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Composition and Distribution of Meiobenthos in Amursky Bay (Peter the Great Bay, the East Sea)

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Abstract – Qualitative and quantitative composition of meiobenthos was studied in Amursky Bay (Peter the Great Bay, the East Sea). Ten taxonomic groups were found, where nematodes were dominant. Density of meiobenthos in ground sediments of the Bay were not uniform, and the average density was measured at 126.4±62.3 ind. m^{-2}. 56 species of nematodes were detected, and dominant species were *Sabatieria palmaris, Paracanthonchus macrodon, Sphaerolaimus limosus, S. gracilis* and *Oncholaimium ramosum.* Five taxocenes of nematodes were allocated based on the results of cluster analysis and species domination according to density. Low diversity in species composition of nematodes was noted in the northwestern part of the Bay, which is a zone of desalination, and in the eastern part, which is exposed to household drains.

Key words – meiobenthos, nematodes, density, taxocene, species composition of nematodes, nematode communities

1. Introduction

Amursky Bay is situated in the northwestern part of Peter the Great Bay of the East Sea. The biggest river of the Southern Primorsky Krai named Razdolnaya runs into this bay. Recent research shows that ground sediments of the eastern part of Amursky Bay contain plenty of polluting substances, owing to the influence of the soil dump, and also the dumping of industrial and household sewage (Tkalin *et al.* 1990). The river, bringing organic substances, chemicals containing nitrogen and phosphorus, pesticides and other polluting substances to the northern part of the Bay with fresh waters, is also a source of pollution.

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Amursky Bay is one of the most studied water areas of Peter the Great Bay. Considerable attention has been given to the research of composition and distribution of macrobenthos assemblage communities (Belan 2003; Belan *et al.* 2002; Belan *et al.* 2003; Lutaenko 2003; Silina and Ovsyannikova 2000; Vaschenko 2000; Vaschenko and Zhadan 1995). Communities of meiobenthos, as a rule, remained outside of the zone of attention though meiobenthos is an important component of the marine ecosystems.

The purpose of the present work is to study the composition and density distribution of meiobenthic communities, and specifically one of its most dominant groups – free-living marine nematodes, depending on some factors of the environment found in Amursky Bay.

2. Materials and Methods

Meiobenthos samples, collected in August, 2001 in Amursky Bay (15 stations), were used as sample material for this work (Fig. 1). Depth at stations varied from 6.4 m to 35 m (Table 1). Samples of the ground sediments (4 from each station) were collected by a 20 cm^2 tubular sampler, at that the height of a ground column measuring 5 cm. Samples of meiobenthos were washed out through mill gas with cells of 63 microns, fixed by 4% formalin, and stained with «Rose Bengal» before analysis. All groups of meiobenthos were considered except for foraminifers. Nematodes were identified at a species level, except for damaged and immature specimens.

Index of Shannon-Wiener was used in the characterization of nematode specific diversity:

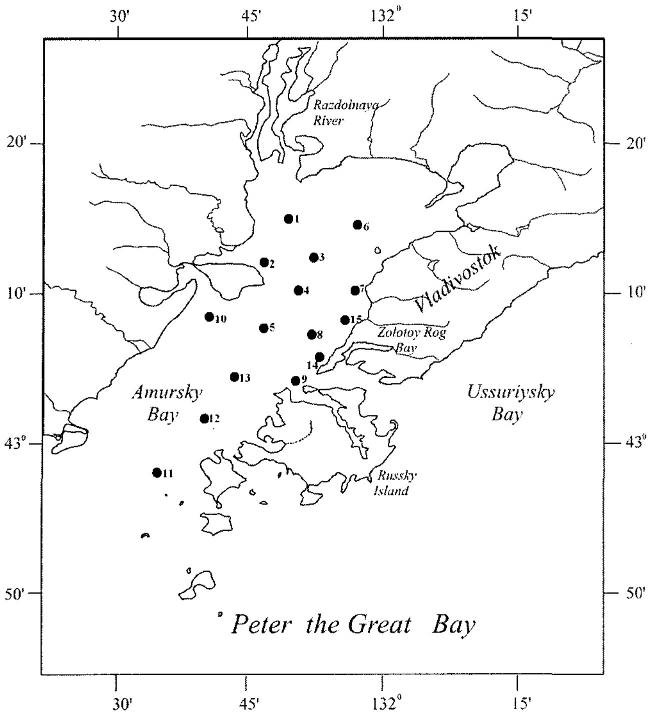

Fig. 1. Schematic map of the sampling stations in Amursky Bay (Peter the Great Bay, East Sea).

$H = -\Sigma ni/N \; x \; \log_{ni/N.}$

Where $_{ni}$ - density of each species, N - total density.

Hierarchical cluster analysis (Ward's method) was used for allocation of ground communities. Clusters with a level of similarity not less than 30% were attributed to the same taxocene.

Ground sediments of the Bay are basically presented by pelites. The content of organic matter in the ground sediments varied from less than 1% in the central part of the Bay to more than 4% in the eastern part of the Bay, in the immediate proximity to the city (Table 1) (Belan *et al.* 2002). During the investigation, salinity of surface waters varied from 1.8‰ in the top part to 29.7‰ in the southern part of the Bay. In the benthonic layer of water, fluctuation salinity was not so significant (Table 1). The temperature at the bottom changed within the limits of 15.6-17.6°C.

For statistical analysis of the material we used standard procedures offered by "Statistica 6.0" software on a personal computer.

3. Results

Taxonomical composition and density of meiobenthos were not uniform in Amursky Bay. The average density of meiobenthos in the Bay was determined to be at 126.4±62.3 ind.m^{-2}. Taxonomical composition was represented by ten groups (Fig. 2). In the middle part of the Bay (stations 4, 5, 8, 10 and 13) density of meiobenthos was determined to be 109.1±46.5 ind.m^{-2}. Taxonomical composition included 8 groups. Eumeiobenthos consisting of Nematodes, Harpacticoids, Ostracods and Turbellarians. Nematodes formed a dominating group (73.9±32.3 ind.m^{-2}). Pseudomeiobenthos included Polychaetes, Bivalves, Amhpipods and Isopods, with the prevalence of Polychaetes (19.9±2.8 ind.m^{-2}). In

Table 1. Environmental and ecological parameters of nematode taxocens in Amursky Bay

Taxocene	Station	Depth, m	Bottom salinity, ‰	Organic carbon content, %	Dominant species	Density, thous. ind.m^{-2}	H
I	1	6.4	16.39	1.73	*Dorylaimopsis peculiaris*	10.72±2.4	2.31
	2	7.5	18.1	1.91	*Sphaerolaimus gracilis*	44.0±12.1	2.90
II	11	35	33.2	3.37	*Sabatieria palmaris*	40.9±10.5	2.65
	12	32	33.2	2.68	*D. peculiaris*	24.9±5.4	3.41
III	3	20	32.9	2.64	*Paracanthonchus macrodon*	32.06±11.6	1.58
	4	17.5	32.9	2.28	*S. palmaris*	8.12±2.1	2.3
	6	8.6	30.6	2	*P. macrodon*	9.2±3.5	2.92
IV	8	21	32.9	3.5	*Oncholaimium ramosum*	120.0±21.0	1.37
	9	16	32.9	1.8	*P. macrodon*	10.5±3.4	2.18
	14	23	32.9	4.28	*O. ramosum*	130.50±11.1	1.07
	15	21.5	32.9	5.37	*O. ramosum*	115.10±22.5	1.37
V	5	16	32.6	2.37	*Sphaerolaimus limosus*	30.75±9.1	4.15
	10	9	32.6	1.82	*S. finitima*	8.70±2.2	2.98
	13	14	32.9	0.82	*P. macrodon*	16.0±3.4	2.85
	7	17	32.6	2.5	*S. finitima*	15.20±4.3	2.52

Note: H- Shannon-Wiener diversity index

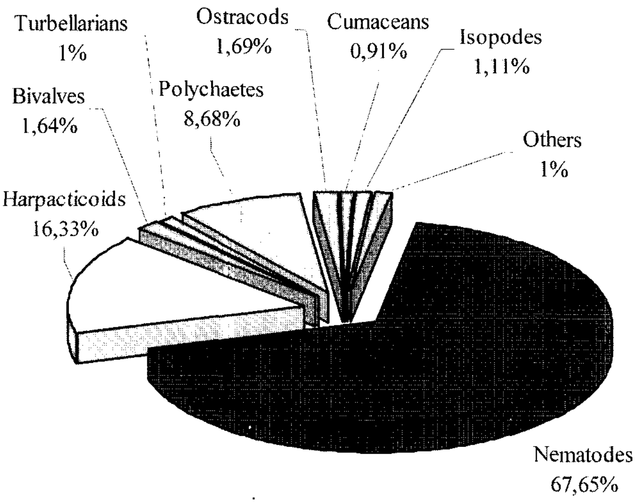

Fig. 2. The percentage of major meiofaunal groups at all stations in Amursky Bay.
Note: 'others', included such groups: Amphipods, Gastropods.

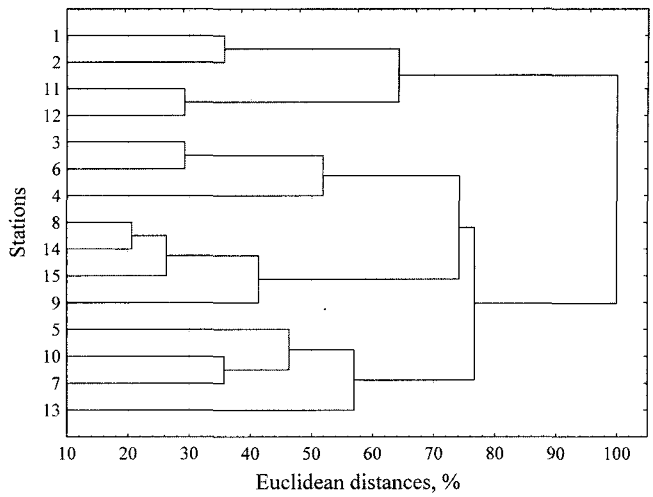

Fig. 3. Cluster analysis (Ward's method, Euclidean distances) based on the nematode specific composition found at the 15 stations.

the southern part of the Bay (stations 11 and 12) the average density of meiobenthos settlement was determined to be at (146.9±69.9 ind.m^{-2}). Taxonomical composition was presented by 7 groups. Eumeiobenthos included Nematodes, Harpacticoids, Ostracods and Turbellarians. Nematodes were dominant (92.9±42.3 ind.m^{-2}). Pseudomeiobenthos, including Polychaetes, Bivalves, Amhpipods, and Polychaetes which prevailed (6.9±2.8 ind. m^{-2}). The greatest density of meiobenthos (167.5±72.8 ind.m^{-2}) was found in the eastern part of the Bay (stations 7, 9, 14 and 15), in immediate proximity to the city (Vladivostok). Taxonomical composition was presented by 7 groups. Eumeiobenthos consisted of Nematodes, Harpacticoids and Ostracods, with Nematodes being dominant (146.9±92.3 ind.m^{-2}). Pseudomeiobenthos included Polychaetes, Bivalves and Gastropods, Cumaceans, Isopods, and Polychaetes were dominant (8.8±3.7 ind.m^{-2}). The lowest density of meiobenthos (60.6±28.1 ind.m^{-2}) was observed in the northwestern part of the Bay, in a zone of influence surrounding the Razdolnaya River (stations 1, 2, 3 and 6). Taxonomical composition of meiobenthos was presented by 5 groups. Eumeiobenthos included Nematodes, Harpacticoids, Ostracods and Turbellarians, Nematodes dominated (45.1±21.5 ind.m^{-2}). In pseudomeiobenthos only Polychaetes (12.2±8.1 ind.m^{-2}) were found.

As nematodes dominated over the ground deposits of Amursky Bay, we paid more attention to this group of meiobenthos animals. 56 species of nematodes were found in the Bay. Judging by species dominating by density, and also by the results of cluster analysis of the Amursky Bay data (Fig. 3), it was possible to distinguish five taxocenes of nematodes. Taxocene I is located in the northwestern part of the Bay at shallow stations (stations 1 and 2), in a zone of desalination. Average density of nematodes was determined to be at 62.7±28.3 ind.m^{-2}. 18 species of nematodes were found with *Sphaerolaimus gracilis*, and subdominants *Dorylaimopsis peculiaris* and *Sabatieria finitima* being dominant (Table 2). The index of species diversity varied from 1.31 to 1.91 (Table 1). In taxocene II, located in the southern part of the Bay (stations 11 and 12), average density of nematodes was measured at 138.4±72.9 ind.m^{-2}. 22 species of nematodes were found with *Sabatieria palmaris,* and subdominants *Dorylaimopsis peculiaris* and *Sabatieria pulchra* being dominant (Table 2). The index of species diversity varied from 2.65 to 3.41 (Table 1). Taxocene III is located in the northern part of the Bay (stations 3, 4, and 6). Average density of nematodes was measured at 77.5±42.1 ind.m^{-2}. 24 species of nematodes were found with *Paracanthonchus macrodon,* and subdominants *Metasphaerolaimus japonicus* and *Sabatieria palmaris* being dominant (Table 2). The index of species diversity varied from 2.58 to 3.54 (Table 1). Taxocene IV is located in the eastern part of the Bay and is exposed to the influence of the city drains (stations 8, 9, 14 and 15). Average density of nematodes was measured at 146.9±92.3 ind.m^{-2}. 14 species of nematodes were found with *Oncholaimium ramosum* found to be

Table 2. Nematode species composition and the portion of each species (%) found in the taxocens in Amursky Bay

Species	taxocene I	taxocene II	taxocene III	taxocene IV	taxocene V
Adoncholaimus sp.	2.05	-	-	-	-
Amphimonchystera galea Fadeeva, 1984	-	-	-	-	0.42
Anticoma possjetica Platonova, Belogurov et Sheyenko, 1979	-	1.21	-	-	8.67
Axonolaimus seticaudatus Platonova, 1971	2.34	1.23	1.94	1.19	1.47
Calyptronema stomodentata Belogurov, 1980	-	-	-	-	0.72
Chromadora nudicapitata Bastian, 1865	0.86	-	-	-	1.19
Comesoma sp.	0.29	-	1.08	-	0.30
Daptonema sp.	-	-	0.38	-	-
Daptonema variacetosa (Pavlyuk, 1984)	0.86	1.82	0.38	-	6.51
Dichromadora amphidiscoides Kito, 1981	1.43	-	2.54	-	-
Dorylaimopsis peculiaris Platonova, 1971	23.85	15.81	2.62	3.10	4.83
Enoploides rimiformis Pavlyuk, 1984	-	-	-	-	0.72
Enoplolaimus medius Pavlyuk, 1984	-	-	-	-	0.30
Euchromadora ezoensis Kito, 1977	-	-	-	-	0.58
Halalaimus leptoderma Platonova, 1971	-	2.43	-	-	-
Halanonchus arenarius Pavlyuk, 1984	-	-	0.38	-	0.30
Halichoanolaimus possjetiensis Belogurov et Fadeeva, 1980	-	-	-	-	1.02
H. sonorous Belogurov et Fadeeva, 1980	-	-	-	-	3.70
Linchomoeus sp.	0.86	1.34	-	0.94	0.72
Metalinchomoeus sp.	-	-	-	0.55	-
Metaparoncholaimus sp.	-	-	-	0.66	-
Metasphaerolaimus japonicus (Fadeeva, 1983)	7.75	-	8.54	-	0.58
Monoposthia latiannulata Platonova, 1971	0.28	2.01	3.26	-	1.33
Neochromadora bilineata Kito, 1978	-	-	-	-	1.18
N. oshoroana Kito, 1981	-	-	-	-	0.42
Oncholaimium olium Belogurov, Belogurova et Pavlyuk, 1975	-	-	2.18	-	-
O. paraolium Belogurov et Fadeeva, 1980	-	-	6.05	1.12	2.36
O. ramosum Smolanko et Belogurov, 1987	-	2.54	-	84.93	-
Oxystomina elegans Platonova, 1971	-	-	-	-	0.44
O. orientalis Platonova, 1971	-	0.88	-	0.60	0.30
Paracanthonchus kamui Kito, 1981	-	-	5.80	-	-
P. macrodon (Ditlevsen, 1919)	-	2.74	34.25	2.78	4.56
Paracyantholaimus sp.	-	-	2.18	-	1.44
Parodontophora marisjaponici Platonova, 1971	-	-	-	-	0.51
P. timmica Pavlyuk et Belogurov, 1979	0.57	2.74	5.08	-	2.07
Pelagonema aspida Smolanko et Belogurov, 1991	-	-	-	0.41	-
Rhabdodemania orientalis Platonova, 1974	-	-	-	-	9.40
Propomponema sp.	-	3.64	-	-	1.20
Pseudoncholaimus asiaticus Belogurov, Belogurova et Pavlyuk, 1980	-	-	-	-	0.58
P. vesicarius (Wieser, 1959)	-	-	0.57	-	-
Pseudosteineria inaequispiculata (Platonova, 1971)	-	-	-	-	1.19
Sabatieria intacta Fadeeva et Belogurov, 1984	-	2.16	-	-	-
S. finitima Fadeeva et Belogurov, 1984	19.84	8.60	1.17	-	5.66
S. palmaris Fadeeva et Belogurov, 1984	5.47	20.45	8.93	1.5	2.33
S. pulchra (Schnejder, 1906)	-	13.94	0.92	1.45	-
Sabatieria sp.	-	-	-	-	0.21
Sphaerolaimus gracilis De Man, 1876	29.73	-	0.78	-	0.72

Note: '-' species not found at this taxocene

(**Table 2.** Continued)

Species	taxocene I	taxocene II	taxocene III	taxocene IV	taxocene V
S. limosus Fadeeva, 1983	0.57	3.06	4.12	-	24.72
Steineria copiosa Fadeeva, 1991	1.17	1.05	1.08	-	2.81
Synonchiella japonica Fadeeva, 1988	-	3.50	-	-	1.80
S. dilarae Fadeeva, 1988	-	-	-	-	0.60
Terschillingia glabricutis Platonova, 1971	-	-	1.08	-	0.51
Terschillingia sp.	-	0.84	-	-	0.63
Tricoma sp.	1.02	-	-	-	-
Theristus sp.	-	6.15	-	0.53	-
Viscosia stenostoma Platonova, 1971	1.02	1.82	4.51	0.24	-

Note: '-' species not found at this taxocene

dominant, with average density measuring 124.8±89.9 ind.m^{-2} (Table 2). The index of species diversity in this taxocene was the lowest and varied from 1.07 to 1.37 (Table 1). Taxocene V occupies the central part (stations 5, 10 and 13), and also a small site in the western part of the Bay (station 7). Average density of nematodes was measured at 71±37 ind.m^{-2}. 40 species of nematodes were found with *Sphaerolaimus limosus,* subdominants *Rhabdodemania orientalis* and *Sabatieria finitima* being dominant (Table 2). The index of species diversity in this taxocene was the highest and varied from 2.98 to 4.15 (Table 1).

4. Discussion

Species composition and density of nematodes are distributed non-uniformly in Amursky Bay. The lowest species diversity of nematodes is recorded in taxocenes I and IV. Taxocene I is located in the northwestern part of the Bay at a depth of 6.4–8.5 m in the zone of influence of Razdolnaya River. At the maximal drain of the river during the summer period, salinity in the benthonic layer of water can fall to 21.43‰ (Podorvanova *et al.* 1989). It is known that desalination greatly affects the density of meiobenthos animals, nematodes in particular (Gerlach 1953; Wieser 1975; Bouwman 1983). However, for sublittoral meiobenthos animals, a narrower range of salinity (Wieser 1975) is typical. In biotopes with low salinity waters, such as estuary, coastal lagoons and salty marshes, lowered water salinity influences both - species composition and density of nematodes (Gerlach 1953; Bouwman 1983). Investigations of meiofauna in the Belgian coastal waters (North Sea) showed, that the impact of Western Scheldt River, a highly polluted stream, leads to reduction of diversity on all taxonomical levels in the meiobenthos community (Heip *et al.* 1984). Nematodes were dominant throughout the community, their share making up more than 90% of all meiofauna. Diversity in species composition of nematodes was low (Heip *et al.* 1984). Studying the influence of the Morlaix River on nematodes communities of the muddy sediments (French), it was established that species composition of nematodes first of all depended on the granulometric structure of the ground, and secondly on changes in the salinity range (Gourbault 1981). In the estuary of Western Scheldt River (Netherlands), when studying meiofauna, it was found that in terms of species diversity of nematodes, in sandy sediments in the mouth of the River, a great effect produced high turbulence and periodical re-working of sediments (Van Damme *et al.* 1980). Investigation of composition and nematode density in the open coastal zone of Kievka Bay (the East Sea), where the nematode population was exposed not only to desalination, but also to wave action, it was shown that reduction of water salinity results not in the appearance of species living in low salinity waters, but in a sharp reduction of species composition as well as the density of sea nematodes in the freshened zone (Fadeeva 1991).

Thus, it has been shown by the authors, that along with desalination, species composition and density of meiobenthos animals are influenced by such factors, as the granulometric composition of the ground, the content of organic matter, seasonal prevalence, turbulence, and other factors.

In the northwestern part of Amursky Bay, where meiobenthos communities are exposed to the influence of the Razdolnaya River, which drains to the greatest extent, there is a reduction in the number of taxonomical groups and a reduction in meiobenthos density, as well as a reduction in the number of nematodes species.

Polluting substances produce a significant influence on the taxonomical composition and density of meiobenthos. Taxocene IV is located in the eastern part of the Bay in immediate proximity to the city, and it is exposed to the influence of household sewage. The content of organic matter in the bottom sediment of this area makes up more than 4% of the total. Raised concentrations of oil hydrocarbons (0.15 μg/g) and low content of dissolved oxygen in the benthonic water layer (3.4 ml/l) are registered here too (Belan *et al.* 2002). Correlation analysis revealed a reliable negative correlation between the content of organic matter in the bottom sediments and the index of species diversity (the Pearson's correlation coefficient equaled -0.59, $p<0.05$). Practically only one species of nematodes was dominant in taxocene IV – *Oncholaimium ramosum*, whose density made up more than 120 ind.m^{-2} of the total. Under conditions of maximal pollution, there are significant changes in the structure of the nematode community, which are closely related to the content of sulfides in the ground deposits (Warwick and Price 1979). In extreme oxygen-free conditions, the specific species composition of nematodes frequently develops, presented by 1-2 species, which have an abnormally high density. *O. ramosum* is one such species (Fadeev and Fadeeva 1999; Fadeeva *et al.* 2003). In other areas of Peter the Great Bay, where a high content of oil hydrocarbons was recorded (Nakhodka Bay, Gaydamak Bay and Golden Horn Bay), the density of this species reached more than 100 ind./m^2 (Fadeev and Fadeeva 1999; Fadeeva and Sobolevskya 1999; Pavlyuk and Trebukhova 2002). *O. ramosum* is tolerant to the low content of oxygen and high content of oil hydrocarbons. This species is not only tolerant to high concentrations of toxic substances, but also uses these substances to feed on. It is shown, that the carbon of oil hydrocarbons is included in a trophic chain within the community as an additional source of organic substances (Fadeeva *et al.* 2003).

Thus, polluting substances coming into the Bay, influence the quality of sea ground sediments, and hence, organisms inhabiting them. In conditions of maximal pollution, significant changes in the composition of meiobenthos community occur. In the ground sediments of the investigated area, not all meiobenthos organisms could adapt to life in the polluted conditions. Nematodes were a prosperous group and they made up almost 90% of the general density of meiobenthos. Investigation of nematofauna composition in the polluted area confirms that under conditions of anthropogenous, an unusual species composition of nematodes develops, where the density of one species (*O. ramosum*) can make up more than 85% of the general density of nematodes.

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