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The Parasite Fauna of the Round Goby *Neogobius melanostomus* (Perciformes, Gobiidae) in the Kuybyshev Reservoir (Middle Volga)

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Abstract—The fauna of multicellular parasites of the round goby *Neogobius melanostomus* (Pallas, 1814) was studied in three reaches of the Kuybyshev Reservoir. Ten species and forms of parasites unidentified to species level were found, including metacercariae *Holostephanus cobitidis* and *Apatemon gracilis* that are specific to the family Gobiidae. The alien trematode *Nicolla skrjabini* is the dominant species in the parasite fauna of the round goby in the studied reservoir; its native range is restricted to the rivers of the Sea of Azov and Black Sea basin.

Keywords: round goby, parasite fauna, infestation, Kuybyshev Reservoir

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INTRODUCTION

The intensification of biological invasions in recent years is associated with significant anthropogenic (numerous intentional introductions of species, river flow regulation, canal construction, increased shipping, etc.) and climate (first of all, an increase in the average annual ground temperature and surface water temperature) changes on the planet (*Biologicheskie invazii*..., 2004; Slynko et al., 2010; Semenchenko and Rizevskii, 2013). Appearance and subsequent naturalization of living organisms outside their historical (native) ranges lead to displacement of local species, to changes in the trophic, topical, and other interactions, and, eventually, to the degradation of whole ecosystems (Biserova, 2010; Orlova, 2011; *Samye opasnye*..., 2018). Biological invasions along with anthropogenic pollution of the environment and habitat destruction are the main cause of the extinction of native species and loss of biodiversity (Semenchenko and Rizevskii, 2013).

This problem also concerns the Volga River, the largest river of Russia, which is one of the main transit routes of penetration and spread of alien species of hydrobionts. The Volga invasive corridor promotes spreading of the Ponto-Caspian species to Central and Northern Europe and boreal-arctic species (from lakes of northwestern Russia) southward (Slynko et al., 2010; Kvach et al., 2015).

The Kuybyshev Reservoir, one of the oldest reservoirs in the Volga cascade, is subjected to a strong anthropogenic load due, inter alia, to invasions of fish and aquatic invertebrates. The modern composition of ichthyofauna in the reservoir includes 59 species, 18 of which are alien ones (Shakirova et al., 2015). Some of them (silver and bighead carps, grass carp, and peled) appeared as a result of intentional introductions; the others penetrated independently. Among the latter, the round goby *Neogobius melanostomus* (Pallas 1814) is the most abundant species.

The native range of the species covers the coastal areas of the Black and Caspian seas, lower reaches of the rivers that flow into the seas, the entire area of the Sea of Azov, and the Sea of Marmara (Moskalkova, 1996; *Atlas*..., 2003). Starting the spread in tributaries of the Black and Caspian seas several decades ago, now round goby is recorded in most countries of Europe (Rakauskas et al., 2013; Mierzejewska et al., 2014; Kvach et al., 2017; Ramler and Keckeis, 2019). At the end of the 1980s, round goby penetrated to the North American continent, where it has naturalized in all five Great Lakes and some rivers and bays of the United States and Canada (Camp et al., 1999; *Biologicheskie invazii* ..., 2004; Gendron et al., 2012).

Round goby was known in the Volga River before its flow regulation; its stable populations were recorded in the lower reaches of the river (settlement of Sarepta, now Krasnoarmeisky district of the city of Volgograd) (Berg, 1949). In the second half of the past century along with the decline in the abundance in traditional habitats, *N. melanostomus* significantly

expanded its range in the Volga basin. At present, the Cheboksary Reservoir is the northern boundary of its distribution; round goby formed an abundant stable population in its northern part (Slynko and Tereshchenko, 2014).

Round goby was detected in the Kuybyshev Reservoir in 1968 (Sharonov, 1971). Despite the fact that *N. melanostomus* is considered to be one of the most successful fish invaders, the colonization of the reservoir area by round goby lasted several decades. More than 30 years passed after the first record of round goby in the lower reaches of the Kuybyshev Reservoir (1968, Priplotinny reach, area of the Togliatti river port) (Sharonov, 1971) before the species was found in the upper part of the Volga reach (2000) (Galanin, 2012). According to some authors (Galanin, 2012; Shakirova et al., 2015), such pattern of fish distribution in the reservoir is determined by heterogeneous conditions in the water body.

There is still no consensus in the literature about the vector (way) of *N. melanostomus* invasion into the Kuybyshev Reservoir. Some researchers (Evlanov et al., 1998) suppose a gradual and successive migration of round goby from the Ponto-Caspian water bodies. The others indicate its Azov-Black Sea origin and assume that the main vector of its invasion is via ballast waters during intentional introduction of food invertebrate organisms from the Don River delta and Tsimlyansk Reservoir and with sand transported on barges (Tyutin et al., 2012; Shakirova et al., 2015).

Extremely high eurybionicity of round goby promotes its intense spreading and naturalization in new marine and freshwater ecosystems. The species has low requirements regarding such parameters in the reservoir as salinity, gas regime (oxygen concentration), water temperature, and depth. Round goby is characterized by a wide food spectrum (euryphage), which changes as fish grow. Once round gobies penetrate into a new ecosystem, they quickly become the dominant fish species. A high increase in the abundance of *N. melanostomus* is facilitated by its early sexual maturation (at the end of the first year of life), highly extended spawning period at an unusually wide temperature range (from 10 to 30°C), portioned spawning, plasticity in the choice of spawning substrate, and guarding of egg masses by males (Moskalkova, 1996; Hôrková and Kováč, 2015).

Numerous studies have reported the consequences of the round goby invasion into recipient water bodies and its effect on native fish species. Round goby becomes actively incorporated into food webs, which, on one hand, has a positive effect on local predators since their food supply is significantly improved (Ramler and Keckeis, 2019). On the other hand, round goby poses a threat to native species with which it competes for food and habitat. Thus, after invasion of *N. melanostomus*, there was a significant decrease in the number (up to the complete extinction of populations) of barbell and white-finned gudgeon in the Danube River (Ramler and Keckeis, 2019), ruffe in the lagoons of the Baltic Sea and lakes of the Netherlands (Rakauskas et al., 2013; Jůza et al., 2018), and bullhead, smallmouth bass, and lake trout in the Great Lakes of North America (Perello et al., 2015). Round goby, as a euryphage, can act as a predator in relation to local fish species, actively consuming their eggs and juveniles.

The most important consequence of the invasion of alien gobies to recipient water bodies is their impact on local parasite communities. Changes in the ranges of free-living animals (vertebrate and invertebrate) are accompanied by corresponding changes in the ranges of their parasites, some of which may cause epizootic diseases of native species (Biserova, 2010). At present, 47 alien species of parasites are recorded in the Volga River basin; the majority of them occurred outside their historical range as a result of unintentional introduction together with hosts (Zhokhov et al., 2019). The most common consequence of naturalization of invading species is broadening of the host range for local parasites, the total abundance of which may significantly change in native hosts (Gendron et al., 2012; Mineeva, 2019).

The parasite fauna of round goby is actively studied in different areas of the acquired range (Camp et al., 1999; Rakauskas et al., 2008; Francová et al., 2011; Kvach et al., 2017); however, there is very little information about round goby infestation in the Kuybyshev Reservoir (Middle Volga). The only work devoted to this issue was published in the regional collection of scientific papers (Khvatkov and Zolotukhin, 2016); therefore, it remained unnoticed by researchers.

The aim of this work is to study the parasite fauna of *N. melanostomus* in the Kuybyshev Reservoir.

MATERIALS AND METHODS

The material was collected in three reaches of the Kuybyshev Reservoir (Undorsky, Ulyanovsky, and Priplotinny) in June–August 2019. Fifty-four specimens of round goby were caught using hooks and lines; the biological and morphometric parameters of the fish determined according to the common methods (Pravdin, 1966) are presented in Table 1.

At the sampling site, round gobies were fixed in 70% ethanol.

Fish dissection, collection, and laboratory treatment of parasites were carried out according to the standard method (Bykhovskaya-Pavlovskaya, 1985). The species of worms were identified using the keys (*Opredelitel'...*, 1985; Sudarikov et al., 2006).

The following parameters were used for quantitative characteristics of infestation of fish: extensity of invasion or prevalence (the percent of infected specimens of the total number of examined fish), intensity of invasion (the minimum and maximum number of

Table 1. Data on the studied samples of round goby collected at different stations in the Kuybyshev Reservoir

Station/coordinates	Date of sampling	Number of examined fish, ind.	Standard length of fish (*SL*), mm		Fish age
			$M \pm m$	min–max	
Ulyanovsky reach (city of Ulyanovsk) 54°25′46″ N, 48°35′49″ E	June 18–19, 2019	9	71.0 ± 6.3	54.4–102.7	2+, 3+
Undorsky reach (village of Dubki) 54°60′62″ N, 48°43′65″ E	July 29–30, 2019	6	61.9 ± 3.8	51.5–73.2	1+, 2+
Priplotinny reach (Usinsky Bay) 53°29′64″ N, 49°25′53″ E	June 21, August 21, 2019	39	62.1 ± 1.3	48.1–91.6	1+–3+

Table 2. Infestation of round goby with parasites in the Kuybyshev Reservoir (according to the data of 2019)

Parasite/localization	EI, %	II, ind.	IA, ind.
Trematoda			
Rhipidocotyle campanula Dujardin, 1845, mtc. gills	1.85 ± 1.85	17	0.31 ± 0.31
Nicolla skrjabini Iwanitzky, 1928 intestine	72.22 ± 6.15	1–157	22.20 ± 5.10
Holostephanus cobitidis Opravilova, 1968, mtc. body muscles	1.85 ± 1.85	2	0.04 ± 0.04
Diplostomum spp., mtc. crystalline lens	9.26 ± 3.98	1–2	0.13 ± 0.06
Apatemon gracilis Szidat, 1928, mtc. liver, eye tissues	3.70 ± 2.59	1	0.04 ± 0.03
Cromadorea (Nematoda)			
Capillaria tomentosa Dujardin, 1843 intestine	16.67 ± 5.12	1–3	0.26 ± 0.09
Camallanus lacustris Zoega, 1776 intestine	5.56 ± 3.15	1	0.06 ± 0.03
Camallanus truncatus Rudolphi, 1814 intestine	1.85 ± 1.85	3	0.06 ± 0.06
Nematoda sp. intestine	1.85 ± 1.85	1	0.02 ± 0.02
Bivalvia			
Unionidae gen. sp. pectoral fin	1.85 ± 1.85	9	0.17 ± 0.17

EI, extensity of invasion; II, intensity of invasion; IA, index of abundance.

parasites per one host), and the index of abundance of parasites (the average abundance of parasites in all examined fish including uninfected ones). The mathematical data analysis was performed using Microsoft Excel software.

The similarity of the composition of the parasite fauna of round goby in different water bodies was assessed using the Sørensen coefficient (Pesenko, 1982).

RESULTS AND DISCUSSION

In the surveyed water area of the Kuybyshev Reservoir, ten species and forms of multicellular parasites unidentified to species level of different systematic groups were recorded: trematodes, nematodes, and glochidia of bivalves (Table 2).

The group of digenetic flukes is the most numerous and includes five species. Most of them (metacercariae of *Rhipidocotyle campanula*, *Holostephanus*

cobitidis, and *Diplostomum* spp., *Apatemon gracilis*) actively infect the hosts by directly penetrating the skin.

A single recorded trematode *Rh. campanula* is an atypical parasite of round goby. *N. melanostomus* has been recorded as a host of flukes neither in the native nor in the acquired range. The initial stages of the helminth life cycle are not studied (an intermediate host is unknown); mainly cyprinid fish are an additional host and the trematode reaches sexual maturity in the organism of predatory fish (pike, wels catfish, perches) (Sudarikov et al., 2006).

In the first year of the existence of the Kuybyshev Reservoir (1956), *Rh. campanula* was a widespread parasite of pike (prevalence 46.2%, index of abundance 30.3 ind.); in the subsequent 7 years, the occurrence and abundance of the helminth significantly declined down to the complete absence of the species in fish (Kosheva, 1964). We do not have up-to-date data about infestation of additional and definitive hosts of the parasites, but the analysis of the published data indicates high abundance and density of this rheophilic helminth in fish from the tributaries of the reservoir. Thus, the infestation of roach with metacercariae of *Rh. campanula* in the Tashelka River (a second-order tributary) reaches 100%, the intensity of invasion is 1008 ind. (larvae are localized in fin rays) (Rubanova, 2019).

Metacercaria of trematodes *H. cobitidis*, a specific parasite of gobies and spined loach (Sudarikov et al., 2006; Semenova et al., 2007), was not previously recorded in fish from the Middle Volga basin (Molodozhnikova and Zhokhov, 2007). The mollusk *Bithynia tentaculata* (Linnaeus, 1758) is an intermediate host in the life cycle of the parasite; adult worms in an experiment were grown in kestrel and hooded crow (Sudarikov et al., 2006). The trematode is known in round goby both in the native range (Dnieper delta, Volga delta) (Semenova et al., 2007; Kvach et al., 2014) and in the acquired range (Saratov Reservoir) (Mineeva, 2019). As shown by the example of the Saratov Reservoir, infestation of a native species, spined loach, with the fluke significantly decreased owing to the invasion of Ponto-Caspian gobies into the reservoir (Mineeva, 2019).

A. gracilis is one more specific parasite to gobies, which are additional hosts in the life cycle of the parasite. The mollusk *Physa fontinalis* (Linnaeus, 1758) and ichthyophagous birds are also hosts of different categories of the parasite (Sudarikov et al., 2006). The species was not previously detected in the Kuybyshev Reservoir. The trematode is known in round goby both in the native range (Caspian Sea, Volga delta) (Sudarikov et al., 2006; Kvach et al., 2015) and in the acquired range (lower course of the Volga River (Saratov Reservoir), Hungarian and Slovakian sectors of the Danube River) (Molnar, 2006; Francová et al., 2011; Mineeva, 2019). In Europe, the species is registered as *A. cobitidis* Linstow, 1890 (=*Tetracotyle cobitidis* (Linstow, 1890)), which refers to the synonym *A. gracilis* (Rud., 1819) Szidat, 1928 (Sudarikov et al., 2006). Infestation of the host in different sites of the range is insignificant (prevalence does not exceed several percent). The exceptions are specimens of *N. melanostomus* caught in the Volga River downstream of the city of Volgograd (75% of fish were infected with flukes, the average abundance of worms 2.2 ind.) (Kvach et al., 2015).

Metacercariae of the genus *Diplostomum* (embryonic tissues of diplostomids deform when fixed in 70% alcohol and become unsuitable for identification (Bykhovskaya-Pavlovskaya, 1985)) are also rare parasites of round goby in the reservoir studied (Table 2). In the Kuybyshev Reservoir, *D. spathaceum* (Rudolhi, 1819) Braun, 1893 is recorded in the native fish species; cyprinids (sabrefish, roach, silver bream, white-eye bream, and blue bream) are the most infected fish (Kosheva, 1964).

At least five species of diplostomids, including one narrowly specific, *D. gobiorum* Schigin, 1965, are described for gobies in the native range (Black Sea, Sea of Azov, Caspian Sea, and lower reaches of rivers discharging into them) (Naidenova, 1974; Sudarikov et al., 2006; Semenova et al., 2007). Larvae of *Diplostomum* spp. unidentified to species level were recorded for *N. melanostomus* by most researchers in the acquired part of the range (Tyutin et al., 2012; Gendron et al., 2012; Ondračková et al., 2012). In the Baltic Sea and water bodies of North America, round goby is reported as an additional host of *D. spathaceum* (Pronin et al., 1997; Kvach and Skóra, 2007; Rakauskas et al., 2008).

There is little information about dispersal of the specific *D. gobiorum* following its additional hosts. Mierzejewska et al. (2014) report about records of the species in the parasite fauna of the tubenose goby *Proterorhinus semilunaris* (Heckel, 1837) in water bodies of Poland (Wloclawek Reservoir, the lower course of the Vistula River). Khvatkov and Zolotukhin (2016) indicate round goby in the Kuybyshev Reservoir as an additional host of *D. gobiorum* (prevalence 20%, index of abundance 3.25 ind.). This finding requires additional confirmation (since it remains unclear what specimens (live or fixed) were used for identification), but it is possible, considering the wide distribution in the reservoir of the gastropod *Lymnaea auricularia* (Linnaeus, 1758) (Mikhailov, 2014), an additional host in the cycle of the helminth development.

The dominance of larval forms of worms is characteristic of the trematode fauna of gobies both in the native range and in the acquired range (Naidenova, 1974; Semenova et al., 2007; Francová et al., 2011; Kvach et al., 2015; Mineeva, 2019). However, round goby does not play an important role in the circulation of fluke larvae in the conditions of the Kuybyshev Reservoir, since it is insufficiently integrated into their parasitic systems as evidenced by a low frequency of

occurrence and index of abundance of metacercariae (Table 2).

In the ecological aspect, round goby is a full-fledged host of the trematode *N. skrjabini*, which was first recorded in the parasite fauna of fish of the reservoir studied. Flukes, whose native range is restricted to the rivers of the Azov-Black Sea basin (Zhokhov et al., 2019), are a clear example of "invasion meltdown" (Simberloff and Von Holle, 1999), when the naturalization of one or several species promotes the invasion of other species (Orlova, 2011).

At present, the trematode is widespread in water bodies and watercourses of many European countries (Bulgaria, Hungary, Russia, Ukraine, Poland, Slovakia, Latvia, Lithuania, Czech Republic, and Germany) (Ondračkova et al., 2005, 2012; Molnar, 2006; Kirjušina and Vismanis, 2007; Zhokhov et al., 2019). *N. skrjabini* is recorded in the Volga basin from the delta to the Rybinsk Reservoir (Zhokhov et al., 2019).

Such invasive success of the fluke is determined by high dispersal rates of the gastropod *Lithoglyphus naticoides* (Pfeiffer, 1828), an intermediate host in the cycle of the parasite development. Included in the "blacklist" of alien animals in European inland water bodies (as species with a high degree of the impact) (*Samye opasnye*..., 2018), in recent decades, the lithoglyth has significantly broadened its range in the Volga basin against the background of steady increase in average annual temperatures. *L. naticoides* was recorded in the Volga delta in 1971, and at present, it has spread upstream along the cascade to the Uglich Reservoir, where its abundance reaches 520 ind./m^2 (Perova et al., 2018).

Solitary specimens of the mollusk were first detected in the Kuybyshev Reservoir in the middle of the 1990s (Yakovlev et al., 2009); at present, it is a common species both in the reservoir and in its tributaries (Sviyaga, Maina, Utka, and Usa rivers) (Kurina, 2014; Mikhailov, 2014).

Various amphipod species (Gammaridea), including invasive ones (the genera *Dikerogammarus*, *Pontogammarus*, *Chaetogammarus*) which are able to significantly increase their abundance in new habitats for a short period, i.e., being close to r-strategists, are additional hosts in the developmental cycle of the alien trematode *N. skrjabini* (*Biologicheskie invazii*..., 2004).

N. skrjabini reaches sexual maturity in the organism of fish, mainly benthophages. It is interesting that introduced Ponto-Caspian gobies of the family Gobiidae also become definitive hosts in the acquired range (Molnar, 2006; Ondračková et al., 2010, 2012; Tyutin et al., 2012; Mineeva, 2019). Fish are infected when they feed on infested amphipods. In the conditions of the Kuybyshev Reservoir, the trematode *N. skrjabini* has a high frequency of occurrence and abundance in the round goby population (Table 2), which indicates an important role of amphipods in the diet of gobies in the reservoir studied.

Nematodes of the genus *Camallanus* are the only tapeworms in the parasite fauna of round goby the development of which is associated with zooplankton (copepods). Low parameters of fish invasion (Table 2) indicate a small proportion of this component in their diet. The analysis of the published data (Rolbiecki, 2006; Rakauskas et al., 2008; Francová et al., 2011; Tyutin et al., 2012) indicates that round goby is an occasional host of nematodes *C. lacustris* and *C. truncates* in the other parts of the acquired range as well. At the same time, one-third of the examined specimens of *N. melanostomus* (33.3%) are infected with *C. lacustris* in the Volga delta (Kvach et al., 2015). Such wide distribution of the nematode in the round goby populations may be due to large ichthyophagous gobies which acquire nematodes of the genus *Camallanus* from non-predatory fish (juvenile cyprinids play the role of paratenic hosts) since these species of roundworms can act as passengers. Representatives of the genus *Camallanus* reach sexual maturity in the organism of predatory fish (percids, esocids, silurids).

The life cycle of the pathogenic nematode *C. tomentosa*, which affects the intestinal mucosa of fish, involves oligochaetes of the genera *Tubifex* and *Limnodrilus* as paratenic or intermediate hosts (*Opredelitel'*..., 1987). The parasite is recorded in round goby in the native part (the Dnieper delta) (Kvach et al., 2014 and in the acquired part of the range (Rhine River (Germany) and lower course of the Volga River (Saratov Reservoir)) (Ondračková et al., 2015; Mineeva, 2018); the infestation of fish does not exceed several percent.

An adult specimen of Nematoda sp. from the intestine of round goby is not identified to species level because of its poor preservation.

Solitary glochidia of mollusks (Table 2) detected on pectoral fins of fish topically infect the host. Larvae of mollusks (genera *Anodonta* and *Pseudoanodonta*) are common ectoparasites of round goby in water bodies of the native and acquired ranges (Naidenova, 1974; Ondračková et al., 2012; Kvach et al., 2014, 2017); the extensity of invasion in different seasons of the year may reach 65–83% (in the Bulgarian and Slovak sectors of the Danube River) (Francová et al., 2011).

The presented list of parasites of round goby in the Kuybyshev Reservoir cannot claim to be complete. First, any fixation of fish after capture decreases the informativeness of dissection and, as a result, leads to incomplete qualitative and quantitative data on the composition of parasites (Kvach et al., 2018). Second, our studies were conducted only in a small part of the area of the reservoir, and it is shown in the literature that specific features of the hydrological regime in some parts (reaches) of reservoirs affect their fauna, including the fauna of fish parasites (Izyumova, 1977). The study of infestation of round goby from other parts of the reservoir will definitely broaden knowl-

edge about the composition of the parasite fauna of the species. Third, the level regime in the Kuybyshev Reservoir in 2019 was subject to significant fluctuations that affected benthic and zooplankton communities of its ecosystem, that is, the primary links of the life cycle of parasites ensuring the transmission of infections to fish.

We consider it necessary to supplement our list of round goby parasites in the Kuybyshev Reservoir with the data obtained by Khvatkov and Zolotukhin (2016) from fish caught in the Ulyanovsk reach. The researchers recorded eight species of multicellular parasites of different systematic groups in this part of the reservoir: (cestode *Proteocephalus* sp.; trematodes *Phyllodistomum pseudofolium* Nybelin, 1926, *Plagioporus angusticolle* (Hausmann, 1896), *Diplostomum gobiorum* mtc., *Posthodiplostomum brevicaudatum* mtc. (Nordmann, 1832) Wisniewski, 1958, *Tylodelphys clavata* mtc. (Nordmann, 1832) Diesing, 1850; metacercariae of *Trematoda* gen. sp., unidentified to species level; acanthocephalans *Pomphorhynchus laevis* (Müller, 1776)); the paper presents their photomicrographs. As mentioned above, the presence of *D. gobiorum* in the list requires confirmation based on viable metacercariae that reached the invasive stage. The records of the trematode *Plagioporus angusticolle* (Fasciolida, Opecoelidae) (extensity of invasion 10%, intensity of invasion 3–30 ind., index of abundance 16.5 ind.) by the authors are doubtful (Khvatkov and Zolotukhin, 2016). Within the territory of Russia, this representative of the boreal piedmont complex is known in common bullhead *Cottus gobio* (Linnaeus, 1758) in Lakes Ladoga and Onega; the development of the fluke occurs with participation of mollusks of the genus *Sphaerium* and amphipods *Gammarus pulex* (Linnaeus, 1758) as an intermediate and an additional host, respectively (*Opredelitel'*..., 1987).

Thus, the analysis of the literature (Khvatkov and Zolotukhin, 2016) and our original data makes it possible to state that, in the modern period, the list of multicellular parasites of round goby in the Kuybyshev Reservoir (middle course of the Volga River) includes at least 16 species of five systematic groups (Table 3).

This is less than the number of species recorded in *N. melanostomus* in the downstream Saratov Reservoir (21 species) (Mineeva, 2013, 2018, 2019). Parasitological studies of unfixed fish from different parts of the Kuybyshev Reservoir will make it possible to sufficiently expand knowledge of the parasite composition of this alien species in the Middle Volga basin.

The list of Metazoa of round goby in the native range includes at least 104 species of parasites of different ecological groups (marine, euryhaline, freshwater), including four species of monogeneans, eight species of cestodes, one species of aspidogastreans, 55 species of trematodes, 19 species of nematodes, eight species of acanthocephalans, four species of mollusks, and five species of crustaceans (Naidenova, 1974; Kvach, 2005; Sudarikov et al., 2006; Semenova et al., 2007; Özer, 2007; Ondračková et al., 2010, 2012; Francová et al., 2011; Krasnovyd et al., 2012; Kvach et al., 2014, 2015). Some of the specific parasites (monogenean *Gyrodactylus proterorhini* Ergens, 1967; cestodes *Proteocephalus gobiorum* Dogiel et Bychowsky, 1939 and *Triaenophorus crassus* Forel, 1868; trematodes *Apatemon gracilis*, *Cryptocotyle concave* (Creplin, 1825) Lühe, 1909, *C. lingua* (Creplin, 1825) Fishhoeder, 1903, and *Holostephanus cobitidis*; nematode *Dichelyne minutus* (Rudolphi, 1819)) remain in round goby in the acquired range as well (Molnar, 2006; Rolbiecki, 2006; Kvach and Skóra, 2007; Francová et al., 2011; Ondračková et al., 2015; Mineeva and Mineev, 2019; Mineeva, 2019). Fish of the family Gobiidae are characterized by a high potential for infection with local parasites in recipient water bodies. In the acquired range (Europe and North America), 98 species of multicellular parasites of nine systematic groups are known for *N. melanostomus*: Monogenea (1), Cestoda (13), Aspidogastrea (2), Trematoda (29), Nematoda (29), Acanthocephala (14), Bivalvia (5), Crustacea (3), Hirudinea (2) (Pronin et al., 1997; Camp et al., 1999; Ondračková et al., 2005, 2010, 2012, 2015; Molnar, 2006; Rolbiecki, 2006; Kvach and Skóra, 2007; Rakauskas et al., 2008; Francová et al., 2011; Tyutin et al., 2012; Gendron et al., 2012; Mineeva, 2013, 2018; Kvach et al., 2014, 2017; Khvatkov and Zolotukhin, 2016; Gendron and Marcogliese, 2016; Güven and Öztürk, 2018; Mineeva and Mineev, 2019; Mineeva, 2019).

Such high species diversity of parasites of round goby in recipient ecosystems is due to the broad diet spectrum and lifestyle. The confinement of fish to warm-water shallow areas with abundant aquatic vegetation facilitates infestation of animals with metacercariae of trematodes (due to spatial proximity between fish and mollusks, intermediate hosts of flukes) and ectoparasites. Many species of parasites are acquired by gobies via a trophic transmission. In seas (native range), bivalves and gastropods are the main food items of round goby (in Sea of Azov up to 80–90% of the diet); fish can consume attached forms as well (Moskalkova, 1996; *Atlas*..., 2003). Gobies are easily incorporated into local food webs in recipient ecosystems; eurypagia of gobies is one of the factors facilitating the species distribution. Thus, in Lake Erie in North America (the system of the Great Lakes), 21 types of food items are identified in the diet of *N. melanostomus*. Cladocerans (Cladocera), larvae of dipterans, and bivalves (mainly of the genus *Dreissena*) dominate in terms of the frequency of occurrence and abundance. To a lesser extent, round goby feeds on other groups of crustaceans (Amphipoda, Copepoda, Isopoda), gastropods, mayfly larvae, fish, and algae (Perello et al., 2015). The authors indicate variability of the diet spectrum of males and females of *N. melanostomus* in different seasons of the year. The round goby in the middle course of the Danube River (Slova-

Table 3. List of species and characteristic of macroparasites of round goby in the Kuybyshev Reservoir (according to original and published data)

Parasite	Species status	Specificity	General distribution
Cestoda			
Proteocephalus sp.	Unknown	Unknown	Unknown
Trematoda			
A. gracilis	Native	Specific to gobiids, balitorids, cottids	Europe, Central Asia (Kazakhstan, Kyrgyzstan), Primorsky Territory
Diplostomum spp.	Unknown	Unknown	Unknown
H. cobitidis	Native	Specific to gobiids and spined loach	Ural, Siberia, Eastern Europe
N. skrjabini	Alien, Don River as a donor water body	Widely specific	Europe (Eastern, Central, Western)
Ph. pseudofolium	Native	Specific to percids	Palearctic
P. brevicaudatum	Native	Widely specific	Europe (Eastern, Central), Western and Eastern Siberia, Kazakhstan
Rh. campanula	Native	Specific to cyprinids at larval stage	Palearctic
T. clavata	Native	Widely specific	Palearctic
Trematoda gen. sp.	Unknown	Unknown	Unknown
Cromadorea (Nematoda)			
C. tomentosa	Native	Widely specific	Palearctic
C. lacustris	Native	Specific to percids	Palearctic
C. truncatus	Native	Specific to percids	Palearctic
Nematoda sp.	Unknown	Unknown	Unknown
Acanthocephala			
P. laevis	Native	Widely specific	Europe (Eastern, Central), Western Siberia
Bivalvia			
Unionidae gen. sp.	Unknown	Unknown	Unknown

kia) mainly consumes chironomid larvae, gastropods (*Corophium*), bryozoans, and cladocerans; thus, the food niche overlap is demonstrated between round goby and native ruffe and perch (Hôrkov and Kováč, 2015). The alien round goby in the Curonian Lagoon of the Baltic Sea and lakes of the Netherlands (catchment area of the Meuse River) consumes mollusks (bivalves of the genus *Dreissena* and gastropods), amphipods, and chironomid larvae (Rakauskas et al., 2013; Jůza et al., 2018).

In the Kuybyshev Reservoir, the diet spectrum of round goby is determined by availability of food items and significantly differs in some parts of the reservoir. The main food items of *N. melanostomus* in the Ulyanovsk reach (the middle part of the reservoir) are mollusks (predominantly of the genus *Dreissena*), which constitute up to 90% of the diet; crustaceans (gammarids) are secondary food items (Soltis, 2012). The diet of round goby in the upper part of the Kuybyshev Reservoir (Volga reach, Sviyazhsky Bay) is more diverse (a total of 17 types of food components were recorded). Amphipods (including alien ones), oligochaetes, larvae of caddisflies and chironomids, and mollusks prevail in the diet of round goby among benthic organisms. Large copepods and benthic cladocerans of the genus *Alona* dominate among zooplankton organisms (Frolova, 2009).

Our studies have shown that, in 2019, in low-water conditions, round goby fed mainly on chironomid larvae (Diptera, Chironomidae) in the lower and middle parts of the Kuybyshev Reservoir. Mollusks of the genera *Anisus* and *Dreissena* and crustaceans (Amphipoda, Copepoda, and Cladocera) were the secondary sources of food. Fish was also recorded among food items of gobies in the Usinsky Bay (Priplotinny reach).

The parasite faunas of round goby in the Kuybyshev Reservoir (16 species) (Table 3) and in the downstream Saratov Reservoir (21 species) (Mineeva, 2013, 2018, 2019) are characterized by a rather high similarity (the Sørensen coefficient $K_s = 54\%$). Ten species of multicellular parasites (*Proteocephalus* sp., *N. skrjabini*, *H. cobitidis*, *Diplostomum* sp., *T. clavata*, *A. grac-*

ilis, *C. tomentosa*, *C. lacustris*, *P. laevis*, and Unionidae gen. sp.) are common for fish in both reservoirs. The life cycle of most of them involves different categories of benthic invertebrates (mollusks, amphipods, and oligochaetes) as host organisms. Only two species of helminths (the cestode *Proteocephalus* sp. and nematode *C. lacustris*) infect fish through zooplankton crustaceans.

In general, it should be noted that infestation of fish with parasites common for both reservoirs is rather similar (Mineeva, 2013, 2018, 2019). The exceptions are metacercariae of the genus *Diplostomum*, which are the most widespread species in the parasite fauna of *N. melanostomus* in the Saratov Reservoir (Mineeva, 2019) and have low frequency of occurrence and abundance in the host population in the Kuybyshev Reservoir (Table 2).

Many parasite species of round goby in the Saratov Reservoir have not yet been recorded in the upstream reservoir. Thus, larvae of the trematode *Contracaecum microcephalum* (Rudolphi, 1819) widespread in gobies in the middle part of the Saratov Reservoir (prevalence 57.8%) (Mineeva, 2018) and the goby-specific cestode *Triaenophorus crassus* Forel, 1868, which also develops in copepods (Copepoda), were not found in the surveyed area of the Kuybyshev Reservoir. Some rare parasites of round goby in the Lower Volga which infect fish in a trophic way (when feeding on benthic organisms) (nematode *Eustrongylides excisus* Jägerskiöld, 1909, acanthocephalans *Neoechinorhynchus rutili* (Müller, 1780) and *Pseudoechinorhynchus borealis* (Linstow, 1901)) and a topical (active) way (metacercariae *Paracoenogonimus ovatus* Katsurada, 1914 and *Apharhyngostrigea cornu* Ciurea, 1927, monogeneans *Gyrodactylus* sp., leech *Caspiobdella fadejewi* (Epstein, 1961), crustaceans *Argulus foliaceus* (Linnaeus, 1758)) were also not recorded in the surveyed reaches. Thus, it can be stated that the composition of the parasite fauna of *N. melanostomus* in the Kuybyshev Reservoir is a shortened list of parasites of the Lower Volga populations of the species.

Thirteen species of multicellular parasites are reported for round goby in the Cheboksary Reservoir located upstream along the cascade (Tyutin et al., 2012). The similarity of Metazoa faunas of gobies in two Middle Volga reservoirs (the Sørensen coefficient) is only 34%; five species of parasites (*N. skrjabini*, *Diplostomum* sp., *C. lacustris*, *C. truncatus*, *P. laevis*) are common for gobies.

CONCLUSIONS

Ten species of multicellular parasites have been identified in the course of the study on round goby from the middle and lower parts of the Kuybyshev Reservoir (Undorsky, Ulyanovsk, and Priplotinny reaches), which considerably broadens the currently known list of Metazoa of this alien species in the Middle Volga basin. The round goby does not play a critical role in circulation of most recorded parasites since it is not sufficiently integrated into their parasite systems as evidenced by a low frequency of occurrence and index of abundance. *Neogobius melanostomus* is the most important definitive host for the alien trematode *Nicolla skrjabini*, thus confirming a similar tendency at different sites of the acquired range of fish.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest. The authors declare that they have no conflict of interest.

Statement on the welfare of animals. All applicable international, national, and/or institutional guidelines for the care of animals were followed.

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