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The Community Structure and Grazing Rates of Meiobenthos in Chunsu Bay, West Coast of Korea

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ABSTRACT

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The community structure and grazing rates of meiobenthos was studied in Chunsu bay on west coast of Korea. To examine feeding habit of major meiofaunal groups, grazing rate of nematodes and harpacticoid copepods was measured using the isotope-tracer (^{3}H thymidine, ^{14}C amino acid) method at 3 stations in subtidal area and 1 station in intertidal area of Chunsu bay. Time-serial measurement of grazing rate was made to elucidate the effects of day/night and tidal cycle on diel feeding rhythm of the animals. The number of culturable bacteria fluctuated from $1.73\pm0.25\times10^5$ to $18.23\pm1.17\times10^5$ CFU/cm^3 during the study period, and was highest in October. The Concentration of Chl.a in the sediment at the study site was 18.0~168.2 mg/m^2 in April and 36.6~111.0 mg/ m^2 in October. The most abundant meiobenthos was nematodes and followed by sarcomastigophorans, harpacticoid copepods. Density of meiobenthos were 5~1632 inds./10cm^2 during the study period. The grazing rates of nematode varied 0.5~57.2%/h on bacteria and 0.4~53.3%/h on microalgae at the station in tidal flat. The grazing rates of harpacticoid copepods were 0.2~14.2%/h on bacteria and 0.3~12.2%/h on benthic microalgae at the station in tidal flat. In the subtidal area, the grazing rates of nematode were 33.4~82.5%/h on bacteria and 10.3~71.5%/h on microalgae and harpacticoid copepods were 0.2~14.2%/h on bacteria and 0.3~12.2%/h on benthic microalgae.

ADDITIONAL INDEX WORDS: *Grazing rate, Nematodes, Harpacticoid copepods, Benthic microalgae*

INTRODUCTION

Tidal flats are considered as typical environmental resources in the world, and are especially the most productive and important ecosystems among them in Korea. The intertidal area is the largest one (around 6,000km^2) in the world when the west and south coasts of the Korea and the China coast adjacent to Korea are treated as one complex. Coastal wetland associated with tidal flat is the one of the ecosystems of high productivity. Meiobenthos (meiofauna) area important component of tidal flat benthic communities because they are highly abundant and play an important role in the sediment. Meiobenthos can contribute up to 30% of the living biomass in sediment, and it is assumed that their contribution to the food of deposit-feeding macrobenthos is of similar magnitude (Coull, 1999; Gerlach, 1978). Meiobenthos feed on bacteria, benthic algae and protozoa as well as other small organisms. Although, numerous studies document meiobenthos feeding on benthic diatoms (Blanchard, 1991; Montagna, Blanchard, and Dinet, 1995; Pascal *et al*., 2008; Riera *et al*., 1996), the results on their relative importance in the food web are contradictory; some studies indicate that meiofauna has a grazing rate high enough to control microphytobenthic biomass and production (Blanchard, 1991; Montagna, 1984; Montagna, Blanchard, and Dinet, 1995), whereas other studies suggest that meiobenthos uses only a small share of carbon from primary production (Middelburg *et al*., 2000; Moens *et al*., 2002; van Oevelen *et al*., 2006). Knowledge of the trophic position of meiofauna in marine sediments is still contradictory primarily due to the scarcity of experimental data (Rzeznik-Orignac, and Fichet, 2012). Experimental results were extrapolated to compute the consumption of meiobenthos in situ that would attain up to 12% of primary benthic production in the mudflat (Rzeznik-Orignac, and Fichet, 2012).

This work focuses on experimentally assessing the rate of diatom and bacteria carbon uptake by meiofauna from an intertidal mudflat of the Hwangdo in Chunsu Bay (the west Coast of Korea). The main aim of this work was to assess the the grazing rate calculated according to tidal rhythm by meiofauna. For this purpose, an experiment using ^{14}C and ^{3}H as a tracer was conducted in microcosms to measure the grazing rate of carbon originating from bacteria and diatoms in meiofauna and in some dominant taxa in the meiofaunal community such as nematodes and harpacticoid copepods.

METHODS

Study Site

The study was conducted in the Hwangdo mudflat and subtidal area of Chunsu Bay on the West Coast of Korea (Figure 1). The

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Chunsu Bay is a shallow back Bay with its water depth within 25 m located at 36°23'~36°37'N,126°20'~126°30'E, on the western central coast of Korea, surrounded by Anmyeondo of Taean-gun, Ocheon-gun, and the West Sea Line of Taechon (Figure 1). As the reclamation projects proceeded in Seosan A·B zone, the tidal embankment construction clapboard was completed in 1983~1985 and two major channels through the northern part of Chunsu Bay were blocked (Seosan Dyke). This change of velocity field affected various marine environment variables; the production of fish, crustacean and mollusks was reduced by about 1/4 from the end of 1970s to the late 1990s, from the change of the marine environment and sediment due to the geographic variation according to the construction of the tidal embankment and the influx of eutrophic freshwater. The location of sampling stations in this study sites were choosen by these environmental characteristic related to those various habitat conditions.

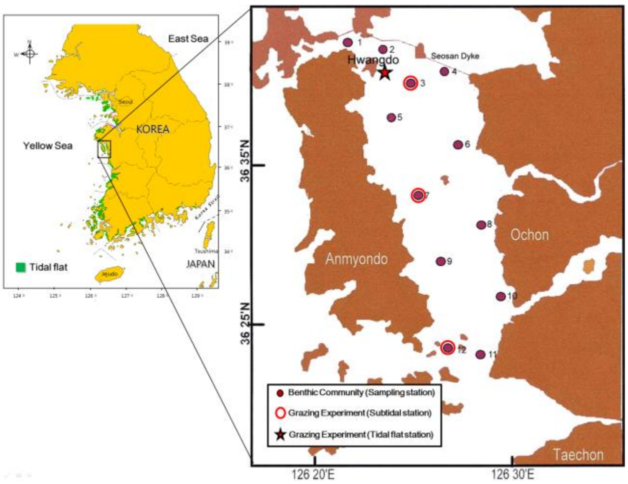


Figure 1. Map of the study area with locations for the various stations in the Chunsu Bay, Yellow Sea of Korea.

Benthic Community

Samples of analyzing for standing stocks of benthic bacteria, microalgae and meiobenthos were collected at 12 stations in Chunsu Bay in the Yellow Sea of Korea on April, July and October 2003 (Figure 1). At a subtidal sampling station, sediment were taken by Smith-McIntyre grab(0.1 m^2) and sub acryl corer(3.4 cm of diameter).

To characterise the standing stocks of microbial community in the sediment, the top 1 cm of two replicated acryl cores (3.4 cm of diameter) were sampled and deep frozen for later analysis.

The benthic chlorophyll *a* samples representing an abundance of benthic algae were taken with acryl corers at each sampling station. After collection the samples were kept cold and dark. Absorbance was measured at 750, 665, 663, 645 and 630nm on a UV-Spectrophotometer (HP 8453) with a 1 cm cell.

Sediment samples for meiobenthos were collected using a 3 acryl sub-corers (3.4 cm of diameter) and were sliced 1 cm deep from the surface to 3 cm. The samples were fixed in 5 % neutralized formalin mixed with Rose Bengal. The samples were size fractioned with variable mesh aperture, and the animals were identified and counted at higher meiobenthic taxa level under a stereomicroscope.

Grazing Experiment

Grazing experiments were conducted at two experimental sites: Tidal flat (upper intertidal area near Hwangdo) and Subtidal stations (st.3, st.7 and st.12). In situ meiofaunal grazing rates on bacteria and microalgae were measured by incubating sediment slurries with two radiolabelled substrates, ^{14}C-bicarbonate and ^{3}H-leucine (Figure 2).

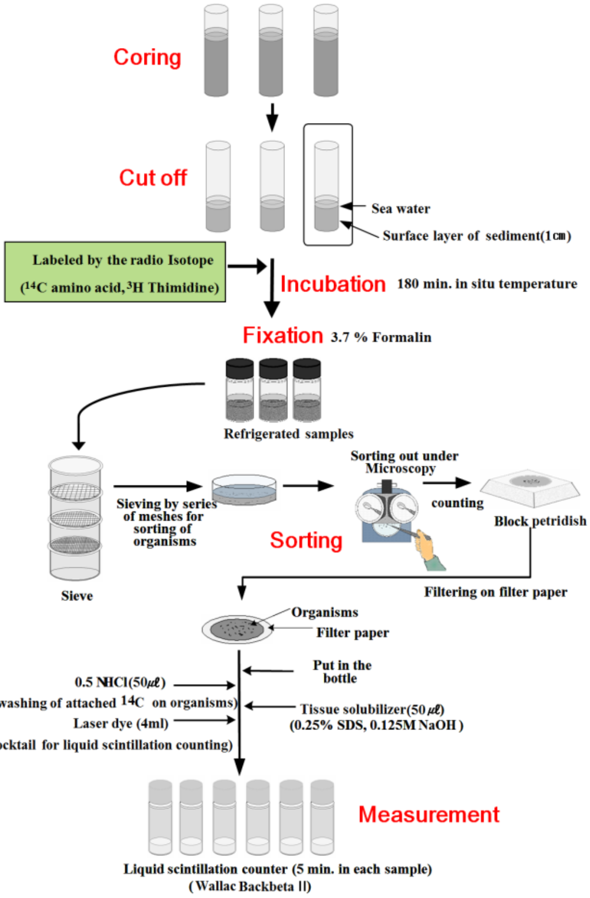


Figure 2. Procedures for analysis of meiobenthic grazing rate.

Time series experiments (3 hrs interval) were carried out at Tidal flat site for 27 hours. In these sites, Prey and predator standing stock was determined in the same containers in which grazing experiments were first conducted. Nine samples were removed from each of the six containers, three to determine bacterial abundance, three to measure chlorophyll *a*, and three to enumerate meiobenthos. In the laboratory, sorting was performed under a dissecting microscope and meiofauna were sorted by taxa into scintillation vials containing 1 ml distilled water. Counts of meiofauna were recorded, and density is reported as the number of individuals per 10cm^2. After sorting, meiofauna were dried at 60°C and solubilized in 100 µl Soluene tissue solubilizer for 24 h.

Samples were counted by dual-label liquid scintillation spectrophotometry. This experiment was conducted according to following steps of Figure 2.

RESULTS

Benthic Community

Bacteria was present an relatively low number at inner part, and were higher numbers towards the mouth part of Bay (Figure 3). Their abundance in sediment ranged from 1.73 ± 0.25 × 10^5 CFU/cm^3 to 18.23 ± 1.17 × 10^5 CFU/cm^3. Number of culturable bacteria was higher in Autumn (October) than in Summer (July) and Spring (April). The between sampling periods differences in abundance were significant ($p < 0.01$)

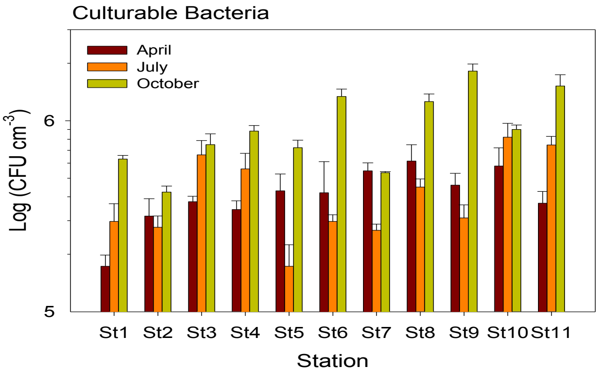


Figure 3. Distribution of Culturable Bacteria in the surface sediments of Chunsu Bay.

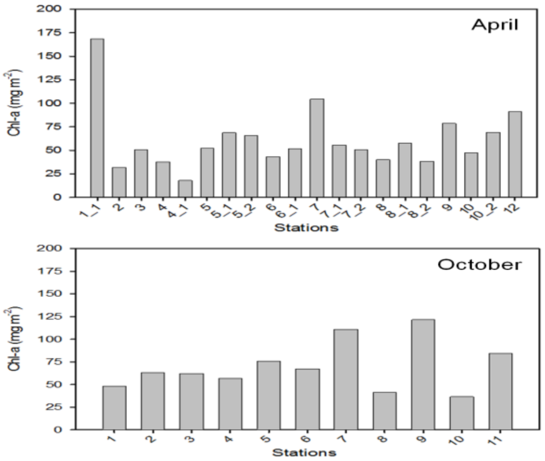


Figure 4. Chlorophyll-a concentration for each station in Chunsu Bay in April and October, 2003.

Concentration of benthic microalgal pigment (chlorophyll *a*) ranged from 18.0 mg/m^2 to 168.2 mg/m^2. The horizontal distribution of chlorophyll *a* concentrations showed differences between stations, but not high or low in a specific areas (Figure 4). Eleven meiobenthic taxa were encountered (nematodes, harpacticoid copepods, nauplius of crustacean, benthic foraminiferans, ciliophorans, polychaetes, ostracods, bivalves, cumaceans, turbellarians, kinorhynchs) at the 9 subtidal stations of Chunsu Bay (Figure 5).

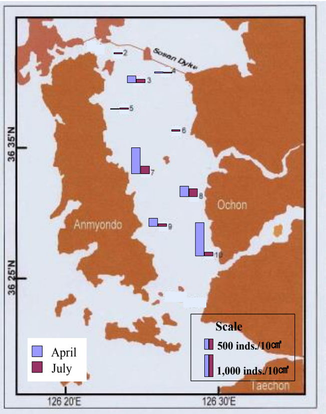


Figure 5. Abundance of meiobenthos at the subtidal survey site in April and July.

Total meiobenthic density at the subtidal site ranged from 5 ind/10 cm^2 (at st.2 in April) to 1,632 ind/10cm^2 (at st.10 in April). Abundance of meiobenthos was higher in spring (April) than in Summer (July). The between sampling periods differences in abundance were significant ($p < 0.01$). Nematodes were the most abundant metazoan taxon at all stations, ranging from 5 ind/10 cm^2 (at st.2 in April) to 1,155 ind/10 cm^2 (at st.2 in April). Harpacticoid copepods was the second dominant taxon in most stations. Abundance of the benthic community on the experimental stations on a subtidal area is illustrated in Figure 6.

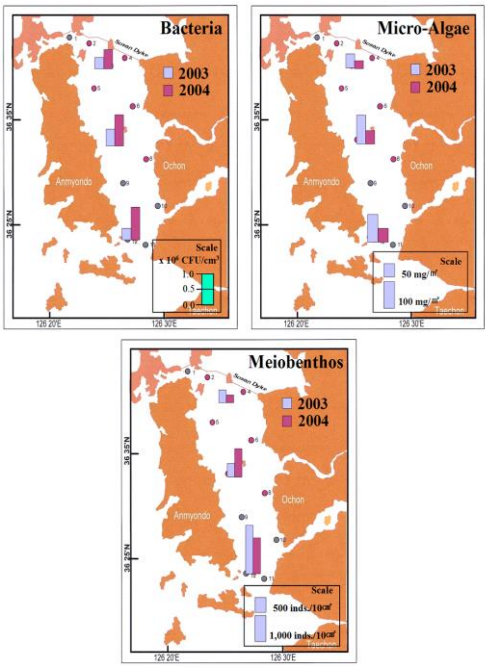


Figure 6. Prey and predater standing stock at the site for grazing experiment in subtidal area.

Abundance of bacteria, micro-algae and meiobenthos was higher at the mouth part of bay and lower at inner part near the dike of Chunsu Bay. Range of bacterial abundance for 27 hours at the tidal flat experiment station was from 2.12 ± 0.06 to 4.27 ± 0.28 × 10^6 CFU/cm^3. It showed relatively low bacterial abundance in the morning, and the time of the highest cultured cell number was at noon. The culturacle bacterial number showed about twice as much as the time of day and tended to increase in relative time and increase gradually with the ebb tide. These results are indicate that tidal cycles and day-night changes affect microbial distribution (Figure 7). The major fluctuative meiobenthic taxa by tidal rhythm were nematodes and nauplius of crustacean (Figure 8). Abundance of the harpacticoid copepods also tended to exhibit high levels when the tidal flats were submerged, and the opposite tended to occur in the nematode. The average meiobenthic abundance at the intertidal station was from 1,713 ind/10 cm^2 to 3,849 ind/10 cm^2. This was very higher than subtidal experimentsl station.

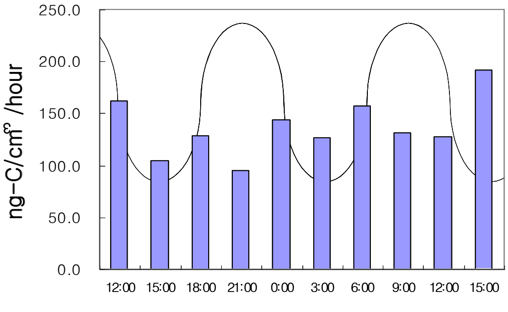
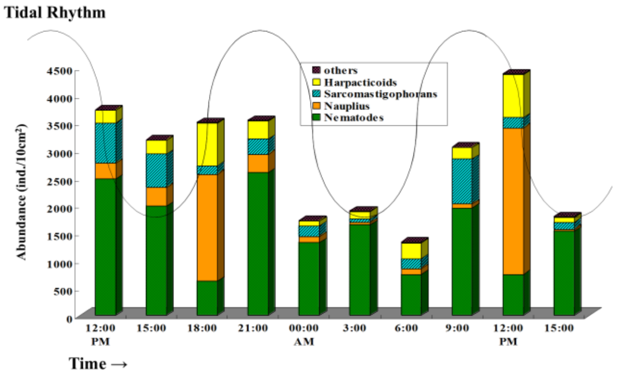


Figure 7. Daily fluctuation of productivity of culturable bacteria according to tidal rhythm (Black solid line show a in situ tide cycle).

Figure 8. Daily fluctuation of density of major meiofauna according to tidal rhythm (Black solid line show a in situ tide cycle).



Grazing Experiments

The grazing rates of nematode varied 0.5~57.2%/h on bacteria and 0.4~53.3%/h on microalgae at the station in tidal flat. The grazing rates of harpacticoid copepods were 0.2~14.2%/h on bacteria and 0.3~12.2%/h on benthic microalgae at the station in tidal flat.

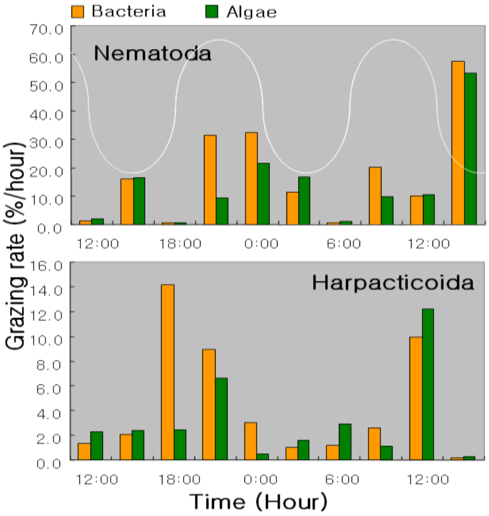


Figure 10. Daily fluctuation of major meiofaunal grazing rate according to tidal rhythm (white line presents in situ tidal cycle) .

In the subtidal area, the grazing rates of nematode were 33.4~82.5%/h on bacteria and 10.3~71.5%/h on microalgae and harpacticoid copepods were 0.2~14.2%/h on bacteria and 0.3~12.2%/h on benthic microalgae. There is no significant difference between the location of station (p>0.01).

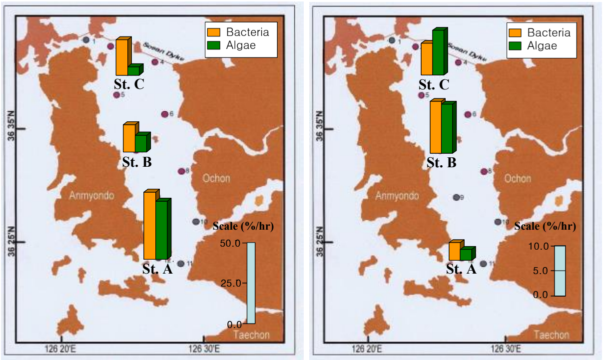


Figure 9. Grazing rate of nematodes(left) and harpacticoid copepods (right) in the surface sediments of Chunsu Bay.

DISCUSSION

Total meiobenthic abundance was higher at the mouth part of bay and lower at inner part near the dike of Chunsu Bay (Figure 5). Very low abundance was observed at st.2 and st.6 located near Dike and outlet of stream. These area were reported as the bottom-water hypoxia area induced by freshwater discharge from two artificial dykes into Chunsu Bay (Jung *et al*., 2015) after construction of Seosan Dike. Lee *et al.* (1997) reported that the spatiotemporal variation in hypoxia is closely related to vertical stratification in the water column, which occurs because of weather conditions, and that hypoxia formation may be stimulated by the large consumption of DO that occurs during the process of sedimentation and biodegradation of dead organisms at the sea bottom after red tide occurrences. Very low abundance of meiobenthos below 100 ind./10cm^2 at near the dike and outlet of freshwater stream indicate that there is an unstable and unhealthy habitat related to hypoxia formation.

The grazing rate of both major meiobenthic taxa was high at high tide periods after low tide. Decho (1988) reported similar results, that highest food consumption occurred just after the mudflat became exposed, while consumption at late low water (LLW: i.e. after mudflat is exposed for several hours) was reduced. The grazing rate of nematode was extremely low at 3 hours after low tide.

The values of grazing rate at subtidal station was higher than tidal flat station. Montagna (1995) stated meiofauna graze an average of 1% of the microbial biomass per hour. Meiofauna do have different grazing rates and different selectivities on different foods, and grazing preferences change ontogenetically (Montagna 1995). Perhaps meiofauna grazing keeps microbial densities constant, or microbial food abundance limits meiofauna abundance. Relationships of feeding processes over a tidal cycle are discussed with regard to distributional patterns in intertidal and subtidal habitats.

CONCLUSIONS

The experiment for grazing rates of meiobenthos carried out in Chunsu bay on west coast of Korea. This study improves our knowledge of the role played by meiobenthos in the interstitial system and allows us to better understanding the fate of carbon from the microphytobenthos and microbial community in the food web. More studies on meiofaunal feeding behavior are needed before a general model can be constructed that would describe the relationship between meiobenthos and microphytobenthos in benthic food webs.

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