MYCTOPHIDS IN THE DIET OF ANTARCTIC PREDATORS

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Abstract

The aim of the present study is to review published data on the diet of various top predators (birds, seals, whales, fish and squids) in order to help evaluate the importance of myctophids in their diets. This review covers publications for the period since 1984-85 to the present. In total, over 50 publications contained some information on the myctophid component of the diet of Antarctic predators. Myctophids were found in the diet of one species of squid, 18 species of fish (*Nototheniidae* - eight, *Channichthyidae* - seven, *Bathydraconidae* - two and *Rajidae* - one), 18 species of birds (penguins - seven, albatrosses - four, petrels - five, prions - one and cormorants - one) and two species of seals. Myctophids in the diet of predatory species are represented by 16 species of genera *Krefftichthys* (one species), *Protomyctophum* (four species), *Electrona* (five species), *Metelectrona* (one species) and *Gymnoscopelus* (four species). However, the total number of species may be underestimated because identification of myctophids in predator food samples is still difficult. Many species of fish, birds and seals take myctophids opportunistically in addition to their staple diet. Penguins have the largest proportion of myctophids in their diet. The king penguin in the Antarctic Polar Front area of the Indian Ocean is the only one specialist predator on myctophids. The *Bathydraconidae* fish, *Gynmodraco acuticeps,* from the Kosmonavtov Sea (Indian Ocean sector) may be the second most important predator of myctophids. The occurrence of myctophids in the diet of predatory species appears to be highly variable though there are insufficient data to evaluate this. It is obvious that myctophids are widespread in diets of many Antarctic predators. More quantitative studies on as many as possible species of predators are required in order to assess the role of myctophids in the Antarctic ecosystem. Information on the diet of myctophids themselves is also important. These studies should use standardised methods, be carried out in different seasons and have a wide geographical coverage.

Résumé

La présente étude a pour objectif d'examiner des données publiées sur le régime alimentaire de divers prédateurs supérieurs (oiseaux, phoques, baleines, poissons et calmars) dans le but de faciliter l'évaluation de l'importance des Myctophidae dans leur régime alimentaire. Cet examen couvre les publications de 1984/85 à nos jours. En tout, plus de 50 publications contenaient des informations sur la composition du régime alimentaire des prédateurs antarctiques. Des Myctophidae ont été trouvés dans le régime alimentaire des espèces suivantes : une espèce de calmar, 18 espèces de poissons (*Nototheniidae* - huit, *Channichthyidae* - sept, *Bathydraconidae* - deux et *Rajidae* - une), 18 espèces d'oiseaux (manchots - sept, albatros - quatre, pétrels - cinq, prions - une et cormorans - une) ainsi que dans

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deux espèces de phoques. Dans le régime alimentaire des espèces prédatrices, les Myctophidae sont représentés par 16 espèces des genres suivants : *Krefftichthys* (une espèce), *Protomyctophum* (quatre), *Electrona* (cinq), *Metelectrona* (une) et *Gymnoscopelus* (quatre). Toutefois, vu la difficulté que présente toujours l'identification des Myctophidae dans les échantillons alimentaires des prédateurs, il se pourrait que le nombre des espèces soit sous-estimé. De nombreuses espèces de poissons, d'oiseaux et de phoques ajoutent, à l'occasion, des Myctophidae à leur régime alimentaire ordinaire. C'est dans le régime alimentaire des manchots que se trouve la proportion la plus élevée de Myctophidae. Le manchot royal de la région du front polaire antarctique de l'océan Indien est le seul prédateur qui se nourrisse spécialement de Myctophidae. Le poisson Bathydraconidae, *Gynmodraco acuticeps*, de la mer Kosmonavtov (secteur de l'océan Indien) pourrait être le deuxième prédateur de Myctophidae par ordre d'importance. La présence de Myctophidae dans le régime alimentaire des espèces prédatrices semble être des plus variables, quoique le nombre insuffisant des données ne permette pas une telle évaluation. De toute évidence, les Myctophidae sont très répandus dans le régime alimentaire de nombreux prédateurs antarctiques. Il conviendrait d'entreprendre de nouvelles études quantitatives sur un maximum d'espèces prédatrices pour pouvoir estimer le rôle des Myctophidae dans l'écosystème antarctique, et également d'élargir nos connaissances du régime alimentaire des Myctophidae mêmes. Ces études devraient être effectuées par des méthodes standard, en différentes saisons, et couvrir une aire géographique étendue.

Резюме

Целью настоящего исследования является обзор опубликованных данных по рациону различных хищников (птиц, тюленей, китов, рыб и кальмаров), что будет способствовать оценке значения миктофид в их рационе. Этот обзор охватывает работы, публиковавшиеся с 1984-85 г. до настоящего времени. В общей сложности, более 50 публикаций имело некоторую информацию по содержанию миктофид в рационе хищников Антарктики. Миктофиды были обнаружены в рационах одного из видов кальмара, 18 видов рыб (*Nototheniidae* - восемь, *Channichthydae* - семь, *Bathydraconidae* - два, *Rajidae* - один), 18 видов птиц (пингвинов- семь, альбатросов- четыре, буревестников - пять, китовых птиц - один и бакланов - один) и двух видов тюленей. Миктофиды в рационе хищников представлены 16 видами рода *Krefftichthys* (один вид), *Protomyctophum* (четыре вида), *Electrona* (пять видов), *Metelectrona* (один вид), *Gymnoscopelus* (четыре вида). Тем не менее, существует опасность недооценки общего количества видов в связи с тем, что идентификация миктофид в пробах пищи хищников до сих пор представляет собой сложный процесс. Многие виды рыб, птиц и тюленей питаются миктофидами только при случае, в дополнение к их основному рациону. Наибольшая пропорция миктофид обнаружена в рационе пингвинов. Королевский пингвин, обитающий в районе Антарктического полярного фронта Индийского океана,

является единственным хищником, основной пищей которого являются миктофиды. Вид *Bathydraconidae, Gymnodraco acuticeps*, обитающий в море Космонавтов (индоокеанский сектор), возможно является вторым по важности хищником миктофид. Присутствие миктофид в рационе хищников - явление весьма переменное, хотя по этому вопросу еще недостаточно данных. Очевидно, что миктофиды широко распространены в рационе многих хищников Антарктики. В целях оценки роли миктофид в антарктической экосистеме необходимо проводить больше количественных исследований всех возможных видов хищников. Данные по рациону самих миктофид также важны. Такие исследования должны использовать стандартизированные методы, проводиться в разные сезоны и иметь широкий географический охват.

Resumen

El objetivo de este estudio es revisar los datos publicados sobre la dieta de algunos depredadores principales (aves, focas, ballenas, peces y calamares) para poder evaluar la importancia de los mictofidos en su dieta. Esta revisión comprende las publicaciones del período 1984-85 hasta la actualidad. En total, más de 50 trabajos contenían información sobre la composición de mictófidos en la dieta de los depredadores antárticos. Se encontraron restos de mictófidos en la dieta de una especie de calamar, 18 especies de peces (ocho de Nototheniidae - siete de Channichthydae - dos de Bathydraconidae y una de Rajidae), 18 especies de aves (siete pingüinos, cuatro albatros, cinco petreles, un prión y un cormorán), además de dos especies de focas. Los mictófidos que forman parte de la dieta de los depredadores comprenden 16 especies del género *Krefftichthys* (una especie) *Protomyctophum* (cuatro especies), *Electrona* (cinco especies), *Metelectrona* (una especie) y *Gymnoscopelus* (cuatro especies). Sin embargo, el número total de especies puede haberse subestimado por la dificultad que entraña su identificación en las muestras tomadas de la dieta de los depredadores. Algunas especies de peces, aves y focas consumen mictofidos esporádicamente si están a su alcance, además de su dieta acostumbrada. Los pingüinos son quienes consumen el mayor porcentaje de mictofidos. El pingüino real, de la zona del Frente Polar Antártico del Océano Indico, es el único depredador que se limita a los mictófidos. El pez Bathydraconidae, *Gymnodraco acuticeps* del mar de Kosmonavtov (sector del Océano Indico) puede ser el segundo depredador más importante de mictófidos. La presencia de éstos en la dieta de las especies depredadoras parece estar sujeta a grandes variaciones, aunque no se tienen datos suficientes para hacer una evaluación. Es obvio que los mictófidos son muy comunes en la alimentación de muchos depredadores antárticos. Es preciso realizar más estudios del mayor número de especies depredadoras posibles para valorar su función dentro del ecosistema antártico. Es igualmente importante que se obtenga información sobre la dieta de los mictófidos. Estos estudios deberían seguir métodos estándar que cubran diferentes temporadas y zonas geográficas extensas.

1. INTRODUCTION

Myctophids or lanternfish, species of the family *Myctophidae,* are widely distributed in the mesopelagic and bathypelagic waters of the World's oceans. In the Antarctic waters to the south of the Antarctic Convergence 35 species of myctophids are found, i.e. within the CCAMLR Convention Area (Hulley, 1990). Of these 35 species, 11 have circumpolar distributions and are mainly widespread from the Antarctic Polar Front zone (APF) to the edge of the Antarctic continental slope. Other species have more restricted distribution and are found in localised areas in APF waters (eight species in the Atlantic sector of the Southern Ocean, 13 species in the Indian Ocean sector and four species in the Pacific sector). The total biomass of myctophids in Antarctic waters is estimated to be 70-200 x 10^6 tonnes (Lubimova, Shust and Popkov, 1987). Myctophids apparently represent the second largest (after krill) and most widely distributed biological resource in Antarctic waters. Four species of myctophids (*Krefftichthys anderssoni, Electrona antarctica, Electrona carlsbergi* and *Gymnoscopelus nicholsi*), all of which are distributed circumpolarly, contribute the bulk of the biomass (over 80%). The position of myctophids in the Antarctic food web is not adequately understood. It was suggested that myctophids might be a part of a separate food chain from krill, e.g. phytoplankton -> copepods -> myctophids -> predatory fish and squids -> toothed whales (Lubimova, Shust and Popkov, 1987). However, it is also known that diets of many other species of top-level predators, such as marine mammals and birds, contain some myctophids (Croxall, 1984; Laws, 1984; Bengtson, 1985). In addition several species of myctophids consume krill (see Sabourenkov, 1991). The aim of the present study is to review published data on the diet of various top predators (birds, seals, whales, fish and squids) in order to help evaluate the importance of myctophids in their diets.

Early studies on food and feeding ecology of Antarctic top predators were summarised in several detailed reviews (e.g., Everson, 1984; Croxall, 1984 and Laws, 1984). These studies were chiefly based on observed contents of animals faeces, stomachs or regurgitations analysed on the basis of frequency of occurrence of main prey items. Very few studies provided a fully quantitative analysis of stomach contents or provided information on numbers of individuals or total weight of each prey class. Such information is essential for assessing trophic interactions between species, particularly if calculations of prey consumption by populations of predators are desired.

Since the time of these reviews more quantitative studies on food of the Antarctic predators were carried out. Methods have become more standardised, particularly because of the effort of such international organisations as SCAR[1] and SC-CAMLR[2].

This review covers publications for the period since the reviews of 1984 to 1985 mentioned above. In total, over 50 publications contained some information on the myctophid component of the diet of Antarctic predators. Many publications report only descriptive information and refer to myctophids only as a group of species. Quite a few publications, however, provide various quantitative estimates on the proportion and species composition of myctophids in the diet of particular predators.

All available information on myctophids was compiled in order to evaluate the number of predator species which have myctophids in their diet and the number of myctophid species found in the diet of each predator. The available quantitative results of stomach analyses were then combined and discussed for each major group of predator species. Several of the most detailed sets of results were summarised and are presented in tabular form in the Annex.

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1 Scientific Committee on Antarctic Research and, in particular, its Group of Specialists on Seals and Bird Biology Subcommittee.

2 Scientific Committee of the Convention on the Conservation of Antarctic Marine Living Resources

2. MYCTOPHID COMPONENT OF THE DIET OF PREDATORS

Recent studies found myctophids in the diet of one species of squid, 18 species of fish (eight *Nototheniidae,* seven *Channichthyidae,* two *Bathydraconidae* and one *Rajidae),* 18 species of birds (penguins - seven, albatrosses - four, petrels - five, prions - one and cormorants - one) and two species of seals (Table 1). No myctophids were reported from studies of whale diets in the Antarctic waters[3]. Two species of myctophids, *E. antarctica* and *G. nicholsi* were found to eat some juvenile myctophids as a part of their diets (Williams, 1985; Takahashi, 1983).

In total, 16 species of myctophids have been identified so far in the diets of Antarctic top predators. They belong to the following five genera: *Krefftichthys* (one species), *Protomyctophum* (four species), *Electrona* (four species), *Metelectrona* (one species) and *Gymnoscopelus* (six species). Identification of myctophid species in food samples is rather difficult and some fish remnants and otoliths remain unidentified or identified only to genus level. For this reason the actual number of species may be presently underestimated.

Species composition of myctophids consumed by Antarctic predators is given in Table 2. Six species of myctophids have been identified to date in the diet of fish, 10 species in the diet of penguins, nine species in the diet of flying birds and 13 species in the diet of seals.

Myctophids were found in the diet of predators in several localities in the Antarctic along the APF area and the Antarctic coast (Figure 1). In the APF area data on myctophids came from sub-Antarctic islands and two shallow banks (Ob and Lena Bank). On the Antarctic coast myctophids were reported from samples taken in the Prydz Bay area, Budd Coast and the east coast of the Weddell sea.

3. QUANTITATIVE AND OTHER DETAILED DATA ON MYCTOPHIDS EATEN BY PREDATORS

3.1 Fish

Three studies from the Indian Ocean sector and the South Shetland Islands area report quantitative data (Takahashi, 1983; Chechun, 1984; Pakhomov and Tseitlin, 1992) (Annex, Table 1) but do not distinguish the species of myctophids involved, treating them as a group.

In the APF area of the Indian Ocean the data come from four different localities: Kerguelen Islands, Crozet Islands, Lena and Ob Banks (Chechun, 1984). The food of 11 species of fish was studied. Myctophids were found in the diet of three species of nototheniids and two species of channichthyids. Myctophids do not comprise a staple food item in the diet of these fish in the area.

The diet of *Notothenia rossii* by percentage of weight contains 3.6% of myctophids in the Ob Bank area; in the other three areas it varies from 0.9 to 2.7%. Species of *Scyphozoa, Ctenophora* and *Tunicata* (salps) comprise the bulk of *N. rossii* diet (over 30%). Fish comprise from 16.1 to 24 % of *N. rossii* diet.

The diet of *Notothenia squamifrons* contains the largest proportion of myctophids (13.5% by weight in the Crozet Islands area) in comparison with other fish. Myctophids of the genus *Gymnoscopelus* were identified as a separate group. They comprise from 1.6 to 3.4% by weight. In other areas (Kerguelen Islands, Lena and Ob Banks) myctophids represent from 1.8 to 7.6% (salps, hyperiids and polychaetes comprise the bulk of food of *N. squamifrons*). In total, fish comprise from 11.6 to 13.8% (by weight).

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[3] Finding of two specimens of *E. antarctica* from stomachs of minke whale sampled in 1982/83 was recently reported (Bushuev, 1991).

The diet of *Dissostichus eleginoides* in the areas surveyed contained 3.3 to 8.4% by weight of myctophids. Fish comprised at about 75% (73.3 to 77.9%) of its diet.

The diet of *Champsocephalus gunnari* and *Chaenichthys rhinoceratus* was studied only in the Kerguelen Islands area. For *C. gunnari* the proportion of myctophids by weight was 2.4% and for *C. rhinoceratus* it was 3.4%. Fish comprised only 7.9% of the diet of *C. gunnari* (the bulk of food was copepods, hyperiids and euphausiids) but 84.3% of the diet of *C. rhinoceratus*.

The data from the South Shetland Islands area give only frequency of occurrence of myctophids in the diet of three species of nototheniids, one species of channichthyid and also of *G. nicholsi* and unidentified *Rajidae* spp. (Takahashi, 1983). Only *Notothenia kempi* has a high frequency of occurrence of myctophids (33.3%); for the other species it is 1.2 to 3.4%. The presence of myctophids in the diet of bottom-dwelling fish such as Rajidae spp. suggested the possibility of migrations of myctophids into benthic habitats.

In the Kosmonavtov Sea, myctophids were found in diets of eight species of fish (Pakhomov and Tseitlin, 1992). The myctophid component in the diet of *Gymnodraco acuticeps* (*Bathydraconidae*) is more than 50% (by weight). This species feeds mainly on fish which constitute 97.1% of its food (other fish food in the diet of the species was *Notothenioidei*). Of three studies species of *Trematomus* (*Nototheniidae*), only one *Trematomus eulepidotus,* has myctophids (23.5%) in its diet. The remaining food items were mainly euphausiids, with *E. superba* comprising 52.2%. *D. eleginoides,* the species which primarily feeds on fish, has 12.0% of myctophids in its diet in Kosmonavtov Sea with the remaining fish food being mainly *Notothenioidei* (82.1%). Myctophids are reported only as a species-group in this study.

In the Atlantic sector, earlier studies in the South Georgia area also found myctophids in the diet of *C. gunnari, Pseudochaenichthys georgianus* (Kock, 1981) and *D. eleginoides* (K.-H. Kock, personal communication). During these studies only the frequency of occurrence of myctophids was determined. The results indicated that myctophids did not comprise a frequent food item of these fish in the South Georgia area.

3.2 Birds

The most complete set of quantitative data on myctophids in the diet of Antarctic predators come from this group of predators, mainly from studies of Antarctic and sub-Antarctic penguins. Summaries of available data are given below by major groups of predators.

3.2.1 Penguins

King penguin *(Aptenodytes patagonicus)*

Information on myctophids in the diet of king penguins came from the APF area of the Indian and Pacific Oceans (Marion, Heard and Macquarie Islands) (Annex, Table 2). The king penguin feeds mainly on fish in all of these three localities. The proportion of fish is about 94% by number and by food weight. A small proportion of squid is also taken. Almost all of the fish taken by king penguin is myctophids with *K. anderssoni* and *E. carlsbergi* being the principal prey items. *Protomyctophum* spp. and *Gymnoscopelus* spp. are also taken but in much smaller quantities. Some variation, however, exists between three localities (Marion, Heard and Macquarie Islands) in species composition of myctophids and their proportions in the diet (see Table 3).

The proportion of *K. anderssoni* in the diet is largest on Heard and Macquarie Islands. On Marion Island an unknown amount of *P. tenisoni is* included in the reported 31.8% of *K. anderssoni* because otoliths of these two species are very difficult to distinguish. All these species of myctophids have circumpolar distribution at least in the APF area with only one exception - *P. normani* which is found to the south of APF only in the Indian Ocean sector. The next most abundant food item in the diet on Marion Island (13.4%) and Macquarie Island (48.5%) is *E. carlsbergi*. This species did not comprise any substantial proportion in the diet on Heard Island, but this might reflect differences in the timing and duration of field studies.

Observations at Marion and Macquarie Islands were carried out for a whole year. Authors noted very distinct seasonal changes in maximum and minimum proportions of *K. anderssoni* and *E. carlsbergi*. The observed seasonal variations are summarised in Table 4. A very close similarity in the distribution of these species in the diet of king penguins is observed on Marion and Macquarie Islands. Observations on Heard Island were conducted in November/December when *E. carlsbergi* is absent in the diet of king penguins at two other surveyed islands. These changes in species composition of the diet may reflect seasonal changes in distribution of *K. anderssoni* and *E. carlsbergi* in the APF area of the Indian Ocean as well as seasonal changes in feeding patterns of king penguins.

Gentoo penguin (*Pygoscelis papua*)

Observations have been conducted at four different localities: South Georgia, Marion, Heard and Macquarie Islands (Annex, Table 3).

On South Georgia observations were conducted during winter (May to September) in 1987 and 1988. Diet composition by sexes was different (Williams, 1991). The diet of females in July/August, 1987 consisted mainly of crustaceans (87% by weight) with *E. superba* being a staple food. The diet of males in the same period consisted mainly of fish (83% by weight). Gentoo penguins show sexual dimorphism in bill size, and males are larger and may be better adapted to catch fish prey. It may also suggest different foraging areas with males feeding close to the shore on fish and females feeding off-shore of krill. Three species of myctophids were identified in food samples: *E. carlsbergi, P. choriodon* and *G. braueri*. However, their total number was only 4.3 to 6.2% of the total number of otoliths in samples. Diet studies in summer (Croxall and Prince, 1980; Croxall, personal communication) have failed to detect myctophids.

On Marion Island the winter diet (September) comprised 70% fish by weight and 30% crustaceans (La Cock, Hecht and Klages, 1984). Three specimens of myctophids belonging to the genera *Electrona, Protomyctophum* and *Gymnoscopelus* (<1.0% of all otoliths) were found. A second study gave results of 86.5% fish, <1.0% of crustaceans and 13.5% of squid (Adams and Klages, 1987).

On Heard Island the diet from November 1986 to January 1987 comprised mainly of crustaceans (75.2% by number) and fish (22.2% by number and 90.5% by weight). Myctophids, mainly *K. anderssoni*, comprised about 12% by number.

On Macquarie Island the diet of gentoo penguin was exclusively fish with 58.3% of myctophids (by weight). Three species of myctophids were observed: *K. anderssoni, E. carlsbergi* and *Gymnoscopelus* spp. A proportion of *E. carlsbergi* was the highest among myctophids (27.5% by weight).

Royal/macaroni penguin (*Eudyptes chrysolophus*)

Two papers were recently published on the diet of royal/macaroni penguins (Annex, Table 4). However, only the data for Macquarie Island contain quantitative details (Hindell, 1988c). Myctophids in the diet comprised 2.2% by number and 41.2% by weight (out of 45.6% of all fish). Four species of myctophids were found: *K. anderssoni, E. carlsbergi* and two species of genus *Protomyctophum* and *Gymnoscopelus*. Other components of the diet were crustaceans (51.3% by weight) and small amount of squids.

On Crozet Islands 35.4 % (by volume) of the diet of royal/macaroni penguins consists of myctophids; *K. anderssoni* (17.2%), *E. carlsbergi (9.0%)* and *P. tenisoni* (6.7%) (Ridoux, 1987).

Results of several studies have been published recently but quantitative data on the diet of this species of penguin is available only for Macquarie Island (Annex, Table 5, Hindell 1988a). The diet of this species contained only a small proportion of fish (1.2% by number and 28.3% by weight). Myctophids comprised only about 0.7% in number and 23.1% by weight. Other food items were crustaceans (69.4% by weight) and a small amount of squids.

3.3 Flying Birds

Quantitative data on myctophids in the diet of flying birds had been obtained for the Wilson's storm petrel from South Georgia and for the blue-eyed cormorant at Macquarie Island (Annex, Table 6). The diet of Wilson's storm petrel contain only 1.0% of fish (by number) forming 28% of the diet by weight. Fish was only myctophids: *P. normani* and *P. bolini*. *G. nicholsi* was found in the diet of the cormorant. It represented 0.2% (by number) of all fish.

Fish form 24% by weight of the diet of white-chinned petrels (Croxall and Prince, 1987). Myctophids comprise 81% by number and about 75% by weight of the fish portion of the diet (Croxall and North, personal communication). Seven species of myctophid were identified (see Table 2) of which *E. antarctica, E. carlsbergi* and *G. nicholsi* were the most common species (contributing 77% by number and 78% by weight of all myctophids).

3.4 Seals

3.4.1 Antarctic fur seal (*Arctocephalus gazella*)

Results of four recent studies on the diet of the Antarctic fur seal contain some quantitative assessments (Annex, Table 7). Myctophids comprised the bulk of all otoliths found in scats of the Antarctic fur seal in the Heard and Macquarie Islands: 60.4 to 85.0% and 88.3%, respectively. Myctophids of the following species were most frequent:

Heard Island - *E. antarctica, E. subaspera* and G. *nicholsi*;
Macquarie Island - *E. subaspera* and one unidentified species of genus *Electrona.*

On South Georgia myctophids (*G. nicholsi)* comprised 10.9% of otoliths in scat samples but by weight this represented only about 2% of the diet (Doidge and Croxall, 1985). Other food items were several species of nototheniids and channichthyids and also some squids with the main diet being Antarctic krill.

4. DISCUSSION

Since the reviews of 1984 and 1985 many quantitative assessments of the diet of the Antarctic predators have been undertaken. Most studies had been carried out on sub-Antarctic islands, on the Antarctic coast and in adjacent waters.

The importance of myctophids as food for other fish is still poorly known. Though myctophids were recently reported from diet studies of 18 species of fish, the number of quantitative studies and their geographical coverage is very limited.

With several exceptions, studies on the diet of birds and seals were generally conducted ashore during their breeding season. Less is known of the diet composition of these predators during winter when most of them feed at sea and do not return ashore. Geographical distribution of sites where myctophids were found in the diet of predators, reflect this situation (Figure 1, Tables 1 and 3). All myctophids were encountered in the two narrow zones: the APF area from the Antarctic Peninsula east to Macquarie Island (nine localities) and the Antarctic coast (four neighbouring localities). Recent studies in the Weddell Sea have shown that outside of breeding seasons in winter myctophids are very significant by mass in diets of Adelie penguins (17%), Antarctic petrel (64%) and snow petrel (87%) (D.G. Ainley, personal communication).

Most quantitative information of myctophids came from studies of diets of penguins. Studies of the diet of king penguin represent the best set of data available. Apparently this species of penguin is the only specialist predator on myctophids at least in the APF area of the Indian Ocean. Unfortunately no quantitative data are available on the diet of king penguins on South Georgia where the bulk of the diet of many predatory species consists of krill, *E. superba*. However, Croxall (1991) lists this species as feeding on myctophids at South Georgia as well. Myctophids were found also in diets of three other species of penguins: gentoo, macaroni and rockhopper. However, the level of quantitative details on myctophids in these studies was not sufficient to make any conclusion on consumption of myctophids or to compare diets in different geographical areas.

Limited quantitative description of myctophids in the diet of two species of flying birds, Wilson's storm petrel and blue-eyed cormorant, is available.

Myctophids in the diet of Antarctic seals in recent studies are reported only for the Antarctic fur seal from South Georgia, Heard and Macquarie Islands. Unfortunately the data basically give only frequency of occurrence of myctophids by species found in collected scats. In 1988 Soviet researchers took more than 200 stomach samples of crabeater, leopard, Weddell, Ross and elephant seals. Preliminary results contained no information on myctophids (Vagin and Shust, 1989).

The diet of Antarctic predators is highly variable temporally and geographically. For many breeding areas information on the diet composition of many predators is not yet available. Table 3 summarises by breeding areas the available information for birds and seals the diet of which, at least at some areas, contain myctophids. This summary table allows a very rough assessment of the extent to which dietary studies have been undertaken at predators' breeding areas. The table also illustrates geographical variations in the diet of some species in relation to myctophids.

The diet of the Antarctic predators in relation to myctophids varies seasonally and annually depending on a stage of the predator life cycle and food availability in the area. Present data on myctophids are insufficient for any sort of quantitative assessment of this variability. Only for the king penguin are data available from year-round studies.

Most of earlier studies which reported myctophids in the diet of predators, contain only one quantitative parameter, frequency of occurrence of food items in samples. Very often

myctophids were reported as a group of fish without species identification. Several recent studies, however, are based on quantitative analysis of dietary components with most fish species identified. Although these studies involve different types of analysis and use different parameters in order to describe the observed diet composition, some of them contain various quantitative characteristics which may enable comparison of the myctophid component of the diet of various predators. However, noting the paucity of available data for some predators and the fact that data come from different geographical localities, conclusions on the diversity of myctophid species in the diet of predators are not possible (Table 2). It appears, however, that myctophids of genus *Electrona* are common in the diet of all predators and, in terms of myctophid component, the diet of birds and seals is more diverse than the diet of fish.

5. CONCLUSION

(i) Most of the data on myctophids in the diet of Antarctic predators came from studies conducted in the following two zones:

- Antarctic Polar Front area between the Antarctic Peninsula and Macquarie Island; and
- Antarctic coast.

(ii) Myctophids were found in the diet of one species of squid, 18 species of fish (eight of *Nototheniidae,* seven - *Channichthyidae,* two - *Bathydraconidae* and one -*Rajidae*), 18 species of birds (penguins - seven, albatrosses - four, petrels - five, prions - one and cormorants - one) and two species of seals (Table 1). No myctophids were reported from studies of whale diets in the Antarctic waters. Two species of myctophids, *E. antarctica* and *G. nicholsi* were found to eat some juvenile myctophids.

(iii) Myctophids in the diet of predatory species are represented by 16 species of genera *Krefftichthys (*one species), *Protomyctophum* (four species), *Electrona (*five species), *Metelectrona (*one species) and *Gymnoscopelus* (four species). However, the total number of species may be underestimated because identification of myctophids in predator food samples is still difficult.

(iv) Many species of fish, birds and seals take myctophids opportunistically in addition to their staple diet. Penguins have the largest proportion of myctophids in their diet. The king penguin in the APF area of the Indian Ocean is the only one specialist predator on myctophids. The *Bathydraconidae* fish, *Gynmodraco acuticeps,* from the Kosmonavtov Sea (Indian Ocean sector) may be the second most important predator of myctophids.

(v) The occurrence of myctophids in the diet of predatory species appears to be highly variable though there are insufficient data to evaluate this. Apart from the obvious variability of the diet composition in different geographical areas, the myctophid diet is subject to seasonal and inter-annual variability.

(vi) It is obvious that myctophids are widespread in diets of many Antarctic predators. However, the available information is mostly descriptive and lacks quantitative assessments. It is clear that more quantitative studies on as many as possible species of predators are required in order to assess the role of myctophids in the Antarctic ecosystem. Information on the diet of myctophids themselves is also important. These studies should use standardised methods, be carried out in different seasons and have a wide geographical coverage.

(vii) Any research in the Antarctic, and in particular on such a widespread and abundant resource as myctophids, will benefit from international cooperation. The CCAMLR Scientific Committee may wish to play an important role in coordinating future international research on Antarctic myctophids.

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Table 1: Known predators of myctophids in Antarctic waters.

++++ Major diet component
+++ Common, although usually not a major diet component
++ Minor diet component
+ Occasional diet component
- Rare diet component

Species	Known Predators	Importance	Area	Reference
***Myctophidae* spp.**	**Squids:**			
	Species not specified	++++	Antarctic open waters	Lubimova 1985
	Moroteuthis knipovitchi	++++	Not specified	Nemoto *et al.* 1985
	Fish:			
	***Nototheniidae*:**			
	N. kempi	+++	South Shetlands	Takahashi 1983
	N. rossii, *N. squamifrons* and *D. eleginoides*	++	Kerguelen Is, Crozet Is, Lena and Ob Banks	Chechun 1984 Duhamel, Hureau 1985
	D. Mawsoni	++	Kosmonavtov Sea	Pakhomov, Tseitlin 1992
	T. eulepidotus	++		
	T. (Pagothenia) hansoni	-		
	T. centronotus	-		
	T. (Pagothenia) hansoni	-	Lützow-Holm Bay	Naito, Iwami 1982
	Channichthyidae:			
	C. gunnari and *Ch. rhinoceratus*	++	Kerguelen Is, Crozet Is Lena and Ob Banks	Chechun 1984 Duhamel, Hureau 1985
	C. gunnari, *P. georgianus* and *C. aceratus*	++	South Georgia	Kozlov *et al.* 1988
	C. rastrospinosus, *C. gunnari* and *P. georgianus*	+	South Shetlands	Takahashi 1983
	C. wilsoni	+	Kosmonavtov Sea	Pakhomov, Tseitlin 1992
	C. hamatus	++		
	***Bathydraconidae*:**			
	Cygnograco mawsoni	+	Kosmonavtov Sea	Pakhomov, Tseitlin 1992
	Gymnodraco acuticeps	+++		
	***Rajidae* spp.**	+	South Shetlands	Takahashi 1983
	***Myctophidae*:**			
	E. antarctica	-	Not specified	Williams 1985
	G. nicholsi	-	South Shetlands	Takahashi 1983
	Birds:			
	Adélie penguin	-	Magnetic Is, Davis	Puddicombe, Johnstone 1988
	Adélie penguin	++++	Weddell Sea	Ainley (pers. comm.)
	Antarctic petrel, storm petrel	++++	Weddell Sea	Ainley (pers. comm.)
	Light-mantled sooty albtrs	++	South Georgia	Thomas 1982
	Black-browed albatross	+	South Georgia	Prince 1980
	Grey-headed albatross	+	South Georgia	Prince 1980
	King penguin, dove prion, blue petrel, black-bellied storm petrel	++	South Georgia	Croxall 1990

Table 1 (continued)

Species	Known Predators	Importance	Area	Reference
	Seals:			
	Ross seal	+	Not specified	As cited by Laws 1984
Krefftichthys anderssoni	King penguin	++++	Marion Is	Adams, Klages 1987; Cooper, Brown 1990
	King, royal/macaroni, rockhopper and gentoo penguins	+++	Macquarie, Heard Is	Williams 1988, 1989; Klages *et al.* 1989; Hindell 1988; Cooper, Brown 1990
	Royal/macaroni penguin	++	Macquarie Is	Horne 1985
		+++	Crozet Is	Ridoux 1987, Ridoux *et al.* 1988
	Antarctic fur seal	++++	Heard Is	Green *et al.* 1989
Protomyctophum bolini	King penguin	+	Marion Is	Adams, Klages 1987; Cooper, Brown 1990
	Royal/macaroni, rockhopper and gentoo penguins	++	Macquarie, Heard Is	Williams 1989, Klages *et al.* 1989; Cooper, Brown 1990
	Antarctic fur seal	+++	Heard Is	Green *et al.* 1989
	Wilson's storm petrel	+	South Georgia	Croxall *et al* 1988a; Croxall, North 1988b
Protomyctophum normani	King penguin	+++	Marion Is	Adams, Klages 1987; Cooper, Brown 1990
	Wilson's storm petrel	+	South Georgia	Croxall *et al* 1988a; Croxall, North 1988b
	White-chinned petrel	+	South Georgia	Croxall, North (pers. comm.)
Protomyctophum choriodon	Gentoo penguin	++	South Georgia	T. Williams 1990
	C. gunnari	-	Kerguelen	Hull, Camus, Hureau 1989
	White-chinned petrel	++	South Georgia	Croxall, North (pers. comm.)
Protomyctophum tenisoni	King, Royal/macaroni, rockhopper, gentoo penguin	+++	Marion Is	Adams, Klages 1987; Cooper,Brown 1990
	Royal/macaroni	+++	Crozet Is	Ridoux 1987, Ridoux *et al.* 1988
	Salvin's prion	++	Marion Is	Cooper, Brown 1990
Protomyctophum	*C. gunnari*	++	South Georgia	Kozlov *et al.* 1988
	C. aceratus	+++		
	P. georgianus	+++		
	Gentoo penguin	+	Marion Is	La Cock *et al.* 1984
	Rockhopper penguin	-	Macquarie Is	Hindell 1988
Electrona antarctica	Adélie penguin	+	Béchervaise Is, Mawson	Kerry (pers. comm.)
	Emperor penguin	+++	Mawson coast	As cited by Williams 1990
	King penguin	+++	Heard Is	Klages *et al.* 1989
	Snow petrel	+++	Budd coast	As cited by Williams 1990

Table 1 (continued)

Species	Known Predators	Importance	Area	Reference
	White-chinned petrel	+++	South Georgia	Croxall, North (pers. comm.)
	Antarctic fur seal	++++	Macquarie Is	Green *et al.* 1989
	Elephant seal	-	Heard, Macquarie Is	Green (pers. comm.)
Electrona carlsbergi	Squids	Not specified	Not specified	Zasel'skiy *et al.* 1985
	Notolepis spp.			
	Chaenichthyidae spp.			
	Adélie penguin	+	Magnetic Is, Davis	R. Williams (pers.comm.)
	King penguin	++++	Macquarie Is	Hindell 1988a, Williams 1988
		+++	Marion Is	Adams, Klages 1987; Cooper, Brown 1990
		++++	Heard Is	Klages *et al.* 1989
	Gentoo penguin	++++	Macquarie Is	Williams 1988
			Heard Is	Hindell 1989
				Klages *et al.* 1989
		++	South Georgia	T. Williams 1990
	Chinstrap penguin	++	Bouvet Is	Cooper *et al.* 1984
	Royal/macaroni penguin	++	Heard, Macquarie Is	Williams 1988, 1989
		++	Crozet Is	Ridoux 1987, Ridoux *et al.* 1988
	Rockhopper penguin	-	Macquarie Is	Hindell 1988c
	King, Royal/macaroni, gentoo, rockhopper penguin	++/+++	Marion Is	Cooper, Brown 1990
	Sooty albatross	+++	Marion Is	Cooper, Klages (in press)
	Light mantled sooty albtrs			
	White-chinned petrel	+++	South Georgia	Croxall, North (pers. comm.)
	Blue petrel, Salvin's prion	++/+	Marion Is	Cooper, Brown 1990
	Antarctic fur seal	++	Macquarie Is	Green *et al.* 1990
		++	Heard Is	Green *et al.* 1989
	C. gunnari	-	Kerguelen	Hulley, Camus, Hureau 1989
Electrona paucirastra	Antarctic fur seal	-	Macquarie Is	Green *et al.* 1990
	C. gunnari	-	Kerguelen Is	Hulley, Camus, Hureau 1989
Electrona subaspera	Gentoo penguin	++++	Macquarie Is	Green *et al* 1990
	Macaroni penguin	+	Marion Is	Cooper, Brown 1990
	Antarctic fur seal	++++	Macquarie Is	Green *et al* 1990
		++	Heard Is	Green *et al.* 1989
	Great-winged petrel, Soft-plumaged petrel	+	Marion Is	Cooper, Brown 1990
	Elephant seal	-	Heard, Macquarie Is	Green (pers. comm.)
***Electrona* spp.**	*C. gunnari*	++	South Georgia	Kozlov *et al.* 1988
	C. aceratus	+++		
	P. georgianus	+++		
	Gentoo penguin	+	Marion Is	La Cock *et al.* 1984

Table 1 (continued)

Species	Known Predators	Importance	Area	Reference
Metelectrona ventralis	*D. elegionoides*	-	Kerguelen Is	Hulley, Camus, Duhamel 1989
	D. eleginoides	-	Heard Is	Williams 1990
	C. gunnari		Kerguelen Is	Hully, Camus, Duhamel 1989
Gymnoscopelus	Gentoo penguin	+	South Georgia	T. Williams 1990
	White-chinned petrel	+	South Georgia	Croxall, North (pers. comm.)
	Antarctic fur seal	+	Heard Is	Green *et al.* 1989
	New Zealand fur seal	+	Macquarie Is	Green *et al.* 1990
	Elephant seal	-	Heard, Macquarie Is	Green (pers. comm.)
Gymnoscopelus bolini	Antarctic fur seal	+	Heard Is	Green *et al.* 1989
		+	Macquarie Is	Green *et al.* 1990
	D. elegionoides		Kerguelen Is	Hulley, Camus, Duhamel 1989
Gymnoscopelus fraseri	Antarctic fur seal	-	Heard, Macquarie Is	Green (pers. comm.)
Gymnoscopelus* nicholsi	Gentoo penguin	+++	Macquarie Is	Hindell 1989
		++	Marion Is	Cooper, Brown 1990
	King penguin	+++	Heard Is	Klages *et al.* 1989
	Rockhopper penguin	+	Marion Is	Cooper, Brown 1990
	White-chinned petrel	+++	South Georgia	Croxall, North (pers. comm.)
	Blue-eyed Cormorant	++++	Macquarie Is	Green *et al.* 1990
	Antarctic fur seal	+++	Macquarie Is	Green *et al.* 1990
		+++	Heard Is	Green *et al.* 1989
		++++	South Georgia	North *et al.* 1983
	Elephant seal	-	Heard, Macquarie Is	Green (pers. comm.)
G. piabilis	Sooty albatross	++	Marion Is	Cooper, Klages (in press)
G. macrolampas	White-chinned petrel	++	South Georgia	Croxall, North (pers. comm.)
***Gymnoscopelus* spp.**	King penguin	+	Marion Is	Adams, Klages 1987
	Gentoo penguin	++	Macquarie Is	Williams 1988
	Gentoo penguin	+	Marion Is	La Cock *et al.* 1984
	Rockhopper penguin	-	Macquarie Is	Hindell 1988
	Sooty albatross	++	Marion Is	Cooper, Klages (in press)
	C. gunnari	++	South Georgia	Kozlov *et al.* 1988
	C. aceratus	+++		
	P. georgianus	+++		
***Diaphus* sp.**	Great- winged petrel	+	Marion Is	Cooper, Brown 1990
	Kerguelen petrel			

* It is possible that *G. piabilis* makes most of the contribution in the predators' diets at Macquarie Is because otoliths of these two species are very hard to distinguish (Williams, 1990).

Table 2: Occurrence of myctophids in the diet of Antarctic predators (for references see Table 1).

* Distribution of myctophids to the south of the Antarctic Convergence:
⊕ Distributed circumpolar between ACC and the Antarctic coast
∅ Distributed circumpolar in the ACC waters
× Localised distribution in the ACC waters

	Myctophidae spp.	*K. andersoni*	*P. bolini*	*P. tenisoni*	*P. normani*	*P. choriodon*	*Protomyctophum* spp.	*E. antarctic*	*E. carlsbergi*	*E. subaspera*	*E. paucirastra*	*Electrona* spp.	*M. ventralis*	*G. nicholsi*	*G. braueri*	*G. bolini*	*G. frazeri*	*G. piabilis*	*G. microlampas*	*Gymnoscopelus* spp.	Total number of spp.
Distribution of myctophids*		⊕	⊕	∅	×	×		⊕	⊕	∅	×		×	⊕	⊕	∅	∅	×	×		
Squids	+							+													1
***Nototheniidae*:**																					
N. rossii	+																				
N. kempi	+																				
N. squamifrons	+												+			+					2
D. eleginoides	+							+													1
D. mawsoni	+																				
T. (Pagathonei) hansoni	+																				
T. eulepidotus	+																				
T. centronotus	+																				
***Channichthyidae*:**																					
P. georgianus	+																				
Ch. rhinoceratus	+					+			+		+		+								4
C. gunnari	+																				
C. aceratus	+																				
C. rastrospinosus	+																				
C. wilsoni	+																				
C. hamatus	+																				
***Bathydraconidae*:**																					
C. mawsoni	+																				
C. acuticeps	+																				
***Rajidae* spp.**	+																				
***Myctophidae*:**																					
E. antarctica	+																				
G. nicholsi	+																				

Table 2 (continued)

	Myctophidae spp.	*K. andersoni*	*P. bolini*	*P. tenisoni*	*P. normani*	*P. choriodon*	*Protomyctophum* spp.	*E. antarctic*	*E. carlsbergi*	*E. subaspera*	*E. paucirastra*	*Electrona* spp.	*M. ventralis*	*G. nicholsi*	*G. braueri*	*G. bolini*	*G. frazeri*	*G. piabilis*	*G. microlampas*	*Gymnoscopelus* spp.	Total number of spp.
Distribution of myctophids*		⊕	⊕	∅	×	×		⊕	⊕	∅	×		×	⊕	⊕	∅	∅	×	×		
Penguins:																					
Emperor	+							+													1
King	+	+	+	+	+			+	+					+							7
Adélie	+							+	+												2
Chinstrap	+								+												1
Gentoo	+	+	+		+	+		+	+	+				+	+						9
Rockhopper	+	+	+						+												3
Macaroni	+	+	+	+					+												4
Flying Birds:																					
Sooty albatross	+								+									+			2
Light-mantled sooty albtrs	+							+	+												2
Black-browed albatross	+																				
Grey-headed albatross	+																				
Snow petrel	+																				
Dove prion	+																				
Salvin's prion									+												1
Blue petrel	+								+												1
White-chinned petrel	+				+	+			+	+			+	+					+		7
Wilson's storm petrel	+		+		+																2
Black-bellied storm petrel	+																				
Great-winged petrel										+											1
Soft-plumaged petrel										+											1
Blue-eyed Cormorant	+													+							1
Seals:																					
Fur seal	+	+	+	+	+			+	+	+	+		+	+	+	+	+				13
Elephant seal	+							+		+				+	+						4

Table 3: Myctophids in the diet of Antarctic birds and marine mammals in breeding areas. (Information on breeding areas is adopted from Bengtson (1985) and publications listed in Table 1).

\+ Species present but no information on the diet available
⊕ Myctophids found in the diet
∅ Myctophids not found in the diet

Predators	Breeding Areas										References to ∅ = No myctophids in the diet (for references to ⊕ = yes, see Table 1)
	Marion Is	Crozet Is	Kerguelen Is	Macquarie Is	Heard Is	South Georgia	South Shetlands, South Orkney, South Sandwich Is	Antarctic Peninsula	Bouvet Is	Antarctic Coast	
Emperor penguin								+		∅ ⊕	Klages 1989; Gales *et al.* 1990; Offredo, Ridoux 1985
King penguin	⊕	+	+	⊕	⊕	⊕					
Adélie penguin							∅	+	+	∅ ⊕	Ridoux, Offredo 1989; Lishman 1985
Chinstrap penguin						+	∅	+	⊕	+	Croxall, Furse 1980; Lishman 1985
Gentoo penguin	⊕	+	+	⊕	⊕	∅ ⊕	+	+			Croxall, Prince 1980
Rockhopper penguin	+	+	+	⊕	⊕						
Macaroni penguin	+	⊕	+	⊕	⊕	∅	∅		+		Croxall, Prince 1980; Croxall, Furse 1980
Sooty albatross	⊕										
Light-mantled sooty albatross	⊕	+	+	+	+	⊕	+	+	+	+	
Grey-headed albatross	+	+	+	+		⊕					
Black-browed albatross		+	+	+	+	⊕					
Snow petrel						+	+	+	+	∅ ⊕	Ridoux, Offredo 1989
Blue petrel	⊕	+	+	+		⊕					Cooper, Brown 1990
Great winged petrel	⊕	+	+								Cooper, Brown 1990
Kerguelen petrel	⊕	+	+								Cooper, Brown 1990
Soft plumaged petrel	⊕	+									Cooper, Brown 1990
Dove prion		+	+	+	+	⊕	+				
Salvin's prion	⊕	+									Cooper, Brown 1990
White-chinned petrel;	+	+	+	+		⊕					
Wilson's storm petrel		+	+		+	⊕	+	+	+	∅	Ridoux, Offredo 1989
Black-bellied storm petrel						⊕					
Cormorant (*P. atriceps)*				⊕	+	∅	+	+			Croxall *et al.* 1991
Fur seal	+	+	+	⊕	⊕	⊕	+	+	+		
Elephant seal	+	+	+	⊕	⊕	∅	+	+	+		Rodhouse *et al* (in press)

Table 4: Myctophids in the diet of king penguins on Marion, Heard and Macquarie Islands in percentage by numbers of food items (adopted from Adams and Klages, 1987; Hindell, 1988b; Klages *et al.*, 1980).

Myctophidae Species	Marion Is	Heard Is	Macquarie Is
K. anderssoni	**31.76**	**96.5**	**48.1**
P. bolini	0.12	+	-
P. normani	0.98	-	-
Protomyctophum spp.	-	-	1.0
E. antarctica	-	+	-
E. carlsbergi	**13.16**	+	**48.5**
G. nicholsi	-	+	-
Gymnoscopelus spp.	0.23	-	0.3
Unidentified	34.75	-	-
Fish total	82.8	99.7	99.1
Myctophids total	81.0	≈99.7	97.9
Squid	17.01	0.15	1.0

Table 5: Seasonal variability in occurrence of *K. anderssoni* and *E. carlsbergi* in the diet of king penguins on Marion, Heard and Macquarie Islands (adopted from Adams and Klages; 1987; Hindell, 1988b; Klages *et al.* 1980).

× observed in the diet
o not observed in the diet

Locality	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Marion Is	*K. anderssoni*	o	o	o	o	o	o	o	o	×	×	×	×
	E. carlsbergi	o	o	o	o	o	o	×	×	o	o	o	o
Macquarie Is	*K. anderssoni*	o	×	×	×	×	o	o	o	o	×	×	×
	E. carlsbergi	o	o	o	o	o	×	×	×	×	o	o	o
Heard Is	*K. anderssoni*											×	×
	E. carlsbergi											o	o

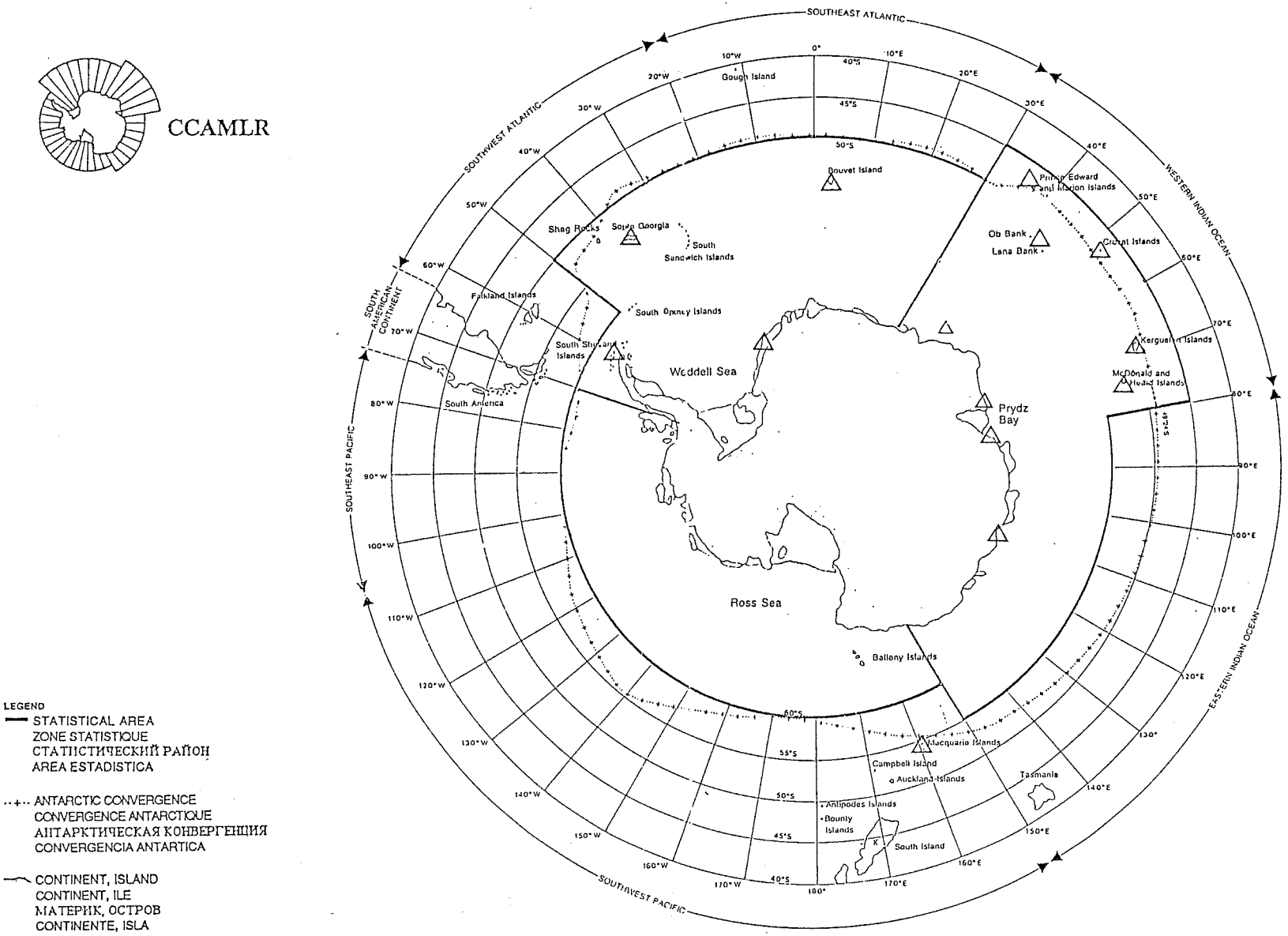

Figure 1: Localities (Δ) where myctophids were found in the diet of Antarctic predators.

Liste des tableaux

Tableau 1: Prédateurs connus de Myctophidae dans les eaux antarctiques.

++++ Elément majeur du régime alimentaire
+++ Elément commun mais rarement majeur du régime alimentaire
++ Elément secondaire du régime alimentaire
+ Elément se trouvant parfois dans le régime alimentaire
- Elément rare du régime alimentaire

Tableau 2: Présence de Myctophidae dans le régime alimentaire des prédateurs antarctiques (cf. tableau 1 pour les légendes).

* Répartition des Myctophidae au sud de la Convergence antarctique;
⊕ Réparti entre le courant circumpolaire antarctique (ACC) et la côte de l'Antarctique
∅ Réparti dans les eaux de l'ACC
× Répartition localisée dans les eaux de l'ACC

Tableau 3: Les Myctophidae dans le régime alimentaire des oiseaux et mammifères marins de l'Antarctique dans les lieux de reproduction (les informations sur les lieux de reproduction proviennent de Bengtson (1985) et des publications citées au tableau 1).

\+ Espèce présente mais pour laquelle on ne dispose d'aucune information sur le régime alimentaire
⊕ Myctophidae présents dans le régime alimentaire
∅ Myctophidae absents du régime alimentaire

Tableau 4: Myctophidae dans le régime alimentaire des manchots royaux des îles Marion, Heard et Macquarie en pourcentage du nombre de spécimens d'aliments (d'après Adams et Klages, 1987; Hindell, 1988b et Klages *et al.*, 1980).

Tableau 5: Variabilité saisonnière de la présence de *K. anderssoni* et *E. carlsbergi* dans le régime alimentaire des manchots royaux des îles Marion, Heard et Macquarie (d'après Adams et Klages, 1987; Hindell, 1988b et Klages *et al.*, 1980).

× Observé dans le régime alimentaire
o Pas observé dans le régime alimentaire

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Figure 1: Emplacements (Δ) où ont été trouvés des Myctophidae dans le régime alimentaire des prédateurs antarctiques.

Список таблиц

Таблица 1: Известные хищники миктофид в акватории Антарктики.

++++ Основной компонент рациона
+++ Часто встречающийся, хотя обычно не основной компонент рациона
++ Второстепенный компонент рациона

+ Случайный компонент рациона
- Редкий компонент рациона

Таблица 2: Присутствие миктофид в рационе Антарктических хищников (для справок см. Таблицу 1).

* Распределение миктофид к югу от Антарктической конвергенции
⊕ Распределенные между АЦТ (Антарктическое циркумполярное течение) и Антарктическим побережьем
∅ Распределенные в водах АЦТ
× Локализированное распределение в водах АЦТ

Таблица 3: Миктофиды в рационе Антарктических птиц и морских млекопитающих в районах размножения (Информация по районам размножения была заимствована из Бенгстона (1985) и публикаций, указанных в Таблице 1).

+ Виды присутствуют, но нет информации о рационе
⊕ Миктофиды обнаружены в рационе
∅ Миктофиды не обнаружены в рационе

Таблица 4: Миктофиды в рационе королевского пингвина на островах Марион, Херд и Макуори в процентном содержании по количеству объектов пищи (взято из Адамс и Клейджес, 1987; Хиндель, 1988 и и Клейджес и др., 1980).

Таблица 5: Сезонное разнообразие присутствия *K. anderssoni* и *E. carlsbergi* в рационе королевского пингвина на островах Марион, Херд и Макуори (взято из Адамс и Клейджес, 1987; Хиндель, 1988и и Клейджес и др., 1980).

× наблюдались в рационе
0 не наблюдались в рационе

Список рисунков

Рисунок 1: Участки (B), на которых были обнаружены миктофиды в рационе Антарктических хищников.

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Tabla 1: Depredadores de mictófidos de las aguas antárticas.

++++ Componente principal de la dieta
+++ Componente común, aunque no es el principal
++ Componente de segundo orden de la dieta
+ Componente poco común de la dieta
- Componente excepcional de la dieta

Tabla 2: Presencia de mictofidos en la dieta de los depredadores antárticos (véase tabla 1 para referencia).

*	Distribución de mictófidos al sur de la Convergencia Antártica
⊕	Distribución circumpolar entre la CCA (Convergencia Circumpolar Antártica) y la costa antártica
∅	Distribución circumpolar en las aguas de la CCA.
x	Distribución localizada en las aguas de la CCA.

Tabla 3: Mictófidos en la dieta de las aves y mamíferos marinos antárticos en las zonas de cría (la información sobre las zonas de cría es de Bengtson (1985) y de las publicaciones que figuran en la tabla 1).

+	Especies encontradas, pero no hay datos sobre la dieta.
⊕	Mictófidos encontrados en la dieta
∅	Mictófidos inexistentes en la dieta

Tabla 4: Mictofidos en la dieta de los pingüinos reales de las islas Marion, Herad y Macquarie, en relación a los distintos alimentos consumidos (según Adam y Klages, 1987; Hindell, 1988 y Klages *et al.* 1980).

Tabla 5: Variabilidad estacional de *K. anderssoni* y *E. carlsbergi* en la dieta de los pingüinos reales de las islas Marion, Heard y Macquarie, (según Adam y Klages, 1987; Hindell, 1988 y Klages *et al.* 1980).

x	presente en la dieta
o	ausente de la dieta

Lista de las figuras

Figura 1: Localidades (Δ) en donde se encontraron mictófidos en la dieta de los depredadores antárticos

ANNEX, TABLES 1 TO 7

Table 1: Myctophids in the diet of Antarctic fish (Chechun, 1984 and Takahashi, 1983).

Fish Species	Area											
	Kerguelen Is			Crozet Is			Lena Bank			Ob Bank		
	%F	%Wt	Sample Size (n)	%F	%Wt	Sample Size (n)	%F	%Wt	Sample Size (n)	%F	%Wt	Sample Size (n)
N. rossii	8.6	2.7	787	6.7	0.9	165	6.7	2.3	318	8.3	3.6	269
N. squamifrons	3.6	3.4	671	14.5	13.5	216	8.4	8.1	123	17.1	10.7	636
D. eleginoides	8.8	5.7	217	12.9	7.7	103	4.8	3.3	69	11.2	8.4	96
C. gunnari	14.2	2.4	1296	-	-		-	-		-	-	
C. rhinoceratus	2.4	3.4	490	-	-		-	-		-	-	

Fish Species	Area		
	South Shetland Is		
	%F	%Wt	Sample Size (n)
P. georgianus	3.4	-	47
C. rastrospinosus	1.2	-	185
N. kempi	33.3	-	10
C. gunnari	1.4	-	89
Rajidae spp.	1.4	-	85
G. nicholsi	3.1	-	39

Table 2: Myctophids in the diet of king penguins.

Myctophidae Species	%F	%N	%W	Prey Size/Mass (*mm/g*)	Stomachs *n*
Macquarie Is, November 1984 to November 1985, seasonal changes in the diet exist (Hindell, 1988b)					
K. anderssoni	68	48.1	37.7	SL55/2.5	80
Protomyctophum spp.	22	1.0	0.9	-	26
E. carlsbergi	71	48.5	53.2	SL76/6.5	84
Gymnoscopelus spp.	3	0.3	0.3	-	3
Unidentified	3	<0.1	<0.1	-	3
Total fish		99.1	97.8		
Heard Is, November 1986 to January 1987 (Klages *et al.*, 1990)					
K. anderssoni	95.8	96.5		SL48.5/1.9	
P. bolini	4.2				
E. antarctica	4.2				
E. carlsbergi	25.0			ST81/8.1	
G. nicholsi	4.2				
Unidentified	20.8				
Total fish		99.7	99.4		18
Marion Is, March 1984 to March 1985 (Adams and Klages, 1987)					
Myctophidae total	83.3	34.75			
K. anderssoni	85.0	31.76		48.3/1.9	
P. bolini	9.2	0.12			
P. normani	28.3	0.98		79.7/6.4	
E. carlsbergi	70.0	13.16		82.3/8.7	
Gymnoscopelus spp.	3.3	0.23			
Total fish		82.8	86.5		120

Table 3: Myctophids in the diet of gentoo penguins.

Myctophidae Species	%F	%N	%W	Prey Size/Mass (*mm/g*)	Stomachs *n*
Heard Is, November 1986 to January 1987 (Klages *et al.*, 1990)					
K. anderssoni	65.5			SL43.1/1.5	
P. bolini	5.5				
E. antarctica	-				
E. carlsbergi	7.7			TL86.0/9.8	
G. nicholsi	-				
Unidentified	1.8				
Total fish		22.2	90.5		54
Macquarie Is, April to November 1985 (Hindell, 1989)					
					96
K. anderssoni			15.1	37.5/1.3	
E. carlsbergi			27.5	45.9/2.4	
Gymnoscopelus spp.			15.7	88.2/6.7	
Total fish		100	100		96
Marion Is, September 1982 (La Cock, Hecht and Klages, 1991)					
Electrona spp., *Protomyctophum* spp. *Gymnoscopelus* spp.		<1.0*			
Total fish	70		72		64
South Georgia, September 1987 and May to September 1988 (T. Williams, 1991)					
E. carlsbergi		3.6-1.7*		79.2/5.0 103.3/8.9	
G. braueri		0.6*		66.3/2.3	
P. choriodon		0.3*		101.5/-	
Unidentified		1.7*		-	
Total fish		4.3-6.2*			10.9

* of all otoliths

Table 4: Myctophids in the diet of royal/macaroni penguins.

Myctophidae Species	%F	%N	%W	Prey Size/Mass (*mm/g*)	Stomachs *n*
Macquarie Is, November 1984 to February 1985 and September to November 1985 (Hindell, 1988c)					
K. anderssoni	48	1.25	23.69	25.1/2.1	
E. carlsbergi	30	0.76	9.64	23.6/1.6	
Protomyctophum spp.	14	0.14	3.84		
Gymnoscopelus spp.	6	0.02	4.03		
Total fish			45.67		182
Heard Is, December 1986 to January 1987 (Klages *et al.*, 1989)					
K. anderssoni	75.0			46.7/1.7	
P. bolini	8.33			55.7/1.5	
E. carlsbergi	6.25			80.2/7.7	
Total fish		0.7	23.2		48

Table 5: Myctophids in the diet of rockhopper penguins.

Myctophidae Species	%F	%N	%W	Prey Size/Mass (*mm/g*)	Stomachs *n*
Heard Is, December 1986 to January 1987 (Klages *et al.*, 1989)					
K. anderssoni	46.2			40.9/1.2	
P. bolini	3.9			60.4/1.7	
Total fish		0.3	8.0		26
Macquarie Is, November 1984 to October 1985 (Hindell, 1988a)					
K. anderssoni	23	0.4	16.0	54.5/3.4	
Protomyctophum spp.	4	<0.1	0.3	53.0/2.8	
E. carlsbergi	5	0.1	2.2		
Gymnoscopelus spp.	5	<0.1	4.6		
Total fish		1.2	28.3		77

Table 6: Myctophids in the diet of flying birds.

Myctophidae Species	%F	%N	%W	Prey Size/Mass (*mm/g*)	Stomachs *n*
Wilson's storm petrel, South Georgia, March 1987 (Croxall and North, 1988)					
P. normani *P. bolini*		83*	87*	TL90.3/4.2 TL67.5/2.25	
Total fish	41	1.0	28.3		51
Macquarie Island cormorant (*Phalacrocorax atriceps purpurascense*), Macquarie Is, March, 1989 (K. Green *et al.*, 1990)					
G. nicholsi		0.2**			
Total fish	100				64
Sooty albatross (*Phoebetria fusca*), Marion Is, February to May 1990 (Cooper and Klages, in press)					
E. carlsbergi *G. piabilis* *Gymnoscopelus* spp. Myctophids total	8.1 2.7 5.4	26.7** 6.7** 13.3** 53.4**			
Total fish	6.8		33.1		37
Light-mantled sooty albatross (*Phoebetria palpebrata*), Marion Is, February to May 1990 (Cooper and Klages, in press)					
E. carlsbergi *Gymnoscopelus* spp. Myctophids total	3.1 6.3	6.7** 13.3** 20.0**			
Total fish	65.6		45.7		32

* of fish only
** of all fish

Table 7: Myctophids in the diet of Antarctic fur seals. Number of myctophids are in percentage to all otoliths found in scat samples and calculated as weighted mean for the period of observation.

	Site			
	Heard Is		Macquarie Is	S. Georgia Is
Date	November 1987-February 1988	May-June 1990	December 1988-March 1989	January-March 1983
Species:				
K. anderssoni	0.8	0.8		-
E. antarctica	9.9	39.6	0.9	-
E. carlsbergi	6.2	0.5	1.9	-
E. subaspera	3.0	30.2	38.0	-
E. paucirastra	-	-	0.2	-
Electrona spp.	-	-	42.5	-
G. bolini	4.3		0.2	-
G. braueri	3.5	0.6		-
G. fraseri	-	0.2		-
G. nicholsi	28.6	7.5	1.9	10.9
Gymnoscopelus spp.	-	1.6	10.9	-
M. ventralis	-	0.7		-
P. bolini	0.1	0.2		-
P. normani	-	2.4	0.2	-
P. tenisoni	-	0.5		-
Unidentified	4.0	0.2	0.6	-
Number of scats analysed	500	374	374	8
Comments	Fish were found in an average of 95.2% of scats	Fish were found in an average of 93.4% of scats	Fish were found in an average of 99.2% of scats	
Reference	Green *et al.*, 1989	Green *et al.*, in press	Green *et al.*, 1990	North *et al.*, 1983