Summer diet of the Salvin's prion at sub-Antarctic Marion Island

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Thirty-nine food samples were collected from Salvin's prions *Pachyptila salvini* at sub-Antarctic Marion Island, Prince Edward Islands. The diet was dominated by crustaceans which formed 44,2% of the mass, 99,7% of prey items and occurred in 97,4% of the samples. Amphipods were of particular importance, the most abundant species being *Themisto gaudichaudii.* There was a marked absence of copepods which are an important element in the diets of both the dove *P. desolata* and broad-billed prions *P. vittata.* Prey included fish (41,9% by mass) and cephalopods. The results are compared with published data for dove, Salvin's and broad-billed prions collected at other islands, and with data from Marion Island for blue petrels *Halobaena caerulea.*

Nege-en-dertig voedselmonsters is van mediumbekwalvisvoëls *Pachyptila salvini* by sub-Antarktiese Marioneiland, Prince Edward-Eilande, versamel. Die dieet is deur skulpdiere oorheers, wat 44,2% van die massa en 99,7% van die prooi-items gevorm het en met 'n frekwensie van 97,4% voorgekom het. Amphipoda was van besondere belang, met *Themisto gaudichaudii* die belangrikste soort. Daar was 'n merkbare afwesigheid van Copepoda, wat 'n belangrike element in die dieet van duifwalvisvoëls *P. desolata* en breëbekwalvisvoëls *P. vittata* is. Prooi-items het vis (41,9% volgens massa) en koppotiges ingesluit. Die resultate word met gepubliseerde data vir duifwalvisvoëls, mediumbekwalvisvoëls en breëbekwalvisvoëls wat by ander eilande versamel is, vergelyk asook met data van bloustormvoëls *Halobaena caerulea* wat by Marioneiland versamel is.

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The Salvin's prion *Pachyptila salvini (sensu* Harper 1980) is known to breed at the Crozet Islands (46°25'S / 51°50'E) (Jouventin, Stahl, Weimerskirch & Mougin 1984) and the Prince Edward Islands (46°52'S / 37°51'E) (Berruti & Hunter 1986), in the southern Indian Ocean. Breeding takes place during the austral summer with the birds dispersing and becoming oceanic over winter (Serventy, Serventy & Warham 1971). Despite being relatively abundant in the southern Indian Ocean the species has been little studied, and no quantitative diet studies have been previously carried out, although there are some published reports on diet (Falla 1937; Bierman & Voous 1950; Mougin 1975; Grindley & Lane 1979; Harper 1980; Imber 1981).

This paper presents the results of a quantitative study on the diet of the Salvin's prion at Marion Island, Prince Edward Islands.

Methods

On 23 and 24 February 1985, 26 birds were collected soon after being killed by sub-Antarctic skuas *Catharacta antarctica,* near the meteorological base. The stomach contents were identified as far as possible, counted, and weighed where applicable. Of the birds collected, only one contained fresh food, two were totally empty and the remaining 23 contained only the hard remains of prey species (cephalopod beaks and otoliths).

A further 38 stomach samples were collected by mist netting adults returning to feed chicks on 10 nights between 13 January and 27 February 1987. Mist netting was carried out in the vicinity of the meteorological base at Transvaal Cove and at Laekop near the north coast of the island. Once trapped in the net most birds readily regurgitated their crop contents and samples were collected using a 300 mm plastic funnel (see Prince 1980). These samples were weighed to the nearest 0,5 g and then frozen for later analysis in the laboratory.

During analysis, any stomach oil present was decanted from the sample and weighed to the nearest 0,1 g. Crustacean prey items were identified where possible using Barnard (1969), Bowman & Gruner (1973) and Kirkwood (1982) as references. Otoliths and squid beaks were compared with specimens in the reference collections of the Port Elizabeth Museum. Identified prey items were then counted and weighed to the nearest 0,1 g. The total lengths of crustaceans were measured in millimetres under a dissecting microscope fitted with a graticule, or by hand with a steel rule. Regressions cited in Brown & Klages (1987) were used to calculate the mass, standard length of fishes and dorsal mantle length of squid ingested. Any plastic material among the stomach contents was noted. Thus, diet analysis was by mass, relative abundance and the frequency of occurrence of prey species.

Results

Full stomach samples

Total mass of the 39 full stomach samples collected was 566,6 g, of which 133,6 g (23,6%) was identifiable material, the composition of which is shown in Table 1. The mean mass of the stomach contents was 14,5 ±

Table 1 Composition of the summer diet of Salvin's prions at Marion Island, 1985–87 (N = 39)

	Frequency of occurrence		Number of items		Mass (g)	
Prey species	*N*	%	*N*	%	M	%
Crustaceans	38	97,4	6 576	99,7	53,9	44,2
Cephalopods	13	33,3	13	0,2	16,9	13,9
Fish	20	51,3	9	0,1	51,1	41,9
Total	39		6 598		121,9	
Oil	14	35,9			11,7	

9,9 g, and ranged from 0,5 g to 52,0 g. The major classes of prey item are discussed below.

Crustaceans

Crustaceans occurred in all but one of the samples (97,4%), and comprised the largest proportion by mass in the diet (44,2%). By numbers, the diet was totally dominated by crustaceans which comprised 99,7% of all prey items. The detailed composition of the crustacean element in the diet is shown in Table 2. Within the crustacea the most important taxon was the Amphipoda (73,7% of crustacean mass), which included several species. The majority of amphipods belonged to the Hyperiidae including *Hyperiella* sp., *Vibilia* sp., *Cyllopus* sp. and the single most important prey species *Themisto gaudichaudii*, which comprised 29,5% of the mass, 20,5% of identified items and occurred in 79,5% of samples. The mean length of ingested *T. gaudichaudii* was 17,6 mm (SD = 3,1 mm, N = 80). Euphausiids were also important in the diet, making up 25,4% of the crustacean mass (Table 2).

Table 2 Composition of the crustacean element in the diet of Salvin's prions at Marion Island

	Frequency of occurrence		Number of items		Mass (g)	
Prey species	*N*	%	*N*	%	M	%
Euphausiacea	21	53,8	684	10,4	13,7	25,4
Euphausia vallentini	9	23,1	320	4,9	13,6	25,2
Euphausiid sp.	12	30,8	364	5,5	0,1	0,2
Ostracoda	1	2,6	69	1,0	0,5	0,9
Ostracod sp.	1	2,6	69	1,0	0,5	0,9
Amphipoda	36	92,3	5 823	88,5	39,7	73,7
Themisto gaudichaudii	31	79,5	1 354	20,6	35,9	66,6
Vibilia propinqua	2	5,1	12	0,2	0,3	0,6
Hyperiella sp.	18	46,2	4 447	67,6	3,1	5,8
Cyllopus sp.	2	5,1	4	0,1	0,1	0,2
Gammaridea sp.	1	2,6	3	<0,1	<0,1	-
Lysiannassidae sp.	3	7,7	3	<0,1	0,3	0,5
Total	39		6 576		53,9	

Fish

Fish are an important element in the diet of Salvin's prions at Marion Island, occurring in 51,3% of samples and comprising 41,9% by mass of the stomach samples collected. Most of the fish remains consisted of eye lenses, scales, bones and partly digested flesh and as such were not identifiable to species. Eighteen otoliths, found in five of the samples, were of three *Electrona carlsbergi* and six *Protomyctophum tenisoni* (Myctophidae), common lantern fishes around Marion Island (Adams & Klages 1987). The calculated mean standard length of *P. tenisoni* was 55,3 mm (SD = 8,9 mm; N = 6; range = 40,7 – 68,5 mm), and the calculated mean mass was 2,5 g (SD = 1,1 g; N = 6; range = 1,0 – 4,4 g). The calculated standard lengths of two specimens of *E. carlsbergi* were 83,2 mm and 58,2 mm.

Cephalopods

Cephalopods occurred in 33,3% of the samples collected and made up 13,6% of the diet by mass. All remains were squid of the family Onychoteuthidae but were not further identifiable. The mean lower rostral length of squid beaks collected was 1,1 mm (SD = 0,5 mm; N = 4; range = 0,8 – 1,8 mm), with a calculated mean dorsal mantle length of 20,7 mm (SD = 17,1 mm; N = 4; range = 7,9 – 45,7 mm) and a calculated mass of 1,5 g (SD = 2,0 g; N = 4; range = 0,4 – 4,5 g).

Oil

Oil occurred in 14 samples (35,9%), in amounts ranging from mere traces up to 3,8 g. The mean mass of oil, in those samples which contained it, was 0,8 ± 1,3 g.

Other material

Small pieces of plastic were found in two samples and a single unidentified insect abdomen in one.

Other samples

Fifty-six upper and 53 lower squid beaks were found in 20 (87,0%) of the 23 samples collected in 1985. All were too worn to be identified. Fish remains occurred in 20 samples (87,0%), and consisted of 161 eye lenses and four otoliths. The otoliths were identified as belonging to fishes of the family Melamphaidae, either *Sio nordenskjoldii* or *Melamphaes* sp. These are relatively small bathypelagic fishes.

Discussion

Comparison with previously published data

Previous records of Salvin's prion diet mention amphipods, euphausiids, small fish, cephalopods, pteropods and small crustaceans such as *Themisto gaudichaudii* and *Cavolina tridentata* (Falla 1937; Bierman & Voous 1950; Serventy *et al.* 1971; Mougin 1975; Watson 1975; Grindley & Lane 1979; Harper 1980; Miller 1985; Prince & Morgan 1987). However, these records are based on a small number of samples. Our findings are essentially similar to the previously

published data since all prey classes recorded, apart from pteropods, were found (Tables 1 and 2).

Surveys of the plankton in the sea around the Prince Edward Islands indicate that *T. gaudichaudii* predominate (Miller 1982). Thus, the importance of this species in the diet of Salvin's prions from the islands is not unexpected.

The proportion of cephalopods in the diet shows a marked difference according to sampling technique. The dissected samples, which contained only the hard remains of prey, grossly over-emphasized the cephalopod element in the diet, in comparison to the full stomach samples (87,0% occurrence versus 33,3% and 40,9% versus 0,2% of prey items). It has been found that cephalopod beaks persist for longer in seabird stomachs than do crustacean and even fish remains, including otoliths (Furness, Laugksch & Duffy 1984). Species of Onychoteuthidae known to occur around Marion Island include *Kondakovia longimana* and *Moroteuthis* sp. which have been noted in the diet of other seabirds at Marion Island (e.g. Berruti & Harcus 1978; Schramm 1986; Adams & Klages 1987; Brown & Klages 1987).

Plastic particles are commonly found in seabird stomachs and have been previously reported in Salvin's prions from Marion Island (Ryan 1988). Insects have also been found in the stomachs of similarly sized blue petrels *Halobaena caerulea* from Marion Island (Steele & Klages 1986; Steele & Crafford 1987; Ryan 1988), and prions feeding in the Benguela current off South Africa (S. Jackson pers. comm.). However, floating insects must be an irregular and unimportant component in the diet of Salvin's prions.

Comparison with the broad-billed and dove prions

Taxonomic classification of the prions is as yet undecided. Harper (1980) divides the genus *Pachyptila* into six species, including Salvin's *P. salvini,* whereas Cox (1980) argues for only three prion species with Salvin's and dove prions *P. desolata* as sub-species of the broad-billed prion *P. vittata.* A comparison of the diet of Salvin's and other closely related prions is therefore of interest.

A number of reports mention the diet of broad-billed prions (Richdale 1944; Serventy *et al.* 1971; Watson 1975; Shaughnessy & Fairall 1976; Imber 1981; Harper 1987) and dove prions (Whitlock 1931; Murphy 1936; Bierman & Voous 1950; Paulian 1953; Ealey 1954; Tickell 1962; Serventy *et al.* 1971; Harper 1972; Mougin 1975; Watson 1975; Prince 1980; Harper 1987), but only two are detailed studies with large sample sizes. Prince (1980) analysed 90 stomach samples from dove prions at Bird Island, South Georgia (54°55'S / 36°38'W) and Imber (1981) studied broad-billed prions at the Chatham Islands (44°00'S / 176°00'E), collecting 57 samples. The results of these two studies are similar, with both species taking very similar proportions of the major prey classes, although the only prey species common to both species was *Themisto gaudichaudii.* The dove prion samples comprised 97,6% crustaceans, 1,8% fish and 0,6% cephalopods by mass (Prince 1980). Broad-billed prion stomach samples collected by Imber (1981) comprised 96,8% crustaceans, 2,3% fish and 0,8% cephalopods/molluscs by mass.

Given the close similarity in diet of broad-billed and dove prions, the results of the present study are surprising. Within the three species, Salvin's prion has a bill of intermediate size, not as heavy and broad as that of *P. vittata,* but wider than that of *P. desolata* (Cox 1980; Harper 1980). It has been suggested that the gradient in bill size shows an increasing specialization towards smaller prey, such as copepods, from *desolata* to *salvini* to *vittata* (Imber 1981). Indeed, Salvin's prions did feed on *T. gaudichaudii* larger than the 6 – 8 mm reported for broad-billed prions (Imber 1981).

Although copepods are important in the diet of both broad-billed and dove prions, comprising 70% (Imber 1981) and 33,1% (from Prince 1980) of the mass respectively, no copepods were found in the stomach samples of Salvin's prions from Marion Island. This is surprising since copepods occur commonly in net hauls of zooplankton around Marion Island (Grindley & Lane 1979; Boden & Parker 1986), and the possibility cannot be overlooked that if samples were collected over a longer period, copepods may be found to be a component in the birds' diet. However, copepods have not been reported in seabirds' diets from Marion Island (Schramm 1986; Steele & Klages 1986; Brown & Klages 1987). Previous publications (cited above) also make no mention of copepods in the diet of Salvin's prions. Furthermore, contrary to Imber's (1981) prediction, Salvin's prions at Marion Island consumed a greater proportion of fish than has been reported for the other two closely related prion species, which is unexpected given their bill morphology.

The greater portion of the samples collected consisted of unidentifiable material and this was almost certainly mostly crustacean in origin. Therefore, the actual proportion of fish in the diet may have been lower than the results indicate. Clearly, further research is needed to confirm the difference in diet between Salvin's, dove and broad-billed prions.

Comparison with the blue petrel

Blue petrels are burrowing petrels of a similar size to Salvin's prions, which also breed in large numbers at the Prince Edward Islands (Fugler, Hunter, Newton & Steele 1987). Prince (1980) compared the diets of the blue petrel and dove prion species-pair at South Georgia and found there were broad similarities. However, dove prions preyed on copepods to a much greater extent than did blue petrels, which took a greater proportion of fish. In addition, dove prions appeared to have been selecting smaller individuals of those prey species common to both (Prince 1980).

At Marion Island the blue petrel and Salvin's prion show a high degree of dietary overlap (Steele & Klages 1986; this study). Both species consume mostly onychoteuthid squid, myctophid fish, *Euphausia vallentini* and a range of amphipod species. However, differences do occur in the proportion of these prey

species eaten. First, Salvin's prions had a far greater proportion of fish in the diet than did blue petrels at Marion Island (41% by mass to 21%) (Steele & Klages 1986; Table 1). Second, blue petrels at Marion Island took a greater amount of crustaceans than did Salvin's prions (60% to 44%), and this was dominated by *E. vallentini* (Steele & Klages 1986), whereas prions concentrated on amphipods. This is in contrast to the situation at South Georgia where blue petrels preyed more on fish (Prince 1980), although both species took much less fish than was the case at Marion Island.

The two species appear to feed on fishes of similar size. Blue petrels at South Georgia took fishes with lengths of 51 mm and 82 mm (Prince 1980), whereas Salvin's prions at Marion Island fed on fishes ranging from 40,7 mm to 83,2 mm.

The preponderance of smaller crustaceans, such as amphipods, in the diet is explained by the Salvin's prion's method of feeding. The most common technique is 'hydroplaning' (Murphy 1936; Harper, Croxall & Cooper 1985), where the bird propels itself across the surface of the water with its feet, while holding its head under water, seizing or filtering food with the bill. The wide gape and palatine lamellae of the bill together with the extensible gular pouch allows the birds to filter out large numbers of small prey items (Murphy 1936; Prince 1980). In contrast, blue petrels, with a much narrower bill, use surface-seizing and surface-diving (Harper *et al.* 1985), with individual prey being selected. The large proportion of fish in the stomach samples of Salvin's prion at Marion Island is unexpected, considering what is known about the species' preferred foraging methods.

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