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THE DIGESTION OF LUCERNE CHAFF BY CAPE BARREN GEESE, *CEREOPSIS NOVAEHOLLANDIAE* LATHAM

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Summary

The digestibility of lucerne chaff by Cape Barren geese was investigated by means of digestibility trials with six birds caged individually.

The geese were found to have large intakes (mean daily dry matter intake 113·9 g/kg of metabolic body weight) but had a very rapid rate of passage (mean retention time 1·3 hr) and digested only 25·8% of the dry matter of the lucerne. Crude protein was well digested (76·4%) but fibre was not significantly digested (0·8% digestibility).

I. Introduction

There is relatively little known about the nutrition of birds (Sturkie 1965), including geese (Kear 1966). Most avian work has been carried out on the chicken which is not closely related to geese, nor similar in its feeding habits.

There has been some work on digestion in geese, though little of it in recent years and practically all with domestic geese derived from the northern-hemisphere genus *Anser*. In these investigations most of the food offered has been cereal grain or roots. The work has usually been carried out with small numbers of birds. In most cases the emphasis has been on whether or not geese digest crude fibre, but the results have been conflicting (e.g. Brüggemann 1931; Olsson 1950; Nehring and Nerge 1966).

The Cape Barren goose, *Cereopsis novaehollandiae* Latham, is an exclusively grazing bird, feeding on the islands off southern Australia and the adjacent mainland. It is not one of the true geese though superficially similar in its grazing habit. The work of Marriott (1970) on its daily food intake, using chaffed lucerne hay, showed a high intake compared with mammalian herbivores. This finding led to the present investigation of the digestibilities of the components of the food.

II. Methods

Six Cape Barren geese were used in the experiment, three males and three females. Their ages ranged from 15 months to about 5 yr, i.e. all were adult or subadult birds. They were all from the stock colony at Monash University and had been reared in captivity. The geese were housed in individual metabolism cages each 180 by 90 by 180 cm high, allowing the birds freedom

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of movement, and fitted with a moveable tray beneath the 2·5-cm wire mesh floor to permit collection of droppings. Feed tins and water buckets were placed inside the cages as the birds ate tidily without spillage.

The experimental diet was commercial-quality dried lucerne, chaffed through a 1-cm screen on a hammer mill. This small particle size was found to be suitable for the birds, because of their relatively small bills, and it was eaten with very little selection. The diet contained 89·1% dry matter, with the following proximate chemical composition: ash, 7·61%; ether extract, 3·17%; crude protein, 18·98%; fibre, 34·40%; soluble carbohydrate, 35·84% [soluble carbohydrate = dry matter − (ash+crude protein+crude fibre+ether extract)]. Lucerne was chosen for the experimental diet as it approximated to the goose's normal diet of pasture and it allowed direct comparison with mammalian herbivores such as sheep.

The birds were fed the experimental diet in holding pens for 2–4 weeks prior to the trials, until they were thoroughly accustomed to it and eating well. They were then transferred to the metabolism cages. There were two experimental periods with three birds tested in each. These experimental periods consisted of a preliminary period of 11–19 days to ensure that the birds were well settled in the metabolism cages, followed by a 4-day collection period for estimation of digestibilities and nitrogen balance. Rations for each bird were weighed out in daily portions at the beginning of each collection period in amounts based on the *ad libitum* intakes determined in the preliminary period. Samples of the feed offered were retained at the same time for analysis. The geese were fed at 8.30 a.m. each day throughout the experiment.

During the collection periods, food residues and droppings were collected daily and weighed. They were subsampled by "quartering" and dried for 72 hr at 70°C in a convection oven, to determine their dry matter content. The dry matter of the samples of feed offered was similarly determined. The intakes for each day were related to the droppings collections for the same day, i.e. no lag period was allowed, as is usual in sheep experiments, since preliminary investigations had indicated a very fast rate of passage, in a few hours. The dried samples were then bulked in 2-day subperiods, ground, and analysed for proximate constituents. Ash, ether extract, and moisture were determined by the methods of the Association of Official Agricultural Chemists (1960) and nitrogen by Kjeldahl determination after partition of the droppings nitrogen into faecal and urinary fractions by the method of Ekman (1948). Fibre was determined by the method of Van Soest (1963) which measures cellulose plus lignin. "Soluble carbohydrate" was determined by subtraction of ash, ether extract, crude protein, and fibre percentages from 100% dry matter. In addition to soluble sugars and starches, this fraction includes the relatively insoluble hemicelluloses. It corresponds approximately to the nitrogen-free extract of earlier proximate analyses, but contains no lignin.

Rate of passage of the diet through the gut was measured by the method of feeding a small portion of dyed lucerne as a marker and following its subsequent excretion in the droppings. The lucerne was dyed by the method of Castle (1956), with brilliant green as dye, because the geese have a marked colour preference for green. In the 20 min during which the dyed feed was offered, the geese ate on average 0·6% of their normal daily intake (excluding bird No. 5 which would not eat the marker at all). Droppings were collected and weighed at hourly intervals for 8 hr (the last coloured particles usually appeared at 6 hr) and, after thorough mixing, 5-g subsamples from each collection were weighed into a Petri dish, suspended in water, and the coloured particles counted. When the concentration of coloured particles was high, five subsamples of 1 g each were counted. This was found to be a suitable counting method as the mean particle size in goose droppings is quite large compared with that in, for example, sheep faeces. The total numbers of coloured particles were then calculated, cumulative totals as percentages plotted against time (taking the removal of the dyed feed as zero time) and mean retention times calculated (Castle 1956).

The rate-of-passage measurements were carried out on the day before the collection period with the first three geese, but had to be repeated 10 days after the collection with the others, as they would not eat the dyed lucerne at the first attempt.

The birds were weighed on the first and last days of the collection periods at the same time of day on each occasion.

III. Results

Dry matter intakes and digestibilities are shown in Table 1. The birds all digested the dry matter of the diet to a similar extent, but their intakes varied widely, so that their digestible dry matter intakes varied also. There was no pattern apparent in this variation. The weights of the birds at the beginning of the collection period are also shown in Table 1. All the birds maintained their weights and some increased slightly, but it was difficult to measure the changes with sufficient accuracy over the short period, as the geese often void their gut contents in a fright reaction when handled for weighing. The reaction is immediate and of short duration, and feed intakes were never affected. Two other Cape Barren geese were maintained on the dried lucerne diet by the authors for 4 months without loss of weight.

Table 1

SEX, WEIGHTS, DRY MATTER INTAKES, AND DRY MATTER DIGESTIBILITIES IN CAPE BARREN GEESE FED LUCERNE CHAFF

Goose No.	Sex	Initial Weight (kg)	Daily D.M.* Intake (g/kg $W^{0\cdot74}$†)	D.M. Digestibility (%)	Daily Digestible D.M. Intake (g/kg $W^{0\cdot74}$)
1	Female	4·15	52·7	28·0	14·7
2	Male	4·30	150·9	26·4	39·8
3	Female	2·75	179·3	26·1	46·8
4	Male	3·95	92·6	25·5	23·6
5	Female	3·20	99·1	22·4	22·2
6	Male	3·70	108·7	26·5	28·8
Mean			113·9	25·8	29·3

* D.M., dry matter.

† $W^{0\cdot74}$, metabolic body weight. 0·74 is the power of body weight calculated by King and Farner (1961) to give the most accurate prediction of metabolic body weight for birds weighing more than about 0·1 kg.

Table 2

APPARENT DIGESTIBILITIES OF ORGANIC MATTER, ETHER EXTRACT, CRUDE PROTEIN, FIBRE, AND SOLUBLE CARBOHYDRATE BY CAPE BARREN GEESE FED LUCERNE CHAFF

Goose No.	Digestibility (%)				
	Organic Matter	Ether Extract	Crude Protein	Fibre	Soluble Carbohydrate
1	30·0	32·5	76·0	5·8	53·6
2	27·8	22·5	77·5	0·7	55·9
3	27·8	33·0	77·3	1·8	51·7
4	27·7	25·1	76·7	−3·2	64·1
5	24·6	18·4	75·3	−0·3	53·2
6	28·7	26·3	75·4	0·2	60·9
Mean	27·8	26·3	76·4	0·8	56·6

Apparent digestibility coefficients for organic matter, ether extract, crude protein, fibre, and soluble carbohydrate are given in Table 2. Organic matter digestibility was only slightly higher than dry matter digestibility, as the organic matter of the diet was little different from the dry matter.

TABLE 3

NITROGEN BALANCES OF CAPE BARREN GEESE FED LUCERNE CHAFF

Goose No.	Daily N Intake (g/kg $W^{0\cdot74}$*)	Daily Faecal N (g/kg $W^{0\cdot74}$)	Daily Urinary N (g/kg $W^{0\cdot74}$)	Daily N Balance (g/kg $W^{0\cdot74}$)
1	1·43	0·34	0·69	+0·39
2	4·47	1·01	2·42	+1·05
3	5·28	1·20	2·62	+1·45
4	2·82	0·66	1·60	+0·57
5	3·13	0·77	1·87	+0·47
6	3·33	0·82	1·79	+0·72
Mean	3·41	0·80	1·83	+0·78

* For explanation, see Table 1.

Protein was well digested by all the geese. Fibre was not digested, the mean digestibility for fibre being only 0·8%. Variations in ether extract digestibility appeared to be related to variations in fibre digestibility, as the geese which had positive fibre digestibility coefficients also digested ether extract better.

Nitrogen balance results are shown in Table 3. All six geese were in positive nitrogen balance, and the highest values were associated with the highest intakes.

TABLE 4

MEAN RETENTION AND 90% EXCRETION TIMES FOR CAPE BARREN GEESE FED LUCERNE CHAFF

Goose No.	Mean Retention Time (hr)	90% Excretion Time (hr)
1	1·51	1·95
2	0·77	2·10
3	1·34	2·65
4	1·63	2·20
5	—*	—
6	1·27	1·90
Mean	1·30	2·16

* Goose No. 5 would not eat the dyed lucerne.

Results of the rate-of-passage measurements are given in Table 4. In all cases the rate of passage was very fast with the bulk of the coloured particles being voided in one or two droppings during 2 hr. The average value for mean retention time was 1·30 hr and for 90% excretion time (when most of the dyed feed had passed through the gut) 2·16 hr.

IV. Discussion

The inability of the geese to digest fibre was clearly an important factor in determining the digestibility of the diet as a whole, as the lucerne had a high fibre content. Geese possess paired caeca at the end of the hind gut and Mangold (1934) considered their presence and the evil-smelling nature of their contents as evidence that crude fibre digestion might well occur in geese, but experimental results have not generally confirmed this. Weiser and Zeitscheck (1902) quote Weiske as being the first to point out the indigestibility of crude fibre for geese and give values of less than 1% in their own experiments. Brüggeman (1931) found no digestion of crude fibre by geese fed with wheat and barley although he found 14·1% digestibility with oats and 22·6% with maize. Olsson (1950) obtained negative values for crude fibre with a variety of feeds including young grass and clover, cereals, and carrots, but Pres, Ruszczyc, and Curlanis (1957) found geese could digest 16·1% of the fibre of carrots. Nehring and Nerge (1966) found crude fibre digestibility by geese varied from negative values (rye) to 33·5% (maize) for different feedstuffs including cereals, legumes, roots, and protein concentrates. Much of this variation can be attributed to differences in the fibre content of the various feeds and to differences in the structural and chemical composition of the cell wall (Mangold 1934).

Poor digestion of fibre is characteristic of poultry generally, and although hens have been found to digest moderate amounts of the fibre of some diets (e.g. Brüggemann 1931; Olsson 1950) they have as poor digestibilities as geese on high-fibre diets. Olsson (1950) found hens digested on average 8·1% of the fibre of lucerne meal (fibre content 19·4% of dry matter), with a wide range of individual values overlapping with the values obtained for Cape Barren geese in this experiment. In experiments comparing hens and geese on the same diets (wheat bran with ground oats, and barley) he found negative fibre values for both species, although the hens digested a slightly higher percentage of the organic matter of both diets. He obtained a mean organic matter digestibility of 40·9% for hens on the 19·4%-fibre lucerne meal, while for the high-fibre lucerne chaff used in the present experiment (fibre 34·4% of dry matter) the geese averaged 27·8% organic matter digestibility. Nehring and Nerge (1966) found that for domestic geese, fibre content of the feed (x) was closely related to digestibility of organic matter (y) by the regression $y = 85 \cdot 5 - 1 \cdot 72x$; the 27·8% organic matter digestibility obtained here with Cape Barren geese for feed of 34·4% fibre content fits this regression well.

The very rapid rate of passage of ingesta limits the extent of fibre digestion, as microbial fermentation of cellulose is a lengthy process, although it is possible that some of the digesta could be diverted into the caeca for longer periods from time to time and undergo limited fermentation there. Microbial decomposition of cellulose has been shown to occur in the caeca of several species of grouse (Suomalainen and Arhimo 1945) and could occur in geese also.

Earlier workers, using dyed material or charcoal as marker, have given various estimates of rate of passage in geese. Brüggemann (1931) quotes Weiske's value of 3·75 hr for the first appearance of the marker, and Groebbels' (1930) value of 4 hr, (though the latter stated that an entire "meal" may take 17 hr). Dorożyńska (1963) gave figures ranging from 1 hr 16 min to 4 hr 30 min for older and younger birds respectively, fed a "green" diet. Ranwell and Downing (1959) found that food passed through a brent goose, *Branta bernicla* (L.), in less than 2 hr. Halnan (1949) showed by X-ray studies that variations in rate-of-passage estimates for chickens could be attributed to the fact that some food boluses are stored in the crop for varying periods while others by-pass the crop completely. However, geese have no crop, so differences between estimates must be attributed to differences between methods and between birds. Despite the range of values, all are very fast when compared with the rate of passage for mammalian herbivores. Although they make little use of fibre, the geese do digest relatively high percentages of soluble carbohydrate and protein in this very short time of passage.

It is of interest to compare the Cape Barren geese with sheep in their digestion of lucerne, as both species normally eat pasture, sometimes grazing competitively with one another. In a similarly designed experiment in this laboratory (Forbes and Tribe, unpublished data) values were obtained for digestibility of lucerne chaff by sheep which give a good comparison, as the lucerne was of very similar composition to that used in the present experiment. The sheep had a mean daily dry matter intake of 66·5 g/kg metabolic body weight, approximately half that of the geese (113·9 g/kg metabolic body weight), but digested 57·9% of the dry matter, more than twice that digested by the geese (25·8%). The differences in mean retention time were very large (52·2 hr for sheep; 1·3 hr for geese) and the greatest effect of this was on the ability to digest fibre (sheep 43·1%; geese 0·8%). The sheep also digested the soluble carbohydrate fraction slightly better than the geese (sheep 70·5%; geese 56·6%), and this may indicate a greater ability of sheep to digest the hemicelluloses included in the soluble carbohydrate fraction with the more soluble sugars and starches. Geese digested the crude protein and ether extract fractions as well as the sheep and all were in positive nitrogen balance.

Thus it is apparent that Cape Barren geese make comparatively poor use of their plant food, digesting only about a quarter of it, mainly because of their inability to digest the fibre fraction, and that they therefore require to eat relatively large amounts. The rapid turnover rate enables them to minimize their body weight; they thus retain their mobility and are able to select the best pastures for feed by flying (often quite long distances) to different areas at different seasons.

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