

CHIRONOMID COMMUNITIES IN THE LITTORAL ZONE ON THE WESTERN COAST OF THE SOUTHERN BAIKAL BASIN (STRUCTURE, DISTRIBUTION, SEASONAL DYNAMICS)

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Abstract

The spatial distribution of chironomid communities in the littoral zone (0-20 m) of the western coast of the southern Baikal basin is investigated. The fauna is composed of 16 species and forms of chironomid larvae, comprising 10 communities. It has been found that the communities are characterized by rather poor species diversity; Shannon's index varies from 0.7 to 2.1 bit. Their distribution is affected by hydro-lithodynamic conditions, type of bottom sediments and macrophyte development. The peak of maximal biomass of chironomid larvae on the facies of non-rounded rock debris near Berezovy Cape is recorded in spring.

Introduction

The fauna of Baikalian Chironomidae is diverse; according to our and references data (Linevich 1981, Kozhova et al., 2000, etc.), it includes 166 species and forms of Chironomidae larvae from 5 subfamilies Tanypodinae (11), Prodiamesinae (2), Diamesinae (10), Orthoclaadiinae (59), Chironominae (84). The species diversity of Chironomidae larvae affects the structure of their communities. At present, Chironomidae distribution and diversity at different Baikalian biotops is known. In open Baikal, chironomid larvae are most abundant and rich in species on rocky ground at 0 to 5 m depth (Shapovalova 1969, Samburova 1982, Kravtsova 2005). In deeper water (more 20 m) they are few in species and only occasionally encountered (Linevich 1981, Kozhova and Kravtsova 1998). The structure of Chironomidae communities found out on the base of species domination principle by biomass is poorly studied. The number of publications on Baikal chironomid communities and their structural peculiarities is extremely limited (Kravtsova and Yerbayeva 1990, Kravtsova 1991, Kravtsova et al. 1999). Chironomidae play a considerable role in water bodies functioning (Lang 2000, Crozet et al.

2001, Scrimgeour et al. 2001, Verneaux and Verneaux, 2002, Brodersen and Anderson 2002, etc.), but papers concerning α -diversity of Chironomidae communities are either not numerous (Pastukhova 1983). Studies of structural organization of communities of Chironomidae plays an important role from the point of view of interspecies interactions, especially in population of water bodies bottom with a complex geological and geomorphological structure, in particular, on Lake Baikal. This work focuses on the structure of chironomid communities, their distribution and seasonal dynamics in the littoral zone of the western coast of the Southern Baikal basin.

Materials and Methods

Research material for this study consisted of 67 quantitative benthos samples with Chironomidae collected in Bolshye Koty Bay, 18 km northeast of the Angara River outflow of the lake, in September 1988. Division into bottom underwater complexes (BUCs): beach (B), shallow water terrace (SWT), underwater slope (US) and underwater canyon (UC) was based on physical-geographical and geomorphological characteristics of the bottom. Subdivision into facies was according to predominant type of bottom deposits. The samples were collected at 0-20 m depth along transects perpendicular to the shoreline. The benthos was sampled by divers using 0.09 m² frames, repeated three times. Boulders were placed in bags and lifted on board where animals and plants were picked or washed off into a basin.

Seasonal dynamics of the chironomid communities were studied from 155 quantitative benthos samples, collected near Berezovy Cape. From August 2000 until August 2001, samples were taken from a 0.1 m² count frame 5-10 times by divers at site N 1 (3 m depth, facies on non-rounded rock debris, total bottom area under study 60 m²). All samples were filtered through

sieves of mill-gauze № 35 and fixed with 4% formalin.

‘Communities’ were defined as populations of different species co-existing in space and time (Begon et al. 1996). The “dominance approach” to the definition was used (Vorobjov 1949). Sub-dominant species of each community were diagnosed using the density index \sqrt{PB} (Brotskaya and Zenkevich 1939), modified by Konstantinov (1986): where P is the frequency of a given species in samples belonging to the community (in %), and B is percentage of a species biomass in the total biomass of the community. Communities were designated by their dominant species, which usually had the highest density index. Species with density index values higher than ten percent were treated as sub-dominant, and species with less than 10% called secondary. When only a single sample was dominated by a set of species, this sample was designated a “coenotic assemblage”. This was typical when sampling took place at the edge of a community. Coenotic assemblages represented by one sample were not examined further, because it is not known if dominance in these cases was due to random fluctuation or not. The community structure characterization was based on: Shannon's species diversity index - $H = -\sum n_i / N \log_2 (n_i / N)$; Simpson dominance index - $c = \Sigma(n_i/N)^2$; equitability by Pielou - $e = H/\log S$, where n_i is the estimate of importance (biomass, mg m⁻²) of each of species in the community, N is the sum of n_i , S is species number (Odum 1971).

Results

Sixteen species and forms of chironomid larvae comprising 10 communities were recorded (Table 1, 2). Chironomid communities are rather poor in species number varying from 3 to 13, the fraction of dominating species makes from 40% to 87% of total biomass. Shannon's index varies from 0.7 to 2.1 bit. In Bol'shiye Koty Bay, the communities of Chironomidae studied occur on facies of gravel, pebble, brick, boulders, non-grained rock debris, silt, mixed silt and pure sand, and near Berezovy Cape – on the facies of non-rounded rock debris. On biotops relatively homogenous by bottom sediments composition, species number in the major part of communities is not great, and Shannon's index, respectively, is not high (see Table 2). In widely distributed Chironomidae communities (Bol'shiye Koty Bay), the concentration of domination of one species is high, and the equitability is low, whereas in spatially localized communities (Berezovy Cape), the concentration of domination of one species is low, and the equitability is high. As a rule, locally distributed communities are formed by species with similar requirements to the environment, and their contribution in total biomass is approximately equal.

Table 1. Characteristics of chironomid communities in Bolshye Koty Bay, Southern Baikal (September, 1988)

Communities	Number of taxa	B±m, mg m ⁻²	%	H, bit	C	e	n
<i>Orthocladius</i> gr. <i>thienemanni</i>	6	28±9	52	1.9	0.35	0.72	4
<i>Orthocladius</i> gr. <i>olivaceus</i>	4	10±5	68	1.4	0.50	0.70	5
<i>Orthocladius</i> <i>frigidus</i>	6	12±11	40	2.1	0.27	0.82	3
<i>Cricotopus</i> <i>bicinctus</i>	6	183±176	84	0.9	0.71	0.37	2
<i>Paratanytarsus</i> <i>baicalensis</i>	6	13±3	82	1.1	0.67	0.42	11
<i>Sergentia</i> <i>baicalensis</i>	13	93±22	87	0.9	0.76	0.24	28
<i>Sergentia</i> <i>nebulosa</i>	3	68±41	83	0.7	0.72	0.44	2
<i>Sergentia</i> sp.	5	130±56	85	0.8	0.74	0.33	5

Note. B±m - mean community biomass; m – mistake of averages; % - part of dominant species in total community biomass; parameters: H – Shannon's species diversity, C - dominance by Simpson, e - equitability by Pielou; n – number of samples.

Table 2. Characteristics of three chironomid communities at the experimental site near Berezovy Cape (Southern Baikal, 2000-2001)

Date	Communities													
	<i>Orthocladius nitidoscutellatus</i>							<i>Paratanytarsus baicalensis</i>						
	N	B±m, mg m ⁻²	%	H, bit	C	e	n	N	B±m, mg m ⁻²	%	H, bit	C	e	n
29.08.00	7	6.7±2.0	60	1.2	0.48	0.61	5	-	-	-	-	-	-	-
19.09.00	-	-	-	-	-	-	-	3	13.4±4.9	46	1.1	0.67	0.97	2
02.11.00	3	1.1±0.3	61	0.8	0.46	0.77	9	2	3.8±2.3	67	0.7	0.51	0.95	2
21.12.00	-	-	-	-	-	-	-	4	5.4±1.6	57	1.0	0.65	0.73	4
29.01.01	4	36.3±16.9	54	1.0	0.62	0.73	4	4	18.4±4.1	44	1.1	0.62	0.77	6
27.02.01	3	94.5±20.1	73	0.7	0.43	0.70	6	-	-	-	-	-	-	
27.03.01	4	153.7±31.8	68	0.8	0.47	0.60	9	-	-	-	-	-	-	
10.04.01	3	23.5±4.8	60	0.9	0.54	0.85	8	-	-	-	-	-	-	
31.05.01	4	609.1±148.2	69	0.8	0.44	0.56	10	-	-	-	-	-	-	
03.07.01	4	27.4±1.9	55	1.0	0.60	0.71	4	4	47.7±14	61	0.9	0.52	0.64	6
30.07.01	4	29.4±7.3	72	0.9	0.43	0.62	4	3	11.8±3.8	74	0.8	0.52	0.70	2
27.08.01	3	3.7±0.6	74	0.8	0.51	0.68	8	-	-	-	-	-	-	

Table 2 continued

Date	Communities						
	<i>Orthocladius</i> sp.						
	N	B±m, mg m ⁻²	%	H, bit	C	e	n
29.08.00	-	-	-	-	-	-	-
19.09.00	5	12.6±2.5	61	0.9	0.56	0.58	5
02.11.00	-	-	-	-	-	-	-
21.12.00	3	5.4±1.4	67	0.9	0.59	0.79	2
29.01.01	-	-	-	-	-	-	-
27.02.01	-	-	-	-	-	-	-
27.03.01	-	-	-	-	-	-	-
10.04.01	-	-	-	-	-	-	-
31.05.01	-	-	-	-	-	-	-
03.07.01	-	-	-	-	-	-	-
30.07.01	4	15.5±5.2	54	1.2	0.61	0.85	3
27.08.01	-	-	-	-	-	-	-

Note. N – number of taxa in community; B+m - mean community biomass; m – mistake of averages; % - part of dominant species in total community biomass; parameters: H – Shannon's species diversity, C - dominance by Simpson, e - equitability by Pielou; n – number of samples.

Seasonal dynamics of chironomid larvae biomass near Berezovy Cape is shown in Figure 1. Maximal Chironomidae larvae biomass is registered in spring, and minimal one – in autumn. In spring, large elder (age groups III- IV) larvae dominate in Lake Baikal. By autumn, imago of major part of species fly out, and Chironomidae populations become rarefied. At that time, small younger larvae (age groups I and II) of new generations widely occur.

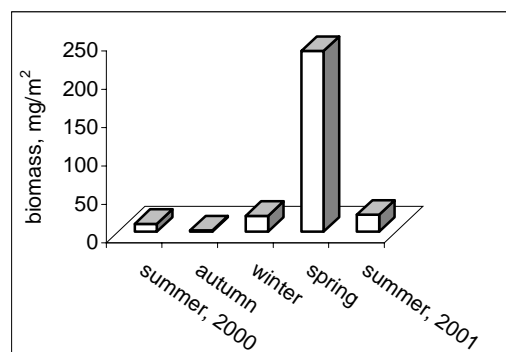


Figure 1. Seasonal dynamics of chironomid larvae biomass near Berezovy Cape (Southern Baikal, 2000-2001)

Discussion

The structure of the communities in some taxocenes, chironomids in particular, differs from that of zoobenthos as a whole.

The species diversity of chironomid communities, assessed according to Shannon's index is much lower, but it exhibits higher dominance concentration indices, according to Simpson, and equitability, according to Pielou, compared to macroinvertebrate communities (Kravtsova et al. 2004). Despite this, the spatial distribution of chironomid communities is governed by the same regularities as the zoobenthos.

Spatial fauna and flora distribution is determined by the character of bottom sediments formed under different sedimentation conditions. The inhabitants of the bottom at 0-1.5 m depth (BUC B) are rather scanty due to intense hydrodynamic activity and wave breaking, where the rates of near-bottom flows reach 5 m/s sometimes (Karabanov and Kulishenko 1990). We can see algal associations *Didymosphenia geminata*, *Tetrasporopsis* sp.+ *D. geminata* with chironomid communities *Orthocladius* gr. *thienemanni*, *O. gr. olivaceus*.

Below 1.5 m, according to hydro- and lithodynamical situations there appear to be two zones different in vegetation composition and community diversity. In the first zone, the bottom consists of coarse-grained material (gravel, pebble, brick, boulders, non-grained rock debris); near-bottom currents are strong and waves break there. There are associations of algae *D. geminata*, *Tetrasporopsis* sp. + *D. geminata*, *Draparnaldioides baicalensis*, *D. pumila*. All the chironomidae communities (Table 1) are found in this area. Nearer to the external edge of SWT (to the bend line in US at 4-5 m depth) algal associations characteristic of the second zone appear.

In the second zone (depth 8-20 m), bottom sediments are fine-grained (silt, mixed silt and pure sand). Lithodynamics are determined by decrease in strength of hydrodynamical processes and increase in gravitation ones, by sediment transit and accumulation (BUCs US, UC). The velocities of near-bottom currents are less than 0.6 sm/s (Slugina et al. 1995). The algal association *Cladophora compacta*, *C. floccosa*, *C. kursanovi*, *Myriophyllum spicatum*, *Fontinalis* sp. and *Stratonostoc verrucosum* is widespread. *Draparnaldioides* associations are absent. Communities of Chironomidae *Sergentia* sp., *S. baicalensis*, *S. nebulosa*, *Paratanytarsus baicalensis* inhabit this zone.

In general, the distribution of chironomid communities at the site studied is patchy. Belt distribution is observed in communities dominated by chironomids of the genus *Orthocladius* (BUCs B, SWT). Analogous

regularities are observed in the shallow zone on the eastern side of southern Lake Baikal. Associations occur of the algae *Ulothrix zonata*, *Tetraspora cylindrica* var. *bullosa*, *D. pilosa*, as well as chironomid communities indicated in Table 1. They are characterized by similar structure. Thus, morphological heterogeneity of bottom, and variability of environmental factors determine the "mosaic" distribution of macroinvertebrates communities in the shallows of Lake Baikal. This is also typical in shallow marine ecosystems (Kusakin et al. 1974).

Chironomid larval biomass varies with the biology of species forming the communities. It seems most likely that the flight time of the species is different.

We found that a fairly small area of bottom near Berezovy Cape is inhabited by three chironomid larval communities existing on relatively homogeneous bottom sediments: *Orthocladius nitidoscutellatus*, *Orthocladius* sp., *Paratanytarsus baicalensis*. An *O. nitidoscutellatus* community becomes abundant in spring but by autumn its biomass is reduced by one order, while the occurrence of the communities with *P. baicalensis* and *Orthocladius* sp. grows. All communities considered have characteristics similar to the chironomid communities inhabiting Bolshye Koty Bay, and also the waters near the east coast of the southern Baikal basin in the region of Utulik-Khara-Murin Rivers (Kravtsova 1991).

Conclusions

Spatial distribution of chironomid communities depends upon hydro-lithodynamic conditions of their habitat, type of bottom sediments and macrophyte development. The community structure of the chironomids is significantly simpler than in Baikal zoobenthic communities in general. Communities are characterized by higher indices of Simpson dominance and Pielou equitability. Seasonal dynamics of chironomid larvae biomass are defined by the life cycles of the species.

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