Diet and size of the digestive organs of Spur-winged Geese

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Introduction

Spur-winged Geese *Plectropterus gambensis* are widespread in Africa and frequently occur in agricultural areas where they have been reported to feed on crops when these are available (Shewell 1959). Crops are a potentially abundant and energy-rich food source for the geese. The primary purpose of this study was to document the diet of Spur-winged Geese in an agricultural area and thus determine the extent to which they actually utilise crops as a food source in such situations.

Several studies have shown that diet can affect the size of a bird's digestive organs. Both quality of the food (particularly its fibre level) (Moss 1972) and quantity eaten (Ankney 1977) have been reported to alter digestive organ size, although it appears that dietary quality only does so indirectly through its effect on the quantity of food consumed (Savory and Gentle 1976). A secondary aim of the study was to examine whether the digestive organs of Spur-winged Geese vary in size during the year and, if so, whether the variation can be explained in terms of changes in dietary parameters.

Methods

A total of 102 birds (56 adult, 17 fledged juvenile males; 22 adult, 7 juvenile females) were shot on or near Barberspan lake (26°33' 25°36'E) in the Transvaal, South Africa, during a study of reproduction in Spur-winged Geese (Halse 1985). Barberspan is one of the most important wetlands for waterfowl in southern Africa (Skead & Dean 1977). It is situated in an area that is cropped intensively with maize and, to a lesser extent, sorghum, sunflower and groundnuts.

The food in the oesophagus, proventriculus and gizzard was removed and stored in 70% alcohol, usually within 30 minutes of death. Longer delays did not appear to cause appreciable post-mortem digestion (cf. Swanson & Bartonek 1970). Later the oesophageal contents were sorted and the dry weight of each type of food was measured after being oven-dried at 65°C for 72 hours. Food items in the proventriculus and gizzard were identified and their presence recorded.

Dietary data were analysed using the aggregate percentage, percentage occurrence (Swanson *et al.* 1974a), and aggregate dry weight (Reinecke & Owen 1980) methods. Because aggregate percentage takes account of both the quantity and frequency with which food items are eaten, it was the method used to express dietary data for comparison of diets.

In adult birds, the remaining digestive organs were also excised. The small intestine and colon (referred to hereafter as the gut) and both caeca were laid out while still full, without being stretched, and their lengths were measured. The gizzard was weighed after fat and mesentery adhering to it had been removed. The pancreas and liver (with the gall bladder removed) were also weighed.

The geese were grouped into six categories (Table 1) which reflected both season of the year and physiological changes. The first category, premoulting, lasted from late autumn to midwinter, postmoulting from midwinter until early spring, prelaying from midspring to midsummer and postlaying from midsummer to late autumn. The wing-moult lasted seven weeks during winter; laying occurred in summer.

Results

Diet

Whether quantity consumed or frequency of occurrence was considered, maize was the most important food of Spur-winged Geese. Pondweed *Potamogeton pectinatus* was also prominent in the diet (Appendix). Altogether the geese ate 13 plant and 9 animal species but the quantity of animal food eaten was very small.

More important than the overall composition of the diet was its seasonal variation. The diet was divided into four food classes – crops, farmland weeds, lake plants, and insects. Data from male and

Table 1. Importance of different types of food in the diet of Spur-winged Geese using aggregate percentage method.

Category	Season	N	Food class (agg. %) Crops	Weeds	Lake plants	Insects
All birds	Whole year	68	53	11	34	2
Premoulting	Autumn/winter	13	76	–	24	tr
Moulting	Winter	6	17	–	83	–
Postmoulting	Winter/spring	14	63	1	36	–
Prelaying	Spring/summer	26	56	16	24	4
Laying	Summer	2	50	–	50	–
Postlaying	Summer/autumn	7	14	43	38	5

female, juvenile and adult birds were combined because there did not seem to be any difference in diet between these groups. There were substantial changes in diet of the geese during the year (Table 1). From mid-autumn to midsummer, non-moulting birds fed predominantly on crops, especially maize. This began ripening in mid-autumn and premoulting birds fed on them. After moulting in midwinter, by which time most crops had been harvested, the geese fed on spilled grain and maize cobs lying on the ground. By the end of spring, grain was becoming scarce and made a smaller contribution to the diet. After the rains of late spring and early summer the leaves of young maize and *Urochloa panicoides* were taken. Later in summer and in early autumn, before crops ripened, seeds and to a lesser extent leaves of weed plants, especially *U. panicoides,* formed the major source of food. Besides having palatable young leaves weeds set seed earlier than crops.

The geese changed their diet abruptly when they moulted during winter. They were flightless at this time (Halse & Skead 1983) so their feeding activity was almost completely confined to Barberspan and its shores; and their diet consisted mostly of lake plants, particularly tubers and leaves of *P. pectinatus.* A single goose had walked from the lake and partaken of the only adjacent maize crop. This was unusual behaviour.

Although lake plants were dominant in the diet only during moulting, small quantities of *P. pectinatus* were eaten frequently during the remainder of the year. It appears from observation and two shot birds (Table 1) that *P. pectinatus* was also important in the diet of laying Spur-winged Geese.

The only insect eaten in quantity was *Somaticus* sp., a large slow-moving tenebrionid beetle, which was present in enormous numbers around Barberspan for a couple of weeks in the autumn of 1981. However, all birds that had eaten *Somaticus* had also eaten a lot of maize, so that the beetles formed only a very small proportion of the total amount of food in their digestive tracts (Appendix).

Digestive organ size

Male Spur-winged Geese had larger digestive organs than females ($P < 0.001$ for all organs, t-tests). Males were larger than females (Halse & Skead 1983) but there was no correlation between body size and digestive organ size within either sex (e.g. total body length vs gizzard weight: males, $r = 0.01$, $n = 52$; females, $r = 0.01$, $n = 20$). Therefore, data on seasonal changes in digestive organ size were analysed separately for the sexes but no adjustment was made for body size.

All digestive organ measurements changed significantly during the year in male geese (Table 2, Figure 1). The greatest changes were associated with the wingmoult when there was hypertrophy of the gizzard, gut and caeca and atrophy of the liver. Ignoring moulting birds, all digestive organs of male birds were larger during "winter" (pre- and postmoulting) than in "summer" (pre- and postlaying).

Data on female digestive organ size were less clearcut, perhaps because of smaller sample sizes. As in males, gizzard weight in female birds was maximal during moulting and liver weight was minimal (Table 2, Figure 1). Gut and caecal dimensions were of similar magnitude in moulting and post-moulting birds. Unlike males, female geese did not have uniformly large digestive organs during "winter" (they were comparatively small in premoulting birds) nor small ones in "summer" (they were large in laying birds).

Table 2. Digestive organ size according to seasonal category. Means ± SE and sample size shown. In males, all measurements showed significant variation during the year ($P<0.001$, except pancreas $P<0.01$, using 1-way ANOVA). In females, gizzard weight ($P<0.001$), gut and caecal lengths ($P<0.01$) and liver weight ($P<0.05$) showed significant variation.

Sex	Category	Digestive organ: Gizzard weight (g)	Gut length (mm)	Caecal length (mm)	Liver weight (g)	Pancreas weight (g)
MALES	Premoulting	$116\pm5^{b,d}$ (14)	2150 ± 58^{a} (14)	$196\pm4^{b,e}$ (14)	105 ± 7^{a} (14)	9.4 ± 0.4 (14)
	Moulting	188 ± 19^{a} (8)	2218 ± 45^{a} (7)	227 ± 8^{a} (7)	64 ± 5^{b} (4)	8.0 ± 1.0 (4)
	Postmoulting	$139\pm8^{b,c}$ (11)	2128 ± 46^{a} (10)	212 ± 6^{c} (11)	116 ± 10^{a} (6)	9.6 ± 0.7 (8)
	Prelaying	$94\pm5^{b,d}$ (16)	1953 ± 35^{b} (13)	$160\pm5^{b,d,e}$ (13)	82 ± 6^{b} (13)	7.2 ± 0.7 (13)
	Postlaying	$89\pm5^{b,d}$ (6)	1901 ± 52^{b} (7)	$187\pm6^{b,d,f}$ (7)	70 ± 5^{b} (4)	6.3 ± 0.3 (4)
FEMALES	Premoulting	$76\pm6^{b,d}$ (4)	1736 ± 57^{b} (5)	165 ± 4 (4)	69 ± 12 (4)	4.9 ± 0.7 (4)
	Moulting	145 ± 2^{a} (4)	1953 ± 16^{a} (4)	182 ± 8^{a} (4)	48 ± 8^{b} (4)	5.4 ± 0.5 (4)
	Postmoulting	104 ± 4^{b} (4)	1910 ± 55 (4)	183 ± 8^{a} (4)	98 ± 12^{a} (4)	6.4 ± 0.4 (4)
	Prelaying	$78\pm7^{b,d}$ (6)	$1705\pm65^{b,d}$ (4)	136 ± 12^{b} (4)	62 ± 8 (4)	5.5 ± 1.1 (4)
	Laying	$79\pm3^{b,d}$ (3)	1919 ± 35^{c} (3)	181 ± 1^{a} (3)	84 ± 3 (3)	6.2 ± 1.1 (2)

$^{a,b;\ c,d;\ e,f}$ within each sex, means with superscripts a and b were different from each other ($P<0.05$, Newman-Keuls test); similarly for c,d and e,f.

Discussion

Diet

According to Swanson *et al.* (1974b), a bird includes food items in its diet as the result of three factors: (1) its physical capabilities in obtaining different types of food; (2) environmental conditions (which control availability); and (3) the biological or nutritional demands on the bird (e.g. breeding). However, as pointed out by Bartonek & Hickey (1969), behaviour (in terms of feeding methods employed) also has a role in food selection that results in birds taking a smaller array of items than they physically could.

Behavioural changes can result in novel items being included in the diet. Because tenebrionids were temporarily so abundant the normally herbivorous geese altered their feeding methods to catch large numbers of the beetles. The same may apply to some of the other insects eaten; others were probably ingested accidentally with plant food.

Although the diet of Spur-winged Geese in a relatively pristine area such as the Kafue Flats, Zambia (Douthwaite 1978), contains no crop plants, its composition is nevertheless similar to that of birds at Barberspan. It consists of grass leaves and seeds, and rhizomes of various terrestrial and aquatic plants. Winged termites are also eaten when they are abundant. Spur-winged Geese would have had to make only small changes in behaviour to begin feeding on maize and other grains or to dig for groundnuts. At Barberspan these changes have resulted in the switch from indigenous foods to crops for most of the year. Many other waterfowl have made the same changes in behaviour in the last eighty years (Bossenmaier & Marshall 1958; Thomas 1981; Halse 1984a) because crops are generally more abundant, accessible and

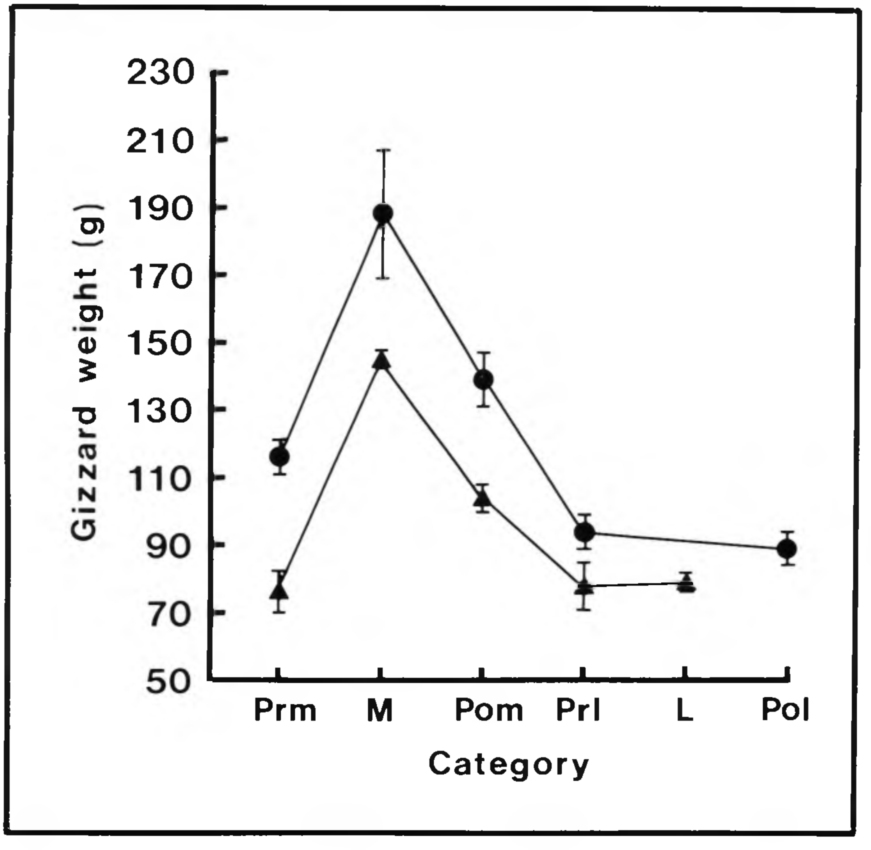

Figure 1. Changes in weight of the gizzard during the year. Means ± SE are plotted, sample sizes are given in Table 2. Prm = premoulting, M = moulting, Pom = postmoulting, Prl = prelaying, L = laying, Pol = postlaying. ● = males, ▲ = females.

energy-rich food sources than traditional waterfowl foods. Maize has become the main component of the diet of Spur-winged Geese at Barberspan.

The most important traditional food plant is *P. pectinatus*. Tubers of this species are the main food of moulting Spur-winged Geese and they are probably also important in the diet of laying birds. Its leaves, and to a lesser extent its tubers and other plant parts, are frequently eaten in small quantities by non-moulting geese.

Digestive organ size

Substantial changes in size of the alimentary tract during the year are especially striking in the gizzard. Because fibre levels have often been implicated in hypertrophy of the tract (Moss 1972; Miller 1985; Burton *et al.* 1979) the crude fibre content of the diet in different seasons was estimated using the values for fibre content given in the Appendix. It is about 4% most of the year, increasing to about 9% during moulting, when the alimentary tract is largest, and 11% during postlaying, when it is small (Table 2). Clearly fibre *per se* has little influence, and no single factor has been found that explains all the seasonal variation in any digestive organ. However, there is a loose correlation between estimated fresh-weight of food intake and alimentary tract size (unpubl. data). Quantity of food eaten has been shown to affect alimentary tract size in many bird species (Savory & Gentle 1976, Ankney 1977, Raveling 1979). However, it seems likely that another factor during moulting, perhaps the nature of the food eaten (cf. Paulus 1982), exerts an additional effect on gizzard size because the change in gizzard weight is so much greater than that in the rest of the tract. A similar dramatic hypertrophy of the gizzard occurs in Egyptian Geese at Barberspan when they moult (Halse 1984a).

In contrast to the alimentary tract, the liver of Spur-winged Geese is smallest during the wing-moult when the geese are losing weight (Halse & Skead 1983), i.e. their energy intake is low. It is largest during postmoulting, and, in females, during laying. Energy intake is high at these times (unpubl. data). It seems that size of the liver, an organ principally involved in intermediary metabolism, is affected by the intake of metabolizable energy rather than food intake as such. When liver size does relate directly to the amount of food consumed (Ankney 1977, Raveling 1979) it is presumably because all the food types have a similar metabolizable energy content. This was not the case with the Spur-winged Geese. The digestibility and metabolizable energy content of maize for these birds is much higher than that of traditional foods (Halse 1984b).

Changes in size of the pancreas were less pronounced than those of the liver. The primary function of the pancreas in digestion is the production of digestive enzymes. It is likely that any fluctuations reflect a combination of both the quantity of food eaten and its chemical composition, and indeed Ankney (1977) found significant changes in pancreas size in Lesser Snow Geese *Anser caerulescens* associated with changes in food intake.

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Summary

Adult and fledged juvenile Spur-winged Geese *Plectropterus gambensis* at Barberspan, South Africa, feed mostly in farmland on maize, other crops and farmland weeds. Indigenous foods growing in the lake and on its shores form the dominant component of the diet only during the wing-moult, although *Potamogeton pectinatus* is eaten in small quantities throughout the year. The geese eat almost no animal food.

There is significant variation during the year in size of the gizzard, gut, caeca, liver and pancreas of Spur-winged Geese. The most dramatic changes are associated with the wing-moult. It appears that fresh-weight of food consumed by the geese is one of the factors influencing size of the gastrointestinal tract and metabolizable energy intake influences liver size.

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Appendix. Importance of different food items in diet of Spur-winged Geese as measured by aggregate dry weight (ADW), aggregate percentage (AP) and percentage occurrence (PO) methods. Approximate fibre contents of foods are indicated.

Food items	Fibre (% DW)	ADW[1] (%) N=68	AP[1] (%) N=68	PO[2] (%) N=91
Zea mays seeds (maize)	3[a]	83	48	55
Z. mays leaves	30[a]	0.3	1.5	6.6
Arachis hyopaea (groundnuts)	27[a]	1.8	2.8	4.4
Helianthus annuus (sunflower)	3[b]	0.1	0.1	1.1
Sorghum verticilliflorum (sorghum)	2[a]	1.4	1.4	1.1
Urochloa panicoides seeds	10[b]	10	4.6	5.5
U. panicoides leaves	30[b]	0.5	0.3	4.4
Eleusine indica seeds	7[b]	0.1	0.1	4.4
Panicum sp. seeds	7[b]	0.1	1.5	5.5
Cyperus esculentus bulbs	5[b]	0.1	0.1	3.3
unidentified leaves	30[b]	0.1	4.4	3.3
Panicum repens seeds	–	–	–	1.1
P. repens leaves	30[b]	0.2	4.2	4.4
P. repens corms	5[b]	0.3	3.3	3.3
Juncellus laevigatus seeds	–	–	–	2.2
Potamogeton pectinatus seeds	40[c]	0.1	0.5	7.7
P. pectinatus leaves	30[c]	0.5	11	41
P. pectinatus tubers	6[c]	1.7	14	15
Stigeoclonium sp.	15[b]	0.1	0.8	2.2
Tenebrionidae *Somaticus* sp.	–	0.1	0.1	3.3
sp. 2	–	0.1	0.5	1.1
sp. 3	–	–	–	2.2
Scarabidae	–	–	–	1.1
Coccinellidae	–	–	–	1.1
Elapteridae	–	–	–	1.1
Coleoptera larvae	–	–	–	1.1
Corixidae	–	0.1	1.5	1.1
Lepidoptera larvae	–	0.1	0.1	1.1

[1]oesophageal data only
[2]oesophageal, proventricular and gizzard data combined
[a]McDonald *et al.* (1973) [b]estimated from fibre contents of similar foods [c]Anderson & Low (1976)