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RESEARCH ARTICLE

New data on *Nippotaenia mogurndae* distributed together with its fish host in European part of Russia

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Abstract

The authors studied the distribution of an invasive species of rotan fish *Perccottus glenii* in diverse water bodies located in the Nizhny Novgorod, Kaluga, and Chelyabinsk regions, Republic of Tatarstan of the Russian Federation. All the studied water bodies are under the influence of anthropogenic press of different nature and degree of impact. Of the 8 water bodies, 4 are located in a specially protected area. The authors identified the habitats of *Perccottus glenii* in all surveyed geographical locations. In these water bodies, the infection of rotan with an associated alien specific cestode, *Nippotaenia mogurndae*, was studied for the first time. The introduction of a parasite with a rotan was revealed in 7 out of 8 geographical points. The parasitic subsystem of "*Nippotaenia mogurndae–Perccottus glenii*" is stable, including in water bodies in protected areas and urbanized territories, under significant anthropogenic stress. For most of the studied water bodies, a "riverine" vector of invasion of the species is currently marked – settlement along the hydrographic network: riverbeds, coastal sections of water bodies, including the development of floodplain water bodies. The cestode *Nippotaenia mogurndae* was used as a biological marker for analysing vectors and pathways of geographical dispersal of *Perccottus glenii*. The effectiveness of using *Nippotaenia mogurndae* in water bodies initially inhabited by "aquarium" individuals was noted to identify the "second wave" of *Perccottus glenii* expansion with a different vector of invasion.

Keywords
Perccottus glenii, *Nippotaenia mogurndae*, biological invasions, vector of invasion, invasion meltdown

Introduction

The large-scale spread of alien species has become one of the key environmental problems of mankind since the middle of the 20th century. In Russia, the introduction and self-dispersal of invasive species and the spread of animal and plant diseases are recognized as one of the main threats to species diversity (National Strategy 2001). Particularly vulnerable ecosystems include aquatic biota and urbanized areas. The intensification of the spread of aquatic organisms in the last 30–40 years has been associated with the construction of canals, dams, and an increase in the volume and number of shipments (Slynko et al. 2011).

Perccottus glenii Dybowski, 1877 is one of the five fish species included in the list of "The Most dangerous invasive species in Russia (TOP 100)" (Dgebuadze et al. 2018). The native range of the species is freshwater water bodies in East Asia in the Amur River basin and some other rivers in the Far East of the Russian Federation, northeastern China, and northern North Korea (Berg 1949; Reshetnikov 2010). The modern range of the rotan was formed as a result of the development of more than 10 subdistricts (Reshetnikov, Ficetola 2011). The species has been recorded in Belarus, Bulgaria, Hungary, northern Kazakhstan, Latvia, Moldova, Mongolia, Poland, Russia, Romania, Serbia, Slovakia, Ukraine, and Estonia (Reshetnikov 2010). In the west, it is found on the territory of Croatia (Çaleta et al. 2010), Germany (Reshetnikov and Schliewen 2013). Rotan is one of the rapidly spreading alien species in the European part of Russia (Reshetnikov et al. 2013). It is believed that in the Russian Federation it has spread in the Amur basin to its upper reaches, the Shilka and Argun rivers, to the Baikal basin and the European part of Russia, and the water bodies of Siberia (Vechkanov et al. 2007; Reshetnikov 2010) rotan was found at the junction of the basins of the Kuanda-Vitim-Lena rivers (Andreev et al. 2011). In the following years, the range of the rotan is projected to expand to most of Western Europe, as well as to other regions of Siberia (Reshetnikov and Ficetola 2011).

The main ways (vectors) of rotan distribution are the release of aquarium specimens, aquaculture and self-settlement (Dgebuadze et al. 2018; Reshetnikov 2013). For example, the formation of the rotan Moscow subrange was connected with the activity of the Amur Ichthyological Expedition (1945–1949) led by G.V. Nikolsky. In 1948, individuals of *Perccottus glenii* were brought to Moscow State University for scientific observation. The offspring of the fish were kept in amateur aquariums, and since 1950 aquarium specimens have been released into water bodies in Moscow and the Moscow Region (Reshetnikov 2001). Rotan was accidentally introduced along with herbivorous fish to Western Ukraine and the Lake Baikal basin (Reshetnikov 2013).

The study of the geographic distribution of one of the most "aggressive" invaders of the Amur River basin and the composition of the fauna of its parasites is of considerable interest for several reasons. The species is highly resistant to changes in environmental factors, has a high reproductive potential, a wide range of nutrition, rapidly increases its numbers, becomes involved in biocenotic relationships, and is capable of disrupting the balance in the ecosystem and destroying established relationships (Elovenko 1979; Reshetnikov and Ficetola 2011). The introduction of *Perccottus glenii* is known to have a negative impact on populations of native species macroinvertebrates, amphibians and a fish (Reshetnikov 2003, 2008; Fayzulin 2021). In small isolated bodies of water, small native fish species may be displaced (Reshetnikov 2003, 2013). The spread of alien species in protected areas (in nature reserves, national parks) requires special attention.

The most effective method of studying the spread of *Perccottus glenii* is a combination of spatial and temporal data analysis, molecular genetic and parasitological analysis (Reshetnikov et al. 2025). The results of studies of the genetic polymorphism of alien species are useful for clarifying their taxonomic status, identifying sources of invasion, and reconstructing distribution routes (Alyamkin et al. 2022). Parasitological studies of *Perccottus glenii* fish should be considered as the most important component of comprehensive studies of invasive species.

Perccottus glenii is able to participate in the circulation of more than 100 species of parasites, including non-native ones (Reshetnikov 2013; Sokolov et al. 2014b). A specific cestode, *Nippotaenia mogurndae* Yamaguti et Miyata, 1940, associated with *Perccottus glenii*, has spread with its host to many European and Siberian invasive populations (Mierzejewska et al. 2010; Reshetnikov et al. 2011b; Sokolov et al. 2014a; Sokolov, Reshetnikov 2020). In recipient water bodies its prevalence, abundance, and aggregation are considerably higher than in the native range (Sokolov et al. 2023). This, combined with the characteristics of the parasite's life cycle, makes it possible to successfully use *Nippotaenia mogurndae* as a biological marker for analyzing the pathways and vectors of rotan invasion (Reshetnikov et al. 2017; Sokolov 2018; Sokolov et al. 2025).

The purpose of this work is to study different types of water bodies in the regions of Russia for the spread of an invasive species in them – *Perccottus glenii*. The specific cestode of *Nippotaenia mogurndae* was used as a biological marker to determine the mode of introduction of rotan in water bodies outside its natural range.

Materials and methods

The authors collected material in 2016, 2017, and 2023 in different types (lake, pond, river) of water bodies located in the Nizhny Novgorod, Kaluga, and Chelyabinsk regions of the Russian Federation (Fig. 1, Table 1). The original data on Lake Maloe Glubokoe and published data are analyzed authors with additions on the distribution of rotan in the lakes Bolshoe Glubokoe, Maloe Lebyazhye, Dryanichnoye, Maryino, located in the city of Kazan (Republic of Tatarstan) (Fig. 2, Table 1).

Figure 1. Cartographic scheme of the regions in which the studied water bodies are located.

Figure 2. Cartographic scheme of sampling points in the Republic of Tatarstan.

Table 1. Coordinates of the location of sampling points of *Perccottus glenii* (2016, 2017, 2023)

No	Geographical point	Coordinates		Years
		N	E	
	Nizhny Novgorod Region			
1	Pond near the village Voznesenskoe	54.8897	42.7375	2016
	Kaluga region			
2	Pond in Kaluga district	54.5714	36.2296	2016
	Chelyabinsk Region			
3	River Miass	55.1752	61.3560	2016
	Republic of Tatarstan (City Kazan)			
4	Lake Bolshoe Glubokoe	55.8401	48.9771	2017[1], 2023
5	Lake Maloe Glubokoe	55.8473	48.9634	2023
6	Lake Maloe Lebyazhye	55.8375	48.9604	2017[1]
7	Lake Dryanichnoye	55.8347	49.0091	2017[1]
8	Lake Maryino	55.8326	49.1032	2017[1]

Note: [1] by Nazarov et al. 2018 with additions.

Fish were caught using a float rod with a set of hook tackle, and a 10×10 mm mesh net was used in the coastal part of the water bodies. The standard body length of fish was measured from the front edge of the snout (with the mouth closed) to the base of the middle rays of the caudal fin SL (cm) (Bykhovskaya-Pavlovskaya 1985). The size range of fish in the samples is represented by individuals with body sizes from 2.3 to 12.4 cm (Table 2).

Fish samples from 7 water bodies are representative, the volume of rotan samples from 3 ponds pond near the village Voznesenskoe is less than the standard minimum (15 ind.). However, the samples from all reservoirs are comparable in size of individuals (Table 2) and allow you to get the primary information.

156 fish rotan specimens were examined for infection with a specific cestode *Nippotaenia mogurndae* using the method of incomplete parasitological autopsy (Bykhovskaya-Pavlovskaya 1985) (Table 2). The taxonomic affiliation of the parasites was determined according to the relevant reference literature (Scarlato 1987). Generally accepted indicators were used to assess the infection of fish: parasite prevalence P (the proportion of host infected with parasites out of the total number of fish in the sample, %), abundance index AI (the average number of parasites of the same species in all studied individuals, including uninfected ones, ind.), intensity of invasion II (min–max) (the minimum and maximum number of parasites of the same species in the host individuals, ind.). When the sample size of fish was less than 15 copies, the parasite prevalence P value was indicated as the number of infected individuals from the total number of fish studied.

Table 2. Parameters of *Perccottus glenii* samples from the studied water bodies (2016, 2017, 2023)

No	Geographical point	N, ind.	SL, cm	Years
1	Pond near the village Voznesenskoe	7	4.6–8.5	2016
2	Pond in Kaluga district	19	3.8–10.9	2016
3	River Miass	15	5.9–6.8	2016
4	Lake Bolshoe Glubokoe	17	3.0–11.5	2017
		21	2.4–9.2	2023
5	Lake Maloe Glubokoe	16	2.3–9.9	2023
6	Lake Maloe Lebyazhye	15	3.9–10.2	2017
7	Lake Dryanichnoye	31	8.1–12.4	2017
8	Lake Maryino	15	4.1–12.0	2017
		$N_{general}$ 156	$SL_{min-max}$ 2.3–12.4	–

Note: N – Number of fish, ind.; SL – fish body length, cm.

Results

The invasive species *Perccottus glenii* was observed in all the studied water bodies (regardless of type) during the entire study period (Tables 1, 2). In these geographical locations, the infection of rotan with the cestode *Nippotaenia mogurndae*, specific to fish of the Odontobutidae family, was studied for the first time (Dubinina 1971). The parasite was registered in *Perccottus glenii* in 7 out of 8 surveyed geographical points, in water bodies with varying degrees of anthropogenic load. The characteristics of fish infection by the parasite are presented in Table 3.

Table 3. Parameters of infection of *Perccottus glenii* by the cestode *Nippotaenia mogurndae* when living in water bodies with varying degrees of anthropogenic impact (2016, 2017, 2023)

No	Water body	P,% AI (II), ind.	Anthropogenic load	Years
1	Pond near the village Voznesenskoe	4 out of 7 2.71 (2–9)	water intake for fire extinguishing, household needs	2016
2	Pond in Kaluga district	0	urbanized territory, man–made impact, pollution (industrial waste)	2016
3	River Miass	20.0 0.33 (1–2)	urbanized territory, man–made impact, pollution (V–VI quality class)	2016

No	Water body	P,% AI (II), ind.	Anthropogenic load	Years
4	Lake Bolshoe Glubokoe	29.41 047 (1–3)	Protected areas, significant recreational impact, recreational fishing[2, 3]	2017
		14.29 0.19 (1–2)		2023
5	Lake Maloe Glubokoe	43.75 1.63 (2–6)	Protected areas, significant recreational impact, recreational fishing[2, 3]	2023
6	Lake Maloe Lebyazhye	53.33 1.53 (1–8)	Protected areas, significant recreational impact, recreational fishing, dredging works, pollution (quality class II–III)2,3	2017
7	Lake Dryanichnoye	93.55 10.48 (1–36)	Protected areas, significant recreational impact, recreational fishing	2017
8	Lake Maryino	53.33 3.0 (2–9)	Urbanized area, significant recreational and man–made impacts, recreational fishing, pollution (quality class III)[4]	2017

Notes: P – parasite prevalence, %; AI – abundance index, ind.; II – intensity of invasion, ind.; [1] – by Zaripova and Fayzulin 2016; [2, 3] – by Barieva 2003; Mingazova et al. 2005; [4] – by Mingazova et al. 2015.

High values of invasion rates of *Nippotaenia mogurndae* were noted for rotan from the lakes of the Republic of Tatarstan (Table 3). The maximum degree of invasion was recorded for fish from Lake Dryanichnoe: parasite prevalence 93.55%, abundance index of more than 10 ind., intensity of invasion of up to 36 ind. parasites per host individual.

In the lakes of Maloe Lebyazhye and Maryino, more than half of the fish in the samples are infected with cestodes. A high infection rate of fish (even with an insufficient sample size) is recorded in pond near the village Voznesenskoe (Nizhny Novgorod region) Minimal infection with *Nippotaenia mogurndae* was noted for *Perccottus glenii* from the River Miass. The cestode is not registered in rotan from three water bodies in Kaluga district.

Using the example of Kazan lakes, the possibility of negative effects of rotan on the native ichthyofauna of recipient water bodies was investigated. Table 4 shows data on the occurrence of juvenile native fish species in the digestive tract *Perccottus glenii*.

Table 4. Occurrence of individuals of *Perccottus glenii* in the lakes of Kazan, in the diet of which juveniles of native fish species are noted

No	Geographical point	Occurrence, %	SL_{juv}, cm	Years
1	Lake Bolshoe Glubokoe	35.29	7.9–8.9	2017
		0	2.4–9.2	2023
2	Lake Maloe Glubokoe	0	2.3–9.9	2023

No	Geographical point	Occurrence, %	SL_{juv}, cm	Years
3	Lake Maloe Lebyazhye	0	3.9–10.2	2017
4	Lake Dryanichnoye	16.13	9.7–11.7	2017
5	Lake Maryino	0	4.1–12.0	2017

Notes: Occurrence, % – the proportion of rotan individuals with juvenile fish of native species (including undetectable remains) in their digestive tract as a percentage of the number of fish in the sample; SL_{juv}, cm – the length of *P. glenii* individuals, at which juvenile fish are found in the intestines of the rotan.

Discussion

The expansion of species ranges often occurs in the form of «invasion meltdown» (Dogel 1949; Simberloff, Von Holle 1999), while the naturalization of one species promotes the establishment of others. The parasitic subsystem "*Nippotaenia mogurndae—Perccottus glenii*" is a vivid example of the spread of an invasive species of parasite associated with a single invasive host species in the ecosystems of recipient water bodies. The cestode *Nippotaenia mogurndae* is widespread in the rotan in both native and invasive parts of its range (Sokolov et al. 2014b; Sokolov, Reshetnikov 2020; Sokolov, Zhukov 2016). The infection of *Perccottus glenii* with a specific parasite outside its natural range indicates the presence of all parts of the complex life cycle of the cestode in the new water body (Scarlato 1987): parasite – copepods *Mesocyclops leuckarti* (Claus, 1857) (main intermediate host) – *Perccottus glenii* (final host). It is known that the ability of *Nippotaenia mogurndae* to colonize new territories is largely determined by the wide distribution of *Mesocyclops leuckarti*, which is used as an intermediate host (Sokolov et al. 2011). In addition to *Mesocyclops leuckarti*, copepods can also serve as intermediate hosts in the acquired parts of the range *Neutrodiaptomus incongruens* (Poppe, 1888), *Eucyclops serrulatus* (Fischer, 1851), *M. crassus* (Fischer, 1853) (Rusinek 1989; Sokolov et al. 2011). When rotan enters recipient water bodies from the aquarium, this chain is interrupted due to the absence of an intermediate host in the aquarium water. During aquarium breeding, parasites with a complex life cycle do not persist (Reshetnikov et al. 2017; Sokolov et al. 2025). Thus, the infection of fish with *Nippotaenia mogurndae* confirms the fact that rotan has penetrated into new water bodies, excluding the stage of keeping in the aquarium, that is, during introduction work or by self-dispersal.

The ways of infection of the *Nippotaenia mogurndae* rotan are determined by the size of the fish: individuals with a body length of up to 8 cm become infected by feeding on planktonic copepods, and larger fish become infected by cannibalism (Reshetnikov et al. 2011a). For individuals larger than 8 cm, the role of cannibalism in the infection of parasites has not been unequivocally confirmed (Gorlacheva et al. 2015). For example, in large specimens of rotan in some water bodies of Poland (the Włocław reservoir) infected with cestoda, their own juveniles are not registered in the diet (Grabowska et al. 2009) or was it detected only once (Mierzejewska et al. 2010). According to our observations, in the water bodies of the Volga region, infection with *Nippotaenia mogurndae* was observed in individuals of rotan, starting from a body length of 3.9 cm (Rubanova, Fayzulin 2025).

Nizhny Novgorod region. Pond near the village of Voznesenskoe also belongs to the basin of the river Barnabas. It is a fire water body for storing water necessary for outdoor firefighting and household needs (Table 3).

The cestode *Nippotaenia mogurndae* was found in rotan from pond near the village of Voznesenskoe, and fish infection is quite high (Table 3). This corresponds to the literature data on the Nizhny Novgorod region, where the parasite was first discovered in 1995-1996 in the floodplain lakes of the Oka River (Fadeeva 2001).

Currently, rotan is widespread everywhere from the upper reaches of the Volga to its lower reaches (Elovenko 1980; Reshetnikov, Ficetola 2011). The introduction of *Perccottus glenii* occurred during unintentional transportation together with stocking of commercial fish in 1970–1971, when, together with *Cyprinus carpio haematopterus* Temminck et Schlegel, 1846, it was brought into the ponds of the Ilevskiy fish farm in the Gorky (Nizhny Novgorod) region (Kuderskiy 1980). The fish ponds of the village of Ilev belong to the basin of the Sarma River, which, like the Barnava River, is a tributary of the Moksha River. According to another version, rotan came to the region as a result of the settlement of the "Moscow population" and the simultaneous accidental import of carp along with its producers (Zaloznih 1984).

Kaluga region. A pond on the territory of abandoned quarries in Kaluga has been investigated. The area adjacent to the reservoir is heavily littered (Table 3).

The cestode *Nippotaenia mogurndae* has not been recorded in rotan. Representative sample size of fish (Table 2) gives grounds to assert that the population of *Perccottus glenii* in this water body was formed due to aquarium individuals, which contributed to the loss of cestodes from the parasites. The results of the parasitological study confirm the literature data on the ways of spreading rotan the region. It is believed that *Perccottus glenii* penetrated from the Moscow region, spreading in floodplain water bodies down the Oka River (Babushkin 1990) and he reached the Kaluga region.

Chelyabinsk region. The sampling site on the coast of the Miass River is located at a distance of 100 m from the Kalininsky district of Chelyabinsk. The Miass River is a tributary of the Iset River (the basin of the Tobol River, the left tributary of the Irtysh River), belongs to the basin of the Ob River, where *Perccottus glenii* is classified as a mass species inhabiting water bodies of various types, with the exception of rivers with a fast current (Korlyakov 2019).

The composition of rotan parasites in the Miass River has not been studied to date. According to researchers, no *Nippotaenia mogurndae* has been found in rotan in the Tobol River basin in four lakes of the Chelyabinsk region (Korlyakov, Dubchak 2010). According to the literature, *Perccottus glenii* got into the water bodies of the Southern Trans-Urals in an "aquarium" way (Dubchak and Magazov 2004;

Korlyakov and Dubchak 2010). The fish specimens we studied from the Miass River were invaded infected by the cestode *Nippotaenia mogurndae*, which allows us to conclude that the current composition of the rotan population in the Miass River basin is formed by individuals who settled in a "non-aquarium" way. That is, two different vectors of invasion can be traced for rotan populations.: 1) an "aquarium" method of distribution; 2) a source of invasion that excludes aquarium fish.

It is known that populations of rotan infected by *Nippotaenia mogurndae* may have mixed origins (Reshetnikov et al. 2011b). For example, populations of *Perccottus glenii* without *Nippotaenia mogurndae* (supporting aquarium release) were found in the upper and middle reaches of the Moskva River basin (Reshetnikov et al. 2017). Populations containing *Nippotaenia mogurndae* have been recorded in the lower reaches of the Moskva River, as well as in the basins of the Klyazma and Tsna Rivers, indicating an indicative non-aquarium release (Reshetnikov et al. 2017). Since these three rivers are tributaries of the Oka River, the current composition of rotan populations in its basin is formed from at least two separate introduction events from different sources (Reshetnikov et al. 2017).

The results obtained are consistent with the literature data on higher polymorphism of rotan populations in the Irtysh River basin, as well as significant genetic differentiation between the populations of rotan in the Volga and Irtysh basins (Zhigileva et al. 2025). The data of genetic studies only partially confirm the generally accepted hypothesis about the colonization of Siberia by rotan through the South Ural transference corridor, indicating the presence of several heterogeneous sources of *Perccottus glenii* introduction in the Ob-Irtysh basin (Zhigileva et al. 2025).

The Republic of Tatarstan. Water bodies located in urbanized territories are exposed to a complex anthropogenic impact of a high degree, which leads to deterioration of water quality, changes in hydrochemical and hydrological regimes, and disruption of the structure of aquatic communities (Mingazova et al. 2005). The studied water bodies are located on the territory of the Kazan city district (Fig. 5, Table 1). Four of them belong to protected areas of local importance – the Lebyazhye urban forest Park (National Register 2007) (Table 3).

Lakes Bolshoe and Maloe Glubokoe

The water bodies are located in the northern part of the Lebyazhye Forest Park. The ecosystems of Lake Bolshoe and Maloe Glubokoe have undergone significant transformation due to agricultural and industrial development of the catchment area (Tokinova et al. 2024), there is a tendency to reduce the area and shallowness (https://docs.cntd.ru/document/917034098).

Lake Maloe Lebyazhye

The water body has undergone significant anthropogenic transformation (Mingazova et al. 2005). The recreational load on the reservoir is many times higher than the recreational capacity. The water corresponds to quality class II-III (Table 3).

Lake Maryino

The ecological condition is assessed as tense (Table 3). The water corresponds to the III quality class "moderately polluted". In 2012–2013, the Maryino Lake Ecopark was established. In 2019–2020 Measures have been taken to ensure the ecorehabilitation of the reservoir (Derevenskaya 2025).

Lake Dryanichnoye

The water body is located in the Kirovsky district, where the Lebyazhye forest park area adjoins the village of Levchenko (https://docs.cntd.ru/document/917034098). The water body is experiencing recreational stress as a place of recreation for the population.

An important factor determining the effectiveness of the implementation of the life cycle of *Nippotaenia mogurndae* is the composition of the zooplankton community. Various types of anthropogenic use of Kazan lakes (recreational, agricultural, communal, etc.) cause non-specific changes in zooplankton communities, which manifest themselves in a decrease in species richness, a change in dominant species, and a change in quantitative indicators (Derevenskaya 2022). *Mesocyclops leuckarti* (recorded in 75% of lakes) and *Eucyclops serrulatus* are among the intermediate hosts of *Nippotaenia mogurndae* in Kazan lakes. These species are not included in the dominant zooplankton complexes of the studied water bodies, but they are among the most widespread (Derevenskaya 2005, 2022, 2025; Urazaeva, Derevenskaya 2017). The widespread distribution of these species contributed to the functioning of the parasitic subsystem "*Nippotaenia mogurndae–Perccottus glenii*" in all studied water bodies with varying degrees of anthropogenic stress (Table 3).

The maximum degree of fish infection was noted in Lake Dryanichnoye. The values of fish infection indicators in Lake Bolshoe Glubokoe are low and have interannual differences (Table 3). Taking into account the unstable level regime of the water body and the tendency to shallowing, this indicates changes in the habitat conditions of aquatic organisms and the structure of the zooplankton community in different years. The indicators of fish infection in Lakes Maloe Glubokoe, Maloe Lebyazhye and Maryino are similar in values (Table 3). High values of parasite prevalence indicate close trophic relations of fish with the zooplankton community.

The discovery of the cestode *Nippotaenia mogurndae* in rotan in all the studied water bodies of Kazan confirms the version that its penetration into the water bodies of the Republic of Tatarstan is associated with accidental import, most likely during introduction work. Analysis of the genetic diversity and differentiation of *Perccottus glenii* populations in the Volga region (Kuibyshev reservoir basin) has shown that samples from different water bodies have a relatively low level of polymorphism, poorly genetically differentiated from each other, which indicates origin from the same source (Zhigileva et al. 2025).

The inclusion of rotan in the ichthyofauna of urban lakes under the influence of anthropogenic stress is the reason for the restructuring of ichthyocenoses, which can lead to a decrease in biodiversity, transformation and degradation of aquatic ecosystems (Kuznetsov et al. 2005). Table 5 shows data on the composition of the ichthyofauna of the studied lakes in Kazan.

Table 5. The current composition of the ichthyofauna of the studied lakes in Kazan (according to: Kuznetsov et al. 2005; Saifullin 2006; Rahimov et al. 2025; authors' data)

No	Geographical point	Types of fish
1	Lake Bolshoe Glubokoe	*Perccottus glenii* (Dybowski, 1877) *Rutilus rutilus* (Linnaeus, 1758)[1] *Leucaspius delineatus* (Heckel, 1843)[1]
2	Lake Maloe Glubokoe	*Perccottus glenii* (Dybowski, 1877) *Carassius carassius* (Linnaeus, 1758)[2] *Rutilus rutilus* (Linnaeus, 1758)[1]
3	Lake Maloe Lebyazhye	*Perccottus glenii* (Dybowski, 1877) *Carassius carassius* (Linnaeus, 1758) *Leucaspius delineatus* (Heckel, 1843)[1]
4	Lake Dryanichnoye	*Perccottus glenii* (Dybowski, 1877)[3]
5	Lake Maryino	*Perccottus glenii* (Dybowski, 1877) *Carassius carassius* (Linnaeus, 1758)[2]

Notes: [1] – species for which rotan is a limiting factor; [2] – the dominant type; [3] – authors' data.

Perccottus glenii got into the water bodies of the Middle Volga region, presumably during introduction work (Karpevich and Bokova 1963; Kuderskiy 1980). According to other sources, the species entered the basin of the Kuibyshev reservoir from reservoirs in the Moscow region (Kuznetsov et al. 2005). The first registration of rotan in the Sviyazhsky Bay of the reservoir dates back to 1981 (Shamov 1983). In the modern composition of the ichthyofauna of the Kuibyshev reservoir, *Perccottus glenii* has the status of a common species with a local distribution (Schakirova et al. 2019). The occurrence of the *Perccottus glenii* in all lakes of the city of Kazan is high (Rahimov et al. 2025). Rotan has been recorded in the ichthyofauna of the Kuibyshev reservoir area near the city of Kazan (Kuznetsov et al. 2005), this indicates a "riverine" vector of invasion of the species on the territory of the Republic of Tatarstan. Rotan spreads through rivers, coastal areas of reservoirs, and floodplain reservoirs. This method of rotan settlement in the lakes of the city of Kazan is consistent with the literature data on the distribution of *Perccottus glenii* in the Middle

Volga region (Semenov 2011; Artaev 2016). Rotan has been registered in the lakes of the Lebyazhye group since 1997–1998 (Saifullin 2006). Rotan was noted in all the studied reservoirs of the city of Kazan (Table. 5). There are no literature data on the composition of ichthyofauna on Lake Dryanichnoye. Rotan is probably the only fish species here (Table 5).

The golden crucian carp *Carassius carassius* (Linnaeus, 1758) is found in almost all the lakes of the city. In small lakes (Maryino, Maloe Glubokoe) it is the dominant species of the ichthyofauna (Table. 5), in Lake Maryino – the only species capable of living together with a *Perccottus glenii* (Rahimov et al. 2025) (табл. 5). The common roach *Rutilus rutilus* (Linnaeus, 1758) is a numerous species in Lakes Bolshoe and Maloe Glubokoe (Rahimov et al. 2025). Rotan is able to exert invasive pressure on the population of *Rutilus rutilus* (Table 5). Prior to the appearance of the rotan, the Sunbleak *Leucaspius delineatus* (Heckel, 1843) was the dominant species in the Lebyazhye Lake system and the background species in other lakes. It is currently found in Lake Maloe Lebyazhye. The distribution of rotan is one of the main limiting factors for *Leucaspius delineatus* (Table 5).

It is known that the rotan diet includes a wide range of animal species of all trophic levels, as a result of which the species is able to reduce the diversity of aquatic macroinvertebrates, amphibian larvae, and fish, including extremely negative effects on reproduction *Carassius carassius* (Reshetnikov 2003). In conditions of urban small lakes under high anthropogenic pressure, the inclusion of rotan in the ichthyofauna often leads to destabilization of hydrobiocenoses, a decrease in biodiversity and degradation of aquatic ecosystems (Rahimov et al. 2025). An analysis of the occurrence of juvenile local fish in the food spectrum of the rotan rat has shown the possibility of a negative impact on the abundance of local species in individual reservoirs water bodies (Table 4). Thus, juvenile *Rutilus rutilus* was observed in rotan with a body length of 7.9 cm in Lake Bolshoe Glubokoe (2017). Here, fish as an object of nutrition is found in rotan with a shorter body length than in other bodies of water. For example, in the bays of the Kuibyshev reservoir, the rotan turns to a predatory lifestyle with a body length of 9.37 cm (Semenov 2010). Native juveniles in the digestive tract of *Perccottus glenii* were not observed even in larger individuals of 9.8–11.5 cm in Lake Bolshoe Glubokoe. Perhaps, in the studied lakes of Kazan, a rotan of this size is not prone to cannibalism and, therefore, does not become infected with *Nippotaenia mogurndae* when consuming its own young. This assumption is confirmed by the absence of cestodes in the intestines of most of the largest fish in the samples. The exception is Perccottus glenii specimens from Lake Dryanichnoe with a body length of 12.1–12.4 cm, infested with cestodes (Table 4). Undetectable remains of juvenile fish were found in rotan specimens with a body length of 9.7 cm in Lake Dryanichnoe. In this case, the infection is most likely the result of cannibalism in the absence or low abundance of other fish species (Table 5). Similar trophic behavior of the rotan is observed in other water bodies (floodplain lakes of the middle reaches of the Oka River), where cannibalism is noted in individuals with a body length of at least 15 cm (Bykov 2022).

The number of rotan in water bodies is able to regulate ichthyophages *Esox lucius* and *Perca fluviatilis* (Litvinov and O'Gorman 1996; Dgebuadze et al. 2018). In the lakes of the city of Kazan, rotan lives in the absence of predators (Rahimov et al. 2025). Therefore, with a low species diversity of the ichthyocenosis, represented by 1–2 species of fish (Table. 5), *Perccottus glenii* is a competitor for the food supply; in some water bodies, the rotan is a direct consumer of juvenile native fish species.

Conclusions

The authors provide new data on the geographical distribution of the "aggressive" alien species *Perccottus glenii* in 8 freshwater water bodies of various types in 4 regions of Russia. Rotan invasion by a specific cestode, *Nippotaenia mogurndae*, was detected in 7 out of 8 surveyed water bodies. The high values of parasite infection in a number of reservoirs indicate the main intermediate host of the cestode *Mesocyclops leuckarti* and the close trophic relationships the zooplankton community. Infection of larger fish is usually associated with the rotan's ability to cannibalize. It is suggested that cannibalism is not observed or is only slightly developed in some reservoirs of the Republic of Tatarstan, as indicated by the absence of *Nippotaenia mogurndae* in larger fish. It is shown that the parasitic subsystem of "*Nippotaenia mogurndae–Perccottus glenii*" successfully functions regardless of the degree and nature of the anthropogenic load on recipient water bodies.

It is noted that the detection of *Nippotaenia mogurndae* in populations of rotan, which has historically been introduced by the "aquarium" method, directly indicates the expansion of water bodies by populations of the "second wave" of *Perccottus glenii*, characterized by a different vector of invasion (excluding the "aquarium" method).

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