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ZOOPLANKTON, ZOOBENTHOS, AND ZOOPERIPHYTON

Macrozoobenthic Communities of the Piedmont and Lowland Watercourses of the Lower Amur Region

M. V. Chertoprud[a, *], E. S. Chertoprud[a, b], L. V. Vorob'eva[c], D. M. Palatov[a, b], A. N. Tsyganov[a, d], I. S. Reshetov[a], and N. P. Kovacheva[c]

[a] *Faculty of Biology, Moscow State University, Moscow, Russia*
[b] *Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia*
[c] *Russian Federal Research Institute of Fisheries and Oceanography, Moscow, Russia*
[d] *Penza State University, Penza, Russia*
**e-mail: lymnaea@yandex.ru*

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Abstract—On the basis of 120 original stations, macrozoobenthic communities of rivers from two adjacent areas of the Lower Amur Region (Khabarovsk krai) have been described. Rivers basins are characterized by contrasting landscape conditions: the Anyuy River basin in the piedmonts of the Sikhote-Alin mountain range and the Simmi River basin on the Amur Lowland. About 250 taxa of macroinvertebrates have been found; 16 types of communities have been described. The principal differences in both benthic fauna and macrozoobenthic communities in the basins of the Anyuy River (cold-water rheophilic fauna as well as ritral and crenal communities predominate) and the Simmi River (warm-water limnophilic fauna and phytal communities predominate) are shown. We discuss the reasons for these differences, specific features of the fauna and communities of the whole region, and the biogeographical position of the region.

Keywords: macrozoobenthos, communities, Amur Region
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INTRODUCTION

The freshwater macrozoobenthos of the southern part of the Russian Far East has been studied in sufficient detail, mainly due to the long-term work of the scientific school and laboratory of river biologists founded by V.Ya. Levanidov. The bibliography on the main groups of aquatic invertebrates in the region, especially amphibiotic insects (Ephemeroptera, Plecoptera, Trichoptera, and Diptera), contains hundreds of works (Bogatov, 1994; Levanidova, 1982; Teslenko 2007; Chernova, 1952; Tiunova, 2009), including those dedicated to individual watercourses or local areas. However, the vast majority of well-known publications are taxonomic or local faunistic works; the structure and variability of bottom communities, even in this region, are still fragmented.

This fully applies to the adjacent basins of the Anyuy and Simmi rivers. The fauna of Mayfly (Ephemeroptera) in the Anyuy and its several tributaries has been described (Tiunova, 2003). Studies were carried out in the late 1940s for the Simmi River benthos. They were based mainly on the identification of organisms just to the family level (Borutskii et al., 1952). There is information about the composition of chironomids (Diptera, Chironomidae) in the basin of the Simmi River (Yavorskaya, 2016). The fauna of aquatic invertebrates of the Bolon Nature Reserve, including the Simmi, was also described (Vshivkova and Nikitina, 2010), although with the identification of a significant part of taxa also just to the family level. Synecological studies of freshwater macrofauna for this area are not known.

The basins of the Simmy and Anyuy rivers are interesting as an example of contrasting groups of watercourses within the compact climatic and biogeographic regions. This is determined by the peculiarities of local landscapes. The Anyuy River and its tributaries flow from the slopes of the Sikhote-Alin mountain range, and they retain a piedmont features even on the plain territory: fast flow, shallow depth, prevalence of rocky ground in the riverbed, and moderate summer water temperature. On the contrary, the Simmi basin is located in the lowlands and its watercourses are of a purely flat nature: almost no channel slope, great depth with significant summer floods, the prevalence of soft grounds, extensive thickets of aquatic macrophytes, and high summer temperatures (typical to the lowlands along the Amur River valley). These two areas can complement each other when studying the characteristics of the fauna and communities of the whole region.

The aim of our work is to compare the taxonomic composition and diversity of zoobenthos communities of watercourses with different hydrological types on the example of basins of the lowland Simmi and piedmont Anyuy rivers and to characterize specific features of the rheophilic macrofauna communities of the Lower Amur Region in comparison with other Eurasian regions previously examined by us (Chertoprud, 2011; Chertoprud and Palatov, 2013; Chertoprud et al., 2018; Palatov et al. 2016; Palatov and Chertoprud, 2018).

MATERIALS AND METHODS

Research Area

The studies were carried out during expeditionary work in the territories of the Anyuysky National Park and the Bolon Nature Reserve in August 2016 (Fig. 1). These two territories are located at a distance of ~100 km from each other and are separated by the Amur River valley.

Anyuysky National Park is located in the Nanaysky district in Khabarovsk krai. It is located on the right bank of the Amur River, in the middle and lower reaches of the Anyuy River, and occupies the taiga region of the western slopes of Sikhote-Alin Mountain range; the territory is weakly affected by anthropogenic activity. The studied area covers heights of 50–250 m above sea level.

The Bolon Nature Reserve is located on the Central Amur Lowland and adjoins from the southwest to Lake Bolon, occupying the interfluve area of the Simmi and Kharpi rivers. It is a swampy plain with a height ~15 m above sea level, covered with meadow and swamp vegetation. Thickets of macrophytes (water caltrop, coontail, floatingheart, and water lilies) occupy up to 50% of the area of watercourses. During the sampling period, due to heavy summer rains, the water level in the region's watercourses was significantly increased.

Sampling Methods

Altogether, 80 quantitative samples of macrozoobenthos at 40 stations in 28 watercourses were collected in the Anyuy River basin (Fig. 1a). One to five samples were taken at each station according to the number of biotopes represented (various types of soil and macrophytes). Similarly, 41 samples at 23 stations in seven watercourses were collected in the basin of the Simmi River (Fig. 1c).

The material was sampled with a hydrobiological scraper 0.02 m^2 in area. The area of one sample was 0.2 m^2. For each station, a general description of the studied watercourse was done, and pH, mineralization, and temperature were measured (the latter using portable devices from Hanna Instruments).

Fauna Identification

The identification of organisms was carried out according to the guide book (*Opredelitel'*..., 1994, 1997, 1999, 2001, 2004) taking into account regional faunistic studies (Levanidova, 1982; Teslenko, 2007). Approximately 70% of taxa were determined up to the species level and the rest, as a rule, up to the genus.

Statistical Analysis

To assess the contribution of the identified species to the potential species pool of the basins, the accumulation curves of the number of species were plotted depending on the number of samples analyzed using the programming language R (R Core Team, 2017) and its vegan package application (Oksanen et al., 2017).

Macrozoobenthic communities were separated using the Brown–Blanke method modified for hydrobiological data (Chertoprud, 2011, 2014) by the relative biomass of species. It is widely used to classify communities in geobotany, where it has been shown to be effective; although it is rarely used in hydrobiology, despite the existence of relevant tasks. A table of rations of species abundance in the community biomass was used as initial data. Species with an abundance exceeding 15% in one of the samples were chosen for analysis.

RESULTS

Characteristics of Watercourses

As expected, the watercourses of the compared river basins differed sharply by most indicators. The average flow rate in the watercourses of the Anyuy basin is 0.2–0.8 m/s and 0.02–0.15 m/s in the watercourses of the Simmi basin, water temperature is 12–17°C and 22–25°C, mineralization is 17–26 mg/L and 10–13 mg/L, and pH 7.7–8.3 and 6.6–7.4, respectively. Thus, the most significant differences were revealed in temperature and flow velocity. In addition, the set of met and examined biotopes sharply differed: in the Anyuy basin watercourses, most of the samples were rocky grounds and sunken wood objects while they were sandy–silty grounds and thickets of macrophytes in the Simmi basin.

Taxonomic Composition and Species Richness

In the watercourses of the Anyuy basin, 184 taxa were found (Supplementary materials ESM_1), of which 35 species are endemic to the Amur–Manchuria region. The richest orders are Diptera (81 species), Ephemeroptera (46 species), and Trichoptera (31 species). Eighty-five species are ritral, preferring stony soils of fast streams; 41 species are ripal, undemanding to the flow; 45 species (mainly chironomids) are pelophilic living in silty–sandy grounds; and 13 species are

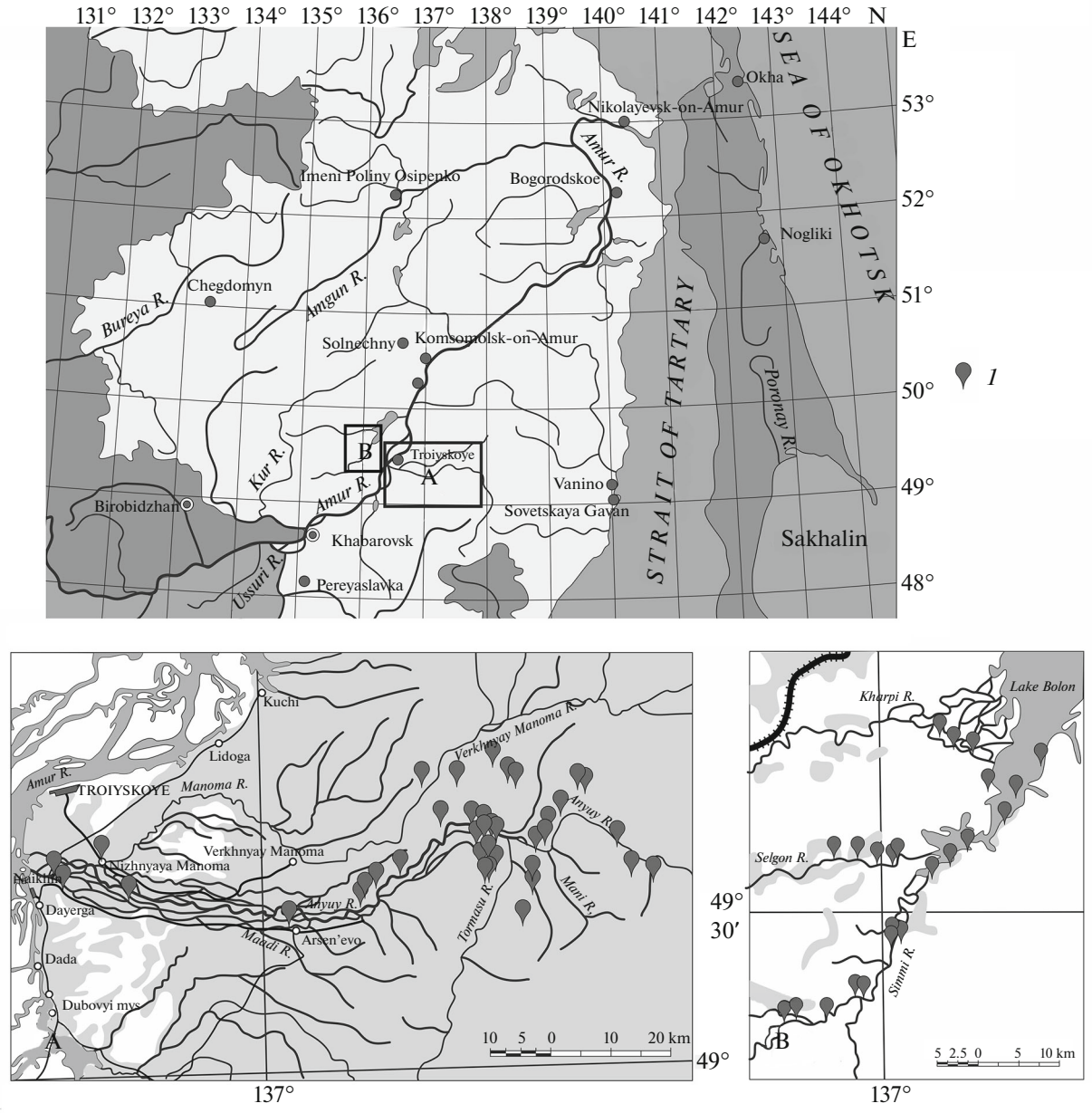

Fig. 1. Studied areas of Khabarovsk krai: (A) basin of the Anyuy River and (B) basin of the Simmi River; (*1*) sampling stations.

crenal, typical for streams and springs. In general, ritral species prevail, as they are relatively cold-water species, usually confined to stony riffles, which is typical for foothill fauna.

In the watercourses of the Simmi basin, 80 taxa were found (Supplementary materials ESM_1): 19 species are endemic to the Amur–Manchuria region. The most common orders are Diptera (25 species), Hemiptera (10 species), and Coleoptera (10 species). Of all the species, 32 are ripal, 20 are phytal (living in thickets of macrophytes without a rapid flow), and 28 are pelophilic. Thus, the main part of the fauna is represented by the pelophilic and phytophilic taxa typical for the lake-type water bodies.

Main Types of Communities in the Anyuy River Basin

Ritral

Ritral communities are communities of solid substrates. In the watercourses of the Anyuy River basin, ritral communities are most common; they occupy the main part of the bottom surface. Six types of communities known in other regions were identified.

Euritral. This community is confined to stony riffles of small and medium-sized rivers (Anyuy, Bok-

basu, Tormasu, Mukhe, and Mani) occupying the main part of their bottom in a fast and moderate water flow (usually 0.4–0.7 m/s). Dominants here are mayflies *Epeorus* gr. *pellucidus* (43.9% of the total biomass) and filter caddisflies *Arctopsyche amurensis* (10.0%), with a wide variety of chironomids, spring flies, and other mayflies and caddisflies. The average biomass is 18.0 g/m^2 and the average abundance is 1343 ind./m^2.

Epiritral. This is a community of fast streams and small rivers with a shaded bottom and weakly developed epibioses on stones. Sedentary shelled scrapers dominate here: caddisflies *Glossosoma* sp. (42.6%), *Neophylax ussuriensis* (14.3), and *Arctopsyche amurensis* (8.1). The average biomass is 33.2 g/m^2; the average abundance is 2830 ind./m^2.

Himaroritral. A community of sites with strong currents (0.7–1.0 m/s), where black fly larvae develop in mass on stones. Larvae of *Simulium* s.str. spp. dominate here (72.8% of total biomass); *Arctopsyche amurensis* is also typical. The average biomass is 48.6 g/m^2; the average abundance is 18620 ind./m^2.

Peloritral. A community of silty rocky bottom, usually on the shallows with a weakened water flow, in particular in the river. Anyuy. Distinguished by a high proportion of chironomid larvae with a weakening of the role of filtrators and scrapers; the complex of dominants includes chironomids *Pagastia orientalis* (21.1%) and *Cricotopus* spp. (5.0%). In addition to them, Ather*ix ibis* (13.9), *Neophylax ussuriensis* (10.7), and other ritral species are typical. The average biomass is 15.6 g/m^2; the average abundance is 2880 ind./m^2.

Lentiritral. A community of rocky bottom in slow water flow and the absence of siltation, occurring on the broads of small rivers and streams. Dominant species here are sedentary shelled scrapers: larvae of caddisflies *Apatania stigmatella* (28.0%) and *Neophylax ussuriensis* (15.0%), as well as *Dicosmoecus jozankeanus* (16.6%). Among other species, the crevice amphipod *Gammarus koreanus* (8.1), chironomid *Pagastia orientalis* (6.5), and large stonefly *Pteronarcys sachalina* (4.4) are also typical. The average biomass is 21.0 g/m^2; the average abundance is 2780 ind./m^2.

Phytoritral. A community of macrophytes, sometimes of flooded terrestrial grass and branches in a fast current. Black fly larvae of the subgenus *Simulium* (42.8%) or mayfly *Baetis* gr. *vernus* (20.3) dominate here. The average biomass is 18.1 g/m^2; the average abundance is 7700 ind./m^2.

Crenal

Crenal communities are communities of mosaic substrates of small watercourses with the dominance of detritophages. They are common in the Anyuy basin.

Gammarocrenal. The main type of crenal communities in the region is associated with the dramatic dominance of the amphipod *Gammarus koreanus* (an average of 82.6% of the total biomass of the community). It occupies almost all streams; along the coastal edge it also penetrates into small rivers. Among other taxa, springflies *Nemoura* sp. and *Suwallia* sp., mayfly *Neoleptophlebia chocolata* Imanishi, 1937, caddisflies *Hydatophylax* sp., chironomids, and planaria *Phagocata* are typical (all with a low abundance). The average biomass is 12.4 g/m^2; the average abundance is 986 ind./m^2.

Xylocrenal. Community of wood substrates (sunken snags and logs) in small streams, usually in a moderate water flow. Large shelled detritophages dominate here; they are represented mainly by limnephilidae caddisflies *Dicosmoecus jozankeanus* (36.6%) and *Hydatophylax* sp. (6.3%). Amphipods *Gammarus koreanus* (12.4%) and a number of small spring flies and mayflies are also typical. The average biomass is 4.6 g/m^2; the average abundance is 166 ind./m^2.

Ripal

This type consists of communities of mosaic substrates of river banks. These communities could be found on the shores of all watercourses on very small areas.

Euripal. A community of coastal organic substrates (roots, terrestrial grass, litter of varying degrees of siltation) in small and medium rivers. It occurs frequently; the structure of dominant species is unstable and mobile phytodetritophages prevail. The dominant complex includes floating mayfly *Baetis* gr. *vernus* (15.4%), caddisflies *Anabolia servata* (McLachlan, 1880) (15.7) and *Hydatophylax* sp. (17.8), and amphipod *Gammarus koreanus* (10.4). A variety of other mayflies, stoneflies, and caddisflies are also typical. The average biomass is 4.0 g/m^2; the average abundance is 231 ind./m^2.

Pelal

Soft ground communities. In the area of the Anyuy, soft grounds are rare and occupy small areas. Nevertheless, the communities in them form three types, mainly related to the size of the watercourse and the characteristics of the substrate.

Eupelal. Community of silty–sandy soil of small and medium rivers with slow water flow. It was found in the Anyuy and Bokbasu rivers. The complex of dominants are represented by oligochaetes *Tubifex tubifex* (Müller, 1774) (24.6%) and *Stylodrilus* sp. (18.5%), chironomids *Polypedilum* spp. (12.8%), *Paratendipes* sp. (9.9%), *Microtendipes* gr. *pedellus* (6.2%), and flies of the genus *Dicranota* (9.9%). The average biomass of macrozoobenthos is low (2.0 g/m^2); the average abundance is 750 ind./m^2.

Epipelal. The community is also rarely found on silty–detrital soil of small rivers (Mukhe, Bludnyi).

Euglesa (*Casertana*) spp. (34.4%); *Sialis longidens* Klingstedt, 1932 (31.9%); *Hydrobaenus* sp. (13.0); *Sergentia baueri* Wulker et al., 1999 (6.3%); and *Procladius* (*Holotanypus*) sp. (9.1%) are dominants. The average biomass is 5.9 g/m^2; the average abundance is 2900 ind./m^2.

Crenopelal. The community of detritus ground of cold stream; it was described only for a single watercourse. *Euglesa* (*Casertana*) sp. (44.1%), *Pseudodiamesa stackelbergi* (32.7%), and *Siphlonurus immanis* Kluge, 1985 (11.0%) dominate here. The average biomass is 16.0 g/m^2; the average abundance is 2680 ind./m^2.

Main Types of Communities in the Simmi River Basin

Ritral

Communities of solid substrates over the water flow. In the Simmi basin, in the absence of rocky grounds, these types of communities are rare and could be found only on organic substrates, flooded snags, and macrophytes.

Xyloritral. A community of woody objects, often more or less silted. The dominant complex includes xylophilic mayfly *Heptagenia flava* (38.6% of the total biomass), a number of other mayflies, and gastropods *Radix* spp. (20.4%) and *Juga nodosa* (10.2%). The average biomass is 2.7 g/m^2; the average abundance is 167 ind./m^2.

Phytoritral. Community of macrophytes in moderate and fast (0.2–0.5 m/s) water flow; larvae of the black flies *Simulium* s. str. sp. prevail (91.8% of the total biomass), reaching a huge density. The average biomass is 35.0 g/m^2; the average abundance is 16300 ind./m^2.

Ripal

Communities of mixed coastal substrates are found almost everywhere, occupying small bands near the water's edge. Due to seasonal floods, they often could be found at considerable depths.

Euripal. A community of flooded coastal vegetation and tree roots in moderate water flow. Small mobile forms dominate here: mayflies *Labiobaetis atrebatinus* (67.6%) and *Heptagenia flava* (11.9) and dragonfly *Calopteryx japonica* (14.0%). This community is relatively rare, mostly replaced by the malacoripal community. The average biomass is 2.9 g/m^2; the average abundance is 330 ind./m^2.

Malacoripal. A community dominated by large gill gastropod mollusks, *Amuropaludina praerosa* (50.9%), *Juga nodosa* (16.2), and *J. heukolemiana* (18.4), which together comprise 50–90% of the community abundance. Distributed on all substrates (stones, snags, macrophytes, sand, and silt) in a weak water flow and some siltation, usually near the coast. This community is associated with wide environmental preferences and high biomass of dominant gastropods. It replaces a number of other types of communities (in particular, pelal communities). Minor species (ripale mayflies of the genus *Baetis*, pelophilic chironomids, phytal *Radix*, etc.) vary depending on the specific biotope. The average biomass of macrozoobenthos is 18.4 g/m^2; the average abundance is 210 ind./m^2.

Phytal

Communities of dense thickets of macrophytes in the watercourses of the Simmi basin are ubiquitous, occupying large areas.

Euphytal. The most common community of the Simmi basin. It is confined to powerful thickets of macrophytes (water caltrop, coontail, floatingheart, etc.) without a noticeable water flow; sometimes it also passes to ripal substrates. The complex of dominants includes gastropods *Radix* spp. (33.7%), *Gyraulus centrifugops* (12.5%), *Boreoelona contortrix* (9.7%), dragonflies *Cercion* sp. (21.9%), and bug *Ranatra unicolor* (8.5%). Small floating forms are also characteristic (*Hesperocorixa sahlbergi*, *Sigara weymarni*, *Haliplus* spp., and *Anopheles hyrcanus*). The average biomass is 3.0 g/m^2; the average abundance is 117 ind./m^2.

Pleistophytal. A community of floating leaves (mainly of the water caltrop) in areas with no water flow. Leaf beetle *Galerucella nipponensis* (58.8%) and dragonfly *Cercion* sp. (34.6) dominate; other species are sporadic. Biomass is 1.4 g/m^2; abundance is 130 ind./m^2.

DISCUSSION

Faunistic Notes

The fauna of macrobenthos of the Russian Far East has been studied relatively well. Apparently, this explains the small number of new faunal finds in our collections. For the region, only *Cloeon macronyx* (Ephemeroptera: Baetidae) from the ripals of the Kharpi and Selgon rivers was not noted before. However, it was found in the basin of the Selenga River in Buryatia and northern Mongolia (Tiunova and Bazova, 2015). We also found an unspecified larva of *Serratella* sp. (Ephemeroptera: Ephemerellidae) morphologically close to the European *Serratella maculocaudata*. In the Simmi River, a rare crayfish, the *Cambaroides schrenckii*, was found; it had been previously known for the region (Birshtein and Vinogradov, 1934), but for noticeably areas farther south.

The position of the Amur region in the biogeographic picture of the world is debatable. Various authors consider it part of the Amur–Japanese subregion of the Sino-Indian region (Starobogatov, 1970; Banarescu, 1992), in the Amur subregion of the Sub-Holarctic region (Belyshev and Kharitonov, 1981), in the Amur transition region (Berg, 1949), in the East Asian subregion of the Holarctic (Voronov et al.,

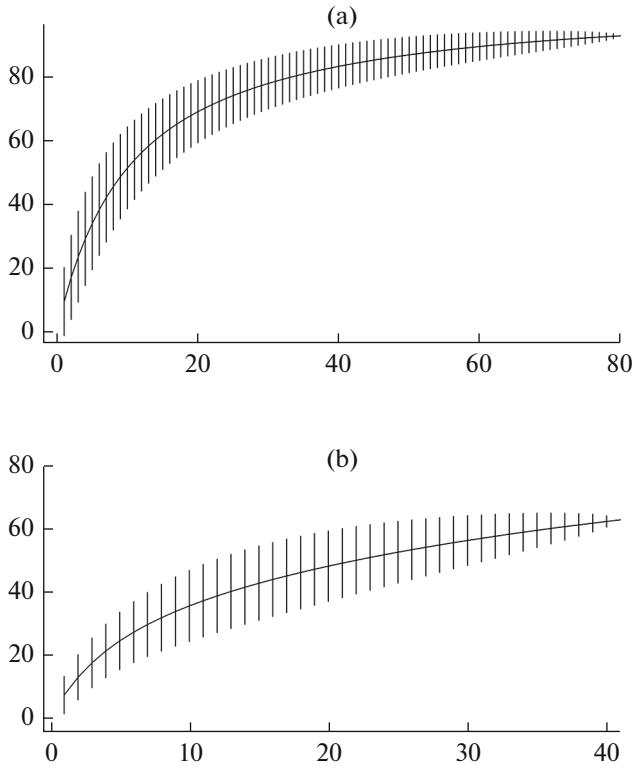

Fig. 2. Curves of species accumulation depending on the number of analyzed samples: (a) the Anyuy basin; (b) the Simmi basin. Error bars designate standard deviation. The ordinate axis shows species abundance; the abscissa axis shows the number of samples.

2002), or in the Amur province of the East Siberian subarea of the Palearctic (Chertoprud, 2010). Among 124 species identified by us, 41 are endemic for the Amur-Manchuria region (Supplementary materials ESM_1). These species are typical for both studied river basins, so there is no reason to draw a biogeographic boundary between these basins. The main differences between the fauna of the basins of the Simmi and Anyuy rivers could be explained by the ecological specificity of the compared areas. Most species of both basins are characteristic of Eastern Siberia or the Palaearctic as a whole. Oriental taxa have not been identified, and the region as a whole should be considered Palearctic, but included in a separate Amur (or Amur-Manchuria) biogeographic province (possibly even a subregion, but this issue needs to be studied separately and in more detail). According to our data, endemic species make up ~30% of the identified fauna with a small number of endemic genera, which corresponds more to the rank of the province than to the subregion (Chertoprud, 2010). It is interesting that, among the insect larvae, East Palaearctic species prevail (distributed to the west, practically to Altai), and among mollusks and crustaceans there are many Amur–Manchuria endemic species, even of the genus level (*Amuropaludina*, *Juga*, *Cambaroides*, etc.).

Comparison of Fauna Complexes of the Anyuy and Simmi River Basins

Species Richness

As shown above, the total number of taxa identified in the Anyuy basin is more than double that in the Simmi one (184 vs. 80). The reasons for this are the following: in the Anyuy basin the number of collected samples was higher (86 vs. 35), as were surveyed watercourses (28 vs. 7), and the diversity of detected biotopes and community types was greater (11 vs. 6). The species accumulation curve for the Anyuy does not reach a plateau, which indicates the significant proportion of species not identified by us (Fig. 2).

The distribution of species among large taxa is quite natural: rheophilic and relatively cold-water groups (caddisflies, mayflies, and stoneflies) are more diverse in the Anyuy and limnophilic and more warm-water gastropods, bugs, and beetles are more diverse in the Simmi (dipterans are widely represented in both pools).

Variety of Community Types

These regions differ radically in the character of prevailing watercourses and biotopes. It is quite natural that the communities identified in them are mainly of different types. In the Anyuy basin, characterized by a large number of fast piedmont rivers and streams, ritral communities are mostly typical and diverse (6 types and 31 samples), crenal communities are also often found (2 types and 28 samples), and other types are relatively rare. On the contrary, the Simmi basin, with weakly flowing warm rivers and overgrown with macrophytes, almost lacks ritral and crenal, although quite uniform phytal (22 samples) and ripal (16 samples) communities are noted in the mass. Interestingly, in both basins, pelal communities are rare or absent: in the Anyuy basin, corresponding biotopes are rare and, in the Simmi basin, silty–sandbanks are occupied by large gill gastropods (malacoripal community); deeper bottom parts are not accessible due to the flood.

Regional Features of the Rheophilic Communities

Significantly differing in the composition of fauna and macrozoobenthos communities, the community complexes of the Anyuy and Simmi rivers complement each other, making it possible to more correctly assess the regional macrobenthos of the Amur Region. The main features of local communities are listed below in comparison with the previously studied regions of Palearctic: the Central part of European Russia (Chertoprud, 2011, 2014), the Novosibirsk region of the Ob River (Chertoprud and Palatov, 2013), and the Caucasus and Transcaucasia (Palatov et al., 2016; Palatov and Chertoprud, 2018). For convenience of comparison, the complexes of dominant taxa in the communities of these regions are given in Table 1.

Ritral

This type of community is found often and is quite diverse, but mainly confined to the piedmonts streams and landscapes (as in other regions). It brings the bulk of the species of rheophilic caddisflies, mayflies, and stoneflies to the fauna. Compared to the most regions of Palearctic, in the Amur region, the role of sedentary scrubbing algophages (first and foremost, caddisflies *Glossosoma*, *Neophylax*, and *Apatania*), which partly replace (especially in the epiritral) swimming algophageous mayflies of the genus *Baetis*, is high. Like almost everywhere in Siberia, the role of black fly larvae is high (in this area, it is true only for representatives of the genus *Simulium*). Caddisflies of the *Hydropsyche* genus, typical for many regions, were not found here and are only partially replaced by the related genus *Arctopsyche*. In general, the structure of the main ritral communities (eu- and epiritral) looks rather specific; lenti-, phyto-, and peloritral communities are close to those from other regions of Palearctic.

Crenal

Like most regions of the southern part of Palearctic (Black Sea region, Transcaucasia, Central Asia, and the south of Western Siberia), most of the crenal biotopes are occupied by amphipods of the genus *Gammarus*, which dominate the community and create a specific type of Gammarocrenal. From region to region, only the gammarus species (in this case, *G. koreanus*) and the density of its populations change. The occurrence of gammarus in streams of the Anyuy basin reaches 100%, and the gammarocrenal replaces almost all other crenal communities (except for the xylocrenal, which is dominated by amphipod-tolerant large caddisflies limnophyllides). However, the biomass of the community is relatively small (an average of 12.4 g/m^2), which is several times less than the average biomass of Gammarocrenal of, for example, Southern Europe and the Caucasus (Palatov and Chertoprud, 2018).

Phytal

In the studied area, this type of commuity is distributed only in the Simmi River basin. This community consists of a large number of warm-water, generally limnophilic species. As in other regions, gastropod mollusks, mainly Lymnaeidae, dominate here. At the family level, the eu- and pleistophytal communities are very similar to the corresponding communities of the Moscow oblast and Novosibirsk region of the Ob river (Chertoprud, 2011; Chertoprud and Palatov, 2013), although they differ completely in species composition.

Pelal

In the studied region, this type of community is rare and poorly studied; therefore, it cannot be compared in detail with other regions. In general, the identified pelophilic communities are similar (consist of closely related forms) to the communities of Eastern Europe: they are also dominated by chironomids, pill clams, and tubificides (although of other species).

Ripal

This type occurs quite often in the studied area, forming two contrasting subtypes. The euripal community, more typical for the Anyuy basin, is close to euripals of most Palaearctic regions. The warm-water malacoripal community is widespread in the Simmi basin. Its dominants (gastropods of the genera *Amuropaludina* and *Juga*) are quite specific and provide the community a subtropical, partly oriental character. Nevertheless, close communities are known for other regions, where they occupy similar spectra of biotopes: for example, malacoripal of Moscow Region, where *Viviparus viviparus* (L., 1758) dominates (Chertoprud, 2011), of Transcaucasia (with dominance of *Melanopsis* spp. or *Viviparus costae* (Heldreich, 1863)) (data by D.M. Palatov), and even of the southern foothills of the Himalayas (*Melanoides* and *Tarebia*) (Chertoprud et al., 2018). Apparently, this type of community is relatively rare in Palaearctic, but is widespread in the tropics and subtropics.

CONCLUSIONS

The species richness and diversity of communities in the basin of the piedmont Anyuy River is significantly higher (184 taxa and 12 types of communities) than in the basin of the lowland Simmi River (80 taxa and 6 types of communities). Ritral and crenal communities dominate in the piedmont region; caddisflies, mayflies, stoneflies, dipterans, and amphipods are dominant taxa. In the lowland region, phytals and ripals are dominant communities and dominant taxa include gastropods, dipterans, beetles, bugs, and dragonflies. Despite the significant differences in the species composition of these two regions, their fauna generally refers to one (Amur) province. The differences found in the Anyuy and Simmi basins could be explained by their hydrological features and, as a consequence, by different habitat conditions. All these communities have analogues (communities of similar types with similar taxonomic structure) in other regions of Eurasia differing from them in species composition and some structural details associated with the regional pool of macrozoobenthos taxa.

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Table 1. Complex of dominant taxa of the main types of macrozoobenthos communities in different Palearctic regions

Community type	Region			
	Amur region (basins of the Anyuy and Simmi Rivers)	Central part of European part of Russia	Novosibirsk region of the Ob River	Caucasus and Transcaucasia
Euritral	*Epeorus* gr. *pellucidus* *Arctopsyche amurensis* *Simulium* sp.	*Ancylus fluviatilis* Müller, 1774 *Baetis rhodani* Pictet 1843 *Heptagenia sulphurea* Müller, 1776 *Ephemerella ignita* *Hydropsyche pellucidula* (Curtis, 1834) *Rhyacophila nubila* Zetterstedt, 1840 *Atherix ibis* *Antocha vitripennis* (Meigen, 1830)	*Baetis ursinus* Kazlauskas 1963 *Ephemerella lenoki* Tshernova, 1952 *Ephemerella lepnevae* Tshernova, 1949 *Hydropsyche pellucidula* *Rhyacophila angulata* Martynov, 1910 Orthocladiinae spp. *Atherix ibis* (Fabricius, 1798)	*Baetis* gr. *lutheri* *Baetis* gr. *rhodani* *Rhithrogena* spp. *Perla pallida* Guérin-Méneville, 1838 *Hydropsyche* spp. *Orthocladius* spp. *Odagmia* spp. *Wilhelmia* sp.
Epiritral	*Epeorus* gr. *pellucidus* *Glossosoma* sp. *Neophylax ussuriensis* *Simulium* sp.	*Ancylus fluviatilis* *Baetis rhodani* *Isoperla difformis* (Klapálek, 1909) *Rhyacophila fasciata* Hagen, 1859 *Hydropsyche pallucidula* *Agapetus fuscipes* Curtis, 1834	*Gammarus balcanicus* Schäferna, 1922 *Baetis* spp. *Ephemerella triacantha* Tshernova, 1949 *Rhithrogena cava* Kluge 1988 *Amphinemura* sp. *Rhyacophila sibirica* McLachlan, 1879 *Odagmia* sp.	*Ancylus* sp. *Baetis* spp. *Electrogena* spp. *Ecdyonurus* spp. *Iron* sp. *Perla pallida* *Hydropsyche* spp. *Diplectrona* sp. *Rhyacophila* spp.
Phytoritral	*Gammarus koreanus* *Baetis* gr. *vernus* *Baetis fuscatus* *Simulium* sp.	*Baetis vernus* *Baetis buceratus* Eaton, 1870 *Ephemerella ignita* (Poda, 1761) *Brachycentrus subnubilus* Curtis 1834 *Simulium* spp. *Odagmia* sp. *Wilhelmia lineata* (Meigen, 1804)	*Gammarus balcanicus* *Baetis vernus* *Odagmia* sp.	*Baetis* spp. *Acentrella* spp. *Protonemura* sp. *Hydropsyche* spp. *Odagmia* spp. *Wilhelmia* sp.
Gammarocrenal	*Gammarus koreanus*	–	*Gammarus balcanicus*	*Gammarus komareki* Schäferna, 1922

Table 1. (Contd.)

Community type	Region			
	Amur region (basins of the Anyuy and Simmi Rivers)	Central part of European part of Russia	Novosibirsk region of the Ob River	Caucasus and Transcaucasia
Eupelal	*Tubifex tubifex* *Stylodrilus* sp. *Polypedilum* spp. *Microtendipes* gr. *pedellus* *Paratendipes* sp. *Dicranota* sp.	*Limnodrilus* spp. *Pisidium amnicum* (Müller, 1774) *Sphaerium rivicola* (Lamarck, 1818) *Henslowiana* spp. *Chironomus* spp. *Stictochironomus* spp. *Polypedilum* spp. *Procladius ferrugineus* Kieffer, 1919	*Limnodrilus* spp. *Cryptochironomus* sp. *Fleuria lacustris* Kieffer, 1924 *Sphaerium westerlundi* Clessin in Westerlund, 1873 *Pseudeupera* sp.	*Limnodrilus* spp. *Polypedilum* spp. *Schizopelex* sp.
Euphytal	*Radix* sp. *Gyraulus centrifugops* *Boreoelona contortrix* *Cercion* sp.	*Lymnaea stagnalis* (L., 1758) *Radix* spp. *Bithynia tentaculata* (L., 1758) *Valvata piscinalis* (Müller, 1774) *Cloeon dipterum* (L., 1761)	*Lymnaea stagnalis* *Radix* sp. *Gyraulus* sp. *Bithynia tentaculata* *loeon dipterum* *Coenagrion* sp.	*Radix* spp. *Planorbis* sp. *Bathyomphalus contortus* (L., 1758) *Gammarus lacustris* Sars, 1863 *Cloeon* sp. *Baetis* gr. *vernus*
Euripal	*Gammarus koreanus* *Baetis* gr. *vernus* *Labiobaetis atrebatinus* *Heptagenia flava* *Anabolia servata* *Hydatophylax* sp. *Calopteryx japonica*	*Bithynia tentaculata* *Baetis vernus* *Baetis niger* (L., 1761) *Cloeon luteolum* (Mueller, 1776) *Labiobaetis atrebatinus* *Calopteryx splendens* Harris, 1780 *Plathycnemis pennipes* (Pallas, 1771)	*Baetis pseudothermicus* Kluge 1983 *Baetis vernus* *Halesus tesselatus* (Rambur, 1842) *Anabolia servata* *Limnephilus rhombicus* (L., 1758)	*Gammarus* spp. *Baetis* gr. *lutheri* *Nigrobaetis* spp. *Procloeon* spp. *Calopteryx* spp. *Platycnemis* spp. *Calamoceras illiesi* Malicky, Kumanski, 1974
Malacoripal	*Amuropaludina praerosa* *Juga heukolemiana* *Juga nodosa*	*Viviparus viviparus* (L., 1758) *Bithynia tentaculata* *Dikerogammarus haemobaphes* (Eichwald, 1841) *Corophium sowinskyi* (Martynov, 1924)	–	*Melanopsis* spp. *Turkogammarus aralensis* (Uljanin, 1875) *Chaetogammarus* sp. *Baetis* gr. *lutheri*

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The authors declare that they have no conflict of interest.

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REFERENCES

Banarescu, P., *Zoogeography of Fresh Waters*, Wiesbaden: Aula,1992, vol. 2.

Belyshev, B.F. and Kharitonov, A.Yu., *Geografiya strekoz (Odonata) Boreal'nogo faunisticheskogo tsarstva* (Geography of Dragonflies (Odonata) of the Boreal Faunal Kingdom), Novosibirsk: Nauka, 1981.

Berg, L.S., *Ryby presnykh vod SSSR i sopredel'nykh stran* (Freshwater Fishes of the USSR and Adjacent Countries), Moscow: Akad. Nauk SSSR, 1949, vol. 3.

Birshtein, Ya.A. and Vinogradov, L.G., Freshwater Decapoda of the USSR and their geographical distribution, *Zool. Zh.*, 1934, vol. 13, no. 1, p. 39.

Bogatov, V.V., *Ekologiya rechnykh soobshchestv rossiiskogo Dal'nego Vostoka* (Ecology of River Communities in the Russian Far East), Vladivostok: Dal'nauka, 1994.

Borutskii, E.V., Klyuchareva, O.A., and Nikol'skii, G.V., Benthic invertebrates (zoobenthos) of the Amur River and their role in the diet of Amur fishes, *Tr. Amur. Ikhtiol. Eksped.*, 1952, vol. 3, p. 5.

Chernova, O.A., Mayflies (Ephemeroptera) of the Amur River basin and adjacent waters and their role in the diet of Amur fishes, in *Trudy Amurskoi ikhtiologicheskoi ekspeditsii 1945–1949 gg.* (Transactions of the Amur Ichthyological Expedition of 1945–1949), Moscow: Mosk. O-va Ispyt. Prir., 1952, vol. 3, p. 229.

Chertoprud, M.V., Biogeographical zoning of freshwaters of Eurasia the macrobenthic fauna, *Zh. Obshch. Biol.*, 2010, vol. 71, no. 2, p. 144.

Chertoprud, M.V., Diversity and classification of rheophilous macrobenthic communities of the central zone of European Russia, *Zh. Obshch. Biol.*, 2011, vol. 72, no. 1, p. 51.

Chertoprud, M.V., Diversity of rheophilous macrobenthos communities, in *Materialy lektsii II-i Vserossiiskoi shkoly-konferentsii "Ekosistemy malykh rek: bioraznoobrazie, ekologiya, okhrana" (Borok, 18–22 noyabrya 2014 g.)* (Proc. Proc. II All-Russia School–Conf. "Ecosystems of Small Rivers: Biodiversity, Ecology, and Protection"), Yaroslavl: Filigran', 2014, vol. 1, p. 112.

Chertoprud, M.V. and Palatov, D.M., Macroscale ecotone effects for the stream macrobenthic fauna and communities of the eastern Novosibirsk region, *Moscow Univ., Biol. Sci. Bull.*, 2013, vol. 68, no. 4, p. 200.

Chertoprud, M., Palatov, D., and Chertoprud, E., Rheophilic macrozoobenthos communities of the Southern Himalayas, *Inland Water Biol.*, vol. 11, no. 4, p. 435. https://doi.org/10.1134/S1995082918040041

R Core Team, R: A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria, 2017. https://www.R-project.org.

Levanidova, I.M., *Amfibioticheskie nasekomye gornykh oblastei Dal'nego Vostoka SSSR. Faunistika, ekologiya* (Amphibiotic Insects of Mountainous Regions of the Soviet Far East: Faunistics and Ecology), Lenigrad: Nauka, 1982.

Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H., Szoecs, E., and Wagner, H., Vegan: Community Ecology Package. R package version 2.4-4, 2017. https://CRAN.R-project.org/package=vegan.

Opredelitel' presnovodnykh bespozvonochnykh Rossii i sopredel'nykh territorii (Identification Guide to Freshwater Invertebrates of Russia and Adjacent Countries), St. Petersburg: Zool. Inst. Ross. Akad. Nauk, 1994, vol. 1.

Opredelitel' presnovodnykh bespozvonochnykh Rossii i sopredel'nykh territorii (Identification Guide to Freshwater Invertebrates of Russia and Adjacent Countries), St. Petersburg: Zool. Inst. Ross. Akad. Nauk, 1997, vol. 3.

Opredelitel' presnovodnykh bespozvonochnykh Rossii i sopredel'nykh territorii (Identification Guide to Freshwater Invertebrates of Russia and Adjacent Countries), St. Petersburg: Zool. Inst. Ross. Akad. Nauk, 1999, vol. 4.

Opredelitel' presnovodnykh bespozvonochnykh Rossii i sopredel'nykh territorii (Identification Guide to Freshwater Invertebrates of Russia and Adjacent Countries), St. Petersburg: Nauka, 2001, vol. 5.

Opredelitel' presnovodnykh bespozvonochnykh Rossii i sopredel'nykh territorii (Identification Guide to Freshwater Invertebrates of Russia and Adjacent Countries), St. Petersburg: Nauka, 2004, vol. 6.

Palatov, D. and Chertopud, M., Macrozoobenthic communities of compact grounds in streams of eastern black sea region, *Russ. J. Ecol.*, 2018, vol. 49, no. 1, p. 80.

Palatov, D., Chertoprud, M., and Frolov, A., Soft-bottom macrobenthic fauna and assemblages in watercourses of eastern black sea coast mountainous regions, *Inland Water Biol.*, 2016, vol. 9, no. 2, p. 150.

Starobogatov, Ya.I., *Fauna mollyuskov i zoogeograficheskoe raionirovanie kontinental'nykh vodoemov zemnogo shara* (Malacofauna and Zoogeographical Zoning of the Continental Waters of the Globe), Leningrad: Nauka, 1970.

Teslenko, V.A., Review of the fauna of stoneflies (Plecoptera) and zoning of watercourses of the Russian Far East, *Evraz. Entomol. Zh.*, 2007, vol. 6, no. 2, p. 157.

Tiunova, T.M., Mayflies (Ephemeroptera) of the southern part of the Far East (fauna, biology, and functional ecology), *Doctoral (Biol.) Dissertation*, Vladivostok: Biol.-Pochv. Inst. Dal'nevost. Otd. Ross. Akad. Nauk, 2003.

Tiunova, T.M., Biodiversity and distribution of mayflies (Ephemeroptera) in the Russian Far East, *Aquat. Insects*, 2009, vol. 31, suppl. 1, p. 671.

Tiunova, T.M. and Bazova, N.V., On the fauna of mayflies (Insecta, Ephemeroptera) of the Lake Baikal basin, *Evraz. Entomol. Zh.*, 2015, vol. 14, no. 1, p. 79.

Voronov, A.G., Drozdov, N.N., Krivolutskii, D.A., and Myalo, E.G., *Biogeografiya s osnovami ekologii* (Biogeography with Fundamentals of Ecology), Moscow: Mosk. Gos. Univ., 2002.

Vshivkova, T.S. and Nikitina, I.A., The first data about the fauna of freshwater invertebrates of Bolon wetlands, in *IX Dal'nevostochnaya konferentsiya po zapovednomu delu: Materialy konf. (Vladivostok, 20–22 oktyabrya 2010 g.)* (Proc. IX Far-Eastern Conf. on Reserve Management (Vladivostok, October 20–22, 2010)), Vladivostok: Dal'nauka, 2010, p. 116.

Yavorskaya, N.M., Benthic invertebrates of the left bank tributaries of the Lower Amur (Khabarovsk Krai), *Region. Probl.*, 2016, vol. 19, no. 3, p. 62.

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