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Energy intake and patterns of growth for male and female fallow deer of two genotypes, between 10 and 21 months of age

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Abstract

European (no. = 36) and hybrid (¼ Mesopotamian, ¾ European; no. = 36) fallow deer (Dama dama) were evaluated for weight gain and energy intake from 10 to 21 months of age. Twelve each of bucks, does and castrated males (haviers) were tested for each genotype, in both concentrate-fed and pasture-based feeding systems. Based on weekly weighing hybrids (H) in each of the sex classes grew more rapidly (5 g/day across all groups) than the European (E) fallow deer ($P < 0.05$). Haviers given concentrates grew significantly faster than pasture-fed haviers ($P < 0.01$), whilst does grown on pasture grew significantly faster than those given concentrates ($P < 0.01$). There was no significant difference in pattern of growth between bucks on pasture and those given concentrates ($P > 0.05$). Does grew significantly less ($P < 0.01$) than bucks and haviers in spring, summer and winter but environmental differences between years could not be accounted for in the analysis.

Animals of all sexes and genotypes experienced rapid growth from 10 to 12 months of age (spring) and this was associated with energy intakes according to metabolic body weight ($M^{0.75}$) these ranging between 0·8 and 1·1 MJ metabolizable energy (ME) per kg $M^{0.75}$ per day. There were significantly ($P < 0.01$) higher levels of energy consumed by H does and haviers in the summer, compared with their E counterparts but this was not associated with greater growth rates. However, H does had significantly higher ($P < 0.01$) dressing proportions at slaughter than E does. The energy intake on a metabolic body weight basis for most groups declined to between 0·7 and 0·8 MJ ME per kg $M^{0.75}$ per day from 12 to 21 months of age, except for the does, which declined even further to between 0·5 and 0·6 MJ ME per kg $M^{0.75}$ per day from 17 months of age.

There were no significant differences between E and H deer for energy intakes per $M^{0.75}$, and H deer were slightly more energy efficient than their E counterparts in terms of growth rate in relation to annual gross energy intake. The food intake : weight gain ratio increased considerably for both genotypes after 14 months of age, indicating the desirability for slaughtering as soon as animals reach the target live weight. It was concluded that the crossbreeding system described is production efficient and produced offspring that reached slaughter weight sooner than E fallow deer and thereby produced carcasses with a greater wholesale value than their E counterparts of the same age.

Keywords: *energy intake, fallow deer, growth, hybrids.*

Introduction

European fallow deer are farmed in many parts of the world, primarily for venison. Fallow deer farmed for venison in Australia are usually slaughtered after they have reached a live weight of 43 kg, which produces a carcass of 24 kg or more. This is the minimum carcass weight required by venison wholesalers. Under Australian pastoral conditions the target live weight for different sexes (bucks, does and castrated males (haviers)) is usually reached between 10 and 21 months of age (Mulley, 1989; Mulley *et al.*, 1996).

Patterns of growth for entire males and castrated males (hereafter called haviers) of this age have been reported by Mulley and English (1985), Hogg *et al.* (1990), Mulley *et al.* (1996), and for females by Asher (1986 and 1992a), Adam (1988) and Mulley (1989). There is evidence that the temperate species of deer exhibit pronounced growth and food intake cycles mediated by photoperiod changes (Suttie and Corson, 1991). In fallow deer this is manifest as distinct growth patterns within the 1st and 2nd years of life (Mulley *et al.*, 1996). Fennessy and Thompson (1990) showed that there were two peaks of biological efficiency in growth and development of red deer, at 30 weeks and 68 weeks of age.

Variation in food supply and quality can influence greatly when animals reach slaughter weight and there are no data available on the energy requirements of fallow deer of different sexes in relation to annual patterns of growth. Mulley (1989) reported energy intakes for group fed European fallow deer (*Dama dama dama*) does throughout pregnancy and Milligan (1984), Adam (1988) and Asher (1992b) reported calculated energy requirements for various sex and age classes of fallow deer that were interpolated from those for red deer (*Cervus elaphus*, Fennessy *et al.*, 1981).

Fallow deer are strictly seasonal breeders (Asher, 1985 and 1986) and most male animals destined for slaughter in any perticular year reach slaughter weight at about the same time. Furthermore production of bruise-free carcasses from bucks during the breeding season (March to July in Australia) can be difficult because of the inherently aggressive behaviour of males towards one another at this time of year (Mulley and English, 1985 and 1992; Asher, 1988). Castration of fallow bucks to modify behaviour during the breeding season has been advocated (Mulley and English, 1985) but various studies (Mulley and English, 1985 and 1992; Asher, 1986; Asher *et al.*, 1987; Adam, 1988; Mulley, 1989; Hogg *et al.*, 1990) have shown that bucks castrated pre-pubertally have a slower growth rate. Does, 1 to 2 years old, and haviers, are now being slaughtered in Australia (Mulley, 1993) at times of the year when bucks are difficult to manage.

To assist production of animals that reach slaughter weight over longer periods of the year, backcrossing of European fallow deer (*Dama dama dama*) does with F_1 hybrid European × Mesopotamian fallow deer bucks, to produce quarter-bred slaughter animals, is now commonly practised. Such hybrids are known to grow faster to slaughter weight than their pure European counterparts and to exhibit comparable carcass characteristics (Hogg *et al.*, 1993). However, the costs of production of the different sexes of European and hybrid fallow deer and comparative evaluation of growth of these classes and genotypes, have not been determined.

This study compares seasonal patterns of growth, daily food intake and daily energy intakes measured on the basis of metabolic body weight ($M^{0.75}$) for European and hybrid fallow deer bucks, does and haviers between 10 and 21 months of age.

Material and methods

Over consecutive years (September 1993 to September 1996), three separate experiments were carried out to determine the daily food and energy intake of European fallow deer (E) and hybrid (H) (0·75 European and 0·25 Mesopotamian fallow deer) fallow deer bucks, does and haviers between 10 and 21 months old. In each of the years, only animals of the same sex were used.

Bucks in the castration (havier) treatment group had a rubber ligature applied above the testes pre-pubertally (Elastrator Co. Ltd, Blenheim, New Zealand) in May 1994 (6 months of age), which was 4 months prior to commencement of the feeding treatments. Castration was performed according to the legal requirements for farmed deer in the State of New South Wales, Australia. The does reached puberty (16 months old) in April 1996 but remained unmated. At the start of each new trial, deer were randomly assigned to treatment group, to be offered either a formulated concentrate diet or on pasture for the duration of the trial. Deer assigned to individual pens and concentrate feeding underwent a 2-week period of habituation to the pens and weighing procedures. Live weights were recorded directly off pasture or concentrate food each week for the duration of the trial. All animals were fasted for 16 h prior to slaughter at 21 months of age.

The 'target' live weight in this study was 43 kg, and is defined as the live weight at which the deer could have been killed to meet the minimum commercial carcass weight of 24 kg. The dressing proportions for E and H fallow deer have been described previously (Mulley and English, 1985; Hogg *et al.*, 1993; Mulley *et al.*, 1996).

Pen feeding

In each of the years, six deer (three of each genotype) were housed individually in pens (12 m^2), which provided natural lighting. Each pen had coarse sawdust flooring and provided shade, shelter from wind and rain and *ad libitum* water. Over a period of approximately 12 months, all deer were given *ad libitum* a pelleted food formulated by Commonwealth Scientific and Industrial Research Organization, Division of Animal Production, Prospect, NSW, Australia, to provide 10·5 MJ metabolizable energy (ME) per kg dry matter (DM) and 120 g/kg protein. Each animal was given food daily between 12:00 and 13:00 h following removal and weighing of residual food from the previous 24 h.

Pasture feeding

In each of the years 18 animals (nine of each genotype) were grazed on Kikuyu-dominant pasture which also contained perennial rye-grass and clover. The ME value of pasture was estimated fortnightly using the method described by Oddy (1978), and ranged between 9 and 11·5 MJ ME per kg DM and 110 to 150 g/kg protein across each of the years. There were three replicate groups of six animals for each sex group, with each group comprised of three animals of each genotype, randomly assigned. All groups were regularly rotated onto 0·25-ha paddocks containing fresh pasture, with sward heights ranging between 10 and 25 cm (Kikuyu dominant) or 8 and 14 cm (ryegrass and clover dominant).

Statistical analysis

Growth rates (g/day) between successive weekly weighings, and energy intakes (MJ ME per kg $M^{0.75}$ per day), were calculated for individually fed penned animals. Each year was divided into four periods, which approximated to seasons of the year but each period was adapted to fit live-weight changes associated with the highly seasonal reproductive cycle (rut) of deer. These periods were: Spring 12 September to 12 December (91 days); Summer 13 December to 23 March (100 days); Autumn 24 March to 2 June (70 days); Winter 3 June to 6 September (95 days).

Differences in growth rate and energy intake for each of the periods between animals given the concentrate diet and those at pasture, for each of the sexes and within genotypes, were estimated using residual maximum likelihood (REML) as implemented in version 4·1 of GENSTAT (GENSTAT 5 Committee, 1993). Between group variation for animals at pasture and animals given concentrates within years, was estimated to be zero and the s.e. for the two groups are therefore taken to be the same. Standard error of difference between the two genotypes is indicated in the tables by s.e.d.

Results

The patterns for animal growth, and daily energy intake per $M^{0.75}$ for penned animals given concentrates for each of the sexes over the period of each trial are shown in Figure 1. Each sex type experienced rapid growth to 15 months of age, with males and haviers for E and H deer reaching the target live weight (43 kg group average) requirement before that time, as did the H does fed at pasture. However the E does grown on pasture, and the E and H does given concentrates, did not reach the required slaughter weight by 21 months of age. Does in all groups lost weight from the end of March, which was coincident with the start of the breeding season and attainment of puberty in these animals.

Of the deer given concentrates, H bucks reached slaughter live weight (43 kg group average) at 11 months of age, which was 30 days sooner than their E counterparts. H haviers reached slaughter weight at 13 months of age, which was 35 days sooner than their E counterparts, whilst neither E nor H does reached slaughter weight prior to 21 months of age:

Table 1 *Mean live-weight gain (kg) and energy intake per $M^{0.75}$ (MJ ME/kg $M^{0.75}$ per day) for three sex types of European (E) and hybrid (H) fallow deer held individually in pens and given concentrates over four seasons of the year (no. = three per group)*

			Spring	Summer	Autumn	Winter
Bucks	Growth (kg)	E	10·87	6·70	−1·60	1·40
(Year 1)		H	9·13	9·53	−1·57	3·97
	Energy intake	E	1·00	0·83	0·79	0·82
	(MJ ME per kg $M^{0.75}$ per day)	H	0·94	0·85	0·79	0·84
Does	Growth (kg)	E	3·33	4·33	1·00	−3·00
(Year 2)		H	3·83	5·50	0·50	−3·00
	Energy intake	E	0·74	0·74[a]	0·82	0·62
	(MJ ME per kg $M^{0.75}$ per day)	H	0·74	0·86[b]	0·85	0·65
Haviers	Growth (kg)	E	9·67	9·17	−1·50	2·83
(Year 3)		H	10·50	6·33	1·17	1·83
	Energy intake	E	0·87	0·73[a]	0·70	0·74
	(MJ ME per kg $M^{0.75}$ per day)	H	0·89	0·81[b]	0·71	0·77
s.e.d.	Growth		1·027	1·173	0·817	1·241
	Energy intake		0·034	0·019	0·046	0·064

[a,b] Means within columns with different superscripts are significantly different ($P < 0{\cdot}01$).

Over the trial period, E bucks, does and haviers given concentrates grew at 54, 16 and 53 g/day respectively, whilst their H counterparts grew at 64, 20 and 54 g/day respectively.

The data were tested for differences in growth between deer given concentrates and deer at pasture. For bucks there was no difference between pasture and concentrate feeding, whereas haviers given concentrates grew significantly faster ($P < 0{\cdot}01$) than deer at pasture and does given concentrates grew significantly more slowly ($P < 0{\cdot}01$) than deer at pasture. There was a significant genotype effect, and H deer given concentrates and at pasture grew more quickly than E deer, for each of the three sex classes ($P < 0{\cdot}05$). Across all sexes, H deer grew 5 g/day more quickly than their E counterparts. Does grew significantly less ($P < 0{\cdot}01$) than bucks and haviers in spring, summer and winter but environmental differences between years could not be accounted for.

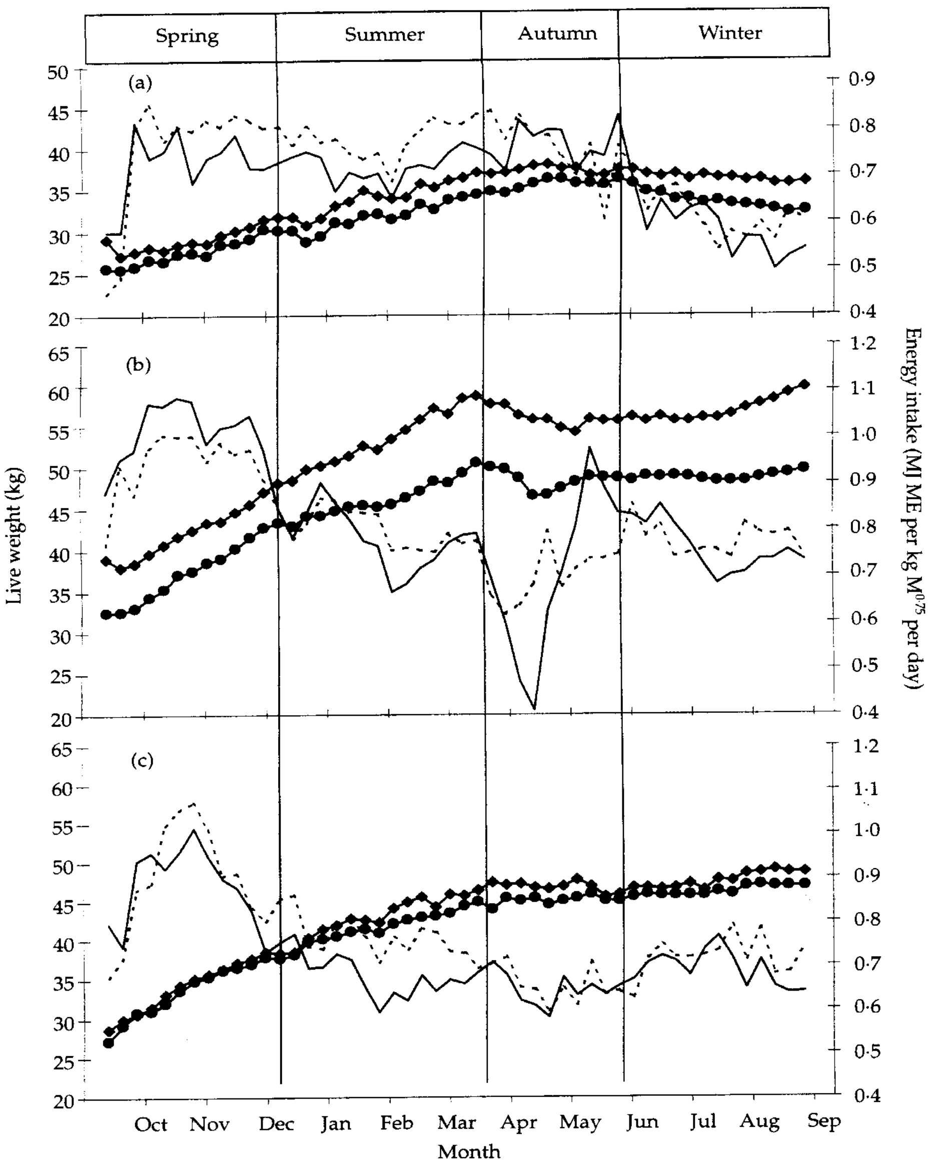

Figure 1 Mean live weights and energy intakes of individually penned (a) does, (b) bucks, (c) haviers of the European (E) and hybrid (H) genotypes of fallow deer over four seasons: live weight (kg) ● E; ◆ H; energy intake (MJ ME per kg $M^{0{\cdot}75}$ per day) ——— E; - - - - -H.

Table 2 *Mean live weight, hot standard carcass weight (HSCW) and dressing proportion (g/kg) for European (E) and hybrid (H) fallow deer given concentrates or at pasture and slaughtered at 21 months of age*

Sex and genotype	Group size (no.)	Live weight (kg)	HSCW (kg)	Dressing proportion (g/kg)
Bucks				
E	8	46·8	27·9	595
H	8	53·4[a]	31·2[a]	595
(s.e.d.)		(1·40)	(0·76)	(8·3)
Does				
E	12	32·6	18·6	570
H	12	37·2[b]	21·8[b]	590[b]
(s.e.d.)		(1·08)	(0·71)	(4·7)
Haviers				
E	12	42·6	25·0	587
H	12	45·4	26·7	588
(s.e.d.)		(1·40)	(0·85)	(4·3)

[a] = H significantly higher than E ($P < 0·05$). [b] = H significantly higher than E ($P < 0·01$).

Rapid growth in spring for bucks and haviers between 10 and 12 months of age was associated with a corresponding increase in energy intake (Table 1). Weight loss associated with the period of the rut in early autumn was more pronounced in E bucks, and was also associated with a greater reduction in voluntary food intake (VFI) in E bucks than for H bucks. However, this period of low VFI was followed by a compensatory increase in VFI in late autumn in E bucks (Figure 1). Apart from the perturbation in energy intake for E bucks during the period of the rut, bucks and haviers of both genotypes maintained a relatively constant energy intake between 12 and 21 months of age. There was a rapid decline in energy intake and growth in E and H does from 16 months of age (mid autumn), which roughly corresponds with the time when they would have reached puberty and commenced their first oestrous cycles. Growth for does of both genotypes was negative throughout winter.

There was a significant ($P < 0·01$) increase in energy consumed by H does and haviers in the summer compared with their E counterparts (Table 1) but this was not associated with a significant increase in growth. At all other times during the period of the trial there was no difference in growth or energy intake between E and H bucks, does and haviers. The growth and energy intake patterns for haviers appeared to mimic those of bucks, except during the period of the rut for E deer.

The live weight and hot standard carcass weight (HSCW) at 21 months old for H does and bucks were significantly higher than their E counterparts (Table 2) but their were no differences between the haviers of the two genotypes. H does also had a significantly higher dressing proportion than E does ($P < 0·01$).

Seasonal variations in daily energy intake, and the annual energy intake for each sex class, are shown in Table 3. These are contrasted with values for bucks and does that were interpolated (Asher, 1992b) from seasonal predictions for red deer stags (Fennessy *et al.*, 1981). The predicted values for fallow deer bucks were similar to the values for bucks in this trial (proportionately 0·013 difference), however the values for does differed proportionately by over 0·30. No similar data are available for comparison with haviers.

Food conversion efficiency (FCE) was best for haviers, followed by bucks and then does, with does significantly less efficient ($P < 0·001$) than either of their male counterparts over the period of the trial (Table 3).

One of the H bucks grew significantly faster than all other deer in the trial and reached a live weight of 74 kg at 21 months of age. For this reason the mean live weight at 21 months of age for H bucks is perhaps higher than would normally be encountered for animals of this genotype at the same age.

Discussion

In this study hybrid bucks, haviers and does at pasture reached slaughter weight sooner than their E counterparts. Hogg *et al.* (1993) had shown that hybrid bucks of similar genotype reached slaughter weight sooner than European fallow deer and that there were no significant genotype differences in carcass composition. The commercial importance of these data is that the supply of fresh venison of similar quality can be produced for longer periods of the year, especially when haviers of each genotype, and hybrid does, can be added to the slaughter schedule. Since haviers of each genotype and hybrid does reached slaughter live weights prior to 15 months of age, this avoids the need for slaughter of entire bucks through the breeding season, when they are difficult to manage through commercial slaughter premises without bruising (Mulley and English, 1985 and 1992). From Figure 1 it can be seen that all sex classes for both genotypes grew rapidly through spring and summer but that little growth occurred after 15 months of age. The high energy intake during spring corresponded with rapid growth but the food intake : weight gain ratio increased considerably for all sex classes of both genotypes

Table 3 *Seasonal variation in energy intake (MJ metabolizable energy (ME) per day) and food conversion efficiency (FCE) for individually penned fallow deer of different sexes, from 10 to 21 months of age. Data for European (E) and hybrid (H) genotypes are represented (no. = 3 per group)*

Sex and genotype	Mean live weight at 10 monthsS of age (kg)	Energy intake (MJ ME per day)				Annual (365 days)	Mean live weight at 21 months of age (kg)	FCE†
		Spring	Summer	Autumn	Winter	(MJ ME per head)		
Bucks								
E	33·0	14·5	14·3	12·1	13·4	5007	51·8	293
		(14·2)	(13·0)	(13·3)	(15·4)	(5051)		
H	38·5	14·9	15·8	13·2	15·1	5559	60·8‡	296
Does								
E	26·5	8·8	9·3	10·1	7·1	3248	32·2	603[a]
		(11·3)	(11·3)	(11·3)	(13·1)	(4242)		
H	28·3	9·6	11·6	11·2	8·2	3697	35·2	544[a]
Haviers								
E	28·6	12·3	10·9	10·3	10·8	4421	47·0	212
H	29·8	12·8	12·7	11·1	11·8	4248	48·8	222

( ) Numbers in brackets refer to estimates for European fallow dear (Asher, 1992b) that were interpolated from the work of Fennessy *et al.* (1981) for red deer stags.
† FCE = food intake (MJ ME) per kg live-weight gain.
‡ Contains one deer that grew significantly faster (g/day) than all other deer in the trial.
[a] = does significantly lower FCE compared with bucks and haviers ($P < 0{\cdot}001$).

after 15 months of age, indicating the need for slaughter as soon as animals reach the target live weight to optimize food resource management on farms. Does, and bucks in particular, lost weight during the breeding season, even when the sexes were separated. Although mating activity did not occur, it is clear that entry into the rutting season has dramatic consequences on all entire animals. In males, this can be explained by a massive increase in mating activity at the time (Asher *et al.*, 1989). However, the effect on does is not so readily explained.

The phenomenon of weight loss in does during autumn and winter has been observed elsewhere (Asher, 1986; Mulley, 1989). In the current trials this was shown to be linked to a concomitant reduction in VFI. The energy intakes of non-pregnant does between 15 and 21 months of age are similar to those reported for pregnant E and H does in late autumn and winter (Flesch *et al.*, 1998) and in both studies there was no significant difference in VFI between the genotypes. It would appear that the maintenance requirement for farmed fallow deer does ranges between 0·5 and 0·6 MJ ME per kg $M^{0{\cdot}75}$ per day throughout winter whether they are pregnant or not.

Depression of VFI during autumn in H bucks was less marked than for E bucks (Figure 1). This may indicate that hybrids mature later than their E counterparts and do not undergo the same intensity of rutting behaviours at 16 months of age. However, differences in energy intake per $M^{0{\cdot}75}$ between E and H bucks throughout autumn were not significant and, although the mean live weight for H bucks appears to be significantly higher than E bucks, this result was affected by the exceptional growth in one animal, which grew to a live weight of 10 to 12 kg heavier than other H bucks at pasture or in individual pens, by 21 months of age.

Haviers appeared to be least affected by seasonal variations in growth or VFI, although H haviers had a significantly higher energy intake per $M^{0{\cdot}75}$ in summer, compared with E haviers. Both the E and H haviers grew at rates that were not significantly different from their entire counterparts (Tables 1 and 3). The reduction in growth of fallow deer castrated pre-pubertally has frequently been reported (Mulley and English, 1985 and 1992; Asher, 1986; Asher *et al.*, 1987; Adam, 1988; Mulley, 1989; Hogg *et al.*, 1990) and it is apparent that the most significant effect on growth is exerted immediately after castration (Mulley *et al.*, 1996). The results of the current study show that the growth potential of haviers in the spring and summer period (10 to 14 months of age) is equivalent to that of entire males providing adequate food for growth is available and that the overlap in live weight of H haviers with E entires during autumn confirm their suitability for inclusion in meat production systems where carcass bruising in entire males is a problem during the breeding season.

The production of Mesopotamian backcross hybrids appears to offer sufficient production advantage to warrant future commercial use. Pemberton (1993) demonstrated the genetic homogeneity of European fallow deer worldwide but the availability of Mesopotamian fallow deer semen (Asher *et al.*, 1990 and 1992) has given fallow deer farmers a unique opportunity to increase selection pressure for commercially important traits such as growth rate. Although hybrid vigour could not be determined in the present study it would be expected that there would be a small heterotic effect on growth in the H deer, based on results of crossbreeding in other domesticated ruminants such as cattle and sheep (Swan, 1992). The higher growth rate of H deer across all groups (5 g/day) for the duration of the trial and the significantly higher final live weight and hot standard carcass weight (Table 2) of does and bucks ($P < 0{\cdot}01$ and $P < 0{\cdot}05$, respectively) are indicators that heterosis may be contributing to the growth advantage but the contribution is unknown.

The energy intakes per $M^{0{\cdot}75}$ for growth of fallow deer to slaughter weight and, in some cases, beyond are shown in Figure 1. Seasonal variations in voluntary intake are immediately obvious, and it would appear that each of the sex classes has a different pattern of growth associated with energy intake. A high energy intake (0·8 to 1·1 MJ ME per kg $M^{0{\cdot}75}$ per day) in spring is consistent for all groups of deer between 10 and 12 months of age, and corresponds with rapid animal growth. This intake then dropped to between 0·7 to 0·8 MJ ME per kg $M^{0{\cdot}75}$ per day and remained relatively constant for most groups of deer thereafter. The intake for fallow does dropped further, to between 0·5 and 0·6 MJ ME per kg $M^{0{\cdot}75}$ per day after 17 months of age. The intake for fallow deer in this study is between the estimates of the requirements for red deer stags given food indoors and outdoors in the South Island of New Zealand of 0·57 and 0·85 MJ ME per kg $M^{0{\cdot}75}$ per day (Fennessy *et al.*, 1981) respectively. Estimates of requirements for fallow deer (Milligan, 1984; Adam, 1988; Asher, 1992b) were interpolated from the work of Fennessy *et al.* (1981)(Table 3). The requirements for red deer stags allowed reasonable predictions of the energy requirements for fallow bucks in each of the seasons and annually but requirements for fallow does may have been substantially overestimated using the same red deer data. It appears that fallow does go through a period of lower food intake during late autumn and winter despite the availability of high quality food, and may require less food than previously estimated to maintain energy balance at this time. This trend was evident in both animals given concentrates and animals at pasture of both genotypes in the current study, although these animals were not pregnant. However, similar trends were more recently shown for pregnant adult fallow does (Flesch *et al.*, 1998), with increases in energy intake only occurring in the last nine weeks of pregnancy (Mulley, 1989; Flesch, *et al.*, 1998), and during lactation (Flesch *et al.*, 1998).

The energy intake for E bucks in the early autumn period decreased proportionately by 0·5, a result in agreement with the work of Jopson *et al.* (1993) who showed that fallow bucks relied principally on body fat reserves to meet energy demands during the rut. They concluded that it is vital to supply high quality food to bucks after the cessation of the rut and through the winter until body fat reserves are replenished. In this respect, Figure 1 shows compensatory food intake associated with the cessation of negative growth immediately after the rut. These data demonstrate clearly the need to provide high quality food to bucks immediately after the rut, to restore body reserves and to restore quickly body condition to the pre-rut condition.

There are no data available with which to compare the energy intake and growth of haviers. However, from this study the requirement appears to be between those for does and bucks (Tables 1 and 3). In terms of metabolic and gross daily energy intake, this result was not unexpected given their relative size. Does had a higher energy intake per $M^{0{\cdot}75}$ during autumn than did haviers and this was coincident with when they began to lose weight. The changes observed are most likely associated with the increased physiological changes that occur in does associated with the breeding season (Asher, 1985).

FCE was best for haviers, followed by bucks and then does (Table 3) but there was no significant genotype difference. Therefore the crossbreeding system described appears to be production efficient and produced offspring that reached the desired slaughter weight sooner than E fallow deer. The commercial importance of these data is that the supply of fresh venison of similar quality can be produced for longer periods of the year and food resource management can be optimized by using the known food intake data for each sex class of fallow deer at various times throughout the year, to achieve target live weights.

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