

# 18. Inter-relationship Between Marine Meiobenthos and Microbes

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## Introduction

Meiofauna are benthic metazoans of small size. They form a heterogeneous group of organisms ranging from 38 to 1000  $\mu\text{m}$  in size. Considerable interest was aroused during 1970s and 80s concerning the importance of meiofauna. Much of the meiofaunal life and their characteristics have been reviewed by McIntyre (1969), Coull and Bell (1979) Coull and Giere (1988) and Montagna (1995). All of these authors have pointed out to the need for increased research on meiofauna and microbial interaction. Today, meiofauna is considered a dynamic element of the marine environment and an integral part of the benthic ecosystem. Obviously, then, their importance must continue to be investigated.

Meiobenthic organisms are ubiquitous. The average density can reach up to  $10^6 \text{ m}^{-2}$  and biomass between 1 and 2  $\text{gm}^{-2}$  (Coull and Bell, 1979). They are represented by both temporary (larval stages of macrofauna) and the adult meiobenthos including Nematoda, Harpacticoida, Turbellaria, Kinorhynchs, Gastrotricha, Tardigrada, Bryozoa etc. Their numbers and biomass decrease with increasing depth in the ocean and the highest values are known from intertidal mudflats (see Coull and Bell, 1979). Nematodes and harpacticoid copepods are generally the most abundant taxa in all almost all types of sediment and certain taxa get restricted to a particular sediment type. Vertically, meiofauna get concentrated in the upper layer of the sediment, decreasing with increasing depth (McLachlan, 1977; Ansari, 1978). Horizontally, meiofauna are known to exhibit a patchy distribution

(Coull and Bell, 1979; Ansari & Parulekar, 1993). They reproduce so rapidly and get so abundant that the sparse quantity of food does not appear to even significantly reduce population size (Coull, 1999).

The abundance and species composition of meiobenthos are controlled primarily by physical factors such as particle size of sediments, temperature and salinity (McIntyre, 1971). While this is true in a most general sense, it is becoming increasingly clear that biological interactions, habitat - heterogeneity and predatory controls, play just as important role in structuring the meiofauna assemblage (Coull & Bell, 1979). The availability of oxygen and food particles appears to be responsible for their vertical zonation and horizontal distribution (Gerlach, 1977). The long - term variations in the meiofaunal abundance are small, but seasonal changes are quite pronounced (Ansari & Parulekar, 1998). Such seasonal changes are largely dependent on the availability of food.

## Trophic Interaction and Microbivory

The quantification of the rate of exchange of carbon seems a prerequisite for understanding the processes regulating the trophic structure in benthic communities (Pickney *et al.*, 2003). The trophic role of meiofauna becomes significant in benthic energetics. In the estuarine soft sediment, meiofauna (1) facilitate biomineralization of organic matter and enhance nutrient regeneration (2) serve as a food for a variety of higher trophic levels and (3) exhibit high sensitivity, where there is estuarine pollution (Coull, 1999). There

Table 1. Food demand and production ( $\text{gC m}^{-2} \text{ yr}^{-1}$ ) of different size category in benthic system (After Ansari and Parulekar, 1994).

Station	Microphyto- benthos production	Meiobenthos		Macrobenthos	
		Food demand	Production	Food demand	Production
1	52.70	70.48	7.48	115.7	11.57
2	41.65	51.00	5.10	82.2	8.22
3	44.35	68.00	6.80	93.5	9.35
4	52.30	62.00	6.20	86.2	8.62
5	50.50	68.00	6.80	103.0	10.30
6	34.60	40.80	4.80	89.5	8.95

is also evidence that meiofauna play a role in making detritus available to macro-consumers (Tenore et al., 1977). It has been suggested that for deriving equivalent biomass, the meiofauna are responsible for about 5 times the total benthic metabolism of the macrofauna (Gerlach, 1971). But in shallow water the meiofauna plays a more significant role in benthic energetics. Generally, mineralization of organic matter is enhanced and bacterial production stimulated in the presence of meiofauna (Gerlach, 1978). Micro-organisms are usually found in localized patches on the surface of sand grains and the meiofauna have a spatial-scale distribution similar to that of their suspected microbial food.

The kinematic of meiofaunal feeding has been defined by Montagna, (1995). Food of meiofauna comes from a variety of sources as shown in Fig. 1. Each major taxonomic species of meiofauna feeds on a variety of diets available in the sediment. Some temporary and permanent groups of meiofauna are deposit-feeders such as nematodes, annelids epistate feeders, scavengers and predators (Turbellaria, Copepoda), meiofauna are just as common. Most of the behaviour seems adapted to pick up specific microbial food items e.g. microalgae, bacteria and protozoans (Alongi, 1988). It has been demonstrated that nematodes feed on bacteria, particulate and dissolved organic matter, detritus and associated microflora (Montagna, 1983).

In most of the cases, the sediments associated with microbiota supply energy to the benthic meiofauna while bacteria and diatoms are responsible for the spatial heterogeneity among meiobenthos (Fenchel, 1969; Hargrave, 1970). In a trophic pyramid, generally the larger and slower growing organisms are coupled to smaller faster growing organisms. If the meiofauna community happens to have a close trophic coupling with microbial community, one would expect peak meiofaunal abundances to follow peaks in bacterial and diatom abundance in the sediment. This is not always true. Diatom and bacteria seem to operate at different spatial and temporal levels to the advantage of meiofaunal density (Chandler and Fleeger, 1983; Carman *et al.*, 1997). In the deep-sea sediment, significant positive correlation between total bacterial count and total meiofauna was observed (Reghukumar *et al.*, 2001). This suggests the possibility of coupling between the meiofauna and the microbes in the deep-sea environment. The heterotrophic bacteria assimilating the dissolved organic matter from the sediment water inter-phase form the nutritious component, the deep-sea benthic organisms ingest. According to Tietjen (1971), bacteria form the basic sources of food for the deep-sea benthos. They produce the nutrient matrix, and most of the deep-sea animals seem to feed on bacteria or their products.

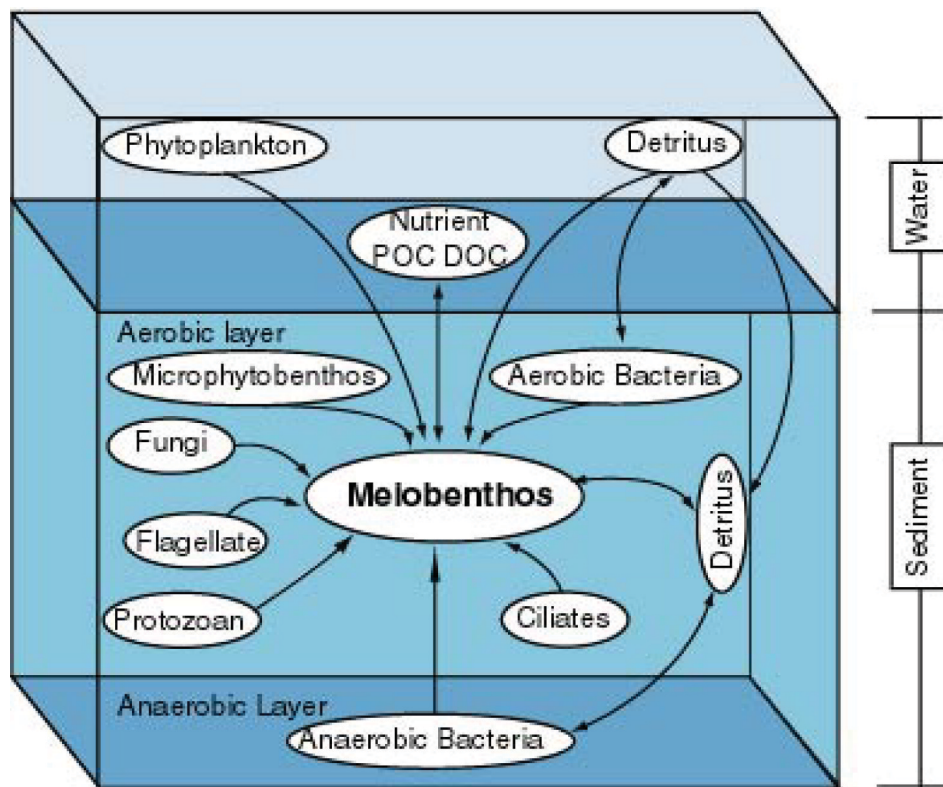


Fig.1. Meiofaunal and microbial interaction

Table 2. Meiofauna grazing rates (units are in  $\times 10^{-4} \text{ h}^{-1}$ ) which is equivalent ( $\% \times 100 \text{ h}^{-1}$ )\*

Taxa	Bacteria	Microalgae	Reference
<b>Nematods:</b>			
<i>Monohystera disjuncta</i>	17.8	-	Herman and Vranken (1988)
<i>Plectus palustris</i>	3.2		Duncan et al. (1974).
<b>Harpacticoida:</b>			
<i>Tisbe furcata</i>	-	0.51	Bergh and Bergmans (1981).
<i>Paramphiacella vararensis</i>	0.059	-	Rieper (1978).
<i>Thompsonula hyaenae</i>	0.002	0.056	Carman and Thistle (1985).
<b>Total meiofauna</b>	-	0.0014	Montagna et al. (1995).

\*The grazing rate was calculated as the fraction of radio activity incorporated per individual

All metazoan meiofauna have benthic life and hence their diet most likely include detritus with its attached microflora, consisting of bacteria, protozoans and diatoms (Danovaro, 1996). The two different interactions, the heterotrophic and autotrophic food web of the meiofauna and microbial community that exist in the marine environment, demonstrated different strategies adapted by the organisms in microbivory (Montagna, et. al, 1995).

There seems to be strong meiofaunal and microbial interaction in the estuarine sediment as well (Coull, 1973; Montagna *et al.*, 1983). The classical predator-prey size relationship does not seem to hold among the meiobenthos. There are instances where many macrofauna skip the intermediate meiofaunal link and feed directly on bacteria and Protozoa (Coull, 1973). Thus, they seem to occupy a similar trophic level as that of their smaller counterparts. They probably compete with meiofauna in consuming bacteria. The real quantification and the role played by the meiofauna in the transfer of energy will be known from the studies aimed at finding the role played by meiofauna in the transfer of primary food sources (diatoms, bacteria) up the food chain till the level of juvenile fish or the extent to which the meiofauna from an energy link in the system.

The complexity and interaction among the microbes and meiofauna seems a highly intriguing problem. Recent comprehensive studies have, however, demonstrated the role of microbes in the benthic system more conclusively (Montagna *et al.*, 1983; Montagna, 1995; Pickney *et al.*, 2003). Several studies to establish the base food of meiofauna have concluded that meiofauna are primarily detrital or indiscriminate feeders on microalgae, bacteria, protozoans and other meiofauna (Montagna *et al.*, 1983; Montagna, 1995). They also seem to have the ability to absorb dissolved organic matter or adsorb dissolved inorganic carbon (Meyer Reil and Faubel, 1980; Montagna, 1983). Bacteria have been demonstrated as the primary source of food for many benthic feeders such as nematodes (Chua and Brinkhurst, 1973; Tietjen and Lee, 1977). Specificity

in the diet of several laboratory-reared nematodes has been elegantly demonstrated, using radio-isotope labelled substrates. Many species of nematodes and benthic copepods are known to use mucous to trap bacteria and thus the bacterial/mucous mixture is ingested (Hicks and Grahame, 1979). In an other feeding experiment, Montagna (1984) labelled the bacteria and diatoms by radio -isotopes and reported that 3% of bacteria and 1% of diatoms were removed by meiofauna. It has also been demonstrated that under natural conditions, the food requirement of estuarine meiobenthos cannot be fully met in the absence of microbial biomass (Ansari and Parulekar, 1994). The bacterial production and its turn over seems sufficient to satisfy the demands of the meiofauna particularly in shallow waters (Montagna *et al.*, 1995). These experiments suggest that benthic microbes are essential components of the food of meiobenthic organisms.

## Meiofaunal grazing

The adaptation to pickup specific items of microbial food by some meiofaunal organisms has been termed as grazing (Montagna, 1995). Some authors have used such a functional response to express similar feeding habits. The grazing rate appears to be functional responses to available food. Most of the grazing experiments have been carried out under laboratory conditions on nematodes and copepods using radio-labelled food as shown in Table 2. Some workers have also estimated the total microbial biomass consumed by the meiofauna (Montagna et.al, 1995). It was found that some meiofaunal groups can vary their ingestion rates of microbes in response to changes in the quality and quantity of food (Decho, 1988). Harpacticoids can exponentially increase their feeding rates as a function of availability of microphytobenthos (Montagna et al., 1995). Similarly, Herman and Vranken (1988) fed the nematode *Monhystera disjuncta* with bacterium *Alteromonas haloplanktis* and reported an increase in feeding rates with age. The females showed a greater feeding rate than males. Similarly, the rate of diatom ingestion



increased with the age and size of the nematode, *Chromadorita tenuis* (Jensen, 1984). It appears that biology of nematodes (growth, respiration, reproduction) is strictly linked with the availability of bacterial food and their grazing rates from a functional response angle to changes in the environment. One of the most important ecological advantages the heterotrophic bacteria will acquire as a consequence of being preyed upon by meiofauna is that their growth rate will be maintained in a log phase (Montagna, 1995). Metazoan meiofauna are not the only grazers in the benthos. Temporary meiofauna and taxa other than nematodes and harpacticoids can also be grazers.

The feeding experiments on benthic copepods with microalgae and bacteria give somewhat different response (Rieper, 1978). He has concluded that meiobenthic copepods alone could consume 68 to 112% of the benthic microalgal biomass on a daily basis (Carman *et al.*, 1997). The overgrazing of benthic microalgae by herbivores (copepods) can reduce productivity and thus would limit the microbial standing crop. Several stable isotope studies have demonstrated that meiofaunal taxa apparently have different grazing rates on different food items, and benthic microalgae from a major source of nutritional fueling at the secondary production level (Montagna, 1995; Herman *et al.*, 2000). The meiofauna on an average, graze at a rate of 0.01 h<sup>-1</sup> for both bacteria and microalgae (Montagna 1995). This suggests that on an average the meiofaunal community is removing about 1% of microbial standing stock per hour world wide. It has also been reported that grazing could control benthic microalgal biomass in the subtidal sediments but not in sandy coastal habitat (Sundback *et al.*, 1996). Coming from the other end, the grazers may indirectly stimulate benthic microalgal production by enhancing nutrient availability through bioturbation. Only one study has come to the conclusion that meiofauna grazing has no impact on bacterial dynamics (Epstein and Shiaris, 1992). This result is in contrast with most published literature.

It is clear from the foregoing account that the total impact of meiofauna on microbes is a complex issue and requires in depth study. Taking the meiofaunal and microbial coupling as natural, the process and pattern measured at different scales, for example, meiobenthos and microbenthos display patchiness at a range, from millimetre to kilometers and from year to year, need to be expressed more realistically so as to narrow down the approximations, as far as possible. It is possible to use the present set of ecological data of meiofauna for *in situ* production and energy transfer. Although the studies discussed above provide evidence of strong coupling of meiofauna with microbial community and the mechanisms underlying

meiofauna-microbial trophodynamics, they reveal little about specific interactions between microbial autotrophy and primary consumers (grazers). Intrageneric and interspecific differences in food ingestion and grazing rates may exist, which provide scope for more work on meiofaunal microbivory. Similarly, the ecological processes mediating the interactions between the two groups discussed above and their dependence on nutrients seem poorly understood and invite our attention for a more detailed study.

## Acknowledgements

The author is thankful to the Director of National Institute of Oceanography, Dona Paula for encouragement. Thanks are also due to Dr. S.Z. Qasim for reading the manuscript and offering suggestions for improvement. Ms Ramila Furtado helped in preparing the manuscript.

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