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SEASONAL CHANGE IN THE ABUNDANCE OF ZOOPLANKTON AND SPECIES COMPOSITION OF COPEPODS IN THE ICE-COVERED SEA NEAR SYOWA STATION, ANTARCTICA

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Abstract: Seasonal change in abundance and composition of zooplankton was studied in the ice-covered sea near Syowa Station (69°00′S, 39°35′E) over the year from January 1982 to January 1983. Total zooplankton showed two maxima in number in mid-winter and mid-summer, the largest number was recorded in mid-June. Five groups which consisted of copepods, polychaets, eggs, the larvae of benthic animals and appendicularians were the major components. Of which copepods were the most dominant zooplankters, occupying over 80% of the total numbers of the whole samples. A total of 11 species of copepods excluding the harpacticoids were recorded. Among them, *Calanus propinquus, Ctenocalanus vanus, Microcalanus pygmaeus, Euchaeta* sp., *Scolecithricella glacialis, Metridia gerlachei, Oithona frigida, Oithona similis* and *Oncaea curvata* were oceanic components which occurred abundantly in the winter-spring season, while *Paralabidocera antarctica* and *Stephus longipes* were characteristic to the Antarctic coastal waters and appeared mainly in the summer season. The larvae and eggs of benthic animals were also coastal and summer constituents.

1. Introduction

The Antarctic zooplankton study in the coastal waters has been concentrated in the austral summer season when the sea ice retreats. There are some works on the seasonal study of zooplankton around the shore-based stations (BUNT, 1960; ZVEREVA, 1975; KREBS, 1983) but their works do not cover the whole year. To understand the structure and function of Antarctic coastal ecosystem, it is required to elucidate the life-histories of the zooplankton which seem to play an important role in the ecosystem. This involves the necessity of quantitative descriptions over a whole year such the basic information as abundance of the respective species. However, seasonal occurrence of zooplankton community at Antarctic coast is still not well known.

In this report the present authors intend to describe the seasonal change in abundance and species composition of main zooplankters on the basis of a year-round survey carried out in the ice-covered sea near Syowa Station (69°00′S, 39°35′E). This study is also involved in the Japanese national program of Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS).

2. Materials and Methods

Samples were obtained at a fixed station of the Kita-no-seto Strait about 500 m north of Syowa Station between January 1982 and January 1983. This station was denoted as "Stn. 1" of the BIOMASS research of the 23rd Japanese Antarctic Research Expedition (JARE-23) and the detailed data of oceanographic conditions and sampling procedure were given in FUKUCHI *et al.* (1985b).

Zooplankton samples were collected by vertical haul from near the bottom of about 10 m depth to the surface through a hole bored into the sea ice with a Norpac net (45 cm in mouth diameter, 0.10 mm mesh openings) at intervals of 2 to 3 weeks. Sampling was usually carried out at hours between 0800–1100 LT in the morning. A flowmeter was equipped on the mouth of a net and volume of water filtered was calculated from its reading.

Zooplankton samples were preserved in 5% formalin-buffered seawater. Depending on the abundance of plankters, a whole or an aliquot of 1/2–1/10 of samples was examined under a dissecting microscope, for the species identification and enumeration.

3. Results

3.1. Environmental conditions

The seasonal changes of the oceanographic conditions and chlorophyll *a* at Stn. 1 were already reported by FUKUCHI *et al.* (1984, 1985a). According to them, water temperature was low throughout the year and fluctuated within small range between −1.19 and −1.87°C. Salinity also varied in small range between 33.75 and 34.24 in practical salinity scale. In 1982 the maximum chlorophyll *a* standing stock was observed in late March (8.14 mg/m^2, 0–10 m). Since then chlorophyll *a* decreased and remained at a low level less than 1.0 mg/m^2 from April to November. Chlorophyll *a* increased from the beginning of December and reached a maximum of 62.2 mg/m^2 in late January 1983.

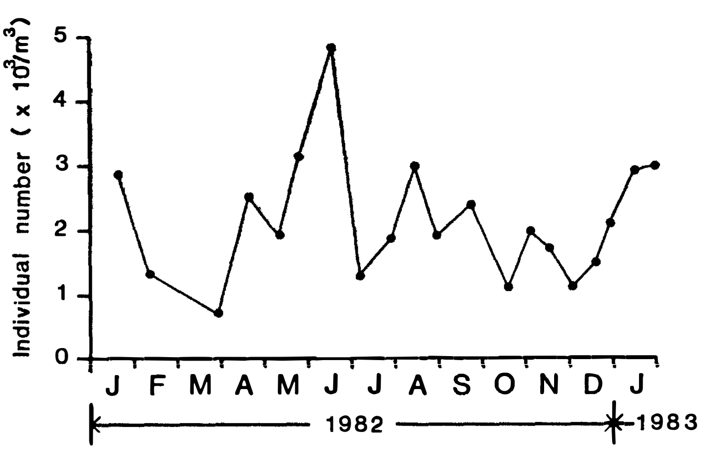

Fig. 1. Seasonal change in total numbers of zooplankton collected at Stn. 1.

3.2. Abundance of zooplankton

Preliminarily, 13 groups of zooplankton were distinguished. They are Copepoda, Polychaeta, eggs, the larvae of benthic animals other than Polychaeta, Appendicularia, Foraminifera, Siphonophora, Ostracoda, Euphausiacea, Chaetognatha, Medusae, Amphipoda and Isopoda in the order of abundance.

Seasonal change of the total numbers of zooplankton is shown in Fig. 1. In 1982 the number of zooplankters was 3×10^3 individ./m^3 in January but it decreased to nearly 0.7×10^3 individ./m^3 in late March. The number increased in April and reached 5×10^3 individ./m^3 in June. After July it decreased gradually toward the beginning of December but remained more than 1×10^3 individ./m^3. In early December the number began to increase and reached again 3×10^3 individ./m^3 in January 1983.

3.3. Abundance of dominant groups

Among 13 zooplankton groups mentioned above, following five groups occupied more than 99% to all plankters of the whole samples. The copepods including their nauplii were by far the most dominant organisms, occupying 84.5% of the total

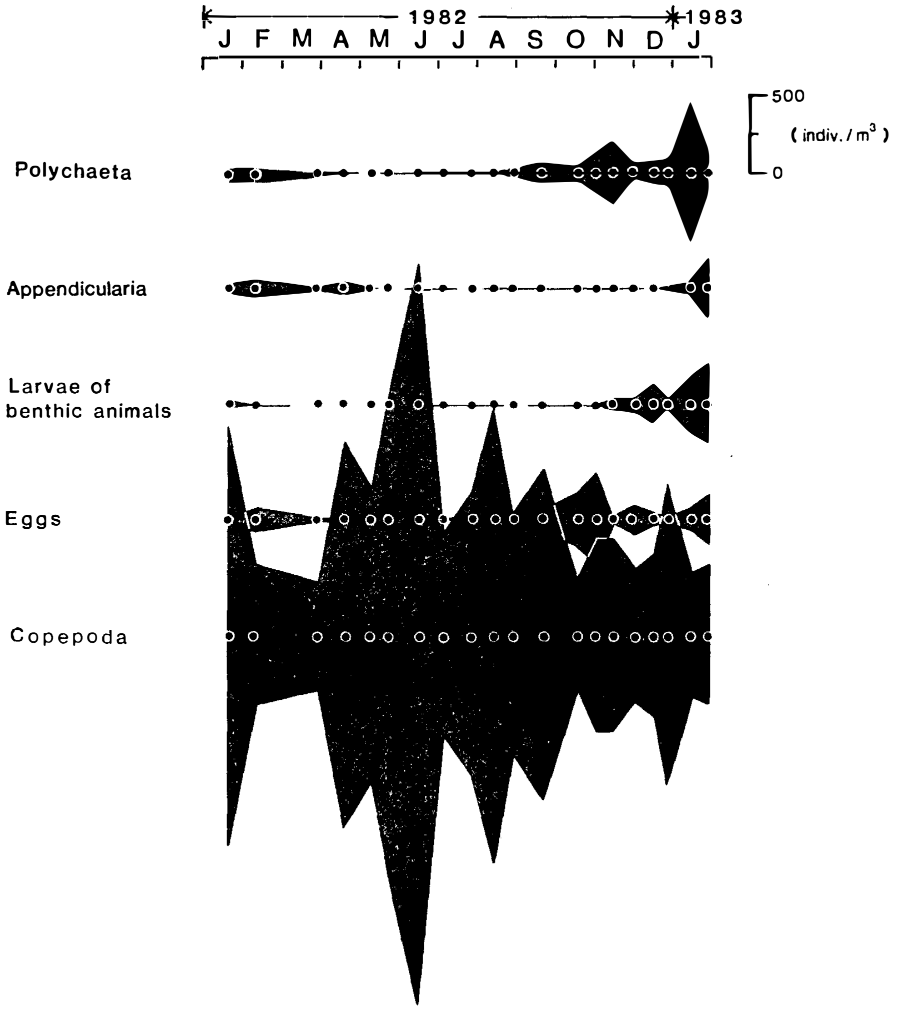

Fig. 2. Seasonal change in abundance of major zooplankton groups collected at Stn. 1.

numbers of the whole samples. The polychaets including larvae of benthic forms ranked next in number (5.2%). The larvae of benthic animals other than polychaets and eggs were also important components of zooplankters, occupying 2.9 and 5.1%, respectively. Aside from these groups, the appendicularians were abundant (1.5%).

Figure 2 shows the seasonal change in abundance of five groups mentioned above. The polychaets, mainly *Pelagobia longicirrata* and Spionidae larvae, occurred throughout the year and were abundant between September and February. *Fritillaria borealis* was the dominant appendicularian. Although they were present in most of the year, they were remarkably abundant between December and April (Fig. 2). The various larvae of benthic animals other than polychaets consisting mainly of lamellibranch veligers, gastropod veligers, echinoderm larvae, bryozoan larvae and ascidians larvae, were numerous between November and January. They were not obtained from March to June but sampled again in small numbers after July (Fig. 2). Eggs were found during the entire year, but they were abundant from September to February (Fig. 2). Although most of eggs could not be identified, the considerable number of eggs found from mid-October to early December were seemed to be the eggs of some ascidian species, based on the observation of developmental process of these eggs. Total copepod numbers decreased during late summer of 1982, thereafter the numbers increased abruptly from March to June and declined gradually from June to October (Fig. 2). They remained low from late October 1982 to January 1983, although a small increase occurred in late December of 1982.

3.4. *Abundance of copepods*

A total of 11 species of copepods except for the harpacticoids were identified; *Calanus propinquus*, *Ctenocalanus vanus*, *Microcalanus pygmaeus*, *Stephus longipes*, *Euchaeta* sp., *Scolecithricella glacialis*, *Metridia gerlachei*, *Paralabidocera antarctica*, *Oithona frigida*, *Oithona similis* and *Oncaea curvata*.

The seasonal change in abundance of these 11 species and the harpacticoids and the nauplii (as a whole) is shown in Fig. 3. *Calanus propinquus* appeared sporadically in small numbers, but it tends to occur somewhat frequently from the autumn to the winter seasons. No adults were captured. *Ctenocalanus vanus* was more abundant in the winter season than in the spring to the summer seasons. On the contrary, *Microcalanus pygmaeus* increased from winter toward spring and reduced in summer to autumn. However, these two species were observed throughout the year. *Stephus longipes* was relatively abundant only in the early summer but was a small in numbers during the other seasons. Immature stages of *Euchaeta* sp. and *Scolecithricella glacialis* occurred in small numbers only in mid-May and mid-April, respectively. No adults were observed. *Metridia gerlachei* occurred in small numbers almost throughout the year, but was slightly abundant during the winter season. *Paralabidocera antarctica* appeared from spring to summer and was dominant in late January 1982 and also late December 1982. It was not captured during the other seasons. Of three cyclopoid copepods, *Oithona similis* and *Oncaea curvata* were dominant species during the entire year except in the summer months; they were abundant throughout the year while peaks in numbers of both species were observed in mid-June. *Oithona frigida* appeared frequently in small numbers but infrequently observed during the winter season. The

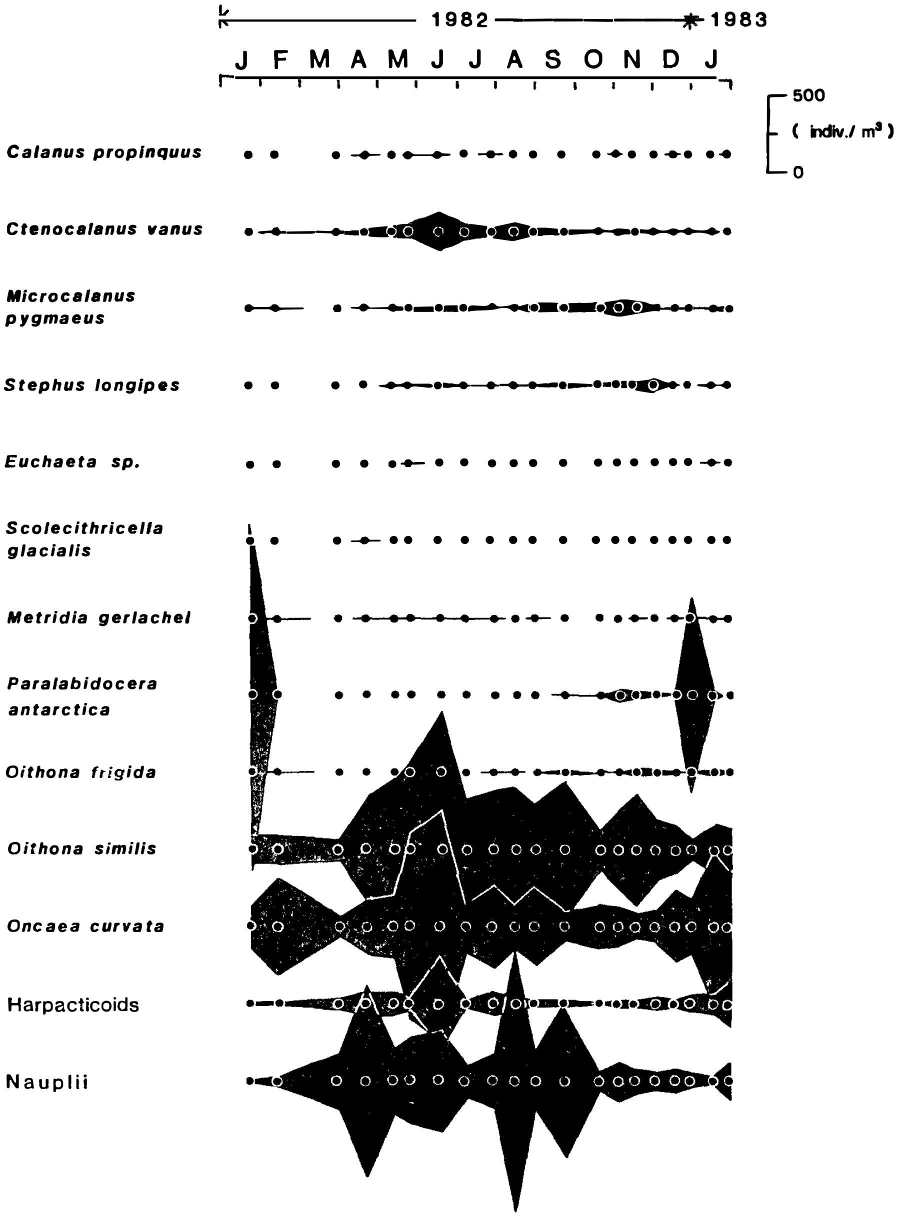

Fig. 3. Seasonal change in abundance of Copepoda collected at Stn. 1.

harpacticoids were present in plankton samples throughout the year and was most abundant in mid-June. The copepod nauplii were also present throughout the year and were abundant in late April and during the early spring season.

The seasonal change of relative abundance of calanoid species is shown in Fig. 4. Four species, *C. vanus*, *M. pygmaeus*, *S. longipes* and *P. antarctica*, were common at the Kita-no-seto Strait, usually exceeding 80% of the total numbers of calanoid copepods. There was a marked seasonality in relative abundance of each species. *C. vanus* was dominant during the long period from the autumn through the winter seasons, occupying over 70% of the total numbers of calanoid copepods. After the prosperity of *C. vanus*, *M. pygmaeus* became to dominant accounting for maximum 70% during the spring months. *S. longipes* became dominant during the short period in the early summer.

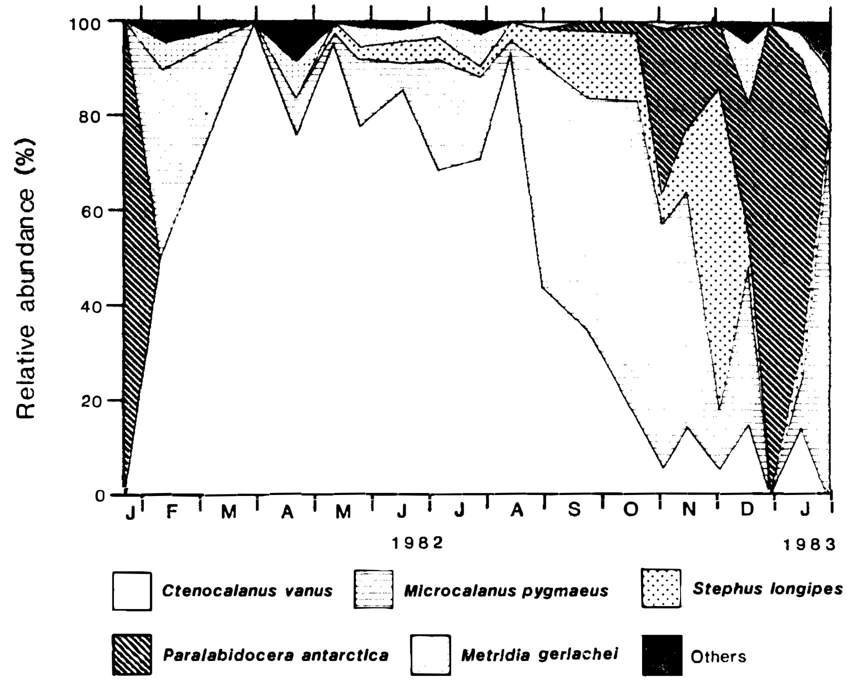

Fig. 4. Seasonal change in relative abundance of calanoid copepods collected at Stn. 1.

Finally *P. antarctica* attained to predominance occupying almost 100% during the mid-summer. The successional change in the dominant species of calanoid copepods as mentioned above is summarized as follow: *P. antarctica*→*C. vanus*→*M. pygmaeus*→ *S. longipes*→*P. antarctica.*

4. Discussion

Previously, FUKUCHI and TANIMURA (1981) carried out the plankton investigations at nearly the same station as that of the present study during January to April and October to November of 1970, and in December of 1975. They found six species of copepods, all of which were also found this time. Five species, *Calanus propinquus*, *Microcalanus pygmaeus*, *Euchaeta* sp., *Scolecithricella glacialis*, and *Metridia gerlachei*, were newly recorded by the present investigation that completely covered a year. These species occurred infrequently during the summer to autumn seasons. It is considered that these 11 species of copepods except for the harpacticoids constitute the majority of planktonic copepods community in the shallow waters near Syowa Station.

BUNT (1960) reported 9 species of copepods excluding the harpacticoids at Mawson Station. Seven out of his 9 species were found in the Kita-no-seto Strait, namely, *Calanus propinquus*, *Ctenocalanus vanus*, *Scolecithricella glacialis*, *Metridia gerlachei*, *Paralabidocera antarctica*, *Oithona similis* and *Oncaea curvata.* ZVEREVA (1975) reported 15 species from Mirny Station and 19 species from Molodezhnaya Station excluding the harpacticoid copepods. All species recorded in the present study were included in her collections. Therefore, it is concluded that all species obtained at the Kita-no-seto Strait are common to the coastal shallow waters of the Indian sector of the Antarctic Ocean.

Most species, *e.g. Calanus propinquus*, *Ctenocalanus vanus*, *Microcalanus pygmaeus*, *Metridia gerlachei*, *Oithona frigida*, *Oithona similis* and *Oncaea curvata*, recorded in the present study were often reported as dominant or abundant components in the Antarctic surface water distant from the Antarctic continent by many authors (MACKINTOSH, 1934; HARDY and GUNTHER, 1935; BAKER, 1954; TANAKA, 1960, 1964; VERVOORT, 1965; SENO *et al.*, 1966; NAKAMURA *et al.*, 1982), while *Paralabidocera antarctica* and *Stephus longipes* were minor components in Antarctic surface water (VERVOORT, 1951, 1957; TANAKA, 1960; SENO *et al.*, 1963). VERVOORT (1965) defined *P. antarctica* and *S. longipes* as the oceanic species in the Antarctic surface water. However, BRADFORD (1971) and WAGHORN (1979) suggested that *P. antarctica* is an Antarctic coastal species. In fact, *P. antarctica* occurred abundantly in the inshore water of Antarctica (FUKUCHI and SASAKI, 1981; TANIMURA *et al.*, 1984). The information on *S. longipes* is still insufficient to make detailed discussion. *S. longipes*, however, seems to be somewhat similar to *P. antarctica* in the distribution because this species was reported from the southernmost part of the Antarctic Ocean (FARRAN, 1929; TANAKA, 1960). Consequently, copepods of the Kita-no-seto Strait can be divided into two groups: one is coastal group represented by *P. antarctica* and *S. longipes*, and the other is oceanic group which contained all species except for the above two species. The larvae and eggs of benthic animals are also characteristic components of coastal zooplankton.

Based on the seasonal prosperity and decay pattern of the plankton population, zooplankters can be divided into two seasonal groups, the winter-spring and the summer-autumn. *Ctenocalanus vanus*, *Microcalanus pygmaeus*, *Oithona similis* and *Oncaea curvata* belong to the winter-spring group. *Calanus propinquus*, *Metridia gerlachei* and *Oithona frigida* are also members of the winter-spring group though their individual numbers are small throughout the year. Meanwhile *Paralabidocera antarctica*, *Stephus longipes*, polychaets, appendicularians and the larvae and eggs of benthic animals are the members of the summer-autumn group. The former group coincides with the oceanic group and the latter is the coastal one mentioned above.

In this study, abundance of copepods was observed in the winter season with a maximum in mid-June. This fact did not agree with that in the Antarctic oceanic waters, where the copepods numbers increased in summer and declined in late autumn (MACKINTOSH, 1934; HARDY and GUNTHER, 1935; FOXTON, 1956, 1964; HOPKINS, 1971). At the present stage of investigation, it is difficult to explain this descrepancy. Water circulation under the fast ice around the Syowa Station area is not well known. However, FUKUCHI *et al.* (1985b) suggested the influence of the Antarctic surface water in the studied area. It may be possible to consider that oceanic copepods which increased in winter might have been brought into coastal waters from northern offshore areas by the oceanic and tidal currents.

Therefore, it is conceivable that the seasonal change in the composition and abundance of zooplankton observed at the Kita-no-seto Strait is a combination of the inflow of oceanic components and the prosperity and decay of coastal constituents.

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