

VERTICAL DISTRIBUTION AND FEEDING BEHAVIOR OF COPEPODS UNDER SEA-ICE IN LAKE SAROMA (EXTENDED ABSTRACT)

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Under sea-ice, copepod feeding on algal communities is one of the most important processes of food web dynamics, just as in the area without ice coverage. Lake Saroma is the southernmost body of water covered by seasonal sea ice in the northern hemisphere. Very little is known about the distribution and feeding behavior of zooplankton under ice in Lake Saroma. In this study, diel changes in vertical distribution and feeding of copepods were examined in Lake Saroma. Our main goal was to estimate energy transport from primary producers to copepods during the early growth periods of phytoplankton under the sea-ice. This study was supported in part by a grant from the Ministry of Education, Science and Culture (No. 03044146).

Zooplankton sampling for vertical distribution, biomass and gut pigment was carried out 7 times a day under sea ice in Lake Saroma during February 25 and 26, 1992. The NIPR-net (FUKUCHI *et al.*, 1979) with 0.33 mm mesh openings was used for sampling at 5 depths from 0 to 9 m below the under-surface of the ice. Distance from the under-surface of the ice to the bottom at the sampling site was 9.5 m. Ingestion rates of individual copepods were obtained from *in situ* gut clearance rate and gut pigment content using the gut fluorescence method of SAITO *et al.* (1991), without homogenizing the samples. In the field, *in situ* gut clearance rates of pigments by copepods were examined in the daytime and nighttime. Total ingestion rate of the entire copepod community was obtained from abundance and ingestion rate of copepods. Temperature, salinity and chlorophyll *a* concentrations in the water column were observed in the middle of the day on February 26.

Water environment

Ice-thickness at the sampling site was 30 cm. In the water column below the ice, water temperature varied between -1.4 and -1.0°C . Relatively low salinity water was found in the upper 3 m layer. In the water column, the highest concentration of chlorophyll *a* was observed just under the ice reaching $185.8 \mu\text{g l}^{-1}$. Chlorophyll *a* levels decreased rapidly with depth: 19.3, 3.9, 3.6 and $2.2 \mu\text{g l}^{-1}$, 1, 3, 6 and 9 m below the under-surface of the sea ice, respectively. Chlorophyll *a* concentration in the ice at the under-surface was as high as $811 \mu\text{g l}^{-1}$ (ROBINEAU, personal com.).

Copepod distributions

Copepods were the dominant zooplankton, accounting for 99.0% of individuals collected in number throughout the day. Among copepods, *Pseudocalanus* spp. and *Acartia* spp. were abundant, accounting for 81.4% and 16.6% of the total number of zooplankton, respectively.

There were two body size classes in females of *Pseudocalanus* spp. One was smaller than 0.9 mm in prosome length and the other was larger than 0.9 mm. Diel vertical migration was observed in both size groups of this species (Fig. 1). Most of both the large and small forms of *Pseudocalanus* spp. were abundant in the top layer just after sunset. They stayed in the top layer from 17:00 to 22:00, then began to descend to the bottom around midnight without apparent stopping in the intermediate layer. From sunrise to sunset, most of the population was concentrated in the bottom layer. At sunset, a part of the population moved to the upper layer (Fig. 1).

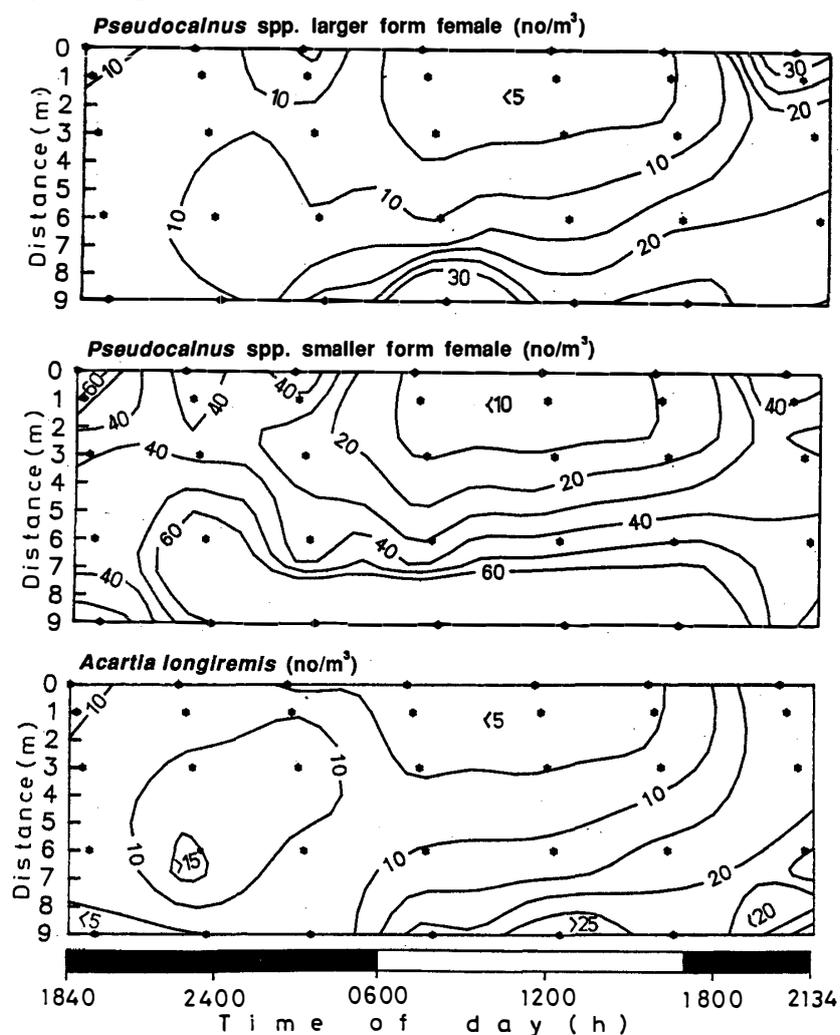


Fig. 1. Temporal variation of vertical distribution of *Pseudocalanus* spp. small form (upper) and large form (middle), *Acartia longiremis* females (lower) in Lake Saroma during the period from February 25 to 26, 1992. Dark and open bars indicate night and day periods, respectively.

Among *Acartia* spp., *Acartia longiremis* was the most abundant in numbers. Distribution pattern of both *Pseudocalanus* spp. and *A. longiremis* in the daytime and in the nighttime were similar. However, diel vertical migration behavior of both species was different. *A. longiremis* stayed in the intermediate layer during their migration at midnight and sunrise, whereas *Pseudocalanus* spp. did not stop in the intermediate layer (Fig. 1).

The above observations were notable for two reasons. First, even in a single species of copepod, some individuals underwent a diel vertical migration, while others did not. Second, the migrating populations did not stay in the food-rich just under sea-ice until sunrise, as is usual for most vertical migrators staying until sunrise. Species that were similar to those in our study were also investigated by ISHII (1990) in the shallow open waters of Onagawa Bay. However, he did not report these two unusual migrating behaviors.

Copepod feeding

The observed gut clearance rates of *Acartia* spp. and *Pseudocalanus* spp. were almost constant during a 24-h-period, while gut pigment contents were higher in nighttime than those in daytime. Diel change in gut pigment contents of these two species at Onagawa Bay were observed by ISHII (1990); remarkable peaks in gut pigment contents occurred around midnight.

In this study, ingestion rate increased after sunset and showed no remarkable peaks during nighttime, and it decreased rapidly after sunrise. The highest ingestion rate was observed in the water layer just below the ice. Ratios of the maximum and minimum ingestion rates, which give a magnitude of variation in ingestion rate, did not show any distinctive difference between the present study and those at Akkeshi Bay on the southeast coast of Hokkaido (SAITO, unpublished data).

The total ingestion rate of the entire copepod community, *i.e.*, the grazing pressure on phytoplankton and ice algae, was lowest during daylight hours in the upper half of the water column (Fig. 2).

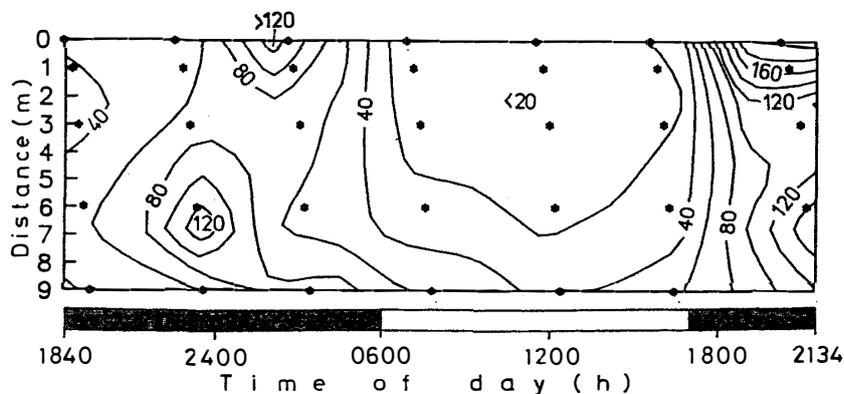


Fig. 2. Temporal variation of total ingestion rate (ng h^{-1}) by *Acartia* spp. plus *Pseudocalanus* spp. female and male with small and large forms in Lake Saroma during the period from February 25 to 26, 1992. Dark and open bars indicate night and day periods, respectively.

Feeding and migratory behaviors of the two copepod genera in Lake Saroma were different from those reported from other areas of open water elsewhere in Japan. Although we are presently unable to explain this difference, it is hoped that current studies on the effect of grazing pressure on primary production in the water column as well as under the surface of the ice will help to answer this question.

References

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