Non-ref.

(608)

Energy intake of farmed fallow deer of 2 genotypes during pregancy, lactation, and growth to slaughter weight

R C Mulley, I S Flesch and G W Asher

Abstract

Daily energy intake was measured for European (E) and hybrid (H) (³/₄ European and ¼ Mesopotamian) fallow deer bucks, does and castrated bucks, and pregnant and lactating does. There was no difference in metabolic bodyweight ($W^{0.75}$) energy intake between E and H deer in any of the groups, but H deer grew faster than E deer for each of the three sex classes ($p<0.05$). The energy intake during early lactation was double the requirement for the second and third trimester of pregnancy. By 16 weeks of age fallow deer fawns had an energy intake equivalent to that of a non-pregnant adult fallow doe.

Animals of all sexes and genotypes experienced rapid growth from 10 to 12 months of age (spring) and this was associated with $W^{0.75}$ energy intakes ranging between 0.8 and 1.1 MJME/$Kg^{0.75}$/day. The energy intake for most groups declined to between 0.75 and 0.8 MJME/$Kg^{0.75}$/day from 12 to 21 months of age, except for the does, which declined even further to between 0.5 and 0.6 MJME/$Kg^{0.75}$/day from 17 months of age.

Hybrid deer were slightly more energy efficient that 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 liveweight. It was concluded that the crossbreeding system described is production efficient and produced offspring that reached slaughter weight sooner that E fallow deer and thereby produced carcasses with a greater wholesale value than their E counterparts of the same age. Furthermore, these data confirm the importance of strategic feeding of fallow does in late pregnancy and lactation.

Key words

fallow deer, nutrition, lactation, pregnant, bucks, does, haviers

Introduction

European fallow deer (*Dama dama dama)* are farmed in many parts of the world, primarily for venison. Under Australian pastoral conditions fallow deer destined for slaughter usually reach the target liveweight between ten and 21 months of age (Mulley *et al*, 1996). Distinctive growth and feed intake cycles mediated by photoperiod changes (Suttie and Corson, 1991), and peaks of biological efficiency (Fennessy and Thompson, 1990) have been described for the larger temperate deer species, and these are also evident for fallow deer (Mulley *et al*, 1996). However, although much is now known about patterns of growth and development of fallow deer, there is little information available on the nutritional requirements of the various age and sex classes of stock that could assist with management decisions on a commercial deer farm.

Mulley (1989) reported energy intakes for group fed European fallow deer does throughout pregnancy, and Milligan (1984), and Asher (1992) 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). Flesch *et al* (1998) reported voluntary feed intake and feeding behaviour patterns of pregnant and lactating fallow deer of two genotypes, but similar data for various sex classes of fallow deer, from weaning to slaughter weight, are necessary for optimal growth and development of animals to meet quality assurance targets.

To assist production of animals that reach slaughter weight over longer periods of the year, backcrossing of European fallow deer does (*Dama dama dama*) with F_1 hybrid European x Mesopotamian (*Dama dama mesopotamica*) 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 paper describes the daily feed intake for pregnant fallow deer of two genotypes, from mid-pregnancy to weaning of their fawns at twelve weeks of age. The feed intake of fawns immediately after weaning at twelve weeks of age has also been determined, as has the growth and feed intake for bucks, does and castrated males (hereafter called haviers) up to 21 months of age.

Materials and methods

Over consecutive years (September 1993 to Feb 1999), the daily feed intake of European fallow deer (E) and hybrid (H) (75% European and 25% Mesopotamian fallow deer) fallow deer bucks, does (pregnant and non pregnant) and haviers was determined. Bucks in the havier treatment group were castrated four months prior to commencement of the feeding treatments. One of the groups of does reached puberty (16 months old) during the feeding treatment, but remained unmated. In each experiment deer were randomly assigned to treatment group, and fed either a formulated concentrate ration, or pasture-fed for the duration of the trial. Deer were weighed weekly throughout all experiments.

Pen Feeding

In each of the years, deer of each genotype were housed individually in pens ($12m^2$), which provided natural lighting. Each pen had coarse sawdust flooring, and provided shade, shelter from wind and rain, and *ad libitum* water. All deer were fed *ad libitum* over a period of approximately twelve months with roughage pelleted feed formulated to provide 10.5MJME/kg DM and 12% crude protein CP). Each animal was fed daily between 12noon and 1pm following removal and weighing of residual feed from the previous 24 hours.

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 metabolisable energy (ME) value of pasture was estimated fortnightly using the method described by Oddy (1978), and ranged between 9 and 11.5 MJME/kg DM and 11-15% CP 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 hectare paddocks containing fresh pasture, with sward heights ranging between 10-25cm (Kikuyu dominant) or 8-14cm (rye-grass and clover dominant).

Experiment 1

Fallow deer bucks, non-pregnant does and haviers ($n = 6$ per group) (three E and three H for each sex) were fed *ad libitum* on concentrates (10.5 MJME/KgDM and 12% protein) from 10 months of age to 21 months of age. For each sex type, 18 pasture-fed controls (nine of each genotype) of the same age were compared for growth.

Experiment 2

In each of two years, 15 three-year-old E fallow does and 15 three-year-old H fallow does were mated to E fallow bucks, following oestrus synchronisation with CIDR devices. All of these does had successfully rared a fawn as maidens. Does were randomly assigned to treatment groups, to be fed either concentrates or pasture *ad libitum* for the duration of pregnancy and lactation. Does were allowed to fawn in their individual pens, or at pasture, with the birthweight, six-week and twelve-week weights recorded for each fawn.

Experiment 3

Ten fallow deer fawns were fed *ad libitum* a concentrate ration containing 14 MJME and 16% CP for eight weeks following weaning at twelve weeks of age. Control animals remained on pasture.

Statistical analysis

Growth rates (g/day) between successive weekly weighings, and energy intakes (MJME/kg$^{0.75}$/day), were calculated daily for individual pen-fed animals. In experiment 1, each year was divided into four periods, which approximated to seasons of the year, but each period was adapted to fit liveweight changes associated with the highly seasonal reproductive cycle (rut) of deer. These periods were: Autumn – 24th March to 2nd June (70 days); winter - 3rd June to 6th September (95 days); spring - 12th September to 12th December (91 days); summer – 13th December to 23rd March (100 days). Differences in growth rate and energy intake for each of the periods between animals fed the concentrate ration and pasture-fed animals, for each of the sexes and within genotypes, were estimated using a residual maximum likelihood (REML) as implemented in Genstat 5 Version 4.1 (1993). Between group variation for pasture-fed animals, and concentrate-fed animals within years, was estimated to be zero, and the SE for pasture-fed and concentrate-fed animals are therefore taken to be the same. SED on table 1 refers to standard error of difference between the two genotypes.

Results

Experiment 1

Over the trial period E bucks, does and haviers fed concentrates grew at 54, 16 and 53g/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 fed concentrates, and pasture-fed deer. For bucks there was no difference between pasture and concentrate feeding, whereas haviers fed concentrates grew significantly faster ($p<0.01$) than pasture-fed deer, and does fed concentrates grew significantly slower ($p<0.01$) than pasture-fed deer. There was a significant genotype effect, and H deer fed concentrates and at pasture grew faster than E deer, for each of the three sex classes ($p<0.05$). Across all sexes, H deer grew 5g/day faster than their E counterparts. 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.

Rapid growth in spring for bucks and haviers between ten and twelve 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 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. Apart from the reduction 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 twelve and 21 months of age (Figure 1). 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.

Table 1: Mean liveweight gain (kg) and energy intake per $W^{0.75}$ (MJME/kg$^{0.75}$/day) for three sex types of European (E) and hybrid (H) fallow deer held individually in pens and fed concentrates over four seasons of the year (n=3 per group).

Sex	Season		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
	(MJME/kg $^{0.75}$/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
	(MJME/kg $^{0.75}$/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
	(MJME/kg $^{0.75}$/day)	H	0.89	0.81[b]	0.71	0.77
SED	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 ($p<0.01$)

Seasonal variations in energy intake, and the annual energy intake for each sex class, are shown in Table 2. These are contrasted with values for bucks and does that were interpolated (Asher, 1992) from seasonal predictions for red deer stags (Fennessy *et al*, 1981). The predicted values for fallow deer bucks were similar to that for bucks in this trial (1.3% difference). However, the values for does differed by over 30%. No similar data are available for comparison with haviers.

Table 2: Seasonal variation in energy intake (MJME/day) and feed conversion efficiency (FCE) for individually penned fallow deer of different sexes, from ten to 21 months of age. Data for European (E) and Hybrid (H) genotypes are represented (n=3 per group).

Sex of Animal		Mean liveweight at 10 months old (kg)	Spring	Summer	Autumn	Winter	Annual intake (365 days)	Mean liveweight at 21 months old (kg)	FCE
			MJME/day				MJME/head		
Bucks	E	33.0	14.5 (14.2)	14.3 (13.0)	12.1 (13.3)	13.4 (15.4)	5007 (5051)	51.8	293
	H	38.5	14.9	15.8	13.2	15.1	5559	60.8*	296
Does	E	26.5	8.8 (11.3)	9.3 (11.3)	10.1 (11.3)	7.1 (13.1)	3248 (4242)	32.2	603[a]
	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 deer (Asher, 1992) that were interpolated from the work of Fennessy *et al* (1981) for red deer stags.

* contains one deer that grew significantly faster (g/day) than all other deer in the trial.

FCE = feed intake (MJME) per kg liveweight gain.

a = does significantly lower FCE compared with bucks and haviers ($p<0.001$).

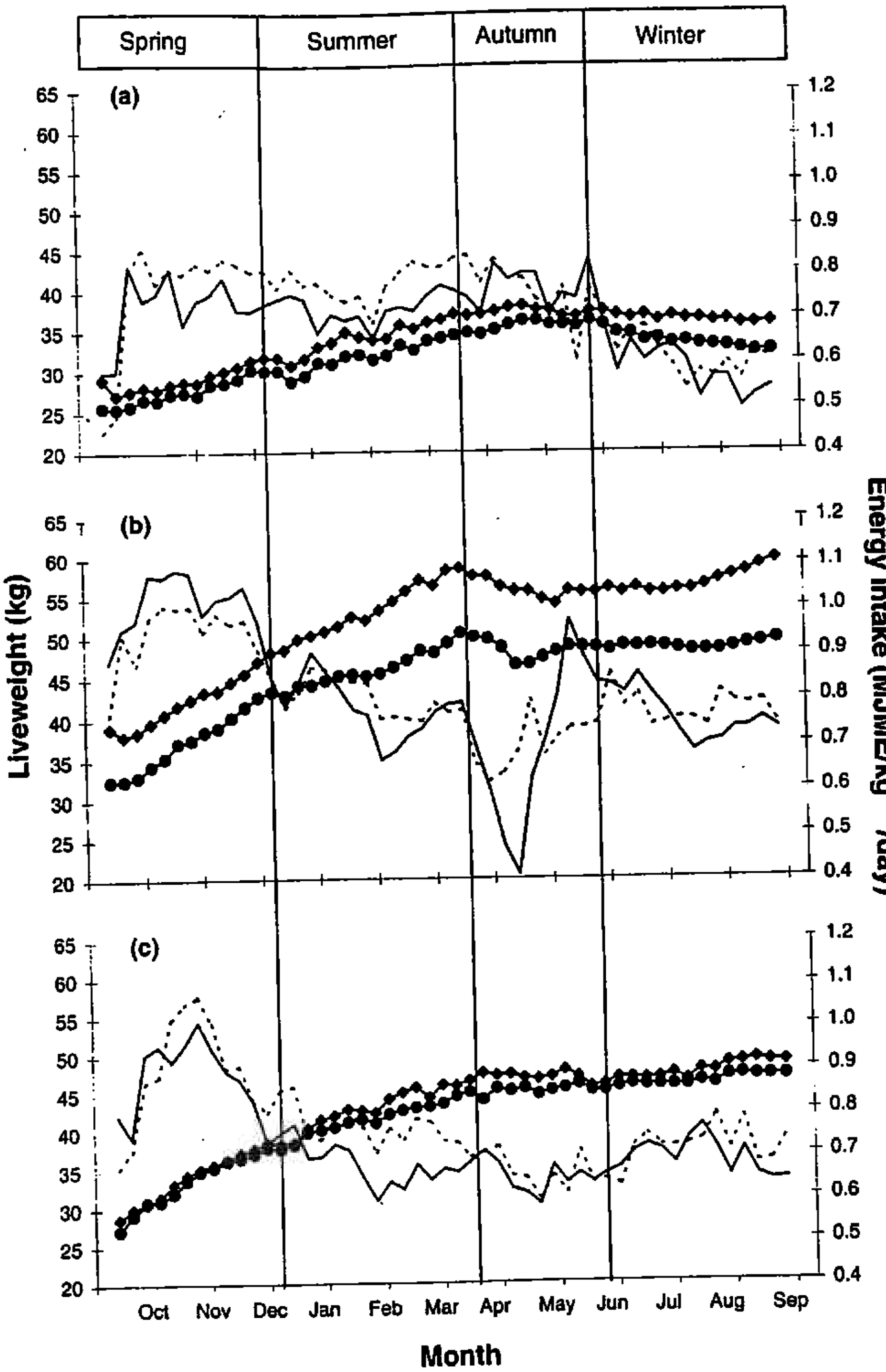

Figure 1: Mean live weights and energy intakes of individually penned (a) does, (b) bucks, (c) haviers of the European (E) and hybrid (H) genotypes of fallow deer over four seasons: live weight (kg) •E ✦H; Energy intake (MJME/Kg $W^{0.75}$/day): ________E; ---------------H.

Feed conversion efficiency (FCE) was highest 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 2).

Of the deer that were fed concentrates, H bucks reach slaughter liveweight (43 kg group average) at 11 months of age, which was 30 days sooner than their E counterparts. Hybrid 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.

The liveweight and standard carcass weight (HSCW) at 21 months old for H does and bucks were significantly higher than their E counterparts (Table 3) but their were no differences between the haviers of the two genotypes. Hybrid does also had a significantly higher dressing proportion that E does (P <0.01).

Table 3: Mean liveweight, hot standard carcass weight (HSCW) and dressing percentage (%) for concentrate-fed and pasture-fed European (E) and hybrid (H) fallow deer slaughtered at 21 months of age.

Sex of Animals		Group Size (n)	Liveweight (kg)	HSCW (kg)	Dressing Percentage (%)
Bucks	E	8	46.8	27.9	59.5
	H	8	53.4[a]	31.2[a]	59.5
	(SED)		(1.40)	(0.76)	(0.83)
Does	E	12	32.6	18.6	57.0
	H	12	37.2[b]	21.8[b]	59.0[b]
	(SED)		(1.08)	(0.71)	(0.47)
Haviers	E	12	42.6	25.0	58.7
	H	12	45.4	26.7	58.8
	(SED)		(1.40)	(0.85)	(0.43)

[a] = H significantly higher than E (P<0.05)
[b] = H significantly higher than E (P<0.01)

Experiment 2

In this experiment, growth of does from conception to fawning for E and H on pasture was 57g/day and 51g/day respectively, and 54g/day and 46g/day for E and H does fed concentrate ration, respectively. There was no significant difference in average daily weight gain or gross energy intake between genotype, or between animals fed concentrates or pasture. The voluntary metabolisable energy (ME) intake for E and H does was therefore combined (Figure 2).

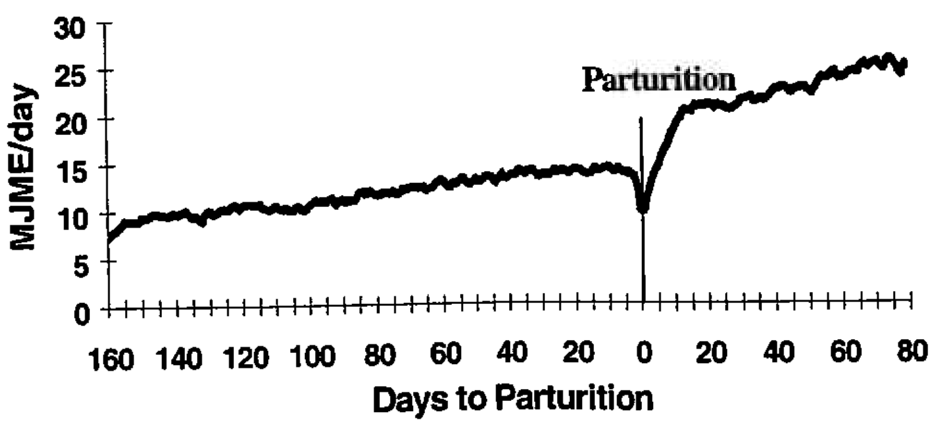

Figure 2: Average daily metabolisable energy intake for E and H fallow does (n = 24) from week ten of pregnancy to six weeks post-partum.

Experiment 3

There were no differences in fawn birthweight, six-week weights or twelve-week weights between the two genotypes being fed concentrates, or between deer fed pasture and deer fed concentrates, with average weights of fawns at these times being 5kg, 14kg and 22kg respectively.

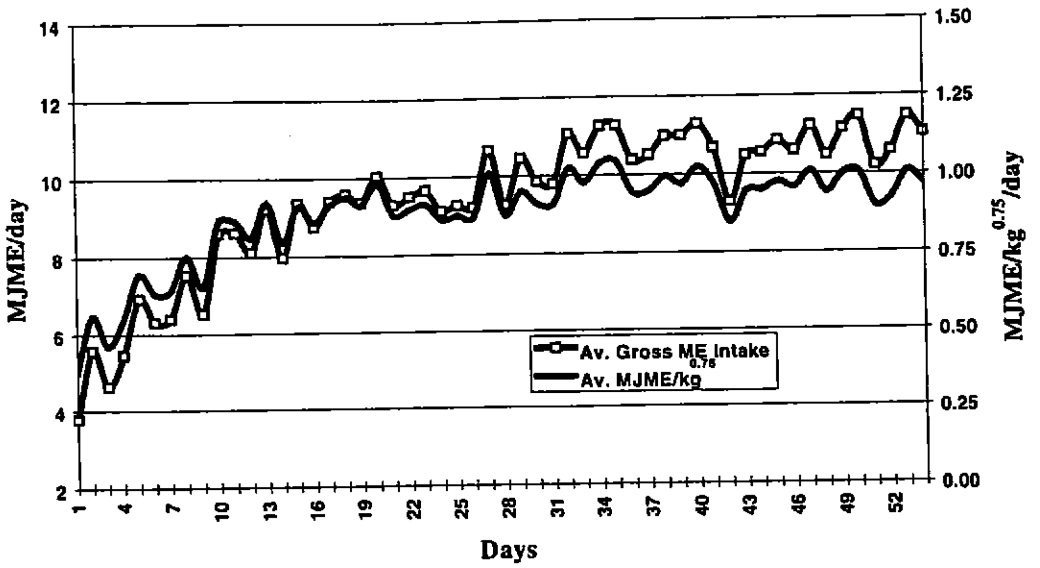

Figure 3: Mean daily metabolic boydweight energy intake (MJME/kg $^{0.75}$/day) and voluntary feed intake (MJME/day) for fallow deer fawns (n=10) between 12 and 20 weeks of age.

Discussion

In this study hybrid bucks, haviers and pasture-fed does 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 this 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 liveweights 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, 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 feed intake : weight gain ratio increased considerably for all sex classes of both genotypes after 15 months of age, indicating the need for slaughter as soon as animals reach the target liveweight to optimise feed 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 MJME/kg$^{0.75}$/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 $W^{0.75}$ between E and H bucks throughout autumn were not significant, and although the mean liveweight 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 liveweight of 10-12kg 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 $W^{0.75}$ 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, 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 (10-14 months of age) is equivalent to that of entire males providing adequate food for growth is available, and that the overlap in liveweight 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, 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 (5g/day) for the duration of the trial, and the significantly higher final liveweight and HSCW (Table 3) of does and bucks ($P<0.01$ and $P<0.05$, respectively) are indicators that heterosis may be contributing to the growth advantage, but the contribution is unknown.

The energy intakes per $W^{0.75}$ 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 (0.8-1.1 MJME/kg$^{0.75}$/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 MJME/kg$^{0.75}$/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 MJME/kg$^{0.75}$/day after 12 months of age. The intake for fallow deer in this study is between the estimates of the requirements for red deer stags fed indoors and outdoors in the South Island of New Zealand of 0.57 and 0.85 MJME/kg$^{0.75}$/day (Fennessy *et al.*, 1981) respectively. Estimates of requirements for fallow deer (Milligan, 1984, Adam, 1988, Asher, 1992) 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 feed intake during late autumn and winter despite the availability of high quality feed, and may require less feed than previously estimated to maintain energy balance at this time. This trend was evident in both concentrate-fed and pasture-fed animals 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 fell by 50%, 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 feed 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 feed intake associated with the cessation of negative growth immediately after the rut. These data demonstrate clearly the need to provide high quality feed to bucks immediately after the rut, to restore body reserves, and to quickly restore 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 $W^{0.75}$ 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).

Feed conversion efficiency was highest 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 VFI for does ranged between 0.5 and 0.65 MJME/kg$^{0.75}$/day throughout winter for both pregnant and non-pregnant stock. The daily energy intake (MJME) of does during the second and third trimesters of pregnancy and during lactation (10.1 ± 0.87, 13.2 ± 0.87, 21.8 ± 3.1 MJME/day respectively) established from the present study were lower than previous estimates for fallow deer (Milligan 1984, Asher 1992). These data indicate that the energy requirement during the first twelve weeks of lactation accounts for 60% (2856 MJME) of the annual ME requirement. These data also indicate the highly seasonal nutritional requirements for management of a breeding herd of fallow deer, a situation that requires particularly careful monitoring under Australian pastoral conditions, where seasonal rainfall is unreliable in most areas where deer are farmed.

The energy intakes of the larger and heavier hybrid does in this study were marginally lower than for their European counterparts, with 36% (1596 MJME) of their annual ME intake during the first twelve weeks of lactation, and 57% (2520 MJME) during the last trimester of pregnancy plus lactation. Based on these observations, the larger framed ¼ Mesopotamian fallow deer doe should be viewed favourably by fallow deer farmers, where feed utilisation efficiency and ease of fawning are major considerations for successful reproductive performance.

In experiment 3 there was no difference in growth rate between animals in each of the weaning groups, although males grew significantly ($p<0.05$) faster than females overall. Feed intake for weaner fallow deer was shown to be 10-11MJME/day, which equated to a metabolic bodyweight energy intake ($W^{0.75}$) of approximately 0.95 MJME/kg$^{0.75}$/day. All sex classes for both genotypes grew rapidly through spring and summer, but little growth occurred after 15 months of age. The high energy intake during spring corresponded with rapid growth, but the feed intake:weight gain ratio increased considerably for all sex classes of both genotypes after 15 months of age, indicating the need for slaughter as soon as animals reach the target liveweight, to optimise feed resource management on farms.

Data from this study indicate levels of feeding requirement for various age classes of stock on a commercial fallow deer farm. Furthermore, strategic feeding of fallow deer does, as suggested for red deer by Suttie *et al* (1996), should be implemented in the third trimester of pregnancy, and during lactation, if pasture conditions in late spring are unfavourable. The commercial importance of this data is that the supply of fresh venison of similar quality can be produced for longer periods of the year, and feed resource management can be optimised by using the known feed intake data for each sex class of fallow deer at various times throughout the year, to achieve target liveweights.

Acknowledgements

We wish to thank Mr Peter Johnstone for the statistical analysis. This work was funded by the Rural Industries Research and Development Corporation, and a University of Western Sydney Research Grant.

References

Adam, J.L. 1988. Growth. In *Progressive Fallow Farming*, (ed. P.L. Allen and G.W. Asher, MAF, Ruakura Agricultural Centre, Hamilton, New Zealand), pp 47-55.

Asher, G.W. 1985. Oestrous cycle and breeding season of farmed fallow deer (*Dama dama*). *Journal of Reproduction and Fertility*, **75**: 521-529.

Asher, G.W. 1986. Studies on the reproduction of farmed fallow deer (*Dama dama*). *PhD Thesis*, University of Canterbury, Lincoln College, New Zealand, pp

Asher, G.W. 1992. Growth and nutrition of fallow deer. *In Progressive Fallow Deer Farming*, 2nd edition, (ed. G.W. Asher and M. Langridge, Ruakura Agricultural Centre, Hamilton, New Zealand), pp 59-67.

Asher, G.W., Day, A.M. and Barrell, G.K. 1987. Annual cycle of liveweight and reproductive changes of farmed fallow deer (*Dama dama*) and the effect of daily oral administration of melatonin in summer on the attainment of seasonal fertility. *Journal of Reproduction and Fertility* **79**: 353-362.

Asher, G.W., Kraemer, D.C., Magyar, S.J., Brunner, M., Moerbe, R. And Giaquinto, M. 1990. Intrauterine insemination of farmed fallow deer (*Dama dama*) with frozen-thawed semen via laparoscopy. Theriogenology, **34**: 569-577.

Asher, G.W.; Morrow, C.J.; Jabbour, H.N.; Mulley, R.C.; Veldhuizen, F. and Langridge, M. 1992. Laparoscopic intrauterine insemination of farmed fallow deer (*Dama dama*) with frozen-thawed semen. *New Zealand Veterinary Journal* **40**: 8-14.

Asher, G.W.; Peterson, A.J. and Bass, J.J. 1989. Seasonal pattern of LH and testosterone secretion in adult male fallow deer, *Dama dama. Journal of Reproduction & Fertility* **85**: 657-665.

Fennessy, P.F. and Thompson, J.M. 1990. Hybridisation and biological efficiency for venison production in red deer. *Australian Deer Farming* **1(4)**: 34-35.

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.

Flesch, J.S., Mulley, R.C. and Asher G.W. 1998. Nutritional requirements of pregnant and lactating fallow deer of two genotypes. In *Proceedings 4th International Deer Biology Congress*, Pannon Agricultural University, Kaposvar, Hungary *(in press)*.

Genstat 5 Committee 1993. Genstat 5 Release 4.1 Reference Manual. Clarendon Press, Oxford.

Hogg, B.W. Mortimer, B.J. and Mercer, G.J.K. 1993. The influence of the Mesopotamian genotype on carcass quality and composition of fallow deer bucks. *Proceedings 1st World Forum on Fallow Deer Farming*. (ed. G.W. Asher, Ruakura Agricultural Centre, Hamilton, New Zealand), pp 191-196.

Hogg, B.W.; Catcheside, L.M. and Mercer, G.J.K. 1990. Carcass composition in male fallow deer: age and castration effects on dissected tissue distribution. *Animal Production* **51**: 405:413.

Jopson, N.B., Thompson, J.M. and Fennessy, P.F. 1993. Body compositional changes during fasting periods in fallow bucks. In *Proceedings First World Forum on Fallow Deer Farming*, (ed. G.W. Asher, Ruakura Agricultural Centre, Hamilton, New Zealand, pp 199-206.

Milligan, K.E. 1984. Deer nutrition - feed demands and how to meet them. In *Proceedings of a Deer Course for Veterinarians*, Number 1, Palmerston North, New Zealand. (ed. P.R. Wilson, Massey University), pp 46-58.

Mulley, R.C. 1989. Reproduction and performance of farmed fallow deer (*Dama dama*). *PhD thesis*, The University of Sydney, Sydney, NSW, Australia, pp 520.

Mulley, R.C. and English, A.W. 1985. The effects of castration of fallow deer (*Dama dama*) on body growth and venison production. *Animal Production* **41**: 359-361.

Mulley, R.C. and English, A.W. 1992. Evaluation of carcass composition changes to fallow bucks castrated pre-pubertally. In *The Biology of Deer*, (ed. R.D. Brown, Springer-Verlag, NY), pp 238-243.

Mulley, R.C., English, A.W., Thompson, J.M., Butterfield, R.M. and Martin, P. 1996. Growth and body composition of entire and castrated fallow bucks (*Dama dama*) treated with zeranol. *Animal Science* **63**: 159-165.

Oddy, V.H. (1978). Feed Requirements of Sheep and Cattle during Drought using a Metabolisable Energy System. AgBulletin 3, Department of Agriculture, NSW Australia. pp 1-31.

Pemberton, J.M. 1993. The genetics of fallow deer production. In *Proceedings 1st World Forum on Fallow Deer Farming*. (ed. G.W. Asher, Ruakura Agricultural Centre, Hamilton, New Zealand), pp 129-135.

Suttie, J.M. and Corson, I.D. 1991. Deer growth and production: a review. In *Proceedings of a Deer Course for Veterinarians*, No 8 (ed. P.R. Wilson, New Zealand Veterinary Association (Deer Branch), Massey University, Palmerston North, New Zealand Australia).

Suttie J.M., Webster, J.R. and Corson, I.D. (1996). In *Proceedings of a Deer Course for Veterinarians.* Number 13, Timaru, New Zealand (ed. P.R. Wilson, Massey University) pp 135-139.

Swan, A. 1992. Across-breed genetic evaluation. In Animal Breeding: The Modern Approach, (ed. K. Hammond, H-V. Graser and C.A. McDonald, Post-graduate Foundation in Veterinary Science, University of Sydney, Sydney, NSW, Australia.