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ORIGINAL ARTICLE

Benthic fauna and communities of the lagoon water bodies of the White Sea by the example of Lake Kislo-Sladkoe

M.V. Chertoprud[1], E.S. Chertoprud[1], D.M. Palatov[1,2], A.A. Novichkova[1]

[1]Moscow State University, Biological Faculty, Leninskie Gory 1/12, Moscow, 119992, Russia
[2]Altai State University, Lenina 61, Barnaul, 656049, Russia
E-mail: lymnaea@ya.ru (corresponding author)
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In the present research the investigation of the lake Kislo-Sladkoe, a small brackish lagoon on the coast of Kandalakshsky Gulf of the White Sea, was conducted. In total 21 species of macrobenthic invertebrates identified and seven types of macrobenthic communities, derived from marine, estuarial and freshwater types, descried. Also, six meiobenthic species of the order Harpacticoida were found. The ecological peculiarities of the macro and meiobenthic taxa and the comparison with the biota of other brackish waters of the White Sea coast are described.
Key words: macrobenthos; meiobenthos; communities; Harpacticoida; White Sea; environmental factors

Introduction

The specific communities of the brackish waterbodies, in particular across the White Sea region, has repeatedly claimed the researcher's attention (Azovsky et al., 1998; M.Chertoprud et al., 2004), but are still poorly described. Of many types of water bodies, greater effort has been invested in researching the river estuaries – running systems with sharp time and spatial salinity gradients. Apart from that, the number of more or less closed or low flow coastal water bodies with the transitional salinity separated from the White Sea (Krasnova et al., 2015).

The Kislo-Sladkaya Lagoon is one of such water bodies, formed as a result of the separation of a sea bay. By the time, the lagoon is shaded by the sea with the wide rocky dam and can be called as a lake, although the fresh flow filling from the land is negligible, while seawater flow is significant. The salinity of the surface layer during the summer is about 10-15, the salinity of the near-bottom layer (at the depth of 2-4 m) is higher compared with the marine, and the layers are not fully mixed (Krasnova, 2008). Noticeable tidal effects in the lagoon are absent. The lake is 100x150 m in size, the bottom is covered with the fine-grained silt, and the shores are occupied with the moss-and-sedge floating bog. The small swamped inlet coming from the inland usually almost stop to circulate by the end of the summer.

Thus, the lagoon combines treats of the estuary (fresh water mixes with the seawater and forms zones with transitional salinity) and landlocked water body with the tendency to get swamped, which can lead to the development of the specific fauna and benthos communities. We investigated the shoal zone of the lagoon to educe and describe these communities and to compare them with those of the estuaries of the White Sea studied earlier (E.Chertoprud, 2002; M.Chertoprud et al., 2004).

Materials and methods

Lake Kislo-Sladkoe is located on the south of the Murmansk district on the shore of the Velikaya Salma Strait, 2 km to the east from the WSBS (Moscow State University White Sea Biological Research Station) (66°32' N, 32°08'E). Samples were taken in two different ways for two size groups of benthic invertebrates: macro- and meiobenthos. The fieldwork was conducted on 27-30 August, 2010.

Samples of macrobenthos were taken with a spherical scarper with 0.5 mm mesh from all the available biotopes up to 1 meter depth (i.e. except for the central deepwater part of the lagoon). Altogether, 15 quantitative samples of 0.1 m^2 area. For each identified species we evaluated its abundance, biomass and metabolism per unit area.

Meiobenthos was sampled qualitatively with a plastic tube on the soft grounds ща the shallow zone. Among collected organisms representatives of the order Harpacticoida (Copepoda) were analyzed in detail.

The communities of macrobenthos were allocated on the basis of the educed species complexes dominating in metabolism rates.

Results

Macrobenthos

Altogether, 21 species of macrobenthos were found in the lagoon. Among them only one species, gastropod *Hydrobia ulvae* can be regarded as marine, two brackish species (amphipod *Gammarus duebeni* and chironomidae larvae *Chironomus salinarius*), while all the rest are typical for the fresh waters, moreover most of them are larvae of Diptera. As long as they inhabit not typical environmental conditions here, we provide first the ecological features of 14 mass species across the lagoon. Seven species more were encountered singly.

Fauna and autecology of dominant macrobenthos species

Hydrobia ulvae (Pennant, 1777) (Gastropoda Hydrobiidae). The only marine species and the only mollusk in the lake's fauna. Inhabits all coastal silty substrates: the edge of the floating bog (silty sward), silty stones, snags and the surface of the silty bottom of the lagoon itself. Usually dominates in abundance in shallow water (up to 30cm depth) and decrease in number with the distance from the shore. Such an abundance of *Hydrobia* likens the community with the marine one (where *Hydrobia* also dominates on the silty littoral).

Gammarus duebeni Lilljeborg, 1852 (Amphipoda Gammaridae). Brackish amphipod inhabiting rocky areas of the shore in the lagoon (the edge of the dam, isolating it from the sea) and comes up to a very high density in the gaps under the stones. Avoids both silty bottom and floating bog, but occurs on the snags. In the White Sea it usually dominates in small low flow estuaries with violent fluctuations of the salinity.

Chironomus salinarius Kieffer, 1915 (Diptera Chironomidae). Brackish species occurring in the estuaries and on the silty bottom of the littoral zone of the White Sea. In the lagoon occupies peripheral portions of the silty bottom (like *Hydrobia*): silty edge of the floating bog, clay warp on the stones and other alike microbiotopes, while on the open bottom surface its abundance is low.

Chironomus gr. *plumosus* (Diptera Chironomidae). Another one species of the genus *Chironomus* of freshwater origin, which is typical for the water bodies with high saprobity. In the lagoon it inhabits silt of suffocative type (grey silt with strong smell of hydrogen sulfide), typical for some of the bottom areas.

Cladotanytarsus gr. *mancus* (Diptera Chironomidae). Small chironomids, inhabiting aerated surface layer of the bottom sediment. The most abundant species of the open part of the bottom. Typical for the silty substrates of the oligohaline zone of the estuaries in the White Sea (as for example, the estuary of the Chernaya River).

Natarsia punctata Meigen, 1804 (Diptera Chironomidae). Swamp species living in the moss-and-sedge floating bog of the lagoon.

Procladius (*Holotanypus*) sp. (Diptera Chironomidae). Occurs in the micro water bodies of the floating bog, which usually silted up, get thoroughly warmed during the day and have no connection with the main lagoon.

Dasyhelea pallidiventris (Goetghebuer, 1931) (Diptera Ceratopogonidae). Amphibious larvae of the biting midge, inhabits layer of the bog, as well as a little bit higher than the waterline.

Dixella obscura (Loew, 1849) (Diptera Dixidae). Typical species of the shoreline of the stagnant waterbodies. Dwell on the bog surface at the waterline.

Ptychoptera contaminata (L., 1758) (Diptera Ptychopteridae). Polysaprobic species ща minor waters; in the lagoon inhabits micro water bodies of the floating bog.

Cyphon sp. (Coleoptera Scirtidae). The bug larvae of swamp origin, inhabits layer and surface of the bog along the lagoon shore.

Haliplus apicalis Thomson, 1868 (Coleoptera Haliplidae). Halipid beetle, typical for the estuary zone. In the lagoon they concentrate on the hard substrates (mostly sunken timbers), but avoid rocky dam, occupied with amphipods.

Limnephilus nigriceps (Zetterstedt, 1840) (Trichoptera Limnephilidae). Limnophilous larvae of the caddis fly; in a little amount lives on the stones, snags and the bog's edges. Known to inhabit hard sediments of the oligohaline zone of the White Sea estuaries (Chertoprud et al., 2014).

Limnodrilus sp. (Oligochaeta Tubificidae). Limnophilous oligochaeta, occurring in the surface layer of the silty sediment across the whole lagoon water area.

Description of the macrobenthic communities

We described the types of communities on the basis of the complexes of dominant species occurring together in the samples. In the capacity of the abundance measure we used the relative metabolic rate of each species, based on abundance and biomass. We described seven types of the lagoon benthic communities, each of which has its specific set of dominant species and associated with the specific combination of environmental conditions.

1. *Cladotanytarsus* gr. *mancus* (42% of the total abundance) – *Hydrobia ulvae* (31%) – *Chironomus salinarius* (23%). The main biotope is open shallow water of lagoon with silty sediment. The chironomids themselves inhabit only upper oxygenated layer up to 2-3 cm depth, where they are absent. The alike communities had been described earlier for the oligohaline zone of some of the White Sea estuaries (Chertoprud et al., 2004), but the species richness of Chironomidae here is much lower. Rather the same communities with the domination of *Cladotanytarsus* and other chironomids (but not *Hydrobia*) are observed on the soft sediments of many continental waterbodies of Europe.

2. *Chironomus* gr. *plumosus* (90%). Special «suffocative» variation of the previous type of communities, which is typical for the bottom depressions with the sediment enriched with the hydrogen sulfid. This type is close to the polysaprobic communities

of the fresh waters (sapropelal type), but differs by the absence of oligochaeta of the genus *Tubifex* and probably different species of the genus *Chironomus*.
3. *Hydrobia ulvae* (71%) – *Chironomus salinarius* (14%). This community occupies the peripheral zones of the silty littoral and silted edge of the floating bog. In the direction of the center of the lagoon blends gradually to the first type of communities. Structurally (by the predominance of *Hydrobia ulvae*) similar to the communities of the silty sandт littoral of the White Sea (Azovsky et al., 2000), but much poorer in species number.
4. *Cyphon sp.* (33%) – *Dasyhelea pallidiventris* (21%) – *Limnephilus nigriceps* (18%) – *Natarsia punctata* (16%). Specific ripal community, inhabiting the upper layer of the floating bog near the water surface. Possibly, it has some analogues in the swamps, but such examples are unknown for us.
5. *Ptychoptera contaminata* (53%) – *Procladius* (*Holotanypus*) sp. (22%). The second one community of the floating bog, associated with the micro water bodies – small silty puddles, partly filled with decomposing detritus. Occurs throughout decaying micro fresh waters.
6. *Gammarus duebeni* (78%) – *Chironomus salinarius* (18%). Inhabits understones cavities of the littoral zone, mostly by the rocky dam between the sea and the lagoon. The tops of these stones are above the water and lack of hydrobionts. Rather typical brackish community for many minor estuaries of the White Sea.
7. *Hydrobia ulvae* (42%) – *Gammarus duebeni* (17%) – *Cladotanytarsus* gr. *mancus* (16%) – *Haliplus apicalis* (14%) – *Limnephilus nigriceps* (10%). Specific mixed type of the communities, inhabiting sunken timbers in the coastal zone of the lagoon. Consist of the species with different origin: both marine and freshwater, as well as both typical for soft and for hard substrates. Has no obvious analogues, but structurally similar to some of the xylophilous communities of minor water bodies (distinctive combination of Gammaridae and Limnephilidae).

Thus, of seven selected communities, only one can be regarded as derived from marine (№ 3), two as modified communities of estuaries (№ 1 и 6), described by us before (Chertoprud et al., 2004), and the rest four – derived from freshwater communities of pond-bog type. Total diversity of the communities types is evidently too high for a small water body, however the number of species in each community is very low. Altogether these two effects can be regarded as typical for the estuarial zones. The result of both effects – the total number of species (21) – is generally typical for small stagnant water bodies and for minor estuaries of the White Sea (Chertoprud et al., 2004).
Comparing to the neighbouring and well-studied estuary of the Chernaya River, the diversity of macrobenthic communities is generally the same – it also has seven types of communities (Chertoprud et al., 2004). However, species diversity of the communities of the Lake Kislo-Sladkoe is much lower, and the total number of species in the lagoon is 21 against 91 in the Chernaya River estuary. On the other hand, this estuary is much bigger in size (about 2.5 km length) and studied more thoroughly. The level of spatial heterogenity of the communities (their diversity per area unit or length of the shore) in the lake Kislo-Sladkoe is much higher than in the Chernaya River estuary.
It has to be noted, that the current research is preliminary. At least, the structure of the communities can be subject to a considerable season and probably interannual variation.

Meiobenthos (Harpacticoida)

A total of 6 species of Harpacticoida (Copepoda) was found in the lagoon. Three of them are euryhaline, and the other three are brackish. Most of the copepods are associated with the described above community *Gammarus duebeni – Chironomus salinarius*. Harpacticoida are abundant in the deviations under the stones in the coastal zone of the lagoon. The brief ecological characteristics of the species are given below.

Ecological features of the Harpacticoida species

Nitocra spinipes Boeck, 1865 (Ameiridae) inhabits soft sediments mostly in brackish water (Borutsky, 1952). The area comprises southern (the Caspian, Black and Mediterranean Seas) and northern territories (the Baltic, North, Barents Sea and Alaska). In the fauna of the White Sea *N. spinipes* is reported for the first time.
Eurycletodes similis (T. Scott, 1895) (Argestiidae). Marine species, widespread in the seas of northern Russian territory (the White, Barents, Kara, Laptev and East-Siberian Seas), as well as in the Black and Mediterranean Seas. In the White Sea *E. similis* occurs on the silty sediments (Kornev, Chertoprud, 2008).
Itunella muelleri (Gagern, 1923) (Canthocamptidae). Marine eurybiontic species inhabiting silty sediments and on fucus growth in the White Sea (Chislenko, 1967). Occurs throughout the European coast from the Black to the White Sea.
Mesochra rapiens (Schmeil, 1894) (Canthocamptidae). Species is typical for silty sediments of the northern estuaries (Kornev, Chertoprud, 2008). The area comprises coasts of Europe and Japan. In the White *M. rapiens* is reported from the Chernaya River estuary.
Onychocamptus mochammed (Blanchard, Richard, 1891) (Laophontidae). Eurybiontic brackish species (Kornev, Chertoprud, 2008), reported from the Chernaya River estuary. Cosmopolitic.
Stenchelia palustris (Brady, 1868) (Miraciidae). Epibenthic littoral species, typical for the silty sediments (Kornev, Chertoprud, 2008; Chislenko, 1967). Widespread on the northern coasts of Europe and Russia. In the White Sea is common and sometimes dominate in the community. Also reported for the Chernaya River estuary.
Harpacticoid fauna of the Kislo-Sladkaya lagoon is understudied yet. Further investigations will likely 1.5-2 times increase the species list of taxa.

Brief comparison of Harpacticoida fauna of the Chernaya River estuary and the lagoon Kislo-Sladkaya

The Chernaya estuary (Loukhsky District of the Republic of Karelia) is one of the nearest (about 8 km to the south-west) to the Lake Kislo-Sladkoe and well-studied estuaries in the White Sea. There are 13 species of Harpacticoida reported here (Chertoprud, 2002). These are marine euryhaline species *Huntemannia jadensis, Stenhelia palustris, Heterolaophonte minuta, Platychelius littoralis, Paraleptastacus kliei, Halectinosoma curticorne, H. brevirostre, Nannopus palustris, Tachidius discipes*; brackish species *Tachidius littoralis, Mesochra rapiens, Laophonte mohammed, Halectinosoma abrau*. Thus, the brackish-marine species ratio in the estuary is 1/2.

Of the reported for the Lake Kislo-Sladkoe species, only three are in common: marine *Stenhelia palustris* and brackish *Mesochra rapiens* and *Laophonte mohammed*. However, in the lagoon the diversity of the marine species compareв to the brackish is almost two times lower, the number of brackish species is equal to marine ones.

It is characteristic, that the salinity of the surface water of the Kislo-Sladkaya lagoon during the summer is almost the same with the sealine waters of the Chernaya River estuary (Chertoprud, 2002) and amount to 10–15 ‰. Thus, the environmental conditions for the marine Harpacticoida species are the same in both water bodies. Probably, the impoverishment of the marine Harpacticoida fauna in the lagoon Kislo-Sladkaya is depended on the existence of isolation – the wide rocky dam, separating the lagoon from the sea, make the dispersion of the marine species difficult. In the Chernaya River estuary the aquatory is separated by the sea with narrow stony rift and do not bring such difficulties for dispersal of species. The marine Harpacticoida can penetrate into the lagoon only by the wave overwash of the outbreak of the macrophytes (storm outcome). The possibility of marine species to penetrate into the lagoon together with the interstitial waters (i.e. directly under the dam) seems doubtful. However, this hypothesis needs additional revision.

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