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THE DIET OF GENTOO PENGUINS *Pygoscelis papua* IN EARLY WINTER AT HEARD ISLAND

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In Gentoo Penguin faecal samples taken from both sides of the Heard Island Spit, the most common prey was *Parathemisto gaudichaudii* followed by fish. There were significant differences in the diet between the north and south sides of the Spit, only three kilometres apart. The main difference was the presence of *Euphausia vallentini* in 46.7 per cent of samples from the north side of the Spit and its complete absence to the south. In addition, fish were more commonly taken on the north side and there were significant differences in the species of fish taken.

INTRODUCTION

The diet of Gentoo Penguins *Pygoscelis papua* varies greatly with locality, being mainly krill *Euphausia superba* at antarctic breeding locations (Croxall and Prince 1980; Volkman *et al.* 1980; Jablonski 1985; Williams 1991), with fish being more important at subantarctic localities, where *E. superba* is replaced by other species, especially *E. vallentini* (LaCock *et al.* 1984; Ridoux 1988; Klages *et al.* 1990).

Ealey (1954) reported on the occurrence of fish (nototheniids), amphipods and cephalopods in stomach contents of Gentoo Penguins from Heard Island, and Klages *et al.* (1990) reported that the summer diet was dominated by fish (myctophids) together with *E. vallentini*, gammarid amphipods and small cephalopods.

The aim of this study was to examine the winter diet of Gentoo Penguins at a locality rarely visited by the biologists in winter, based on examination of fresh faecal material.

METHODS

Fresh faecal samples were collected in Gentoo Penguin colonies on the north (Spit Bay) and south (Doppler Hill) sides of the Spit at the eastern end of Heard Island in June 1990. Samples consisted of all faecal material deposited on the snow around each stationary animal (temporarily occupying a nest site) and therefore consisted of material from more than one defecation. They were kept chilled until removal to the laboratory on board RSV *Aurora Australis*. Samples were broken open in water in a sieve of 1.0 mm mesh. Fish otoliths and vertebrae, crustacean remains and cephalopod beaks were removed for further identification and measurement.

Relatively intact crustacean exoskeletons were measured from the anterior lateral edge of the carapace to the posterior tip of the uropod (Mauchline 1980). A reference sample of 52 *Parathemisto gaudichaudii* and 10 *Euphausia vallentini* from concurrent marine science sampling

was measured in the same way. Otoliths were identified by reference to the fish otolith atlas of Williams and McEldowney (1990) and to a reference collection of fish otoliths collected from fur seals at Heard Island and identified by R. Williams. The proportions of fish otolith types taken at different sides of the Spit were compared using the Mantle Test (Patterson 1986) which compares individual samples from each site. Squid beaks were identified by comparison with a reference collection collected from fur seals at Heard Island and identified by M. Clarke (Green *et al.* 1991).

RESULTS

Thirty samples were collected at Spit Bay and 29 at Doppler Hill. The most commonly occurring prey remains in samples were of *Parathemisto gaudichaudii* followed by fish (Table 1). There were differences in the samples between the north and south sides of the Spit. Samples from Spit Bay had a greater frequency of fish, squid and euphausiid, but a lower frequency of *P. gaudichaudii*. *Euphausia vallentini* remains were found only in samples from the north side of Heard Island and Spit Bay. Where both *P. gaudichaudii* and *E. vallentini* were found in the same sample on 11 occasions, *E. vallentini* remains were more common in nine and *P. gaudichaudii* in two. The composition of the fish species taken by Gentoo Penguins (Table 2) was significantly different between the two sites (Mantle test, $p < .05$).

There was no significant difference between the size of *P. gaudichaudii* taken at Spit Bay and Doppler Hill. The mean size of 30 *P. gaudichaudii* taken by Gentoo Penguins (16.8 ± 3.0 mm) was, however, significantly smaller (t-test, $p < .001$) than the mean size of 52 individuals (18.7 ± 1.6) taken randomly from a sample caught by a marine science cruise in the vicinity of Heard Island during the sampling period. Only one *E. vallentini* was measurable; it too was smaller than the mean size of 22.95 mm of 10 samples from the marine science sampling. There was no significant difference between the size of the squid *Mastigoteuthis*? taken at Spit Bay and Doppler Hill; lower rostral lengths were 1.2 ± 0.2 mm and 1.3 ± 0.52 mm respectively. The lower rostral length for *Kondakovia longimana* was 6.5 mm.

TABLE 1

Frequency of occurrence of animal remains (%) in faecal samples from Gentoo Penguins.

Prey	Spit Bay	Doppler Hill
Fish	57	48
Squid	47	31
Parathemisto	87	97
Euphausia	47	0
Isopod	0	3
Unidentified crustacean	7	3
Parasitic worms	0	3
Number of samples	30	29

TABLE 2

Fish otoliths and squid beaks identified from faecal samples of Gentoo Penguins.

Prey	Spit Bay	Doppler Hill
FISH		
Myctophidae		
Krefftichthys anderssoni	3	137
Protomyctophum normani		2
Electrona carlsbergi		1
Electrona sp.	7	
Gymnoscopelus sp.	1	
Indet. myctophid		14
Paralepididae		
Magnisudis prionosa	1	
Nototheniidae		
Notothenia sp.	1	
Gempylidae		
Paradiplospinus		5
Unidentified	13	11
Number	26	170
SQUID		
Kondakovia longimana	1	
Mastigoteuthis?*	8	14
Number	9	14

**Mastigoteuthis*? is the same unidentified species as reported in Green *et al.* 1991.

DISCUSSION

An investigation of the diet of Gentoo Penguins at Heard Island in the summer of 1986/87 (Klages *et al.* 1990) showed that fish were the major food; myctophids, predominantly *Krefftichthys anderssoni*, constituted the majority (57%) of fish taken. Although no comparison has yet been made validating faecal sampling with stomach flushing, similar results were found in the present study with 80.5 per cent of all otoliths coming from *K. anderssoni*. Squid remains occurred in about 50 per cent of samples collected in summer

by Klages *et al.* (1990) and in 40–50 per cent of samples collected at Macquarie Island (Hindell 1989). The figures presented here, while slightly lower, are only marginally so. The major crustacean found by Klages *et al.* (1990) was *E. vallentini* which they found in 52.7 per cent of Gentoo Penguin stomachs. In the present study on the north side of the Island, they appeared in a similar number (46.7%) of samples but did not occur at all on the south side, so that the overall frequency of occurrence was 23.7 per cent.

Although Klages *et al.* (1990) reported gammaridean amphipods as occurring regularly (41.8%) in the diet of Gentoo Penguins, they occurred in low numbers and no identification was given. In the present study, the rate of occurrence was high (91.5%) as was the amount of material, with remains of at least 100 individuals of *P. gaudichaudii* occurring in 26 of the 59 samples. *Parathemisto gaudichaudii* have been reported in the diet of Gentoo Penguins at south Georgia (Croxall and Prince 1980) but in very small amounts. The smaller size of *P. gaudichaudii* taken by Gentoo Penguins compared with net hauls may indicate different areas of operation, with Gentoo Penguins operating closer to shore (see also Klages *et al.* 1990) than did the marine science cruise. The sea bed drops off more rapidly to the south of the island but it was the birds on the north of the island (where extensive banks occur) that took the oceanic *E. vallentini* and more squid.

The method of sampling faeces is not the preferred method for dietary studies. Nevertheless, this method is non-intrusive subjecting the birds to a minimal level of disturbance, and it did provide easily obtained and valuable results. Particularly, it showed the greater dependence on *P. gaudichaudii* than shown in the study by Klages *et al.* (1990) and that the diet can vary significantly between two sites separated by only a small land distance.

The finding of such major differences in the diet of Gentoo Penguins from one side of Heard Island to the other at the same time raises questions about interspecific or intraspecific comparisons when the samples are taken at different times, or as in the case of Klages *et al.* (1990), at different times and places. If the diet of Gentoo Penguins is so different (particularly as regards the presence of *E. vallentini*) across the width of the Spit (three kilometres) then differences between the ends of the Island (24 km apart) where Klages *et al.* (1990) compared the diets of King Penguins *Aptenodytes patagonicus* and Gentoo Penguins, may obscure the interspecific differences. Hindell (1989) found differences in the diet of Gentoo Penguins from two sites only 10 km apart on the same side of Macquarie Island and suggested that 'care must be taken where interpreting dietary information . . . from only one breeding site.' Interspecific comparisons on subantarctic islands should try to standardize all parameters before drawing conclusions about interspecific differences.

Because the samples described in this paper were taken so long after those reported by Klages *et al.* (1990), it is difficult to postulate a seasonal difference in the diet, and a full year's study will be required to obtain this information. Williams (1980) reported a change in faecal type from red (crustaceans) to white (fish) in October at Marion Island, but LaCock *et al.* (1984) in another year at Marion Island found fish to be the main component of the diet in early September. Hindell (1989) documented changes in the diet of Gentoo Penguins through the winter at Macquarie Island, which were largely related to changes up to and through the breeding season. Hindell (1989) stated that 'throughout the winter . . . non-breeding Gentoo Penguins forage close to shore and opportunistically prey on species that are both temporally and spatially patchy in distribution.' This explanation for Macquarie Island also fits the data for Heard Island.

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LONGEVITY OF CAPE PETRELS *Daption capense* AT BLUFF ISLAND, VESTFOLD HILLS, EAST ANTARCTICA

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The Cape Petrel *Daption capense* nests on the Antarctic Peninsula, on Antarctic and Subantarctic islands as well as on the continent itself (Watson 1975; Marchant and Higgins 1990). Breeding occurs in East Antarctica, including sites in Prydz Bay (Woehler and Johnstone 1991). Bluff Island (68°33′S, 77°54′E), off Davis Station in the Vestfold Hills, is one such nesting area where Cape Petrels have been banded intermittently since 1959. To the end of the 1989/90 summer 299 pulli and 130 adult birds at nests have been marked there.

Bluff Island was visited briefly in early February 1989 and again, for a longer period, on 7 January 1991 during studies on the South Polar Skua *Catharacta maccormicki*. Previously-banded Cape Petrels were noted in 1989. In 1991 petrels at nests over much of the Island were examined, particularly where nest density was high and where birds banded prior to 1989 were breeding. Of 334 adults caught at nest sites, 15 had been banded previously. Four adults were banded in 1989, one breeding adult was banded as a chick in February 1974 and another as a pullus in 1984;