Studia Marina 2019, 32 (1): 33-46 UDC: 597.4/.5:639.3
Review article DOI: 10.5281/zenodo.3274548

Review of allochthonous fish species with the marine origin in Serbian freshwater system

Marija SMEDEREVAC-LALIĆ[1*], Slobodan REGNER[1], Mirjana LENHARDT[2], Dušan NIKOLIĆ[1], Gorčin CVIJANOVIĆ[1], Milica JAĆIMOVIĆ[1] & Aleksandar HEGEDIŠ[1]

[1]Institute for Multidisciplinary Research, University of Belgrade, Kneza Višeslava 1, 11030 Belgrade, Serbia, *e-mail: marijasmederevac@imsi.rs,
[2]Institute for Biological Research "Siniša Stanković", Bulevar despota Stefana 142, 11060 Belgrade, Serbia

ABSTRACT

During the last decades in the freshwater system in Serbia 32 allochthonous fish species appeared, and they can be divided into five groups according to their region of origin: Asian, Ponto-Caspian, North American, South American, and Europe without Ponto-Caspian region. The Asian and Ponto-Caspian species are the most numerous. In the first group are representatives of fish fauna which are originally from Asia and they are intentionally introduced into open waters and aquaculture in Serbia, while the second group represents the migrants spreading their range from the Black Sea into freshwater systems. Some of these species already have established populations. Representatives of marine origin that inhabit freshwater systems in Serbia are: *Syngnathus abaster, Neogobius fluviatilis, Neogobius melanostomus, Babka gymnotrachelus, Ponticola kessleri, Proterorhinus semilunaris, Knipowitschia caucasica, Benthophyllus stellatus, Gasterosteus aculeatus, Morone saxatilis x Morone chrysops.* Gobiidae and Sygnathidae extended their geographical distribution outside their native range and expanded their area of distribution throughout whole Danube River Basin, while for the other specimens there are no literature data about established populations.

Keywords: allochthonous fish, freshwater, distribution, expansion

INTRODUCTION

Aquatic habitats are among the most exposed ecosystems in terms of biological invasions, while freshwater ecosystems are especially endangered (Sala *et al*., 2000; Zorić, 2015). Under the anthropogenic influence the introduction of allochthonous fish has occurred for centuries (Lenhardt *et al*., 2011), and it is known even from prehistory (Leppäkoski *et al*., 2002; Zorić, 2015). But even without anthropogenic influence some species expand their distribution and adapt to new eco-regions. The good hydrological conditions on the territory of Europe and great diversity of habitats in the Danube basin provide favorable conditions for the development of various aquatic fauna. The Danube Basin represents a ''hot spot'' of freshwater biodiversity ecosystems of Europe, with more than 100 different fish species (Zorić, 2015). In addition to the size and diversity of conditions, this river system was east-west corridor for migration and recolonization in periods of glaciation and interglacialization (Sommerwerk *et al*., 2009). The Danube and its tributaries, as part of the Southern Invasive Corridor of Europe are one of the most interesting river systems for monitoring the introduction and spreading of non-native aquatic species connecting Black with the North Sea, across the Danube, Rhine and Main (Panov et al., 2009; Zorić, 2015). Due to the complexity of the problem and the lack of relevant data from the past, it is clear that there are species for which it is not possible to determine with certainty are they native or non-native species (allochthonous, non-indigenous species). Such species are defined as cryptogenic (Carlton, 1996; Zorić *et al*., 2014; Zorić, 2015). A significant factor that can affect the naturalization of allochthonous species is the uniformity of ecosystems, but also disturbance of the balance caused by the influence of external factors (interruption of longitudinal continuity - dams, constraints, interruption of transverse connections - loss of flood areas, coast protection and hydrological changes - water capture and sudden change in water level) (Zorić, 2015).

The ichthyofaunistic research of the Danube dates from XVIII and XIX century, but in the recent times there are numerous publications, especially those related to non-indigenous species in the Danube River: Harka, 1993; Simonović & Nikolić, 1997; Freyhof, 2003; Ciolac, 2004; Kováč & Siryová, 2005; Wiesner, 2005; Ćaleta *et al*., 2010; Piria *et al*., 2011; Lenhardt *et al*., 2011, Djikanovic *et al*., 2018; while the special attention for allohthonous species that extended their geographical distribution outside their native range from Black Sea throughout Danube in Serbia, was observed by following authors: Hegediš *et al*., 1991; Simonović *et al*., 1998; Sekulić *et al*., 1999; Cakić *et al*., 2000; Smederevac *et al*., 2001; Lenhardt *et al*., 2016.

In open waters in Serbia 32 non indigenous species are recorded. But the real question is which of these are really non-indigenous, taking into account that there are findings that some of these species were in a particular ecosystem for an entire century, and that they extended their distribution as a natural process of adaptation to new habitat conditions.

MATERIAL AND METHODS

The data observed in this study were collected from the available literature and through research conducted by the authors of the present study.

This review attempts to present recent distribution of the non-indigenous fish species

in Serbia that originaly have marine or brackish origin and to disscuss ecological impacts of these fish species in the freshwater system.

RESULTS

The allochthonous fish species that have been reported for the Serbian part of the Danube River basin have North American, Asian, Ponto-Caspian origin, South American, and origin from Europe without Ponto-Caspian region (Zorić *et al*., 2014). They are representatives of 14 different families (Tab. 1). Non-native fish species contribute with 27.66% of Serbian ichthyofaunistic diversity (Djikanović *et al*., 2018).

Ten allochthonous fish species that have marine or brackish origin are representatives of 4 different families. Most abundant are representatives of Gobiidae family. Expanding distribution in combination with water transport is the main mean of spreading the Ponto-Caspian Gobies (Roche *et al*., 2013). The family Gobiidae counts probably more than 1900 species. They are mainly small fish inhabiting temperate marine, brackish and freshwater systems. According to their origin, Black Sea gobies are divided in Ponto-Caspian relicts and Mediterranean immigrants (Vassilev *et al*., 2012).

Western tubenose goby (*Proterorhinus semilunaris* Heckel, 1837) were recorded for the first time in Serbian waters in XIX century (Lenhardt *et al*., 2011), which doesn't mean that it was not present before. According to Harka and Bíró (2007), the first documented report of the tubenose goby is from a creek flowing into the Danube near Budapest (Hungary) in 1872 (Roche *et al*., 2013). Western tubenose goby *Proterorhinus semilunaris* Heckel, 1837 (synonyms: *Proterorhinus marmoratus* Pallas, 1814; *Gobio marmoratus* Pallas, 1814) inhabit Black Sea basin and drainages in eastern Aegean basin. In Danube, historically present up to Vienna, but in 1999 arrived from Danube canal system reaching Rhine River watershed (Vassilev *et al*., 2012). Although it is considered as an invasive species since 1970s (IUCN and Fishbase) it should be observed as cryptogenic, and the further detailed research is needed.

Monkey goby *Neogobius fluviatilis* Pallas, 1814 (synonym *Gobius fluviatilis* Pallas, 1814) was first registered in Danube 1927 (Svetovidov, 1964). During the 1972 the monkey goby *Neogobius fluviatilis* was distributed upstream to Hungary. Rapid upstream expansion was recorded in Serbia (Janković *et al*., 1987; Simonović *et al*., 1996; Smederevac *et al*., 2001; Djikanović, 2013), Bosnia and Herzegovina (Sorfadžija, 2009; Nedić *et al*., 2014), Croatia (Ćaleta, 2007, Piria *et al*., 2011; Jelić *et al*., 2012; Piria *et al*., 2013), Hungary (Ahnelt *et al*., 1988), Slovakia (Jurajda *et al*., 2005) Poland (Grabowska & Grabowski, 2005), Austria (Wiesner, 2005) and Netherlands (van Kessel *et al*., 2009). The original range of *N. fluviatilis* comprises the inshore habitats, estuaries, brackish lagoons and rivers of the Black Sea basin with sandy or muddy bottom (Delić *et al*., 2014).

Round goby *Neogobius melanostomus* Pallas, 1814 (synonyms: *Gobius melanostomus*, *Gobius cephalarges*, etc.) was recorded in the Danube in Serbia in late 1990's (Simonović *et al*., 1998). After 2000 it was recorded in most of the upstream countries: Croatia (Mustafić, 2005; Piria *et al*., 2011), Hungary (Erős *et al*., 2005), Slovakia (Adamek *et al*., 2007), in the Rhine River Basin in Switzerland (Kalchhauser *et al*., 2012), Belgium (Verreycken *et al*., 2011), and in the Baltic Sea (Sapota, 2004) (Jakšić *et al*., 2016). This species inhabits marine, freshwater, brackish and demersal zone with

sandy or rocky bottom. It also prefers well vegetated or rock bottom (Kottelat & Freyhof, 2007).

According to description of Pančić (1869) (as *Gobius cephalarges*), the bighead goby *Ponticola kessleri* Günther, 1861 (synonyms: *Gobius kessleri*, *Neogobius kessleri*, *Gobius platycephalus*) inhabits the Danube in Serbia (sector Sip 952 rkm – Radujevac 852 rkm). Jakšić *et al*. (2016) noticed that the first individuals of bighead goby were caught in the Danube in Serbia in 1910 according to Vutskits (1911). Ristić (1977) mentioned that bighead goby *N. kessleri* was distributed up to the rkm 1,214 (Lenhardt *et al*., 2011). It was recorded in the Danube in Hungary (Erős *et al*., 2005), Croatia and Slovakia (Polačik *et al*., 2008), Germany (Seifert & Hartmann, 2000), in the Rhine in Germany (Borcherding *et al*., 2011) and Switzerland (Kalchhauser *et al*., 2012) (Jakšić *et al*., 2016). Bighead goby prefers freshwater and brackish water with very low salinity (Kottelat & Freyhof, 2007).

The first record of the racer goby *Babka gymnotrachelus* Kessler, 1857 (synonyms: *Neogobius gymnotrachelus*, *Gobius gymnotrachelus*, etc.) in Serbia was in 1991 (Hegediš *et al*., 1991). The species is widespread in Danube River. In the past it was known to occur up to Rousse, recently it is spread up to Vienna and in Danube tributaries. In Black Sea it inhabits the coastal areas with fresh and brackish waters with lower salinities (Vassilev *et al*., 2012).

Table 1. Non-native fish species in Serbian freshwater system according to different literature sources. Some of them marked in bold in the table should be considered as cryptogenic, and some underlined have marine origin.

Family	**Species**	**Status (appearance, established populations/no established populations)**	**Reference of the first record in Serbian waters**
Cyprinidae	1. *Alburnus scoranza*	Rare, no established populations	Simonović & Nikolić, 1995
	2.*Ctenopharyngodon idella*	Often records, no established populations	Toth, 1971; Cakić & Hristić, 1987
	3.Carassius gibelio	Often records, established populations	Maletin & Budakov, 1982
	4.*Hypophthalmichthys nobilis*	Often records, no established populations	Cakić & Hristić, 1987
	5.*Hypophthalmichthys molitrix*	Often records, established populations	Cakić & Hristić, 1987
	6.*Pachychilon macedonicus*	Rare, no established populations	Simonović & Nikolić, 1995, 1997
	7.*Pseudorasbora parva*	Often records, established populations	Cakić, 1983
	8. *Scardinius knezevici*	Rare, established populations	Simonović & Nikolić, 1995, 1997
Salmonidae	9.*Oncorhynchus mykiss*	Often records, no established populations	Janković & Raspopović, 1960
	10.*Salvelinus alpinus* (or *Salvelinus umbla* after Kottelat & Freyhof, 2007)	established populations	Simonović, 2001

	11.*Salvelinus fontinalis*	Rare, no established populations	Simonović, 2001
	12.*Salmo letnica*	Rare, no established populations	Janković & Raspopović, 1960
Coregonidae	13.*Coregonus peled*	Rare, no established populations	Maletin & Đukić, 1991
Ictaluridae	14.*Ameiurus nebulosus*	established populations	Maletin *et al*., 1997
	15.*Ameiurus melas*	established populations	Cvijanović, *et al.*, 2005
Centrarchidae	16.*Lepomis gibbosus*	established populations	Ristić, 1940
	17.*Micropterus salmoides*	established populations	Maletin, 1988
Syngnathidae	18.*Syngnathus abaster*	established populations	Sekulić *et al.*, 1999
Gobiidae	19.*Neogobius fluviatilis*	established populations	Bănărescu, 1964; Ristić, 1977
	20.*Babka gymnotrachelus*	established populations	Hegediš *et al*., 1991
	21.***Ponticola kessleri***	established populations	Pančić, 1869; Ristić, 1977
	22.*Neogobius melanostomus*	established populations	Simonović *et al.*, 1998
	23.***Proterorhinus semilunaris***	established populations	XIX century Lenhardt *et al*., 2011
	24.*Knipowitschia caucasica*	Rare	Harka *et al*., 2015
	25.*Benthophyllus stellatus*	Rare, no established populations	Lenhardt *et al*., 2011
Gasterosteidae	26.*Gasterosteus aculeatus*	Rare, no established populations	Cakić *et al.*, 2000
Odontobutidae	27.*Perccottus glenii*	Often records, established populations	Šipoš *et al*., 2004
Polyodontidae	28.*Polyodon spathula*	Rare, no established populations	Simonović *et al*., 2006
Moronidae	29. *Morone saxatilis* etx *Morone chrysops*	Rare, no established populations	Skorić *et al*., 2013
Loricariidae	30. *Pterygoplichthys pardalis*	Rare, no established populations	Simonović *et al*., 2010
Poeciliidae	31. *Poecilia reticulata*	Rare, no established populations	Milenković *et al.*, 2014
Cichlidae	32. *Oreochromis* sp.	Rare, no established populations	Hegediš (2002, unpublished data)

The first record of Caucasian dwarf goby *Knipowitschia caucasica* Berg, 1916 (synonyms: *Pomatoschistus caucasicus*, *Gobius lencoranicus*, etc.) in Serbia was 2015 (Harka *et al*., 2015). This species represents a unique type

of spreading of a goby species, appearing in Serbia from the upper part of the Tisa River. The first record of the species in the Carpathian Basin was in the Hungarian section of the River Szamos in 2009. In 2013 it had become a species of mass occurrence in the Lake Tisza reservoir. The first specimens were collected in the lower section of the River Tisza at the Serbian border close to Senta and Kanjiža in March 2015 (Harka *et al*., 2015). The distribution includes Black, Caspian, Azov and Marmara Seas, and the Northern part of Eastern Mediterranean. It was also introduced into Aral Sea. *K. caucasica* is euryhaline species that inhabit from hyperhaline waters to freshwater habitats (rivers, lakes). Prefers shallow water closer to the shore, with sandy, muddy or rocky bottom, covered with vegetation (Vassilev *et al*., 2012). The species has been described by Kovačić & Pallaoro (2003) for the eastern coast of the Adriatic Sea, and there are data about species in Greek

marine and brackish waters (Harka *et al*., 2015).

The stellate tadpole goby *Benthophyllus stellatus* (Sauvage, 1874) (synonyms: *Benthophilus macrocephalus* (non Pallas) Nordmann, 1840; *Doliichthys stellatus* Sauvage, 1874; etc.) is reportedly recorded in one of the Djerdap reservoirs (Lenhardt *et al*., 2016), and given that there are findings that is on the list of species in Romania and Bulgaria (fishbase) it can be expected in the upstream course of the Serbian part of the Danube River. In Bulgarian waters it can be found only in Danube River and its tributaries. Inhabit shallow coastal lagoons, estuaries and lower stretches of the rivers, adjacent to northwestern Black sea, the Azov Sea and eastern and northern Caspian Sea (Vassilev *et al*., 2012).

The first record of three-spined stickleback *Gasterosteus aculeatus* Linnaeus, 1758 in Serbian section of Danube River was in 1980 in floodplain zone near village Ivanovo (1139 rkm) (Hegediš, unpublished data). The first published record of three-spined stickleback was in 1995 at Mala Vrbica rkm 927 (Cakić *et al*., 2000), while in Serbian upper sector of Danube, in Vojvodina, first record was in 2007 (Šipoš *et al*., 2007), and in Croatian part of the Danube basin in 2014 (Lisjak *et al*., 2015). According to Ahnelt *et al*. (1998) species was introduced in Austria in the drainage systems of the Rhine and Danube rivers in the second half of the XIX century. There are three different morphs of *G. aculeatus* regarding development of different plate morphs (Ahnelt *et al*., 1998). These species are benthopelagic and inhabit marine, freshwater, brackish water. They are anadromous species, with resident populations in brackish or freshwater. Usually feed in the sea until the age of two, and then moves to rivers to reproduce. Prefers quiet weedy pools and vegetation over sand and mud bottom substrates (Page & Burr, 1991).

The first record of a hybrid striped bass (*Morone saxatilis x Morone chrysops*) in the Danube River was in 2013 (Skorić *et al*., 2013). The introduction of the striped bass (*Morone saxatilis*) from USA into European waters was in 1965 for aquaculture purposes in the former USSR. Production of hybrid striped bass (HSB) for aquaculture dates from 1980's (Israel, Germany, Italy, Turkey and Hungary). Safner *et al*. (2013) reported that in 2010 the first specimen of (HSB- *M. saxatilis x M. chrysops*) was caught in the Croatian section of the river Danube. The initial morpha *M. saxatilis* inhabit marine and estuarine coastal waters and moves far upstream in channels of medium to large rivers during spawning migrations (Eschmeyer *et al*., 1983), while *M. chrysops* occurs in lakes, ponds and pools of rivers (Page & Burr, 1991).

The first official record of short-snouted pipefish *Syngnathus abaster* Risso, 1827 in Serbia was in 1998 by Sekulic *et al*. (1999), but there are records under the name *Syngnathus nigrolineatus* Eichwald 1831 in the Danube at the 864 rkm published by Bacalbasa-Dobrovici *et al*. (1984). The natural distribution of these species includes Mediterranean and Black Sea, and the Atlantic coast northward to southern Biscay. Their typical habitats are estuaries and sea coasts with sand, mud, or sea-grass bed and shallow warm water (temperature range of 8–24°C). Occurrence of freshwater short-snouted pipefish populations in the Danube (900 rkm) (Cakić *et al*., 2002), and increase in abundance in grassy littoral habitats of Danube River (Djerdap reservoir) during 1994, 1995 and 2000 (Simić & Simić, 2004), supports the idea that this species established populations in Danube River after introduction. It was found upstream to Belgrade region of the Danube River in Serbia (Djikanović *et al*., 2013). Also, there are findings of their presence in Neretva River, which belongs to the Adriatic Sea

watershed (Tutman *et al*., 2012). According to Riede (2004) these species are probably an amphidromous species (born in freshwater/estuaries, then drift into ocean as larvae before migrating back into freshwater to grow into adults and spawn.

DISCUSSION

East–west invasions included the dispersal of Gobiids and short-snouted pipefish (*Syngnathus abaster*) along the Danube River from the Black Sea. Only individual findings in Serbia have been reported for the three-spined stickleback (*Gasterosteus aculeatus*) and no sufficient data are available for spreading of the species (Lenhardt *et al*., 2011).

Non-native fish may have ecological impact which has been defined as quantifiable negative on the recipient environment, but negative effects of introduction have never been clearly established and sometimes some introductions can have positive outcomes. Ecological risk associated with freshwater fish introduction varies between different families of fish
(Lenhardt *et al*., 2011).

Cryptogenic taxa have completely adapted to the area and they reproduce establishing their populations (Zorić, 2015). Several gobies and short-snouted pipefish, have managed to survive in ballast waters before entering into freshwater (Zorić *et al*., 2014). Their cryptic way of life in stony (e.g., bighead goby), weed (e.g., pipefish, tubenose goby), mosaic (e.g., round, racer and sand goby) habitats enables the successful acclimatization and naturalization in recipient area. These successful invaders display parental care (males guarding offspring prior to and after hatching, fanning the clutch, and defending the nest aggressively (stickleback, gobies), sac brooding of short-snouted pipefish. The feeding characteristics also contribute to the successful invasiveness in new areas. Invasiveness in general is a very complex process linked to the ability of certain fish species to utilize a broad range of habitat types (racer goby), to low environmental requirements and to tolerance to physical and chemical variables of water quality (Zorić *et al*., 2014).

Majority of freshwater fish introductions were not identified as having an ecological impact, but it is inappropriate to conclude as ‘‘no impact’’ when there is a lack of data or just a very little is actually known about the ecological impacts associated with fish introductions (Lenhardt *et al*., 2011). Negative effects may also include predation, trophic competition, behavioural interference, hybridization, spread of novel parasites and diseases, alteration of food webs and modification of biochemical cycles (Djikanović *et al*., 2018).

Regarding non-native species that have marine/brackish origin in Serbia, according to research of Zorić (2015) just *N. melanostomus*
have a high level of biological contamination.

For species of the Gobiidae family, expanding distribution is the main mean of spreading the Ponto-Caspian fish species upstream along the Danube (Roche *et al*., 2013). The border of the Ponto-Caspian region is located in the lower part of the Danube near the locality of Banatska Palanka - Bazijas at 1071 rkm. Due to that fact species originating from the Ponto-Caspian region, can’t be non-native for the lower Danube, but for the rest of the upstream course of the Danube River, upper from the Iron Gate I. It is clear that, especially in aquatic ecosystems, there are no precise borders (Zorić, 2015).

On the other hand, anthropogenic habitat modifications contributed to the water

becoming a suitable recipient area for invasiveness. According to Paunović *et al*. (2006, 2007, 2012), this is the situation in the Danube area around the Iron Gate and Danube tributaries (Sava and Tisa). The river-lake flow character of the Danube actually goes to the mouth of the Tisza and Danube, while up to Smederevo city the Danube is considered as water reservoir.

CONCLUSION

According to material presented, allochthonus character of certain species that have cryptogenic status should be reconsidered in the Danube River basin, especially taking into account lack of the historical data. Despite anthropogenic influence in their expansion there are implications that some of these species were already present in Danube River basin but not enough abundant and economical important to be observed in the previous findings. Additional research is needed in order to improve knowledge in this field.

ACKNOWLEDGEMENTS

This study is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Projects No. IO 173045 and No. TR 37009.

REFERENCES

Ahnelt, H., P. Bănărescu, R. Spolwind, A. Harka & H. Waidbacher (1988): Occurrence and distribution of three gobiid species (Pisces: Gobiidae) in the middle and upper Danube region – example of different dispersal patterns)? Biologia (Bratislava), 53: 661–674.

Ahnelt, H., H. Pohl, H. Hilgers & H. Splechtna (1998): The threespine stickleback in Austria (Gasterosteus aculeatus L., Pisces: Gasterosteidae). Morphological variations. Ann Naturhist Mus Wien, 100B: 395–404.

Bănărescu, P. (1964): Pisces – Osteichthyes. Fauna R. P. Romine, Vol. 13. Academiei Republicii Populare Romine, Bucuresti, 959 (in Romanian).

Bacalbasa - Dobrovici, N., P. Banarescu, J. Holcik, R. Janisch, D. Janković, C. Keiz & E. Weber (1984): 24 Arbeitstagung der IAD, Wissenschaftliche Kurzreferate II, 149-156.

Cakić, P. (1983): Pseudorasbora parva Schlegel, Pisces Cyprinidae nova vrsta za ihtiofaunu SR Srbije. Drugi simpozijum o fauni SR Srbije – Zbornik: 131-134.

Cakić, P. & Đ. Hristić (1987): The ichthyofauna of Pančevački rit wetlands (Belgrade) with special reference to the allochthonous fish species. Bulletin du Museum d'Histoire Naturelle, Belgrade, Serie B, Livre, 42: 103-118.

Cakić, P., M. Lenhardt & Z. Petrović (2000): The first record of Gasterosteus aculeatus L. 1758 (Pisces: Gasterosteidae) in the Yugoslav section of Danube. Ichthyologia, 32 (1): 79-82.

Ćaleta, M. (2007): Ekološke značajke ihthyofaune nizinskog dijela rijeke Save (Ecological characteristics of the ichthyofauna of the Sava River lowlands). Ph.D. Thesis, Faculty of Science, University of Zagreb, 232.

Ćaleta, M., D. Jelić, I. Buj, D. Zanella, Z. Marčić, P. Mustafć & M. Mrakovčić (2010): First record of the alien invasive species rotan (Perccottus glenii Dybowski, 1877) in Croatia. Journal of Applied Ichthyology, 27(1): 146-147.

Carlton, J.T. (1996): Biological invasions and cryptogenic species. Ecology, 77(6): 1653-1655.

Ciolac, A. (2004): Migration of fishes in Romania Danube river. Applied Ecology and Environmental Research, 2(1): 143-163.

Cvijanović, G., M. Lenhardt & A. Hegediš (2005): The first record of black bullhead Ameiurus melas (Pisces, Ictaluridae) in Serbian waters. Archives of Biological Sciences, 57(4): 21P-22P.

Delić, A., R. Šanda, M. Bučar, I. Mihoci, M. Vilenica, J. Vukić, L. Suvad & M. Kučinić (2014): New data on distribution of the monkey goby, Neogobius fluviatilis (Pallas, 1814) in Bosnia and Herzegovina and Croatia with notes on ecology and associated fish fauna. Natura Croatica, 23 (2): 297–302.

Djikanović, V., S. Skorić & P. Cakić (2013): Representatives of tapeworms (Cestoda) of fishes in Belgrade section of the Danube River. VI International Conference "Water & Fish" June 12-14, Faculty of Agriculture, Belgrade-Zemun, Serbia, Conference Proceedings: 402-408.

Djikanović, V., G. Marković & S. Skorić (2013): New record of Neogobius fluviatilis (Pallas, 1814) (Gobiidae) in the Danube River Basin (Serbia). Archives of Biological Sciences, 65: 1469–1472.

Djikanović, V., P. Simonović, P. Cakić & V. Nikolić (2018): Parasitofauna of allochthonous fish species in the open waters of the Danube river basin (Serbian part) – impact on the native fish fauna. Applied Ecology and Environmental Research, 16(5): 6129-6142.

Eschmeyer, W.N., E.S. Herald & H. Hammann (1983): A field guide to Pacific coast fishes of North America. Boston (MA, USA): Houghton Mifflin Company. xii+336 p.

Freyhof, J. (2003): Immigration and potential impacts of invasive freshwater fishes in Germany. Berichtes des IGB, 17: 51-58.

Grabowska, J. & M. Grabowski (2005): Diet feeding activity in early summer of racer goby Neogobius gymnotrachelus (Gobiidae): a new invader in the Baltic basin. Journal of Applied Ichthyology, 21: 296–299.

Harka, Á. (1993): Invasion of the Neogobius fuviatilis. Halászat, 86(4): 180-181.

Harka, A. & P. Biro (2007): New patterns in Danubian distribution of Ponto-Caspian gobies – A result of global climatic change and/or canalization. Electronic Journal of Ichthyology, 1: 1–14.

Harka, A., Zs. Szepesi, A. Bajić & S. Sipos (2015): First record of the invasive Caucasian dwarf goby – Knipowitschia caucasica (Berg, 1916) – in Serbia. Pisces Hungarici, 9: 89–92.

Hegedis, A., M. Nikcevic, B. Mickovic, D. Jankovic & R.K. Andjus (1991): Discovery of the goby Neogobius gymnotrachelus in Yugoslav fresh waters. Archives of Biological Sciences, 43: 39-40.

Jakšić, G., M. Jadan & M. Piria (2016): The review of ecological and genetic research of Ponto-Caspian gobies (Pisces, Gobiidae) in Europe. Croatian Journal of Fisheries, 74, accepted article, online first, 93-114.

Janković, D. & M. Raspopović (1960): Ohridska pastrmka (Salmo letnica typicus K.) pod promenjenim uslovima u Vlasinskom baražnom jezeru. Arhiv bioloških nauka, 12 (3-4): 117-122.

Jelić, M., D. Jelić, P. Žutinić & M. Ćaleta (2012): Značajke faune riba donjeg toka rijeke Drave i okolnih poplavnih staništa kod Donjeg Miholjca (Istočna Hrvatska). Croatian Journal of Fisheries, 70: 153–167.

Jurajda, P., J. Černý, M. Polačik, Z. Valová, M. Janáč, R. Blažek & M. Ondračková (2005): The recent distribution and

abundance of non-native Neogobius fishes in the Slovak section of the River Danube. Journal of Applied Ichthyology, 21: 319–323.

Kováč, V. & S. Siryová (2005): Ontogenetic variability in external morphology of bighead goby Neogobius kessleri from the middle Danube, Slovakia. Journal of Applied Ichthyology, 21(4): 312-315.

Kottelat, M. & J. Freyhof (2007): Handbook of European freshwater fishes. Publications Kottelat, Cornol and Freyhof, Berlin. 646 pp.

Lenhardt, M., G. Marković, A. Hegediš, S. Maletin, M. Ćirković & Z. Marković (2011): Non-native and translocated fish species in Serbia and their impact on the native ichthyofauna. Reviews in Fish Biology and Fisheries, 21: 407–421.

Lenhardt, M., V. Đikanović, A. Hegediš, A. Višnjić-Jeftić, S. Skorić & M. Smederevac-Lalić (2016): Kvalitativno-kvantitativne promene ihtiofaune u protočnim dunavskim akumulacijama posle izgradnje brana đerdapskih hidroelektrana. Naučni skup ″Ekološki i ekonomski značaj faune Srbije″, Naučni skupovi Srpske akademije nauka i umetnosti, knj.CLXXI, Odeljenje hemijskih i bioloških nauka, knj.12, Akademski odbor za proučavanje faune Srbije, Beograd, Srbija, 17. Nov, 2016, Zbornik radova: 143-172.

Leppäkoski, E., S. Olenin & S. Gollasch (2002): The Baltic Sea – a field laboratory for invasion biology. In: Invasive aquatic species of Europe – distribution, impact and management (ur. Leppäkoski, E., Gollasch, S., Olenin, S.) Kluwer Academic Publishers, Dordrecht, Boston, London, pp. 253-259.

Lisjak, D., D. Zanella, P. Mustafić, M. Ćaleta, I. Buj, T. Mihinjač, M. Mrakovčić & Z. Marčić (2015): First record of three-spined stickleback (Gasterosteus aculeatus Linnaeus, 1758) in the Danube basin of Croatia. Croatian Journal of Fisheries, 73: 70 – 72.

Maletin, S. (1988): The large-mouthed black bass (Micropterus salmoides Lacepede, 1802 Pisces, Centrarchidae) presence in the open waters of Vojvodina (In Serbo-Croatian). The Proceeding of scientific meeting ‘‘Minerali, stijene, izumrli i živi svijet’’ Sarajevo, pp. 537–539.

Maletin, S. & N. Đukić (1991): Coregonus peled (Gmelin, 1788; Osteichthyes, Coregonidae) prvi nalaz u ihtiofauni jugoslovenskog dela Dunava. Zbornik Matice srpske za prirodne nauke, 80: 157-163.

Maletin, S., N. Djukić, B. Miljanović & B. Ivanc
(1997): Status of allochthonous ichthyofauna of Pannonian basin in Yugoslavia. Ekologija, 32: 87–98.

Milenković, M., V. Žikić, S.S. Stanković & S. Marić (2014): First study of the guppy fish (Poecilia reticulata Peters,†) occurring in natural thermal waters of Serbia. Journal of Applied Ichthyology, 30: 160-163.

Nedić, Z., S. Begović, M. Dogan, E.J. Hadžiahmetović, J. Ferizbegović & R. Terzić (2014): Decreasing of biodiversity of fish populations from the Sava River in Bosnia and Herzegovina. Basic Research Journal of Agriculture Science and Review, 3(5): 35–40.

Page, L.M. & B. M. Burr (1991): A field guide to freshwater fishes of the North America north to Mexico. Houghton Mifflin Company, Boston. 432 pp.

Pančić, J. (1869): Građa za faunu kneževine Srbije. Zoološki radovi. Državna štamparija u Beogradu. Beograd. 348-349.

Panov, V.E., B. Alexandrov, K. Arbaciauskas, R. Binimelis, G.H. Copp, M. Grabowski, F. Lucy, R.S.E.W. Leuven, S. Nehring, M.

Paunovic, V. Semenchenko & M.O. Son (2009): Assessing the Risks of Aquatic Species Invasions via European Inland Waterways: From Concepts to Environmental Indicators. Integrated Environmental Assessment and Management, 5(1): 110-126.

Paunović, M., B. Csany, V. Simić, B. Stojanović & P. Cakić (2006): Distribution of Anodonta (Sinanodonta) woodiana (Lea, 1834) in inland waters of Serbia. Aquatic Invasions, 1: 154-160.

Paunović, M., B. Csanyi, S. Knežević, V. Simić, D. Nenadić, D. Jakovčev-Todorović, B. Stojanović & P. Cakić (2007): Distribution of Asian clams Corbicula fluminea (Muller, 1774) and C. fluminalis (Muller, 1774) in Serbia. Aquatic Invasions, 2 (2): 99-106.

Paunović, M., K. Žganec, V. Simić, S. Hudina, J. Lajtner, S. Gottstein, S. Kovačević, J. Tomović, K. Zorić & A. Lucić (2012): Preliminary results of the macroinvertebrates investigation within examined sector of the Sava River between Zagreb and Belgrade, "Water 2012", Conference Proceedings, Divčibare: 57-62. (in Serbian)

Piria, M., N. Šprem, I. Jakovlić, T. Tomljanović, D. Matulić, T. Treer, I. Ančić & R. Safner (2011): First record of round goby, Neogobius melanostomus (Pallas, 1814) in the Sava river, Croatia. Aquatic Invasions 6(1): 153-157.

Piria, M., I. Jakovlić, N. Šprem, T. Tomljanović, D. Matulić & T. Treer (2013): Distribution, condition and abundance of non-native Ponto Caspian gobies from the tributaries of the Danube in Croatia. FINS Freshwater invasives networking for strategy. In: Caffrey, J. (ed), Dublin: Inland Fisheries Ireland, 53–54.

Poff, N.L., M.T. Sykes, B.H. Walker, M. Walker & D.H. Wal (2000): Biodiversity – Global biodiversity scenarios for the year 2100. Science, 287(5459): 1770-1774.

Riede, K. (2004): Global register of migratory species – from global to regional scales. Final Report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation, Bonn, Germany, 329 p.

Ristić, M. (1940): Fishery and fishery tools on the Tisza River (In Serbian). Ribarstvo, Beograd III: 11–12.

Ristić, M. (1977): Fishes and fishery in freshwater (In Serbian). Nolit, Beograd, p 330.

Roche, K.F., M. Janač & P. Jurajda (2013): A review of Gobiid expansion along the Danube-Rhine corridor – geopolitical change as a driver for invasion. Knowledge and Management of Aquatic Ecosystems, 411, 01.

Sala, O.E, F.S. Chapin, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker & D.H. Wal (2000): Biodiversity – Global biodiversity scenarios for the year 2100. Science, 287(5459): 1770-1774.

Sekulić, N., P. Cakić, M. Lenhardt, D. Vučić & Lj. Budakov (1999): Short-snouted pipefish Syngnathus abaster (Acanthopterygii: Syngnathidae) in the Yugoslav section of the Danube. Ichthyologia, 31 (1):79–82.

Simić, S. & V. Simić (2004): Macro-invertebrates and fishes in the part of the Danube flowing through the iron gate national park and possibilities of their protection under in situ and ex situ

conditions. Archives of Biological Sciences, 56: 53–57.

Simonović, P. (2006): The Fishes in Serbia. 2nd edition. NNK International, Faculty of Biology and Agency for Environment Protection, Belgrade, Serbia.

Simonović, P. & V. Nikolić (1995): Ichthyofauna of the Vlasinsko jezero reservoir. Archives of Biological Sciences, 47(1-2): 71-74.

Simonović, P.D., V.P. Nikolić & K.E. Skora (1996): Vertebra number in Ponto–Caspian gobies: phylogenetic relevance. Journal of Fish Biology, 49: 1027–1029.

Simonović, P. & V. Nikolić (1997): Freshwater fish of Serbia: an annotated check list with some faunistic and zoogeographic consi- derations. Bios Thessaloniki, 4: 137-156.

Simonović, P., B. Valković & M. Paunović (1998): Round goby Neogobius melanostomus, a new Ponto-Caspian element for Yugoslavia. Folia Zoologica, Brno, 47: 305-312.

Simonović, P., S. Marić & V. Nikolić (2006): Occurrence of paddlefish Polyodon spathula (Walbaum, 1792) in the Serbian part of the lower River Danube. Aquatic Invasions, 1 (3): 183-185.

Simonović, P., V. Nikolić & S. Grujić (2010): Amazon Sailfin Catfish Pterygoplichthys pardalis (Castellnnau, 1855) (Loricariidae, Siluriformes), a New Fish Species Recorded in the Serbian Section of the Danube River. Biotechnology & Biotechnological Equipment, 24 (sup1): 655-660.

Simić, V., S. Simić, M. Paunović, P. Simonović, N. Radojković & A. Petrović (2012): Scardinius knezevici Bianco & Kottelat, 2005 and Alburnus scoranza Bonaparte, 1845: new species of ichthyofauna of Serbia and the Danube basin. Archives of Biological Sciences, 64 (3): 981-990.

Šipoš, Š., B. Miljanović & Lj. Pelčić (2004): The first record of Amur sleeper (Perccottus glenii Dybowsky 1877, fam. Odontobutidae) in the Danube River. 35th Conference IAD, 19-23. April 2004, Novi Sad, Serbia and Montenegro. Limnological reports, Vol. 35. Proceedings: 509-510.

Šipoš, Š., B. Miljanović & D. Grujić (2007): The first record of three-spined stickleback (Gasterosteus aculeatus L. 1758, Fam. Gasterosteidae) in Vojvodina. Pisces Hungarici, 2: 29-30.

Skorić, S., G. Cvijanović, K. Kohlmann, A. Hegediš, I.Jarić & M. Lenhardt (2013): First
record of a hybrid striped bass (Morone saxatilis x Morone chrysops) in the Danube River.Journal of Applied Ichthyology,29: 668-670.

Sofradžija, A. (2009): Ribe Bosne i Hercegovine. Vijeće kongresa bošnjačkih intelektualaca, Sarajevo, 309 pp.

Sommerwerk, N., C. Baumgartner, J. Bloesch, T. Hein, A. Ostojić, M. Paunović, M. Schneider-Jakoby, R. Siber & K. Tockner (2009): The Danube River Basin, Part 3. In: Rivers of Europe (ed. Tockner, K., Uehlinger, U., Robinson, C.T.). Academic Press, San Diego, pp. 59-113.

Smederevac, M., Ž. Višnjić & A. Hegediš (2001): New data of the distribution of the Gobies (gen. Neogobius; fam. Gobiidae) in Yugoslav course of the Danube River. Ichthyologia, 33 (1): 77-80.

Stanković, J.B. (2016): Dužinsko-maseni odnosi i kondicioni faktor kalifornijske pastrmke (Oncorhynchus mykiss Walbaum, 1792) gajene u ribnjačkim sistemima. Master rad. Univerzitet u Nišu, Prirodno-Matematički Fakultet, Departman za biologiju i ekologiju. 41 str.

Svetovidov, A.N. (1964): Рыбы Черного моря [Fishes of the Black Sea]. Nauka. Moscow-Leningrad (in Russian).

Tutman, P., M. Burić & B. Skaramuca (2012): First substantiated record of the black-striped pipefish, Syngnathus abaster (Actinopterygii: Syngnathiformes: Syngnathidae), in the freshwater of Bosnia and Herzegovina. Acta Ichthyologica et Piscatoria, 42(3): 259-262.

Toth, J. (1971): Data on the presence of plantivorous fishes imported from Far East in the middle reach of the Danube. Ann Univ Bud Rolando Eotvos Sep Sec Biol, 13: 327–328.

Van Kessel, N., M. Dorenbosch & F. Spikmans (2009): First record of Pontian monkey goby, Neogobius fluviatilis (Pallas, 1814), in the Dutch Rhine. Aquatic Invasions, 4: 421–424.

Vassilev, M., A. Apostolou, B. Velkov, D. Dobrev & V. Zarev (2012): Atlas of the Gobies (Gobiidae) in Bulgaria. Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Sofia, 2012.

Vutskits, G.Y. (1911): A new fish species of our fauna. Állattani Közlemények, 31–44 (in Hungarian).

Wiesner, C. (2005): New records on non-indigenous gobies (Neogobius spp.) in the Austrian Danube. Journal of Applied Ichthyology, 21: 324-327.

Zorić, K., P. Simonović, V. Djikanović, V. Marković, V. Nikolić, V. Simić & M. Paunović (2014): Checklist of non-indigenous fish species of the River Danube. Archives of Biological Sciences, 66(2): 629-639.

Zorić, K. (2015): Invasiveness of allochthonous macroinvertebrate and fish species of the Danube River Doctoral dissertation, Belgrade.

Received: 09. 05. 2019.
Accepted: 28. 05. 2019.

Pregled alohtonih vrsta riba porijeklom iz mora u srpskom slatkovodnom sistemu

Marija SMEDEREVAC-LALIĆ, Slobodan REGNER, Mirjana LENHARDT, Dušan NIKOLIĆ,

Gorčin CVIJANOVIĆ, Milica JAĆIMOVIĆ & Aleksandar HEGEDIŠ

SAŽETAK

Tokom poslednjih dekada u rijekama i jezerima u Srbiji su se pojavile 32 alohtone vrste riba i prema regiji njihovog porijekla mogu se podijeliti u pet grupa: Azijske, Ponto-Kaspijske, Sjeverno Američke i Evropske bez Ponto-Kaspijskog regiona. Azijske i Ponto-Kaspijske su najbrojnije. U prvoj grupi su predstavnici riblje faune koji su porijeklom iz Azije i one su namjerno unesene u otvorene vode i akvakulturu Srbije, dok druga grupa predstavlja migrante iz Crnog mora koji šire svoj areal u sistemu rijeka i jezera. Neke od ovih vrsta su već uspostavile svoje populacije. Predstavnici morskog porijekla koji naseljavaju rijeke i jezera u Srbiji su: *Syngnathus abaster, Neogobius fluviatilis, Neogobius melanostomus, Babka gymnotrachelus, Ponticola kessleri, Proterorhinus semilunaris, Knipowitschia caucasica, Benthophyllus stellatus, Gasterosteus aculeatus, Morone saxatilis x Morone chrysops.* Gobiidae i Sygnathidae su proširile svoju geografsku distribuciju van nativnog areala i proširile distribuciju kroz cijeli bazen rijeke Dunav, dok za druge vrste nema literaturnih podataka o uspostavljenim populacijama.

Ključne riječi: alohtone ribe, rijeke i jezera, distribucija, širenje