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Review

History of invasion of water bodies in northwestern Russia by amphipods *Gmelinoides fasciatus* (Crustacea)

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Abstract. The summarized literature and our own data on spread of the invasive species *Gmelinoides fasciatus* (Stebbing, 1899) (Crustacea: Amphipoda) in water bodies of northwestern Russia, as well as the chronology of its introduction and invasive corridors for the past 60 years (1962–2022) are presented. *G. fasciatus* began to settle upstream and downstream along the river system after its intentional introduction into the Gorky Reservoir and water bodies of Leningrad Oblast to increase food supply for fish. Currently, this amphipod is recorded in the littoral zone of the largest water bodies of Europe (lakes Ladoga and Onega) and in the easternmost part of the Gulf of Finland. The obtained scenario of *G. fasciatus* invasion can be used in predicting dispersion of another Baikal invader (*Micruropus possolskii* Sowinsky, 1915), which actively colonizes the shallow areas in the southwestern part of Lake Ladoga and is able to expand its habitat under favorable temperature and hydrochemical conditions.

Keywords: invasive species, invasive corridor, Lake Onega, intentional introduction, amphipods

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Научный обзор

История расселения амфиподы *Gmelinoides fasciatus* (Crustacea) в водоемах северо-запада России

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Аннотация. На основе литературных и собственных данных обобщена информация о распространении инвазионного вида *Gmelinoides fasciatus* (Stebbing, 1899) (Crustacea: Amphipoda) в водоемах северо-запада России. Приводится хронология вселения и рассматриваются инвазионные коридоры вида-вселенца за последние 60 лет (1962–2022 гг.). Показано, что после преднамеренной интродукции вида в Горьковское водохранилище и водоемы Ленинградской области с целью увеличения кормовой базы рыб *G. fasciatus* стал расселяться по системе рек вверх и вниз по течению. В настоящее время амфипода зарегистрирована в литоральной зоне крупнейших водоемов Европы (Ладожском и Онежском озерах), а также в самой восточной части Финского залива. Установленный нами сценарий инвазии *G. fasciatus* может быть использован для прогноза распространения другого байкальского вселенца *Micruropus possolskii* Sowinsky, 1915, который активно осваивает мелководные участки в юго-западной части Ладожского озера и может распространиться более широко при благоприятных для него температурных и гидрохимических условиях.

Ключевые слова: инвазионный вид, инвазионный коридор, Онежское озеро, преднамеренная интродукция, бокоплавы

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Introduction

The number of intentional and unintentional introductions of alien species for the last hundred years has dramatically increased worldwide. In spite of numerous research on intentional introduction of invasive species done in the last centuries, we know little about the rates of dispersion and accumulation dynamics of invaders in different regions (Seebens et al., 2017).

Nowadays, the appearance of alien species in the aquatic ecosystems of northwestern Russia occurs quite intensely (Kurashov et al., 2018; Barbashova et al., 2021). Amphipods are among the most active invaders, which are settling beyond their natural ranges and thereby significantly transform the recipient ecosystems (Arbačiauskas, 2002; Berezina, 2007b; Grabowski et al., 2007; Jazdzewski and Konopacka, 2002).

Man-caused elimination of natural barriers between different water basins is one of the most important factors contributing to penetration of many amphipod species into the new aquatic ecosystems. Water transport (shipping) and intentional introduction play a significant role in dispersion of invertebrates as well (Berezina, 2004).

A wealth of material has been gained due to the conducted long-term investigations of distribution of the invasive amphipod *G. fasciatus* (Stebbing, 1899) in the water bodies of northwestern Russia. This paper summarizes the available data on the current spread of the species in water bodies of Northwestern Federal District of Russia (the Republic of Karelia, Leningrad, Pskov, Vologda and Novgorod Oblasts), as well as in the Volga River basin (Cheboksary, Kuibyshev, Volgograd Reservoirs) and the Kama River (Kama and Votkinsk Reservoirs). In addition, the identified invasion routes are proposed and probable further spread of *G. fasciatus* is assessed. This allows to plan works on studying the invasive species and its impact on aquatic ecosystems.

G. fasciatus introduction

G.fasciatus is the only amphipod species of Baikal origin (Berezina et al., 2012). Aquatic invertebrates, including *G. fasciatus,* were introduced in the 1960s and 1970s to improve a food base for fish (Beckman, 1962; Ioffe, 1960, 1968).

First direction of intentional introduction of the species and its subsequent spread

In Leningrad Oblast, *G. fasciatus* introduction into lakes Pravdinskoye and Vorobyevo (Matafonov et al., 2005) was implemented in 1971–1975 and into Lake Otradnoye, where the crustacean population rapidly increased – in 1971 (Nilova, 1976). In 1973–1981, the species was also introduced into Lake Ilmen (Matafonov et al., 2005) (Fig. 1).

From the lakes of the Karelian Isthmus, the crustacean migrated into the largest water body of Europe – Lake Ladoga (see Fig. 1, white arrows), where it was first discovered in 1988 in the coastal thickets of pondweed and reeds near Cape Osinovets of the Petrokrepost Bay. In 1988–1990, *G. fasciatus* was recorded in numerous littoral macrobenthic communities of the western and northern shores of Lake Ladoga (Panov, 1996) (Table 1). In 2006, this species was found throughout the littoral of Lake Ladoga and Valaam Island (Barkov, 2006). The Baikal amphipod managed to inhabit several hundred kilometers to the west (the Neva River estuary) and to the east (Lake Onega) in no time. The species introduction into the Neva Bay of the Gulf of Finland of the Baltic Sea could have occurred naturally from Lake Ladoga and the water bodies of the Karelian Isthmus (Berezina, 2007). In the freshwater part of the Neva Bay, *G. fasciatus* was first detected in 1996 (Alimov et al., 1998). In 1999, it was noted for the first time in brackish waters of the Neva oligohaline estuary (Berezina and Panov, 2003b).

The studies of the benthic fauna of Lake Onega began in the late 18th century, but until the 2000s *G. fasciatus* was not recorded. (Alexandrov, 1954; Kaufman and Polyakova, 1981, 1984, 1990; Polyakova, 1999; Sokolova, 1969, 1974). In 2001, the crustacean was discovered in the western part of the lake (Berezina and Panov, 2003a). N.A. Berezina and V.E. Panov (2003a) believe that *G. fasciatus* could enter this reservoir from Lake Ladoga by the Svir River or from Lake Beloye via the Volga-Baltic Canal. According to Z.S. Kaufman (2011), amphipods penetrated from the Upper Volga basin by the Volga-Baltic Canal.

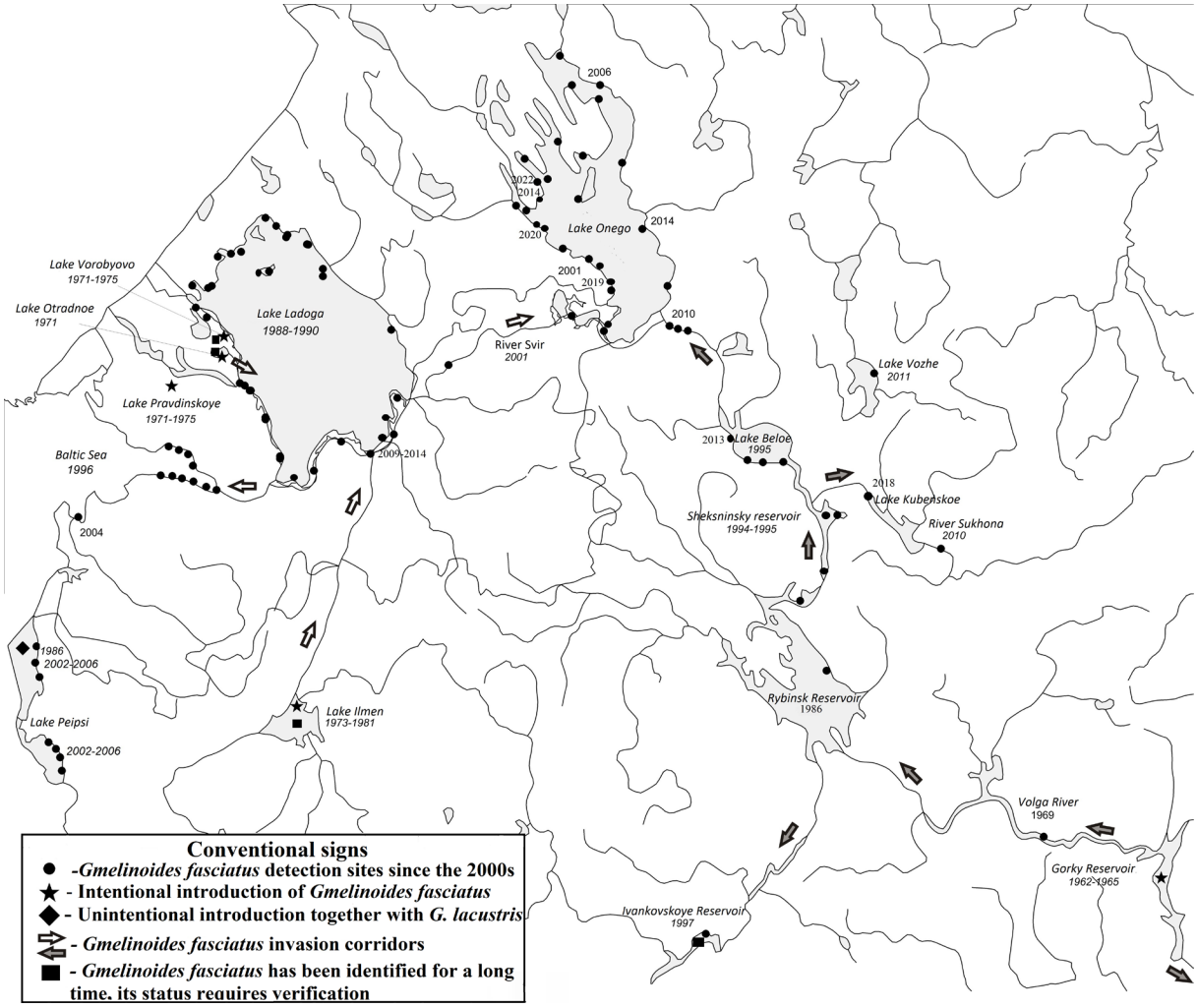

Fig. 1. Schematic map of biological invasion routes of G. fasciatus in lake-river ecosystems of northwestern Russia.

The second direction of intentional introduction of the species and its subsequent spread

In 1962–1965, *G. fasciatus* was introduced into the Gorky Reservoir (Volga River) (Ivanov, 2005). By 1969, it had colonized the entire lake part of the reservoir (Panov and Berezina, 2002). By 1986, this amphipod had penetrated upstream, settled in the Rybinsk Reservoir and reached (1988) Cherepovets town (see Fig. 1, gray arrows) (Matafonov et al., 2005; Panov and Berezina, 2002; Skal'skaya, 1994). At present, it is still recorded in the Rybinsk Reservoir (Perova, 2012; Perova et al., 2018).

Crustaceans continued their settling upstream along the rivers Volga and Sheksna. In 1994–1995, *G. fasciatus* was marked in the river network of the Sheksna Reservoir and in the southern part of Lake Beloye (Shcherbina, 2009). By 1997, this species had populated the Ivankovsk Reservoir (upper reaches of the Volga River) (Matafonov et al., 2005).

Amphipods dispersion occurred along the Volga River, both upstream and downstream. In 1977, they were recorded in the upper part of the Kuibyshev Reservoir (Borodich, 1979; Zinchenko et al., 2008). *G. fasciatus* is still found in this reservoir (Yakovleva et al., 2009).

Unintentional introduction

In 1970–1975, *G. fasciatus* together with *Gammarus lacustris* Sars, 1863 was accidentally introduced to Lake Peipus, where it was identified only in 1986 (Timm and Timm, 1993; Timm et al, 1996).

Current distribution of *G. fasciatus* in the region

Since the 2000s, *G. fasciatus* has become common in the Neva estuary (Berezina, 2009; Orlova et al, 2006; Panov et al, 2002). It is found in the easternmost part of the Gulf of Finland (Berezina, 2007a; Berezina and Panov, 2002; Berezina et al, 2005; Panov et al, 2003). The western boundary of its distribution falls on the southwestern part of the bay, the Luga Bay. Distinguished by its numerous population, the species has been noted in the Luga River mouth since 2004. Initially, the *G. fasciatus* population, apparently, came either from the Narva River basin and Narva Bay, being abundant here since the mid-1990s (Panov et al., 2000), or from the Neva River estuary. Crustaceans could have been brought here with ballast waters of ships (Berezina and Petryashev, 2012).

In recent years, *G. fasciatus* is often noted in the coastal zone of Lake Beloye (Rumelskaya and Filonenko, 2015). According to K.F. Ivicheva (2012), *G. fasciatus* was found throghout during the hydrobiological studies (2009–2011) of the Volga-Baltic Waterway. In the 1990s–2000s, crustacean abundance in Lake Beloye increased (Bolotova and Maximova, 2008). In the aquatic invertebrate communities of the Volga-Baltic Waterway, the discovered at most stations *G. fasciatus* was the dominant species. Note that four stations accounted for more than 96% of biomass (Ivicheva and Filippov, 2013). In the lower reaches of the Sheksna River (2010), this species was plentful on substrates, including large pebbles (Ivicheva and Filonenko, 2011*).*

To date, *G. fasciatus* in Vologda Oblast is recorded both in the tributaries of the Volga-Baltic water system and beyond. This amphipod was found in Topornya Canal and Lake Siverskoye – the part of the Northern Dvina water system connected with the Volga-Baltic water system near the Topornya site (Ivicheva, 2012). In the summer of 2010, *G. fasciatus* was also noted in the Sukhona River, where it had been previously identified by other researchers (Chertoprud, 2006). In 2011, the species was first discovered in Lake Vozhe (Ivicheva, 2012), while in 2018 – in Lake Kubenskoye (Ivicheva et al., 2021). Of the crustaceans, only the Baikal amphipod *G. fasciatus* inhabited thickets of higher aquatic plants in the coastal zone of the Gorky Reservoir accounting up to 27.9% of invaders' biomass in the shallows (Kurina and Seleznev, 2019). In the Cheboksary Reservoir, the species was rare (Perova et al., 2018). Single representatives were discovered in the Kuibyshev and Volgograd Reservoirs (Kurina and Seleznev, 2019). In 2006, *G. fasciatus* was found in the Volga River at the city of Tver (Schletterer and Kuzovlev, 2012). It also colonizes the Kama River, the lower and middle reaches of which are regulated and represent a cascade of reservoirs. In 2012, *G. fasciatus* was first recorded in the Sylva Bay of the Kama Reservoir, the Sylva-Chusov section, at the dam area of the Kama Reach (Levshino settlement and Dobryanka town), and in the Obvinsky Bay mouth. *G. fasciatus* was most abundant in the Sylva Bay. In some sites, its number reached 7.4 thous. specimens/m^2 (Istomina, 2015). In 2014–2016, the invader became a permanent component of the benthic fauna of the dam and central (below the Obvinsky Bay mouth) parts of the Kama Reach. At different stations, its number varied from 20 to 2000 specimens/m^2 (Istomina, 2017). Mass development of *G. fasciatus* was also noted in the Votkinsk Reservoir (Kurina et al., 2021). In the Kama Reservoir, its frequency of occurrence reached 25% (Kurina et al., 2021).

In 2002–2006, the invasive species *G. fasciatus* became dominant (about 43% of the total number of macrozoobenthos) in the coastal zone of Lake Pskov-Chudskoye (Kangur et al., 2010). According to V.E. Panov et al. (2000), it inhabited the littoral zone and the Narva River.

Barbashova M.A. et al. (2021) reported about settling the invasive amphipods of the Baikal (*G. fasciatus*, *Micruropus possolskii* Sowinsky, 1915) and Ponto-Caspian origin (*Pontogammarus robustoides* Sars, 1894, *Chelicorophium curvispinum* (Sars, 1895)) in Lake Ladoga. *G. fasciatus* dominated only in sites free from invaders. The range of Ponto-Caspian amphipods was limited by the Volkhov Bay. A significant development of *P. robustoides* and intensive expansion of *M. possolskii* to the south along the western coast of the lake indicate the ongoing structural reorganization of littoral biocenoses.

Our previous studies demonstrate a wide spread of *G. fasciatus* across the littoral of Lake Onega. For instance, the materials of 2012 are evidence of the Baikal amphipod appearance in the southern part of the lake near the village of Voznesenye. Observations (2014) show the presence of *G. fasciatus* in the littoral of Sosnovets and Megostrov islands, where this species plays a key role in terms of abundance (own data). It was also found in the eastern part of the lake (Cape Besov Nos, Cape Pery Nos, Andoma) (Sidorova and Belicheva, 2017). In 2012, *G. fasciatus* was noted in the littoral of Kizhi Island (Baryshev et al., 2016); its share in Lake Onega benthos in 2014 exceeded 50% (own data).

According to the literature data, the amphipod was first noted in Keften Bay of Lake Onega in 2006–2009. (Savosin, 2010), where solely coastal areas of the Lizhemsk Bay were not subject to its invasion (Kalinkina et al., 2009; Kukharev et al., 2008; Polyakova, 2008). Based on our findings, the native *G. lacustris* and invasive *G. fasciatus* species coexist simultaneously only in one habitat (station 9, Cape Chazhnavolok) (Fig. 2). In bottom biocenosis, the biomass of the native species is higher (38%) than that of the invader (19%) (own data).

In 2022, we conducted thorough studies of the littoral in the northern part of Lake Onega. The invasive species in the previously unstudied coastal zone of the Orov Bay of the Povenets Gulf was recorded for the first time (own data). A proportion of *G. fasciatus* in the bottom community of almost all studied habitats of the lake was significant. For instance, amphipods exceeded 58% (stations 14, 16) in the littoral of the Povenets Gulf up to the locks of the White Sea-Baltic Canal (Fig. 2). To the north, i.e. along the White Sea-Baltic Canal, station 15 located at a flood site between locks 2 and 3, crustaceans were completely absent (own data). Further studies should pay attention to probable species appearance in bottom biocenoses to the north, between the locks of the canal and the littoral of lakes Volozero, Matkozero, Telekino, Vygozero, Palokorskoye and the Matkozhnensk Reservoir, including the White Sea.

In spite of recent wide spread of the alien amphipod in the littoral, it was not previously recorded in the rivers of the Lake Onega basin. In 2019 and 2020, it was found in the estuarine zones of watercourses (rivers Rybreka and Drugaya), far from the lake littoral (0.5 and 1.7 km, respectively) (Baryshev, 2021).

Potential routes of further migration

The invasive species *G. fasciatus* is constantly expanding its current range, moving upstream and downstream from the sites of introduction (Berezina, 2007; Berezina et al., 2001; Nilova, 1976; Panov, 1996; Panov and Berezina, 2002; Panov et al., 2000; Skal'skaya, 1994; Timoskin, 2001). Interconnection of river basins in Europe provides active or passive migrations (with ballast water or by attaching to ship hulls) of aquatic animals from one region to another. There are four invasion corridors between the southern and northern European seas (Galil et al., 2007). In particular, the northern corridor includes the route Volga → Lake Beloye → Lake Onega → Lake Ladoga → Neva River → Baltic Sea (Bij de Vaate et al., 2002). Due to intensive shipping, the Baikal species *G. fasciatus* is able to penetrate from the Gulf of Finland of the Baltic Sea into the Great Lakes of North America (Panov and Berezina, 2002). The open shipping route through the Saimaa Canal also represents a corridor for migration of invasive species with water transport going from the Baltic Sea to the inland lakes of Finland (Dudakova et al., 2017; Pienimaki and Leppäkoski, 2004). The species invasion from Lake Ladoga to Lake Saimaa is also possible via the Vuoksi River. However, the recent studies by D.S. Dudakova et al. (2017) show that the native species *G. lacustris* in Lake Saimaa still represents the main and, apparently, the only species of littoral amphipods. Introduction of alien species has been not recorded. It is worth noting that the species may spread through Lake Onega → White Sea-Baltic Canal → White Sea as well (Panov et al., 2007).

Important, invasive amphipods currently play a significant role in the benthic communities of the littoral zone of Lake Ladoga despite their relatively recent appearance here. In contrast to *M. possolskii,* the species *G. fasciatus* turned out to be the most common in 2014 likely because of its later appearance in the lake. The conducted studies (2017–2019) suggest that the Baikal invader *M. possolskii* is actively developing the shallows of the southwestern part of the lake and has already entered from the coastal biotopes into the central part of the Petrokrepost Bay demonstrating quite high quantitative indicators. The habitat of *P. robustoides* and *C. curvispinum* is still limited to the Volkhov Bay. Further spread of Ponto-Caspian amphipods is probably hindered by low mineralization of lake waters.

Conclusion

In the course of our research, a map of the range of the alien species *G. fasciatus* was created. It represents the current distribution and invasion of this species in water bodies of Northwestern Russia. In the past 60 years, intentioanal introduction of *G. fasciatus* greatly contributed to its wide spread in the lake-river systems of the study territory. The obtained invasion scenario can be used in predicting a probable expansion of another Baikal invader, i.e. *M. possolskii* (in case of favourable temperature and hydrochemical conditions), which intensively colonizes the shallow areas in the southwestern part of Lake Ladoga and has already penetrated from the coastal biotopes into the central part of the Petrokrepost Bay (Barbashova et al., 2021). Invasion of other water bodies by two alien species (*P. robustoides* and *C. curvispinum*) from Lake Ladoga is not currently feasible because of their insignificant number.

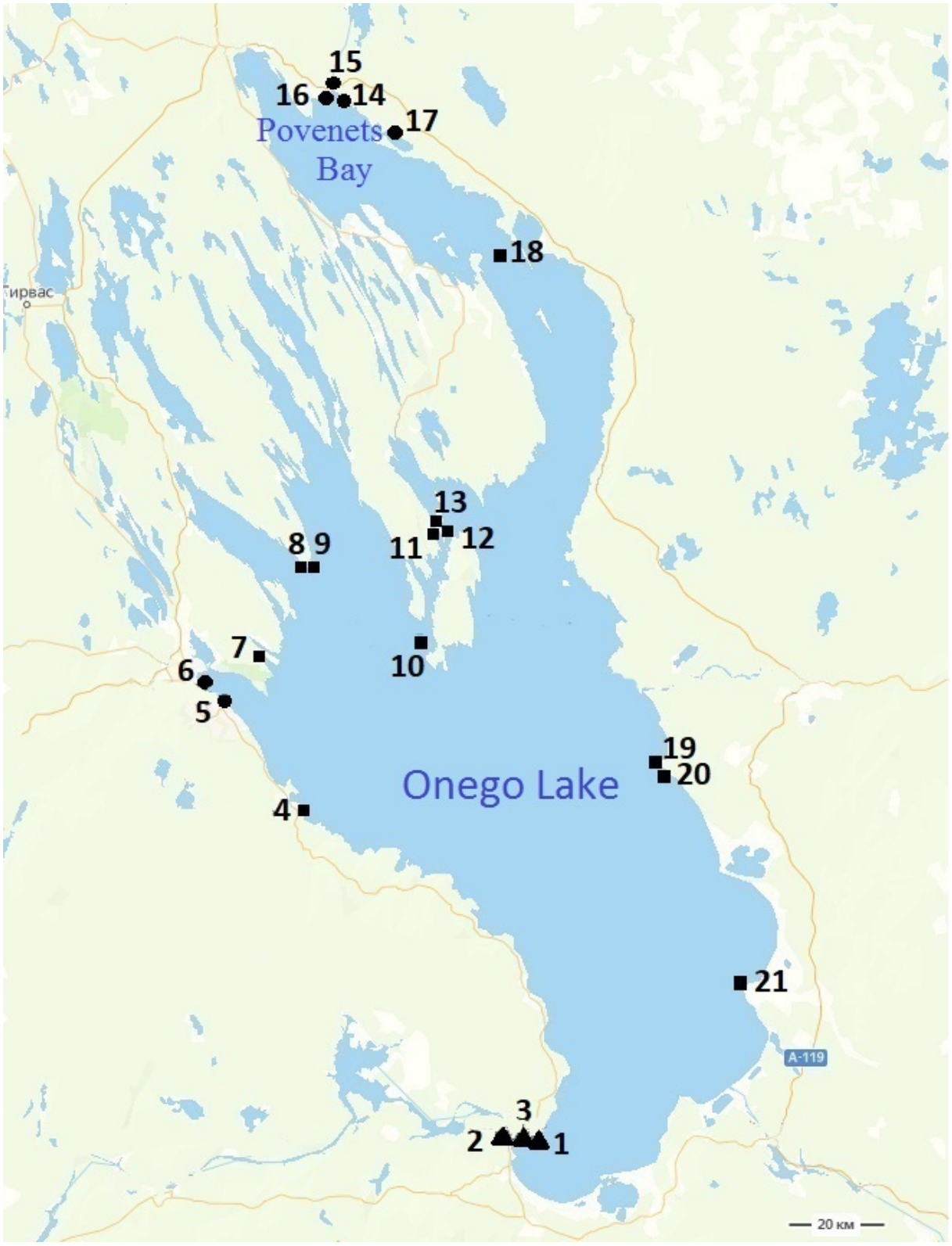

Fig. 2. Map of localities of *G. fasciatus* found in Lake Onega. Triangle – 2012 (own data); square – 2014 (Sidorova and Belicheva, 2017); circle – 2022 (own data). Station numbers are given in Table 1.

Table 1. CSummary data on sites of *G. fasciatus* detection in water bodies of northwestern Russia. * – stations are indicated in Fig. 2.

Water body	Station no.	Station name	Coordinates according to literature		Coordinates		Year of discovery	Source
			N	E	N	E		
Lake Ladoga	1		60°06.2'	31°05.0'	60.103333	31.083333	1988	Panov, 1996
Lake Ladoga	2		60°22.9'	30°53.0'	60.381667	30.883333	1989	Panov, 1996
Lake Ladoga	3		60°34.2'	30°40.8'	60.57	30.68	1989	Panov, 1996
Lake Ladoga	4		60°36.2'	30°36.3'	60.603333	30.605	1989	Panov, 1996
Lake Ladoga	5		60°37.1'	30°32.1'	60.618333	30.535	1989	Panov, 1996
Lake Ladoga	6		61°04.8'	30°05.4'	61.08	30.09	1989	Panov, 1996
Lake Ladoga	7		61°08.8'	29°56.0'	61.146667	29.933333	1990	Panov, 1996
Lake Ladoga	8		61°16.8'	30°06.8'	61.28	30.113333	1990	Panov, 1996
Lake Ladoga	9		61°17.6'	29°53.6'	61.293333	29.893333	1990	Panov, 1996
Lake Ladoga	10		61°31.2'	30°33.4'	61.52	30.556667	1990	Panov, 1996
Lake Ladoga	11		61°34.8'	31°27.2'	61.58	31.453333	1989	Panov, 1996
Lake Ladoga	L3–10	Naziya	59°53.991′	31°23.311′	59.89985	31.388517	2017–2019	Barbashova et al., 2021
Lake Ladoga	L2	Kobona	60°01.282′	31°32.678′	60.021367	31.544633	2017–2019	Barbashova et al., 2021
Lake Ladoga	L3	Dubno	60°13.271′	31°55.006′	60.221183	31.916767	2014	Barbashova et al., 2021
Lake Ladoga	L10-14	Volkhov Bay, 4 km from Volkhov mouth, left	60°07.643′	32°15.693′	60.127383	32.26155	2009–2014	Barbashova et al., 2021
Lake Ladoga	L13–10	Syas River mouth	60°09.090′	32°27.996′	60.1515	32.4666	2009–2014	Barbashova et al., 2021
Lake Ladoga	5	Voronovo village	60°16.353′	32°37.525′	60.27255	32.625417	2009–2014	Barbashova et al., 2021
Lake Ladoga	6	Svir Bay	60°31.449′	32°41.063′	60.52415	32.684383	2014	Barbashova et al., 2021
Lake Ladoga	7	Andrusovskaya Cove	60°58.735′	32°36.235′	60.978917	32.603917	2014	Barbashova et al., 2021
Lake Ladoga	8	Near Mantinsari Island	61°20.521′	31°39.832′	61.342017	31.663867	2014	Barbashova et al., 2021

Water body	Station no.	Station name	Coordinates according to literature		Coordinates		Year of discovery	Source
			N	E	N	E		
Lake Ladoga	10	Near Pitkjaranta, in strait opposite factory	61°33.954′	31°28.040′	61.5659	31.467333	2014	Barbashova et al., 2021
Lake Ladoga	13	Haukkalahti Bay	61°38.121′	31°11.263′	61.63535	31.187717	2014	Barbashova et al., 2021
Lake Ladoga	13b	Haukkalahti Bay	61°38.121′	31°11.263′	61.63535	31.187717	2014	Barbashova et al., 2021
Lake Ladoga	12	Entrance to Impilahti Bay	61°37.276′	31°10.404′	61.621267	31.1734	2014	Barbashova et al., 2021
Lake Ladoga	15	Near Ljaskelja	61°42.415′	31°00.037′	61.706917	31.000617	2014	Barbashova et al., 2021
Lake Ladoga	17	Bay near Rautalahti Peninsula	61°45.063′	30°52.716′	61.75105	30.8786	2014	Barbashova et al., 2021
Lake Ladoga	18	Valaam Island, Lake Sisjarvi	61°22.840′	30°55.946′	61.380667	30.932433	2014	Barbashova et al., 2021
Lake Ladoga	19	Valaam Island, cove near Nikolsky hermitage	61°23.722′	30°56.573′	61.395367	30.942883	2014	Barbashova et al., 2021
Lake Ladoga	20	West coast of Putsari Island	61°30.868′	30°31.784′	61.514467	30.529733	2014	Barbashova et al., 2021
Lake Ladoga	21	Yakkimvarskiy Bay, Sorolo	61°29.159′	30°13.816′	61.485983	30.230267	2014	Barbashova et al., 2021
Lake Ladoga	22	Koyeonsari Island	61°17.069	30°08.891′	61.284483	30.148183	2014	Barbashova et al., 2021
Lake Ladoga	22b	Koyeonsari Island, 200 m to left of station 22	61°17.069	30°08.891′	61.284483	30.148183	2014	Barbashova et al., 2021
Lake Ladoga	4	Shchuchiy Bay, Littoral, thickets	61°04.920′	30°05.420′	61.082	30.090333	2013–2018	Barbashova et al., 2021
Lake Ladoga	4a	Shchuchiy Bay, Littoral, thickets	61°04.910′	30°05.430′	61.081833	30.0905	2013–2018	Barbashova et al., 2021
Lake Ladoga	23	Priozersk, mouth of Vuoksa River, bay near factory	61°02.446′	30°09.756	61.040767	30.1626	2014	Barbashova et al., 2021
Lake Ladoga	23b	Priozersk, 400 m to exit to Ladoga	61°02.629′	30°10.707	61.043817	30.17845	2014	Barbashova et al., 2021
Lake Ladoga	26	Vladimirskaya Cove	60°50.093′	30°27.931′	60.834883	30.465517	2014	Barbashova et al., 2021

Water body	Station no.	Station name	Coordinates according to literature		Coordinates		Year of discovery	Source
			N	E	N	E		
Lake Ladoga	28	Dalekaya Cove	60°34.320′	30°40.552′	60.572	30.675867	2014	Barbashova et al., 2021
Lake Ladoga	30	Cape Osinovets	60°06.662′	31°05.306′	60.111033	31.088433	2014	Barbashova et al., 2021
Lake Onega	1	Above the city of Petrozavodsk	61°48' 08"	34°26'30"	61.802222	34.441667	2001	Berezina and Panov, 2003
Lake Onega	2	Petrozavodsk, shipyard	61°50' 08"	34°18'06"	61.835556	34.301667	2001	Berezina and Panov, 2003
Lake Onega	3	Devichiy Bay	61°31' 37"	30°00'03"	61.526944	30.000833	2001	Berezina and Panov, 2003
Lake Onega	4	Brusno Island	61°28' 05"	35°17'45"	61.468056	35.295833	2001	Berezina and Panov, 2003
Lake Onega	5	South-western part	61°15' 11"	35°36'03"	61.253056	35.600833	2001	Berezina and Panov, 2003
Lake Onega	6	Svirskaya Bay	60°58' 28"	35°29'59"	60.974444	35.499722	2001	Berezina and Panov, 2003
Lake Onega	7	Svir River, Voznesenskoye village	61°04' 44"	35°03'34"	61.078889	35.059444	2001	Berezina and Panov, 2003
Lake Onega	8	Svir River, Lodeynoye Pole village	61°44' 47"	33°36'57"	61.746389	33.615833	2001	Berezina and Panov, 2003
Lake Onega	1	Povenetsky Bay, northern part	62°49,026	34°48,989	62.8171	34.816483	2006	Kukharev et al, 2008
Lake Onega	2	Povenetsky Bay, central part	62°36,088	35°01,961	62.601467	35.032683	2006	Kukharev et al, 2008
Lake Onega	3	Povenetsky Bay, southern part	62°47.994	34°42.709	62.7999	34.711817	2006	Kukharev et al, 2008
Lake Onega	4	Maloe Onego Bay	62°06.629	35°43.876	62.110483	35.731267	2006	Kukharev et al, 2008
Lake Onega	5	Velikaya Bay	62°07.557	35°22.071	62.12595	35.36785	2006	Kukharev et al, 2008
Lake Onega	6	Kizhi skerries	62°06.408	35°14.082	62.1068	35.2347	2006	Kukharev et al, 2008
Lake Onega	7	Bolshoye Onego Bay	62°07.643	34°56.657	62.127383	34.944283	2006	Kukharev et al, 2008
Lake Onega	8	Kondopoga Bay	62°09.801	34°16.021	62.16335	34.267017	2006	Kukharev et al, 2008

Water body	Station no.	Station name	Coordinates according to literature		Coordinates		Year of discovery	Source
			N	E	N	E		
Lake Onega	1*	Voznesenye village			61.014343	35.493751	2012	own data
Lake Onega	2*	Voznesenye village			61.015441	35.492748	2012	own data
Lake Onega	3*	Voznesenye village			61.016129	35.491926	2012	own data
Lake Onega	4*	Area Sosnovy Bor			61.5732205	34.7172096	2014	own data
Lake Onega	5*	Petrozavodsk Bay, st. 2, Petrozavodsk, Sainavolok area			61.750830	34.482612	2022	own data
Lake Onega	6*	Petrozavodsk Bay, st. 1, Petrozavodsk, ul. Moskovskaya			61.804436	34.350120	2022	own data
Lake Onega	7*	Pin-guba			61.8670686	34.5458994	2014	own data
Lake Onega	8*	Cape Chazhnavolok, st. 1			62.015785	34.732926	2014	Sidorova and Belicheva, 2017
Lake Onega	9*	Cape Chazhnavolok, st. 2			62.015258	34.732392	2014	own data
Lake Onega	10*	Sosnowiec Island			61.878489	35.149960	2014	Sidorova and Belicheva, 2017
Lake Onega	11*	Kizhi Island, st. 1			62.074419	35.221299	2014	own data
Lake Onega	12*	Kizhi Island, st. 2			62.080124	35.226964	2014	own data
Lake Onega	13*	Kizhi Island, st. 3			62.083907	35.219840	2014	own data
Lake Onega	14*	Povenets village, st. 1			62° 49,682'	34° 50,702'	2022	own data
Lake Onega	15*	Povenets village, st. 2			62° 51,076'	34° 50,608'	2022	own data
Lake Onega	16*	Povenets village, st. 3			62° 50,463'	34° 49,330'	2022	own data
Lake Onega	17*	Orov-guba			62.764214	35.048733	2022	own data
Lake Onega	18*	Megostrov Island			62.563463	35.430866	2014	Sidorova and Belicheva, 2017
Lake Onega	19*	Cape Periy Nos			61.681303	36.037790	2014	own data
Lake Onega	20*	Cape Besov Nos			61.674086	36.024275	2014	Sidorova and Belicheva, 2017

Water body	Station no.	Station name	Coordinates according to literature		Coordinates		Year of discovery	Source
			N	E	N	E		
Lake Onega	21*	Andoma village			61.283288	36.366783	2014	Sidorova and Belicheva, 2017
Lake Onega	1	Rybreka River	61°16′21″	35°31′55″	61.2725	35.531944	2019	Baryshev, 2021
Lake Onega	2	River Drugaya	61°16′21″	35°33′27″	61.2725	35.5575	2020	Baryshev, 2021
Lake Onega	2	River Drugaya	61°15′36″	35°32′37″	61.26	35.543611	2020	Baryshev, 2021
Lake Onega	3	Sheltozerka River	61°22′47″	35°21′52″	61.379722	35.364444	2020	Baryshev, 2021
Lake Onega	4	Orzega River	61°48′38″	34°35′33″	61.810556	34.5925	2020	Baryshev, 2021
Vytegra Reservoir	1	Vytegra reservoir, between the village of Ankhimovo and the village of Shestovo	60°58′02,6″	36°29′10,8″	60.967389	36.486333	2013	Ivicheva and Filippov, 2013
Belousovo Reservoir	2	Belousovo reservoir, mouth of the river Nagazhma	60°58′11,5″	36°32′46,8″	60.969861	36.546333	2013	Ivicheva and Filippov, 2013
Belousovo Reservoir	3	Belousovo reservoir, south of the village of Ozerki	60°56′57,8″	36°36′27,2″	60.949389	36.607556	2013	Ivicheva and Filippov, 2013
Sheksna Reservoir	7	Sheksna reservoir, mouth of the river Megra	60°11′04,9″	37°14′23,0″	60.184694	37.239722	2013	Ivicheva and Filippov, 2013
Sheksna Reservoir	8	Sheksna reservoir, near the village of Topornya	59°41′34,4″	38°26′33,4″	59.692889	38.442611	2013	Ivicheva and Filippov, 2013
Sheksna Reservoir	9	Sheksna reservoir, northern part of the island Razbuy	59°40′08,2″	38°28′04,1″	59.668944	38.467806	2013	Ivicheva and Filippov, 2013
Sheksna Reservoir	10	Sheksna reservoir, below the village of Sheksna	59°07′59,9″	38°19′25,8″	59.133306	38.323833	2013	Ivicheva and Filippov, 2013

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