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Article

The European river lamprey *Lampetra fluviatilis* (L., 1758) (Petromyzontidae) as a component of the Neva Bay bottom coenoses

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Abstract. The presence of larvae of the European river lamprey *Lampetra fluviatilis* was reported for the first time from in macrobenthic communities of the Neva Bay of the Gulf of Finland (St. Petersburg, Russia). It has been shown that ammocoetes inhabit several areas, at depths to 12 meters. Apart from ammocoetes, the communities with lamprey larvae contain abundant oligochaetes, bivalves, and less commonly chironomid larvae. At some sites, the number of larvae was up to 80 specimens/m^2, while their biomass was over 90% of the total of the community. The abundance of macrozoobenthos in these sites is generally low (average abundance 190 specimens/m^2, biomass – 70 g/m^2), which is usual in autumn. Intestines of the ammocoetes constantly contained large quantities of diatoms representing common phytoplankton of the Gulf of Finland.

Keywords: ammocoetes, Gulf of Finland, macrozoobenthos, habitat structure, diatoms, phytoplankton, specimens abundance.

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Introduction

The Neva River and its tributaries are sites of active migrations of the European river lamprey *Lampetra fluviatilis* (Linnaeus, 1758). During the spawning run, lampreys are caught on a commercial level within the city borders of St. Petersburg. Despite the strong anthropogenic modification of the river system, lamprey also spawn in small rivers of St. Petersburg, for example, the Smolenka (E.B. Malashichev, St. Petersburg State University, pers. comm., 2019). Also, in 2018, during educational fieldwork, students of St. Petersburg State University found ammocoetes at these sites.

There is no information in the literature on lamprey larvae in the rivers of the historical center of St. Petersburg. In addition to a series of studies by researchers of the Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences (IPEE RAS) on the biology of the European river lamprey in the Chernaya River in the Kurortny District (Pavlov et al., 2014; Polyakova et al., 2019, etc.), we know only the work of Berg (1948), indicating the presence of a large number of ammocoetes in the Fontanka River. We also found no information about the presence of larvae in the Gulf of Finland, in particular, in the Neva Bay. Despite the fact that the Neva Bay is a well-studied basin, and monitoring studies of bottom coenoses are carried out here regularly (Balushkina et al., 2008; Berezina et al., 2008; Maximov, 2015, 2018; Orlova et al., 2008), we found no mention of the presence of lamprey larvae either in the coastal or in the open areas of the bay. Perhaps this because ammocoetes are not taken into account in the analysis of benthic communities. However even in personal communications, specialists of the Zoological Institute of the Russian Academy of Sciences, who extensively study the macrozoobenthos of the Gulf of Finland in general and in the Neva Bay in particular, assert that ammocoetes were not found in the samples. An exception was the monitoring station on the Kanonerskaya shoal, where the larvae were recorded constantly, albeit in low quantities, to depths of two meters (N.A. Berezina and A.A. Maximov (Zoological Institute of the Russian Academy of Sciences (ZIN RAS), pers. comm., 2020). They were not taken into account in their further analyses.

Materials and methods

During hydrobiological monitoring in the Neva Bay of the Gulf of Finland in September - November 2019, lamprey larvae were found in samples of macrozoobenthos.

Sampling was performed at six stations in the water area (Table 1). Most sampling stations are located within the city, near the Neva River or its tributary Yekateringofka River; two stations (station 3 and station 5) are located in the open part of the Neva Bay. The number of individual points at the station ranged from 1 to 8, the number of samples ranged from 1 to 24. A total of 33 samples were taken. Material was collected using a bottom grab (van Veen grab sampler) with a capture area of 0.025 m^2. Two replicates were taken in each sample. At the same time, phyto- and zooplankton were collected from the surface.

The total length and body weight of specimens from the Neva Bay were compared with specimens caught in September 2018 in the Chernaya, Kamenka, and Serebristaya rivers (Leningrad Region). The degree of filling of the intestine of the larvae was assessed visually in points according to Lebedev's (1936) six-point scale.

Results and discussion

Lampreys were recorded at five stations, a total of 18 individuals. The number of individuals at a station ranged from 0 to 8, in some samples it varied from 0 to 4. The abundance in some samples reached 80 specimens/m^2, averaging 10.9 specimens/m^2.

Characteristics of individuals

According to the "Atlas of Freshwater Fish of Russia" (2002), the rivers of the Gulf of Finland are inhabited by the sea lamprey *Petromyzon marinus* Linnaeus, 1758, the European river lamprey *L. fluviatilis*, and the European brook lamprey *L. planeri* (Bloch, 1748). Works on the hybridization of the so-called lamprey species within the genus *Lampetra* within the Baltic basin (Staponkus and Kesminas, 2014; Tsimbalov et al., 2018), data on their ontogeny in different parts of their range (Eneqvist, 1937; Hume, 2012; Privolnev, 1964), and conclusions drawn by Kucheryavyy et al. (Kucheryavyi et al., 2016; Kucheryavyy et al., 2016) allow us to treat the European river and European brook lampreys as a single species *Lampetra fluviatilis*. In addition, the upper lip, cheek, and suboocular area of the captured individuals had no pigmentation (Fig. 1), which is typical of the juvenile European river lamprey, in contrast to the sea lamprey. The tooth formula of the oral disc of the captured smolt was also similar to the formulas of smolts of the European river lamprey: teeth on the lateral fields of the disc were absent.

The total body length (*TL*) of caught lampreys ranged from 40 to 125 mm, body weight (*W*) was 0.08–2.36 g. These included larvae (*n* = 16), one specimen in a state of metamorphosis, and one

Table 1. Structure of the material. N_P – number of sampling sites at a station, N_S – number of samples, N_{SL} – number of samples with lamprey larvae, N_L – number of larvae in samples.

Date	Station	N_P	N_S	N_{SL}	N_L
22.09	st. 1	2	2	2	4; 4
30.09	st. 2	2	2	1	1
04.10	st. 3	2	2	2	1; 2
08.10	st. 4	2	2	0	0
08.11	st. 5	1	1	1	2
29.11	st. 6	8	24	4	2; 1; 1
Total		**17**	**33**	**10**	**18**

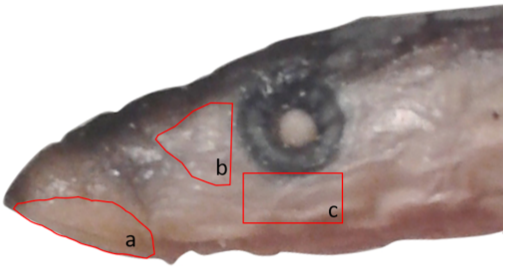

Fig. 1. Pigmentation of the head section of a juvenile specimen of the European river lamprey *Lampetra fluviatilis* from the Neva Bay: (a) upper lip; (b) cheek; (c) subocular area.

smolt. Since the benthic samples were immediately fixed with alcohol, it is difficult to make a reliable morphological comparison with other larvae from the rivers flowing into the Neva Bay. However, the body weight of the recorded ammocoetes is similar (albeit somewhat less) compared to the body weight of larvae of the European river lamprey *L. fluviatilis* (*n* = 46), similar in *TL* caught in the rivers of the Leningrad Region in September 2018 (0.19–2.56 g for larvae of *TL* 45–124 mm). The *TL* of the metamorphic specimen was 125 mm, and of the smolt – 114 mm, which corresponds to the common *TL* for European river lamprey during metamorphosis and downstream migration of smolts from the rivers of the Leningrad region (95–163 mm) (Kucheryaviy et al., 2017), and smaller than the sizes known for metamorphic sea lamprey larvae (136–167 mm) (Renaud, 2011).

Biotope structure

Lamprey larvae were caught at depths of 4 to 12 m in a sediment layer up to 20 cm thick (Table 2). No data were found in the literature of European river lamprey larvae being found at such depths. Larvae of other lamprey species are mainly found at depths to 1 m (Renaud, 2011); only for the sea lamprey *P. marinus* and the Caspian lamprey *Caspiomyzon wagneri* (Kessler, 1870), greater depths of vertical distribution of larvae are indicated, to 16 and 22 m, respectively (Renaud, 2011).

The sediment at the stations consisted mainly of silty fractions; clay, sand and plant debris were also recorded in places (Table 2). The composition of the sediment is quite consistent with the literature data on the typical habitats of lamprey larvae (Fodale et al., 2003; Nazarov et al., 2016; Slade et al., 2003).

Macrozoobenthos

Apart from ammocoetes, invertebrates were also present in the bottom samples. The macrozoobenthos included representatives of eight large taxa: of annelids (Annelida), mollusks (Mollusca), arthropods (Arthropoda) and vertebrates (Vertebrata) (Table 3). Oligochaetes showed the highest frequency of occurrence at all stations of the studied water area. Occurrence of more than 80% was recorded for bivalves (Bivalvia), mainly of the family Unionidae, larvae of midges of the family Chironomidae (Diptera) and larvae of the European river lamprey *L. fluviatilis* (Petromyzontiformes). The remaining organisms had a frequency of no more than 50% and were often represented by single individuals. All these groups, with the exception of lampreys, are typical representatives of the macrozoobenthos of the Gulf of Finland, constituting the basis of the communities of coastal areas (Balushkina and Golubkov, 2017; Berezina et al., 2008; Orlova et al., 2008).

The average number of organisms at all six stations did not exceed 190 specimens/m^2, and the biomass – 70 g/m^2 (Table 3). The abundance indices at the studied sites are significantly lower than those published for the Neva Bay (Balushkina and Golubkov, 2017; Balushkina et al, 2008; Berezina and Golubkov, 2008; Maksimov, 2018; Orlova et al., 2008). Perhaps this is because the samples were taken near hydraulic structures, in places subject to strong anthropogenic impact. The abundance is mainly due to the presence of the Oligochaeta; high biomass values are due to the presence of bivalves and lamprey larvae (Fig. 2). This is typical of this water area, where Oligochaeta, Chironomidae, and Bivalvia total up to 100% of the benthos biomass (Balushkina and Golubkov, 2017; Balushkina et al., 2008; Berezina et al., 2008; Orlova et al., 2008).

Phytoplankton

The phytoplankton was dominated by cyanobacteria and diatoms (Bacillariophyta) characteristic of the phytoplankton of the Neva Bay. The proportion of cyanobacteria ranged from 30 to 99% of abundance and 5–40% of biomass. Diatoms predominantly dominated in biomass, accounting for 50–80% of the total at all stations; their proportion of the abundance is lower, 30–52%, which is consistent with the literature data for autumn phytoplankton (Gubelit, 2008; Gubelit and Nikulina, 2011; Nikulina, 2008).

Zooplankton

At the studied stations, zooplankton is represented by an association of rotifers and crustaceans typical of the Neva Bay in autumn. The samples were

Table 2. Characteristics of habitats. Substrate types[1] according to Fodale et al., 2003: 1 – silt with organic inclusions and plant detritus; 6 – sand with clay; 8 – silt; 9 – sand with clay and silt; 10 – silt with sand. Larval density: figures above the line indicate range, below the line – mean for a station. Bed type[2] by Nazarov et al., 2016: L – low abundance (up to 20 specimens/m^2), M – medium abundance (20–60 specimens/m^2), N – high abundance (> 60 m^2); biotope[3] type by Slade et al., 2003: I – preferred type; II – acceptable type; III – unsuitable type.

Station	Depth, m	Substrate type[1]	Surface / bottom temperature	Larvae density, specimens/m^2	Total biomass of macrozoobenthos, g/m^2	Bed type[2]	Biotope type[3]
st. 1	8.0	9	10.5/–	$\frac{80}{80}$	62.66–76.68	M–H	I
st. 2	9.0–9.5	8	7.0/8.0	$\frac{0\text{–}20}{10}$	0.356–64.02	L–M	I
st. 3	11.8–12.0	10	7.0/–	$\frac{20\text{–}40}{30}$	39.02–220.74	L–M	I
st. 4	5.0	9	6.1/6.6	0	2.88–25.11	–	III
st. 5	12.5	1	4.0/–	$\frac{40}{\text{–}}$	272.557	L–M	II
st. 6	4.0–7.0	6	–/–	$\frac{0\text{–}20}{3.3}$	4.55–52.88	L–M	II

Табл. 3. Characteristics of the macrozoobenthos of the studied water area. O – frequency of occurrence at stations, %; N – number, specimens/m^2; B – biomass, g/m^2 (above the line – variation limits, below the line – mean ± Se).

	O	N	B
Phylum Annelidae			
Class Clitellata			
Subclass Oligochaeta	100	0–440 / 120.0 ± 33.3	0–8.3 / 1.17 ± 0.32
Subclass Hirudinea	17	0–20 / 1.5 ± 0.4	0–0.05 / 0.004 ± 0.001
Class Mollusca			
Class Bivalvia	83	0–60 / 18.5 ± 5.1	0–263.6 / 39.62 ± 11.01
Class Gastropoda	50	0–20 / 4.6 ± 1.3	0–4.86 / 0.43 ± 0.12
Phylum Arthropoda			
Class Malacostraca			
Order Amphipoda	33	0–20 / 3.1 ± 0.9	0–0.3 / 0.03 ± 0.01
Class Insecta			
Order Diptera	83	0–40 / 13.8 ± 3.8	0–0.2 / 0.04 ± 0.01
Order Hemiptera	17	0–20 / 1.5 ± 0.4	0–0.09 / 0.01 ± 0.002
Phylum Chordata			
Class Petromyzontida			
Order Petromyzontiformes			
Lampetra fluviatilis	83	0–80 / 10.9 ± 3.7	0–76.5 / 10.20 ± 3.68
Total		40–520 / 189.2 ± 3.0	0.36–272.2 / 66.95 ± 2.83

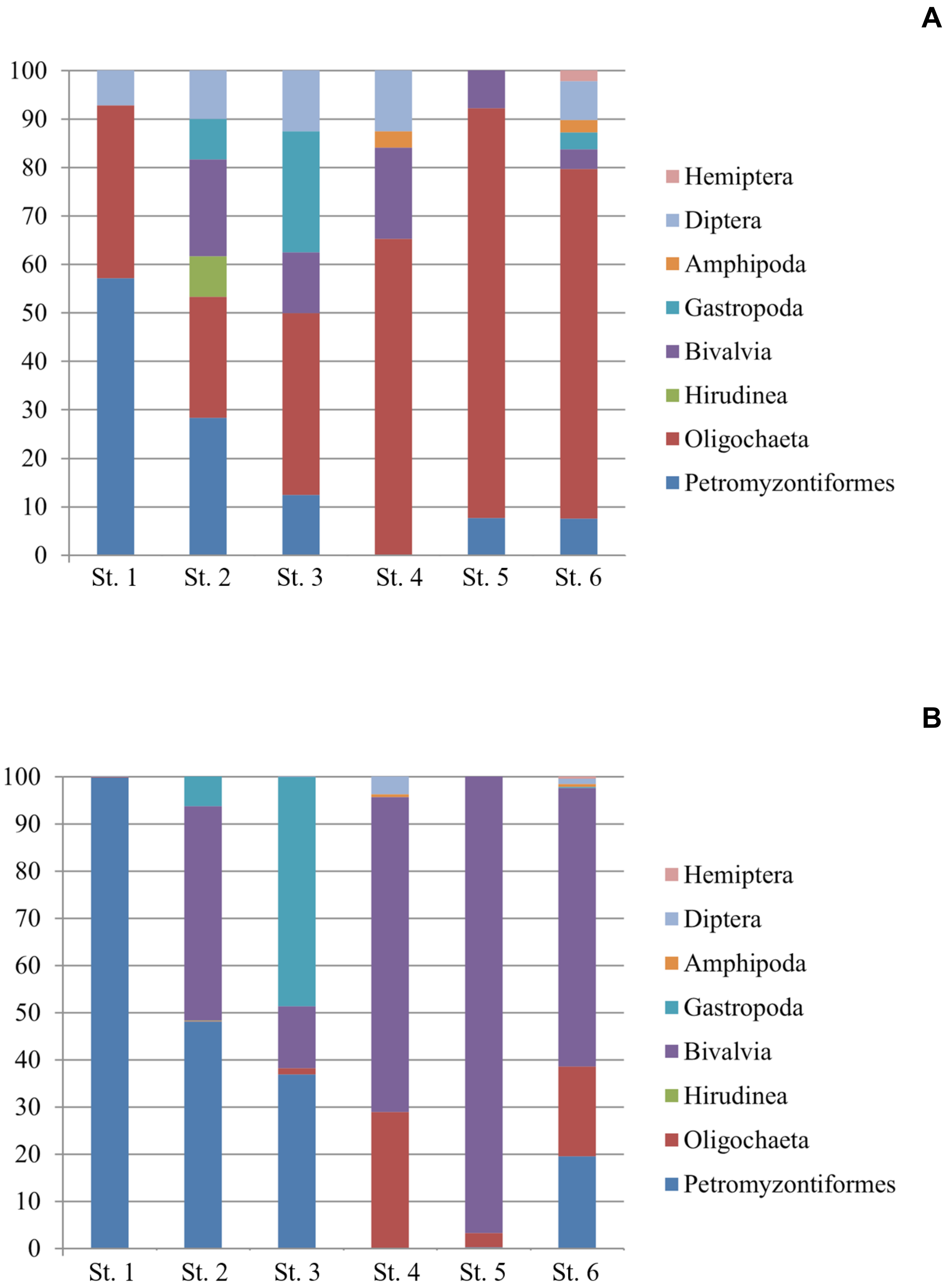

Fig. 2. Mean proportion (%) of individual taxa by abundance (**A**) and biomass (**B**) of macrozoobenthos.

dominated by rotifers and juvenile stages of copepods. Species diversity and abundance indices were very low throughout the entire period at most stations, the abundance was less than 100 specimens/m^3 (38–250 specimens/m^3), and the biomass was in the range of 0.05–4.1 mg/m^3. However, in samples taken at the end of November at station 6, these indices were significantly higher and averaged 425 specimens/m^3 and 14.3 mg/m^3 due to the development of copepods typical of winter zooplankton. In general, the species diversity and abundance of zooplankton was lower than is usually indicated for the Neva Bay in autumn (Telesh, 2008).

Content of the intestine of larvae

The intestines of the metamorphosed larva and the smolt were empty. The rest of the individuals showed a high degree of filling of the intestine. The anterior section had a degree of filling of 1–4 points on Lebedev's (1936) six-point scale of (the majority – 3); middle and posterior sections had 2–4 points (the majority – 4); these sections are densely and evenly filled. The bolus was sediment and plant debris; pollen grains of gymnosperms were recorded. In the intestine of all larvae, diatoms (*Aulacoseira* spp.) were abundantly present, which are most typical and abundant phytoplankton taxa in the Gulf of Finland. Also, *Tabellaria* spp. were found in large numbers in all larvae, while the majority contained *Navicula* spp. and *Cyclotella* sp. Other diatom taxa were recorded singly. The intestine of some individuals contained the green algae *Pediastrum* sp. and golden algae *Dynobrion* sp. recorded in the phytoplankton of the Gulf of Finland. Large phytobenthic forms, usually present in the intestines of ammocoetes in rivers (Polyakova et al., 2019), were not recorded. Since the larvae were found at considerable depths, phytobenthos may be absent from the sediment. This suggests that the larvae can actively feed not only on organisms within the substrate, but also on benthic and planktonic organisms. Animals were not found in food lumps, except for the presence of shells and one whole specimen of the rotifer *Keratella cochlearis* (Gosse, 1851) in two larvae.

Conclusions

The size distribution of the European river lamprey larvae (Polyakova et al., 2019) in the studied samples showed that lamprey larvae of different ages, except for the smallest ones, are found in the Neva Bay. The larvae in the Neva Bay not only survive, but also develop normally, undergo metamorphosis and smoltification. The number of ammocoetes in the Neva Bay can be quite high, their proportion in the biomass of zoobenthos in some cases exceeded 50%. The species diversity of macrozoobenthos in the areas where ammocoetes were captured is impoverished, and the abundance of invertebrates is generally low. The predominant groups were small oligochaetes and bivalves.

The question remains, at what point do the ammocoetes enter the bay? It is currently unknown whether the eggs are carried away immediately after spawning, the larvae enter the Neva Bay as a result of emergence from the spawning grounds and primary dispersal, or the older larvae populate the bay from the rivers flowing into it during redistribution. Further research will help answer these questions.

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