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ZOOPLANKTON, ZOOBENTHOS, AND ZOOPERIPHYTON

Species Composition and Structure of Macrozoobenthos in Lake Ulaagchny Khar (Mongolia)

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Abstract—The assessment of modern state of zoobenthos in Ulaagchny Khar Lake (Western Mongolia) is presented. A list of macroinvertebrate species recorded in the lake in 2011–2013 is given. This list includes 44 species of six classes. Insects account for the largest number of species (33), among which chironomid larvae and pupae prevail (28 species). It has been found that chironomid larvae play a leading role in the structure of bottom communities of Ulaagchny Khar Lake, both in terms of species richness (63.6% of total number of species) and quantitative development. In 2011–2013, the average biomass of macrozoobenthos in the lake increased severalfold when compared to 1997 and 1998. According to the Pantle–Buck saprobity index, the lake is a β-mesosaprobic waterbody.

Keywords: Ulaagchny Khar Lake, fauna, macrozoobenthos, chironomids, crustaceans, biomass

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INTRODUCTION

Specific ecological traits of bottom animals and their communities make them good indicators of environmental changes, including those of anthropogenic nature. The life cycle in most bottom macroinvertebrates is relatively long, reaching several months and years. This is why the bottom communities accumulate changes in the living conditions for quite a long period of time. The main structural characteristics of the communities of bottom macroinvertebrates are considered good, and sometimes the only hydrobiological indicator of pollution of bottom grounds and near-bottom layer of water [1, 2].

There are a huge number of lakes in Mongolia, the majority of which had been fishless in the past. Since 1978 ichthyologists attempted to increase fish productivity in Mongolian lakes by intentionally introducing valuable fish species originating from Russian waterbodies. The studies on the fishless Lake Ulaagchny Khar situated in the Goby region (Western Mongolia) were started in 1980 in relation to intentional introduction of Baikal omul and peled [4].

The goal of the present paper is to study taxonomic and quantitative structures of macrozoobenthos in the Lake Ulaagchny Khar and assess the lake's ecological state using bottom macroinvertebrates as indicators.

MATERIALS AND METHODS

Lake Ulaagchny Khar is situated in the Erdenekhairkhan somon of Zavkhan aimak in Western Mongolia at an elevation of 1980 m above sea level. The lake is closed and is fed mainly by atmospheric deposition and ground springs; the lake has elongated shape; two large islands are situated at the lake's eastern part. The lake's area is 84.5 km^2, length is 32 km, maximal width is 7 km, water volume is 1.7 km^3, water catchment area is 1450 km^2, maximal depth is 50 m, and average depth is 25 m [8]. The shores are low, stony; in some places the shores are built by rocks descending directly to the lake with deep waters just near these rocky shores. The bottom is sandy–silty, clay; sometimes sandy–stony grounds with vegetation occur. The water is fresh: total mineralization is 542.5 mg/L and the water is of hydrocarbonate class of calcium group, pH 9.13. In the end of November to the beginning of December, the lake is covered by 120- to 150-cm-thick ice; the ice breaks in June; i.e., the ice-cover period lasts about 7 months. The list of macrophytes includes 30 species. The zones of sandy–slity and silty grounds overgrown by *Chara foetida* (Braun A.), *Nitella mucronata* (Braun A.), and *Fontinalis antipyretica* Hedw., to the depth of to 20 m are most densely populated, with *Gammarus lacustris* exhibiting highest abundance [4].

The studies were performed in 2011–2013 during the iceless period (August) and in March when the lake was covered by ice. The macrozoobenthos was sampled using 0.025 m^2 Petersens's bottom sampler in three replicates at a sandy bottom (depths of less than 1 m), at the sandy biotopes with aquatic plants stands (3–5 m), at sandy–clay (9–14 m) and silty–clay grounds (20–33 m).

The live animals were picked from the samples under MBS-10 binocular and preserved in 8% formalin and 70% ethanol. In the laboratory the animals were identified when possible to the species and weighed (after preliminary drying on the filter paper) using torsion scales with division value of 0.05 mg. The cameral and statistical processing of the material followed standard routine [10]. In total, 61 quantitative samples of macrozoobenthos were collected and processed.

The lake food capacity in the lake was determined according to the classification given in [12]: waterbodies with biomass less than 3 g/m^2 are of "poor food capacity," those of 3–5 g/m^2 are of "medium food capacity," those of 5–8 g/m^2 are of "capacity above the medium level," those of 8–15 g/m^2 are of "high food capacity," and those of above 15 g/m^2 are of "very high food capacity." Upon calculating saprobity index values according to the Pantle–Buck method as modified by Sladecek [9], the mean indicator weights of animals were taken as given in the papers [14, 16, 19, 20].

To characterize the status of bottom macroinvertebrates, the following parameters were analyzed: number of species, abundance (N, ind./m^2), biomass (B, g/m^2), occurrence frequency (P, %), saprobity index value according to Pantle–Buck (S), and the Shannon–Weaver species diversity index (H, bit/ind.).

RESULTS

In total, 41 taxa of bottom macroinvertebrates were found in the macrozoobenthos of Lake Ulaagchny Khar with chironomid larvae and pupae as more divers (28 species, followed by leeches (5 species) and caddisflies (4 species) (Table 1)). A chironomid species *Chironomus nigrocaudatus* (fam. Chironomidae) is found in Mongolia for the first time. In different seasons and years, the number of species reached 8–14 in the lake littoral, 7–16 in the sublittoral, and 2 to 7 in the profundal (Table 2). The value of Shannon index by number increased in littoral from 1.04 bit/ind. in 2011 to 1.98 bit/ind. in 2013; in the lake's sublittoral and profundal the pattern of change was reverse: decrease from 2.09 bit/ind. to 1.28 bit/ind. and from 1.36 bit/ind. to 0.49 bit/ind., respectively (Table 2).

An amphipod *Gammarus lacustris* exhibited highest occurrence frequency in the macrozoobenthos at various depths of the lake. At the depths of less than 1 m, the frequency reached 100%, decreasing with depth to 50% in the lake's profundal. Mean occurrence frequency of this species was 84.4% (Table 1). The maximal abundance (1933 ind./m^2) and biomass (4.16 g/m^2) of this amphipod was recorded in August 2011 within the moss thickets at depth of 20 m. Among chironomids, the following species occurred most frequently: *Microtendipes pedellus* ($P = 80\%$), *Cryptochironomus obreptans*, *Stictochironomus crassiforceps*, and *Tanypus punctipennis* (66.6% each). The highest number of species (four) belonged to g. *Chironomus*. At depths of 2.5–4.5 m the larvae of *Microtendipes pedellus* were most numerous, with abundance reaching 3420–5500 ind./m^2 and biomass 13.10–21.08 g/m^2. The larvae of gg. *Tanytarsus* and *Stictochironomus* were leading among psammophyls. In March at a depth of 33 m on the biotopes of black and gray silts *Micropsectra radialis*, larvae dominated (about 90% of macrozoobenthos biomass and number). In all lake zones the mollusks *Lymnaea ovata* and *Euglesa casertana* were noted at the highest occurrence frequency of 60–70% recorded in the coastal overgrown zone of the lake.

The values of Pantle–Buck saprobity index in various lake areas varied inconsiderably, from 1.57 to 2.39 (Table 2), averaging 2.10, which corresponds to the β-mesosaprobic zone.

The highest number and biomass of macrozoobenthos were recorded in winter 2013 in the lake littoral at depths of 3–5 m, the lowest number was found in the lake profundal in 2013, and the least amount of biomass was found at depths of less than 1 m in August 2011 (Table 2). In all lake's areas, chironomid larvae and pupae dominated, reaching 44–91% of the total macrozoobenthos abundance and 45–98% of the total biomass. The only exception concerned biotopes with depths of less than 1 m, where the share of chironomids was 25% and amphipod *Gammarus lacustris* dominated at 47% of total biomass.

In terms of fish-food capacity, Lake Ulaagchny Khar in summer is classified as belonging to the high food-capacity waterbody type; in winter (at depths of 3–14 m) its food capacity is very high and in profundal it has high food capacity.

DISCUSSION

The studies on Lake Ulaagchny Khar macrozoobenthos carried out in 2011–213 revealed 44 species, only three of which (*Gammarus lacustris*, *Euglesa casertana* and *Microtendipes pedellus*) may be considered constantly occurring: they exhibit an occurrence frequency of more than 50% at various biotopes. Six species (*Stictochironomus crassiphorceps*, *Tanypus punctipennis*, *Procladius choreus*, *Cryptochironomus obreptans*, *Lymnaea ovata*, and *Glossiphonia complanata*) are common; the other 35 species occurred rarely and in small numbers. Highest species richness of chironomid larvae and pupae (63.6% of the total number of species) is quite natural for Mongolian high-latitude lakes. The studies carried out in 2003–2004 at eight high-mountain Mongolian lakes revealed that the share of chironomids in these lakes

Table 1. Species composition, indicator weights (*S*), and occurrence frequency (*P*, %) of bottom macroinvertebrates in Lake Ulaagchny Khar in summer and winter 2011–2013

Taxon	Summer	Winter	*S*	*P*
Phylum Mollusca				
Class Gastropoda				
Lymnaea ovata Draparnaud	+	+	2.4	28.1
Gyraulus gredleri borealis Loven	+	+	2.3	15.6
Class Bivalvia				
Euglesa casertana (Poli)	+	+	2.2	65.6
Phylum Annelides				
Class Oligochaeta				
Nais barbata O.F. Müller	+	+	2.8	6.3
Limnodrilus profundicola (Verril)	+	+	3.0	28.1
Class Hirudinea				
Erpobdella octoculata (L.)	+	+	2.9	12.5
E. sp.	+	–	2.7	6.3
Glossiphonia complanata (L.)	+	+	2.5	21.9
G. heteroclita (L.)	+	+	2.6	3.1
Helobdella stagnalis (L.)	+	+	2.8	3.1
Phylum Arthropoda				
Class Crustacea				
Gammarus lacustris Sars	+	+	2.0	84.4
Class Insecta				
Order Trichoptera				
Agrypnia crassicornis (McLachlan)	+	+	1.5	6.3
Limnephilus major (Martynov)	+	+	1.8	9.4
Philarctus rhomboidalis Martynov	+	+	2.0	9.4
Oecetis ochracea (Curtis)	+	+	1.9	3.1
Order Diptera				
Fam. Culicidae				
Sphaeromias pictus (Meigen)	+	+	2.1	9.4
Fam. Chironomidae				
Tanypus punctipennis (Meigen)	+	+	2.2	28.1
T. villipennis (Kieffer, 1918)	+	–	2.8	6.3
Procladius (*Holotanypus*) *choreus* (Meigen)	+	+	2.6	21.9
P. (H.) ferrugineus (Kieffer)	+	–	2.2	6.3
P. (*Psilotanupus*) *imicola* Kieffer	+	–	1.9	3.1
Corynoneura celeripes Winner	+	–	2.0	12.5
Cricotopus sylvestris (Fabricius)	+	–	2.5	12.5
Psectrocladius zelentzovi Makarchenko	+	–	2.0	12.5
Camptochironomus tentans Fabricius	+	–	2.2	3.1
Chironomus palidus Linevitsh et Erbaeva	+	–	3.0	6.3
Ch. plumosus L.	+	–	3.0	3.1
Ch. nirgocaudatus Erbaeva	–	+	3.1	12.5
Ch. sp. n.	+	–	3.5	3.1
Cryptochironomus psittacinus (Meigen)	+	–	2.5	6.3
C. obreptans (Walker)	+	+	2.0	21.9

Table 1. (Contd.)

Taxon	Summer	Winter	*S*	*P*
Endochironomus stackelbergi Goetghebuer	+	–	2.0	3.1
Glyptotendipes barbipes (Staeger)	+	–	2.2	9.4
G. paripes (Edwards)	+	–	2.8	3.1
Microtendipes pedellus (De Geer)	+	+	2.5	65.6
Polypedilum bicrenatum Kieffer	+	–	2.1	3.1
P. griseopunctatum (Malloch)	+	–	2.0	6.3
Stictochironomus crassiforceps (Kieffer)	+	–	2.1	40.6
S. pictulus (Meigen)	+	–	2.5	15.6
Cladotanytarsus mancus (Walker)	+	–	2.0	9.4
Micropsectra radialis Goetghebuer	–	+	1.5	6.3
Paratanytarsus tenius Meigen	+	–	1.6	6.3
Tanytarsus mendax Reiss et Fittkau	+	+	1.9	18.8
T. pallidicornis (Walker)	+	+	2.1	18.8
Total number of species	42	23		

(+) taxon is presented; (–) taxon is absent.

was 57–82% [16]. The larvae and pupae of chironomids also prevailed (71.1% of the total number of species) in the macrozoobenthos of high-mountain Lake Sevan (Armenia) [15]. In all zones of Lake Sevan, oligochaetes prevailed in macrozoobenthos by number. On the other hand, in Lake Ulaagchny Khar, the share of these invertebrates is negligible. It is likely that this is because the latter lake is closed and covered by ice for 7 months. Consequently, in winter the oxygen regime in the near-bottom layer of water is unfavorable for oligochaetes.

Mollusks occur mainly at the stony–sandy littoral with macrophyte stands. The species *Euglesa casertana* occurs in Lake Ulaagchny Khar most frequently (65.5%), exhibiting at some biotopes biomass of 54 g/m^2. The relatively high share by number (about 10%) of the mollusks of g. *Euglesa* indicates that the lake's ecosystem is not yet subject to heavy load of organic pollutants [18].

Two oligochaete species were found in the lake (*Limnodrilus profundicola* and *Nais barbata*). These species are confined to the coastal biotopes with macrophyte stands. At various lake biotopes, the abundance of oligochaetes ranged from 40 to 1200 ind./m^2; biomass was from 0.002 to 1.7 g/m^2. These values averaged about 1% of the total number and biomass of zoobenthos. In the Khangay lakes of Mongoli (lakes Ugyi, Ust and Khag) the share of oligochaetes by number was much higher: in Lake Khag it was about 30% [17]. Both oligochaetes species were noted in the mouths of the rivers inflowing Lake Hovsgol [6].

Among leeches, solitary specimens of *Erpobdella* sp., *Glossiphonia complanata, G. heteroclite* and *Helobdella stagnalis* were found on silty sand in the zone of plant thickets. The latter three species are already listed in the fauna of Mongolian waterbodies [3, 5, 6, 16, 17].

Among crustaceans, only aboriginal species, *Gammarus lacustris*, widespread in the lake (average occurrence frequency of 84.4%), was found at all depths. We revealed that in Lake Ulaagchny Khar peled is one of the main consumers of this amphipod: the share of *G. lacustris* in the stomach content of this fish averages about 80%, or ≤98% if other macroinvertebrates are considered.

The larvae of Trichoptera and Ceratopogonidae were solitary and play no any noticeable roles in the lake macrozoobenthos.

The species of fam. Chironomidae dominated macroinvertebrate community in terms of species diversity and quantity. More than half (66.6%) out of 27 species and larval forms found belong to subfam. Chironominae. The most common are the larvae of *Microtendipes pedellus* (mean occurrence frequency 65.6%), *Stictochironomus crassiforceps* (40.6%) and *Tanypus punctipennis* (28.1%). The larvae of *Microtendipes pedellus* made the greatest contribution to the quantitative development of benthic community: at the coastal sampling sites the abundance of this species reached 6280 ind./m^2 and biomass was 21.8 g/m^2; at the deepwater habitats *Chironomus nigrocaudatus* dominated (2082 ind./m^2 and 20.82 g/m^2, respectively).

The benthic communities in the eastern part of the lake differed from those in its western part in terms of composition, structure, dominant species, and quantitative parameters. Over vast areas of the western part of the lake, the profundal is subject to minimal anthropogenic impact and is characterized by low temperatures at the near-bottom water layer. At these areas the

Table 2. Mean values of main structural characteristics of macrozoobenthos at various grounds and depths of Lake Ulaagchny Khar in 2011–2013

Characteristic	Month and year of sampling								
	VIII 2011	VIII 2011	VIII 2012	III 2013	VIII 2011	VIII 2012	III 2013	VIII 2011	III 2013
Ground	Sand	Sand with water horsetail and macrophytes			Sandy–silty			Silty–clay	
Depth, m	<1	3–5	3–5	3–5	9–14	9–14	9–14	20–33	20–33
Number of: samples	3	10	12	6	12	6	6	3	3
species	7	13	14	8	15	16	7	7	2
H, bit/ind.:	1.04	1.46	1.97	1.98	2.09	2.02	1.28	1.36	0.49
S	2.01	2.18	2.19	2.39	2.26	2.31	2.0	2.06	1.57
Abundance, ind./m^2 of:									
chironomids	1146 ± 827	3624 ± 851	2946 ± 1033	6020 ± 883	4168 ± 1122	7173 ± 1222	1570 ± 664	2266 ± 277	1540 ± 100
	(42)	(77)	(81)	(51)	(91)	(85)	(62)	(44)	(88)
mollusks	13 ± 13	278 ± 66.6	493 ± 318	5290 ± 10	104 ± 71	326 ± 267	150 ± 58	886 ± 76	210 ± 10
	(1)	(6)	(13)	(44)	(2)	(4)	(6)	(17)	(12)
amphipods	1333 ± 285	712 ± 312	153 ± 44	80 ± 80	280 ± 151	886 ± 467	770 ± 404	1933 ± 604	–
	(49)	(15)	(4)	(1)	(6)	(10)	(31)	(38)	
other	179 ± 149	86 ± 32	40 ± 20	290 ± 167	32 ± 12	20 ± 12	30 ± 6	33.3 ± 13	–
	(8)	(2)	(1)	(2)	(1)	(1)	(1)	(1)	
total	2672 ± 1274	4700 ± 1261	3631 ± 1414	11680 ± 1140	4584 ± 1355	8405 ± 1967	2520 ± 1131	5118 ± 970	1750 ± 0.33
Biomass, g/m^2									
chironomids	0.43 ± 0.31	2.99 ± 0.34	4.8 ± 0.70	16.7 ± 2.70	3.53 ± 2.07	7.1 ± 2.80	9.3 ± 5.10	4.27 ± 0.26	5.88 ± 0.33
	(25)	(87)	(55)	(55)	(98)	(53)	(50)	(45)	(90)
mollusks	0.01 ± 0.001	0.11 ± 0.04	1.19 ± 0.55	10.89 ± 3.00	0.01 ± 0.01	1.53 ± 0.71	0.36 ± 0.20	1.16 ± 0.15	0.57 ± 0.27
	(1)	(3)	(13)	(36)	(0.2)	(12)	(2)	(12)	(10)
amphipods	0.81 ± 0.36	0.22 ± 0.11	2.42 ± 1.42	2.37 ± 1.00	0.03 ± 0.02	3.44 ± 0.66	8.8 ± 3.50	4.16 ± 0.09	–
	(47)	(7)	(28)	(7)	(1)	(26)	(47)	(42)	
other	0.48 ± 0.35	0.1 ± 0.06	0.24 ± 0.20	0.53 ± 0.04	0.01 ± 0.01	1.26 ± 0.63	0.04 ± 0.00	0.01 ± 0.01	–
	(27)	(3)	(4)	(1)	(0.2)	(9)	(1)	(0.1)	
total	1.73 ± 1.02	3.42 ± 0.55	8.65 ± 2.87	30.49 ± 6.70	3.57 ± 2.10	13.3 ± 4.80	18.5 ± 3.90	9.59 ± 0.50	6.45 ± 0.60

Mean values and their standard errors are given; shares of total values (%) are given in parentheses.

assemblage of benthic communities is poor, including inconsiderable amounts of *Euglesa casertana* and larvae of *Micropsectra radialis*, *Chironomus nigrocaudatus*, and *Gammarus lacustris*.

Micropsectra radialis larvae was the most interesting find. This species, referred as *Lauterbornia coracina* Kieffer, is one of the mass chironomids in Lake Hovsgol, where it was found at the sandy littoral (depths of 1 m to 5 m) [7]. At the aleurite silts in Lake Vyshtynetskoye (Kaliningrad oblast, Russia), *M. radialis* dwells at depths from 13 to 45 m; the larvae are relatively numerous (≤840 ind./m^2); occurrence frequency is 85%; and the species is monocyclic, emerging in September to October [13]. Hence, in Vyshtynetskoye and Ulaagchny Khar lakes, *M. radialis* is a deepwater species, while in Lake Hovsgol it is coastal, shallow-water. In Russia this species was found in Karelia and Siberia and characterized as a deepwater and cryophilic species [11]. In Lake Ulaagchny Khar the maximal abundance (1460–2020 ind./m^2) and biomass (4.7–5.3 g/m^2) of *M. radialis* were revealed at depths of 20–33 m.

A comparative analysis of macrozoobenthos at various areas and depths of Lake Ulaagchny Khar revealed the following patterns of benthos distribution: at all parts of the lake, macrozoobenthos was dominated in terms of average abundance (1146–7173 ind./m^2) and biomass (0.43–16.7 g/m^2) by chironomid larvae (Table 2), followed by gammarides and mollusks; the importance of oligochaetes and caddisfly larvae was lower.

According to A. Dulmaa [4], in LakeUlaagchny Khar the mean biomass of zoobenthos in July 1977 was 9.75 g/m^2; in August 1998, it was 5.53 g/m^2. In these years the biotopes of silted sands and silts in the overgrowths of *Chara foetida*, *Nitella mucronata*, and *Fontinalis antipyretica* were richest in benthos. At these biotopes the share of *Gammarus lacustris* was more than 50%. In 2011–2013—when compared to 1977 and 1998—the values of abundance and biomass were higher by factors of two to six; the share of chironomid larvae and pupae was 62%, while the share of *G. lacustris* dropped to 25%. These changes indicate an increase in the trophic status of the lake.

CONCLUSIONS

The studies on macrozoobenthos in various areas of Lake Ulaagchny Khar carried out in summer and winter 2011–2013 revealed 44 species, one of which, *Chironomus nigrocaudatus*, was found in Mongolia for the first time. The larvae and pupae of chironomids are most diverse (28 species). An amphipod *Gammarus lacustris* along with bivalve mollusk *Euglesa casertana* larvae and pupae of chironomids *Microtendipes pedellus*, *Stictochironomus crassiforceps*, and *Tanypus punctipennis* dominate benthos in the coastal areas of the lake (depths of 3–5 m); *Gammarus lacustris* and *Chironomus nigrocaudatus* dominate the sublittoral benthos (depths of 9–14 m). At the deepwater habitats (20–33 m), larvae of chironomid *Micropsectra radialis* accounted for more than 90% of the abundance and biomass of macrozoobenthos. At the habitats situated at depths of 3–5 and 9–14 m overgrown by vegetation, the mean abundance and biomass of macrozoobenthos differ inconsiderably; in the profundal of the lake, respective values are two-fold lower. In Lake Ulaagchny Khar, macrozoobenthos play the leading role in peled feeding, accounting for up to 98% of the stomach content of the fish.

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