THE DIET OF POST-BREEDING MARBLED TEAL *MARMARONETTA ANGUSTIROSTRIS* AND MALLARD *ANAS PLATYRHYNCHOS* IN THE GÖKSU DELTA, TURKEY

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RÉSUMÉ

L'analyse des fèces a été utilisée pour étudier le régime alimentaire de la Sarcelle marbrée *Marmaronetta angustirostris* et du Colvert *Anas platyrhynchos* dans le delta de Göksu, Turquie, du 13 juillet au 5 août 1995. Les aliments potentiels ont été récoltés sur les sites d'alimentation de la Sarcelle marbrée, permettant l'identification des fragments d'invertébrés et une étude des préférences alimentaires de l'espèce. Les graines de *Scirpus* dominaient (95 % du poids sec) dans les fèces de la Sarcelle marbrée et sept familles d'invertébrés (appartenant aux Hétéroptères, Diptères, Coléoptères et Ostracodes) ont été identifiées. En revanche, 93 % (en poids sec) des fèces du Colvert consistaient en végétaux verts où dominaient *Potamogeton pectinatus* et *Chara vulgaris vars* ; des graines (5 % en poids sec) et 10 familles d'invertébrés (également des Hétéroptères, Diptères, Coléoptères et Ostracodes) étaient aussi présentes. La combinaison de l'analyse des fèces et des échantillonnages d'invertébrés donne des informations sur les sites d'alimentation fréquentés par la Sarcelle marbrée. Bien que basée sur de petits échantillons, il s'agit de la première étude un peu précise du régime alimentaire de cette espèce globalement menacée.

SUMMARY

Faecal analysis was used to study the diet of the Marbled Teal *Marmaronetta angustirostris* and the Mallard *Anas platyrhynchos* in the Göksu Delta, Turkey from 13 July to 5 August 1995. Potential food items were netted at Marbled Teal feeding sites, enabling the identification of invertebrate fragments in the faeces and a study of food selection by this species. Marbled Teal faeces were dominated by *Scirpus* seeds (95 % of dry weight), and seven families of invertebrates (from orders Heteroptera, Diptera, Coleoptera and Ostracoda) were identified. In contrast, 93 % of Mallard faeces (dry weight) was green plant matter, which was dominated by *Potamogeton pectinatus* and *Chara vulgaris vars.* Seeds (5 % by dry weight) and 10 families of invertebrates (from orders Heteroptera, Diptera, Coleoptera and Ostracoda) were also present. The combination of faecal analysis with invertebrate sampling can give information about the feeding areas used by Marbled Teal. Although based on a small number of samples, this is the first detailed study of the diet of this globally threatened species.

INTRODUCTION

Faecal analysis is a standard method for studying animal diet. Amongst Anatidae, its use has been largely restricted to herbivorous species (Owen, 1975;

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Black *et al.*, 1994), although a detailed analysis has been conducted for the insectivorous Blue Duck *Hymenolaimus malacorhynchos* (Collier, 1991; Wakelin, 1993; Veltman *et al.*, 1995). Diet in omnivorous duck species has usually been studied by collecting specimens and analysing their gut contents (e.g. Krapu & Reinecke, 1992; Thompson *et al.*, 1992; Nummi, 1993). Faecal analysis is subject to biases because softer and more easily digestable components of duck diet are under-represented (Swanson & Bartonek, 1970; Sedinger, 1986). However, when collection of specimens is not practicable or desirable, faecal analysis can provide valuable data on the diet of omnivorous ducks, although the only published analysis we are aware of is Hartman's (1985) study of Mallard *Anas platyrhynchos.*

Here, we use faecal analysis in the first detailed study of the diet of the Marbled Teal *Marmaronetta angustirostris*, a globally threatened species (Green, 1993; Navarro & Robledano, 1995; Green, 1996). We compare a small number of faecal samples from the Göksu Delta, Turkey, in July-August with a larger number of samples from Mallard, confirming differences in diet of these two omnivorous species expected due to differences in their foraging behaviour and habitat selection (Green, 1998a,b). We compare the abundance of different animal and plant items available in the wetland with their abundance in the faeces to determine the dietary preferences of each species.

STUDY AREA

The Göksu Delta is located on the Turkish Mediterranean coast (Fig. 1, see Green, 1998a for detailed description). Approximately 50 pairs of each duck species breed in the delta, and Mallard numbers increase in summer (c. 145 Marbled Teal and c.733 Mallard were present at the time of this study). We concentrated our study at Lake Akgöl (Fig. 1), a well vegetated, fresh to brackish, eutrophic lake (1,400 ha) with extensive beds of *Phragmites australis, Typha* sp., *Scirpus* (= *Schoenoplectus*) *litoralis* and *Potamogeton pectinatus.* The great majority of individuals of all duck species in the delta were concentrated at Akgöl during our study (Green, 1998a). Data on the abundance of food items were also collected from a small, shallow, mesohaline lagoon (2.8 ha) along the eastern lake shore with stands of *Scirpus maritimus,* a short variety of *P. australis, Salicornia* sp. and *Arthrocnemum* (Fig. 1). This lagoon was selected for study because it held a higher density of Marbled Teal and Mallard than other parts of Akgöl (Green, 1998a).

METHODS

Fieldwork was conducted from 13 July to 5 August 1995. Faeces were collected from clumps of emergent vegetation at locations within Akgöl where Marbled Teal and Mallard were observed roosting out of the water. Fresh Marbled Teal faeces were collected (at two separate locations) on four occasions between 21 July and 1 August. Mallard faeces were collected from four separate locations during 13-27 July. We analysed a total of five samples of Marbled Teal faeces and 15 samples of Mallard faeces (each sample consisted of one or more droppings

Figure 1. — The location of the Göksu delta in Turkey, showing Akgöl and the lagoon on its eastern shore (marked with an "L").

taken from the same spot on the same day). Four of the five Marbled Teal samples were collected from a roost site along the eastern shore of Akgöl, c.1.5 km to the south of the lagoon. The fifth was collected from the centre of Akgöl, c.3 km from the lagoon. More samples could not be collected because Marbled Teal were rarely seen out of the water (Green, 1998a). Marbled Teal droppings were easily distinguished from Mallard droppings by their narrower width.

Each dropping was dampened with distilled water, then examined under a binocular microscope, carefully separating different types of seeds, green plant matter, insects, crustaceans and grit. Dry weight (to the nearest 0.0001 g) of each component of each sample was calculated after drying at 45 °C for 96 h. A total of 9.5 g (dry mass) of Marbled Teal faeces and 21.5 g of Mallard faeces were analysed.

Net samples of potential food items were taken from feeding sites within Lake Akgöl and the lagoon immediately after Marbled Teal were observed feeding within the top 10 cm of the water column (Green, 1998a,b). A sweep-net (head width 38 cm, height of 20 cm, mesh 0.2 mm) was dragged parallel to the water surface for a measured distance (1-5 m), sampling the top c.10 cm of the water column. A total of 38 m was sampled from 12 points in Akgöl, and 3 m were sampled in the lagoon. In the lagoon, the only feeding site where depth was less than 10 cm, the top 3 cm of benthic sediments were also sampled with the net.

Samples were immediately washed inside a net of 0.2 mm, placed in a plastic bag and sorted in the laboratory within 24 hours. They were washed through sieves with meshes of 2, 1 and 0.5 mm, and all seeds and animals visible to the naked eye were removed and stored in 80 % ethanol. Seeds were identified and counted at species level. Animals were later identified and counted to family level in the laboratory, using appropriate keys (e.g. Campredon *et al.*, 1982; Richoux, 1982; Tachet *et al.*, 1987; Chinery, 1988; Nieser *et al.*, 1994). To compare size of animals in samples with those in the faeces, each family was assigned to length classes used in previous studies of dabbling duck diet (Nudds & Bowlby, 1984; Nummi, 1993).

It was not possible to distinguish between seeds of *Scirpus litoralis* and *S. maritimus* in faeces, although almost all *Scirpus* seeds net sampled in Akgöl were *S. litoralis* whereas almost all those in the eastern lagoon were *S. maritimus*. Fragments of insects and crustaceans in faeces were identified to family level as often as possible, using relevant keys and the net samples as a reference. Most insect fragments were too small to identify to family level.

It was not practical to separate green plant matter into the various components (*P. pectinatus, Scirpus litoralis, Chara* sp. etc). We therefore quantified species composition of each dropping using a procedure similar to that of Owen (1975). We spread a sample on a slide and, with a microscope at a magnification of 100, chose 30 fields at random. In each field, epidermal structure was used to identify the vegetation types present, using samples and microscopic preparations of each plant species taken from Akgöl and micro-photographs of various aquatic plant species in Spain (Amat & Soriguer, 1982) as a reference.

We summarize the faecal composition for the two species using percentage of occurrence and mean of dry weight percentages (aggregate percentage) of each component in the faecal samples (excluding grit). Similar parameters are used to describe duck gut contents (Swanson *et al.*, 1974).

RESULTS

Mallard faeces were dominated by green plant matter, which was present in all samples (N = 15) with an aggregate percentage dry weight of 93 % (Table I). Microscopic sampling of this plant matter showed that it was dominated by *Potamogeton pectinatus* which was present in all samples and 79 % of microscope fields. Charophytes (probably all *Chara vulgaris vars.*) were present in 80 % of samples and 28 % of fields. The only other detectable component was *Scirpus* sp. tissue, present in 47 % of samples and 8 % of fields.

Marbled Teal faeces were very different, with an aggregate percentage dry weight of only 0.2 % green plant matter (Table I). Microscopic analysis showed that this was *P. pectinatus*. Marbled Teal faeces were dominated by *Scirpus* seeds, which had an aggregate percentage dry weight of 95 % (N = 5) and were present in all samples (Table I). Insects (particularly Heteroptera, Coleoptera and Diptera) were an important component of the faeces of both species, present in 100 % of Marbled Teal droppings and 87 % of Mallard droppings (Table I).

Comparisons of the percentage of dry weight made up by seeds, green plant material and animal matter in samples from Mallard and Marbled Teal reveal significant differences (Mann-Whitney U tests). Marbled Teal faeces contained more seeds ($U = 0, P < 0.002$) and animal matter ($U = 12, P < 0.03$) and less green plant material ($U = 0, P < 0.002$) than Mallard faeces.

Both Marbled Teal and Mallard showed a basic similarity in their selection of animal matter, with neither species apparently feeding on the molluscs (Gastropoda), shrimps (Palaemonidae) or small fish that were relatively abundant in Akgöl (Table I). Those animal taxa found in Marbled Teal faeces tended to be smaller than other taxa sampled at feeding sites but not found in faeces (Fig. 2). However, differences in length were not statistically significant (Mann-Whitney U test, N = 18, 7; $U = 41.5$; $P > 0.1$).

TABLE I

Abundance (number m^{-2}) of plants and animals in net samples taken from Marbled Teal feeding sites, compared with the content of Marbled Teal and Mallard faeces.

	Abundance		Marbled Teal		Mallard	
	Akgöl	Lagoon	agg%[1]	%occ[2]	agg%	%occ
SEEDS						
Charophyta (oospores)	—	—	tr	20	0.12	67
Scirpus sp.	90	600	94.79	100	2.21	93
Potamogeton pectinatus	31	8	0.007	20	2.29	53
Potamogeton panormitanus	106					
Typha sp.	—	—	0.002	40	tr	7
Unidentified	0.1		0.007	20	0.043	7
GREEN PLANT MATTER	—	—	0.21	40	93.02	100
VERTEBRATA						
Fish	9.5	2.6				
MOLLUSCA						
Cl. Gastropoda	14.9	5.3				
CRUSTACEA						
O. Ostracoda	0.1		0.002	20	0.002	7
O. Decapoda	2.7					
ARACHNIDA						
O. Araneae	0.2	2.6				
O. Acari	0.1					
INSECTA						
All insects combined	27.2	200	4.89	100	1.34	87
O. Heteroptera	7.0	151	—	40	—	20
F. Naucoridae	0.5				—	20
F. Corixidae						
Corixa sp.		151	—	40		
Micronecta sp.	0.4					
F. Pleidae	6.1					
O. Coleoptera	3.2	11.8	(0.1)	100	(0.001)	67
F. Chrysomelidae	0.1				—	47
F. Dryopidae		1.3	—	40	—	20
F. Dytiscidae	0.7	9.2			—	7
F. Elmidae	0.04		(0.09)	40		
F. Hydrophilidae	2.2		—	40	—	27
O. Odonata	2.5				—	7
O. Diptera	9.3	26.3	(4.27)	40	(1.06)	33
F. Ceratopogonidae	2.2		(0.001)	20		
F. Chironomidae	6.3	5.3			—	13
F. Ephydridae	0.1	19.7	(4.27)	20	(1.06)	13
F. Psychodidae	0.5					
F. Stratiomyidae	0.1				—	7
O. Trichoptera	1.0					
O. Lepidoptera	1.1					

[1] Aggregate percentage dry weight (mean of dry weight percentages for each faeces sample).
[2] Percentage of occurrence (percentage of samples in which presence was confirmed). Invertebrates were identified to the levels of class (Cl.), order (O.) and family (F.). "tr" indicates aggregate percentage of less than 0.001. Blank spaces indicate zero values. Hyphens indicate items that were present in quantities that were not measured satisfactorily. Values in brackets indicate minimum values, where those insect fragments identified to family level were weighed.

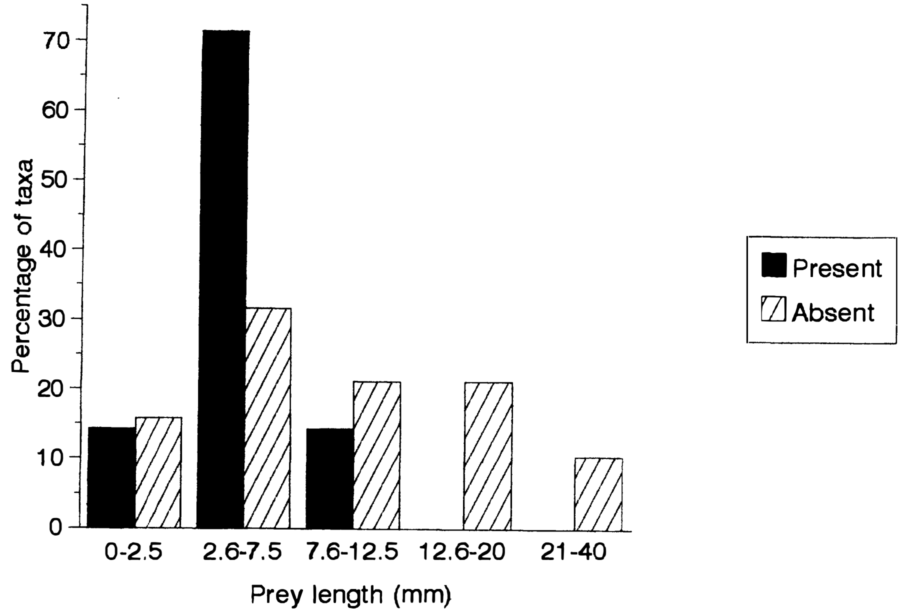

Figure 2. — Length distribution of animal taxa (mean length for each family) sampled at Marbled Teal feeding sites and present (N = 7) or absent (N = 19) in Marbled Teal faeces.

The percentage dry weight composed of insects was exceptionally high in one Marbled Teal sample (22 %) and one Mallard sample (17 %), with a range of only 0-2.2 % in other samples. In both cases, over 90 % of insect dry mass was made of Ephydridae larvae, suggesting that these dipterans may have been highly represented in faecal samples owing to relative indigestibility of the larval cuticle. Six insect families found in Mallard faeces were not found in Marbled Teal faeces (Naucoridae, Chrysomelidae, Dytiscidae, Chironomidae, Stratiomyidae and unidentified Odonata), and three insect families found in Marbled Teal faeces were not found in Mallard faeces (Corixidae, Elmidae and Ceratopogonidae, Table I).

Two different Corixidae species were identified in the net samples. *Corixa* sp. were very abundant in the lagoon, but absent in lake Akgöl (Table I). These corixids were identified in two of the four samples of Marbled Teal faeces taken from the roost site 1.5 km to the south of the lagoon. This suggests that birds roosting at this site were feeding at the lagoon, and this was supported by the flight paths of birds to and from the lagoon (Green, unpubl.). However, faeces collected at this site also contained Elmidae and Hydrophilidae, neither of which were present in net samples from the lagoon (Table I). This suggests that these birds also fed in Akgöl itself, and feeding birds were seen in the lake c.30 m from this roost site.

DISCUSSION

When collection of specimens for gut analysis is undesirable (e.g. studies of threatened species), faecal analysis provides a useful alternative method for studying the diet of omnivorous ducks, particularly when it is complemented by observations of foraging ecology. During the current study, most Marbled Teal and Mallard were feeding in dense beds of *Potamogeton pectinatus* in Akgöl (Green, 1998a), but their feeding behaviour was different (Green, 1998b). Mallards fed mainly by up-ending or neck-dipping at depths of 25-45 cm within the water column, rarely changing their position. Marbled Teal fed by bill or head dipping or gleaning (bill held in the plane of the water surface with only lower mandible submerged, straining items from the water surface) at depths of 0-10 cm, changing position continuously.

Direct observations, combined with the faecal analysis, suggest that the active, bill-dipping adopted by most Marbled Teal in Akgöl was used mainly to take small insects (particularly Heteroptera, Coleoptera and Diptera) while gleaning was used to ingest floating *S. litoralis* seeds. Marbled Teal observed gleaning were always close to stands of *S. litoralis* in Akgöl, at points with higher densities of *S. litoralis* seeds than where Marbled Teal were bill or head dipping (gleaning: N = 2, range = 54-921 seeds m^{-2}, median = 488 m^{-2}. Bill/head-dipping: N = 11, range = 0-66 seeds m^{-2}, median = 5 m^{-2}. One-tailed Mann-Whitney test, $U = 4$, N = 2, 11, $P = 0.03$).

Both duck species appeared to be eating important quantities of insects, which were underrepresented in faeces. As food moves down the alimentary canal, seeds become more represented than green plant matter, which in turn becomes more represented than insects (Swanson & Bartonek, 1970; Sedinger, 1986). Marbled Teal faeces contained a significantly higher proportion of invertebrates, despite the fact that they were accompanied by seeds, suggesting that the proportion of ingested food (dry weight) made up of insects was much higher than for Mallard. Ducks generally increase their intake of invertebrates during the breeding season (Krapu & Reinecke, 1992) and, unlike Mallard, some Marbled Teal were still breeding during this study (Green, 1998a). However, the Marbled Teal observed where faeces were collected appeared to have completed breeding. There is considerable variation between species in the proportion of animal matter in the diet of post-breeding ducks (Hohman *et al.*, 1992).

Owing to the small sample size and difficulties identifying insect fragments in the faeces, no firm conclusions can be drawn about differences in the invertebrates selected by the two duck species. However, such differences can be expected given the observed differences in foraging ecology (Green, 1998a,b) and bill morphology. Marbled Teal have finer bill lamellae (similar to Green-winged Teal *A. crecca,* Green unpubl.) and are thus likely to select smaller prey and seeds (Thomas, 1982; Nudds & Bowlby, 1984; Nummi, 1993; Tamisier & Dehorter, 1999). This may explain the importance of the relatively small *Scirpus* seeds (mean dimensions 2.9 × 1.8 × 0.8 mm) to Marbled Teal and the greater prevalence of the relatively large *Potamogeton pectinatus* seeds (4.2 × 4.0 × 3.0 mm) in Mallard faeces. Marbled Teal took relatively small animals from those available in feeding areas, a result repeated in Spain and Morocco (Green, Sánchez & Selva, unpubl.). The absence of gastropods from the faeces of either species in this study is noteworthy, given their abundance in lake Akgöl, size (length 3-8 mm) and importance in the diet of some populations of Mallard (Swanson *et al.*, 1985) and other dabbling ducks (Krapu & Reinecke, 1992; Thompson *et al.*, 1992).

The diet of Mallard shows much variation between sites and seasons (e.g. Jorde *et al.*, 1983; Hartman, 1985; Krapu & Reinecke, 1992; Nummi, 1993). Some previous studies have also found that Mallard consumed the green parts and seeds of *Potamogeton,* whole *Chara* and *Scirpus* seeds (Anderson & Low, 1976; Cramp & Simmons, 1977).

A difference in Corixidae taxa present in the lagoon and in Akgöl enabled us to confirm that Marbled Teal roosting in one part of the lake were feeding in the lagoon. This illustrates how, when combined with the sampling of potential food items in different habitats, faecal analysis can provide information on the feeding locations used. This may be useful in the study of feeding locations used by nocturnal ducks (McNeil *et al.*, 1992; Tamisier & Dehorter, 1999).

This study provides the first detailed information about Marbled Teal diet, but not enough faeces could be collected to enable a complete description of the diet of this species. On one occasion (30 July), juveniles and ducklings were observed diving in Akgöl where grab sampling and direct observation suggested that they were feeding principally on *Chara vulgaris vars.* Further work is required to document the diet of this globally threatened species at different sites and times of the year. Faecal analysis will be an invaluable method in that work.

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