Gizzard grit in some Australian waterfowl

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Introduction

The ingestion of inorganic grit by waterfowl assists in the breakdown of harder food items (Thomas *et al.* 1977); it may also provide a source of trace elements (Nestler 1946; Trost 1981; Walton 1984). Anderson (1959) gave some details from ducks collected in Illinois, U.S.A., and considered that there was no relationship between the amount of grit and the species' size, food or feeding strategy. However, Thomas *et al.* (1977) thought that the amount of grit present in gizzards of duck shot in England was to some extent related to gizzard size, with species selecting grit sizes appropriate to the food eaten. Skead & Mitchell (1983), discussing South African waterfowl, felt that the type and, perhaps more important, the amount of grit might reflect both the specific diet and gizzard size. Halse (1983) also found a correlation between the weights of gizzards and the amount of grit they contained in the Spur-winged Goose *Plectropterus gambensis;* since gizzard weights were not constant this implied that the grit intake was regulated to maintain a constant relationship. In captive Mallard *Anas platyrhynchos,* Trost (1981) found that active consumption of grit was affected by diet, sex and season, as well as particle size and composition.

There has been little discussion on the grit ingested by Australian waterfowl. Information was therefore collected from ducks shot during the opening weekend of the 1984 hunting season (3–4 March) in Victoria, at Dowd's Morass, Lake Buloke, Tower Hill Game Reserve, First Marsh and Cullen's Lake, Kerang. Some Freckled Ducks *Stictonetta naevosa* were also collected during the 1985 hunting season at Lake Buloke.

Methods

Gizzards were collected from adult ducks (sexed and aged using cloacal and plumage characteristics), data from the five wetlands being combined. The gizzards were stored in 70% ethanol until examination. Any small portions of anterior and posterior alimentary tracts were removed, as was excess fat, and the gizzard contents were extracted by brush and washing. The empty gizzards were roll-dried and weighed. Gizzard contents were sorted into food fragments and inorganic grit. The grit was dried, rechecked for any seeds, and weighed before being shaken through five sieves of graduated sizes (Table 1). The five fractions were then weighed, a sixth fraction (< 35 mm) being determined by subtraction. The grit was classified as being of sedimentary or basaltic (Tower Hill), quartzitic (most sites) or calcareous origin. Other inorganic materials were noted. The grit fractions were also examined for shotgun pellets. Uneroded pellets with flattened areas were considered to be "shot-in", i.e. involved in the charge which killed the duck (see Bellrose 1959, Mudge 1983) and their entry points were sought.

Food remains, when present in the gizzard, were classified as: (1) completely animal; (2) mostly animal; (3) mostly plant; and (4) entirely plant. In this study Grey Teal *Anas gibberifrons* was the most abundant species in hunters' bags and hence in the samples obtained. To investigate whether plant seeds were being used as grit, the seeds present in male Grey Teal gizzards (the group presumably least likely to be affected by dietary changes during breeding) were sorted from other food remains and weighed when dry.

Individual body weights were available only for the sample of Freckled Ducks.

Results

The average total weights and size fractions of the grit found in the gizzards are summarised in Table 1. Australian Shelduck *Tadorna tadornoides* held more grit per gizzard on average than did the combined sexes of other species, but female Maned Goose *Chenonetta jubata* contained slightly more grit than did female shelducks. Apart from the perhaps anomalous result from the single male Musk Duck *Biziura lobata* with very little grit, the smaller ducks, i.e. Grey Teal and Pink-eared Duck *Malacorhynchus membranaceus* held least grit.

Table 1. Average grit content (g) of gizzards of some Australian waterfowl with gizzard weights (all ± S.D.). No grit was retained in sieve size 1 (>4.0 mm).

		Weight of grit (g) in sieve size					
	Sieve size (mm)	2 2.72 – <4.00	3 1.70 – 2.27	4 0.85 – <1.70	5 0.35 – <0.85	Total weight (g)	Sample size
Australian Black Duck							
Anas superciliosa	males	0.05 ± 0.09	0.69 ± 0.65	1.41 ± 0.96	0.55 ± 0.63	2.88 ± 1.70	47
	females	0.03 ± 0.15	0.60 ± 0.49	1.54 ± 0.76	0.44 ± 0.43	2.78 ± 1.19	40
	all birds	0.04 ± 0.12	0.65 ± 0.58	1.47 ± 0.87	0.50 ± 0.55	2.83 ± 1.48	87
Chestnut Teal							
A. castanea	males	–	0.03 ± 0.04	1.04 ± 0.53	0.55 ± 0.43	1.74 ± 0.71	18
	females	0.008 ± 0.02	0.01 ± 0.03	1.17 ± 0.43	0.54 ± 0.42	1.78 ± 0.66	9
	all birds	0.003 ± 0.01	0.02 ± 0.04	1.09 ± 0.50	0.55 ± 0.42	1.75 ± 0.68	27
Grey Teal							
A. gibberifrons	males	–	0.009 ± 0.02	0.41 ± 0.25	0.67 ± 0.40	1.14 ± 0.47	65
	females	–	0.007 ± 0.02	0.35 ± 0.19	0.60 ± 0.38	1.00 ± 0.48	60
	all birds	–	0.008 ± 0.02	0.38 ± 0.23	0.64 ± 0.39	1.07 ± 0.47	125
Australian White-eye							
Aythya australis	females	0.001 ± 0.001	0.31 ± 0.22	0.71 ± 0.09	0.82 ± 0.30	1.95 ± 0.44	2
Australian Shelduck							
Tadorna tadornoides	males	0.02 ± 0.04	0.06 ± 0.11	1.64 ± 1.00	3.17 ± 1.23	5.65 ± 1.98	36
	females	0.01 ± 0.04	0.06 ± 0.14	1.40 ± 0.75	2.48 ± 1.25	4.67 ± 1.89	32
	all birds	0.01 ± 0.04	0.06 ± 0.12	1.53 ± 0.89	2.85 ± 1.28	5.19 ± 1.99	68
Pink-eared Duck							
Malacorhynchus membranaceus	males	–	0.05 ± 0.09	0.42 ± 0.20	0.45 ± 0.29	1.06 ± 0.39	11
	females	0.01 ± 0.02	0.04 ± 0.06	0.60 ± 0.27	0.46 ± 0.25	1.28 ± 0.43	10 (9)*
	all birds	0.003 ± 0.01	0.04 ± 0.08	0.50 ± 0.25	0.45 ± 0.26	1.16 ± 0.42	21 (20)
Australian Shoveler							
Anas rhynchotis	males	–	0.32 ± 0.21	1.06 ± 0.59	0.35 ± 0.20	1.89 ± 0.51	5
	females	0.05 ± 0.12	0.36 ± 0.28	1.03 ± 0.51	0.45 ± 0.20	2.11 ± 0.68	6
	all birds	0.03 ± 0.09	0.34 ± 0.24	1.04 ± 0.52	1.04 ± 0.20	2.01 ± 0.59	11
Maned Goose							
Chenonetta jubata	males	0.01 ± 0.01	0.001 ± 0.002	0.68 ± 0.57	2.47 ± 0.27	4.03 ± 0.55	3
	females	–	0.004 ± 0.01	0.31 ± 0.10	2.59 ± 1.09	5.25 ± 1.59	4
	all birds	0.003 ± 0.008	0.003 ± 0.006	0.47 ± 0.39	2.54 ± 0.79	4.73 ± 1.34	7
Blue-billed Duck							
Oxyura australis	female	–	0.039	1.606	0.119	1.771	1
Musk Duck							
Biziura lobata	male	–	0.22	0.01	–	0.03	1
	female	0.65	0.11	0.13	0.48	1.65	1
	all birds	0.33 ± 0.46	0.06 ± 0.06	0.07 ± 0.09	0.24 ± 0.09	0.84 ± 1.15	2
Freckled Duck							
Stictonetta naevosa	male	–	0.25 ± 0.032	1.64 ± 0.69	0.92 ± 0.41	2.80 ± 0.49	6
	female	–	–	0.94 ± 0.47	1.12 ± 0.62	2.28 ± 0.68	5
	all birds	–	0.014 ± 0.026	1.32 ± 0.68	1.01 ± 0.50	2.56 ± 0.62	11

*grit was lost in one female

In Chestnut Teal *Anas castanea*, gizzards of females contained size 2 grit whilst males did not; female Maned Goose contained more fine grit (size 6) than males (t – test, p = 0.026). However, in no species were there sex differences in the total amounts of grit in gizzards. For the three species with the biggest samples, Grey Teal, Australian Shelduck and Australian Black Duck *Anas superciliosa*, the larger species contained more total grit (in paired comparisons, t – tests, $p < 0.001$), and usually significantly more in each size fraction.

Average gizzard weights are given in Table 2 and compared with mean body weights. The gizzard comprised from about 1 to 4.5% of the given body weights. This proportion was lowest in Musk Duck and Pink-eared Duck, and highest in Maned Geese. Only in Black Duck was the difference between male and female gizzard weight significant (t – test, p = 0.003). However, when expressed as a proportion of body weight females of most species had relatively larger gizzards than males. In the males examined, the average total grit in gizzards increased with average gizzard weights ($r = 0.6175$, $p = 0.0382$). In females the relationship was more significant ($r = 0.8515$, $p = 0.0004$). In both sexes, all correlations were improved by elimination of those species with small samples, i.e. Australian White-eye *Aythya australis*, Australian Blue-billed Duck *Oxyura australis* and Musk Duck.

In adult male Grey Teal there were no significant correlations between grit and gizzard weight, nor did seed weights vary significantly with changes in gizzard size even when the larger, apparently most homogenous group (those collected at Lake Buloke) was examined ($r = 0.101$, $p = 0.2449$). In Freckled Duck, gizzard weight was well correlated with body weight

Table 2. Average gizzard weights (± S.D.) compared with body weights (data from Frith 1982; Chestnut Teal from Norman unpublished). Sample sizes as in Table 1.

		Body weight (g)	Gizzard weight (g)	Gizzard/ body weight (%)	Female gizzard weight/ male gizzard weight (%)
Australian Black Duck	– males	1114	32.19 ± 8.45	2.9	84.4
	– females	805	27.16 ± 6.46	3.4	
Chestnut Teal	– males	580	11.76 ± 2.43	2.0	94.6
	– females	496	11.12 ± 2.39	2.4	
Grey Teal	– males	507	9.30 ± 1.87	1.8	93.3
	– females	474	8.68 ± 1.77	1.8	
Australian White-eye	– females	838	24.05 ± 5.25	2.9	–
Australian Shelduck	– males	1559	29.44 ± 6.87	1.9	102.9
	– females	1291	30.29 ± 10.78	2.4	
Pink-eared Duck	– males	404	4.74 ± 1.14	1.2	99.2
	– females	344	4.70 ± 0.89	1.4	
Australian Shoveler	– males	667	10.56 ± 1.17	1.6	89.9
	– females	665	9.49 ± 2.10	1.4	
Maned Goose	– males	815	32.10 ± 4.62	3.9	110.9
	– females	800	35.60 ± 6.37	4.4	
Blue-billed Duck	– female	852	9.67	1.2	–
Musk Duck	– male	2398	23.80	1.0	62.9
	– female	1551	14.97	1.0	
Freckled Duck	– male	966	32.32 ± 5.04	3.3	82.3
	– female	837	26.60 ± 5.84	3.2	

($r = 0.8715$, $p = 0.0002$); this level of significance was maintained in both sexes.

Most gizzards of all species (154 of 192 males, 128 of 169 females) held entirely quartzitic grit and in only a few did shell fragments predominate. Only 15 had shotgun pellets in gizzards; in 13 these were "shot-in" but in two male Black Duck (from Dowd's Morass) no holes were found in the gizzard and the pellets had apparently been ingested. Glass fragments and a few fossil molluscs were also found.

Food material present in gizzards was also categorised. None had remains entirely of animal origin and only six had mainly animal fragments. Of 192 gizzards from male ducks containing food, 182 (94.8%) were considered to have only vegetable remains, as were 153 (92.7%) of the female gizzards.

Discussion

Frith (1982) considered the Maned Goose was entirely a herbivore; the Grey Teal and Chestnut Teal, Freckled Duck, Black Duck, Blue-billed Duck, White-eye and Australian Shelduck ate predominantly plant material whilst the Australian Shoveler *Anas rhynchotis,* Pink-eared Duck and Musk Duck took mainly animal food. According to Skead & Mitchell (1983), the carnivorous species should have the smaller gizzards and the least amount of grit. The gizzard weights of the two Musk Duck and the 21 Pink-eared Ducks, as a proportion of the body weights, were indeed low but so too was that from the single female Blue-billed Duck. Certainly the Maned Geese, particularly females, had the highest gizzard : body weight ratio and those for the Freckled Duck, Black Duck, female White-eye and Australian Shelduck were also generally higher than in other species. The Grey Teal, Chestnut Teal and Australian Shoveler were intermediate.

The apparent anomalies may be because Frith (1982) assigned dietary classification on the basis of gizzard contents alone. More recently the effect of post-mortem digestion has been recognised and oesophageal contents are used to provide more accurate information on food ingested. Thus Briggs (1982) pointed out differences between food samples from oesophagi and gizzards in the Freckled Duck, Grey Teal and Pink-eared Duck, noting that gizzards held more plant material. Norman & Mumford (1982) and Norman (1983) also showed that Chestnut Teal took a range of plant and animal food in different habitats. Presumably in the variable Australian environment some species modify their diet opportunistically. Gizzard weights and contents, varying with diet, sex and season

(Trost 1981; Halse 1983) may therefore reflect local conditions as well as differences between species.

Skead & Mitchell (1983) noted that the carnivorous Cape Shoveler *Anas smithii* and Cape Teal *A. capensis* had the smallest gizzards and grit load in their study, whilst the more herbivorous Yellow-billed Duck *A. undulata* had a large gizzard and proportionately more grit. The Australian Black Duck, weighing slightly more than *undulata,* held less grit than it and the Mallard (Thomas *et at.* 1977). The Chestnut Teal resembled the similarly sized, mainly carnivorous Red-billed Teal *A. erythrorhyncha* in grit load whereas the small Grey Teal held less than *erythrorhyncha* but more than *capensis.* The Cape Shoveler held less grit than its somewhat heavier Australasian counterpart as did the European Shoveler *A. clypeata* reported by Thomas *et al.* (1977).

In contrast to results elsewhere (Mudge 1983), few birds had ingested shotgun pellets, but a low incidence has been reported for Australian waterfowl previously (Norman 1976), a consequence of the variability of wetland water-levels. Moreover, birds would have had little opportunity to pick up pellets during the opening days of the season.

In future investigations it would be interesting to compare gizzard parameters of females through the breeding season as they are known then to eat more invertebrates, particularly during egg-laying (e.g. Serie & Swanson 1976).

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Summary

Gizzard weights and their grit contents are measured and discussed for ten species of Australian waterfowl. Most ingested grit was of quartzitic origin and tended to be small. Species considered to be carnivorous had smaller gizzards and less grit than those which take predominantly plant foods. Apparent anomalies may be because gizzard contents do not accurately reflect diet and because some species are opportunistic feeders.

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