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Diet of Cape petrel *Daption capense* during the post-hatching period at Laurie Island, South Orkney Islands, Antarctica

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Abstract The diet of Cape petrel *Daption capense* was investigated at Laurie Island, South Orkney Islands (60°46'S, 44°42'W), Antarctica, in the period January–February 1996. Stomach contents of adults and regurgitate of chicks were sampled during the post-hatching period. The analysis showed that during the whole sampling period Antarctic krill and fish represented the predominant preys in terms of frequency of occurrence, forming nearly 35.8% and 64% by mass, respectively. The species *Electrona antarctica* was the most frequent fish prey. Amphipods were present in lower numbers and cephalopods were detected in the diet, but in a very small proportion. Diet composition in terms of frequency of occurrence, mass and number is compared with results of previous studies.

Introduction

Cape or Pintado petrel *Daption capense* breeds on South Georgia, South Sandwich, South Orkney, South Shetland, Bouvet, Crozet, Kerguelen, Heart, Macquarie, Balleny and Peter I Islands and at several localities on the Antarctic Peninsula and continent (Watson 1975).

The diet of this fulmarine petrel during the breeding period has been the subject of several studies, usually by

means of identification of prey items present in regurgitations (Beck 1969; Green 1986; Ridoux and Offredo 1989; Arnould and Whitehead 1991; Ridoux 1994). Only the studies by van Franeker and Williams (1992), Creet et al. (1994), and Soave et al. (in press) have been based on material obtained by stomach flushing. More recently, Soave et al. (1996) combined the stomach flushing method with analysis of regurgitations to obtain food samples.

Cape petrels are widespread on the South Orkney Islands and the breeding population is estimated to be between 10^4 and 10^5 pairs (Croxall et al. 1984). Despite the importance of this species in terms of biomass, few studies have included detailed quantitative analysis of its diet in this area (Beck 1969; Soave et al. in press).

This paper provides data on the diet of *Daption capense*, a species designated as an indicator species by the Scientific Committee of the Commission for the Conservation of Antarctic Marine Living Resources (SC-CCAMLR 1991), over the whole chick-rearing period on Laurie Island, South Orkney Islands.

Materials and methods

The stomach contents of 32 Cape petrel adults and regurgitations from 40 chicks were collected at the eastern coast of Mossman Peninsula, Laurie Island, South Orkney Islands (60°46'S, 44°42'W) from 11 January to 20 February 1996. Approximately 1,450 pairs of Cape petrel breed at Mossman Peninsula (N.R. Coria unpublished work).

Food samples were collected at approximately weekly intervals from the beginning of the chick-brooding period until the early stage of the chick-fledging period. In 1996, the first Cape petrel hatched on 9 January and the first one fledged on 12 February. The length of the brooding period ranges around 12–22 days.

Stomach flushing was used to obtain stomach contents from adults during the brooding period. During the post-brooding period, when it is difficult to collect food samples from adults, regurgitations of chicks were also sampled.

Samples were collected from adult birds when they returned to feed their chicks after foraging at sea. Only birds with seemingly full stomachs when handled were sampled. Stomach content

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samples were collected from breeding adults by the water-off-loading method (Wilson 1984). Two flushes were performed. Before flushing, Cape petrels regurgitate oily food material as soon as they are handled, as observed in other dietary studies (e.g. Green 1986). Regurgitates of adults were collected and included in stomach content samples. After collection, stomach contents were drained and preserved in 70% ethanol until analysis.

Chick regurgitations were collected by using a funnel (18-cm diameter) mounted on a stick; the material was retained in polythene bags tied to the neck of the funnel.

In the laboratory, samples were filtered through sieves of 0.5-mm mesh, blotted dry and weighed to the nearest 0.1 g. "Oil" residues, if present, were drained, weighed and discarded.

Contents were sorted into fish, krill, amphipods, octopods or unidentified components using a binocular stereo microscope. Individuals represented by intact specimens and semidigested remains (krill eyes, fish eye lenses) of each prey taxon were counted. The length of euphausiid bodies, telsons and uropods was used to estimate prey body size. The size of the consumed Antarctic krill was calculated using the regression formulae $BL = 11.86458 + 5.595021EL$ (where BL = body length and EL = length of uropod exopodite) and $BL = 10.05732 + 4.251469TL$ (where TL = length of telson) (E. Marschoff, unpublished work).

The minimum number of fish was determined by counting eye lenses or otoliths. Otoliths were examined microscopically and, when possible, identified by comparison with a reference collection of otoliths from known species stored at the Instituto Antártico Argentino, and by using keys to Southern Ocean fish otoliths (Hecht 1987). Amphipods were identified to species level in few cases.

All identified material was analysed by frequency of occurrence, number of individuals and mass. These data were calculated for pooled stomach samples.

Results

The mean mass of stomach samples obtained from adult birds was 25.2 g (SD 14, range 3.3–56 g; $n = 32$). The mean number of prey individuals was 58.7 (SD 15.6, range 3–304).

Regurgitations obtained from chicks had a mean mass of 19.7 g (SD 12.6, range 3.1–53 g; $n = 40$), which was not significantly different from the value measured for adults ($t = 1.749$, $df = 70$, $P > 0.05$).

Euphausiids and fish represented the predominant preys in terms of frequency of occurrence during the whole sampling period. Fish formed nearly 64% by mass, and krill 35.8% (Table 1).

Antarctic krill *Euphausia superba* was the only crustacean species occurring in all samples. The mean body length of Antarctic krill was 39.9 mm (SD = 6.73; range = 26.2–56 mm; $n = 64$).

Amphipods were present in lower numbers and ranged in size from 9 to 37 mm (mean 16.2 mm, SD 6.3, $n = 31$). The hyperiids *Themisto gaudichaudii* and *Cylopus lucassi*, as well as the gammariids *Pontogeneiella antarctica* and *Eurithenes* sp., were found in a few samples.

Fish otoliths were present in 58% of the 72 food samples containing prey remains. A total of 164 otoliths was collected from food samples with an average of 2.3 otoliths per sample. Of the total number of otoliths retrieved, 87.2% belonged to myctophids and the rest to

Table 1 Composition of the diet of *Daption capense* at Laurie Island, South Orkney Islands based on stomach contents and regurgitations. (F%) Percentage by frequency of occurrence; (No.%) percentage by number

		F%	No.%	Mass%
<i>Adults (n = 32)</i>				
Stomach contents	Krill	100.0	90.4	35.0
	Fish	100.0	8.5	64.7
	Amphipods	56.2	1.0	0.2
	Octopods	3.1	0.1	0.1
<i>Chicks (n = 40)</i>				
Regurgitations	Krill	100.0	93.9	36.5
	Fish	100.0	5.2	62.5
	Amphipods	30.0	0.9	1.0
	Octopods	0	0	0
<i>Total (n = 72)</i>				
	Krill	100.0	92.2	35.8
	Fish	100.0	6.9	63.6
	Amphipods	34.7	0.9	0.6
	Octopods	1.4	<0.1	<0.1

unidentified fish. The lengths of the otoliths indicate that the ingested fish ranged from 35 to 171 mm in total length, and had weighed from 0.6 to almost 19.9 g. The species *Electrona antarctica* was the most frequent fish prey. A list of fish species that were identified based on otoliths found in food samples is given in Table 2.

Cephalopods only constituted a very small portion of the diet of Cape petrel at Laurie Island.

Discussion

The mean mass of stomach contents of Cape petrels collected at Laurie Island (25.2 g) was similar to that of samples collected on the South Shetland Islands by Creet et al. (1994) (30 g, SD 16.6), but higher than reported by Soave et al. (1996) (12 g, SD 11.8, at Fildes Peninsula and 13.8 g, SD 10.2, at Harmony Point). Cape petrel stomach samples collected at Laurie Island in 1996 were also heavier than those collected by Soave et al. (in press) at the same locality in 1995. Observed differences in food size between localities may reflect

Table 2 Composition of the fish component of the diet of *Daption capense* at Laurie Island

Taxa	% F ^a	Otoliths ^b	
		Number	%
Myctophidae			
<i>Electrona antarctica</i>	92.3	122	74.4
<i>Krefflichthys anderssoni</i>	9.5	8	4.9
<i>Gymnoscopelus braueri</i>	14.3	9	5.5
<i>Gymnoscopelus nicholsi</i>	2.4	2	1.2
Unidentified myctophids	2.4	2	1.2
Unidentified fish	21.4	21	12.8

^a Frequency of occurrence on basis of 42 samples in which identifiable material was detected

^b Based on the 164 otoliths obtained

Table 3 Diet of Cape petrels at different breeding localities of the Scotia Arc (*T* trace)

Locality	Diet by mass (%)				References
	Euphausiids	Fish	Amphipod	Other	
<i>South Orkney Islands</i>					
Signy Island	64	15		21	Beck 1969
Laurie Island	97.2	1.8	< 0.5	0.9	Soave et al. in press
Laurie Island	35.8	63.6	0.6	T	This study
<i>South Shetland Islands</i>					
King George Island	9	67	23	T	Creet et al. 1994
King George Island	71.2	25.5	2.5	0.8	Soave et al. 1996
Nelson Island	41.6	45.2	13.2	0	Soave et al. 1996

differences in sampling techniques, local differences in the availability of food and, perhaps, different stages of the breeding cycle.

Weight of regurgitations of Cape petrels was higher than those values reported in other studies (Green 1986; Ridoux and Offredo 1989; Arnould and Whitehead 1991, Soave et al. 1996). Such differences may be caused by different sampling or estimation methods and/or local variation in food availability and abundance.

A number of dietary studies of Cape petrels during the breeding season were carried out (for review, see Soave et al. in press). Table 3 compares the diet of Cape petrels at different breeding localities of the Scotia Arc. On the South Orkney Islands (Beck 1969; Soave et al. in press) these birds fed predominantly on krill (64% and 97.2% by mass, respectively). At Fildes Peninsula, on King George Island (Soave et al. 1996), krill was also the most important constituent of the diet, while at Harmony Point (Soave et al. 1996) fish slightly predominated over krill. In general, our results are similar to those obtained at Demay Point (Creet et al. 1994) where fish were by far the main prey, although the contribution of other components to the diet varied. The crustacean component of the diet seems to make the most important difference between the two localities, since at Demay Point it is usually represented by amphipods, while in this study it was predominantly krill.

The fish component of the diet of Cape petrel at Laurie Island was dominated by pelagic myctophids, particularly *Electrona antarctica*. This is consistent with results from a recent study carried out on the South Shetland Islands (Soave et al. 1996). In contrast, other studies had reported nototheniids as forming the bulk of the fish portion. Thus, *Pleuragramma antarcticum* was the most frequent fish species in Prydz Bay (Arnould and Whitehead 1991), at Ardery Island (van Franeker and Williams 1992) and at Demay Point (Creet et al. 1994). *Pagothenia borchgrevinki* and *Trematomus* sp. were also found in Prydz Bay (Green 1986).

The impact of predators on myctophid populations in the Southern Ocean ecosystem is not well understood (Kozlov 1995). However, published data show that myctophids play an important role in the diet of Antarctic penguins, especially in the vicinity of Antarctic and sub-Antarctic islands (Williams 1988; Croxall et al. 1990).

Sabourenkov (1991) suggested that the presence of myctophid otoliths in the stomachs of flying seabirds might indicate that these fishes were direct prey items or that they could indirectly occur in birds' stomachs via the diet of another primary prey, such as nototheniids, channichthyid fish or squid. In our study these fish species did not occur in the diet of Cape petrels, and the presence of squid was negligible, which indicates that myctophid fishes are caught by Cape petrels.

The marked dominance of pelagic myctophids in the diet of Cape petrels at Laurie Island suggests that this group of fish plays a significant role in this area.

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