ACTA THERIOLOGICA
Vol. 25, 33: 403—413, 1980

Consumption, Protein and Energy Intake of Fallow Deer Fawns on Diets of Differing Nutritional Quality

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Putman R. J., 1980: Consumption, protein and energy intake of fallow deer fawns on diets of differing nutritional quality. Acta theriol., 25, 33: 403—413 [With 5 Tables & 1 Figs.].

Dry matter consumption, protein and energy intake were measured for four fallow deer fawns, *Dama dama* (Linnaeus, 1758) of 5—8 months old on a series of diets of different nutritional quality. Mean daily dry matter consumption was found to be equivalent between the two sexes and to increase significantly with age of the fawns. Within this, dry matter intake increased still further when diet quality was reduced, such that gross protein intake remained constant at a value of between 31 and 34 g per day (2.35 g/kg$W^{0.75}$). Further reduction in diet quality resulted in a slightly decreased dry matter intake (although still significantly higher than consumption of controls) with a decrease in gross protein intake below this level; and a reduction in condition of the fawns. Increased quality of the diet had no significant effect on dry matter consumption, although, as a result of the higher percentage protein of the diet mix, mean daily protein intake increased to 40.27 g (3.02 g/kg$W^{0.75}$). Gross energy never appeared limiting and intake related purely to the amount of dry matter consumed and calorific value of the diet; however, levels of digestible energy may have been limiting and it is suggested that increased dry matter intake as dietary quality decreased may have been in an attempt to maintain a minimum required intake of digestible energy even on the poorer quality rations. Changes in dry matter intake in relation to forage quality are consistent with those reported by other authors and represent a compensatory mechanism to maintain nutritional intake on diets of varying digestibility.

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1. INTRODUCTION

Any scheme of wildlife management, whether derived for control, conservation or exploitation, must be based firmly on a clear understanding of the physiology, behaviour and ecology of the species to be managed. Together with knowledge of social organization, population dynamics, patterns of range use, habitat and food preferences, some knowledge of nutritional requirements and energy balance within the animal will form an integral part of this profile and a bank of information on the nutrient balance and the use and apportionment of consumed energy has been built up for many species. Thus the energy dynamics and nutritional requirements of white-tailed deer, *Odocoileus virginianus*, have been investigated by, for example, U l l r e y *et al.* (1967, 1969, 1970), A m m a n n *et al.* (1973), T h o m p s o n *et al.* (1973) and S m i t h *et al.* (1975); similar studies of red deer, *Cervus elaphus*, have been undertaken by B r o c k w a y & M a l o i y (1967), M a l o i y *et al.* (1968), K a y (1969), A r m a n n *et al.* (1975) while some data is also available on roe deer, *Capreolus capreolus*, (D r o ż d ż *et al.*, 1975) and pronghorn antelope, *Antilocapra americana* (W e s l e y *et al.*, 1970, 1973). Such considerations of energy utilisation and nutritional balance assume particular relevance when a species is being considered as a possible commercial proposition, to be exploited as an alternative to, or in complement to conventional domestic stock.

The present paper presents preliminary results for required consumption, energy and protein nitrogen intake of young Fallow deer, *Dama dama* as part of an investigation into the meat production potential of this species under exploitation.

2. METHODS

Four fallow deer fawns of approximately 5 months old were immobilised with tranquilliser darts in November 1977 and moved to experimental pens at the Hampshire College of Agriculture, Sparsholt, Winchester, Hampshire. Each fawn

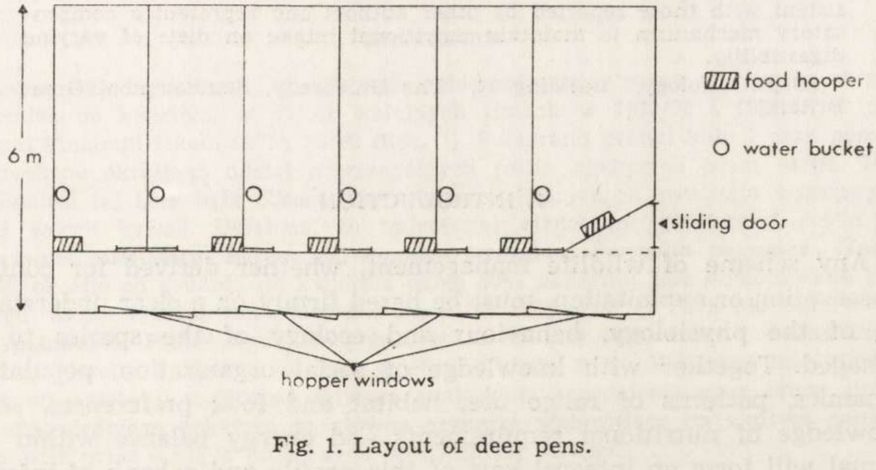

Fig. 1. Layout of deer pens.

was housed individually in 4.5 m × 2 m looseboxes within a 10 m × 6 m timbered animal house. Pens were constructed of 1/8" tempered hardboard on frames, to a height of 1.2 m, with 50 mm mesh, strained pignetting above to the full height of 2.25 m. Each loosebox opened with a 0.6 m door in one end onto a windowed corridor (Fig. 1). The animal house was open to the outside air through hoppered windows; overhead fans operated by thermostatic switches ensured that temperatures in the animal house remained equivalent to external air temperatures throughout the experiment. Artificial light to supplement the daylight entering the house was controlled by a time-clock and followed natural daylight patterns.

Each pen was littered with a 40—50 mm depth of oak sawdust as bedding, and furnished with a waterbucket and food through at the end by the door. Food hoppers were made of plywood, 450 mm × 25 mm and 25 mm deep, and each hopper was positioned on a plywood tray 600 mm × 600 mm to catch spillage. Each morning a bucket of fresh water was exchanged for the bucket of the previous day, the spilled food collected from the tray and, together with any unused food remaining in the hopper, removed from the pen. A weighed amount of fresh food in a clean hopper was replaced on the tray and the previous day's wastage and spillage weighed and discarded. Pens were cleaned out and fresh sawdust scattered once every two weeks.

Food provided consisted of a mixture of chopped wheat straw and cereals. In periods before and between feeding trials this was supplemented with *ad lib* hay and cut browse. The wheat straw used in compounding the diet mix had been chopped and shredded to a loose mass of fibres with particle length approximately 10 mm. This was added as bulk to a cereal mixture composed of equal proportions of whole oats, rolled oats, flaked maize and bran. Diet mixes were developed as a series of mixtures of chopped wheat straw and cereal mix in different proportions to provide a range of similar diets of different nutritional quality. Four different mixtures were compounded: a »control mix«, by weight 55% straw, 45% cereals; a »high concentrate« mix, 40% straw, 60% cereal; »low concentrate«, 70% straw, 30% cereal; and »extra-low«, 75% straw, 25% cereal. Regular samples of these mixtures were taken for analysis of crude fibre content, organic matter, protein nitrogen and calorific value.

After arrival, the fawns were given six weeks to settle and to adjust to the daily routine. Throughout this period they were fed on a free diet of hay, cut browse and the »control« mix of straw and cereals. After this initial period, hay and browse were withdrawn for 14 days as a pre-trial preparation. The fawns, two male, two female, were then paired for experimental treatments. While one pair (pair B) remained on the control diet, one male and one female (pair A) were fed only the »low concentrate« mix. After a trial of 21 days, pair A were returned to a control diet while pair B were fed the »high concentrate« mixture. This pattern of alternating controls continued throughout the trial period so that no pair was exposed to two different experimental diets in succession and every experimental trial was paired with a control run (Table 1). The alternation of controls also ensured that allowances could be made for changes in dietary intake with growth of the fawns. Further, results for any experimental trial could be related to a control on the same animal measured immediately before and immediately after the trial period.

Daily weighings of food offered, food wasted or spilled were continued throughout, but in analysis only those data derived after the deer had had three days to adjust to the new diet have been used. While, during trials, the straw/cereal mixture was the only food offered, free access to water was given throughout.

From these trials, figures may be derived for required gross consumption (as dry matter intake) of the diets of different nutritional quality. Chemical analysis

Table 1
Sequence of feeding trials and kinds of diets is being shown.

Pair A	Pair B	Number of Days
Control	Control	14
Low Concentrate	Control	21
Control	High Concentrate	21
Extra low	Control	14
Control	Control	14

of the food mixes permits derivation of crude fibre proportion of the diets and actual organic matter, protein and energy consumption by the fawns. Crude fibre analysis followed the method of Allen (1974) with samples boiled successively in 1.25% w/v sulphuric acid and 1.25% w/v sodium hydroxide, after an initial pre-extraction with ether in a Sohxlet apparatus. Nitrogen content of feeds were analysed by modified Kjeldahl extraction and protein estimated as 6.25 × nitrogen contained. Pellets of oven-dried foodstuffs were burnt in a Gallenkamp Adiabatic bomb calorimeter, calibrated to 10.76 kjoules deg C^{-1} (standard error: 0.047) to determine calorific content. Ash residues from these samples were treated overnight in a muffle furnace at 600°C, weighed, and used to estimate, by difference, the percentage organic matter content of the original sample. In each case, at least six determinations were made for each food material.

The fawns were released in April 1978.

3. RESULTS

The compositions of the various diet mixes with respect to crude fibre, percent organic matter, percent protein and gross calorific value are presented in Table 2. While calorific value and organic matter content do not differ significantly between the different diets, percent crude fibre increased steadily and percent protein decreased with decreasing diet »quality«.

Table 2
Composition of diet mixtures.

Diet	Dietary Component			
	Percent Crude Fibre	Percent Organic Matter	Percent Protein	kJ/g
High Concentrate	21.33±0.97	97.82±0.28	7.33±0.47	16.97±0.07
Control	26.85±1.14	97.50±0.35	6.37±0.41	16.87±0.07
Low Concentrate	32.37±1.31	97.20±0.41	5.41±0.36	16.78±0.08
Extra Low	34.21±1.37	97.10±0.44	5.10±0.34	16.75±0.08

Figures are presented as means of six trials ± standard errors.

Food intake on the different dietary regimes did not at any time differ significantly between the sexes or indeed between individual fawns. Results may therefore be presented, where appropriate, as mean values. However, as anticipated, there was a significant increase in total intake (as measured on the »control« diet) with increasing age, both within individuals and in the overall means. Mean daily intake increased from 479.93 g dry matter (s.e. 11.36) over the first two control periods of the experiment to 522.62 g dry matter (s.e. 12.39) over the last two weeks on control diets some seven weeks later (Table 3; difference significant: $p=0.01$). For further analyses therefore, where performance on diets of different quality is to be compared against performance on control diets, results for individual animals are compared against mean daily intake for that same animal in the control periods immediately preceding and immediately following the »experimental« trial, while means derived for a pair of animals are compared against a mean intake calculated for the paired control over the same time period. Table 4 shows overall means for total dry matter intake per day on the different diet mixtures, by reference to these paired controls, and a breakdown of the intake of the various dietary constituents.

Table 3
Changes in consumption with age.

Figures are presented as mean ± standard error. All calculations are for fawns on control diet only.

Age in Weeks	Diet	Mean daily consumption			
		Dry matter, g	Organic matter, g	Protein, g	kilojoules
33—35	Control	479.73±11.36	467.74±11.09	30.56±0.95	8094.48±192.01
40—42	Control	522.62±12.39	509.55±12.06	33.30±1.06	8818.17±209.47

In summary, these figures show a significant increase in dry matter intake per day on the low concentrate mixtures (»low« and »extra low«) by reference to the control ($p=0.01$), although total intake on the »extra low« ration is less that that on the »low« diet ($p=0.09$) rather than being still higher as might have been expected. Dry matter consumption on the »high concentrate« mixture remained equal to the intake of controls.

Increased dry matter intake on the »low concentrate« diet results in the gross protein gain from this ration remaining much the same as on the control diet. Lack of any further increase in dry matter consumption on the »extra low« ration leads to a reduction in protein intake below this level. It should be noted that subjective impressions of the general condition of the deer suggested that this deteriorated during their period on the »extra low« diet and that therefore this plane of nutrition was too poor to sustain the animals in good order; a minimum daily protein requirement of between 31 and 34 g (mean over all controls 31.8 g) is thus postulated. Dry matter consumption on the »high concentrate« mixture remained equivalent to that of controls. Due to the higher quality of the diet, mean daily protein intake increased (40.27 g against 34.6 g for paired controls).

All differences noted here are confirmed by analysis of results within individual animals. That is, mean daily consumption of dry matter increases significantly on the »low concentrate« diet by comparison to the control, while protein intake remains the same on the two diets.

Table 4
Changes in consumption with food quality.
Figures are means ± standard error.

Diet	Mean daily consumption			
	Dry matter, g	Organic matter, g	Protein, g	kilojoules
High Concentrate	549.33±13.02	537.35±12.75	40.27±1.37	9321.03±221.38
Paired Control	543.87±12.89	530.27±12.59	34.64±1.11	9176.72±217.93
Low Concentrate	582.74±13.81	566.42±13.46	31.55±1.09	9777.79±232.52
Paired Control	527.35±12.50	514.17±12.21	33.59±1.21	8897.98±211.58
Extra-low Concentrate	550.61±13.05	534.64±12.72	28.08±0.98	9221.06±188.55
Paired Control	488.36±11.72	476.15±11.45	31.11±1.19	8240.10±198.49

Mean daily dry matter consumption on the »extra low« ration decreases by comparison to intake on the »low« diet, but is still significantly greater than under control conditions. Consumption on the »high concentrate« diet is, in this case, slightly, but not significantly higher than on the control diet, but significantly lower ($p=0.01$) than intake on either »low concentrate« mixture.

Throughout, intake of total organic matter clearly relates solely to bulk dry matter intake, increasing and decreasing as a direct result of changes in dry matter consumption; similarly gross calorific intake changes only in response to changes in overall dry matter consumption and diet quality *per se*. However, while gross energy intake shows no clear relationship with dietary quality, actual digestible energy may be limiting in the poorer quality — increasingly fibrous and indigestible — diet mixes. Protein content of the diet is for the most part contributed by the cereal component; thus protein availability will be loosely correlated with digestible energy content of the diets. Increased dry matter intake with decreasing diet quality, while maintaining protein gain at a constant level, may thus also be maintaining a constant minimum intake of digestible energy. In the same way, loss of condition of the animals on the »extra low« ration may be related not only to a reduced protein intake, but also to a reduced intake of digestible energy.

4. DISCUSSION

Dry matter intake by the fawns increased significantly as dietary quality decreased. Beyond a certain limit however, further decrease in dietary quality not only did not result in any further increase in dry matter consumption, but was accompanied by a decrease in dry matter intake. Increased consumption of dry matter on the »low concentrate« diet was sufficient to maintain protein intake at a level comparable to that of control animals. When protein intake fell below this level — for animals on the »extra low« ration — condition of the fawns deteriorated. These observations suggest that, over a certain range of dietary quality, the animals are able to maintain a constant level of nutrition, compensating for reduced quality of their food — whether in protein or digestible energy — by increased dry matter intake; beyond a certain limit, however, no further compensation in this way is possible and dry matter intake actually decreases.

Such compensation for changing forage quality is well-established amongst domestic ruminants (*e.g.*, Blaxter *et al.* 1961, Conrad *et al.* 1964). These present results, as those of Ammann *et al* (1973) for white-tailed deer, show that this same ability is found in wild species — and illustrate very clearly the two distinct stages of this adjustment mechanism as modelled by Montgomery & Baumgardt (1965). Thus on diets of reasonably high digestibility, consumption of dry matter increases as forage quality/digestibility decreases, establishing a negative correlation between dry matter intake and dietary quality. Increased dry matter intake as noted here, ensures that the net gain of protein and digestible energy remain equal to that required. As digestibility further decreases, a point is reached where the animal is eating to the maximum capacity of the digestive system. Beyond this point the limits of digestive tract fill prevent further increase in dry matter intake. Some further compensation is possible however, and as digestibility of feed decreases further, the rate of passage of food through the gut declines: the effect is thus decreased intake for each decrease in digestibility. With decreasing dietary quality, dry matter intake at first increases and then declines — exactly as observed in the present study.

Actual values presented here for overall dry matter, energy and protein consumption of Fallow fawns may be compared with those reported for consumption by other species. Using Dansie's (1977) figures for the average weight of Fallow fawns at 5—6 months of age to give an overall mean weight of 31.6 kg (n=16), results presented here may be standardised as per kg metabolic body weight ($W^{0.75}$) and these figures (Table 5) compared with published data for other species. (It is accepted that such an adjustment, using a mean weight from published material, is somewhat crude; regrettably, however, it was not possible to weigh individually the animals of the present experiments.) Results for total dry matter and calorific intake calculated

Table 5

Daily consumption per kg. metabolic body weight.

Results (Mean ± Standard error) are presented per kg $W^{0.75}$. Mean body weight taken as 31.6 kg — see text.

Diet	Mean daily consumption per $kgW^{0.75}$			
	Dry matter, g	Organic matter, g	Protein, g	kilojoules
High Concentrate	41.22±0.98	40.32±0.96	3.02±0.10	699.36±16.61
Control Overall	37.48±0.89	36.54±0.87	2.35±0.07	632.37±15.00
Low Concentrate	43.72±1.04	42.50±1.01	2.38±0.08	733.63±17.44
Extra Low	41.31±0.98	40.11±0.95	2.10±0.07	691.85±14.14

in this way compare well with those for pronghorn antelope of equivalent age and assumed metabolic weight. Wesley *et al.* (1973) quote a mean daily dry matter intake for pronghorns at 7.5 months of age of 44.47 g/kg $W^{0.75}$: calorific equivalent 181 kcal (757.85 kjoules). Data presented by Thompson *et al.* (1973) for white-tailed deer fawns are also comparable in terms of dry matter intake. Although the overall mean value quoted (53.6 g/kg$W^{0.75}$/day) is higher than that obtained in the present study, if figures are taken only for fawns between 6—8 months (that is of equivalent age and, with a mean body weight of 33.9 kg, equivalent also in body weight to the fallow fawns of this study), a new mean daily intake may be calculated as 42.8 g/kg$W^{0.75}$. Figures for gross energy intake reported by Thompson *et al.* are somewhat higher, at 2551.5 kcal (10683.0 kJ) per day, equivalent to 761.83 kJ/$W^{0.75}$; however, actual digestible energy in each case is unknown.

Comparisons with published results for other species are more difficult with respect to protein intake, since, throughout all diets offered in these parallel experiments were far higher in protein content than those used in the present trials. Thus for white-tailed deer on a diet containing 16.8% protein, Thompson *et al.* (1973) present figures representing a mean daily nitrogen intake for fawns of 6—8 months of age of 16.5 g/kg$W^{0.75}$ — equivalent to 100 g protein. Smith *et al.* (1975), using a diet containing 10.7% crude protein for their fawns, quote a minimum daily nitrogen intake of 1.7 g/kg$W^{0.75}$, equivalent to 12.4 g protein, and still a factor of four times as much as the required protein intake of healthy fallow fawns. However, one of the experimental diets offered to three-year-old red deer hinds by Maloiy *et al.* (1968) contained only 0.84 g N per 100 g: equal to 5.25% protein and therefore approximating to the levels of crude protein present in the »control« and »low concentrate« diets of this study. An intake of 1200 g food daily offered the hinds a daily protein intake of 63 g, or 3.1 g/kg$W^{0.75}$. This level was »sufficient to allow the animals to maintain their body weight over the experimental period« and compares favourably with the minimum daily protein requirement of fallow fawns suggested here of c. 2.35 g/kg$W^{0.75}$. McEwen *et al.* (1957) also report restricted protein intake (of some 50 g protein per day) being tolerated by adult white-tailed deer over the winter months without apparent stress. It should be remembered, however, that the actual amounts of protein absorbed by an animal from its food depend on a variety of other factors in the diet.

In conclusion, in the present experiments with fallow deer, mean daily dry matter consumption was found to be equivalent between the two sexes and to increase significantly with age of the fawns ($p=0.01$). Within this, dry matter intake increased still further if diet quality was reduced, such that gross protein intake remained constant at a value of between 31 and 34 g per day (2.35 g/kg$W^{0.75}$). Further reduction in diet quality resulted in a slightly decreased dry matter intake (although still significantly higher than consumption of the »control« mixture) with a decrease in gross protein intake and a loss of condition of the animals. Increased quality of the diet had no significant effect on dry matter consumption although, as a result of the higher percentage protein of the diet mix, mean daily protein intake increased to 40.27 g (3.02 g/kg$W^{0.75}$). Gross energy never appeared limiting, and intake related purely to the amount of dry matter consumed and the calorific value of the diet. However, levels of digestible energy may have been limiting, and it is suggested that the increased dry matter intake on lower quality diets may have been in an attempt to maintain a minimum required intake of digestible energy from these poorer quality rations.

Acknowledgements: My thanks are due to the Principal of the Hampshire College of Agriculture for agreeing to cooperate on this programme and for providing facilities, and to Mr. John Collins and Mr. Bill Mariner and various students of the College for occasional assistance with the day to day running of the experiments. I would thank also Mr. Kenneth MacDiarmid for providing me with the deer for these trials. The programme was supported by the Department of Biology at Southampton University. Mr. R. C. Cornick assisted with analysis of diet materials.

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Accepted, May 15, 1980.

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ZAPOTRZEBOWANIE POKARMOWE I POBIERANIE BIAŁKA U CIELĄT DANIELI PRZY RÓŻNYCH POZIOMACH ŻYWIENIA

Streszczenie

Obiektem badań były 4 cielęta danieli w wieku 4—8 miesięcy. Mierzono u nich zjadanie suchej masy oraz pobieranie białka i energii w pokarmach o różnej wartości odżywczej (Tabele 1, 2). Różną wartość pokarmową paszy uzyskiwano przez zmianę stosunku ciętej słomy i jęczmienia w dawce. Średnia dobowa konsumpcja suchej masy była równa u obu płci i wzrastała istotnie z wiekiem cieląt (Tabela 3). Pobranie suchej masy wzrastało również wtedy gdy jakość paszy obniżała się a ilość pobranego białka pozostawała stała i wynosiła od 31 do 34 g/dobę (2,35 g/kg$W^{0,75}$) (Tabela 4). Dalsze obniżanie jakości paszy powodowało lekki spadek pobrania suchej masy, chociaż było ono jeszcze istotnie wyższe niż u zwierząt kontrolnych. Równocześnie ilość pobranego białka, spadała poniżej ustalonego poziomu i obniżała się kondycja zwierząt (Tabela 5). Podniesienie jakości diety nie miało istotnego wpływu na konsumpcję suchej masy, jednakże w wyniku wyższej zawartości białka w paszy mieszanej, średnie dobowe pobranie białka wzrastało do 40,27 g (3,02 g/kg$W^{0,75}$). Całkowita energia paszy nigdy nie była czynnikiem ograniczającym a energia pobrana zależała od ilości konsumowanej suchej masy i wartości kalorycznej diety. Zmiany w pobieraniu suchej masy związane z jakością karmy są porównywalne z odpowiednimi danymi innych autorów.