

SHORT NOTE

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Fish prey of Antarctic fur seals *Arctocephalus gazella* at Ile de Croy, Kerguelen

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Abstract The composition of Antarctic fur seal prey was assessed through analysis of scats collected in March 1994 on Ile de Croy, Iles Nuageuses. Fish remains predominated in samples, occurring in 95% of droppings. A total of 968 otoliths allowed the identification of 16 fish species. Myctophid fish (12 species) dominated the diet both by number (94% of the otoliths) and by fish reconstituted mass (76%). Three fish species constituted together 87% of the reconstituted mass: the myctophids *Gymnoscopelus nicholsi* (52%) and *G. piabilis* (12%), and the channichthyid *Champscephalus gunnari* (23%). Prey distribution suggests that during late summer seals forage in upper slope waters in the northeast of the Kerguelen Archipelago.

Orkney Islands (Daneri and Coria 1993) and females either made up only a minor fraction of the population studied at Heard Island (Green et al. 1989), or they were mixed with females of the sub-Antarctic fur seal *A. tropicalis* at Macquarie Island (Green et al. 1990).

Here, we report on the fish diet of lactating female Antarctic fur seals belonging to an increasing population at Kerguelen Island. The main colony occurs on a remote island, Ile de Croy, where 1,500 breeding females were counted in spring 1984 (Jouventin and Stonehouse 1985) and about 1,900 pups in late summer 1994 (unpublished data).

Introduction

The food of Antarctic fur seals (*Arctocephalus gazella*) has been investigated in detail at only two breeding localities. At South Georgia, mature Antarctic krill (*Euphausia superba*) dominates the diet of female fur seals in summer, while males feed both on krill and fish, the major prey being the channichthyid *Champscephalus gunnari* (North et al. 1983; Doidge and Croxall 1985; Reid and Arnould 1996). At Heard Island, *C. gunnari* and pelagic myctophid fish composed the bulk of the food of males during the summer months (Green et al. 1989). No information on the diet of females is available except for South Georgia. Only males occurred in the surveyed area in the South

Materials and methods

Fieldwork was carried out on the 6th March 1994 on Ile de Croy, Iles Nuageuses, located in the north of the Kerguelen Archipelago (48°38'S, 68°38'E). Twenty-five scats were collected at a time when pups and lactating females, together with a few juvenile males, were present ashore. Individual faecal samples were kept separately and returned frozen to the laboratory for analysis. Prey items (fish otoliths, bones, scales and eye lenses, cephalopod beaks and lenses, crustacean exoskeletons) were carefully extracted for determination and measurement. Fish otoliths and jaws were identified by using the descriptions in Williams and McEldowney (1990) and Iwami (1985), and our own reference collection. Only otoliths showing little or no signs of erosion were measured (otolith length = distance from the anterior to the posterior margin of the otolith) to estimate the standard length and body mass of the prey. Allometric equations used were those given in Williams and McEldowney (1990), except equations for *Protomyctophum choriodon* (Olsson and North in press) and *P. tenisoni* (Adams and Klages 1987). Since no equations were available for *Metelectrona ventralis*, we used those calculated for *Electrona carlsbergi* (Adams and Klages 1987), a closely related species by otolith shape and fish size. Finally, we calculated the following equations for *Gymnoscopelus piabilis* from fish caught as bycatch by trawlers in Kerguelen waters (Y. Cherel, unpublished data):

$$SL = 14.509 + 21.020 OL, r = 0.881, n = 27$$

$$BM = 8.290 \times 10^{-6} \times SL^{3.074}, r = 0.940, n = 27$$

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where OL = otolith length (mm), SL = standard length (mm) and BM = body mass (g). Reconstituted mass is the sum of calculated body mass from measured otoliths multiplied by the ratio of total/measured otoliths for each species. Of the 25 scats, 3 contained no food remains and were therefore not used in further analysis.

Results

Fish remains predominated in fur seal faeces, occurring in 95% of scats containing food items. Cephalopods (17 small squid beaks) and crustaceans were only minor prey, being found in 36 and 41% of the faecal samples, respectively. Identifiable fish remains included both jaws and otoliths. Dentary bones (lower jaws) of at least two different species of nototheniid fish were positively identified in 36% of the scats. Their length averaged 3.27 ± 0.06 mm (range: 2.84–3.75 mm, $n = 20$), thus corresponding to individuals of about 40-mm standard length.

A total of 968 otoliths were recovered at a mean number of 44.0 otoliths per scat (range: 2–301). Sixteen different fish species were identified, including 12 species of myctophid fish (Table 1). Myctophids dominated the diet both by fish number (represented by 913 otoliths, 94%) and fish reconstituted mass (76%). Otoliths that could be identified only as *Gymnoscopelus* sp. ($n = 110$), myctophids ($n = 75$) and channichthyids ($n = 5$) together composed 20% of the total number of otoliths obtained. The remaining 24 otoliths (2%) were unidentifiable.

The main prey species was *Gymnoscopelus nicholsi* (51% by number), with a mean standard length and mass of 81 mm and 6.4 g, respectively. All the *G. nicholsi* eaten were juvenile fish of various age classes,

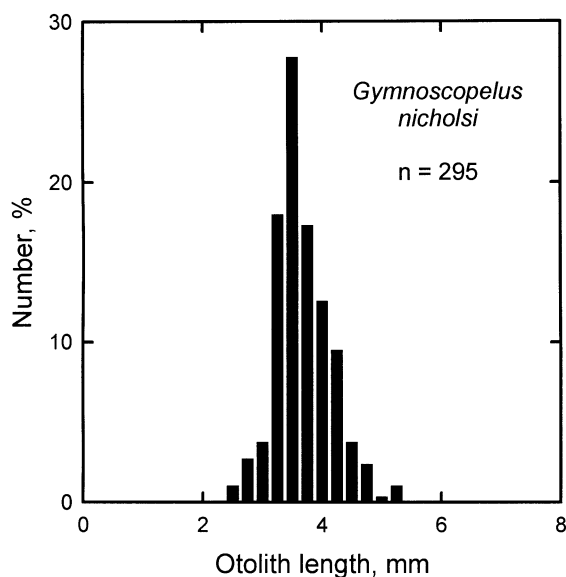


Fig. 1 Length-frequency distribution of otoliths of *Gymnoscopelus nicholsi* consumed by Antarctic fur seals at Ile de Croy

the modal value of otolith length being 3.25–3.50 mm (Fig. 1). Three fish species accounted together for 87% of the reconstituted mass: *G. nicholsi* (52%), the channichthyid *C. gunnari* (23%; mean standard length and mass, 210 mm and 64 g, respectively) and *Gymnoscopelus piabilis* (12%; 103 mm, 14 g). Four other species ranged between 1 and 10% by mass (*Electrona subaspera*, *Gymnoscopelus fraseri*, *Protomyctophum choriodon* and *Metelectrona ventralis*), while the remaining nine species were negligible in mass (< 1% each).

Discussion

Myctophid fish were the main prey of Antarctic fur seals at a time when lactating females predominated by number over juvenile males at Ile de Croy, Kerguelen. Myctophids have been previously reported as important food for the New Zealand (*A. forsteri*), Fernandez (*A. philippii*) and sub-Antarctic fur seals (Green et al. 1990; Carey 1992; Acuna and Francis 1995), and for non-breeding male Antarctic fur seals (Green et al. 1989, 1991), suggesting that both sexes of the genus *Arctocephalus* are well adapted to feed on pelagic fish. Crustaceans were only minor components of the diet, the hyperiid amphipod *Themisto gaudichaudii* being the most abundant crustacean prey of seals at Kerguelen.

Due to the remoteness of Ile de Croy and the difficulty of landing there, the 25 scats had to be collected during only 1 day. This precludes the assessment of temporal variations in fish prey, as studied at South Georgia and Heard Island during the summer months (Green et al. 1989; Reid and Arnould 1996). Slightly less than 1,000 otoliths were, however, recovered from 22 faecal samples, i.e. about 44 otoliths per scat. This number is fairly large when compared to that reported in other studies, these mostly being in the range of 4–9 otoliths per scat (Green et al. 1989, 1991; Daneri and Coria 1993) with a maximum number of 21 (Green et al. 1990). We believe that about 1,000 otoliths compose a sufficiently large sample to give a first insight in to the fish prey of Antarctic fur seals at Kerguelen Archipelago. One possible bias when scats are used to determine the diet composition of pinnipeds is that fish with small otoliths are underestimated because they can be digested quickly. In this study, this is probably the case for the small demersal nototheniid fish (about 40-mm standard length based on the presence of lower jaws).

Sixteen species of fish have been identified (Table 1), a value similar to that previously reported from South Georgia and Heard Island during the whole summer period (Green et al. 1989; Reid and Arnould 1996). The diet, however, is more diverse at Ile de Croy when compared to Heard Island during January/February

Table 1 Frequency of occurrence, numbers, length and mass of fish prey recovered from Antarctic fur seal scats ($n = 22$) at Ile de Croix, Kerguelen Archipelago. Values are means \pm SE with ranges in parentheses

| Species | Occurrence | | Numbers | | Mass | | (n) | Otolith length (mm) | Fish standard length (mm) |
|-----------------------------------|------------|-----|---------|-------|--------|-------|-----|-----------------------------|-------------------------------|
| | (n) | (%) | (n) | (%) | (g) | (%) | | | |
| Myctophidae | | | | | | | | | |
| <i>Electrona antarctica</i> | 3 | | 19 | 2.0 | 49.6 | 0.8 | 16 | 1.31 \pm 0.06 (0.96–1.87) | 56.1 \pm 2.7 (41.3–80.1) |
| <i>E. subaspera</i> | 4 | | 43 | 4.4 | 308.7 | 5.1 | 8 | 2.77 \pm 0.16 (1.98–3.21) | 71.4 \pm 4.7 (48.4–84.1) |
| <i>Gymnoscopelus bolini</i> | 1 | | 1 | 0.1 | 3.2 | < 0.1 | 1 | 3.15 | 65.0 |
| <i>G. braueri</i> | 1 | | 2 | 0.2 | 25.1 | 0.4 | 2 | 2.44–2.71 | 105.0–116.7 |
| <i>G. nicholsi</i> | 9 | | 498 | 51.4 | 3172.3 | 51.9 | 295 | 3.55 \pm 0.03 (2.49–5.23) | 80.9 \pm 0.8 (50.5–128.9) |
| <i>G. fraseri</i> | 4 | | 28 | 2.9 | 159.6 | 2.6 | 15 | 3.54 \pm 0.08 (3.02–3.84) | 79.0 \pm 1.7 (67.7–85.6) |
| <i>G. piabilis</i> | 4 | | 53 | 5.5 | 753.7 | 12.3 | 32 | 4.21 \pm 0.16 (3.22–6.11) | 103.0 \pm 3.4 (82.2–142.9) |
| <i>Gymnoscopelus</i> sp. | 5 | | 110 | 11.4 | – | – | – | – | – |
| <i>Krefflichthys anderssoni</i> | 2 | | 7 | 0.7 | 4.6 | < 0.1 | 7 | 1.28 \pm 0.08 (1.04–1.56) | 39.0 \pm 3.1 (29.0–50.4) |
| <i>Metelctrona ventralis</i> | 1 | | 21 | 2.2 | 73.9 | 1.2 | 16 | 2.85 \pm 0.08 (2.31–3.26) | 61.8 \pm 1.9 (49.0–71.6) |
| <i>Protomyctophum bolini</i> | 3 | | 36 | 3.7 | 25.9 | 0.4 | 17 | 1.58 \pm 0.02 (1.42–1.75) | 37.0 \pm 0.6 (32.5–41.4) |
| <i>P. choriodon</i> ^a | 3 | | 17 | 1.8 | 86.2 | 1.4 | 11 | 2.03 \pm 0.05 (1.75–2.23) | 70.0 \pm 2.0 (57.8–78.5) |
| <i>P. temisoni</i> | 2 | | 3 | 0.3 | 2.9 | < 0.1 | 2 | 1.19–1.41 | 35.2–45.2 |
| Unidentified Myctophidae | 5 | | 75 | 7.7 | – | – | – | – | – |
| Nototheniidae | | | | | | | | | |
| <i>Gobionotothen acuta</i> | 1 | | 2 | 0.2 | 4.9 | < 0.1 | 1 | 2.56 | 73.2 |
| <i>Lepidonotothen squamifrons</i> | 1 | | 1 | 0.1 | 0.7 | < 0.1 | 1 | 2.17 | 35.3 |
| Channichthyidae | | | | | | | | | |
| <i>Champsoscephalus gumhari</i> | 3 | | 22 | 2.3 | 1408.2 | 23.0 | 7 | 2.38 \pm 0.07 (2.12–2.58) | 210.5 \pm 6.4 (184.9–229.4) |
| Unidentified Channichthyidae | 2 | | 5 | 0.5 | – | – | – | – | – |
| Gempylidae | | | | | | | | | |
| <i>Paradiplospinus gracilis</i> | 1 | | 1 | 0.1 | 32.7 | 0.5 | 1 | 3.14 | 309.7 |
| Unidentified otoliths | 7 | | 24 | 2.5 | – | – | – | – | – |
| Total | – | | 968 | 100.0 | 6112.2 | 100.0 | – | – | – |

^a Formerly misidentified as *Protomyctophum normani* in Cherel and Ridoux (1992)

(11 species including 7 myctophids; Green et al. 1989). In both studies, myctophids dominate the fish diet by number and *Gymnoscopelus nicholsi* is by far the most numerous prey item (Table 1, this study; Green et al. 1989). The main difference between these two closely related localities is the tenfold higher abundance of *C. gunnari* at Heard Island in late summer (25.6 vs 2.3%).

Antarctic and sub-Antarctic myctophids are mostly pelagic in oceanic waters, some of them being also epibenthic during the day in slope areas (*E. subaspera*, *G. nicholsi*, *G. piabilis*, *M. ventralis* and *P. choriodon*; Hulley et al. 1989). In Kerguelen waters, the benthopelagic channichthyid *C. gunnari* inhabits mainly the outer shelf/upper slope area where it feeds on swarming crustaceans and myctophids, including *E. subaspera*, *M. ventralis*, *P. choriodon* and *P. tenisoni* (Hulley et al. 1989; Duhamel 1991). Prey distribution, therefore, suggests that female Antarctic fur seals forage during late summer in upper slope waters in the north/northeast of the Kerguelen Archipelago. The nocturnal diving behaviour of fur seals (Croxall et al. 1985) allows them to feed on vertical migrators that occur in shallow depths at night. This foraging strategy complements that of the other major predator of myctophid fish, the king penguin, *Aptenodytes patagonicus*, which feeds mainly during the daylight hours, at deeper depths, and on truly oceanic species of lanternfishes (*Krefflichthys anderssoni* and *Electrona carlsbergi*) (Klages et al. 1990; Kooyman et al. 1992; Pütz and Bost 1994).

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