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ORIGINAL ARTICLE

Taxonomic diversity of benthic invertebrates of the Moskva River in the Moscow area: diversity and distribution

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Biological diversity and distribution of benthic invertebrates in the Moskva River within the frames of Moscow are studied. Totally, 72 invertebrate taxa were found including 8 invasive species with amphipod *Gmelinoides fasciatus* (Stebbing, 1899), an invader from the Lake Baikal. A number of observed species are characterized with high abundance and biomass while most of observed taxa are represented by a small number of individuals. The greatest species diversity was revealed for insect larvae, mainly due to Chironomidae. The main species on the investigated section of the river are various crustaceans, mainly amphipods and decapods (when present in samples) showing more than 70-90% of all biomass of zoobenthos at all stations (sites). Multivariate cluster analysis allowed concluding that bottom communities in Moskva River, the degree of their quantitative development, species richness and diversity are mainly influenced by the structure of bottom substrates rather than other factors. The most diverse benthic communities are presented on silty bottom with mixture of shells of mollusks and plant remains. The lowest diversity of benthic communities is characteristic for sites with relatively strong water and well washed sand as the main bottom substrate. Obtained data starts annual monitoring of the river at indicated stations using biological indicators, namely native amphipod *Gammarus lacustris* and invasive *G. fasciatus*.
Keywords: diversity; distribution; benthos; benthic invertebrates; river Moskva; Moscow

Introduction

The Moskva River is one of the largest rivers of the East European Plain, the left tributary of the Oka River and further into the Volga River (Bakanov, 2003). The length of the Moskva River is only 473 km, but the area of the basin is about 17,600 km². The river flows through a number of large cities, including the metropolitan center of Moscow City and its water is widely used for water supply of the city. It is obvious that the river and its channel system are under a significant anthropogenic press. In this connection, there is no doubt that it is necessary to study its ecological state of the river, including the state of hydrobiocenoses, which react sensitively to changes in environmental conditions.
At the same time, a few publications have been devoted to the hydrobiological study of the Moskva River. In particular, invasive amphipod *Gmelinoides fasciatus* (Stebbing, 1899) (Crustacea: Amphipoda: Micruropodidae) was discovered in the river only in 2016 (Marin & Sinelnikov, 2016), although this species has long been present in the watercourses of the European part of Russia since 1960th (e.g. Pirozhnikov, 1955; Ioffe, 1975; Ioffe & Nilova, 1975; Matafonov, 2005). Hydrobiological research of the Moskva River become particularly relevant due to the fact that it is a source of technical and, in some cases, drinking water for a number of large cities, and its ecological status requires constant monitoring (Makrushin, 1974; Kutikova & Starobogatova, 1977).

Material and methods

In the course of studies on the biological diversity several sites were sampled in the basin of the Moskva River in April-May 2016; in each site macrobenthic organisms were collected from the area of 1 sq. meter (1X1 meters) using a hand net. Samples were washed with pure water and then fixed with 70% ethanol solution (after Sladecek, 1973; Zimbalevskaya, 1981; Salazkina et al., 1984; Tsololikhin, 1994-2004). Totally, 8 sites were investigated in three sections on the river: upstream the Moscow City, inside the borders of the city and downstream the city (Fig. 1; Table 1). One area (site 1), as a "control" site was selected in the River

Oka in the area of the Prioksko-Terrasny Nature Reserve (PTNR). All sites were located in the coastal zone, from the water line to the depth of 2 meters. Geographic coordinates of sites were determined using Global Positioning Systems (GPS). Animals were identified based on Yakovlev (2010). The bottom at most sites consisted of sand, boulders, shells, and, rarely, of completely silty substrates (within the borders of the Moscow city) (see Table 1). After collection, all animals were identified and weighed using a torsion scale according to standard methods. Samples were examined using a stereoscopic microscope MBS-10 in a Bogorov's chamber. The specimens of collected animals were dried on filter paper before weighing. For several species the stomach and gut contents were dissected to study their nutrition. Standard indices were used for the determination of biocenoses conditions; average indices are recalculated for 1 sq. m with the help of STATISTICA programs (after Paliy, 1961; Woodiwiss, 1964; Wentzel, 1969; Mitropolsky & Mordukhai-Boltovsky, 1975; Wegl, 1983; Mordukhai-Boltovskoy, 1978; Megarran, 1992; Popchenko, 1992; Borovikov, 1998).

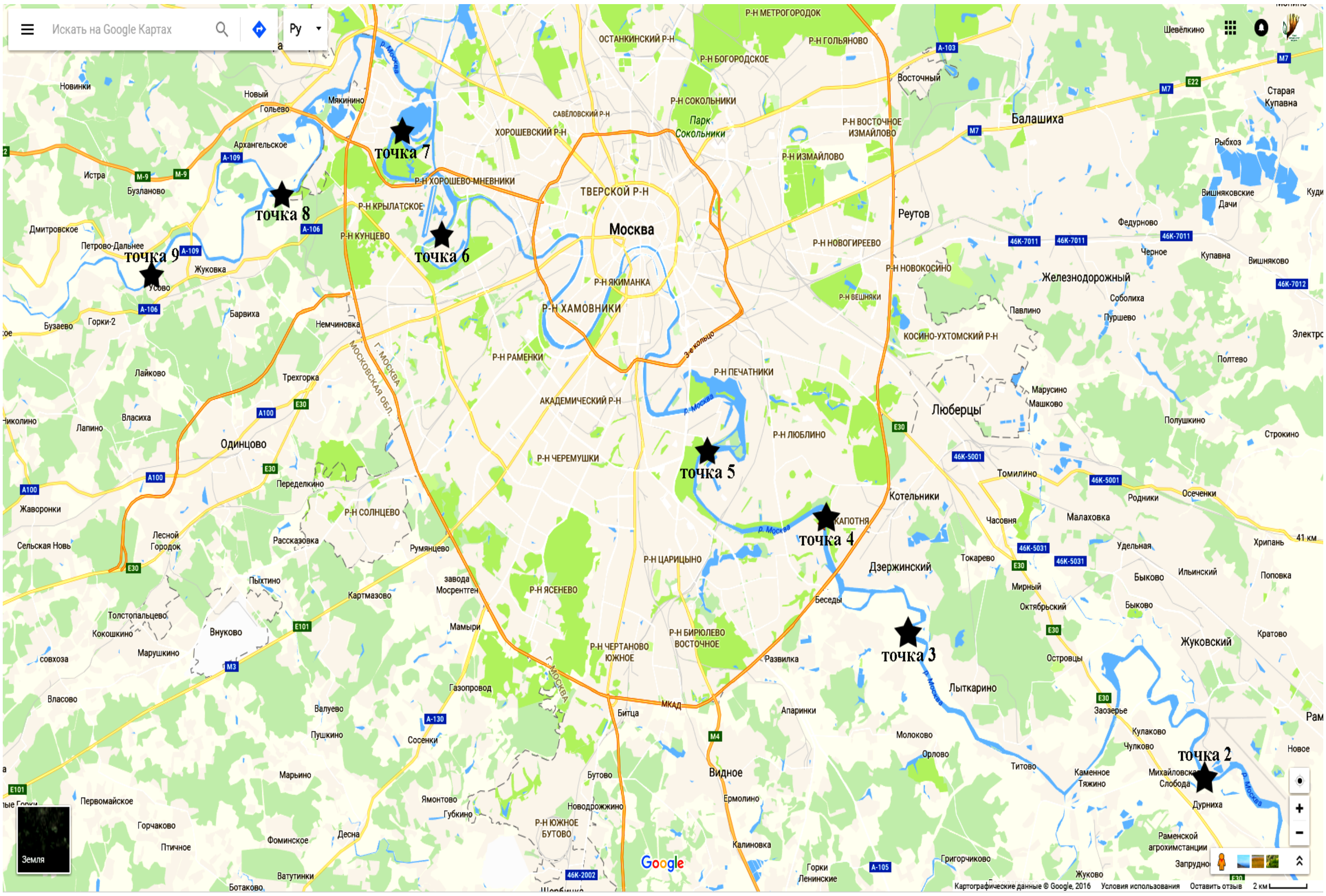

Fig. 1. The map of sampling sites at the basin of the Moskva River in the frames of Moscow City

Table 1. Sites sampled in the River Moskva in April and May 2016.

Site 1	54°50'40"N 37°42'24"E	sand, sandy-rocky substrates, numerous algae
Site 2	55°32'41"N 38°6'41"E	sandy-rocky substrates
Site 3	55°36'7"N 37°51'15"E	sandy-rocky substrates
Site 4	55°38'32"N 37°46'54"E	muddy bottom
Site 5	55°40'18"N 37°40'59"E	muddy bottom
Site 6	55°45'14"N 37°27'6"E	muddy sand
Site 7	55°47'34"N 37°25'6"E	sand, rocks
Site 8	55°46'8"N 37°19'4"E	sand, rocks
Site 9	55°44'17"N 37°12'4"E	sandy-rocky substrates

Sampling and treatment of samples were carried out according to conventional hydrobiological methods. The depth and nature of bottom was established in the sampling sites. During the processing the collected materials, the species composition, abundance and biomass of the zoobenthos were determined. The dominance was estimated using the Pali-Kovnacki dominance index. The complexity of the structural organization of benthic communities was assessed using the Shannon species diversity index. Statistical processing of data was carried out using the Statistica 6.0 software package.

Results

Totally, 64 species were found in our samples regularly, including 1 species of Cnidaria, 5 species of both Gastropoda and Bivalvia, 16 species of annelid worms, 8 species of higher crustaceans and 24 species of different water insects (mostly, their larvae).

Cnidaria
Hydra vulgaris Pallas, 1766

Gastorpoda
Viviparus viviparus (Linnaeus, 1758)
Bithynia tentaculata (Linnaeus, 1758)
Lithoglyphus naticoides C. Pfeiffer, 1828
Lymnaea lagotis (Schranck, 1803)
L. auricularia (Linnaeus, 1758)

Bivalvia
Pisidium amnicum (O.F. Müller, 1774)
Sphaerium corneum (Linnaeus, 1758)
Sphaeriastrum rivicola (Lamarck, 1818)
*Dreissena polymorpha (*Pallas, 1771)
Unio pictorum (Linnaeus, 1758)

Annelida
Limnodrilus hoffmeisteri Claparede, 1862
Limnodrilus claparedianus Ratzel, 1868
Psammoryctides albicola (Michaelsen, 1901)
Potamothrix moldaviensis (Vejdovský & Mrázek, 1903)
P. hammoniensis (Michaelsen, 1901)
*Spirosperma ferox (*Eisen, 1879)
Tubifex newaensis (Michaelsen, 1903)
T. tubifex (O.F. Muller, 1773)
Dero digitata (O.F. Muller, 1773)
Stylaria lacustris (Linnaeus, 1767)
Lumbriculus variegatus (O.F. Muller, 1773)
Propappus volki Michaelsen, 1916
Nais barbata Müller, 1774
Glossiphonia complanata (Linnaeus, 1758)
Helobdella stagnalis (Linnaeus, 1758)
Erpobdella octoculata (Linnaeus, 1758)

Crustacea
Dikerogammarus hemobaphes (Eichwald, 1841)
Chelicorophium curvispinum (G.O. Sars, 1895)
Gmelinoides fasciatus (Stebbing, 1899)
Gammarus lacustris G.O. Sars, 1864
Pontogammarus obesus (G.O. Sars, 1894)
P. sarsi (Sowinsky, 1898)
Astacus astacus (Linnaeus, 1758)

Insecta
Chaleolestes viridis (van der Linden, 1825
Ablabesmyia gr. monilis (Linnaeus, 1758)
Procladius ferrugineus Kieffer, 1919
Cricotopus aff. algarum Kieffer, 1911
Psectrocladius psilopterus Kieffer, 1906
Chironomus aff. plumosus Linnaeus, 1758
Chironomus plumosus (Linnaeus, 1758)
Camptochironomus tentans (Fabricius, 1805)
Cryptochironomus aff. defectus Kieffer, 1921
Xenochironomus xenolabis (Kieffer)
Harnischia fuscimanus Kieffer, 1921

Limnochironomus nervosus Staeger, 1839
Hexatoma bicolor (Meigen, 1818)
Lipiniella araenicola Shilova, 1961
Parachironomus arcuatus (Goetghebuer, 1919)
P. vitiosus (Goetghebuer, 1919)
Paracladopelma camptolabis Kieffer, 1913
H. ornatula McLachlan, 1878
Polypedilum convictum Walker, 1856
P. breviantennatum Tshernovskij, 1949
P. gr. nubeculosum Meigen, 1818
Robackia demeijerei (Kruseman, 1933)
Micropsectra praecox Meigen, 1818
Cheumatopsyche lepida (Pictet 1834)

Among identified zoobenthos taxa, 8 species belong to invasive species, including oligochaetes *P. moldaviensis* and *P. hammoniensis*, bivalve *D. polymorpha*, gastropod *L. naticoides*, amphipods *D. hemobaphes, G. fasciatus, P. obesus* and *P. sarsi*. The main species of zoobenthos (with the occurrence more than 50%) at this section of the Moskva River are gastropods *L. naticoides*, all species of amphipods and decapod crustaceans *A. astacus*, which formed from 75 to 95% of the total biomass of all zoobenthos at the stations. The secondary species with the occurrence about 25-30% were represented by 15 taxa, including nematodes, bivalves *B. tentaculata, V. depressa* and *V. viviparus*, chironomids from genera *Demicryptochironomus* and *Polypedilum*. Most of the species found posses with the indices of occurrence less than 15%. Analysis of structural indicators of zoobenthic communities showed that the average number of taxa in the sample was 22±1, with the maximum number in the sample was 42 species (control site). The average values of abundance and biomass at all points is 3762±1425 ind./m2 and 41.32±18.98 g/m2, respectively, the Shannon index is 1.65±0.7 bit per specimen. The habitats of benthic invertebrates vary considerably over Moskva River. Probably, that the bottom zoobenthic communities is primarily affected by factors such as water flow, velocity, depth, type of the bottom and the presence of macrophytes. In this connection it is possible to conclude that zoobenthos of the Moskva River is very heterogeneous and characterized by mosaic distribution. The index of saprobity of studied area is fluctuated within 1.73-3.26, which corresponds to zones from polysaprobic to β-mesosaprobic on the vast majority of sites, characterizing the main river flow as α-mesosaprobic. The biotic index of WoodWiss varied from 1 to 6, which characterizes water from slightly polluted (sites 1, 2) to very dirty (site 9). At the same time, high level of the pollution of site 9 is affected by the close mouth of Pakhra River.
Based on the results of multivariate cluster analysis, it is possible to conclude the main influence on bottom communities states in Moskva River, the degree of their quantitative development, species richness and diversity is affected by the bottom substratum rather than other factors. The most diverse benthic communities are presented on silty soil with an admixture of shells of mollusks and plant remains. The lowest diversity of benthic communities is characteristic for parts, where the water flow is relatively strong, and the bottom substrate is mainly represented by sand.

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