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Alien invasive fish species in Bulgarian waters: An overview

Maria Yankova

Abstract
This paper provides a review of the non-indigenous ichthyofauna occurring in the Bulgarian marine and fresh waters. The most important vectors of introduction are imports for aquaculture purposes and mediterranization. Prime source regions are the Mediterranean Sea and North America. However, for a significant part of the introductions both the establishment success and mode of introduction remain unknown. I also list legislation and international conventions pertinent to the non-native species.

Keywords: Non-Indigenous Species, Introduction, Invasion, Impact of Exotic Species

1. Introduction
A non-indigenous species (NIS, also known as exotic, introduced, invasive, alien or non-native species) is any species whose translocation into an environment outside its native geographical habitat, within historical times, has been either man-mediated (either intentionally or accidentally) [1] or has been an action of active dispersal via natural pathways. Biological invasions are increasingly recognized as a primary threat to global biodiversity [2-4]. The worldwide vectors for alien marine species are diverse and can be listed under 15 broad categories, including prominent factors such as commercial shipping activities, canals, aquaculture and fisheries, drilling platforms and the aquarium industry [3]. In aquatic systems, ballast-water transfer by oceangoing vessels has been identified as a leading invasion pathway [5-7]. Other frequently cited vectors for marine species introductions include the intentional or accidental transport of species in shipments of fisheries products [8] and the deliberate release of non-indigenous species to create or enhance commercial fisheries [9]. Although the intentional release or escape of fishes from private aquaria and ornamental fish farms has led to successful freshwater fish invasions [10-12] the role of the aquarium trade in marine invasions has received little attention. Drensky [13] had documented that the presence and likely establishment of the native to North America pumpkinseed sunfish *Lepomis gibbosus* in the Bulgaria (Svishtov marsh). He postulated that the source of the introduction was the marine aquarium trade. This is not the first time that aquarium releases have been identified as the probable source of marine fish introductions, but it is the first time aquarium releases have been identified as the likely source of a successfully established non-native fish.
The negative impact of alien fish species on native ecosystems in Bulgaria is still speculative rather than proved and needs further studies. One group of threats is related to their foraging behavior. It is usually expected that aliens may compete with indigenous fish species for food resources (*Pseudorasbora parva, Lepomis gibbosus, Oncorhynchus mykiss*). The presence of non-native species can lead to native habitats modification. First, if the alien fish is a predator it can profoundly affect the population dynamics of indigenous prey species and result in decline or a depletion of native food resources.
The Black Sea Commission in 2011 initiated a checklist of non-native fish species introduced into Black Sea http://www.blacksea-commission.org/_publications.asp [102] which included 20 fish.
The most detailed analysis was hitherto conducted by Yankova *et al.* [14] which compiled a list of 21 fish alien species recorded from Black Sea. To date, only one study has examined the introduction of non-native marine fishes in Bulgaria- http://bsbd.org/UserFiles/File/Initial%20Assessment.pdf [103]. Information about the fish fresh waters exotic for Bulgaria can be found in several ichthyological articles (Uzunova and Zlatanova [58], Zhivkov *et al*. [94], Vassilev and Pehlivanov [54]. This study aims to (i) provide an updated record of non-native marine and freshwater fishes in Bulgaria; (ii) determining the major vectors and pathways as well as to discuss possible impacts of non-indigenous species on the native ecosystems.

2. Materials and Methods

A total of 104 published sources were used in the present study. The data sources used for the current compilation are cited in the references. The nomenclature for genera and Latin names of the marine species follows Eschmeyer and Fong [15]. The taxonomy of freshwater fishes was based on the review of Kottelat [101].

3. Results and discussion

3.1 Origin of introductions

On the basis of original and published data which are presented in the list of references, during the past years, the findings of 36 alien fish species in the Bulgarian marine and fresh waters. Analyzing the geographic origin of marine alien invasive species, most of them (22%) are Mediterranean and North American species each, 21% are from Eastern Atlantic and 7% have Atlantic, Atlantic-Pacific, Pacific, European waters and North Europe origin species, as Fig. 1.

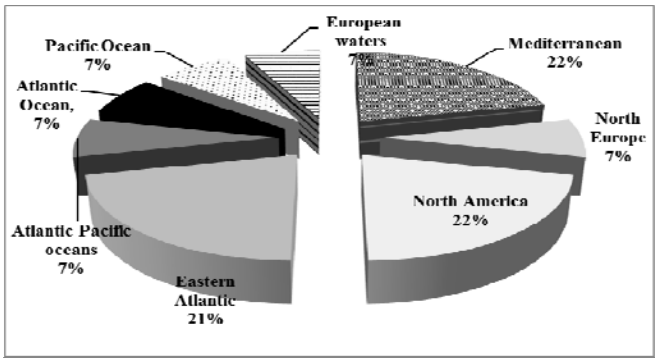

Fig 1: Origin of marine alien invasive species at the Bulgarian waters.

Table 1 gives the list of alien ichthyofauna occurring in the Bulgarian marine and fresh waters together with their possible date of introduction, establishment successes, possible origin and means of introduction, and their habitat and depth preferences.

Table 1: List of alien fish species and their first year of observation from the Bulgarian coast. BS: Black Sea, BBS: Bulgarian Black Sea, ES: Establishment Success (E: Established, C: Casual, Q: Questionable, Cr: Cryptogenic), O: Origin (NA: North America, NE: North Europe, EA: Eastern Atlantic, AP: Atlantic Pacific oceans; AO: Atlantic Ocean, PO: Pacific Ocean, EW: European waters, M: Mediterranean origin) MI= Probable method of introduction (M: Mediterranean, Aq: Aquaculture, Un: Unknown), H: Habitat (PN: Pelagic-neretic, DBP: Demersal, Bentho-pelagic P: pelagic, B: benthic, F: Freshwater), DR: Depth Range (I: 1–10 m, II: 10–50m, III: 51–100 m, IV: 101–200 m). For each species protection status (as per www.iucnredlist.org), is reported.

Family/Species	Protection status/IUCN	BS	BBS	MI	Type of reproduction	O	MI	H	DR	References:
Acipenseridae /*Acipenser baerii* Brandt, 1869	EN		1998		Artificial					Uzunova and Zlatanova [58]
Acipenseridae/ *Polyodon spathula* (Walbaum, 1792)	VU		2003		Artificial					Uzunova and Zlatanova [58]
Catostomidae/*Ictiobus bubalus* (Rafinesque, 1818)	LC		1977		Artificial /Natural					Uzunova and Zlatanova [58]
Catostomidae/*Ictiobus niger* (Rafinesque, 1819)	LC		1977		Artificial /Natural					Uzunova and Zlatanova [58]
Catostomidae/*Ictiobus cyprinellus* (Valenciennes, 1844)	LC		1977		Artificial /Natural					Uzunova and Zlatanova [58]
Centratchidae/*Lepomis gibbosus* (Linnaeus, 1758)	LC		1930	Aq		NA	Established	F		Alexandrov *et al*., [96]; Apostolou [48]; Bulgurkov [67]; Drensky [13]; Karapetkova [68]; Karapetkova [70]; TDA [97]; Karapetkova and Dikov [71]; Vassilev [52]; Pehlivanov [73]; Steffanov and Trichkova [74] 2004; Vassilev [53]; Zhivkov and Grupcheva [72]; Uzunova *et al*., [98];
Cichlidae/*Oreochromis mossambicus* (Peters, 1852)	NT		1990		Artificial					Uzunova and Zlatanova [58]
Clariidae/ *Clarias gariepinus* (Burchell, 1822)	LC		2007		No data available					Uzunova and Zlatanova [58]
Cyprinidae/*Pseudorasbora parva* Temmnick & Schlegel, 1846	LC		1979	Aq		PO	Established	F		Boyadjiev and Bassamakov, [83]; Marinov [82];
Cyprinidae/*Aristichthys nobilis* (Richardson, 1845)	NT		1964		Artificial					Uzunova and Zlatanova [58]
Cyprinidae/*Ctenopharyngodon idella* (Valenciennes, 1844)	NT		1964		Artificial					Uzunova and Zlatanova [58]
Cyprinidae/*Hypophthalmichthys molitrix* (Valenciennes, 1844)	DD		1964		Artificial					Uzunova and Zlatanova [58]
Cyprinidae/*Mylopharyngodon piceus* (Richardson, 1846)	DD				Artificial					Uzunova and Zlatanova [58]
Clupeidae/*Sardinella aurita* (Valenciennes, 1847)	LC	1905		M		AP	Rare	P	II, III, IV	Karapetkova and Zhivkov [50];Yankova *et al*., [96];
Gobiidae/*Pomatoshistus marmoratus* (Risso, 1810)	LC		2010	Un		M	Very rare	B	I,II	Apostolou *et al*., [85]; Drensky [84] 1923; Vassilev *et al*., [99];
Gobiidae/*Pomatoschistus bathi* Miller, 1982	DD	2003	2010	M		EA	Established	B	I	Vasil'eva [27]; Vassilev *et al*., [99];
Ictaluridae/*Ictalurus punctatus* (Rafinesque, 1818)	LC	1975			Artificial /Natural					Uzunova and Zlatanova [58]
Ictaluridae/*Ameiurus nebulosus* (Lesueur, 1819)	LC	1975			Artificial /Natural					Uzunova and Zlatanova [58]
Latidae/*Lates calcarifer* (Bloch,	NT	2007			No data					Uzunova and Zlatanova [58]

1790)					available					
Mugilidae/*Chelon labrosus* Risso,1827	LC	2007	1999	Un		M	Very rare	P	II, III	Dobrovolov *et al*., [93]; Vasil'eva [27];
Mugilidae/*Liza haematocheila* Temmnick & Schlegel, 1845	NE		1980	Aq		NE	Established	PN	II	Dobrovolov *et al*., [93]; Karapetkova and Zhivkov[50]; Vasil'eva [27]; Zhivkov *et al*., [94];
Odontobutidae/ *Perccottus glenii* Dybowski, 1877	NE		2005		Natural					Uzunova and Zlatanova [58]
Poeciliidae/*Gambusia holbrooki* (Girard, 1859)	LC		1924	Un		NA	Established	F		Apostolou [48]; Apostolou *et al*., [49]; Karapetkova and Zhivkov [50]; Manea [95]; Polacik *et al*., [51]; Vassilev, 1995; Vassilev [52]; Vassilev and Pehlivanov [54];
Poeciliidae/*Poecilia reticulata* Peters, 1859	NE		2004		No data available					Uzunova and Zlatanova [58]
Salmonidae/*Oncorhynchus mykiss* (Walbaum, 1792)	NE		1924	Aq		NA	Established	F		Karapetkova and Zhivkov [50]; Vasil'eva [27]; Uzunova and Zlatanova [58]
Salmonidae/ *Salmo salar sebago* Girard, 1853	NE		1997		Artificial					Uzunova and Zlatanova [58]
Salmonidae/*Salvelinus fontinalis* (Mitchill, 1814)	NE		1930		(not documented)					Uzunova and Zlatanova [58]
Salmonidae/ *Coregonus lavaretus* (L.)	VU		1978		Natural					Uzunova and Zlatanova [58]
Salmonidae/*Coregonus peled* (Gmelin, 1789)	LC		1970		Natural					Uzunova and Zlatanova [58]
Salmonidae/*Coregonus albula* (L.)	LC		1964		No data available					Uzunova and Zlatanova [58]
Salmonidae/ *Thymallus thymallus* (L.)	LC		1978		No data available					Uzunova and Zlatanova [58]
Sparidae/*Lithognathus mormyrus* (Linnaeus, 1758)	LC	1980		M		M	Very rare	DBP	I,II,III, IV	Karapetkova and Zhivkov [50]; Svetovidov [25]; Vasil'eva [27];
Sparidae/*Sarpa salpa* (Linnaeus, 1758)	LC	1938	1949	M		EA	Very rare	DBP	I, II,	Karapetkova and Zhivkov [50]; Yankova *et al*.,[96];
Sparidae/*Sparus aurata* Linnaeus, 1758	LC	1933		M		EA	Single record	DBP	II, III, IV	Karapetkova and Zhivkov [50]; Vasil'eva [27];
Sphyraenidae/*Sphyraena sphyraena* (Linnaeus, 1758)	LC		1999	Un		AO	Very rare	P	II	Karapetkova and Zhivkov [50]; TDA [97]; Yankova *et al*., [96];
Umbridae/*Umbra krameri* Walbaum, 1792	VU		2010	Un		EW	Single record	F		Drensky [13]; Karapetkova and Zhivkov [90]; Raykov *et al*., [92]; Velkov *et al*. [91];

3.2 Probable vectors of introduction

Non-indigenous species in general are intentionally or accidentally transported and released by man. In many cases the introductory vector is unknown or assumed, whereas in some others the introduction has been facilitated by more than one vector. The introduction vector is mediterranization for 5 species (36%), (*Lithognathus mormyrus, Sarpa salpa, Sparus aurata, Sardinella aurita* and *Pomatoschistus bathi*) as Fig. 2.

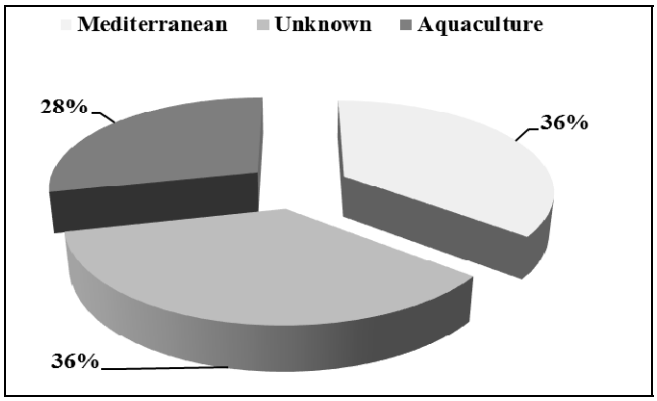

Fig 2: Pathways of introduction of alien species into Bulgarian waters.

For other 5 species (*Sphyraena sphyraena*, *Chelon labrosus*, *Umbra krameri*, *Pomatoshistus marmoratus* and *Gambusia holbrooki*) the vector of introduction is unknown. A total of 4 species (*Liza haematocheila*, *Oncorhynchus mykiss, Lepomis gibbosus* and *Pseudorasbora parva*) were introduced to the Mediterranean and Black Seas for aquaculture purposes. The most successful species among them is *L. hematochezia*, which was first released into the Azov Sea from the Molochny Lagoon in 1985 and then largely expanded its distribution range to the Aegean Sea (Homa Lagoon) within 10 years [16]. The eastern Mediterranean - Black Seas system is perhaps the largest nearly-isolated basin of Large Marine Ecosystems of the world with considerable differences in their oceanographic characteristics, plankton and fish faunas [17]. The Turkish Straits System (TSS) formed by the Istanbul Strait (Bosphorus), the Marmara Sea and the Çanakkale Strait serves as a corridor for two-way translocation of species from their native habitats in the Black and Mediterranean Seas [18, 19]. Aquaculture is the leading vector of aquatic species introduction worldwide [20], with more than 50% non-native species having been intentionally introduced for aquaculture [20-22].

3.3 Invasive species

The thicklip grey mullet (*Chelon labrosus* Risso, 1827) was first recorded in Bulgaria Black Sea in October 1999, and during the following ten years, thicklip grey mullet has been constantly recorded near the different region of the Black Sea (southwestern coast of Crimea) [23, 24]. However, since the beginning of the 2010s, the species has not been recorded in the Black Sea because of difficulties of its capturing and the cyclicity of its migration to the Crimean coasts. Despite

earlier numerous reports of thicklip grey mullet findings in different regions of the Black Sea, this information up to the present has been considered doubtful or has been disregarded [25-26]. In addition to Crimea, thicklip grey mullet was recorded near Turkey and Bulgaria [26-27]. The species performs spontaneous seasonal migrations to the Black Sea [28].

So-iuy mullet (*Liza haematocheila* Temmnick & Schlegel, 1845): The Black Sea populations of so-iuy mullet started being established after its introduction for aquaculture purposes in the Black Sea in 1972 [29]. The initial population was formed by juveniles captured in the mouth of the Sukhodol (Kangauz) river and in the Ussuri Bay in the Sea of Japan, near Vladivostok, and transported by airplane to Odessa [29]. The reason for this introduction was the drastic decrease of the abundance of the valuable local commercial fish species (mainly grey mullets) and the ineffective artificial propagation attempts in the early 1970s [30- 31]. Since 1984, coastal lagoons of Molochny, Shabolatsky and Burnassk, began to be stocked with fish produced from artificial propagation. It seems that from these lagoons so-iuy mullet escaped to the free waters of the Azov and the Black Seas [29]. During sampling in the Azov and Black Seas mature or ready to spawn individuals were found but never developing eggs [32]. Initial data confirming the natural spawning were obtained during June 1989, when in the Molochny estuary (Azov Sea) young individuals were collected at the stage of the laying of scales [32] and in 1990 fertilized eggs and larvae were found [33]. However, the first information about the presence of eggs of so-iuy mullet in the Black Sea was in 1996 [34- 35] and proved that this species which was introduced into the northern lagoons during 1972–1986 now spawns along the coasts of the Black Sea. The acclimatization of the species in this sea was completed at the end of the 1980s – beginning of the 1990s – by the formation of a self-reproducing population [32]. In 1992, so-iuy mullet was included into the Inventory of Edible Fishes of the Sea of Azov/Black Sea Basin and in 1993 it was officially permitted to catch it commercially [36]. At present, the increase in the abundance of the so-iuy mullet population throughout the Black Sea basin has resulted its occurrence in many lagoons, river mouths and coastal areas of Romania, Bulgaria, the Ukraine, Russia, Georgia and Turkey and made it one of the most important and common commercial fish, reaching first place in catches of grey mullets, providing a total catch of 12,430 t in 2006 [37-39] and successfully replacing the depleted stocks of the three local mullets [29]. It is worth mentioning that in native waters (Primorskiy Bay) it did not exceed 500 t [40]. Actually, recently in the Turkish coasts of Black Sea remarkable quantities of catches of this fish have been recorded. This fact suggests that the fish should be abundant all along the coast line of the Turkish Black Sea, perhaps even up to the Bosporus channel. Normally developing eggs in different stages were found during June in the Sevastopol region (Black Sea) at water temperatures of 18-20 °C, salinity of 17.6-18 ‰, above the depths of 20-100 m [32]. According to Matishov and Luzhnyak, [36] so-iuy mullet switched its spawning standards after its acclimation in the Azov Sea and not only winters but also reproduces into rivers and streams with low salinity. This capability to perform spawning migrations to rivers and to reproduce into them has not been previously recorded either in water bodies of the Primorsky or in the Azov–Black Sea basin. Why did the species adopt so quickly a different reproduction strategy, leaving the open sea for inland waters, while the native mullet species (*L. aurata*, *L. saliens* and *M. cephalus*) did not [33]. Since invader species have more influence on the local populations, parasite fauna carried by the so-iuy mullet can progressively affect local closely related species (*M. cephalus*, *L. aurata* and *L. saliens*) that are in contact with this species, possibly infecting them with a gill parasite of the Mugilidae family such as Ligophorus [41]. Finally, this new invader species in the Black Sea-Mediterranean environment represents an unpredictable prospect. The more negative result would be the successful adaptation of the species in the Black Sea and Mediterranean and the replacement of all or several native mullet. But for this perspective there is not any serious evidence at the moment [41].

The Eastern mosquito (*Gambusia holbrooki* Girard 1859) is native to the southeastern United States. They have been introduced worldwide and have become an invasive species in many places including Australia and Europe. Eastern mosquito fish are found in shallow, standing to slow-flowing water, mostly in vegetated ponds, lakes, and sloughs [42]. This species thrives in water between 31° and 35 °C, and seems to be able to acclimate to temperatures above and below this. *G. holbrooki* has been shown to survive in water with pH and chemical levels known to kill other fish species, and prefers to live in areas where the water flows at a slow pace, is clear and without free-floating plant life, and seeks shelter in rooted plants. No decrease in this species due to human activities has been noted [43]. Intentional introductions were undertaken for using mosquito fish as biological agent for prevention of malaria. In many countries introduction of this fish caused a negative impact on native ecosystems. There are records that confirm its negative impact and predatory behavior on many native fish and amphibians and their larvae [44-46]. Eastern mosquito fish is included in Top 100 of the most dangerous invasive species of GISP (Global Invasive Species Programme, http://www.issg.org/database/). In Europe *Gambusia holbrooki* was introduced first in Italy in 1921 with the presumption that it is a very good biological agent for prevention of malaria. In Bulgaria it was introduced in 1924. First successful attempts for breeding were made near river Tundzha by Slivensky [47]. Then fish were massively breed and introduced in malaria rich areas, such as swamps, lakes, coastal lakes and wet-lands near Black Sea shore and Danube River, as a biological agent in the fight with malaria. The present distribution of mosquito fish in Bulgaria is well known. Its range covers most of the territory of the country, as reported by several authors [48-54].

Sand steenbras (*Lithognathus mormyrus* Linnaeus, 1758) is known from the Black Sea by solitary findings in Varna Bay near the coast of Bulgaria [27].

The rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) is one of the most widely introduced fish species in the world. The first fish introduction in Bulgaria was dated at the end of 18th century, when rainbow trout was imported [58]. Native to western North America, from Alaska to the Baja Peninsula *Oncorhynchus mykiss* have been introduced to numerous countries for sport and commercial aquaculture [55]. Impacts include hybridization, disease transmission, predation and competition with native species.

Pumpkinseed sunfish (*Lepomis gibbosus* Linnaeus, 1758): *Lepomis gibbosus* is a native fish species to the eastern North America [56]. Introduced to Europe freshwaters during the late nineteenth century the pumpkinseed is now wide spread in at least 28 European countries [57]. In recent years, the species spread rapidly into the Bulgarian inland water bodies [58-59]. In

general the ecological effect of pumpkinseed on native species and habitats is determined as adverse [20]. It has been reported to be responsible for the decline of other fish species [60-62], gastropods [63] and other invertebrates [64]. Since 1930, and probably earlier, the pumpkinseed is present in Danube River [13-65-66]. About 30 – 40 years later new locations started to appear. All of them are Danube's online marshes [13-65-67], tributaries [68- 69] and a reservoir [68]. Danube tributaries located further upstream were later found to contain pumpkinseed approximately simultaneously [70-71]. After the western and the central part of northern Bulgaria were invaded by the species, came probably the first record from the Southern Bulgaria – Ovcharitsa Reservoir [72]. The spread south from the Balkan/Haemus Mountain, proceeded in constantly increasing rates and many vectors- Struma/Strimon River [52-73], Mesta/Nestos River [48], Arda/Ardas River [73-74]. The first observation of the pumpkinseed in Maritsa/Evros River and Tundja River in the literature in unclear, according to many personal communications with colleagues and fisherman however the period is the same (in 80s and 90s). Probably the area, which was most recently included in the area, is North-Eastern part of Bulgaria. The latest Bulgarian watershed invaded by the pumpkinseed was Black Sea watershed, except Kamchiya River probably [52]. Personal communications revealed that the pumpkinseed recently invaded many of the Black Sea lakes, Shabla, Durankulak (Stefanov, pers. comm.), Varna and Bourgas lakes
http://www.powershow.com/view/1d17f-ZmNjM/Status_and_distribution_of_the_pumpkinseed_sunfish_powerpoint_ppt_presentation [104].

The salema porgy (*Sarpa salpa* Linnaeus, 1758) was caught for the first time near the Gulf of Varna (Bulgaria) in 1949. In the Black Sea, solitary specimens of salema porgy were recorded in coastal waters of Turkey, Georgia (Batumi), Ukraine (Crimea in Balaklava Bay), and Romania (Constana) [25-27]. Over the past years, salema porgy occurred more frequently along all coasts of the Black Sea. From 1995, it has been annually recorded in the northwestern Black Sea in Tendrovsky and Yagorlytsky bays and in the coastal zone of Kinburn Spit and Tendra Island [75]. In December 2007, salema porgy was recorded for the first time in the northeastern part of the sea near the settlement of Lazarevskoye (Krasnodar krai) [76]. Salema is a sparid fish that lives in shallow waters, where there are rocky bottoms or seagrass beds, such as *Posidonia oceanica* or *Cymodocea nodosa*, typical of temperate and tropical areas like the Mediterranean Sea, the east Atlantic, and the west Indian Ocean. It makes up schools sometimes formed by several hundred individuals and is the main herbivorous demersal fish of the west Mediterranean [77]. The introduction vector is mediterranization.

Gilthead bream (*Sparus aurata* Linnaeus, 1758): Earlier rare findings of the species were recorded in coastal water of Bulgaria, Turkey, Ukraine (Balaklava Bay), Romania, and Georgia (Sukhumi Bay) [23-25-27-78]. The introduction vector is mediterranization.

The round sardinella (*Sardinella aurita* Valenciennes, 1847) occurs rarely near Crimea and in the Black Sea. The recordings of species were made near Burgas, Constana, and Batumi [25]. In the coastal waters of Crimea, one specimen of the species was documented near Karadag in 1981 and 1988 [79] and in Sevastopol bays (in Balaklava Bay in October 1998 and Streletskaya Bay in July 2008) [78]. The introduction vector is mediterranization.

Stone moroko (*Pseudorasbora parva* Temmnick & Schlegel, 1846): Commonly known as the top mouth gudgeon or stone moroko, is a small cyprinid originating from East Asia. Its natural distribution area includes Japan, the Korean section of the Amur River Basin, China (basins of the rivers Yangtze and Hoanghe), and Taiwan [80]. After the accidental introduction to Romania in 1961[81] many of the records came from European and Asian countries and even from Africa. In Bulgaria, the species was seemingly brought from the Ukraine and was found in many regions: Bulgaria-northern part [82] and Bulgaria-Southern part [83]. The introduction of Chinese cyprinids significantly diversified the aquaculture production and at the same time changed the composition of fish species in almost all Bulgarian water bodies [58-100]. The introductions of grass carp, *Ctenopharyngodon idella* and bighead carp, *Aristichthys nobilis*, give an opportunity to apply so called "top-down control" for improving water quality [58]. Black carp, *Mylopharyngodon piceus*, is used as a tool in biological control of zebra mussel, *Dreisena polymorpha*, and population in Ovcharitza reservoir [58].

In 1977, three catostomid species (Catostomidae) were introduced and only several years later their successful naturalization was reported. There is no current data about the status of their populations [58].

Three species representing the family Coregonidae- *Coregonus peled*, *C. albula* and *C. lavaretus* —were naturalized in several very large mountain reservoirs, such as Iskar and Dospat [100]. Conversely, ten years after the first introduction of landlocked salmon, *Salmo salar sebago* Girard, 1853, into several mid- to large reservoirs in Bulgaria, its current survival has not been confirmed [58].

Marbled goby (*Pomatoshistus marmoratus* Risso, 1810): In the beginning of the previous century Drensky [84] assumed that *P. microps* (Kroyer 1838) is also inhabitant of Bulgarian Black Sea sector [85]. Banarescu [81] and Gheorgiev [86] reached to the same conclusion. Later it was reported that *P. micropsis* not typical for Black Sea, and could be found only in the Western Mediterranean and Eastern Atlantic region [87]. The examined specimens of *Pomatoschistus marmoratus* have been distributed in shallow waters (0.3-4 m depth) in various sites of approximately the whole Bulgarian Black Sea coast: from Durankulak in north (43º41'55"N, 28º34'17"E) to Sinemorets in south (42º03'13"N, 27º59'15"E [85]. All of the specimens collected by Drensky during 1926-1928 have occurred to be misidentification as *Pomatoschistus microps* instead of *Pomatoschistus marmoratus*, since the first species is not typical inhabitant in Black Sea according to Miller [88]. On the basis of this mistake further reports have also kept the same line: Banarescu [89] and Gheorgiev [86] reached to the same conclusion. They both gave a good description of the species but did not take into account some important traits as the pale throat, the female's dark spot on mandibula and the presence/absence on scales of the breast area, which are distinguishing between *Pomatoschistus microps* and *Pomatoschistus marmoratus* [85]. Other authors in their work concerning the circumpontic gobiid fish fauna also mention that the fish is not typical for Black Sea [87]. On the basis of the mentioned data, it is presence has not been noted more recently, in view to misidentification as *Pomatoschistus microps* and lack of further investigations till mid-sixties [85].

Bathi's goby (*Pomatoschistus bathi* Miller, 1982): The Bathi's goby is distributed across the Mediterranean, Aegean, Marmara and Black Seas. In the Black Sea it was found along the Northeastern and Southwestern coast. Along the Bulgarian

coast it is widespread in the south [53]. It is suggested that the species penetrated into the Black Sea through the Bosphorus Strait and expanded its range along the coast of Crimea and the Caucasus (mediterranization) [28].

The European Mud-minnow (*Umbra krameri* Walbaum, 1792) was introduced to some countries, such as: Great Britain, Germany and Poland. In the past, the species was found in most marshes along the Danube River [13]. Then, for a long time (over 80 years), it had not been recorded, and therefore, it was not included in the comprehensive works on the ichthyofauna of Bulgaria [90]. In 2004, the species was found again in Srebarna Lake, in the canal connecting the lake with the Danube River [91]. Recently, new record of the vulnerable species *U. krameri* (VU, IUCN) was observed in the Black Sea transitional waters of salinity between 8.2–11.8 psu and 36.3 – 41 m depth [92]. The individual survived 72 h in aquarium conditions which proves the species high ecological flexibility. Raykov *et al.*, [92] assumed that the passive way of the specimen introduction into the Black Sea throughout the Danube River waters high inflow.

3.4 Legislation

Legislation dealing with introduced species appears in several international treaties as well as in regional conventions, e.g., the Convention on Biological Diversity (ttps://www.cbd.int/convention), and the Bonn Convention (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Al28051) on the Conservation of Migratory Species of Wild Animals. At the European level, the Berne Convention in 1979 provides that "each contracting party undertakes to strictly control the introduction of non-native species". The EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) requires Member States to "ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native fauna and flora and, if they consider necessary, prohibit such introduction" (article 22(b). More specifically, EU Directives legislate for the protection of the ecosystem against the adverse effects of aquaculture-related introduced organisms Habitats Directive: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora; Regulation on Invasive Alien Species: Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species; Zoos Directive: Council Directive 1999/22/EC of 29 March 1999 on the keeping of wild animals in zoos, Directive on the deliberate release into the environment of Genetically Modified Organisms (GMOs) (90/220/EEC) and Environmental Impact Assessment (EIA), Directive and its amendment (85/337/EEC & 97/11/EC)). The rate of introductions is based on publication dates of first records. However, the time span between the first finding and publication time may range from one to many years.

4. Conclusion

Although the present non-native fish checklist provides information that will facilitate future studies, the future research needs to address specific cases as identification of potential dangerous species and assessment of potential effect on biodiversity.

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