

# The adventive species community changes in the Cheboksary reservoir during 2001-2021

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**Abstract.** Generally publications devoted to invasive fish species in the Volga-Kama cascade of reservoirs represents relative indicators and do not provide data on the abundance, numbers and invasive communities' single species dynamics. It does not allow providing a correct assessment of population's state and changes in the nonindigenous species composition. In this work, changes in the abundance and species structure of the Cheboksary reservoir's invasive fish community during 2001-2021 were estimated. The total fish count was determined on data of active fishing gears catches and precise reservoir area. Differentiation into mass, widespread and relatively numerous and locally found with a small average abundance species was noted. A decrease in the species evenness of the invasive community was recorded in consequence of the Black Sea-Caspian sprat *Clupeonella cultriventris* (Nordmann, 1840) and the round goby *Neogobius melanostomus* (Pallas, 1814) domination rise. The Black Sea-Caspian sprat and the round goby put together for 98.7% of the total number of invasive fish in the current period. Due to this two dominant species there is a tendency to increase the relative abundance of invasive fish species in the reservoir up to 561 unit/ha despite a significant decrease in the abundance of some other invaders.

## 1 Introduction

The formation of Volga-Kama reservoirs cascade led to numerous consequences. One of them is the intensification of non-native for the fluvial ecosystem species invasions, including Pisces [1]. The non-register or single encountered fish species became ordinary and widespread. In this study under «invasion» means species expansion out of historical range induced human activities after late Stone Age, in case of success results in species naturalization in the host ecosystem [2]. There are several vectors of invasive fish distribution: self-diffusion and settlement inside an interconnected system of reservoirs cascades and channels; drifting with vessels ballast water [3]; intentional or contaminant introduction [4, 5]; accidental and irresponsible releases by aquarists [6].

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The Cheboksary reservoir existed for a long time as an unregulated part of the Volga River between two reservoirs. That's why the invaders penetration carried out mainly by self-settlement from nearest reservoirs. The northern arctic freshwater faunal complex migrants appeared from upper Gorky water basin, the southern Ponto-Caspian sea-water faunal complex invaders came from the downstream Kuibyshev reservoir. Arctic-boreal and the Caspian plain faunal complex members got from tributaries and secondary reservoirs. Species of the gen. *Hypophthalmichthys* and the grass carp *Ctenopharyngodon idella* (Valensiennes, 1844) were specially released into the reservoir with fishery purpose.

There are a lot of studies about adventive fishes in the Volga and Kama basins devoted to single species and reservoirs [7- 9] or generalizing to all cascade and the region [10, 11].

Most researchers provides data on the occurrence of invasive species, their share in catches, morphometric indicators, and there are no assessments of the main population's static characteristics - the abundance, total number count and their dynamics, as well as long-term changes for the whole complex of nonindigenous fish species [9, 10].

Few attempts to assess the invasive species abundance and number dynamics in the Cheboksary reservoir were made earlier for the period up to 2018 [12, 13].

The current work provides a refined description of changes in invasive fish abundance and community structure in the Cheboksary reservoir for the period 2001-2021. The study based on additional ichthyological explorations and the latest data about area of the reservoir. The obtained results can serve as a basis for predicting further changes in the role of invasive species in the fish community and optimizing the commercial use of stocks.

## 2 Materials and methods

The material collection and processing were carried out according to standard ichthyologic methods [14] using a complex of active filtering-type fishing gear with various arrangement. Fishing was carried out all over Cheboksary reservoir over the entire range of depths. The taxon description is given according to Yu.S. Reshetnikov [15]. The structure of invasion community was presented on the data of species population's size. Population's size was determined using areas method, separately to biotopes caught by fishing gear of one type [16, 17]. The abundance (allocation density, population density) throughout reservoir was determined on the refining reservoir backwater zone area [18].

## 3 Results and discussion

The Cheboksary water basin is the last one filled in Volga-Kama reservoirs cascade (1982). The reservoir was not filled to the project level at 63 m in Baltic Height System for various reasons, that's why it distinctive peculiarities are an intermediate lentic-lotic water regime and rapid water exchange.

The Cheboksary reservoir located in central part of Northern invasion corridor connecting the Black, Azov, Caspian seas between themselves and with the Baltic and White seas [19]. The Cheboksary reservoir finished cascade formation and promoted the spreading up to the Volga river for such Ponto-Caspian invaders as the Black Sea-Caspian Sea sprat *Clupeonella cultriventris* (Nordmann, 1840) and the stellate tadpole goby *Benthophilus Stellatus* (Sauvage, 1874).

The fish composition in the Cheboksary reservoir counts up to 61 species with Cypriniformes family dominance. About 48 species were regularly noted in research catches [20]. The reservoir belongs to the bream-roach type with a significant proportion of silver bream and perch.

Up to 21 invasive species were recorded in the reservoir basin at different times [21], but only 9 of them formed populations [12]. It confirmed by the different age's fish unit regular occurrence in the catches since the 2000s. The intentionally introduced silver carp and grass carp didn't pass acclimatization. The share of naturalized alien species among the most representative species in the fish community is quite high - 18.8%.

The direct donor of most adventive fish was the neighborhood Kuibyshev reservoir.

Despite of significant biological differences, adventive species common ecological features are relatively small size, short-term life cycle and relative eurybionty.

As a result of diffusion and interpopulation interactions processes all invasive species divides into the two conditional groups by prevalence and abundance (tab. 1).

Dominant species (the Black Sea-Caspian Sea sprat; the Amur sleeper *Percottus glenii* Dybowski, 1877; the round goby *Neogobius melanostomus* (Pallas, 1814); the Caspian bighead goby *Neogobius iljini* Vasiljeva et Vasiljev, 1996 and the tubenose goby *Proterorhinus marmoratus* (Pallas, 1814)) have a wide distribution on larger part of reservoir and abundance at the same level as an ecology-similar native species.

**Table 1.** The invasive fish species average abundance changes in Cheboksary reservoir integrally during 2001-2021 years, units per hectare.

Species	Average abundance, unit/ha						
	2001-2003	2004-2006	2007-2009	2010-2012	2013-2015	2016-2018	2019-2021
Black Sea-Caspian Sea sprat	25.9	288.4	101.1	57.3	28.3	45.3	297.4
Round goby	50.5	14.9	48.4	67.8	140.8	142.2	256.6
Caspian bighead goby	19.7	49.4	28.0	8.2	19.7	5.7	0.4
Tubenose gobies	12.0	31.0	7.3	26.4	15.4	139.4	6.9
Monkey goby	3.7	6.6	7.4	0.9	2.5	0.2	0.0
Amur sleeper	43.2	27.6	2.7	55.6	0.4	6.9	0.0
European vendace	0.0	0.5	0.2	0.3	6.2	0.1	0.0
Stellate tadpole goby	14.3	0.0	9.9	1.1	2.0	1.0	0.1
Nine-spine stickleback	0.0	7.6	0.0	0.1	0.1	0.1	0.0
Total	169.3	425.9	205.0	217.7	215.3	340.8	561.5

The monkey goby *Neogobius fluviatilis* (Pallas, 1814); the European vendace *Coregonus albula* (Linnaeus, 1758); the stellate tadpole goby; the nine-spine stickleback *Pungitius pungitius* (Linnaeus, 1758) are inhabit generally local dwellings and have unessential total abundance for the whole reservoir. At the same time, both of this conditional group can form aggregated clumping with significantly higher than the average abundance in favorable habitats or during some phases of life cycle.

The relative abundance of the Caspian bighead goby and the Amur sleeper decreased in many times from 2013, down to the complete absence in the catches. In a long-term aspect this species became non-mass in the reservoir.

Under the mixed lake-river conditions of the Cheboksary reservoir the stellate tadpole goby could potentially become a numerous species [22]. But for its population were not noted high levels of the average density in the last decade.

It is necessary to pay attention to significant range in the relative abundance fluctuations of the tubenose goby in period 2013 to 2021. Despite the pronounced depression in recent

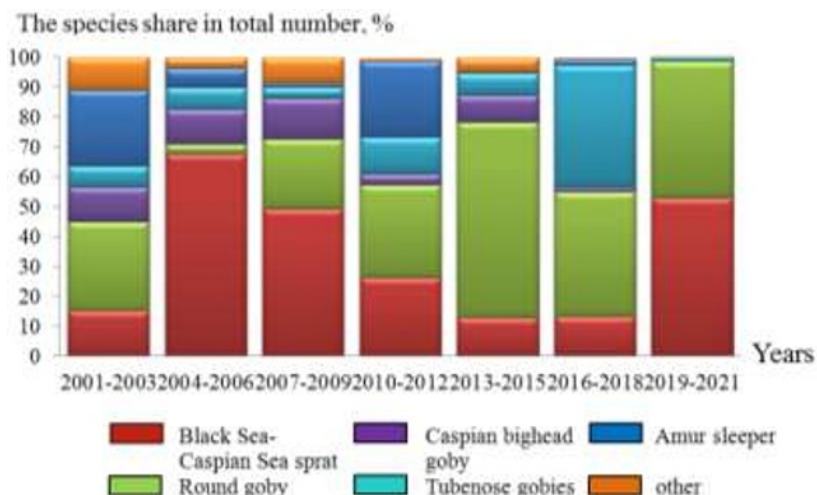
years, this species dynamic suggests the possibility of a sharp surge in numbers in the future, especially in the case of decrease in the density of the round goby population.

The population ratio changes for adventive community members are also affected by expressed outbreaks and depressions typical to short-term life cycle species.

Despite the actual reduction of some species, the total relative abundance of invaders tends to increase. The same trend also was noted in other studies for period until 2018 [12, 13].

The structure of invasive fish species community based on total number (absolute abundance) also had significant changes (fig. 1).

Composition of adventive species in the early 2000s was more justified, especially for species of Gobiidae family. To the extent the population's growth and interactions in biocommunity 1-2 species increased their domination due to other invaders significance lost.



**Fig. 1.** The Cheboksary reservoir invasive species community's structure changes from 2001 to 2021.

Shannon's diversity index calculated for only non-indigenous species numbers decreased from 1.75 bit per unit in 2001-2003 to 0.76 bit per unit in 2019-2021.

The abundance increase and overdomination of the Black Sea-Caspian sprat in the pelagic zone of the Cheboksary and other reservoirs of the cascade also was noted by different studies [23, 24].

Species, tenuously distributed by entire reservoir's area on account of their ecological requirements, had lost their importance even more.

Amur sleeper, Caspian bighead and monkey gobies numbers declining may be caused by competition with another invader - the round goby, that has a more aggressive and successful breeding strategy in the reservoir's terms.

The total shares of the most numerous invasive species in the whole stock (in tons) of the Cheboksary reservoir fish community is rather small and amounts to 4.3%. A significant decrease in the native fish species total number as a result of invaders population increase for the present time has not been observed. However, the absolute number of invaders has reached a comparable level to native species with contiguous or partially overlapping ecological niches. Such native species as the ruff *Gymnocephalus cernuus* (Linnaeus, 1758), the gudgeon *Gobio gobio* (Linnaeus, 1758), the dace *Leuciscus leuciscus* (Linnaeus, 1758), the bleak *Alburnus alburnus* (Linnaeus, 1758) in future may be extruded or displaced by nonindigenous fishes in some habitats of the reservoir [25].

## 4 Conclusions

The invasive fish species structure in the Cheboksary reservoir has a pronounced division into mass species with a significant abundance and species with an unessential abundance and numbers. At the present stage the invaders fish species evenness has decreased with a trend to increase their total number. The Black Sea-Caspian sprat and the round goby put together for 98.7 % of nonindigenous fishes absolute abundance and became the dominants of the adventive community.

These two species abundance growth trend can lead to competition exacerbation with native species and various negative consequences for the fish community of the reservoir in the future. In places of the round goby mass allocations in the littoral zone the decrease of species diversity is possible. The similar effect has already noted in the pelagial as a result of the Black Sea-Caspian sprat number increase.

The small and inferior species share rising reduces the potential value for commercial exploitation of fish stocks in reservoir.

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