ABS ACTA BIOLOGICA SIBIRICA
A journal on the biodiversity of Siberia and the adjacent lands

Acta Biologica Sibirica 7: 39–48 (2021)
doi: 10.3897/abs.7.e65636
https://abs.pensoft.net

RESEARCH ARTICLE

New data regarding ecology of freshwater pelagic amphipod *Macrohectopus branickii* (Dybowsky, 1874) (Amphipoda: Macrohectopodidae) and other crustaceans of plankton from the southern part of Lake Baikal (Russia, Southern Siberia)

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Academic editor: R. Yakovlev | Received 8 March 2021 | Accepted 29 March 2021 | Published 12 April 2021

http://zoobank.org/60A0ADF9-7471-41D2-BC18-BE56088BE7A6

Citation: Karnaukhov DYu, Dolinskaya EM, Biritskaya SA, Teplykh MA, Ermolaeva YK, Pushnica VA, Kuznetsova IV, Okholina AI, Bukhaeva LB, Rusanovskaya OO, Silow EA (2021) New data regarding ecology of freshwater pelagic amphipod *Macrohectopus branickii* (Dybowsky, 1874) (Amphipoda: Macrohectopodidae) and other crustaceans of plankton from the southern part of Lake Baikal (Russia, Southern Siberia). Acta Biologica Sibirica 7: 39–48 https://doi.org/10.3897/abs.7.e65636

Abstract

In this study, we present a list of crustaceans traced in plankton of the southern basin Lake Baikal in addition to some details regarding ecological peculiarities of the only known freshwater pelagic amphipod *Macrohectopus branickii* (Amphipoda: Macrohectopodidae). The amphipod is an active predator among major parts of the Lake Baikal food chain. Its role in the lake's ecosystem is similar to that of Antarctic krill and mysids in Europe and North America water bodies. As an active swimmer, *M. branickii* performs daily vertical migrations. Besides, the species also has horizontal migrations and migrating swarms, including time during breeding period, that hamper species studies. We were interested in clarifying some features of the species ecology. As a material we used samples obtained in the 0 to 250 m water layer with a plankton Juday net every 7 to 10 days from 2013 until 2018 as a part of long-term ecological monitoring project of Lake Baikal pelagial. Sampling was conducted in the southern part of the lake off the shore of Bolshie Koty Village (Irkutsk region). The results showed the presence of one peak of young during breeding period, which is at its maximum in May. The maximum of the 1 to 6 mm group containing young individuals and males occurs in July, and during the same period, a slight increase in immature females in comparison with the first group can also be seen. This finding might be directly linked to the warming trend in Lake Baikal.

Keywords
Ecology of crustaceans, Lake Baikal, *Macrohectopus branickii*, pelagic amphipod

Introduction

The fauna of amphipods of terrestrial water bodies of Russia consists of 61% of the Lake Baikal's amphipods, which are almost completely endemic and include 354 species and subspecies (Takhteev et al. 2015). Lake Baikal amphipods master many ecological niches (Takhteev 2000; Takhteev and Didorenko 2015). Thus, the amphipod *Macrohectopus branickii* (Dybowsky, 1874) (Amphipoda: Macrohectopodidae) is the only known freshwater pelagic species among amphipods (Takhteev and Didorenko 2015). As a true pelagic species, *M. branickii* lives in all sections of the lake and plays a major roles in the food chain (Vilisova 1962; Kozhov 1963; Mel'nik et al. 1995; Kozhova and Izmest'eva 1998). Analogous organisms in other water bodies with similar lifestyles and roles in the food chain are Antarctic krill and mysids (Rudstam et al. 1992; Mel'nik et al. 1995; Rudstam et al. 1998; Gaten et al. 2008; Okkonen et al. 2020).

Knowledge about the ecology of the species is scarce, although it would be extremely important for understanding the ecosystem of Lake Baikal. A few reports of amphipod migration into the lake littoral zone (Karnaukhov et al. 2016), swarming behavior (Karnaukhov et al. 2018), and previously unknown trophic links occasionally appear (Didorenko et al. 2020; Watanabe et al. 2020), it should be noted that *Epischura baicalensis* Sars, 1900 (Calanoida: Temoridae) and *Cyclops kolensis* Lilljeborg, 1901 (Cyclopoida: Cyclopidae) are one of the main objects in the diet of *M. branickii*. Very little is known about reproduction of the species; however, it was noticed that this species has a year-round reproduction period with two elongated peaks of juveniles' number (Nikolaeva 1967; Mel'nik et al. 1995).

Expanding the knowledge about the ecology of *M. branickii*, clarification of reproduction period time, number of young, and comparison of ecological and size groups was the goal of this study.

Material and methods

Data on abundance of *M. branickii* for this study were obtained from 2013 to 2018 (from 2013 to 2017 for *E. baicalensis* and *C. kolensis*). The sampling site (pelagic stationary station 1) was located opposite to the Bolshie Koty Village about 2.7 km from the shore at the depth of 800 m (51052´48″N 105005´02″E) (Fig. 1). The sam-

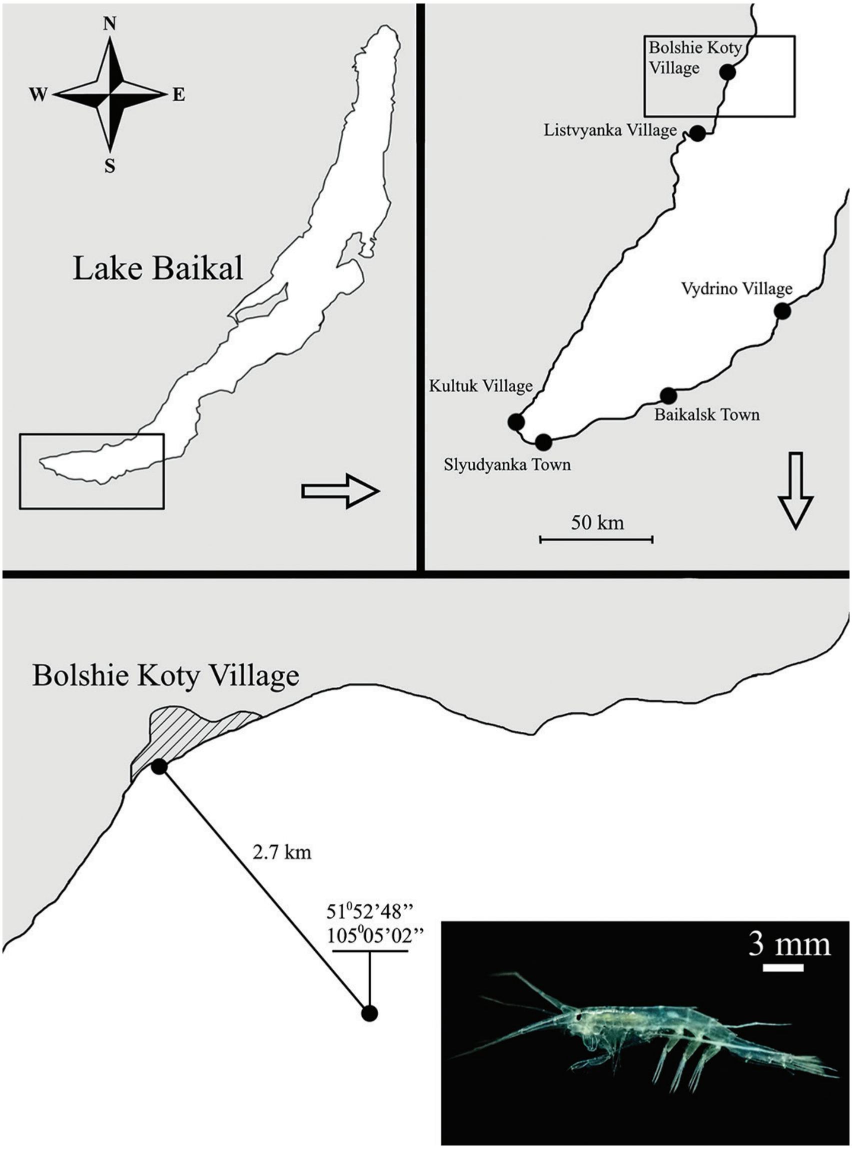

Figure 1. Scheme of pelagic stationary station 1 disposition (female of *M. branickii* - photo by P. Drozdova).

Table 1. Number of samples by year.

№	Year	Number of samples
1	2013	19
2	2014	25
3	2015	16
4	2016	26
5	2017	12
6	2018	27

ples were obtained with a closed Juday plankton net with a 37.5 cm diameter inlet port in the water layer of 0 to 250 m (of 0 to 50 for *E. baicalensis* and *C. kolensis*). Sampling was conducted year-round every 7 to 10 days but stopped during ice-breaker and ice convergence periods. During the summer, sampling was done from the research vessel and in winter, from the ice. Laboratory sample treatment was done according to the standard hydrobiological method. A total of 125 samples were taken to analyze the abundance of *M. branickii* (Table 1).

In order to reveal reproduction peaks of *M. branickii*, we analyzed young individuals with body lengths of 1 mm during the year. Besides, we analyzed numbers of two size-ecological groups of the species: (1) 1–6 mm (juveniles and males) and (2) 7–14 mm (immature females). Data analysis was done with PAST3.x.

Results and discussion

Open pelagial of Lake Baikal at the study site was inhabited by 10 species of crustaceans (Table 2).

Representatives of Copepoda (*E. baicalensis* and *C. kolensis*) are among the most abundant planktonic inhabitants of the pelagic zone. The abundance of *E. baicalensis* can reach several million with a biomass of tens of grams per 1 m2, which can be up to 90-99% of the total biomass of zooplankton (Baicalogy 2012). At the same time, periodically, when the number of *E. baicalensis* decreases, *C. kolensis* occupies a dominant position. Periods of a sharp increase in the abundance of this species are usually associated with outbreaks of phytoplankton (Mazepova 1995).

According to our data, from 2013 to 2017, an increase in the number of individuals of *E. baicalensis* was observed annually (Fig. 2). The number of individuals of *C. kolensis* was noticeably lower than the number of *E. baicalensis*. However, from 2013 to 2016, an increase in the number of individuals was also noted. In 2017, there was a decrease in the number of *C. kolensis*.

Table 2. Crustaceans of the plankton in the southern basin of Lake Baikal that are registered at pelagic stationary station 1.

№	Crustacean species
	Order Amphipoda
	Suborder Gammaridea
	Superfamily Gammaroidea
	Family Macrohectopodidae
	Genus *Macrohectopus* Stebbing, 1906
1	*Macrohectopus branickii* (Dybowsky, 1874) (Fig. 1)
	Subclass Copepoda
	Order Calanoida
	Family Temoridae
	Genus *Epischura* Forbes, 1882
	Subgenus *Epischurella* Smirnov, 1936
2	*Epischura baicalensis* Sars, 1900
	Order Cyclopoida
	Family Cyclopidae
	Genus *Cyclops* (O.F. Müller, 1776)
3	*Cyclops kolensis* Lilljeborg, 1901
	Order Harpacticoida
	Family Harpacticidae
	Genus *Harpacticella* Sars, 1908
4	*Harpacticella inopinata* Sars, 1908
	Subclass Cladocera
	Order Anomopoda
	Family Daphniidae
	Genus *Daphnia* O.F. Müller, 1785
5	*Daphnia cucullat*a Sars, 1862
6	*Daphnia longispina* O.F. Müller, 1785
7	*Daphnia galeata* Sars, 1863
8	*Daphnia pulex* Leydig, 1860
	Family Bosminidae
	Genus *Bosmina* Baird, 1850
9	*Bosmina longirostris* (O.F. Müller, 1776)
	Genus *Eubosmina* Seligo, 1900
10	*Eubosmina longispina* (Leydig, 1860)

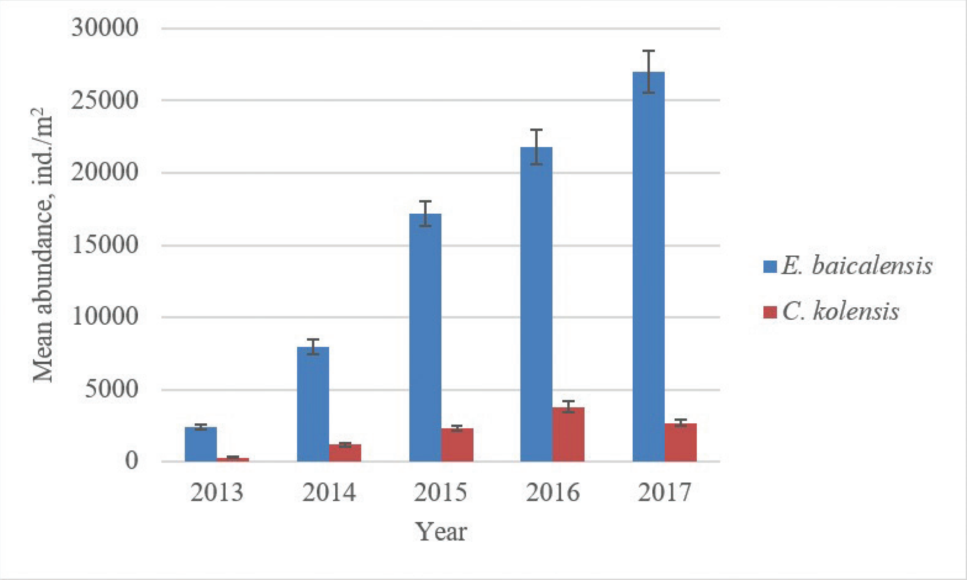

Figure 2. Mean abundance of *E. baicalensis* and *C. kolensis* in the 0-50 m water layer from 2013 until 2017; marked – standard error.

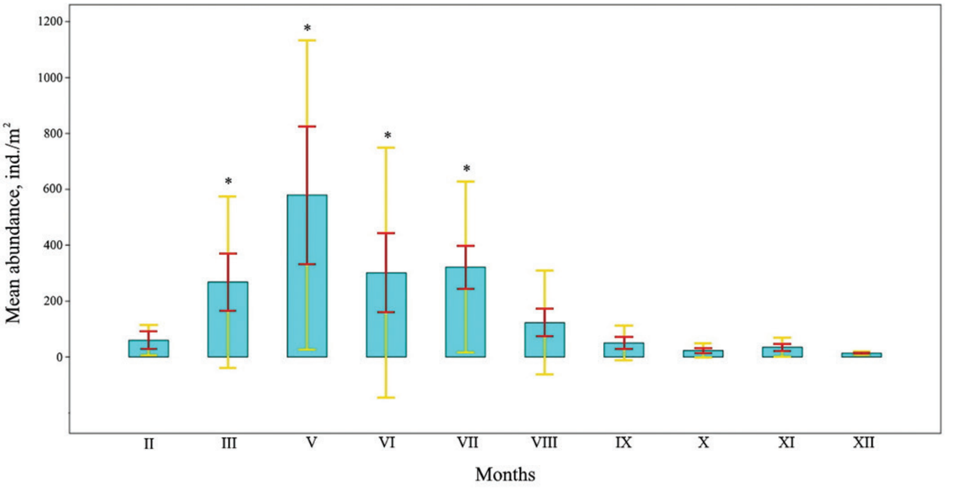

Figure 3. Number of young *Macrohectopus branickii* (1 mm) per month in the 0 to 250 m water layer from 2013 until 2018; red – standard error, yellow – standard deviation (* – the differences are statistically significant).

However, the main position in the list certainly includes *M. branickii*, which on one hand, is the only specimen in the lake pelagial that belongs to the class Malacostraca and on the other hand, is a species that occupies the top of the food chain in the list.

Comparison of numbers of young individuals shows the presence in the 0 to 250 m layer during the period from 2013 to 2018 with only one elongated peak of reproduction numbers throughout this period with its maximum occurrence in May (Fig. 3). Such visual differences were confirmed with the Kruskal–Wallis test, which showed that statistically significant differences between months were found, and further use of Dann's post hoc test helped to identify during which months differences actually existed.

Evidently, instead of two peaks as stated previously (Nikolaeva 1967), only one peak can be seen. Perhaps, previous conclusions were made based on individual pelagial samplings (not always systematic), and it is also possible that calculations were done that included individuals of different sizes, for example, those that were 2 mm. Changes in the environment, for example increasing temperatures, cannot be excluded.

Comparison of median values of numbers of ecological and size groups per months showed that from February until July, an increase of the numbers in the 1 to 6 mm size group (young and males) could be observed, while the numbers in the 7 to 14 mm group (immature females) remained constant and did not show a significant peak (Fig. 4). This difference in numbers for the two ecological size groups have occurred because no males of this species were found in the second group since they are much smaller than females (Mel'nik et al. 1995) and are included in the first groups with young individuals of both sexes. Also, a significant portion of young females in the first group is eaten before these females reach larger sizes and become more active swimmers.

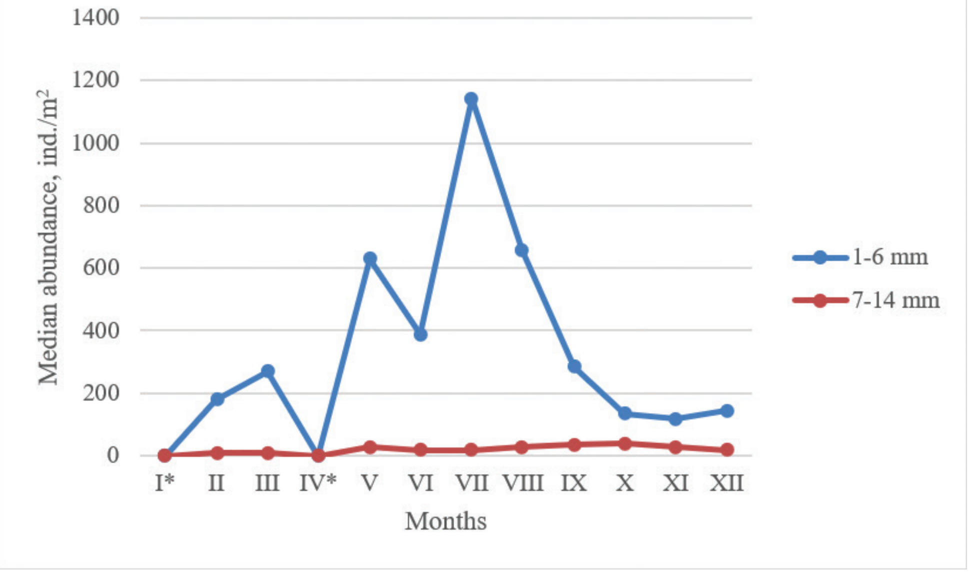

Figure 4. Number of *M. branickii* individuals of different size groups, including the 1 to 6 mm group (young and males) and 7 to 14 mm group (immature females) per month in the 0 to 250 m water layer from 2013 until 2018.

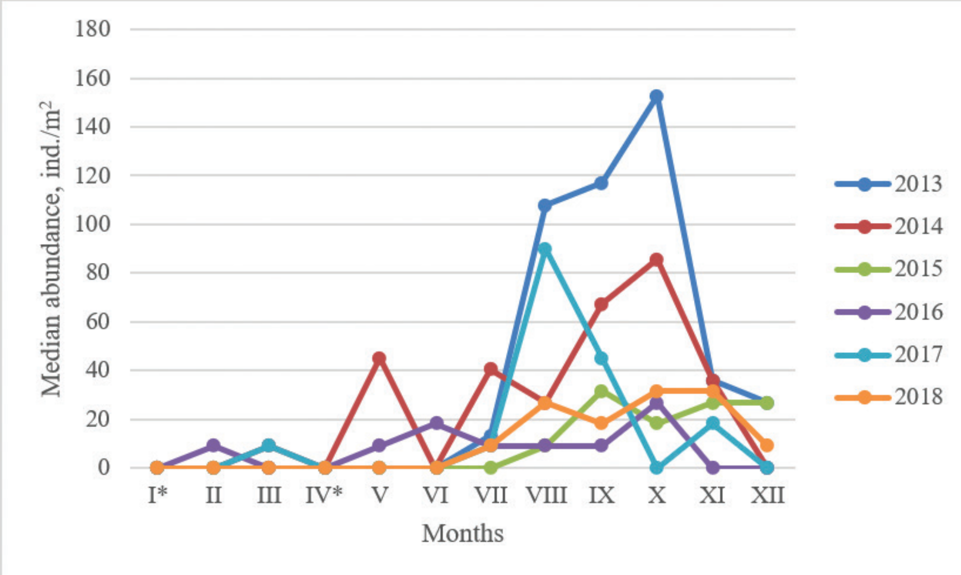

Figure 5. Number of *M. branickii* individuals in the 7 to 14 mm size group (immature females) per month in the 0 to 250 m water layer from 2013 until 2018 (no data for January and April for the period from 2013 to 2018).

However, in the second part of the year, the increase in the number of individuals from the ecological 7 to 14 mm size group can be monitored. Such increases generally become more visible starting in July (Fig. 5). The increase in numbers during the second part of the year might be related to the increase in surface water temperature in the lake, which normally happens at this time (Kozhova and Izmest'eva 1998).

Conclusion

Studies of *M. branickii* ecological features are an important part of the understanding of the whole Lake Baikal ecosystem. Detected biases of ecological and the 7 to 14 mm size group might pinpoint the preferences of the group toward warmer waters, while the maximum hatching of the young individuals happens in the earlier period. Based on this finding, we suggest that globally detected temperature increases in surface waters (Carrea et al. 2020) might have negative effects for the vital functions of this species and lead to the partial rearrangement of the Lake Baikal food chain.

Acknowledgements

The study was supported by the Project of Russian Ministry of Science and Education N FZZE-2020-0026.

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