

SHORT NOTE

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Sexual differences in the diet of king cormorants at Macquarie Island

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Abstract Sexual differences in the diet of king cormorants, *Phalacrocorax albiventer*, were investigated during the 1993/1994 austral summer at Macquarie Island. The major food items, identified by otoliths in regurgitations, were demersal fish; fish mass consumed could be estimated using a wet mass–otolith length relationship. Two fish species, *Paranotothenia magellanica* and *Harpagifer georgianus*, constituted 98% of the wet mass (male and female cormorants combined). Estimated individual fish mass of *Paranotothenia magellanica* (19.6 ± 11.6 g) was greater than that of *H. georgianus* (2.8 ± 1.3 g). Total wet mass of food and number of fish in regurgitations did not differ statistically between the sexes of cormorants. However, males tended to feed on larger fish than did females.

Introduction

King cormorants *Phalacrocorax albiventer* are endemic to Macquarie Island; about 600 pairs breed among boulders on the shoreline, stacks attached to the shore, offshore stacks, or islets (Brothers 1985; N.P. Brothers personal communication). They are considered to be the only inshore, bottom-feeding seabird breeding on the island. They are sexually dimorphic, the males being 19% heavier than the females (Brothers 1985). Blue-eyed shags, *P. atriceps*, closely related to the king cormorant, show a clear sexual difference in daily foraging pattern: males forage in the morning and females in the afternoon (Bernstein and Maxson 1984).

Brothers (1985) and Green et al. (1990) reported on the diet of king cormorants from stomach regurgitations and pellets, respectively, but sexual differences were not studied. The present study investigated sexual differences in the diet of king cormorants, using otoliths collected from their regurgitations and pellets.

Materials and methods

The study was carried out at the Handspike Point Colony, Macquarie Island (54°30'S, 158°57'E), from December 1993 to February 1994. Chick-rearing adults were caught by hand at the nest. The sex of the birds was determined by their vocalization (Brothers 1985). Birds regurgitated when they were handled or held upside down. Regurgitations were collected one to three times from each individual of known sex, while pellets were collected from around nests. All samples were kept separately and frozen in plastic bags.

Regurgitations were thawed in the laboratory and sorted into major prey components, and each prey item was weighed separately. Otoliths were removed from all fish brain cases and loose fish otoliths were separated for subsequent measurement and identification. To determine regressions for estimating fish mass from otolith size, the wet masses (WM) of intact fish found in regurgitations were weighed to the nearest 0.1 g on an electronic balance. The length of each otolith removed (OL) was measured to the nearest 0.01 mm using a microscope graticule. Pellets were broken open in water and sorted, and fish otoliths were removed for species identification. Otolith identification was aided by Williams and McEldowney (1990) and Hecht (1987).

Values are indicated as mean \pm 1 standard deviation and statistical differences were examined using the Mann-Whitney *U*-test.

Result**Regurgitations**

Totals of 31 and 46 regurgitations were collected from male and female king cormorants, respectively (Table 1). Samples consisted mainly of fish; some crustacea, gastropods, bivalves and algae were also found, but they represented < 1% of total wet mass. Although 7 species of fish were identified from regurgitations,

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Table 1 Fishes identified from the regurgitations and pellets of king cormorants, Macquarie Island, 1993–1994

| | Regurgitations | | | | Pellets | |
|-----------------------------------|----------------|--------|-----------------|--------|--------------|------------|
| | Male (n = 31) | | Female (n = 46) | | % occurrence | % number |
| | % occurrence | % mass | % occurrence | % mass | (n = 42) | (n = 2609) |
| <i>Paranotothenia magellanica</i> | 97 | 95.7 | 91 | 82.2 | 100 | 41.2 |
| <i>Harpagifer georgianus</i> | 26 | 2.0 | 52 | 15.6 | 83 | 58.0 |
| <i>Notothenia rossi</i> | 3 | – | 0 | – | 0 | 0 |
| <i>Muraenolepis marmoratus</i> | 0 | – | 2 | 2.2 | 10 | 0.3 |
| <i>Gymnoscopelus</i> sp. | 3 | – | 0 | – | 5 | 0.2 |
| <i>Protomyctophum</i> sp. | 0 | – | 2 | – | 0 | 0 |
| <i>Electrona subaspera</i> | 0 | – | 0 | – | 2 | 0.04 |
| Unknown sp. | 3 | 2.4 | 0 | – | 5 | 0.2 |
| Unidentified | 0 | – | 0 | – | 7 | 0.2 |

61% (47) of all regurgitation samples consisted of a single fish species. Two fish species, the demersal *Paranotothenia magellanica* and *Harpagifer georgianus*, represented 98% by mass and 97% by frequency of occurrence.

Relationships between otolith length (OL) and wet mass (WM) plotted for *Paranotothenia magellanica* and *H. georgianus* (Fig. 1) were described by the following power curves:

$$\text{Paranotothenia magellanica: WM} = 2.4 \times \text{OL}^{3.0}$$

($r = 0.82$, $P < 0.01$, $n = 6$)

$$\text{H. georgianus: WM} = 0.22 \times \text{OL}^{2.8}$$

($r = 0.93$, $P < 0.01$, $n = 11$)

The mean estimated mass of *Paranotothenia magellanica* (19.6 ± 11.6 g, $n = 330$) was 7 times that of *H. georgianus* (2.8 ± 1.3 g, $n = 270$, $U = 9687$, $P < 0.001$).

Male cormorants ate more *Paranotothenia magellanica* and fewer *H. georgianus* than females (male: $94.3 \pm 19.0\%$, female: $81.1 \pm 32.4\%$ *Paranotothenia magellanica* by mass; $U = 483$, $P < 0.02$ and male: $2.4 \pm 6.7\%$, female: $16.7 \pm 30.1\%$ *H. georgianus*; $U = 468$, $P < 0.01$). Thus, males tended to feed on

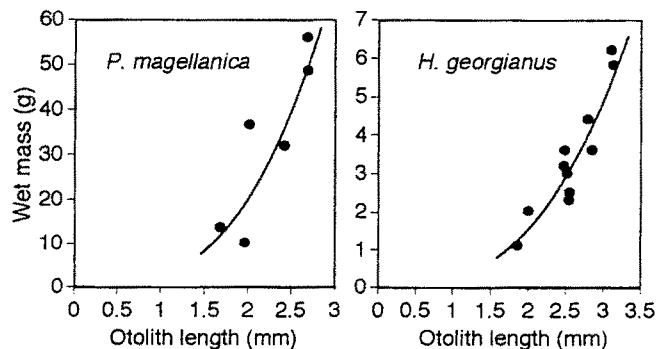


Fig. 1 Relationships between otolith length and wet mass for *Paranotothenia magellanica* and *Harpagifer georgianus* in the diet of king cormorants at Macquarie Island

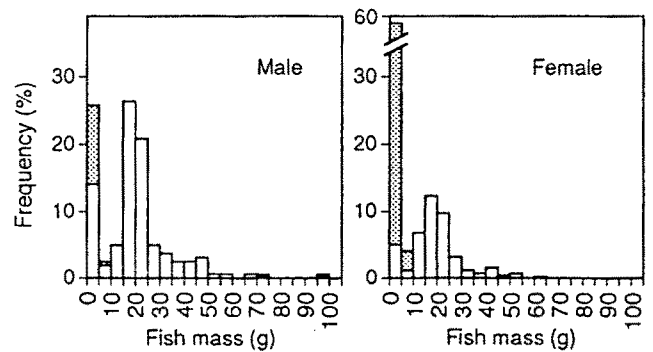


Fig. 2 Frequency distribution of fish size taken by male and female king cormorants, Macquarie Island, 1993–1994. □ *Paranotothenia magellanica*, ▨ *Harpagifer georgianus*, ■ others

larger fish than females (male: 18.7 ± 15.0 g, $n = 163$, female: 9.9 ± 10.9 g, $n = 459$; $U = 23380$, $P < 0.001$; Fig. 2). Regurgitations of females contained larger numbers of fish than did those of males, although the difference was not significant (male: 5.3 ± 5.1 , female: 9.7 ± 11.5 ; $U = 568$, NS). Therefore, total mass of food was not different between the sexes (male: 98.0 ± 86.4 g, $n = 31$, female: 96.4 ± 74.1 g, $n = 46$; $U = 687$, NS).

Pellets

A total of 42 pellets was collected; each pellet contained a mean of 62.1 ± 68.6 otoliths. Six fish species were identified (Table 1). Only six pellets (14%) were composed of a single fish species and these pellets contained a smaller number of otoliths (10.2 ± 6.0) than pellets composed of more than two species (70.8 ± 70.5 ; $U = 19$, $P = 0.001$).

Discussion

Fish otolith shape is species specific and otolith size is highly related to fish body size. The mass of

Paranotothenia magellanica was estimated to be lighter by our equation than by that of Hecht and Cooper (1986), possibly because of the difference in the range of size among fish sampled, differences in methods for sampling and preservation on fish and the small sample size in this study. The fish species that we found in the diet of king cormorants were similar to those reported by Brothers (1985) and Green et al. (1990).

To determine the diet of cormorants, we used both regurgitations and pellets (see Harris and Wanless 1993). A pellet contained 6–12 times as many otoliths as did a regurgitation and otoliths in pellets were too eroded to estimate the fish mass from their length. Regurgitations are assumed to represent the food ingested during the last foraging bout of blue-eyed shag (Wanless et al. 1992) and a shag (*Phalacrocorax aristotelis*) usually produces one or two pellets every 24 h (Johnstone et al. 1990). In the present study, 61% of regurgitation samples contained only one species of fish while 86% of pellets contained more than two species. This suggests that birds do not specialize in particular prey species but that individual birds might change their diets within a day, perhaps as a function of foraging locality and prey availability. Wanless et al. (1992) reported the relationship between diet and diving pattern and the variations in them for blue-eyed shags.

Sexual size dimorphism is common among many seabird families (Fairbairn and Shine 1993); accordingly, male king cormorants are 19% heavier than females (Brothers 1985). The diving depth of seabirds is strongly influenced by body mass (Burger 1991; Cooper 1986) and, not surprisingly, male king cormorants are known to dive deeper than females (Kato et al. unpublished data). The timing of foraging also differs between the sexes (Kato et al. unpublished data). King cormorants are bottom feeders and the maximum foraging depth represents the water depth of the foraging area. It may be that males catch larger fish because more are available at deeper depths. Birt et al. (1987) have shown that marine cormorants can deplete fish stocks in the vicinity of their colonies. If this is true also for the king cormorant, then the larger body size and greater diving

depth of males may serve to increase the amount of prey available to the population.

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