the selected diets were approximately 50% roughage. NDF was not digested efficiently at any stage, and the overall mean NDF digestibility was 0.18 ± 0.109. These results, taken together with the health observations reported previously and the nature of the selected diets, suggest that early-weaning diets should contain a minimum of plant fibre. The differences between the age groups in the first digestibility trial were not obtained in the second trial, and may have been artefacts of the lignin determination.

Weaning at 7 weeks appeared to disadvantage the calves, compared to weaning at 9 weeks. When they were compared at the same calendar dates, food intakes (changes in air-dry concentrate consumption, and the absolute DM intakes during the digestibility trials) and growth rates (increases in liveweight) were less in the 7-week weaned calves than in those weaned at 9 weeks. However, these comparisons are biased against the younger animals. DM intakes did not differ when they were adjusted for metabolic size. The calves had similar frame size measurements at the same age (i.e. 9 weeks), and differences at a particular calendar date in frame size measurements disappeared as the calves' age increased.

Comparison of the growth rates obtained in this experiment with other growth data further supports the feasibility of early weaning. The calves in the present experiment grew faster, during the artificial rearing period of the experiment, than naturally-reared red deer fawns in an earlier Queensland study (Ritchie, *et al* 1986) but slower than some New Zealand red deer calves (Moore, *et al* 1988c).

The lifetime effects of early weaning have not yet been fully explored. It is noteworthy that during the artificial rearing period, the 7-weeks weaned calves grew a little more slowly than those weaned at 9 weeks of age, and were smaller than the later-weaned animals for several months.

Sub-optimal feeding of red deer was examined by Suttie in two experiments. In each case, stags exhibited compensatory growth when realimented after a period of underfeeding following weaning. Compensation was not complete when compared against the performance of well-fed animals (Suttie and Hamilton 1983), but the extent of growth depression appeared to be more related to the nature of the feed given than to age. Suttie, *et al* (1983) observed compensatory growth in housed stags after each of three periods of winter feed restriction. Again, liveweight compensation was never complete, and stags underfed (70% of *ad lib.*) between approximately two and 11 months had a permanently smaller frame, as judged by their hind foot length (i.e. the lower hind leg). This reduced body size indicates a lower capacity for adult growth (Moore, *et al* 1988b).

However, the adult liveweight achieved by underfed deer calves may be more influenced by feeding in early adulthood, than by feeding immediately post-weaning. Calves underfed from weaning to 15 months were heavier at 27 months after eating a barley-based diet than calves well-fed until 15 months and then grazed on poor quality pasture (Suttie 1983). New Zealand red deer data indicate that 15 month liveweight is a better predictor of adult size than weight at three months (Moore, *et al* 1988b). The deer in the present experiment reached similar liveweights when they were yearlings, after both groups had experienced the same nutritional management when they were released to pasture.

There is little information about effects of weaning age on the reproductive performance of hinds at maturity, although a two month delay in weaning British red deer calves delayed the next calving by eight days (Milne, *et al* 1987). Moore, *et al* (1988a) noted that increased hind calving weight gave faster growth in New Zealand red deer calves. It is possible that any effects of early weaning on mature liveweight may affect the performance of the next generation.

The objectives of this investigation were to improve the ability of deer farmers to control the growth and survival of young deer by investigating the feasibility and effects of weaning at various ages and recommending a practicable early-weaning strategy. These results show that weaning at 7 weeks is a practicable option for red deer farmers. Calves weaned at this age will accept the type of diet used in this experiment without ill-effects, and will grow at acceptably fast rates. They may be smaller than later-weaned counterparts for some months. However, it is possible that differences in size are due to birth date effects, rather than the effects of early weaning (provided that this is accomplished successfully), and that the liveweights of early- and late-weaned calves will eventually be similar.

6. Implications

Australian red deer farmers can use more flexible nutritional management of young stock with greater confidence of success.

Losses because of mismothering, abandoned calves and predation can reach 10 % of the calf drop. Early weaning may allow deer farmers to better manage their calf crop. This may lead to substantial direct savings due to reduced calf losses. If 0.5 % of deer calves are orphaned, the value of saving these animals so that they grow to slaughter weight is about \$50000 per year, nationally. If droughts affect 75 % of Queensland deer herds once in 10 years, the value of ensuring that hinds calve successfully in the next season and that drought-season calves reach maturity without suffering a permanent growth check, may be worth \$3 million over 10 years in Queensland alone.

Indirect losses following pasture degradation, and reduced growth rates or calving percentages in drought-affected deer are more difficult to quantify but are nonetheless real. Early weaning reduces the nutritional demands of lactating hinds, and may allow farmers to reduce the grazing pressure on droughted pastures, promote the regain of body condition in hinds in preparation for the next rut, and promote growth in weaned calves by using a more nutritious alternative to natural rearing.

7. Recommendations

Exploitation of early weaning by the deer farming industry depends on using a suitable weaner ration, and on managing the calves as a group. The ration used in this study was expensive (based on a good quality lucerne hay, and a concentrate containing cereal grain, soybean meal, and lysine). Further work should explore the use of less nutritionally dense (and thus less expensive) ration ingredients. Because the intensive housing used in this study is not usually available on commercial farms, possible problems (e.g. of dominance) which may occur when early-weaned calves are managed in groups should also be investigated.

The feeding system used successfully in this study could serve as the basis of commercial early-weaning rations, perhaps produced under licence.

8. References

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