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ALGAE AND INVERTEBRATES IN FRESHWATER ICE (ZABAIKALSKY KRAI)

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The species composition of algae and invertebrates inhabiting the ice of Lake Arakhley are described in this paper. Diatoms and dinoflagellates, rotifers and crustaceans determine the taxonomic composition of the lake ice. The greatest diversity of the algae has been found in the ice cover above the deep part of the lake, whereas that of invertebrates was found above its littoral part. It has been found that the large number of species and the largest amount of biomass of organisms are observed during the period of maximum ice cover growth. Vertical zonation is characterized by distribution of aquatic organisms in the upper and middle ice horizons. The lake ice has been shown to have high hydrolytic enzyme activity, and the highest amount of biogenic elements has been noted to occur during formation and destruction of the ice cover.

Algae, invertebrates, hydrolytic enzyme activity, nutrients, ice, Lake Arakhley

INTRODUCTION

Ice is a structural component of the biosphere and a kind of an ecological niche for aquatic ecosystems. Its importance in the natural processes taking place in lakes is undoubted [*Salonen et al., 2009; Melnikov, 2014*]. The discovery of the ice biota resulted in the formation of views of a community for which ice plays the role of a substrate having specific properties [*Melnikov, 1984; Thomas and Dieckmann, 2002*]. Hydrobionts inhabit both ice interstitial [*Obolkina et al., 2000*] and subglacial formations [*Yuryev, 1992;Juhl et al., 2011*]. After ice melting, the animals return to active life and continue living on the lake bottom or in the mass of water [*Andriyashev and Gruzov, 1974; Mekhannikova et al., 2009*].

Currently, extensive information has been accumulated on the structure and functioning of the biota of marine and oceanic ice [*Horner, 1976; Vinogradov and Melnikov, 1980; Melnikov, 1984; Legendre et al., 1992; Okolodkov, 1992; Gradinger, 1999; Nozais et al., 2001; Garrison et al., 2005; Mogilnikova et al., 2009; Ilyash et al., 2012; Ewert and Deming, 2013; Kolosova et al., 2013*], whereas fresh water ice is one of the least studied aspects of winter hydrobiology [*Shkundina, 1988; Yuryev, 1992; Felip et al., 1995; Ivanov, 1995; Poglazova et al., 2001; Bordonskiy et al., 2003; Frenette et al., 2008; Bulat et al., 2009; Slastina et al., 2011; Kondratyeva and Fisher, 2012; Bazhenova and Korzhova, 2014*]. There is very limited information about the lakes of the Zabaikalsky krai, where the ice season lasts from early November to early May [*Semernoy and Gorlachev, 1969; Topolov, 1991*].

The studies of the biotic components of the ice cover were held in Lake Arakhley, which is a model lake in the Zabaikalsky krai's territory: hydrobiological monitoring has been conducted there for many years. The researchers' main task was to study the species composition and the spatial-temporal distribution of algae and invertebrates in the ice of Lake Arakhley.

MATERIALS AND METHODS

Lake Arakhley located in the territory of the Zabaikalsky krai in the moderate latitudes having a sharply continental climate, is part of the Ivano-Arakhley aquatic system, located at the watershed of two basins: Lake Baikal and Lena River basins. The lake is located in the south of the Vitim highland, between the Yablonovy and Osinovy ridges (Fig. 1).

The area of the aquatic surface of Lake Arakhley is 59 km^2, the volume of the water mass is 0.60 km^3. The length of the lake is 11 km, its average width is 5.3 km. The maximum depth of the lake reaches 17 m, and the average depth is 10.2 m.The chemical composition of the water includes magnesium and calcium hydrocarbonates, and water mineralization does not exceed 220 mg/L.

The first ice manifestations as shore ice usually appear in the lake in the second half of October–early November. The ice growth rate is non-uniform in time and space. In the early period of the freeze-up, the intensity of vertical ice growth often exceeds 2 cm/day. Later this intensity gets reduced, and by the end of February, the intensity of ice increment reduces to 1.0–1.1 cm/day. Growth of ice continues till late March–early April, though with lower intensity (0.3–0.4 cm/day). Maximum ice thickness of Lake Arakhley may sometimes reach more than 170 cm. In April, ice melts, and by the end of the month, its thickness decreases by 20–25 cm. In the second half of April–the first half of May, ice cover begins to melt [*Obyazov, 2013*].

The studies of ice of Lake Arakhley were conducted from December 2009 to May 2010, from December 2010 to April 2011, in December 2011, in March and April 2012, and in March, April, and December 2013. To obtain ice cores, 5 or 6 holes were drilled as a circle. The ice core formed in the center 20 cm in diameter was divided into samples up to 20 cm long, which were packed into plastic bags each and transported to the laboratory, where the ice remained sealed until its complete melting at room temperature. Sub-samples were taken from the melt water for further hydrobiological tests (algae and invertebrates), hydrochemical tests (the presence of nitrates, phosphates, organic matter, chemical oxygen consumption (COC) and permanganate oxidation of oxygen (POO). To identify the presence of the living matter, the enzyme activity (proteolytic activity PA and amylolytic activity AA) of ice was determined.

To investigate the species composition and to study the quantitative characteristics of the algae, the melt was fixated with the 40%-formaldehyde solution, melted during 10–15 days and then concentrated by the sedimentation method. The material was studied microscopically with the Nicon Eclipse E200 microscope having a DS Camera Control Unit DS-L2 (one thousand-fold magnification of the image). The algae were counted in the concentrate by Hansen's method using a counting plate [*Topachevsky and Masyuk, 1984*]. The amount of the biomass was determined by the volume of individual cells or algae colonies, with the specific weight assumed to be equal to unity [*Sadchikov, 2003*]. The total list of the algae was composed using a system adopted at the major algae base website AlgaeBase [*Guiry M.D. and Guiry G.M., 2013*].

To determine the species composition and to count the invertebrates, the melt water was poured through a hydrobiological sieve (the mesh diameter of the capron sieve was 0.064 mm) and was immediately examined under a microscope MBS-9. The samples were processed in accordance with the standard quantity-weight procedure [*Kiselev, 1969*]. The animals' species were identified in accordance with [*Kutikova, 1970; Tsalolikhin, 1995*].

Hydrochemical analysis was conducted using standard methods [*Semenov, 1977*], the enzyme study

Fig. 1. A schematic map of ice sampling locations.
1 – center (depth 13–14 m); 2 – sublittoral (7–9 m); 3 – littoral (2–3 m).

was based on the method proposed by *G.A. Korneeva et al.* [*1990*].

RESULTS

The characteristic of the ice cover. The ice of Lake Arakhley is solid and transparent; for its structure, it consists of large crystals without visible boundaries, oriented by geometric and optic axes normally to the freezing surface plane. It contains gas inclusions of various shapes, formed by chemical transformations in the lake sediments [*Topolov, 1991*].

The times of the beginning and end of the glacial events and of setting in and destruction of the ice cover of Lake Arakhley in the period under study are shown in Table 1. The total duration of the ice period

Table 1. **Timelines for formation and destruction of ice in Lake Arakhley (2009–2012)**

Period	Beginning of			End of	
	ice manifestations**	freeze-up***	destruction of ice cover****	freeze-up***	ice manifestation**
Mean date*	October 25	November 3	May 4	May 21	June 4
2009–2010	October 17	October 30	May 3	May 25	June 1
2010–2011	October 11	November 1	April 16	May 5	May 11
2011–2012	October 21	November 11	April 11	May 9	May 15

* Mean date for many years' period (1954–2012).
** Shore ice, edge ice, ice fields on the lake surface.
*** Period during which a non-moving solid ice cover on the lake.
**** Formation of cracks, ice shifts, formation of edge ice on the lake.

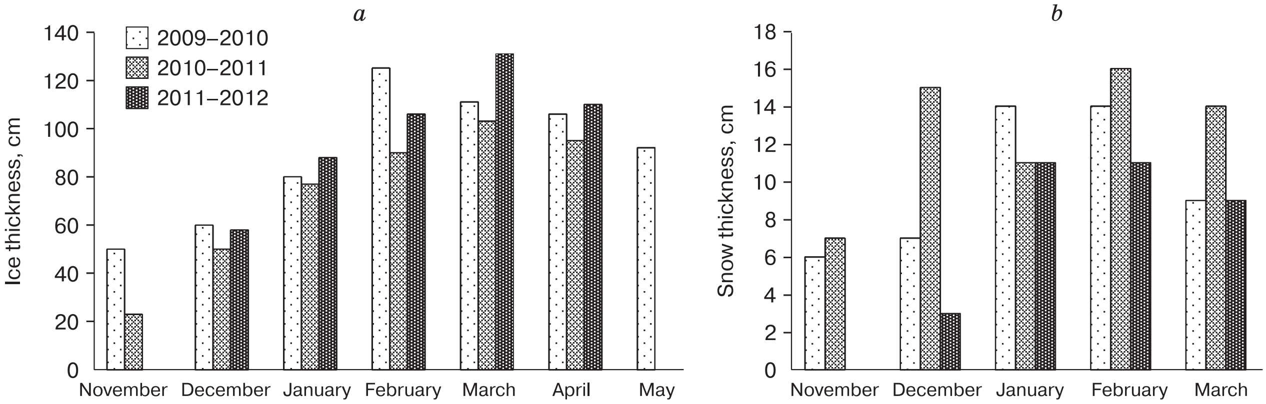

Fig. 2. Annual fluctuations in the thickness of ice (*a*) and snow (*b*) in Lake Arakhley at the central station.

in 2009–2010 was 209 days, in 2010–2011, it was 186 days, and in 2011–2012 – 181 days.

The ice in the littoral area (the depth 2–3 m) was thicker than in the central part of the lake by 8–9 %. In the winter period of 2010/11, ice thickness was less by 13–21 % compared to the previous year and by 4–17 % – compared to the subsequent year. Ice was thickest in February 2010 and in March 2012. The snowiest season was 2010/11, when the thickness of snow on the lake was 13–53 % greater compared to 2009/10 and by 31–80 % compared to 2011/12. The major precipitation fell in January–February (Fig. 2). The snow covered 80–100 % of the lake surface.

The enzyme activity in the ice. The hydrolytic activity of ice both in the center and in the littoral area of the lake grew from winter to spring. In 2010, the increase occurred from January to March (PA – from 0 to 603 U (U = enzyme activity unit), AA – от 0 to 499 U), in 2010–2011 – from December to February (PA – from 72 to 841 U, AA – from 0.44 to 120 U). Later on, activity of the hydrolytic enzymes in the ice decreased (Fig. 3).

In vertical differentiation, the highest enzyme activity was recorded in the upper (0–20 cm) and middle (40–80 cm) ice strata. In the lowest ice strata (100–120 cm), the enzyme activity was lower than that in the surface stratum 1.5–4 (PA) and 4–10 (AA) times.

The concentration of biogenic substances in ice. The highest concentrations of nitrates and phosphates in ice were recorded in the periods of setting and destruction of the ice cover. The maximum concentrations of PO_4^{3-} and NO_3^- in 2009–2010 reached, accordingly, 0.04 and 0.05 mg/L (January–February), in 2010–2011 – 0.023 and 0.018 mg/L (April), in 2011–2012 – 0.066 and 0.027 mg/L (December). Vertically, the high concentration of phosphate and nitrate ions was largely recorded in the upper and lower strata of ice. Activation of the processes of mineralization of the organic matter took place in the period of the highest ice growth, which is confirmed by the values of bichromate oxidation. The POO/COC ratio was on average 29–38 %, indicating the prevalence of newly formed organic matter (Fig. 3).

Algae in ice. The algae were represented in the ice by 22 species, varieties and forms relating to 6 categories: Cyanobacteria, Chrysophyta, Bacillariophyta, Euglenophyta, Dinophyta and Chlorophyta, making up 15 % of the total number of the algal taxa found in the subglacial water. All the algal species mentioned, with the exception of *Peridinium* sp., are common representatives of subglacial phytoplankton [*Tashlykova, 2013*]. The dinoflagellate *Peridinium* sp. was found only in the ice cores, not in water. In all the periods of the study, diatoms *Asterionella formosa*, *Handmania comta*, as well as *Peridinium* sp., were the permanent components of the ice. The total number of species varied from 8 to 18 (Table 2).

The spatial distribution of the algae in the ice was non-uniform. In the littoral area, the algal composition was rather poor. The highest concentrations of the algae were recorded in the lower strata of the ice, where littoral diatoms prevailed. Such species as *Navicula radiosa*, *Cymbella turgida*, *Achnanthes lanceolata*, *Gomphonema constrictum*, etc. were found mostly destroyed (as single rows), whereas whole organisms occurred rarely. In the upper strata of the ice cores, diatoms *Asterionella formosa*, *Handmania comta*, as well as the yellow-green algae *Chrysococcus rufescens*, were present. At the central station, *A. formosa* and *H. comta* were found in the upper and lower ice strata. As ice thickness increased in the lower strata, beginning with 60–80 cm, the dinoflagellate *Peridinium* sp. prevailed.

In December 2009, algae were differentiated at the central station vertically mostly in the upper strata of the ice (0–40 cm). In February–April, algae were found throughout the entire ice mass, the highest concentration occurring in the lower strata. In the ice cores samples from the littoral area in 2010–2011,

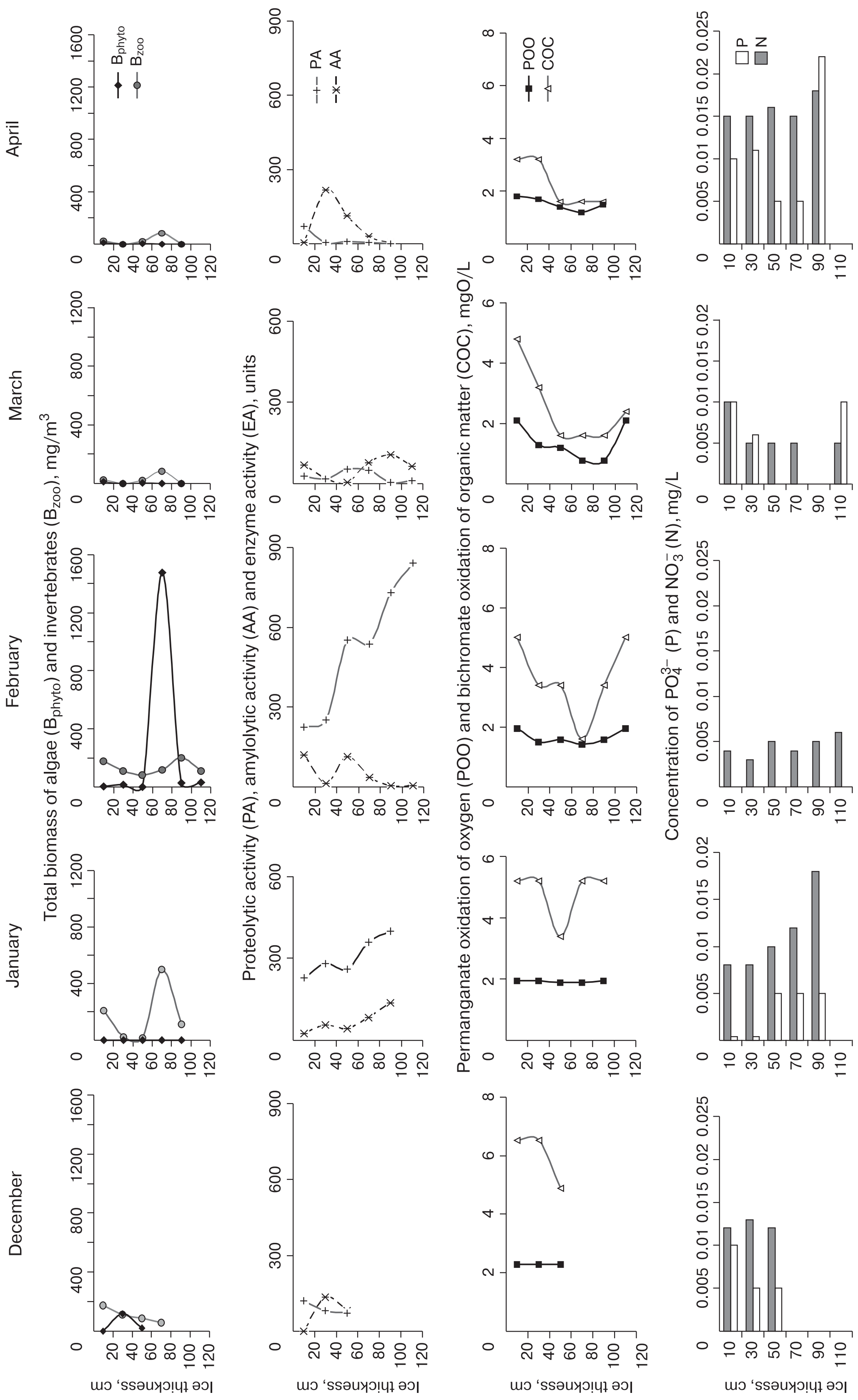

Fig. 3. Vertical distribution of hydrochemical and biological parameters in an ice column from Lake Arakhley at the littoral station in 2010–2011.

Table 2. **The species composition of the algae and invertebrates in the ice of Lake Arakhley**

Taxon	Ice season			
	2009–2010	2010–2011	2011–2012	2012–2013
Algae				
Cyanoprokaryota (Cyanobacteria)				
Anabaena flos-aquae Brébisson ex Bornet & Flahault, 1886	+	–	–	–
Chrysophyta				
Chrysococcus rufescens Klebs, 1893	+	–	+	+
Chromulina sp.	+	+	–	+
Mallomonas sp.	–	–	+	+
Bacillariophyta				
Handmania comta (Ehrenberg) Kociolek et Khursevich emend. Genkal	+	+	+	+
Asterionella formosa Hassall, 1850	+	+	+	+
Fragilaria capucina Desmazières, 1830	–	+	–	–
F. crotonensis Kitton, 1869	–	–	–	+
Pseudostaurosira brevistriata (Grunow) D.M. Williams & Round, 1987	–	–	+	–
Diatoma vulgaris Bory, 1824	–	–	+	+
Navicula radiosa Kützing, 1844	–	–	+	–
Achnanthes lanceolata (Brébisson ex Kützing) Grunow in Van Heurck, 1880	–	–	+	+
Cymbella turgida (Ehrenberg) Hassall, 1845	–	–	+	–
Gomphonema constrictum Ehrenberg, 1832	–	+	+	–
Nitzschia acicularis (Kützing) W. Smith, 1853	–	–	+	+
Euglenophyta				
Phacus sp.	–	–	+	–
Dinophyta				
Peridinium sp.	+	+	+	+
Gymnodinium sp.	+	+	–	+
Gymnodinium sp.[1]	+	–	+	–
Chlorophyta				
Closteriopsis acicularis (Chodat) J.H. Belcher & Swale, 1962	–	–	+	–
Monoraphidium contortum (Thuret) Komàrková–Legnerová, 1969	–	–	+	+
Tetrastrum triangulare (Chodat) Komárek, 1974	–	+	+	–
Elakatothrix genevensis (Reverdin) Hindák, 1962	–	–	+	+
Total species	8	8	18	13
Invertebrates				
Rotifera				
Keratella cochlearis (Gosse, 1851)	–	+	–	+
Kellicottia longispina (Kellicott, 1879)	+	+	–	–
Cladocera				
Sida crystallina (Müller, 1776)	–	–	+	–
Ceriodaphnia quadrangula (Müller, 1785)	–	+	–	–
Daphnia galeata Sars, 1864	+	+	+	+
Bosmina longirostris (Müller, 1785)	–	+	+	–
Copepoda				
Eudiaptomus graciloides (Lilljeborg, 1888)	+	+	+	+
Macrocyclops albidus (Jurine, 1820)	–	–	+	–
Cyclops vicinus Uljanin, 1875	+	+	+	+
Mesocyclops arakhlensis (Alekseev, 1993)	–	–	+	+
Thermocyclops crassus (Fischer, 1853)	–	+	+	–
Amphipoda				
Gmelinoides fasciatus Stebbing, 1899	–	+	–	–
Total species	4	9	8	5

algae were found in the upper and middle ice samples (20–60 cm). In 2012, algae were found only in the lower strata of the ice core, near the water edge.

In the period under study, the highest values of the abundance and the biomass concentrations of the algae were recorded in 2009–2010 at the central station, when the abundance of the algae varied from $0.3 \cdot 10^3$ to $158 \cdot 10^3$ cells/L, while the amount of the biomass varied from 0.4 to 1500 mg/m^3. The February peak (the 60–80 cm horizon) was caused by the affluence of the dinoflagellate *Peridinium* sp. In 2010–2011 period and varied from $0.2 \cdot 10^3$ to $28.6 \cdot 10^3$ cells/L, and from 0.1 to 98.6 mg/m^3. The largest concentrations of the algae were also noted in February and were due to dinoflagellates. In 2011–2012, their amount varied from $0.4 \cdot 10^3$ to $33 \cdot 10^3$ cells/L, while the biomass varied from 0.7 to 1472 mg/m^3. As opposed to the previous years of investigations, when the maximum values of the abundance and the biomass amount were revealed at the central station, and in 2011–2012, the largest amount of the algae was found at the littoral station. The low values of the quantitative characteristics of the algae at all the stations were recorded in 2012–2013. The abundance of the algae was $(0.25–14.7) \cdot 10^3$ cells/L, while the biomass was 0.8–15.3 mg/m^3.

Invertebrates in ice. In the lake ice, 12 species of invertebrates were recorded, among which there were 10 species of crustaceans and 2 species of rotifers. In the ice samples, mass species of subglacial zooplankton were present: *Daphnia galeata*, *Cyclops vicinus*, and *Eudiaptomus graciloides* [*Itigilova, 2013*]. In the littoral ice cover, representatives of the summer plankton (*Bosmina longirostris*, *Mesocyclops arakhlensis*, *Thermocyclops crassus*) and phytophilous forms (*Sida crystallina*, *Ceriodaphnia quadrangula*, *Macrocyclops albidus*) were recorded. Amphipods were represented by *Gmelinoides fasciatus* (Table 2). After melting of the ice, two such crustaceans remained viable and actively swam in the water tank. The presence of fat inclusions in the crustaceans' tissues (Diaptomus and Cyclops) could suggest their living condition; however, no movements of the copepods in the melt were noticed. Most animals were found nonliving in the water melt.

The lowest species variety of hydrobionts was noted in April–May, whereas the highest variety was recorded in December–January. The abundance of the species in the lower strata of the ice was greater than in the upper strata. The littoral ice was found to be qualitatively more varied than the ice from the deep water part of the lake.

The abundance of the glacial organisms is by an order of magnitude lower than that of the subglacial zooplankton [*Itigilova, 2013*]. The distribution of animals in the ice was characterized by spatial-temporal variability. The lowest abundance of species ($(0.03–0.17) \cdot 10^3$ ind./m^3) was recorded in the winter season 2009/10. In the winter period of 2010/11 with much snowfall, the total abundance of the species varied from $0.29 \cdot 10^3$ to $3.89 \cdot 10^3$ ind./m^3, and in 2011/12 – from $0.34 \cdot 10^3$ to $6.45 \cdot 10^3$ ind./m^3. In the winter months, the amount of hydrobionts in the center of the lake was 10–17 times lower, compared to the littoral area, while in the spring months, conversely, it was 1.5–3 times higher. In the deep-water of the lake, the amount of invertebrates grew from winter to spring (from $0.35 \cdot 10^3$ to $0.94 \cdot 10^3$ ind./m^3), whereas in the littoral area it decreased (from $3.58 \cdot 10^3$ to $0.35 \cdot 10^3$ ind./m^3). Thus, the quantitative maximum of hydrobionts was recorded in the littoral part of the lake in the period of the maximum increment of the ice cover (December–February), the minimum amount was found before the beginning of the ice cover destruction (April), in the central zone the largest number of the hydrobionts was recorded in March–April, while in the winter months, the organisms occurred only singly.

In vertical zonality, the highest concentration of invertebrates was recorded in December–January, both in the center and in the littoral area of the lake, in the upper ice strata (0–40 cm). In March–April, crustaceans were concentrated in the lower horizons (80–120 cm) in the center of the lake, and in the littoral area, their concentration was higher in the middle and at the bottom of the ice column (Fig. 3).

DISCUSSION

The main component of the ice of Lake Arakhley is formed by the representatives of subglacial plankton among diatom algae and crustaceans. The greatest taxonomic variety of the algae and invertebrates was observed in the early period of establishment of the ice cover. The studies of Lake Baikal ice have shown algae, rotifers, copepods and amphipods to be massively found in the interstitial ice water and in the ice overgrowth. The high level of species variety, biodiversity and endemism are characteristic of algae and rotifers [*Timoshkin, 2001*]. Cryophilic biotope appears in the period of melting of 'black ice' [*Obolkina et al., 2000*]. The total abundance of hydrobionts included into the ice of Lake Arakhley is low, as the autumn and winter phyto- and zooplankton is also scarce. The results of auto-fluorescence of the cells containing photosynthetic pigments [*Bondarenko et al., 2011*], and data relating to chlorophyll concentration [*Tashlykova and Koryakina, 2013*] indicate the photosynthetic activity of algal cells in Lake Arakhley, which has been shown for other fresh water systems, too [*Lebedev et al., 1981; Zavoruyev, 2000*].

The species composition of algae in the ice of the lake in question essentially differed from the algal composition of the cryophyton of other freshwater lakes. The glacial organisms of mesotrophic Lake Arakhley are richer compared to ultraolygotrophic

Lake Baunt [*Bondarenko et al., 2011*], where representatives of centric diatoms and dinoflagellates mostly inhabited the ice, but were more scarce compared to the eutrophic urbanized lakes of Karelia and the Omsk region [*Slastina et al., 2011; Bazhenova and Korzhova, 2014*], where more diverse composition of the algae was observed, with dominating Chlorococcales and cyanobacteria. Commonly found in the ice of Lake Arakhley, similarly to marine waters [*Horner, 1976*], freshwater lakes [*Felip et al., 1995; Obolkina et al., 2000*] and rivers [*Yuryev, 1992; Frenette et al., 2008*], were dinoflagellates and diatoms. In the ice of Lake Arakhley, nano- and picoforms of algae prevailed, as opposed to the ice communities of high mountain lakes [*Felip et al., 1995; Bondarenko et al., 2011*], where large forms were present. Studies have shown that the composition of the ice inhabitants of freshwater lakes and their quantitative parameters depend on the ice structure, the amount of interstitial ice water and the chemical composition of the water [*Bondarenko et al., 2011*] and that it is conditioned by the composition of subglacial phytoplankton, from which it is formed [*Slastina et al., 2011; Bazhenova and Korzhova, 2014*].

The high concentration and variety of rotifers observed in other fresh water lakes was not found to be typical of the invertebrates of the ice of Lake Arakhley. In the complex of organisms associated with ice, mostly copepods prevailed, capable, according to some authors [*Grainger et al., 1985*], of living in ice itself. There were fat inclusions in the tissues of *Eudiaptomus graciloides*, *Cyclops vicinus*, which could suggest their living condition in the melt. The ability of certain invertebrates inhabiting Lake Arakhley to remain alive after being frozen into ice and to regain their living function after ice melting has been noted by other researchers [*Semernoy and Gorlachev, 1969; Mekhannikova et al., 2009*].

The vertical distribution of algae and invertebrates was characterized by their aggregation in the upper (0–40 cm) and/or middle (40–80 cm) ice strata, where high proteolytic activity was observed. However, according to [*Obolkina et al., 2000; Poglazova et al., 2001; Bondarenko et al., 2012; Ilyash et al., 2013*], the major accumulation of hydrobionts in the lakes, rivers, and seas is recorded primarily in the lower spongy strata of ice near the very water edge. The algae found in the ice were more varied quantitatively and qualitatively in the deep-water part of Lake Arakhley, whereas invertebrates were more commonly found in the littoral part. Spatial variability is a characteristic feature of both Arctic and fresh water ice [*Gosselin et al., 1986; Yuryev, 1992; Nozais et al., 2001; Timoshkin, 2001; Bondarenko et al., 2012; Ilyash et al., 2013*] and may be attributed both to abiotic factors (temperature, illumination, the structure and direction of ice growth, etc.) and the nature of the physico-chemical processes occurring in the ice [*Bordonskiy et al., 2003*].

Entrance of the plankton and benthic organists into ice seems to be caused by vertically turbulent diffusion generated by the subglacial flow of water [*Verbolov, 1979*] and by mechanical entrapment of the plankton organisms which are in water, into the ice crystal structure. Water freezing on the lower surface of the ice results in casual inclusion of hydrobionts inhabiting the suglacial water into ice [*Melnikov, 1989*]. No active colonization of ice in Lake Arakhley has been observed. The abundance of the dinoflagellate *Peridinium* sp. in ice at the beginning of the biological spring seems to be related to its capability of mixed nutrition. The possible causes of intense 'bloom' of these algae in the ice are natural accumulation of biogenic elements, increase in illumination and the beginning warming of water under ice [*Bondarenko, 2009*].

High insolation, transparence of ice and the thin snow cover contribute to activation of life in the ice. The presence of hydrolytic elements in the ice indicates functioning of hydrobionts, both bacteria and micromycetae and plankton organisms, and the processes of decomposition of organic polymers and of enriching the plankton with monosaccharides and with phosphorus and nitrogen compound minerals. Practically close values of the parameters of the activity of proteases and amylases in the upper and lower horizons of ice suggest gradual inflow of the organic matter into the ice structure due to subglacial water, as in the period of the beginning of ice melting (March) life develops in the system of ice pores and fractures.

Reduction of the enzyme activity in April seems to be accountable to the process of the organisms' outflow with water, due to the increase in the number of pores in the ice, which begin to streak the ice from its surface to the subglacial water.

CONCLUSION

The species composition of the algae and invertebrates found in the ice of Lake Arakhley is scarce to include both hydrobionts frozen into ice and the hydrobionts which inhabit subglacial water. Inclusion of organisms into ice occurs due to gradual freezing of ice from below, whereas no active colonization of ice has been observed. The species found are typical representatives of the lacustrine plankton flora and fauna. The ice algae are most abundant and diverse in the central part of the lake, while invertebrates are more common in the littoral part. In the ice formed in the deep part of the lake, 18 species of algae were found, with the largest number being $158 \cdot 10^3$ cells/L, and in the littoral part, there were 8 algal species and $21.56 \cdot 10^3$ cells/L, respectively. The animals in the ice in different zones of the lake were represented by 4 (center) and 12 (the littoral area) species. The highest populations were $0.44 \cdot 10^3$ and $18.67 \cdot 10^3$ ind./m^3. Hydrobionts are vertically stratified primarily in the upper and middle strata of the ice.

For their main structural characteristics (the taxonomic composition, vertical zonality and seasonal fluctuations in the abundance of hydrobionts), the ice fauna and flora of Lake Arakhley have similar features with the glacial communities of other fresh water lakes.

The process of biological degradation of organic matter in the ice of Lake Arakhley takes place due to the presence of living organisms producing hydrolytic enzymes. The ascertained biochemical process of decomposition of the substances referring to proteins and carbohydrates in ice contributes to formation of nutrients and to decomposition of the organisms' waste products, which eventually ensures evolvement of life in the ice cover. Activation of the processes of mineralization of organic matter takes place in the period of the highest growth of ice. The high content of biogenic elements is recorded in the periods of setting and destruction of the ice cover.

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