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Spatial Distribution of Zoobenthos, In the Shallow Saline Lake Zun-Torey In The Low-Water Phase.

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ABSTRACT

There is few research of the zoobenthos spatial distribution in the shallow saline lakes with very turbid water. The spatial distribution of zoobenthos one of the largest lake of Transbaikal region Zun-Torey Lake were studied in July 2014. Zoobenthos was represented by fourteen amphibiotic insect species, seven of which were Chironomidae. The spatial distribution of zoobenthos abundance in Lake Zun-Torey is non-uniform. All species were found in the nearshore zone within a depth of 0.2 m. Only *Procladius* gr. *ferrugineus* and *Palpomyia* (*Gluhovia*) sp. species is inhabited the zone of depths more than 0.8 m. Cluster analysis detected the three groups of sampling sites differing in composition and abundance of zoobenthos. Low transparency is the main factor determining the limited spatial distribution of littoral benthos in the Zun-Torey Lake. The Zun-Torey Lake ecosystem can be a model for hydrobiological studies in the «Daurian steppe» ecoregion.

Keywords: saline lakes, zoobenthos, spatial distribution, littoral zone, «Daurian steppe» ecoregion.

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INTRODUCTION

Salt lakes exist under extreme and highly variable environmental conditions; therefore, it's not uncommon that their ecosystems are structurally simple and the changes taking place in them are well defined. These features of the salt lakes are attractive for researchers, as they are convenient to simulate processes and mechanisms of a lake ecosystem functioning in conjunction with variable environmental factors [1; 2; 3; 4] and allocate alternative stable states [5].

Lakes in the Transbaikal region are diverse in their origin, trophic level, chemical composition, mineralisation and economic use. Until now, freshwater lakes has been better studied [6; 7]. Lake Zun-Torey is an example of a shallow saline lake with high turbidity of water and low primary production. Hydrobiological studies on the Zun-Torey Lake have been carried out since 1982 [8]. At the same time, studies of the lake zoobenthos are few [9; 10; 11] and up to the present identifying regularities of perennial zoobenthos dynamics in the Zun-Torey Lake in relationship with specifics of the natural habitat dynamics in the region is still topical [10]. The goal of this investigation was to identify the spatial distribution of zoobenthos in the Zun-Torey Lake in the low-water period.

MATERIALS AND METHODS OF RESEARCH

Zun-Torey Lake (50.076063° N, 115.800986° E) is 60 km westward from the junction of the borders of China, Mongolia and Russia. Zun-Torey Lake – one of the largest lakes of the Transbaikal region – is in the steppe zone of a globally significant ecoregion «Daurian steppe» [12] and one of the key aquatic objects of the Dauria International Chinese-Mongolian-Russian Protected Area [13].

The height above sea level is 600 m, the local climate is strongly continental, average yearly air temperature varies from 0 to -2° C, annual rainfall is 290 mm [14]. The water level of the lake is associated with the specific weather for the area, alternating between dry weather and relatively moist periods with periodicity about 26 – 29 years [14]. In wet years the area of the lake is up to 300 km^2, length – 22 km, width – 18 km, depth – 6.5 meters (Tab. 1). In drought years the lake level significantly decreases. In July 2014 there was no surface-water input into the lake and the maximum depth was 1.48 m. Mineralisation of the lake varies over a wide range (Tab. 1).

Zoobenthos samples in Zun-Torey Lake were taken on 23-24 July 2014, according to the layout of the sampling sites uniformly spread over the entire lake [10]. One zoobenthos sample was taken by a modified Petersen grab with sampling area 0.025 m^2 at each station, due to the homogeneity of biotopes in the lake [9]. The samples taken were washed on a sieve with mesh size 0.300 mm and preserved with 4% formaldehyde. Identification was carried out to the lowest level possible using MBS-10, Mikmed-1 and Zeiss Acsio Scope microscopes at a magnification up to 400* and with using identification keys «Key to freshwater invertebrates of Russia and adjacent lands» [17]. The wet weigh of organisms is determined on the torsion scales with an accuracy of 1.0 mg after organisms are dried until the moisture disappears on the surface of the organisms.

Table 1: Dynamics of some abiotic parameters

Date	Depth, m	Transparency, m	Mineralization, g/l	Data source
1983 – 1986 years	2.5	0.15	5 - 25	[8]
10.08.1999	6.5	0.5	2.12	[15]
10.08.2003	5.6	0.5	-	Our results
25.07.2011	2.0	0.3	8.14	[16]
23.07.2014	1.48 (sampling sites «10», «11», «15»)	0.2±0.03	14.5	Our results

In terms of content and ratio of main ions, the hydrochemical type of lake waters in 2011 with mineralisation of 8.14 g/l was sodium bicarbonate [16]. Primary production over the vegetation season in 1986 was 61 kcal/m^2 [8].

Bottom sediments are characterised by a visual estimate, according to the accepted scale [18].

The data were statistically processed with XLStat. Sampling stations were clustered on the basis of a matrix of zoobenthos similarity of stations calculated with use of Chekanovsky-Serensen index by zoobenthos density.

RESULTS

The zoobenthos of Zun-Torey Lake was represented by fourteen amphibiotic insect species, seven of which were Chironomidae (Tab.2). In the sample taken at the depth of 0.14 m in the southern part of the lake, the diversity was up to seven species. The larvae of only chironomids *Procladius* gr. *ferrugineus* and *Palpomyia* (*Gluhovia*) sp. were found in more than 50% of samples (Tab. 2). The occurrence of other species was less than 30%.

The spatial distribution of zoobenthos abundance in Zun-Torey Lake is non-uniform. Zoobenthos was absent in the southern and eastern parts of the lake at sampling sites «17», «18», and «19». At sites «2.1» and «4» in the northern part, its density was 3840 – 3920 ind./m^2. In the central part at station «9», the biomass of zoobenthos was up to 6.16 g/m^2. In the structure of the lake's zoobenthos *P.* gr. *ferrugineus* amounted to 75% of its density and 70.4% of the biomass, *B.* (E.) *fulvus* amounted to 13.3% of the biomass. The contribution of other species into the density and the biomass of the lake's zoobenthos did not exceed 6.5%

Cluster analysis composition and abundance of zoobenthos in Zun-Torey Lake detected three main station groups.

Cluster 1 (C1) combines stations of the lake's shallow zone with the depth range of 0.20±0.08 m (Fig. 1). The similarity of these stations by the Chekanovsky-Serensen index was not more than 0.58. In this part of the lake, zoobenthos exhibits not-too-high abundance and maximum diversity (Tab. 2). The composition of zoobenthos included all 14 species (Tab. 1). The number of species in a sample varied from one (sites «21.1») to seven (sites «21»). *B. fulvus* beetles amounted to 52% and *Paracorixa sp.* water bugs were 18 % of the biomass of the total zoobenthos. The density of *B. fulvus* was up to 560 ind./m^2 at station «8» in the western part of the lake that of *Paracorixa* sp*.* was 1200 ind./m^2 in the eastern part of the lake at station «20». At station «13», in addition to *B. fulvus,* there were numerous larvae of *P. scalaenum* (760 ind./m^2), *Cr.* sp. (gen. №9 Lipina) (640 ind./m^2) and *C. riethi* (Kieffer, 1914) (480 ind./m^2).

Cluster 2 (C2) combines stations mostly in the central part of the lake at a depth zone of 1.27±0.23 m (Fig. 1). The similarity of stations using the Chekanovsky-Serensen index was more than 0.5. Here there were two zoobenthos species found (Tab. 2). In the second cluster, the structure of zoobenthos was differed dominated by *Pr. gr. ferrugineus* larvae amounting to 96% of the density and 97% of the biomass. Density and biomass of *Palpomyia* (*G.*) sp. were up to 240 ind./m^2 and 0.24 g/m^2 at the station «10

Cluster 3 (C3) combined stations of the depth zone 1.10±0.08 m in the southern and eastern parts of the lake (Fig. 1), where zoobenthos was absent.

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Table 2: Density (D, ind./m²), biomass (B, g/m²) and occurrence (O, %) of zoobenthos in Zun-Torey Lake (Mean±SD)

Taxa	C1 (n=8)		C2 (n=11)		C3 (n=3)		Mean (n=22)		O
	D	B	D	B	D	B	D	B	
Diptera									
Procladius gr. *Ferrugineus*	5±14	0.01±0.01	**2240±1253**	**2.80±1.75**	-	-	**1122±1434**	**1.40±1.87**	**70**
Crycotopus atritarsis Kieffer, 1915	5±14	0.01±0.01	-	-	-	-	2±9	0.00±0.01	4.5
C. maritimus Tshernovskij, 1949	10±28	0.01±0.03	-	-	-	-	4± 17	0.00±0.02	4.5
Orthocladius sp.	5±14	0.01±0.01	-	-	-	-	2±9	0.00±0.01	4.5
Cryptochironomus sp. (Chironominae genuinae №9 Lipina)	100±220	0.09±0.21	-	-	-	-	36±136	0.03±0.13	18.2
C. gr. *Defectus*	10±29	0.01±0.01	-	-	-	-	4±17	0.00±0.01	4.5
Polypedilum (*T.*) *scalaenum* (Schrank, 1803)	170±272	0.09±0.13	-	-	-	-	62±173	0.03±0.09	18.2
Dolichopodidae indet.	5±14	0.01±0.01	-	-	-	-	2±9	0.00±0.01	4.5
Culicoides riethi (Kieffer, 1914)	80±167	0.04±0.07	-	-	-	-	18± 56	0.05±0.16	13.6
Palpomyia (*Gluhovia*) sp. (*tuvae*?)	15±30	0.01±0.02	98.2±82.7	0.07±0.08	-	-	82±115	0.05±0.07	**50.0**
Coleoptera									
Berosus (E.) fulvus Kuwert, 1888	170±187	**0.73±0.98**	-	-	-	-	62±137	0.27±0.67	27.3
Gyrinus aerates Stephens, 1835	5±14	0.06±0.16	-	-	-	-	2±9	0.02±0.09	4.5
Heteroptera									
Hesperocorixa parallela (Fieber, 1860)	75±212	0.11±0.30	-	-	-	-	27±128	0.04±0.18	4.5
Paracorixa sp.	**190±413**	0.25±0.43	-	-	-	-	69±256	0.09±0.28	18
Total	845±631	1.40±1.22	**2338±1286**	**2.88±1.80**	-	-	1493±1327	1.99±1.77	
Number of species in sample	**4.3±1.9**		1.8±0.40		-		3±2.0		
Total number of species	**14**		2		-		14		

Semi-bold indicates the highest values.

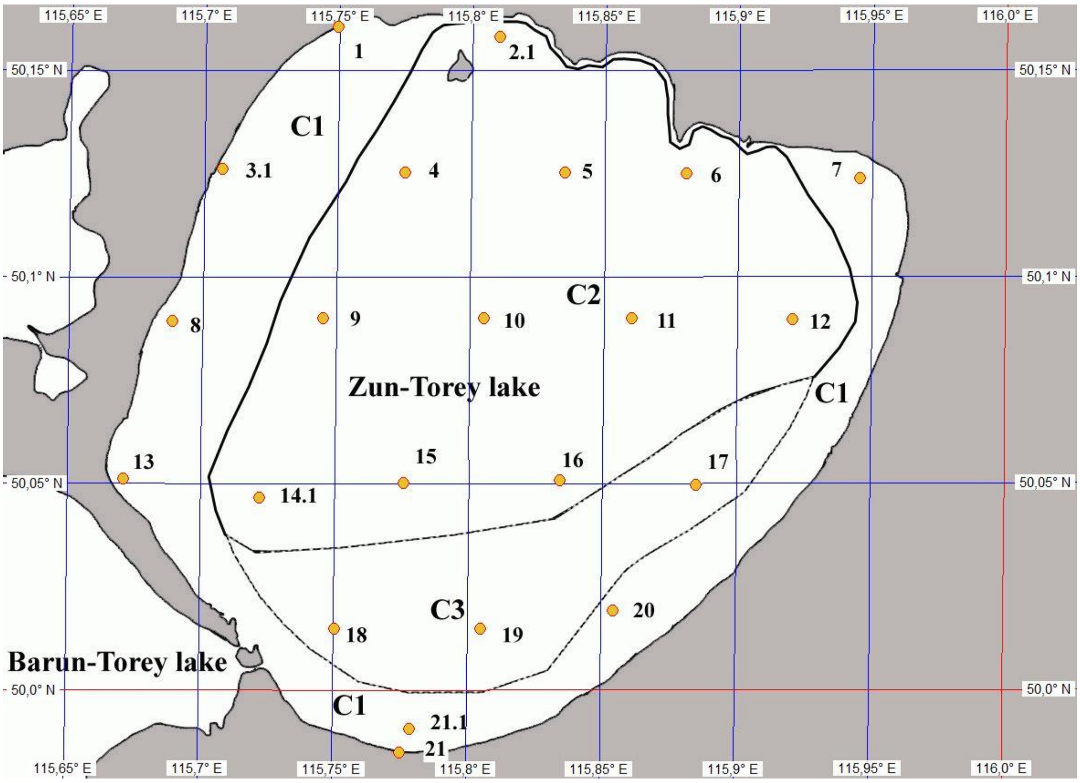

Fig 1: Spatial distribution of the three affinity stations groups identified by the cluster analysis.

Cluster 3 (C3) combined stations of the depth zone 1.10±0.08 m in the southern and eastern parts of the lake (Fig. 1), where zoobenthos was absent.

Environmental parameters in Zun-Torey Lake are presented in Table 3. The identified clusters differ in bottom sediments. As the depth in Zun-Torey Lake increases the diversity and sediments size decreases. The correlation analysis showed the number of taxa in zoobenthos samples to decrease with increasing depth (r_s=-0.44, p=0.04).

Table 3: Comparison of environmental variables among the three groups (Mean±SD (min-max))

Parameter	C1	C2	C3	All lake
Depth, m	**0.20±0.08**	1.27±0.23	1.10±0.08	0.86±0.54
Temperature, °C	23.6±4.21	21.8±1.18	22.4±1.36	22.5± 2.72 (17.6-29.1)
Sediment	sand, sand with gruss, silt sand, silt clay-sand, sand-clay with gruss	white clay	sand-clay	

DISCUSSION

Quantitative and qualitative parameters of zoobenthos in shallow lakes largely depend on the water level fluctuations. Detailed studies of several Torey Lakes carried out in 1983 and 1986 first gave insight into zoobenthos of Zun-Torey Lake – its taxonomic composition, quantitative development, seasonal dynamics, functional parameters, and relation with some environmental factors [8; 19]. These studies coincided with the initial phase of raising of the water level in the Zun-Torey Lake. In July 2014, zoobenthos was studied at the lowest water level. Investigation of Zun-Torey Lake benthos during a high-water period was carried out only on 6-8 August 2003, at two nearshore monitoring stations and at one station in the central part of the lake [11]. Analysis of available perennial data of the lake's zoobenthos shows their heterogeneity was determined by the scarcity of studies, the difference in the scope of collected material, and the different level of generalisation. This makes a comparison and identification of response of the Zun-Torey Lake benthos to climate changes in the «Daurian steppe» ecoregion difficult [10].

Results of all studies show the low taxonomic diversity and abundance of zoobenthos in Zun-Torey Lake (Tab. 4), which is typical for the shallow steppe lakes in the Transbaikal region and neighbouring Mongolia, and is determined by extreme environmental conditions [20; 21]. Zoobenthos of Zun-Torey lake in 2014 was differed lack of oligochaete, Artemia, Amphipoda, Gastropoda, Caddisflies and Chaoboridae as compared to the results of previous studies (Tab. 4). In 2014, the structure of Zun-Torey Lake benthos combines certain specifics of those of 1983 and 1986 – dominated by predatory Chironomidae with a high biomass of beetles and water bugs. Comparatively high density and biomass of Chironomidae larvae is a common feature of the zoobenthos structure in 2014, in 1986, and in 2003.

Data on the spatial distribution of zoobenthos and the ecology of dominant zoobenthos species in Zun-Torey Lake are scarce. The earlier surveys mentioned uniform distribution of zoobenthos in the lake and the lack of significant differences in the composition and abundance of zoobenthos of the nearshore and central of the lake parts that was explained by a similarity of bottom sediments and other conditions [8]. By contrast to this, in 2014, zoobenthos of the nearshore and central of the lake parts demonstrated the considerable difference in their composition and structure. The similarity of zoobenthos of the first and second clusters with the Chekanovsky-Serensen index was 0.01 only.

The main changes in the composition and structure of zoobenthos of the lake are coupled with depth. Considerable differences between the zoobenthos of the first and second clusters to be due to the location of sampling sites in different photic layers. The major portion of the stations of the first cluster is within the photic layer of Zun-Torey Lake and only two stations were beyond the transparency boundaries (Tab. 1), which reached 0.25 and 0.27 metres in 2014. All sampling stations of the second cluster were in the aphotic layer deeper than double transparency. Transparency is an important factor of the functional organisation of aquatic ecosystems and of zoobenthos, respectively. The statistical relationship of zoobenthos with water transparency in the lakes was noted in studies of the salt lakes of Ob-Irtysh interstream [22]. As in other lakes [23], the effect of transparency on the zoobenthos of Zun-Torey Lake maybe intermediated by the abundance and spatial distribution of plant communities. Primary producers are known to determine species diversity, abundance, trophic specialisation, and other parameters of zoobenthos [2; 24; 25; 26; 27].

In lake Zun Torey plant communities occupy negligble areas due low transparency [8; 13]. In high-water years submerged aquatic vegetation in Zun-Torey Lake is limited at depths from 0.5 to 1.0 m [12]. In low-water years, it disappears. This, in turn, determines the extremely limited spatial distribution of littoral zoobenthos in the Lake Zun-Torey in low-water years.

Table 4: Structure of Zun-Torey Lake zoobenthos in different years (Mean±SD)

Taxa	Density, ind./m^2				Biomass, g/m^2			
	1983*	1986*	2003**	2014	1983*	1986*	2003**	2014
Chironomidae (predatory)	107	**1400**	**1473±755**	**1162± 1408**	0.069	**1.187**	**0.620±0.539**	**1.440±1.850**
Chironomidae (pacific)	**297**	30		69± 185	0.045	0.006		0.040±0.010
Oligochaeta	**-**	-	207±341	-	-	-	0.063±0.101	-
Gastropoda	7	-	-	-	0.012	-	-	-
Trichoptera	13	-	-	-	0.042	-	-	**-**
Diptera indet.	13	10	-	2± 9	0.015	0.045	-	0.0±0.010
Ceratopogonidae	117	60	7±12	100±148	0.025	0.070	0.003±0.006	0.100±0.200
Chaoboridae	-	-	13±23	-	-	-	0.113±0.196	-
Coleoptera	83	-	-	64± 140	**0.355**	-	-	**0.290±0.720**
Heteroptera	33	70	-	96± 279	**0.215**	0.166	-	**0.130±0.320**
Artemia	-	30	-	-	-	**0.653**	-	-
Total	650	1530	1700±1086	1493± 1327	0.665	1.692	0.800±0.677	1.990±1.770

* average for July and August (according to [8])
** - without division of predatory and pacific Chironomidae [11].

CONCLUSION

Despite the simplicity of the lake Zun-Torey ecosystem regular monitoring studies the euphotic and afotic communities as the main model communities in the lake are necessary to solve hydrobiological tasks and identify patterns of long-term dynamics of the structural and functional organization of the zoobenthos and the ecosystem of lake Zun-Torey, as well as their changes under the influence of natural and anthropogenic factors.

Zun-Torey Lake is in the protective zone of the Dauria International Chinese-Mongolian-Russian Protected Area and enters the program of monitoring research «Effect of climate changes on the Daurian ecoregion ecosystems and environmental adaptations to them» [13]; therefore, it has a great future to be a model range for hydrobiological research in a global ecoregion «Daurian steppe».

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