Original Article

Role of the invasive amphipod Gmelinoides fasciatus (Crustacea: Amphipoda) of littoral macrozoobenthos of the Zaonezhye area of Lake Onego

Sidorova A.I.

Northern Water Problems Institute of the Karelian Research Centre of the Russian Academy of Sciences, Aleksander Nevsky Str. 50, Petrozavodsk, 185030, Russia

ABSTRACT. The results of research of bottom biocenoses of the Zaonezhye area (Zaonezhsky Peninsula in the northeastern part) of Lake Onego in 2023 are presented. Insignificant differences in the spatial distribution of quantitative characteristics of macrozoobenthos were revealed. Quantitative indicators such as abundance and biomass of macrozoobenthos ranged from 1.56-4,01 thousand ind/m^2 and 0.35-3.19 g/m^2, respectively. It is shown that the invasive species *Gmelinoides fasciatus* (Stebbing 1899) (Crustacea: Amphipoda) has naturalized in the littoral. Amphipoda *G. fasciatus* plays a dominant role in the abundance of the bottom community in Keften-Guba and in the vicinity of Padmozero village. It was noted that the native species *Gammarus lacustris* Sars 1863 was not recorded anywhere. Quite rapid dispersal of the Baikal species *G. fasciatus* on the littoral of the reservoir suggests that in the coming years these amphipods may colonize the Lizhemskaya Guba (Bay) of the lake, where there are habitats not subject to its invasion, according to the literature.

Keywords: macrozoobenthos, *Gmelinoides fasciatus*, littoral zone, Onego Lake, invasive species

For citation: Sidorova A.I. Role of the invasive amphipod Gmelinoides fasciatus (Crustacea: Amphipoda) of littoral macrozoobenthos of the Zaonezhye area of Lake Onego // Limnology and Freshwater Biology. 2024. - № 5. - P. 1243-1252. DOI: 10.31951/2658-3518-2024-A-5-1243

1. Introduction

Intentional and unintentional introductions of alien species have increased dramatically worldwide over the past century. Although studies related to human activities that facilitate species exchange have increased substantially, we know little about the rate of alien species accumulation in different regions (Seebens et al., 2017). The process of invasion of alien species into aquatic ecosystems of Northwest Russia has recently been proceeding quite intensively (Kurashov et al., 2018; Barbashova et al., 2021). Amphipods are among the most active invasive species, dispersing in modern conditions outside their natural habitats, which leads to significant changes in the recipient ecosystems (Jazdzewski and Konopacka, 2002; Arbačiauskas, 2002; Berezina, 2007; Grabowski et al., 2007).

The Baikal amphipod *G. fasciatus* has been registered in Lake Onego since 2001 (Berezina and Panov, 2003). High ecological plasticity of the crustaceans, availability and feeding value for many fishes benthophages allowed using them as objects for deliberate introduction in reservoirs and lakes. In the 1960-1970s, aquatic invertebrates, including *G. fasciatus*, were introduced to increase the fish food base (Ioffe, 1960; Bekman, 1962; Ioffe, 1968). The species has successfully taken root in 28 water bodies of the country (Zadoenko et al., 1985).

To date, materials have been published on the distribution of *G. fasciatus* on the southwestern part of the littoral of Lake Onego (Berezina and Panov, 2003), the northern part (Kukharev et al., 2008) and the littoral of Megostrov and Sosnovets islands and the eastern part of the reservoir (Sidorova and Belicheva, 2017). However, the role of the invasive species on the littoral of the Zaonezhye area (Zaonezhsky Peninsula in the northeastern part) of Lake Onego has not been previously investigated. For the first time, we obtained materials on the distribution of the species in the littoral zone in Guba Svyatukha and in the vicinity of Padmozero village.

The purpose of the study is to clarify the distribution and role of the invasive amphipod *G. fasciatus* in macrozoobenthos on the littoral of the Zaonezhye area of Lake Onego.

*Corresponding author.
E-mail address: bolt-nastya@yandex.ru (A.I. Sidorova)

Received: June 27, 2024; ***Accepted:*** October 01, 2024;
Available online: October 31, 2024

2. Materials and methods

Lake Onego is located in the European North of Russia and it is the second largest freshwater lake in Europe (Filatov, 2010). Macrozoobenthos samples were collected on the littoral of Zaonezhye synchronously at all stations on the same day, July 2, 2023 (Fig. 1). The monitoring station in Keften-Guba is represented by a sandy quiet littoral with macrophyte thickets, mainly common reed *Phragmites australis* (Cavanilles). The area of overgrowth at the station was about 10 m^2. The biotope of Svyatukha Bay is represented by a stony littoral with thickets of common reed. The biotope of the littoral near Padmozero village is sandy with common reed.

Samples were collected and processed in accordance with freshwater benthos collection guidelines (Vinberg and Lavrentieva, 1962). A tubular metal Panov-Pavlov sampler with a 0.07 m^2capture area and 0.65 m height was used for benthos sampling (Panov and Pavlov, 1986). The cylinder was lowered to the bottom and rotationally buried 5-7 cm into the ground so that the upper edge of the cylinder was above the water surface. The volume of water confined by the cylinder was agitated and thoroughly fished with a net for several minutes. The contents of the net were periodically transferred to a container with water. Then the rocks on the bottom and plants were examined. Animals from the rocks were also transferred to the sample. Collections were made at depths of up to 0.4 m from 3 points approximately 5 meters apart. A total of 18 macrozoobenthos samples were collected at all stations.

Macrozoobenthos organisms were identified using a LOMO Mikmed-6 microscope (LOMO, Russia), according to the identifier (Alekseev and Tsalolikhin, 2016). In the laboratory, the crude weight of *G. fasciatus* individuals fixed in formalin was determined by weighing after drying on filter paper with an accuracy of 0.0001 g., using laboratory analytical scales VL-124V (GOSMETR, Russia). Statistical processing of the data was performed according to the methodological guidelines (Ivanter and Korosov, 2010).

3. Results and discussion

The results of the study showed that the macrozoobenthos of the littoral zone is quite diverse and it is represented by the main groups of benthic invertebrates. Seven groups of different taxonomic rank were identified. These groups widely distribute in the littoral zone of Lake Onego as in most water bodies of the North-West (Table 1). The most common and abundant groups were Amphipoda (100% occurrence), Chironomidae (100% occurrence), Oligochaeta (100% occurrence) and Ceratopogonidae (100% occurrence). Ephemeroptera (33% occurrence) and Hydracarina (33% occurrence) were rarely observed. Bivalvia molluscs were found in more than half of the samples (67% occurrence).

The amphipod *G.fasciatus* was firstly observed in Keften-Guba of Lake Onego in 2006-2009 (Savosin, 2010). The native amphipod *Gammarus lacustris* Sars was not found by us in the studied habitats. The invasive amphipod *G. fasciatus* in Lake Onego is currently a mass species in the littoral of the lake on rocky and thicket biocenoses. In the present only coastal areas in Lizhemskaya Guba are not subject to its invasion (Kukharev et al., 2008). In addition, according to our results, only in one habitat around Cape Chazhnavolok the native amphipod *Gammarus lacustris* Sars 1863 and *G. fasciatus* occurred simultaneously. In this benthic biocenosis, the biomass of the native species is 38%, while *G.fasciatus* is 19% from the total biomasse (Sidorova, in press).

According to Berezina (2004), when an invasive alien species enters new conditions where there is no natural limitation of its dispersal and where there are no predators, parasites and competitors, an ideal situation for population (or biomass) growth is created. At the first, it happens imperceptibly and slowly, and then it becomes rapid, which can lead to a population explosion. In the absence of constraints from environmental conditions, such growth can continue for an indefinite period of time. As a rule, limitation is occurred by one or another environmental factor or factors occurs at

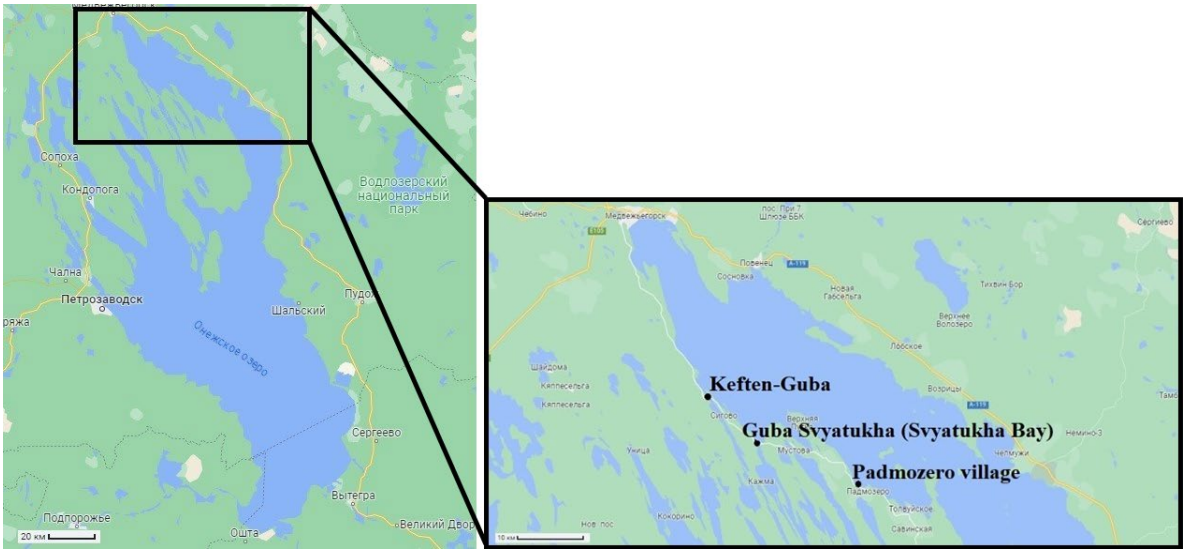

Fig.1. Location map of macrozoobenthos sampling stations on the littoral of Lake Onego in 2023.

Table 1. Taxonomic structure and average quantitative characteristics of macrozoobenthos communities on the littoral of Lake Onego in 2023.

Station	Numbers, thousand ind/m²								
	N total	Amph.	Olig.	Chir.	Biv.	Hydrac.	Cerat.	Eph.	n
Keften-Guba	3.27	1.76	1.10	0.25	0.08	0.01	0.01	0.04	6
Guba Svyatukha	1.56	0.04	1.09	0.38	-	-	0.04	-	6
Padmozero village	4.01	1.84	1.02	0.50	0.03	-	0.62	-	6
	Biomass. g/m²								
	B total	Amph.	Olig.	Chir.	Biv.	Hydrac.	Cerat.	Eph.	n
Keften-Guba	1.34	0.82	0.36	0.03	0.08	0.03	0.01	0.01	6
Guba Svyatukha	0.35	0.02	0.27	0.04	-	-	0.02	-	6
Padmozero village	3.19	1.77	0.67	0.23	0.01	-	0.51	-	6
f, %		100	100	100	67	33	100	33	

Note: n – number of samples; N total - total abundance, thousand ind/m²; B total - total biomass, g/m²; f - frequency of occurrence, %; Amph – Amphipoda; Olig. – Oligochaeta; Chir.- Chironomidae L.; Biv.- Bivalvia; Hydrac. – Hydracarina; Cerat. – Ceratopogonidae; Eph.- Ephemeroptera.

a certain stage in the build-up of a particular species' abundance. This leads to a slowdown in the growth of abundance (or biomass), which reaches an upper limit and then remains at about the same level. This type of population expansion into new habitats is typical of most amphipod species. According to Ryabinkin and Polyakova (2008), the characteristics of *G. fasciatus* are a short life cycle, high fecundity and a high ecological plasticity, which allowed the species to disperse rapidly throughout the water body and to participate in the ecosystem processes of material and energy transformation in Lake Onego.

According to our data, the abundance of macrozoobenthos in Keften-Guba and around Padmozero village was similar, at 3,27 and 4,01 ind/m² respectively. In Guba Svyatukha the total benthos abundance was 2 times lower. Total biomass of bottom organisms was highest near ty of Padmozero village (3.19 g/m²), mainly due to the contribution of Amphipoda.

In terms of abundance in Keften-Guba and near Padmozero village, amphipods were dominates in bottom cenosis (from 46 to 54% of the total abundance) (Fig. 2). Oligochaetes accounted for a significant proportion of abundance (25-34%). Other groups accounted for less than 16% of total abundance.

In Guba Svyatukha, oligochaetes reliably dominate (70% of total abundance), with other groups contributing insignificantly.

In the littoral zone of all studied habitats, amphipods are represented by only one species - the invasive *G. fasciatus*. The native species *G. lacustris*, which previously inhabited the littoral zone of Lake Onego, was not recorded anywhere.

In terms of biomass, *G. fasciatus* dominates in Keften-Guba and Padmozero village 61 and 56 %, respectively (Fig. 2). The rate of oligochaetes is also significant (21-27% of the total biomass). The remaining groups each contribute less than 16%. In Guba Svyatukha, oligochaetes are the dominant species in terms of biomass, representing 77% of the total biomass, while amphipods account for only 5% of the total biomass of bottom organisms.

Our results prove that *G. fasciatus* is widely distributed on the littoral in the Zaonezhye region. Furthermore, materials from the year 2012 indicate that baikalian amphipoda was recorded in the southern part of the reservoir near Voznesenye village (Fig. 3). Observations in the year 2014 showed that *G. fasciatus* was registered on the littoral of Sosnovets and Megostrov islands, where the amphipod plays a key role in terms of abundance. In addition, for the first time, the amphipoda was found in the eastern part of the lake (Cape Besov Nos, Andoma) (Sidorova and Belicheva, 2017). Previously, *G. fasciatus* was identified along the shoreline of Kizhi Island in 2012 (Baryshev et al., 2016). We have shown that in the year 2014 the share of invasive species in benthic abundance exceeded 50%. (Sidorova, in press).

In 2022, we conducted a detailed study of the littoral in the northern part of the water body. For the first time, an invasive species was registered in the littoral zone of Orov-guba in Povenets Bay, where no studies had been conducted before.

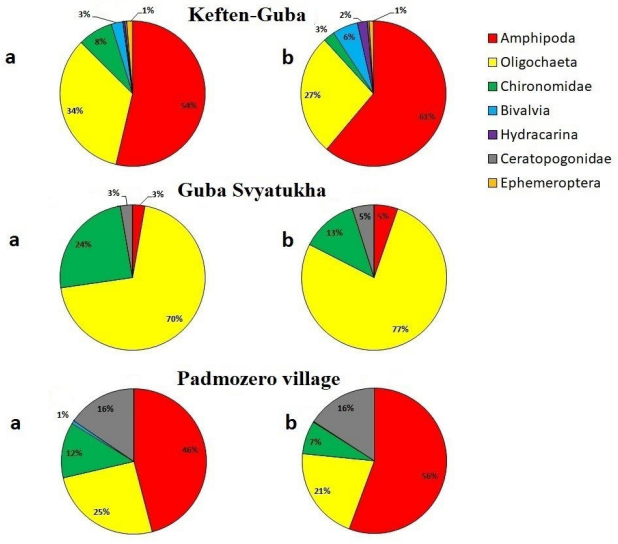

Fig.2. The ratio of macrozoobenthos groups by abundance (a) and biomass (b) at stations of Lake Onego in July 2023.

We have shown that *G. fasciatus* plays a significant role in abundance of the benthic community in almost all studied habitats of the reservoir. On the littoral of Povenets Bay up to the locks of the White Sea-Baltic Canal, the share of amphipods in the community abundance is more than 58%. To the north along the course of the White Sea-Baltic Canal between locks 2 and 3, the crustaceans were completely absent (Sidorova, in press). Future attention should be given to this phenomenon, namely, to the study of the possibility of the species to be included in the benthic biocenoses to the north between the canal locks and the littoral of Lakes Volozero, Matkozero, Telekino, Vygozero, Palokorgskoye and Matkozhnenskoye water bodies and the White Sea.

In addition, a detailed study of the littoral zone of the Lizhemskaya and Unitskaya Bays of Lake Onego is necessary in order to obtain up-to-date data on the distribution of the invasive species *G. fasciatus* and the habitat of the native species *G. lacustris*.

4. Conclusions

The 2023 surveys showed insignificant differences in the spatial distribution of quantitative characteristics of macrozoobenthos, which are related to the diversity of littoral habitats. Macrozoobenthos abundance and biomass varied within the range of 1,56-4,01 ind/m^{2}and 0.35-3.19 g/m^2.

For the first time, the invasive species *G. fasciatus* was registered in the northeastern part of the reservoir on the littoral of Guba Svyatukha and in the vicinity of Padmozero village, where no studies have been conducted before. We have shown that *G. fasciatus* plays a dominant role in terms of communities abundance in two studied stations of the reservoir (in Keften-Guba and Padmozero village). In addition, the native species *G. lacustris* was not registered anywhere. Thus, the results of our study prove that the invasive species has successfully naturalized in the recipient water body - Lake Onego. The range map for this species has been refined to reflect its current distribution in the northeastern part of Lake Onego. It is shown that *G. fasciatus* is included in communities and becomes a frequently occurring and dominant species. Quite rapid dispersal of the Baikal species *G. fasciatus* on the littoral of the reservoir suggests that in the coming years these amphipods may colonize the Lizhemskaya Guba of the lake, where there are habitats not subject to its invasion, according to literature data (Kukharev et al., 2008; Polyakova, 2008).

Acknowledgements

The study was financially supported by the state assignment of the Northern Water Problems Institute of the Karelian Research Centre of the Russian Academy of Sciences.

Conflict of interests

The authors declare that there is no conflict of interest.

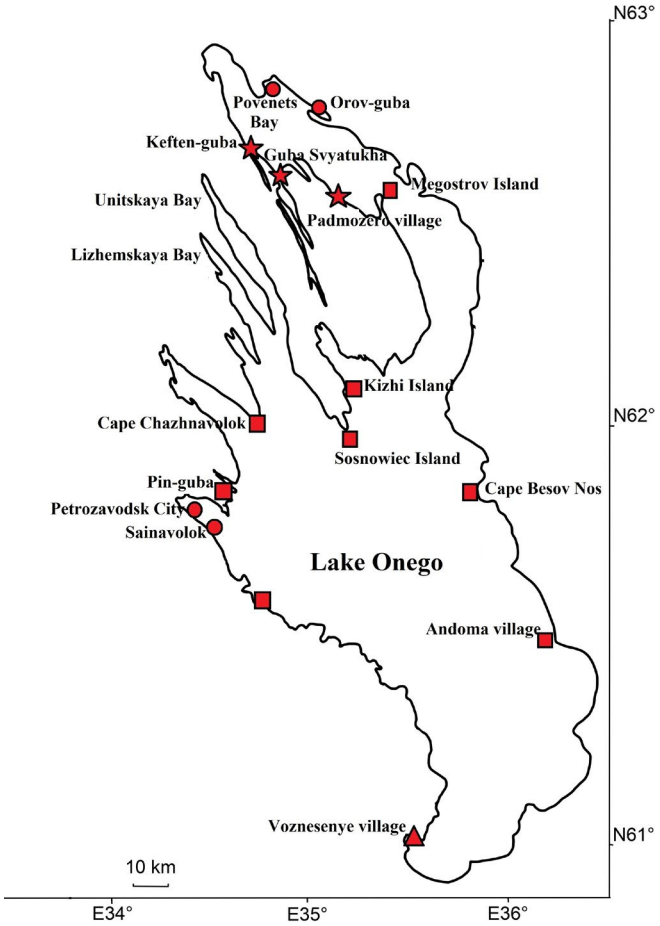

Fig.3. Map of identification of the amphipod *G. fasciatus* in Lake Onego. Star – data from 2023. Triangle – data from 2012 (Sidorova, in press). Square – data from 2014 (Sidorova and Belicheva, 2017). Circle – data from 2022 (Sidorova, in press).

References

Alekseev V.A., Tsalolikhin S.Ya. 2016. Determinator of zooplankton and zoobenthos of fresh waters of European Russia. Vol. 2. Zoobenthos. Moscow- Saint-Petersburg: Scientific Publishing Association KMK. (in Russian)

Arbačiauskas K. 2002. Ponto-Caspian amphipods and mysids in the inland waters of Lithuania: history of introduction, current distribution and relations with native malacostracans. In: Leppäkoski E., Gollasch S., Olenin S. (Eds.), Invasive Aquatic Species of Europe – Distribution, Impacts and Management. Dordrecht, pp. 104–115.

Barbashova M.A., Trifonova M.S., Kurashov E.A. 2021. Features of the spatial distribution of invasive amphipod species in the littoral of Lake Ladoga. Russian Journal of Biological Invasions 12 (2): 136–147. DOI: 10.1134/S207511172102003X

Baryshev I.A., Dyadichko V.G., Savosin E.S. 2016. Aquatic macroinvertebrates of the littoral, marshy shore and puddles of Kizhi Island. Proceedings of the Kivach State Nature Reserve. 7. Petrozavodsk, pp. 85-88. (in Russian)

Bekman M.Yu. 1962. Ecology and production of *Micruropus possolsii* Sow and *Gmelinoides fasciatus* Stebb. Proceedings of the Limnological Institute of the Siberian Branch of the USSR Academy of Sciences 2(1) (in Russian)

Berezina N.A., Panov V.E. 2003. The introduction of the Baikal amphipod *Gmelinoides fasciatus* (Amphipoda, Crustacea) into Lake Onego. Zoologicheskij zhurnal [Zoological Journal] 82(6): 731-734. (in Russian)

Berezina N.A. 2004. Causes, features and consequences of the spread of alien species of amphipods in aquatic ecosystems of Europe. In the book Biological invasions in aquatic and terrestrial ecosystems. Moscow: Partnership of scientific publications KMK, pp. 254-268. (in Russian)

Berezina N.A. 2007. Invasions of alien amphipods (Amphipoda: Gammaridae) in aquatic ecosystems of North-Western Russia: pathways and consequences. Hydrobiologia 590: 15-19.

Filatov N.N. 2010. Onego Lake. Atlas. Petrozavodsk: Karelian Scientific Center of RAS. (in Russian)

Grabowski M., Jażdżewski K., Konopacka A. 2007. Alien Crustacea in Polish waters – Amphipoda. Aquatic Invasions 2(1): 25-38.

Ioffe Ts.I. 1960. Methods of transportation of freshwater invertebrates. Methods of transportation of aquatic invertebrates and fish larvae for the purpose of their acclimatization. Moscow, pp. 25-34. (in Russian)

Ioffe Ts.I. 1968. Review of works performed on acclimatization of forage invertebrates for fish in reservoirs. Proceedings of State Research Institute of Lake and River Fisheries 67: 7-29. (in Russian)

Ivanter E.V., Korosov A.V. 2010. Elementary biometrics. Petrozavodsk. (in Russian)

Jazdzewski K., Konopacka A. 2002. Invasive Ponto-Caspian species n Waters of the Vistula and Oder basins and the southern Baltic Sea. In: Leppäkoski E., Olenin S., Golasch S. (Eds.) Invasive Aquatic Species of Europe. Distribution, Impacts and Management Dordrecht, Boston, London, pp. 384–398.

Kukharev V.I., Polyakova T.N., Ryabinkin A.V. 2008. Distribution of the Baikal amphipod *Gmelinoides fasciatus (Ampipoda, Crustacea)* in Lake Onego. Zoological Journal 87 (10): 1270-1273. (in Russian)

Kurashov E.A., Barbashova M.A., Dudakova D.S. et al. 2018. Ecosystem of Lake Ladoga: current state and trends of its changes at the end of XX - beginning of XXI century. Biosphere 10 (2): pp. 65–121. DOI: 10.24855/BIOSFERA.V10I2.439 (in Russian)

Panov V.E., Pavlov A.M. 1986. Methodology for quantitative counting of aquatic invertebrates in reed and reed beds. Journal of Hydrobiology 22 (6): 87-88. (in Russian)

Polyakova T.N. 2008. “Biological” pollution of aquatic ecosystems. Aquatic environment: an integrated approach to study, protection and utilization. Petrozavodsk: 26-31. (in Russian)

Ryabinkin A.V., Polyakova T.N. 2008. Macrozoobenthos of the lake and its role in fish nutrition. In the book Bioresources of Lake Onega. Petrozavodsk: Karelian Research Center of the Russian Academy of Sciences: 67-91. (in Russian)

Savosin E.S. 2010. Macrozoobenthos and its dynamics during commercial trout farming in Karelia. Abstract of the dissertation. Cand.Sc. (Biology) Petrozavodsk. (in Russian)

Seebens H., Blackburn T.M., Dyer E.E. et al. 2017. No saturation in the accumulation of alien species worldwide. Nature Communications. 8(1): 14435. DOI: 10.1038/ncomms14435

Sidorova A., Belicheva L. 2017. Distribution and population structure of the invasive amphipod *Gmelinoides fasciatus* (Stebbing) in Lake Onego. Environment. Technology. Resources, Rezekne, Latvia Proceedings of the 11th International Scientific and Practical Conference. I: 259-264.

Vinberg G.G., Lavrentieva G.M. 1962. Methodical recommendations on collection and processing of materials for hydrobiological studies in freshwater reservoirs. Zoobenthos and its production. Leningrad, GosNIORX Publ. (in Russian)

Zadoenko I.N., Leys O.A., Grigoriev V.F. 1985. Results and prospects of acclimatization of Baikal gammarids in the USSR reservoirs. Results and prospects of acclimatization of fodder invertebrates in fishery reservoirs. State Research Institute of Lake and River Fisheries, 232. Leningrad, pp. 3-34. (in Russian)