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Freshwater oligochaetes (Oligochaeta, Clitellata, Annelida) of North Pribaikalye (East Siberia, Russia)

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Abstract: The oligochaete fauna of freshwater reservoirs and rivers in North Pribaikalye was investigated for the first time. In total, 38 oligochaete species were collected. Of these, 16 species belong to the subfamily Naidinae, 6 to Pristininae, and 10 to the 3 subfamilies of Tubificidae. In addition, 5 species belonging to Enchytraeidae and 1 widespread species belonging to the family Lumbriculidae, *Lumbriculus variegatus*, were collected.

Key words: Oligochaeta, fauna, North Pribaikalye

Introduction

The area of Pribaikalye is situated in East Siberia (the Asian part of Russia) and includes Lake Baikal. The area is dissected by a well-developed river and a regularly divided river network with a density in the north exceeding 0.5 km km^{-2} (Bachurin, 1980). Small- and medium-sized rivers flow down from the slopes of the Verkhne-Angarsk Ridge. The current velocity of these fast-flowing streams ranges from 1 to 3 m s^{-1}. Some of these rivers flow directly into Lake Baikal and others flow north toward the basin of the Lena River.

The mountainous relief of the Pribaikalye area gave rise to a high number of small lakes (surface areas of less than 0.5 km^2) that cover about 0.8%-1.2% of the total surface area. Freshwater lakes with mineralization of up to 100-150 mg L^{-1} prevail in this area.

The rivers and lakes start freezing between 25 October and 30 October. The average duration of the ice cover is about 200 days. In late May, all water reservoirs and rivers of North Pribaikalye are usually free of ice cover.

The temperature of the littoral zone of the lakes can exceed 20 °C in summer and fluctuates between 10 and 12 °C in September. As for the rivers, the water is always very cold. The temperature is never higher than 10 °C and usually fluctuates between 2.0 and 6.5 °C.

The bottoms of the lakes consist mostly of sand and gravel and are covered with a thick detritus layer. The riverbeds are covered with numerous boulders in multiple layers.

The Pribaikalye area is rich in water resources with high water quality. Unfortunately, these waters

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are poorly studied. The Oligochaeta fauna of the northern part of Lake Baikal was described in detail by Snimschikova (1987). The major zoobenthic groups of the Upper Angara River basin, a territory adjacent to Lake Baikal, were quantitatively described by Aleksandrov et al. (1981), and Evstigneeva and Naumov (1983) listed the zoobenthos of the lakes of Northwest Pribaikalye in the Baikal-Amur railroad zone.

This paper contributes to the knowledge of the oligochaete fauna of the extreme north of Pribaikalye, namely the watershed that lies between the Lena River basin and the Lake Baikal basin.

Materials and methods

Sampling was carried out during the expedition of 2007, from 11-20 September. In total, 63 quantitative zoobenthos samples, including oligochaetes, were collected at the littoral zones of 6 lakes (Avkit, Asektomur, Aelita, Bair, Nomama, and a nameless lake near the former settlement Ozernyi, further indicated as Lake Ozernyi) and 5 rivers (Nomama, Kholodnaya, Ondoko, Olokit, and Tyja) (Figure 1). Samples were taken at a depth of 0-1.5 m. A hydrobiological grab was used to sample soft substrates such as silt, sand, gravel, and others in the lakes. Epiphyton of large boulders were washed off by hand. Rivers were sampled using a special benthic frame (25 × 25 cm). All samples were preserved in 4% formalin. Geographical coordinates, depth, and type of substrate were recorded (Table 1).

The samples were sorted in the laboratory using a binocular microscope. Oligochaetes were counted, and biomass was analyzed and identified based on morphological characters. Mature worms were dissected, colored with carmine, and deprived of water using a series of alcohol concentrations. The internal structures were cleared up using xylene and mounted with Canada balsam. Specimens were identified to the species level using the keys developed by Chekanovskaya (1962) and Semernoy (2004).

Ordination was designed for data analysis in community ecology. Used in an explorative way, it shows an ordination diagram that optimally displays how community composition varies (ter Braak and Šmilauer, 2002). In order to analyze oligochaete species composition in relation to water types (river vs. lake) and habitat type (clay, silt, detritus, bark residue, silted sand, and boulder), redundancy analysis (RDA) was used. RDA is a direct ordination

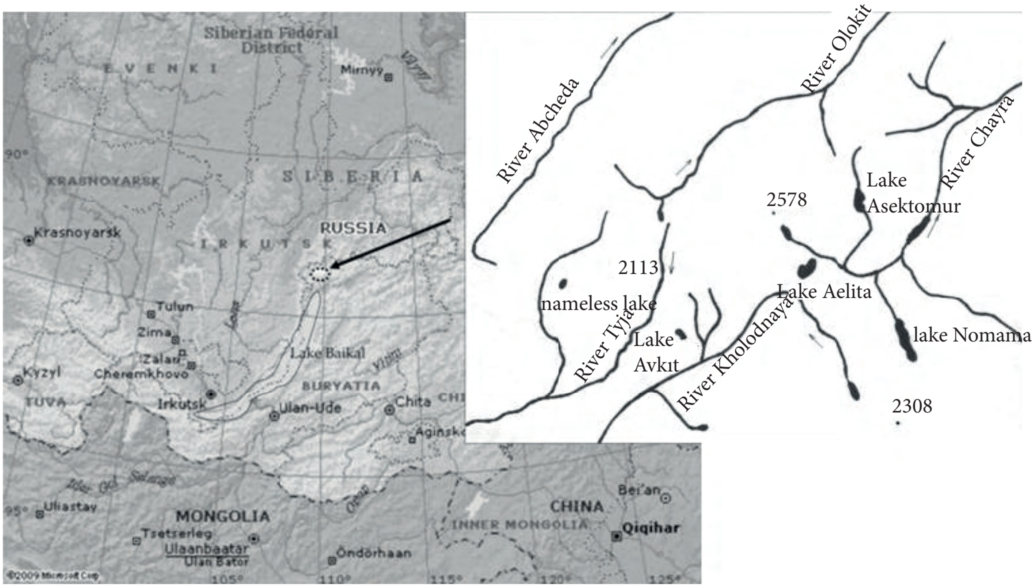

Figure 1. Location of the study region (left) and schematic map of the sampling area (right) with the sampled water bodies indicated.

Table 1. List of sampling sites with coordinates, sampling depth, and substrate type.

Site	Coordinates	Depth (m)	Substrate type
Lake Avkit	56°12′740″N, 109°46′903″E	1.5	Silt, detritus, bark residue
	56°12′742″N, 109°46′901″E	1.4	Silt, detritus, bark residue
	56°12′739″N, 109°46′905″E	1.5	Silt, detritus, bark residue
Lake Asektomur	56°19′603″N, 110°07′309″E	0.8	Slightly silted sand, detritus
	56°19′599″N, 110°07′308″E	0.8	Slightly silted sand, detritus
	56°19′600″N, 110°07′306″E	0.8	Slightly silted sand, detritus
	56°19′603″N, 110°07′311″E	0.7	Boulders
	56°19′602″N, 110°07′312″E	0.8	Boulders
Lake Nomama	56°17′437″N, 110°15′245″E	0.8	Boulders
	56°17′435″N, 110°15′242″E	0.2	Boulders
	56°17′435″N, 110°15′241″E	0.1	Boulders
	56°17′440″N, 110°15′251″E	1.5	Bluish-grey silt, clay, detritus
	56°17′439″N, 110°15′248″E	1.5	Bluish-grey silt, clay, detritus
	56°17′438″N, 110°15′249″E	1.5	Bluish-grey silt, clay, detritus
	56°17′436″N, 110°15′240″E	Shoreline	Boulders
Lake Ozernyi	56°27′232″N, 110°01′095″E	0.8	Silted sand
	56°27′231″N, 110°01′092″E	0.8	Silted sand
	56°27′232″N, 110°01′097″E	0.8	Silted sand
	56°27′229”N, 110°01′090″E	0.2	Boulders
Lake Aelita	56°00′000”N, 109°56′297″E	1.0	Silt, detritus
	56°00′003”N, 109°56′295″E	1.0	Silt, detritus
	56°00′005”N, 109°56′299″E	1.0	Silt, detritus
	56°00′001”N, 109°56′298″E	1.0	Silt, detritus
River Tyja	56°17′060”N, 109°53′067″E	0.3	Boulders
	56°17′065”N, 109°53′064″E	0.3	Boulders
	56°17′063”N, 109°53′068″E	0.3	Boulders
	56°17′064”N, 109°53′066″E	0.3	Boulders
	56°13′904”N, 109°49′242″E	0.15	Boulders
	56°13′903”N, 109°49′245″E	0.15	Boulders
	56°13′901”N, 109°49′239″E	0.15	Boulders
	56°13′901”N, 109°49′241″E	0.15	Boulders
River Olokit	56°27′229”N, 110°01′088″E	0.1	Boulders
	56°27′229”N, 110°01′088″E	0.1	Boulders
	56°27′229”N, 110°01′088″E	0.1	Boulders
	56°27′229”N, 110°01′088″E	0.1	Boulders

technique and part of the program CANOCO for Windows, version 4.2 (ter Braak and Šmilauer, 2002). RDA is fully described by Verdonschot and ter Braak (1994). RDA assumes a linear model for the relationship between the response of each taxon and the ordination axes, and it is used if the gradient length in the data is short (<4 units of standard deviation (SD)). In our case, the gradient length was smaller than 3 SD, which implies that the data were quite homogeneous. RDA is the constraint form of principal component analysis (PCA) of taxon data, in which the components (axes) are constrained by linear combinations of environmental variables.

The ordination results are presented as correlation biplots of both sites and taxa in combination with environmental variables. The eigenvalue of an ordination axis in RDA is the proportion of the total variance explained by that axis and indicates its relative importance. Forward selection was used to compare the order of importance of the environmental variables in the explanation of the taxa distribution. The marginal effects of the environmental variables were used as parameters. In the marginal test, the relation between the response and a variable on its own is tested.

Results and discussion

Rivers

The zoobenthos of the rivers studied were poor (Table 2, Figure 2). These mountain rivers are paved with rough boulders that offer a less suitable habitat for oligochaetes. As expected, the dominant groups at these sites were larvae of amphibiotic insects belonging to Diptera (especially Chironomidae), Ephemeroptera, Trichoptera, and Plecoptera. Oligochaete worms accounted for less than 1% of the total number and biomass of river zoobenthos in the area. They were found in samples from only 2 rivers: Olokit (Lena River basin) and Tyja (Lake Baikal basin). The population density and biomass of oligochaetes in the upstream parts of the Olokit River, where the current velocity is rather high and the riverbed is covered with small and large boulders, were 24 ind m^{-2} and 0.02 g m^{-2}, respectively. The enchytraeid worm *Henlea ventriculosa* (4 ind m^{-2}) and 2 species of tubificids, namely *Limnodrilus hoffmeisteri* (8 ind m^{-2}) and *Psammoryctides* sp. (12 ind m^{-2}), were recorded. In the upstream parts of the Tyja, only 1 oligochaete species, *Enchytraeus buchholzi*, was detected, with a population density and biomass of 48 ind m^{-2} and 0.0016 g m^{-2}, respectively.

Lakes

The lakes in the study area were formed in tectonic depressions of the Baikal system and as such can be very ancient. The lakes have either a tectonic (e.g. Avkit, Nomama) or a glacial (e.g. Asektomur) origin. The lakes studied belong to both the Lena (Nomama, Asektomur, and Aelita) and Baikal (Ozernyi and Avkit) water basins. All lakes are located at high altitudes, more than 2000 m above sea level, and are referred to as mountainous lakes (Figure 1). Lake bottoms consist mainly of sand and gravel and are covered with a relatively thick silt layer.

The differences in the numbers of specimens and biomass of the zoobenthos were substantial (Table 2, Figure 3). Therefore, the lakes were divided into 3 groups: 1) Lake Ozernyi and Lake Aelita, with a high faunal density and a biomass ranging between 25,000 and 30,000 mg m^{-2}; 2) Lake Asektomur and Lake Nomama, with a moderate faunal density and a biomass ranging between 5000 and 6000 mg m^{-2}; and 3) Lake Avkit, with a low faunal density and a biomass around 2500 mg m^{-2}. The Oligochaeta diversity in the 5 studied lakes includes 34 species (Table 3) of the families of Naididae, Enchytraeidae, and Lumbriculidae.

Lake Ozernyi

Lake Ozernyi is situated close to the settlement of Ozernyi in the upper part of the Tyja River catchments, which are part of the Baikal water basin. The lake is oval and slightly extended from northeast to southwest. The bottom consists of sand and occasional boulders and is covered with silt. A total of 4 samples were taken, each from a different substrate (Table 1).

The benthic fauna of the lake was dominated by Chironomidae larvae (Table 2), both in number and biomass. Mollusks were more dominant in the littoral zone. The average number (27,127 ind m^{-2}) and biomass (25,302 mg m^{-2}) of zoobenthic organisms were both very high (Figure 3).

Table 2. Quantitative characteristics of main macrozoobenthic groups per sampled water body in North Pribaikalye; N: density, ind m^{-2}; B: biomass, mg m^{-2}.

Water body	Lakes					Rivers		
	Avkit	Asektomur	Aelita	Nomama	Ozernyi	Tyja	Olokit	Kholodnaya
	N B	N B	N B	N B	N B	N B	N B	N B
Annelida								
Oligochaeta	20 93	2800 2090	800 790	380 14	1000 14	16 1.6	24 20	
Hirudinea	7 200			187 3	7 1			
Mollusca								
Bivalvia	193 202	400 2050	1760 8290	300 1440	2207 7360			
Gastropoda		73 190	133 560	40 4130	20 530			
Arthropoda								
Amphipoda	133 2193		480 18320					
Chironimidae	110 68	4907 410	1867 1470	1007 400	20,833 16,930	181 45	960 232	1360 73
Limoniidae								11 17
Psychodidae								69 35
Tipulidae							11 1205	
Ephemeroptera						997 389	1259 832	635 213
Plecoptera				33 93		192 37	107 565	48 44
Trichoptera		47 170	53 780	20 8	7 240	16 16	133 2635	384 119
Collembola			107 200					

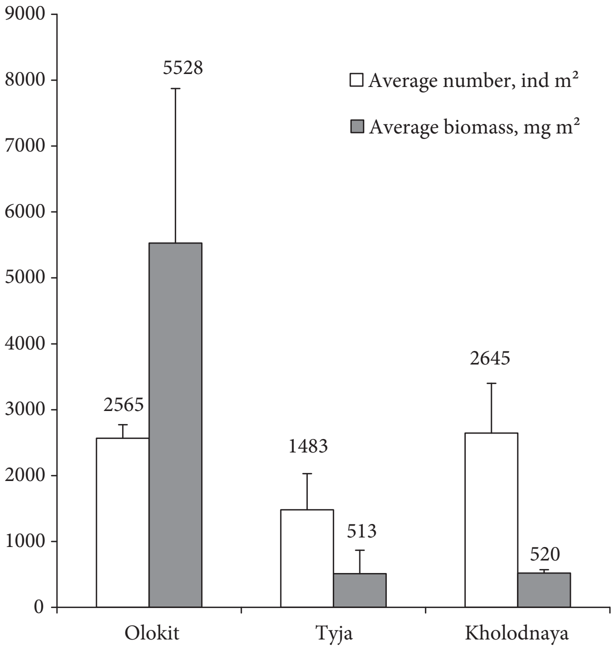

Figure 2. Abundance and biomass of all macroinvertebrates per river.

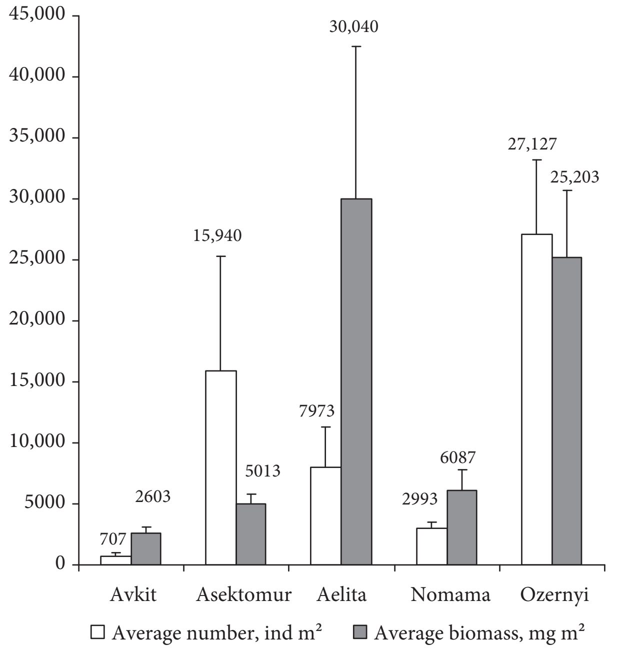

Figure 3. Abundance and biomass of all macroinvertebrates per lake.

The frequency of occurrence of Oligochaeta was 4% of the total of macroinvertebrates, with an average abundance of 1000 ind m^{-2} and an average biomass of 0.14 g m^{-2} (Figure 4). In total, 16 species belonging to 3 families, Enchytraeidae (1 species, *Marionina argentea*), Naididae (12 species, including 2 subfamilies of Naidinae (9 species) and Pristininae (3 species)), and Tubificidae (3 species belonging to 3 different subfamilies, Tubificinae, Phallodrilinae, and Rhyacodrilinae), were collected (Table 2). *Spirosperma nikolskyi* (147 ind m^{-2}) and *Pristina rosea* (133 ind m^{-2}) were the most common species, with an abundance proportion of 26% and 24%, respectively, of all oligochaetes of the lake (Table 3, Figure 5). Naidinae was the dominant group, representing 41% of all Oligochaeta collected in this lake. The most abundant species were *Piguetiella amurensis*, *Nais elinguis*, and *Nais simplex*, with averages of 40, 67, and 80 ind m^{-2}, respectively.

Lake Avkit

Lake Avkit is situated close the Kholodnaya River, which runs into Lake Baikal. The lake is bean-shaped and extends from the northwest to the southeast. The bottom substrate consists of silt and detritus, with a substantial amount of bark residue

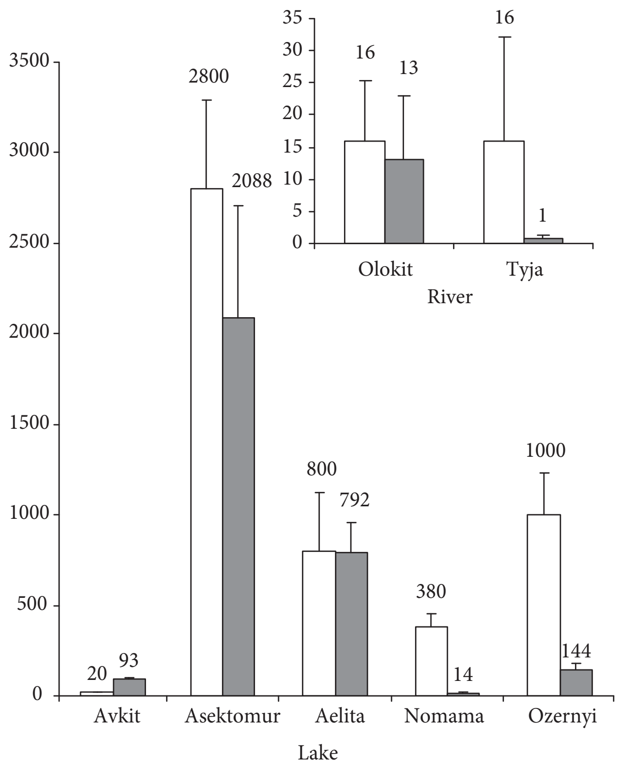

Figure 4. Number and biomass of oligochaetes per sampled water body in Northern Pribaikalye.

Table 3. Oligochaeta species composition and density (ind/m^{-2}) per sampled water body in North Pribaikalye.

Water body	**Rivers**			**Lakes**			
	Tyja	**Olokit**	**Nomama**	**Ozernyi**	**Avkit**	**Aelita**	**Asektomur**
ENCHYTRAEIDAE Vejdovský, 1879							
Cognettia aliger (Michaelsen, 1930)			93				
Enchytraeus buchholzi Vejdovský, 1878	48						
Fridericia callosa (Eisen, 1878)							100
Henlea ventriculosa (d'Udekem, 1854)		4					
Marionina argentea Michaelsen, 1889				13			20
NAIDIDAE: NAIDINAE							
Nais barbata Müller, 1773			13	7			
Nais communis Piguet, 1906			27	7		27	
Nais elinguis Müller, 1773				67		107	
Nais pardalis Piguet, 1906				7			
Nais pseudobtusa Piguet, 1906			7				27
Nais simplex Piguet, 1906			7	80			7
Nais variabilis Piguet, 1906			7			80	
Nais sp. 1			7				
Nais sp. 2				13			
Chaetogaster diastrophus (Gruithuisen, 1828)				7			
Ophidonais serpentina (Müller, 1773)			7				7
Piguetiella amurensis Sokolskaja, 1958				40			
Specaria josinae (Vejdovský, 1883)							7
Uncinais uncinata (Oesrsted, 1842)							233
Vejdovskyella comata Vejdovský, 1883				7		53	20
Slavina appendiculata (d'Udekem, 1855)			7			133	
NAIDIDAE: PRISININAE							
Pristina amphibiotica Lastočkin, 1927			13	7			
Pristina aequiseta Bourne, 1891			7				
Pristina bilobata				7			
Pristina longiseta Ehrenberg, 1828						53	
Pristina menoi (Aiyer, 1929)						27	
Pristina rosea (Piguet, 1906)			127	133		133	
TUBIFICIDAE: PHALLODRILINAE							
Spiridion insigne Knöllner, 1935				7			
TUBIFICIDAE: RHYACODRILINAE							
Rhyacodrilus coccineus (Vejdovský, 1875)				20			
Rhyacodrilus stephensoni Černosvitov, 1942						27	
Pararhyacodrilus sp.						27	
TUBIFICIDAE: TUBIFICINAE							
Baikalodrilus sp.						53	
Limnodrilus claparedianus Ratzel, 1869							7
Limnodrilus hoffmeisteri Claparède, 1862		8					
Psammoryctides sp.		12					
Spirosperma ferox (Eisen, 1879)							493
Spirosperma nikolskyi (Lastočkin, 1953)				147			173
LUMBRICULIDAE Vejdovsky, 1884							
Lumbriculus variegatus (Müller, 1773)			20		20	160	
Polychaeta: AELOSOMATIDAE Beddard, 1895							
Aelosoma hemprichi Ehrenberg, 1828			33				

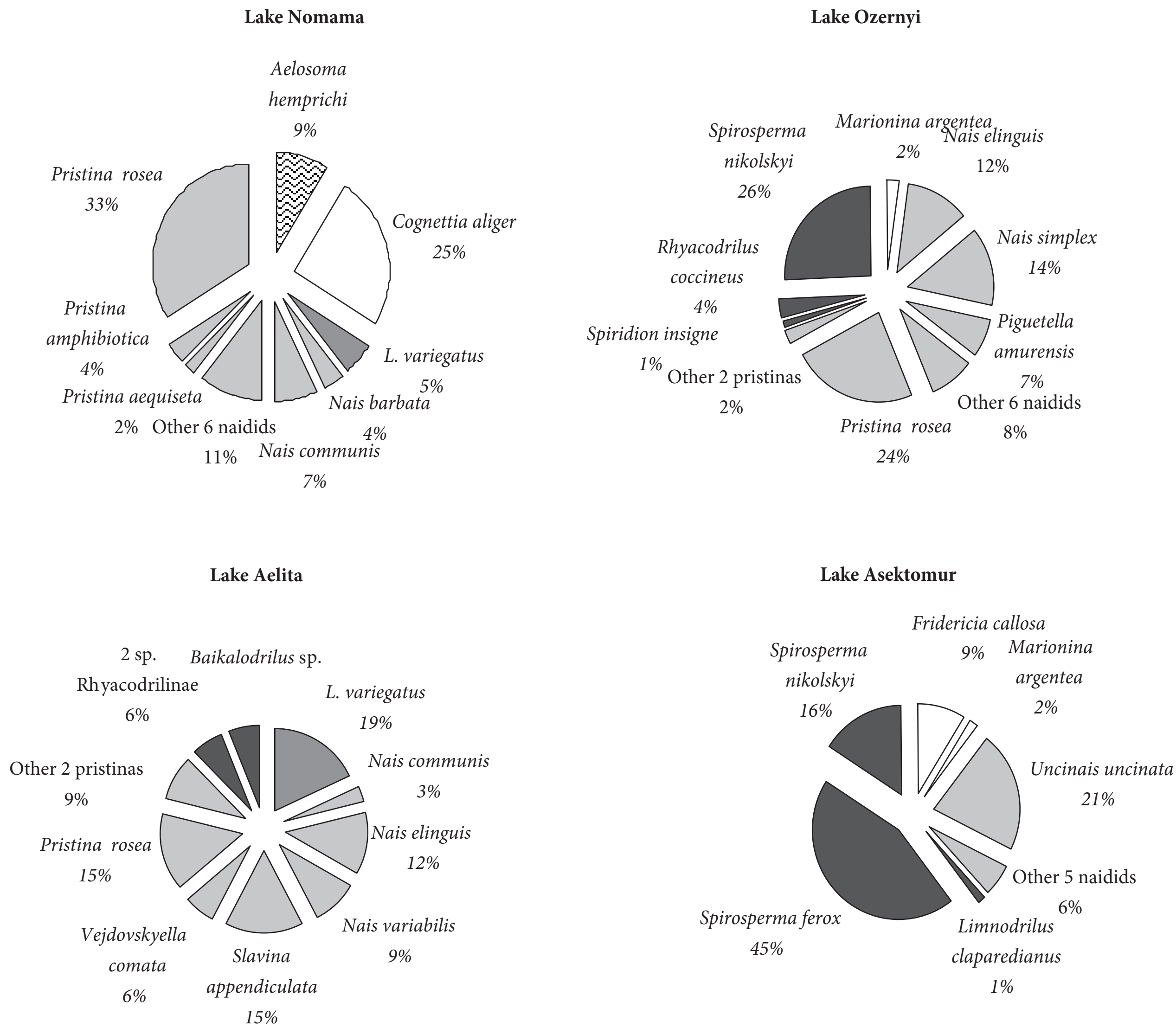

Figure 5. Proportion of number of oligochaete species in the lakes of North Pribaikalye. Family membership is indicated by color: black, Tubificidae; gray, Naididae; dark gray, Lumbriculidae; white, Enchytraeidae; striped, Aelosomatidae.

and other tree waste. The number of specimens collected in 3 samples from a depth of 1.5 m (Table 1) was poor (Table 2, Figure 3). A total of 7 groups of invertebrates, including Oligochaeta, Hirudinea, Bivalvia, Amphipoda, Branchiopoda, Maxillopoda, and larvae of Chironomidae, were identified.

The macroinvertebrate composition of the lake was less diverse in comparison to the other lakes studied, with a low average density of 707 ind m^{-2} (Figure 3) and a low average total biomass of 2.6 g m^{-2} (Figure 3). Mollusks (41%), amphipods (29%), and chironomids (24%) prevailed in numbers, whereas *Gammarus lacustris* (Crustacea, Amphipoda) represented the largest part of the biomass (on average, 2.19 g m^{-2}), or 81% of the total benthic biomass of this lake (Table 2). The contribution of the other macroinvertebrate groups to biomass was 19%; mollusks took 7%, leeches 7%, oligochaete worms 3%, and Chironomidae larvae 2% (Table 2). The only oligochaete species collected in Lake Avkit, *Lumbriculus variegates*, had an average abundance of 20 ind m^{-2} and an average weight of 0.09 g m^{-2} (Tables 2 and 3, Figure 4).

Lake Nomama

Lake Nomama is situated high in the mountains and is part of the Lena River basin. The lake is rather large, with an elongated shape. Lake Nomama is connected through a channel with the Chaya River. The lake bottom mainly consists of stones, and the interstitials were filled with bluish-grey silt, clay, and detritus. Samples were taken from different substrate types in the littoral zone at depths of 0.1-1.5 m (Table 1).

The numbers of specimens of macroinvertebrates were low in comparison to the other studied lakes (Figure 3), but considerably higher in comparison to other lakes in this region (Alexandrov et al., 1981). Different proportions of macroinvertebrate groups were collected: Chironomidae (40%), Nematoda (20%), Oligochaeta (16%), Mollusca (14%), and Hirudinea (8%) (Table 2). In terms of biomass, the mollusks took the largest part (5.57 g m^{-2}), representing 91% of the total macroinvertebrate biomass of Lake Nomama.

Despite the stony substrate and the high number of boulders, the Oligochaeta fauna in Lake Nomama was diverse, with an average abundance of 380 ind m^{-2} and a very low average biomass of 0.014 g m^{-2} (Figure 4). A total of 14 species belonging to 3 families were identified: Enchytraeidae (*Cognettia aliger* (Michaelsen, 1930)), Lumbriculidae (*Lumbriculus variegates*), and 2 subfamilies of Naididae (Naidinae, 8 species, and Pristininae, 3 species) (Table 3). The most frequently collected species were *Cognettia aliger* (93 ind m^{-2}), *Pristina rosea* (127 ind m^{-2}), *Nais communis* (27 ind m^{-2}), and the polychaete worm *Aelosoma hemprichi* (33 ind m^{-2}). Lake Nomama is the only water body in the region in which representatives of Pristininae dominated, representing 39% of all Oligochaeta of the lake (Figure 5). Only 1 species, *Pristina rosea*, took 33% of the total oligochaete abundance. Another abundant species was the enchytraeid *Cognettia aliger* (25%).

Lake Aelita

Lake Aelita is situated on the watershed boundary of the upper reaches of the Kholodnaya and Chaya rivers; however, it is part of the Lena River basin. This lake is almost round and extends slightly from the northeast to the southwest.

At a depth of 1.0-1.2 m, 4 samples were taken from silt and detritus substrates (Table 1).

The total macroinvertebrate biomass of Lake Aelita was the highest (more than 30 g m^{-2}) of all the studied lakes, whereas macroinvertebrate abundance (on average 7973 ind m^{-2}) was moderate (Figure 3). Mollusca, Amphipoda, and larvae of Chironomidae were the dominant groups (Table 2). Oligochaeta specimens were present in all samples, accounting for up to 15% of the total abundance and 3% of the total biomass (Table 2, Figure 4). From the families Lumbriculidae (1 species), Naididae (8 species), and Tubificidae (3 species), 12 species were identified from the littoral zone of the lake. The families Naididae and Tubificidae were represented by 4 subfamilies: Naidinae, Pristininae, Rhyacodrilinae, and Tubificinae (Table 3, Figure 5). Naidinae was the most diverse subfamily and occurred frequently in the samples, representing 45% of the total abundance of Oligochaeta. The subfamily was represented by 5 species: *Nais communis*, *N. elinguis*, *N. variabilis*, *Slavina appendiculata*, and *Vejdovskyella comata*. *Pristina rosea*, *P. longiseta*, and *P. menoi*, 3 species from the subfamily Pristininae, represented 17% of all Oligochaeta. Tubificid species were less abundant and represented 12% of all lake oligochaetes. The most frequent collected species were *Lumbriculus variegatus*, with 160 ind m^{-2}; *Pristina rosea* and *Slavina appendiculata*, both with 133 ind m^{-2}; *Nais elinguis*, with 107 ind m^{-2}; *Nais variabilis*, with 80 ind m^{-2}; and *Baikalodrilus* sp., with 53 ind m^{-2} (Table 3, Figure 5).

There were 5 species restricted to Lake Aelita: *Pristina longiseta*, *P. menoi*, *Rhyacodrilus stephensoni*, *Pararhyacodrilus* sp., and *Baikalodrilus* sp.

Lake Asektomur

Lake Asektomur is situated between the Olokit and Chaya rivers and belongs to the Lena River basin (Figure 1). The lake is part of a small mountain river, the Asektomurka, a tributary of the Chaya that runs into the lake from the north and flows out in the south. The main bottom type consists of sand with occasional boulders and is covered with silt.

Samples were taken from different substrate types at depths of 0.7-0.8 m (Table 1). The macroinvertebrate fauna of Lake Asektomur was diverse, with a high average density of 15,940 ind m^{-2} (Figure 3) and a moderate biomass of 4.86 g m^{-2} on average (Figure 3).

Aquatic macroinvertebrates such as Hydrozoa, Nematoda, Oligochaeta, Bivalvia, Gastropoda, Branchiopoda, Maxillopoda, Ostracoda, Arachnida, Diptera, and Trichoptera were present. In the littoral zone of the lake the most numerous findings were Chironomidae larvae, with 4907 ind m^{-2}; Nematoda, with 4087 ind m^{-2}; and Oligochaeta, with 2800 ind m^{-2}, or 39%, 33%, and 23% of the total abundance, respectively (Table 2). Nevertheless, a small group of mollusks (4% of the overall abundance) dominated in weight, representing 45% of the total biomass.

Lake Asektomur is the only lake in the area in which Oligochaeta was one of the most numerous groups. Its contribution to the zoobenthos was considerable and represented 23% of the total abundance and 43% of the total biomass (Figures 4 and 5). Species composition of oligochaetes was diverse, with 11 species collected in the near-shore littoral zone of the lake (Table 3). Of these, 2 species belonged to Enchytraeidae, 3 species to Tubificidae, and 6 species to Naididae. From Tubificinae, 3 species, *Limnodrilus claparedianus*, *Spirosperma nikolskyi*, and *S. ferox*, represented 62% of the total oligochaete abundance, whereas representatives of the subfamily Naidinae consisted of 6 species and represented 27% of the total oligochaete abundance (Figure 5). Not a single species of Pristininae was found in the samples from Lake Asektomur. *Specaria josinae*, *Uncinais uncinata*, and *Spirosperma ferox*, which are currently classified in family Naididae, and the enchytraeid *Fridericia callosa* were detected only in this lake.

The oligochaete fauna of Lake Asektomur was not only rather diverse in terms of species composition, but also had the highest population density (2800 ind m^{-2}) and biomass (2.09 g m^{-2}) in comparison to all other studied lakes (Table 2, Figure 4). The dominant species were *Spirosperma ferox*, with 493 ind m^{-2}; *Spirosperma nikolskyi*, with 173 ind m^{-2}; *Uncinais uncinata*, with 233 ind m^{-2}; and *Fridericia callosa*, with 100 ind m^{-2} (Table 3, Figure 5).

Community analysis

The RDA ordination diagram shows that the 2 rivers (Figure 6) are separated from all of the lakes, except Lake Avkit. This lake is close to both rivers. Lake Asektomur is situated to the left, which indicates the presence of boulders. The lakes Ozernyi, Aelita, and Nomama are plotted in the upper left quadrant (Figure

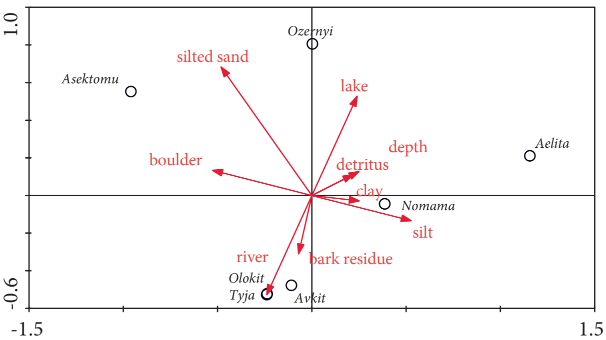

Figure 6. RDA ordination diagram of axis 1 and 2 of the sites (both lakes and rivers) and the environmental variables.

6), indicating silted sand (especially Lake Ozernyi), clay, silt, detritus, and depth. As for the taxa, the environmental variables plot shows the same grouping of environmental variables (Figure 7) in comparison to the sites. The 4 typical river species, *Enchytraeus buchholzi* Vejdovský, 1878, *Henlea ventriculosa* (d'Udekem, 1854), *Limnodrilus hoffmeisteri* Claparède, 1862, and *Psammoryctides* sp., are plotted below; these species were lacking in all lakes. The relation between the rivers and Lake Avkit is a reflection of the poor taxon composition of both rivers and the lake, which only sustains one species. This species, *Lumbriculus variegatus* (Müller, 1773), is plotted to the lower left in Figure 7, indicating its occurrence in Lake Aelita and Lake Nomama, as well. The other species groupings are dominated by 3 major clusters of species, each group occurring solely in 1 lake. Group 1 consists of species

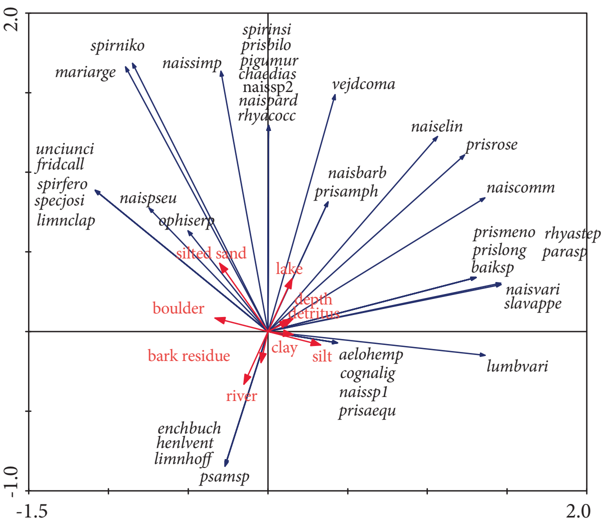

Figure 7. RDA ordination diagram of the axis 1 and 2 of the oligochaete taxa and the environmental variables.

occurring solely in Lake Asektomur: *Uncinais uncinata* (Oesrsted, 1842), *Fridericia callosa* (Eisen, 1878), *Specaria josinae* (Vejdovský, 1883), *Spirosperma ferox* (Eisen, 1879), and *Limnodrilus claparedianus* Ratzel, 1869. Group 2 is composed of species occurring solely in Lake Ozernyi: *Spiridion insigne* Knöllner, 1935, *Pristina bilobata*, *Piguetiella amurensis* Sokolskaja, 1958, *Chaetogaster diastrophus* (Gruithuisen, 1828), *Nais* sp. 2, *Nais pardalis* Piguet, 1906, and *Rhyacodrilus coccineus* (Vejdovský, 1875). Group 3 consists of species that occur solely in Lake Aelita: *Pristina longiseta* Ehrenberg, 1828, *Pristina menoi* (Aiyer, 1929), *Rhyacodrilus stephensoni* Černosvitov, 1942, *Pararhyacodrilus* sp., and *Baikalodrilus* sp. Each group inhabits the typical habitats: group 1 is related to boulders, group 2 to silted sand and boulders, and group 3 to silt and detritus. The remaining taxa are spread out over different lakes and can be considered intermediate. *Pristina rosea* (Piguet, 1906), *Nais communis* Piguet, 1906, *Nais simplex* Piguet, 1906, *Vejdovskyella comata* Vejdovský, 1883, and *Lumbriculus variegatus* (Müller, 1773) occur abundantly in the 3 lakes (Nomama, Aelita, and Ozernyi). The first 2 of these species occur in all 3 lakes.

The marginal effects of environmental variables (Table 4) show that silted sand adds the most to the explanation of the ordination diagram and, thus, to the distribution of oligochaetes. Depth and bark residue explain the least, and all other variables are more or less intermediate. Most probably, silted sand is the substrate that sustains the highest oligochaete diversity, as is the case in Lake Ozernyi.

Table 4. Marginal effects of environmental variables in the RDA ordination.

Variable	Lambda1
Silted sand	0.28
Boulder	0.17
Silt	0.17
Clay	0.16
River	0.16
Lake	0.16
Detritus	0.14
Depth	0.06
Bark residue	0.06

Conclusion

In total, 668 individual oligochaetes were found in 35 of the 63 samples. Furthermore, 38 oligochaete taxa were identified, of which 33 were on the species level and 5 on the genus level.

Naidinae was the most diverse group, with 14 species and 2 genera; Pristininae was represented by 6 species; Tubificinae by 4 species and 2 genera; Rhyacodrilinae by 2 species and 1 genus; Phallodrilinae by 1 species; Enchytraeidae by 5 species; and Lumbriculidae by only 1 species.

The most frequently collected taxa were *Nais communis*, *Nais simplex*, *Vejdovskyella comata*, *Pristina rosea*, and *Lumbriculus variegatus*; each was observed in 15 out of the 23 lake samples. Among these taxa, the most dominant were *Pristina rosea* and *Lumbriculus variegatus*.

The oligochaete species composition of the rivers and lakes differed considerably. A total of 4 species, *Enchytraeus buchholzi*, *Henlea ventriculosa*, *Limnodrilus hoffmeisteri*, and *Psammoryctides* sp., only inhabited rivers.

The relations between sites and species showed a clear separation between rivers and lakes. Among the lakes, species-poor Lake Avkit differs from the other species-rich lakes. *Nais simplex* and *Pristina rosea* are both common lake species. There are 3 other groups that occur in 2 out of 3 lakes and can also be typified as lake generalists: *Nais simplex* Piguet, 1906, *Nais barbata* Müller, 1773, and *P. amphibiotica* Lastočkin, 1927; *Lumbriculus variegatus* (Müller, 1773), *Nais variabilis* Piguet, 1906, and *Slavina appendiculata* d'Udekem, 1855; and *Vejdovskyella comata* Vejdovský, 1883 and *Nais elinguis* Müller,1773.

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