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Source: Acta Ornithologica, 35(2) : 191-195

Published By: Museum and Institute of Zoology, Polish Academy of Sciences

URL: https://doi.org/10.3161/068.035.0212

ACTA ORNITHOLOGICA
Vol. 35 (2000) No. 2

Diet of Cape Petrel *Daption capense* chicks on South Shetland Islands, Antarctica

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Soave G., Coria N., Silva P., Montalti D., Favero M. 2000. Diet of Cape Petrel *Daption capense* chicks on South Shetland Islands, Antarctica. Acta orn. 35: 191–195.

Abstract. The diet of the Cape Petrel was investigated in two localities of South Shetland Islands, Antarctica, over the period January–February 1996. Stomach contents of adults obtained by flushing and regurgitates of chicks were sampled during the chick-rearing period. During the whole sampling period, euphausiids represented the predominant prey in terms of frequency of occurrence, mass and number at Fildes Peninsula, while at Harmony Point, euphausiids and fish components were found in similar proportions in terms of mass and frequency. Myctophiids fish, in particular *Electrona antarctica*, formed the bulk of the fish component. The analysis of the diet throughout the breeding season showed significant differences in number and mass of the prey items at Fildes Peninsula, while at Harmony Point, there were significant differences also in the occurrence of preys. Considering both localities, although the occurrence of the prey did not vary significantly during the brooding period, there were significant differences in their number and mass. Similar results were found in the post-brooding period between both localities.

Key words: Cape Petrel, *Daption capense*, diet, South Shetland Islands, Antarctica

Received — March 2000, accepted — Aug. 2000

INTRODUCTION

The Cape Petrel has a very extensive breeding and feeding range, and nests rather sparingly in the mainland and offshore islets of Antarctica, north to the Iles Crozets at 46°S (Warham 1990). Most of the previous studies on Cape Petrel diet were carried out only at some localities, usually involving relatively few birds of unknown status, collected offshore (Falla 1937, Bierman & Voous 1950, Mougin 1975, Ainley et al. 1984), and at breeding sites (Beck 1969, Green 1986, Ridoux & Offredo 1989, Arnould & Whitehead 1991, Van Franeker & Wiliams 1992, Creet et al. 1994, Ridoux 1994, Soave et al. 1996, Coria et al. 1997). All available information on diet at breeding sites seem have been obtained largely from analysis of regurgitation of adults and chicks of this fulmarine petrel. Only the studies by Van Franeker & Williams (1992), Creet et al. (1994), Soave et al. (1996) and Coria et al. (1997) have been based on the analysis of stomach flushing. In this study we provide information on diet of chicks and on its seasonal variation in two localities of South Shetland Islands. We also discuss different sampling techniques for obtaining food samples.

STUDY AREAS AND METHODS

Our study was conducted in the South Shetland Islands at Fildes Peninsula, in southern King George Island (62°12'S, 58°58'W), and at Harmony Point in western Nelson Island (62°18'S, 59°14'W), over the period January–February 1996. Approximately 1500 pairs of the Cape Petrel breed at Fildes Peninsula (Soave et al. 2000) and 479 pairs at Harmony Point (Silva et al. 1998).

Cape Petrels arrive ashore to breed in early September; eggs are laid in late November; chicks

hatch in the first half of January. In 1996 the first Cape Petrel hatched on 7 January at Fildes Peninsula and on 9 January at Harmony Point. The length of the brooding period varies around 8 to 20 days in both places.

The stomach flushing technique was used for obtaining stomach contents from adults during the brooding period. During the post-brooding period, when feeding becomes irregular, regurgitations from chicks were also sampled.

Number of samples taken are: by stomach flushing of adult birds (n = 17) and regurgitations of chicks (n = 20) at Fildes Peninsula, and by stomach flushing of adult birds (n = 20) and regurgitations of chicks (n = 18) at Harmony Point.

Samples were collected from adult birds as they returned to feed their chicks after foraging at sea. Only birds with seemingly full stomachs when handled were sampled. Stomach content samples were collected from breeding adults by the non-destructive method of water off-loading (Wilson 1984). Two flushes were performed. Before flushing, petrels regurgitate oil and food material as soon as they are disturbed (e.g. Beck 1969). This regurgitated material of adults and chicks was collected and included in stomach content samples. After collection, stomach contents were drained and preserved in 70% ethanol until analysis. Stomach contents weighing <1 g (usually with only a few krill eyes or fish flesh) were not included in calculation of food mass.

Regurgitations were collected by using a funnel (18 cm diameter) mounted on a stick, retaining the material in polythene bags tied to the neck of the funnel. Birds were approached as close as 1m, and the funnel was held below the bill. Regurgitation usually followed immediately, and birds were then gently prodded until no more food was produced (Beck 1969).

In the laboratory, samples were filtered through sieves of 0.50-mm mesh, blotted dry and weighed to the nearest 0.01g. "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. Prey specimens were rarely complete, thus requiring counts of krill eyes and uropods in order to enumerate prey. Length of euphausiid bodies, telsons and uropods was used to estimate prey body size. The size of the consumed Antarctic Krill *Euphausia superba* was calculated using the regression formula (E. Marschoff, unpublished): 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).

The minimum number of fish was determined using counts of eye lenses or otoliths. Otoliths were examined microscopically and, whenever possible, identified by using keys to Southern Ocean fish otoliths (Hecht 1987).

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

RESULTS

Total stomach contents (Table 1) weighed on average 9.9 ± 13.4 g (range 1.2–57 g; n = 17) at Fildes Peninsula, and 13.8 ± 10.2 g (range = 1.2–46.3 g; n = 20) at Harmony Point. Mean prey individuals were 31 ± 39 (range = 2–160) and 13 ± 11 (range = 1–42), respectively.

Table 1. Composition (percentage of frequency) of the prey items of the diet of Cape Petrel chicks at Fildes Peninsula (n = 37) and Harmony Point (n = 38).

Taxa	Fildes	Harmony
Crustaceans		
Euphausiacea		
Euphausia superba	100.0	89.5
Amphipoda		
Themisto gaudichaudii	10.8	5.4
Pontogeneiella antarctica	13.5	36.8
Eurythenes grillus	–	8.1
Hiperidean amphipods	2.7	2.7
Gamaridean amphipods	2.7	5.4
Cephalopods		
Gonatus antarcticus	2.7	–
Unidentified cephalopods	5.4	–
Fish		
Electrona antarctica	40.5	23.7
Electrona carlsbergi	5.4	–
Krefftichthys andersonni	2.7	2.7
Protomyctophum bolini	2.7	–
Gymnoscopelus braueri	2.7	–
Unidentified Myctophidae	–	5.3
Unidentified fish	–	10.5

Regurgitations of chicks weighed on average 9.7 ± 8.8 g (range = 0.3–31.1 g; n = 20) and 9.5 ± 11 g (range = 0.7–40 g; n = 18), and mean number of prey 30 ± 52 items (range = 2–156) and 80 ± 167 items (range = 1–684) at Fildes Peninsula and Harmony Point, respectively.

Euphausiids represented the predominant prey in terms of the frequency of occurrence, mass and number at Fildes Peninsula during the whole sampling period, while at Harmony Point, euphausiids

and fish components were found in similar proportions in terms of mass and frequency (Table 2).

Table 2. Diet composition of the Cape Petrel at Fildes Peninsula (FP) and Harmony Point (HP), as shown by the analysis of stomach contents and regurgitations. F — frequency of occurrence, N — percentage composition by number, M — percentage composition by mass, T — insignificant share.

	F		N		M	
	HP	FP	HP	FP	HP	FP
Adults						
Krill	95.0	100.0	85.7	93.4	49.5	81.9
Fish	90.0	94.1	8.8	5.8	49.5	18.1
Amphipods	15.0	23.5	5.5	0.8	1.0	T
Chicks						
Krill	83.3	100.0	7.6	50.9	28.4	62.4
Fish	88.8	90.0	1.6	14.3	38.0	32.5
Amphipods	88.8	30.0	90.8	34.8	33.6	5.1
Total						
Krill	89.5	100.0	20.1	71.7	41.6	71.5
Fish	89.5	94.6	2.7	9.5	45.2	25.8
Amphipods	42.1	27.0	77.1	18.8	13.2	2.7

Antarctic Krill was the only euphausiid species identified in the samples. There was no significant difference in the mean size of krill taken between Fildes Peninsula (44.6 mm, ± 6, n = 17) and Harmony Point (42.3 mm ± 3.6 mm, n = 31) (t = 1.664, ns).

Amphipods comprised the rest of the crustacean component for each locality. The gammarid *Pontogeneiella antarctica* was present in many the samples, and ranged in size from 9 to 14 mm (mean 10.3 mm ± 1.8, n = 107).

Fish remains were regularly found throughout the sampling period; all identified fish were referable to the family Myctophidae (lanternfish). Otoliths indicated that the ingested fish measured about from 20 to 97 mm in total length, and weighed 0.9 to almost 7 g at both localities. The species *Electrona antarctica* was the most frequent fish prey, especially at Fildes Peninsula.

Cephalopods formed a minor part of the chick regurgitations at Fildes Peninsula and only one beck was collected, from *Gonatus antarcticus*. Algal fragments, mollusc shell fragments, stones and parasites of fish were also occasionally found, but are not considered as food items.

The diet composition as reflected by the analysis of adults stomach content and chick regurgitations at Fildes Peninsula showed significant differences in number and mass of the items (χ^2 = 311.1, df = 2, $p < 0.00001$; χ^2 = 24, df = 2, $p < 0.00001$ respectively). Although krill was the main prey items in brooding and post-brooding periods, fish were frequently found, with mass percentages above 30% over the post-brooding period. At Harmony Point, there were significant differences in the occurrence, number and mass of prey items in the diet throughout the breeding season (χ^2 = 12.3, df = 2, $p < 0.0021$; χ^2 = 1891.5, df = 2, $p < 0.00001$; χ^2 = 57.8, df = 2, $p < 0.00001$ respectively). Proportions by mass between fish and krill were similar during the brooding period, though krill decreased during the post-brooding period. Amphipods were a common component during the post-brooding period in both breeding sites (Table 3).

Although, the frequency of occurrence of the prey found in samples did not vary significantly during the brooding period between both localities (χ^2 = 0.94, df = 2, ns), there were significant differences in their number and mass (χ^2 = 27.13, df = 2, $p < 0.00001$; χ^2 = 49.9, df = 2, $p < 0.00001$ respectively). Similar results were found when comparing the post-brooding period between both localities (χ^2 = 3.30 df = 2, ns; χ^2 = 453.3, df = 2, $p < 0.00001$; χ^2 = 68.5, df = 2, $p < 0.00001$ by frequency, number and mass, respectively).

Table 3. Frequency of occurrence (F), percentage composition by number (N) and by mass (M) of prey taken during brooding and post-brooding periods. T — insignificant share.

	Fildes Peninsula						Harmony Point					
	Brooding (n = 19)			Post-brooding (n = 18)			Brooding (n = 16)			Post-brooding (n = 22)		
	F	N	M	F	N	M	F	N	M	F	N	M
Krill	100	93.3	83	100	47.9	59.5	100	89.5	51.4	82	11.0	39.6
Fish	95	6.0	17	94	15.4	34.9	87.5	9	46.1	91	2.0	47.8
Amphipods	17	0.7	T	33	36.7	5.6	6.3	1.5	2.5	68	87.0	22.6

DISCUSSION

Arnould & Whitehead (1991) stated that regurgitations might not provide an accurate representation of the proportion of prey items. Creet et al. (1994) supported this conclusion and emphasized the importance of obtaining complete stomach samples. On the

other hand, individual birds may differ in their willingness to regurgitate, depending on stomach fullness or perhaps on stomach contents (Duffy & Jackson 1986). However, during the post-brooding period, when it is difficult to collect food samples from adults, regurgitations of chicks can be a useful way to carry out dietary studies of the Cape Petrel.

Mean masses of stomach contents of petrels collected at Fildes Peninsula (9.9 g) and Harmony Point (13.8 g) were less than those reported by Creet et al. (1994) at Demay Point, King George Island (30 g, n = 12) and Coria et al. (1997) at Laurie Island (South Orkney Island) (25.2 g n = 32). Such variation may reflect differences in collection techniques, consideration of stomach oil and/or differential local food availability and abundance.

Regurgitations of Cape Petrels were similar in weight to those reported in other studies (Green 1986, Ridoux & Offredo 1989, Arnould & Whitehead 1991).

The comparison of the diet between the two sampling periods at both localities showed significant differences. The importance of euphausiid prey decreased over the breeding period. Furthermore, consumption of fish at Fildes Peninsula increased markedly during the post-brooding period. The data presented here come from and area where krill is abundant, as also in the study area (Kawaguchi et al. 1997). However, myctophiids fish were an important prey, particularly if it is considered that the energy content of these fish is higher that of krill (Cherel & Ridoux 1992). The presence of myctophiids in the diet of Cape Petrel at two sampling sites is explained in detail in Casaux et al. (1998).

The presence of large amounts of amphipods in the records of the post-brooding period at both localities was similar to that observed at the same study area in 1997 breeding season (G. Soave unpublished data). These findings suggest a local phenomena of differential availability of this prey and/or a different foraging strategy during the post-brooding period.

A number of dietary studies of petrels were undertaken during the breeding season. In most of these quantitative studies, these birds fed largely euphausiids (Beck 1969, Green 1986, Ridoux & Offredo 1989, Arnould & Whitehead 1991, Soave et al. 1996). However in many studies fish were the most important prey (Van Franeker & Williams 1992, Creet et al. 1994, Coria et al. 1997).

Our study reported differences in the proportion of prey caught by this bird at two nearby localities in the South Shetland Islands, using equal sampling techniques. At Fildes Peninsula, krill was the most important constituent of the diet, followed by fish, while at Harmony Point, fish slightly predominated over krill. It is likely that such differences generally reflect differential local availability of preys.

It is evident from published accounts that the diet of the Cape Petrel varies with locality, time of season or year. Several studies have reported that Cape Petrels display various feeding techniques including surface seizing, shallow plunges, filter feeding, scavening (Harper et al. 1985, Warham 1990, Ridoux 1994). These facts support the idea that this bird is an opportunistic surface feeder and that the availability of certain prey is the principal factor to explain variations in diet composition.

ACKNOWLEDGMENTS

This research was supported by the Argentine Antarctic Institute (IAA), and was conducted in the frame of Protocols for Collaboration between IAA and the Scientific Department Vertebrate Zoology of the University of La Plata.

G. E. Soave paricipated in the research as member of the Scientific Investigation Commission of Buenos Aires Province (CIC), under the direction of Dr. Hugo L. Lopez.

We are grateful to T. Curtosi for the assistance in the field. F. Momo, who identified amphipods and R. Casaux for his help in the identification of fish otoliths, V. Ferretti and M. Libertelli for assistance in the laboratory. We are particularly grateful to J. Valencia and an anonymous referee for critically commenting on the manuscript.

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STRESZCZENIE

[Skład pokarmu piskląt petrela warcabnika na Szetlandach Południowych]

Badania prowadzono w okresie od stycznia do lutego 1996 r. na półwyspie Fildes (Wyspa Króla Jerzego) i w Harmony Point (Wyspa Nelsona).

Dane o składzie pokarmu dostarczanego pisklętom petrela uzyskiwano za pomocą wypłukiwania zawartości żołądków dorosłych ptaków i wywołując regurgitacje u młodych osobników.

Średnia masa zawartości żołądków (Tab. 1) ptaków gnieżdżących się na płw. Fildes wahała się od 1.2–57 g (śr. 99 ± 13.4 g), w Harmony Point 1.2–46.3 g (śr. 13.8 ± 10.2 g). Średnio w żołądkach znajdowano, odpowiednio 31 ± 39 (od 2 do 160) i 13 ± 11 (1–42) ofiar. Masa materiału otrzymywanego dzięki regurgitacji piskląt wynosiła na Wyspie Króla Jerzego śr. 9.7 ± 8.8 g (stwierdzano w nim 30 ± 52 ofiar) i 95 ± 11 g na Wyspie Nelsona (liczba ofiar — 80 ± 167).

W pokarmie piskląt na półwyspie Fildes zdecydowanie dominowały eufauzje (a wśród nich kryl antarktyczny), na drugim z badanych stanowisk eufauzje współdominowały z rybami (Tab. 2). Wszystkie zidentyfikowane gatunki należały do świetlikowatych. Obunogi stanowiły częsty składnik na obu stanowiskach.

Skład pokarmu piskląt warcabników na półwyspie Fildes wykazał znaczące różnice w liczbie i wadze ofiar (odpowiednio $\chi^2 = 311.1$, df = 2, $p < 0.00001$; $\chi^2 = 24$, df = 2, $p < 0.00001$). Mimo iż kryl stanowił podstawowy składnik pokarmu w czasie całego okresu lęgowego, ryby były częściej stwierdzane (ponad 30% masy) pod koniec sezonu. W Harmony Point stwierdzono istotne różnice w występowaniu, liczbie i masie ofiar w pokarmie w czasie całego sezonu lęgowego (odpowiednio $\chi^2 = 12.3$, df = 2, $p < 0.0021$; $\chi^2 = 1891.5$, df = 2, $p < 0.00001$, $\chi^2 = 57.8$, df = 2, $p < 0.00001$). Udział kryla i ryb w diecie piskląt petrela był podobny przez cały czas badań, chociaż pod koniec tego okresu udział kryla w pokarmie wzrósł (Tab. 3).