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Responses in venison production to grazing pastures based upon perennial ryegrass or annual ryegrass and to immunisation against melatonin.

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ABSTRACT

During 1989, two groups of weaner red deer stags (n=18) grazed either perennial ryegrass (PRG) or Moata annual ryegrass (ARG) based pastures from mid-May until the end of November. Within each group, animals (n=6) were either not immunised or immunised against melatonin using Freund's or Dextran adjuvants. Treatment effects upon winter (W) and spring (S) LWG, proportion of animals attaining target liveweight (93 kg; 50 kg carcass weight by November 30), pasture composition, voluntary DM intake (VFI), anti-melatonin titres and plasma prolactin concentrations were determined.

During winter, LWG (165 v 140 g/day; $P < 0.05$) and VFI (1.62 v 1.20 kg DM/day; $P < 0.001$) were greater for animals grazing ARG than PRG pastures, resulting in a greater proportion of deer attaining the target slaughter weight (60 v 41%). Organic matter digestibility and N content were higher ($P < 0.05$) for the ARG than PRG pastures during winter. Maximum anti-melatonin titres of 1:15,215 ± 5,551 (SE) and 1:1,941 ± 423 were attained in October and May respectively for the Freund's and Dextran adjuvant groups. Plasma prolactin concentrations were higher for immunised than for control animals during W and S. Growth to 6 months of age was depressed in stags immunised using Freund's adjuvant. There was evidence that immunisation using Dextran increased growth from 9-12 months of age, but this did not attain significance ($P > 0.05$).

Keywords Red deer; LWG; VFI; melatonin antibody titre

INTRODUCTION

Red deer exhibit very marked seasonal patterns of feed intake and liveweight change, with both being high over spring-summer and low during autumn-winter (Blaxter *et al.*, 1974, 1988; Pollock, 1975; Fennessy, 1981; Kay and Staines, 1981; Suttie and Kay, 1985; Suttie, *et al.*, 1989). These seasonal cycles are most evident in intact adult stags and less pronounced in young stags (Fennessy and Milligan, 1987). In red deer, seasonal changes in feed intake and growth are under photoperiodic control (Suttie and Simpson, 1985). It is believed that plasma melatonin concentration is the signal which synchronises the cycles of feed intake and body growth with the seasonal changes in photoperiod (Barry, *et al.*, 1990). Low autumn-winter LWG in young grazing deer can be attributed to the low intake point in the animal's 'biological clock' occurring at the same time as the seasonal low points in pasture production and quality.

Annual ryegrasses have better winter DM production than perennial ryegrasses (Armstrong 1981), and in experiments with sheep the annual and short-rotation ryegrasses sustained higher rates of LWG than did perennial ryegrasses (Rae, *et al.*, 1964; Ulyatt, 1971). The first objective of the present experiment was to attempt to maximise growth of weaner red deer stags during winter and spring through providing a high allowance of pastures based upon either perennial ryegrass (PRG) or annual ryegrass (ARG), with the objective of getting as many animals as possible to slaughter at 50 kg carcass weight (93 kg LW) by the end of November at approximately 12 months of age. A second objective was to evaluate the effectiveness of immunisation against melatonin as a means of increasing LWG over winter and early spring, and of increasing the proportion of animals attaining these slaughter criteria.

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MATERIALS AND METHODS

Animals

In a 2 x 3 factorial experiment, 36 weaner red deer stags weighing 52.9 kg ± 0.70 (SE) were assigned to two mixed pasture sward types (perennial ryegrass/white clover and the same direct-drilled with Moata annual ryegrass) on May 15, 1989. The stags on each pasture were randomly assigned to three types of immunisation (none, antigen in Freund's complete adjuvant, and antigen in DEAE-Dextran adjuvant) within the first two days of birth in November/December 1988. They received a primary subcutaneous injection, 1 ml at two separate sites either side of the neck at the rate of 1 mg antigen/calf. First and second booster injections were given in the same manner on February 28 (at weaning) and on May 15, 1989 respectively. Booster vaccine for the Freund's group was prepared using Freund's incomplete adjuvant. All calves were drenched with IVOMEC (Ivermectin; Merck, Sharp and Dohme, N.Z.) at three weekly intervals from weaning to June 1989 and monthly thereafter until November 1989. The stags were also vaccinated against clostridial infections using Tasvax Convax 5 vaccine (Aluminium hydroxide adjuvant and 0.015% thiomersal; Coopers Animal Health N.Z. Limited) on May 14, and weighed and allocated to pasture treatments on May 15, 1989. Thereafter, the stags were weighed straight off pasture at three weekly intervals.

Pasture

The Moata annual ryegrass paddocks were direct-drilled (blanket-sprayed) on March 23, 1989 at a rate of 24 kg seed/ha. The herbicide Roundup R (glyphosate 360; Monsato (N.Z.) Limited) was used as a spray to suppress existing vegetation. The two pasture groups were rotationally grazed (weekly shift) at a level of initial pasture mass of 2100 kg DM~/ha ± 88 (10 cm height PRG; 12 cm height ARG). Post-grazing herbage mass was 1600 kg DM/ha ± 78 (8 cm height PRG; 10 cm height ARG).

To estimate feed intake, all stags were orally dosed with intraruminal chromium controlled release devices (CRD) (Captec R, 3.0 cm core, 65% Cr_2O_3 Matrix, 9.00 mm orifice diameter, QS wing design), on June 14, and November 2, 1989. Group faecal samples (collected in the paddocks) and rectal faecal samples taken from individual animals between 8 and 20th day post-CRD dosing were collected to use for estimating winter and spring dry matter intake (DMI) of the grazing stags respectively. Five hand-reared castrates with oesophageal fistulae were grazed along side the experimental animals twice a month in order to collect samples of feed selected (extrusa) by the grazing stags for *in vitro* digestibility analysis. Five random herbage sample cuts (pooled) made just above soil level (feed on offer) were also taken from each sward type every month for laboratory *in vitro* digestibility analysis.

Blood sampling

Blood (10 ml) was taken from the jugular vein of all animals by venipuncture on the day of the first booster injection (bleeding before booster vaccination was given), 7 days post-booster and monthly thereafter until November. The blood samples were collected in 10 ml vacutainers (Nipro Medical Industries Limited, Japan) using Na heparin as anti-coagulant. The blood samples were centrifuged at 4°C, at 3000 RPM (1851 g) for 20 min to harvest plasma, which was then stored in 1 ml aliquots at -20°C.

Laboratory methods

All herbage samples were stored at -20°C, freeze dried and ground (1 mm diameter sieve) prior to laboratory analyses. *In vitro* digestibility was determined by the method of Roughan and Holland (1977), using six standards derived from *in vivo* digestion trials with sheep, and ranging in organic matter digestibility (OMD) from 60.40 - 83.40%. Total nitrogen (N) was determined by the Kjeldahl procedure. Chromium analysis was done as reported by Costigan and Ellis (1987).

Anti-melatonin antibody titre was determined as the dilution of plasma necessary to bind 10 pg of [^{3}H] melatonin/ml when 20 pg of [^{3}H] melatonin/ml was available. The results were expressed as titre as reported by Abraham (1974). Prolactin was determined using the method of van Landeghem and van de Weil (1978), as modified by Peterson *et al.*, (unpublished) and validated for red deer plasma (McCutcheon unpublished).

TABLE 1 Botanical composition (% DM) of the swards during winter (W) and spring (S).

Sward type		Season	Perennial ryegrass	Moata annual ryegrass	White clover	Other species	Dead matter
Pasture	(mean	W	87.0	-	3.2	1.1	8.6
	((se)		(1.52)		(0.55)	(0.20)	(1.09)
		S	78.9	-	4.2	3.8	13.1
			(3.51)		(0.23)	(.077)	(2.72)
Moata	(mean	W	9.3	81.9	0.2	5.0	3.6
	((se)		(1.55)	(1.28)	(0.03)	(0.73)	(1.12)
		S	12.0	65.1	2.3	6.4	14.4
			(3.19)	(5.25)	(0.29)	(0.88)	(2.22)

No of samples per season = 15

TABLE 2 Total nitrogen (N) concentration, organic matter digestibility (OMD) and calculated concentration of metabolisable energy (M/D values) for feed on offer for grazing stags during winter (W) and spring (S).

		Pasture	Moata	SE	Significance
Total N (% DM):	W	4.00	4.40	0.27	NS
	S	2.83	2.70	0.49	NS
OMD (%):	W	80.3	86.1	0.95	*
	S	78.9	80.4	2.42	NS
M/D (MJ ME/kg DM):	W	11.2	12.5	0.23	*
	S	11.2	11.5	0.48	NS

* $P < 0.05$

Statistical analyses and calculation of data

The experimental data were analysed as a 2 x 3 factorial using General Linear Models procedure (GLM). Winter LWG (g/d) was calculated from 15 May to 28 August, whilst spring LWG was calculated from 28 August to 30 November. Least Square Means (LSM) was used to test the differences between treatments. Pasture M/D values (MJ metabolisable energy/kg DM) were calculated as DOMD x 16.3. As there were no interactions ($P > 0.05$) between type of pasture and immunisation procedure, main effects for both are given in the results.

RESULTS

Botanical composition and nutritive values of pasture

Moata swards contained less perennial ryegrass than the pasture swards during both seasons (Table 1). Moata annual ryegrass content of the Moata sward was very

TABLE 3 Liveweight gain (g/d), voluntary feed intake (kg DM/d) and percentage of stags attaining slaughter weight (92-95 kg) by November 30, 1989.

	Pasture	Moata	SE	Significance
No of animals/group	17	15		
Liveweight gain:				
Winter	140	165	6.6	*
Spring	220	235	5.4	NS
Voluntary feed intake:				
Winter (rectal faecal sample)	1.20	1.51	0.10	(*)
Spring (rectal faecal sample)	1.75	1.72	0.05	NS
(group faecal sample)	2.32	2.57	0.11	(*)
Stags to slaughter (% of total)	41	60		

(*) P < 0.1; * P < 0.05.

high during winter (82%) and declined to 65% during spring. Moata swards contained lower amounts of white clover than the pasture swards during both seasons, with the difference being largest during winter (0.2 vs 3.2%). The other species and dead matter components of both swards increased during spring. Total nitrogen (N), OMD and M/D values for both sward types were generally high (Table 2). Total N content was especially high during winter for both sward types. The Moata swards had higher OMD and M/D values than the pasture swards, with the differences attaining significance during winter (P < 0.05).

Growth patterns and LWG during winter and spring

The seasonal nature of growth in the young red deer is shown in Figures 1a and 1b, with slow growth during winter and faster growth during spring. The winter and spring LWG (g/d), VFI (kg DM/d) and percentage of stags attaining slaughter weight by the end of November for the pasture and Moata groups are shown in Table 3. The winter LWG (P < 0.05) and VFI (P < 0.1) of the Moata group was significantly greater than that of the pasture group (165 v 140 g/d; 1.62 v 1.20 kg DM/d). Spring LWG and VFI were higher than those recorded during winter and were similar for both groups. During late November, deer grazing Moata were significantly heavier (P < 0.01) than those grazing pasture (Figure 1a). A larger proportion (60%) of animals grazing the Moata swards reached the target liveweight (92-95 kg LW) by November 30, whilst 41% of those grazing the pasture swards attained the target liveweight by this date.

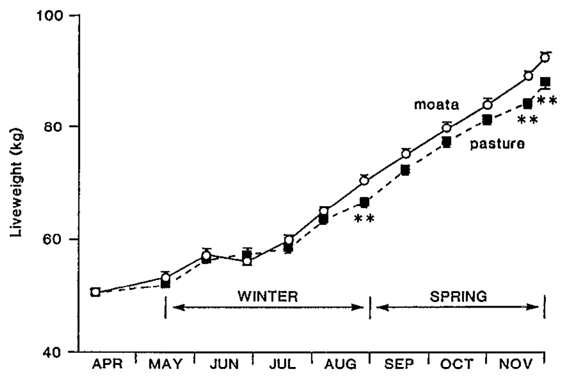

FIG 1a Seasonal liveweight patterns of young red deer stags grazing ARG and PRG pastures. The data are corrected by analysis of covariance to a common post-weaning weight of 50.7 kg in early April. Moata (Moata annual ryegrass); Pasture (perennial ryegrass). Asterisks indicate significance of difference of ARG group from PRG group; ** P < 0.01. Bars at points indicate SEM.

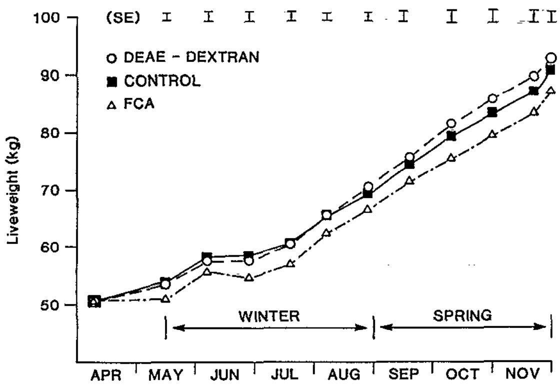

FIG 1b The effect of immunisation against melatonin upon the body weight of young red deer stags. The data are corrected by analysis of covariance to a common post-weaning weight of 50.7 kg in early April. Control deer; melatonin immunised using Freund's adjuvant (FCA); melatonin immunised using dextran adjuvant (DEAE - DEXTRAN). Bars at points indicate SEM.

Plasma anti-melatonin antibody titre and hormone concentrations

The patterns of melatonin antibody titre development in both vaccinated groups (Freund's DEAE-Dextran adjuvant) are shown in Figure 2. The antibody titres of the Freund's group (mean ± SE) were much higher (1:3,545 ± 1.059 to 1:1,5215 ± 5551) than those of the DEAE-Dextran group (1:48 ± 31 to 1:1,941 ± 423), with the highest recorded mean value occurring in October, about 11 months after the primary vaccination. The titre level of the DEAE-Dextran group peaked in May at 1:1,941 ± 423, about 6 months after the primary vaccination, and rapidly declined to undetectable levels by September. The antibody titre level of the Freund's group rose above 1:5,000 shortly after the second booster injection in May, and remained high until the end of the experiment in November.

Plasma prolactin concentration in the control group was slightly above the baseline level during the winter period (0.34 - 1.40 ng/ml; Figure 3), with an indication to increase during spring. Plasma prolactin levels of the vaccinated groups were higher (1.7 - 24.9 ng/ml) during winter, and the spring rise in concentration occurred earlier and was of larger magnitude than in the control group.

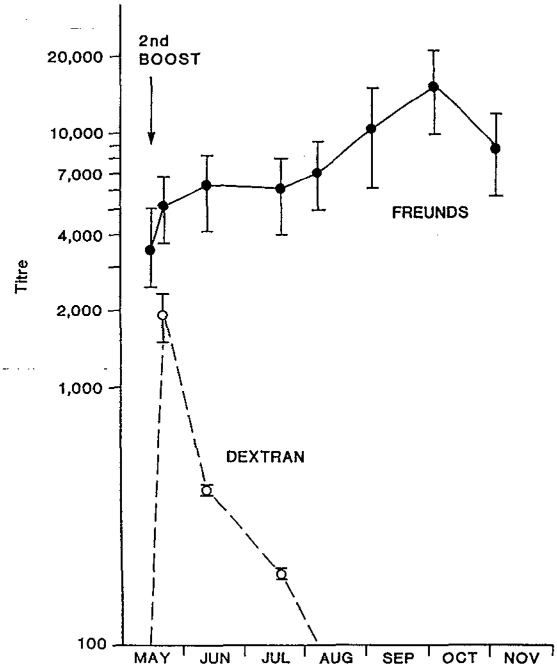

FIG 2 Development of antibody titres in young red deer stags immunised against melatonin using Freund's adjuvant and DEAE-dextran adjuvant; Bars at points indicate SEM.

Stags immunised at birth with Freund's adjuvant had lighter weaning weight (47.7 kg ± 1.25) compared with control animals (51.8 kg ± 2.12; $P < 0.05$) or those immunised with dextran adjuvant (52.5 kg ± 1.38; $P < 0.05$), and the depressed growth rate continued until end of autumn (Figure 1b). Thereafter, animals in all treatment groups grew at a similar rate during winter and spring. There was some indication that calves immunised using dextran adjuvant grew faster in spring (Figure 1b), but the difference did not attain significant. Whilst 73% of calves immunised with dextran and 67% of control group attained the target slaughter weight (92-95 kg LW) by the end of November, no animals from the Freund's group attained the target weight at this date.

DISCUSSION

The young red deer stags in the present experiment showed the normal seasonal pattern in body weight growth (Moore *et al.,* 1988; Ataja *et al.,* 1989; Barry *et al.,* 1990), with slower growth rates during winter (152 g/day) and much faster growth rates during spring (231 g/day). The winter growth rate of 140 g/day obtained from the perennial ryegrass/white clover diet in the present experiment corresponds with the upper limit of winter liveweight gain for weaner deer suggested by Fennessy and Milligan (1987). With an average liveweight of 52.3 kg at the end of autumn (May 15), consistent winter LWG of 140 g/day resulted in 41% of the animals attaining the target slaughter weight at 12 months of age. Application of the results reported here to commercial deer farms will certainly increase the proportion of young red deer stags slaughtered for venison, both by the end of the spring period and by one year of age.

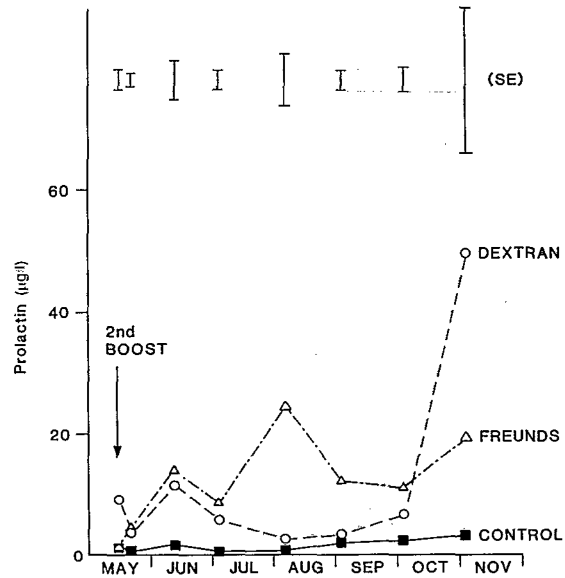

FIG 3 Plasma prolactin concentrations in young red deer stags. Melatonin immunised using Freund's adjuvant (Freunds); melatonin immunised using DEAE-dextran adjuvant (Dextran) and Control. Bars at points indicate SEM.

Animals grazing the Moata swards grew at the rate of 165 g/day during winter (Table 3), significantly greater ($P < 0.05$) than that recorded for animals grazing the perennial ryegrass/white clover swards, which resulted in 60% of them attaining the slaughter weight by November 30. This is in agreement with superior LWG of sheep grazing annual and short rotation ryegrass varieties compared with perennial ryegrass varieties (Rae *et al.,* 1964; Ulyatt 1971). Contributing factors to the greater LWG include the higher OMD of the Moata pastures during winter, and their greater VFI by the young stags.

Compared to commencing immunisation against melatonin at 3 or 6 months of age (Ataja *et al.,* 1989), the present experiment has shown that higher antibody titres were produced when immunisation was commenced at birth. Effective active immunisation resulted in higher plasma prolactin concentrations during winter and earlier onset of the spring rise in prolactin. Ryg and Jacobsen (1982) reported that injections of prolactin to yearling male reindeer during winter were associated with increases in VFI and weight gain. It might therefore be expected that immunisation against melatonin, with its associated elevation of plasma prolactin concentrations, should have increased winter LWG. This was not observed in the present experiment, especially with the Freund's group which could be due to the adverse effect of the adjuvant itself, which apparently reduced the growth of animals until autumn (6 months of age). Ataja *et al.,* (1989) showed that Freund's adjuvant itself (ie vehicle only) did not influence stag growth when immunisation was commenced at 6 months of age. During late winter/spring, the Dextran group showed evidence of superior growth (Figure 1b), which is similar to the effect reported by Duckworth and Barrell (1989), but in the present experiment the response did not attain significance. Further studies are needed in formulating a Dextran-based anti-melatonin vaccine that produces high antibody titres over a longer period of time.

This study has clearly demonstrated that producing venison from young red deer stags based on perennial ryegrass/white clover pasture within one year of age is feasible, and that introduction of Moata annual ryegrass as a high proportion of the sward further increases the growth rate by 18% during winter. The results of this study also show that intensive venison production from grazed pastures will respond to use of pasture plants of high nutritive value. Hunt and Hay, (1989) identified red clover as highly preferred by red deer, and Niezen *et al.,* (1990) showed that grazing pure red clover during lactation increased weaning weight from 42 to 50 kg, compared with perennial ryegrass-based pasture, whilst post-weaning, it increased LWG during autumn from 193 to 262 g/day (Semiadi, unpublished). The present study, together with these reports, show that there is a need to develop specialist pastures for deer production.

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