Impact Assessment of the Amur Sleeper *Perccottus glenii* Dybowski, 1877 on Amphibians in Samara Oblast

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**Abstract.** The author found that in the study area, an invasive alien species of fish, the Amur sleeper *Perccottus glenii*, lives in 35 amphibian habitats. Of these, 14 are large water bodies, coastal areas and bays of watercourses, 21 are small water bodies. Larval development is completed by 8 species of tailless amphibians when they have the same habitats with the Amur sleeper. In 4 out of 17 examined populations of the European fire-bellied toad *Bombina bombina*, the cessation of larval development is noted in syntopic habitats with the Amur sleeper. The author assumes that the distribution of this invasive species is one of the factors in the disappearance of the common newt *Lissotriton vulgaris* and the European fire-bellied toad *Bombina bombina* populations in the reservoirs of Samara and Samarskaya Luka National Park. In the natural biotopes the distribution of the Amur sleeper is slower due to the presence of predators-fish and fish-eating reptiles. The marsh frog and the pool frog co-exist with the Amur sleeper; the green toad successfully spawns and undergoes larval development. The absence of common species of helminths confirms the absence of trophic links between the populations of the Amur sleeper and Amphibians in natural habitats of the study area.

1. Introduction

Non-indigenous species of organisms that are not characteristic of a given territory (both intentional or accidental introduction) are an emerging issue and one of the significant factors affecting aboriginal ecosystems [1,2]. The Amur sleeper *Perccottus glenii* Dybowski, 1877 is one of the rapidly spreading invasive species in the European part of Russia [3]. It is able to inhabit almost all types of persistent water bodies suitable for spawning and larval development of amphibians.

The appearance of this fish species is associated with a decrease in the number of spawning amphibian species in Russia [4, 5], Western Ukraine [6] and Latvia [7]. The Amur sleeper is a widespread fish species on the territory of Samara Oblast, and was studied in the floodplain biocenoses of Samarskaya Luka National Park [8]. However, a comprehensive study of the influence of its dispersal on syntopic amphibian species has not previously been carried out.

The aim of the research is to assess the impact of the Amur sleeper *Perccottus glenii* Dybowski, 1877 on amphibian populations and the possibility of its larval development in water bodies colonized by this invasive species in Samara Oblast.

2. Materials and Methods

Data collection was carried out in 35 geographical points (localities) of Samara Oblast in the period from 1998 to 2019, including 8 geographical points on the territory of Samarskaya Luka National Park.
We used a hook tackle for catching fish; and a net in the thickets of coastal near-water vegetation. We used a net for catching amphibians. The identification of the latter was carried out according to the identification tables [11] using collection specimens. The reliability of the identification of the species of green frogs *Pelophylax esculentus* complex, including the hybridogenic form *Pelophylax esculentus* (Linnaeus, 1758), was confirmed by the methods of DNA analysis by flow cytometry and molecular genetic analysis [12].
Table 1. Geographical points of discovery of Amur sleeper *Percottus glenii* in in amphibian habitats

| № | Geographical point                                      | *P. glenii* | Coordinates | Year |
|---|---------------------------------------------------------|-------------|-------------|------|
| 1 | Klimovka village, Kuibyshev Reservoir shallow water    | (+)         | 53°29'43"   | 49°00'37" | 2005 |
| 2 | Novodevichye village, Kuibyshev Reservoir shallow water| (+)         | 53°37'58"   | 48°51'12" | 2011 |
| 3 | Muranka village, Usa River shallow water                | (+)         | 53°16'56"   | 49°00'19" | 2011 |
| 4 | Mokhovoe village, Bolshoy Cheremshan River floodplain  | +d          | 54°23'30"   | 50°13'10" | 2014 |
| 5 | Verkhny Suskan village, Lake Karasevi                   | +           | 53°49'53"   | 49°19'50" | 2010 |
| 6 | Togliatti, Kuibyshev Reservoir shallow water           | +           | 53°28'28"   | 49°18'48" | 2019 |
| 7 | Vasilyevka village, Lake Vasilyevskoe                   | +           | 53°31'52"   | 49°31'13" | 2005 |
| 8 | Togliatti, Lake Plyazhnoye                             | (+)         | 53°29'38"   | 49°30'13" | 2005 |
| 9 | Togliatti, Fedorovskie meadows, Lake Mashkino           | +           | 53°28'16"   | 49°40'21" | 2014 |
| 10| Zhigulevsk, Alexandrovskoe field a pond                 | +           | 53°21'21"   | 49°27'46" | 2011 |
| 11| Zhiguli village, Usinsky Bay of Kuibyshev Reservoir    | (+)         | 53°23'19"   | 49°17'53" | 2003 |
| 12| Togliatti, lake on the Kopylovo peninsula               | (+)         | 53°27'15"   | 49°33'49" | 2005 |
| 13| Tornovoe village*                                      | +           | 53°16'32"   | 49°58'18" | 2011 |
| 14| Podgori village, Lake Kamennoe                        | +           | 53°19'39"   | 50°70'20" | 2011 |
| 15| Mordova village, Lake Krugloe                          | +           | 53°10'44"   | 49°25'49" | 1998 |
| 16| Mordova village, Lake Soldatskoe                       | +           | 53°10'32"   | 49°25'0"  | 1998 |
| 17| Mordova village, Koltsovskaya Volozhka*, a duct        | +           | 53°09'1"    | 49°29'20" | 1998 |
| 18| Vasilyevsky Islands, Saratov Reservoir shallow water   | (+)         | 53°11'12"   | 49°21'33" | 1998 |
| 19| Shelekhmet village, Lake Klyukvennoye                   | +           | 53°14'42"   | 49°51'2"  | 2009 |
| 20| Shelekhmet village, Lake Bolshe Shelekhmetskoe         | +           | 53°14'20"   | 49°50'26" | 2009 |
| 21| Samara, Lake Yaiskoe                                   | +           | 53°06'27"   | 50°10'18" | 2014 |
| 22| Samara, pond of the park "Metallurg"                   | +           | 53°14'17"   | 50°16'7"  | 2017 |
| 23| Samara, pond of the Gagarin park                       | +           | 53°13'46"   | 50°11'54" | 2014 |
| 24| Samara, ponds of Botanical garden                      | +           | 53°12'59"   | 50°10'42" | 2014 |
| 25| Samara, lakes "Voronezhskie"                           | +           | 53°14'27"   | 50°13'34" | 2014 |
| 26| Samara, pond near the farm Volgar*                     | +           | 53°09'11"   | 50°05'1"  | 2014 |
| 27| Samara, pond near the shopping center "Colosseum"      | +           | 53°14'53"   | 50°14'33" | 2014 |
| 28| Samara, pond on 8 Proseka street                       | +           | 53°15'47"   | 50°11'39" | 2014 |
| 29| neighborhood of the Petra Dubrava village, Lake Novoe Lemno | + | 53°17'53" | 50°22'53" | 2013 |
| 30| Samara, pond in the area of 18 km*                     | +           | 53°16'23"   | 50°15'56" | 2013 |
| 31| Rabochyi village, lake. in the floodplain of the Samara River | +   | 52°59'52"   | 51°33'43" | 2011 |
| 32| Poplavsky village, Lake Chernoe                        | +           | 52°59'19"   | 50°49'8"  | 2011 |
| 33| Vetyanskoe water reservoi., neighborhood of the Vetlanka village | +   | 52°49'59"   | 51°07'51" | 2011 |
| 34| neighborhood of the Obsharovka village, Lake Bestolkovoe | + | 53°7'47" | 48°54'53" | 2011 |
| 35| Bolshaya Glushitsa village, lake in the floodplain of the Bolshoi Irigiz River | +   | 52°21'58"   | 50°28'52" | 2011 |

*a* – reservoirs of Samarskaya Luka National Park,  
*b* – the species is indicated according to published data [9]  
*c* – the species is indicated according to published data [10]  
*d* – "+", "-" indicate our data
We evaluated the successful development of amphibians by the presence of larvae (tadpoles) in the water body at late stages, metamorphosing individuals and underyearlings. In isolated water bodies, where there is no possibility of mass migration from other habitats, we took into account immature specimen that had undergone metamorphosis. Additionally, we used previously published data on extinct amphibian species in the region [13].

3. Results and Discussion
Embryonic and larval development of at least one of the spawning amphibian species proceeds successfully before metamorphosis in 35 studied amphibian habitats inhabited by the Amur sleeper. The species composition of amphibians taking into account this fish species is shown in table 2:

| Species          | Shallow water bodies (up to 8000 m²) | N₁ | Large water bodies and coastal areas | N₂ | N |
|------------------|--------------------------------------|----|-------------------------------------|----|----|
|                  | Locale № | Larvae, underyearlings | Adult specimen | Larvae, underyearlings | Adult specimen |
| L. vulgaris      | 7         | 1                  | –            | –       | 0 1 |
| B. bombina       | 5, 13, 14, 35 | 19             | 5 16, 20, 31, 32, 34 | – 5 10 |
| P. vespertinus   | 3, 5, 13, 14, 35 | 19             | 5 17       | – 1 6 |
| B. bufo          | 4         | 1                  | 2          | – 1 3 |
| B. viridis       | 13, 35    | 2                  | 16, 17, 33, 34 | – 4 6 |
| P. ridibundus    | 1, 3, 5, 14, 15, 19, 29, 35 | 9 16, 17, 18, 20, 31 | – 8 17 |
| P. lessonae      | 5, 19     | 2                  | 31         | – 1 3 |
| P. esculentus    | 5, 19     | 2                  | 20         | – 1 3 |
| R. arvalis       | 1, 35     | 3                  | 2, 16, 17, 20, 31 | – 5 8 |
| R. temporaria    | –         | 1                  | –          | – 0 1 |

| Species          | Shallow water bodies (up to 8000 m²) | N₁ | Large water bodies and coastal areas | N₂ | N |
|------------------|--------------------------------------|----|-------------------------------------|----|----|
|                  | Locale № | Larvae, underyearlings | Adult specimen | Larvae, underyearlings | Adult specimen |
| B. bombina       | 9         | 7, 26, 28             | 4 6, 12, 21   | – 3 7 |
| P. vespertinus   | 7, 9, 26  | 3                  | 11         | – 1 4 |
| B. viridis       | 7, 9, 10, 22, 23, 24, 25, 26, 27, 28, 30 | 11 | 6, 8, 11, 12 | – 4 15 |
| P. ridibundus    | 7, 9, 10, 22, 24, 26, 28, 30 | 8   | 6, 8, 11, 12, 21 | – 5 13 |
| P. lessonae      | 7         | –                  | –          | – 0 1 |
| P. esculentus    | 7         | –                  | –          | – 0 1 |
| R. arvalis       | 9         | –                  | 12, 21     | – 2 3 |

* – the number of habitats for each species: N₁ - shallow water bodies, N₂ - large water bodies and coastal areas, N - total

According to our data, Percottus glenii lives together with amphibians in different types of water bodies: small (N₁), large, as well as the coastal areas of reservoirs (N₂).

Tadpoles of amphibians at the late stages of development and underyearlings were found both in small and large water bodies (table 2). Moreover, in several shallow water bodies, only adults were recorded - the common newt Lissotriton vulgaris (point 7), the common toad (point 1), the moor frog Rana arvalis (point 14), and the common frog Rana temporaria (point 1). We assume this can serve
both as an indicator of the absence or cessation of larval development, and the dispersal of amphibians from spawning reservoirs. On the other hand, we did not find any metamorphosing underyearlings during the observed reproduction and clutches of eggs for the European fire-bellied toad *Bombina bombina* (points 7, 19, 26, 28) (table 2).

According to the literature, the Amur sleeper is found in water bodies where the common and the northern crested newts, the common toad, the pool, the moor and the common frogs live and / or spawn in Moscow Oblast [4]; the marsh, the edible and the pool frogs in Samara Oblast [3]; the marsh frog, the European fire-bellied toad and the common newt in Romania [14]; the European fire-bellied toad in Latvia [7]. At the same time, it is known that introduction of invasive species leads to a significant suppression of the populations of native aquatic organisms, in particular, to the cessation of spawning and larval development in 5 species of amphibians [4]. In the reservoirs of the Upper Volga, inhabited by the Amur sleeper, most amphibian species (with the exception of the gray toad) cannot reproduce successfully: the common newt, the northern crested newt, the pool, the moor and the common frogs [4].

The introduction of *Perccottus glenii* into small isolated water bodies makes spawning and larval development of tailed amphibians impossible, which is most likely associated with their selective consumption [4]. We note the ability of the Amur sleeper to consume not only larvae, but even adults of the common newt, which, in turn, makes this species one of the most vulnerable.

At the process of introduction of the Amur sleeper first of all, water bodies of urbanized territories are populated, which, apparently, is due to the absence of predatory fish species. On the other hand, there is always the possibility of the release of this invasive species into water bodies by the local population [4]. In large cities of Samara Oblast and other parts of the Volga region (Moscow, Nizhniy Novgorod, Saransk, Ulyanovsk, Kazan), *Perccottus glenii* is recorded in most persistent water bodies [15]. Outside the Volga region it is distributed, according to the author's data, in the urbanized territories of the Southern Urals (in the cities of Chelyabinsk, Ufa, and Orsk) along with the marsh frog in relatively large water bodies. It is noted that the distribution of the Amur sleeper in urban water bodies is one of the main factors in the reduction of the common newt and the European fire-bellied toad populations within the city of Samara [13].

It is believed that the influence of this invasive fish species on the number of amphibians is associated with the consumption of the larvae of the latter, as well as adult news [5, 16]. In particular, in Moscow [17] and Tver [18] Oblasts, part of the Amur sleeper's diet includes amphibian tadpoles; similar data are obtained in the western part of the range of this fish species [19]. The proportion of amphibian larvae (metamorphosing tadpoles of the brown frogs *Rana* sp.) reaches about 25.0% in frequency of occurrence and 43.0% in weight [18]. However, in the natural range of *Perccottus glenii*, tadpoles of any amphibian species are not recorded in its diet [18]. According to other data, amphibians are not recorded in the food spectrum of *Perccottus glenii* both in its natural habitat range - Primorye [20] and in its established range: in Samara [3], Ulyanovsk, Nizhny Novgorod, Chelyabinsk Oblasts, the Republics of Bashkortostan [our data] and Mordovia [21], Moscow region [22].

We carried out a comparative helminthological analysis of the "lowervertebrates" fish and amphibians from the reservoirs of Samarskaya Luka National Park and found that the Amur sleeper [3, 10] and its cohabiting water frogs *Pelophylax esculentus* complex (*Pelophylax* spp.) have no common helminth species [3, 13].

On the one hand, this only confirms the fact that amphibians are absent in the diet of *Perccottus glenii*, and hence trophic links between them in the natural populations of the region. On the other hand, the supposed feeding of amphibian larvae in urban conditions may not be accompanied by the transfer of helminths and, accordingly, remain unnoticed in the helminthological aspect. For comparison, let us add that the Amur sleeper in the European part of Russia has only one common internal parasite with amphibians - the trematode *Opisthioglyphe ranae* (Frölich, 1791), whose metacercariae were localized on the gill arches and the operculum of the host [23].
4. Conclusion
The observed cases of interruption of larval development in the European fire-bellied toad and the moor frog are apparently caused by the introduction of the Amur sleeper into these reservoirs. The introduction and distribution of the Amur sleeper in urban water bodies can serve as one of the determining factors in the decline in amphibian populations in the context of urbanization.

According to our data, a significant reduction in amphibian spawning grounds (due to various factors) in Samara Oblast is observed exclusively in tailed amphibians and, in particular, in the common newt within the city of Samara. In the natural biotopes of Samarskaya Luka National Park, the distribution of the Amur sleeper is slower due to the presence of predators - fish and fish-eating reptiles [3, 13]. The absence of common species of helminths testifies against the existence of obvious trophic links between the Amur sleeper and amphibian populations in the natural habitats of the study area.

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