

The Black Sea Trout, *Salmo labrax* Pallas, 1814 (Pisces: *Salmonidae*) in Romanian Waters

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Abstract

The review assembles chronological data on Black Sea trout (*Salmo labrax*) from Romanian waters and brings up-to-date information related to the distribution of the species. The information used dates from 1909 to 2020 and includes books, articles, digital databases, field observations, and notes from different research fields such as ichthyology, biogeography, genetics, aquaculture, conservation, and ecology. Global distribution, migration, meristic characters, and aquaculture of the species were analyzed based on the recorded data from the specialty literature. New information related to a possible population of *Salmo labrax* inside the Carpathian Arch was discussed. In Romanian waters the species is found in the Black Sea, Danube, Danube Delta but the current paper proposes a new hypothesis, namely that resident populations can be found in rivers and lakes adjacent to the Carpathian Arch. The highest migration point of the Black Sea trout in the Danube was recorded near Corabia locality, Olt County, (43°46'25"N- 24°30'12"E). In the Danube Delta, it was caught in all the three branches (Sulina, Sf. Gheorghe and Chilia), and lagoony complexes such as Razim-Sinoe. Sexually matured females were caught especially in Spring Season while unmatured specimens were caught in all seasons. Even if the species is protected under Romanian legislation, fishermen and anglers should report its presence when caught accidentally.

Keywords: *Salmonidae*, ichthyology, rare species, *Salmo* genus, Black Sea.

Introduction

Worldwide, fish species which belong to the Salmonidae family are grouped in three subfamilies (*Coregoninae*, *Salmoninae*, and *Thymallinae*), and eleven genera: *Prosopium*, *Stenodus*, *Salvelinus*, *Btachymystax*, *Parahucho*, *Hucho*, *Salmo*, *Salvelinus*, *Coregonus*, *Oncorhynchus*, *Thymallus* (Eschmeyer's Catalogue of Fishes, 2020). The last six genera are also found in Europe (Kottelat & Freyhof, 2007).

Fishes from the Salmonidae family have economic (food source), environmental (diversity, aquatic ecosystem health) and social (angling) importance (Davidson *et al.*, 2010). In Romania are present all the genera assigned to Europe with the following species: Danube salmon (*Hucho hucho*); brown trout (*Salmo trutta*), Black Sea salmon (*Salmo labrax*), brook trout (*Salvelinus fontinalis*), arctic charr (*Salvelinus alpinus*), European whitefish

(*Coregonus lavaretus*), European cisco (*Coregonus albula*), rainbow trout (*Oncorhynchus mykiss*) and European grayling (*Thymallus thymallus*) (Bănărescu, 1964; Cocan & Mireșan, 2018). The distribution and taxonomy of salmonids in Europe and in Romanian waters is unclear and requires increased attention (Kottelat and Freyhof, 2007; Ihuț *et al.*, 2014). One of the less frequent and studied salmonid fish species is the Black Sea salmon or the Black Sea trout (*Salmo labrax*) (Muhareem *et al.*, 2011). The species was first described by Peter Simon Pallas in 1831. Since then, the Black Sea trout was considered a subspecies of *Salmo trutta* (subspecies name: *Salmo trutta labrax*) by Berg, (1948); Bănărescu, (1964); Svetovidov (1984); Lelek, (1987), synonym to *Salmo trutta* by Kalayci *et al.*, (2018) and as a stand-alone species by Kottelat, (1997); Turan *et al.*, (2014). The valid name of the species is *Salmo labrax* Pallas 1814. The Black Sea trout population is decreasing according to Bănăduc *et al.*, (2016). It is an anadromous species and its presence is threatened by damming and ecosystem stress caused by landscape degradation and conversion (Kalayci *et al.*, 2018). Genetic studies show differences among *Salmo* species from the Black Sea and Danube lineage, Adriatic Sea, and Atlantic lineages (Pustovrh *et al.*, 2014). Interspecific hybridization is possible (*Salmo trutta* vs. *Salmo labrax*) and studies show that purebred specimens preserve coloration patterns similar to their parents (Kalayci *et al.*, 2018). The aim of this paper was to assemble the existing data from the speciality literature and to add new information that may improve the knowledge related to the Black Sea trout.

Materials and methods

In this paper, books, articles, recreational fishing (angling) materials, and field observations were analyzed to gather information related to *Salmo labrax* in Romanian waters. Specialty literature and field observations were used to complement data and information on the species. Chronological data analysis was drafted to facilitate a better understanding of the Black Sea trout distribution and also how information related to this species was previously presented. Biology, ecology, conservation status, and description of the species were compiled based on the speciality literature. Field observations of

ichthyofauna monitoring from Someșul Cald River and Beliș-Fântânele Reservoir (N 46° 38.825' - E 022° 51.842', Cluj County, Romania) were also added, where *Salmo* sp. specimens were found. We strongly believe they belong to *Salmo labrax* species. The specimens were captured using single-pass electrofishing techniques (using SAMUS 725G apparatus, powered by 12V and 24A rechargeable battery) and fly fishing (using artificial nymphs), from July 2018 to August 2019 (Copp, 1989; Ellender *et al.*, 2011).

Results and discussion

The presence of the species in the Black Sea and rivers that flow into the Black Sea was mentioned by many authors (Bușniță & Alexandrescu, 1963; Bănărescu, 1964; Bănărescu, 2005), but data regarding the migration and spawning period and biology of this species is deficient (Oțel, 2007). The presence of the species could not be found when studying the existing literature.

Global distribution of the Black Sea trout

Salmo labrax

The species is distributed along the coasts of the Black and Azov Seas, and also in the rivers emptying into the seas (Bănărescu, 1964; Oțel, 2007). In general, it is referred to as an anadromous species, but there are also isolated potamodromous populations. According to IUCN Redlist, *Salmo labrax* is extant (resident) in Turkey, Georgia, Russia, Ukraine, Moldavia, Belarus, Romania, Bulgaria, Slovakia, Hungary, Serbia, Bosnia and Herzegovina, Czech Republic, Croatia, Montenegro, Macedonia, Poland, Austria, and Slovenia. Since the species is endemic to the Black and Azov Seas it can be assumed that it is present only in Romania, Turkey, Georgia, Russia, Bulgaria, and Ukraine based on the analyzed literature. The species is more frequent in the rivers draining in the northern part of the Black Sea: Kuban River, Don River, Dniester River, Dnieper River (Vasilieva, 2003)

The migration of *Salmo labrax*

Fish migration is a complex process that occurs under specific conditions and circumstances: spawning, food availability, season, searching for a new habitat (Tsukamoto *et al.*, 2009, Guiry *et al.*, 2020). Fish species from the Salmonidae family are anadromous and potamodromous (Quiñones *et al.*, 2014). The adaptation capacity of fish to migrate or to reach new habitats is still an unclear subject.

The Black Sea trout (*Salmo labrax*) is usually migrating for reproduction, food, new habitat, or because of hydrographic conditions (Jonsson Bror & Nina Jonsson, 2011). Post-spawning migration is possible and also sub-adult specimens migrate from marine to freshwater (Oțel, 2007). The anadromous ecotype of *Salmo labrax* is found in the Black Sea coastal waters (Labón-Cerviá, 2018) while the potamodromous ecotype (river resident and lake resident) (Ferguson *et al.*, 2019) is found in lakes and rivers from mountain areas. It is possible that in Europe, the population of Black Sea trout is decreasing because the adults are unable to reach the spawning sites represented by rivers draining into the Black Sea, because of damming, ballast exploitation and riverbed substrate alteration. According to Aurelian Popescu-Gorj and Magdalena Dimitriu (1956), the migration of *Salmo labrax* in the lower Danube is annual and lasts for 2 to 4 months and is stretching for long distances (around 700 km). In some cases, it is also found in the floodplain lakes of the Danube.

Diagnosis

This species raised interest for ichthyologists for many years. It was considered a subspecies of *Salmo trutta* (Cărăușu, 1952; Bănărescu, 1964; Svetovidov, 1984) by some authors and a different species by others (Holcík, 2003; Vasilieva, 2003; Oțel, 2007; Kottelat & Freyhof, 2007). It has anadromous and potamodromous forms (Cărăușu, 1952; Svetovidov, 1984; Vasilieva, 2003; Kottelat & Freyhof, 2007). The coloration of the Black Sea trout *Salmo labrax* is silverier, the number of red spots from the body is reduced (sometimes missing) and the black spots have an X shape compared to those of brown trout *Salmo trutta* (Bănărescu, 1964) which are round. The caudal fin is slightly emarginated and has a darker posterior margin. The adipose fin is less developed than the other trout species (Popescu-Gorj & Dimitriu, 1956; Oțel, 2007). The dentition of *Salmo labrax* is similar to that of *Salmo trutta* (both species have teeth on the upper jaw, lower jaw, tongue and vomer bone), but when compared to other species from the Salmonidae family, like *Salvelinus alpinus* and *Hucho hucho* the main difference is that the vomer dentition is missing (Constantinescu *et al.*, 2015; Ihuț *et al.*, 2017). The number of pyloric caeca is between 40 and 62, usually 46 to 47 (Popescu-Gorj & Dimitriu, 1956). In terms of habitat, the Black Sea trout is found along the coastline at

depths around 50m (anadromous form). Resident forms prefer fast-flowing and cold waters with gravel and stone substrate (Kottelat & Freyhof, 2007). According to some authors the spawning period is during Spring Season (Cărăușu, 1952; Bușniță & Alexandrescu, 1963; Bănărescu, 1964) while other authors state that spawning occurs in the Autumn-Winter Seasons. Males can attain sexual maturity at age 1+ while females mature at 2+ (Makhrov *et al.*, 2018). Large specimens (larger than 2 kg) caught accidentally by local fishermen in the Danube and the Danube Delta (DDBR-Danube Delta Biosphere Reserve) during the Spring Season have well developed gonads in some cases. Small specimens feed on aquatic and terrestrial invertebrates, while adults feed on invertebrates and fish (Popescu-Gorj and Dimitriu, 1956; Bănărescu, 1964; Kottelat and Freyhof, 2007). Specimens caught near Sacalin Island had Gobiidae fish species inside their digestive tract while other specimens caught in the Black Sea feed on Clupeidae species (Popescu-Gorj & Dimitriu, 1956; Bănărescu, 1964; Oțel, 2007).

Since this species was and in some cases is still considered a subspecies of *Salmo trutta*, in Table 1 are presented the meristic characters for both species to highlight the main differences and the overlapping meristic characters and counts. The Black Sea trout *Salmo labrax* can be distinguished from the brown trout *Salmo trutta* by meristic characters. The dorsal fin (D) ray counts of *Salmo labrax* shows that the number of unbranched rays is sometimes overlapping with *Salmo trutta's* (*S. trutta* = III-V vs. *S. labrax* = III-IV), and a fifth unbranched ray in the dorsal fin may indicate *Salmo trutta*. A similar result can be noticed for the branched rays (*S. trutta* = 9-10(11) vs. *S. labrax* = 9-10). Eleven branched rays of the dorsal fin may indicate *Salmo trutta*. The Anal fin (A) unbranched rays number of *Salmo labrax* overlap to *Salmo trutta* (*S. trutta* = II-IV vs. *S. labrax* = III-IV). The branched rays of the anal fin are sometimes larger in the case of *Salmo labrax* (*S. trutta* = 8-9 vs. *S. labrax* = 8(10)), but in some specimens the number of branched rays is reaching 10. Ventral fin (V) unbranched ray count is equal for both species, meaning a full overlapping for this meristic character. The branched rays of the ventral fin of *Salmo labrax* are always equal to 8, while in the case of *Salmo trutta* the number ranges from 7 to 9. The unbranched rays of the pectoral fin (P)

overlap for both species. The branched ray count of the pectoral fin is overlapping if the count is 12. Eleven branched rays indicate *Salmo labrax*, while 13 or 14 indicate *Salmo trutta*. The scale count on the lateral line (LL) of *Salmo labrax* is between 112 and 135, while in the case of *Salmo trutta* is between 110 and 132. The number of scales above the lateral line (Sc A) can be used as an important meristic character for *Salmo labrax* diagnosis versus *Salmo trutta* (*S. trutta* = 25-26 vs. *S. labrax* = 25-31). The number of scales below the lateral line (Sc B) is usually larger in the case of *Salmo labrax* (*S. trutta* = 20-23 vs. *S. labrax* = 22-30). Another meristic character that may help distinguish the two species is the number of scales from the dorsal fin to the lateral line (D/LL), (*S. trutta* = 12-17 vs. *S. labrax* = 16-23). The most important and eloquent meristic characters are the number of scales in an oblique row from the base of the adipose fin to the lateral line (Ad/LL) (*S. trutta* = 15-17 vs. *S. labrax* = 18-19) and the number of gill rakers (GR) (*S. trutta* = 13-16 vs. *S. labrax* = 16-21). The number of vertebrae (Ver) is similar (*S. trutta* = 56-61 vs. *S. labrax* = 57-60). The branchiostegal rays (Brs R) show similar counts

but in some cases, *Salmo labrax* has two more rays (*S. trutta* = 10 vs. *S. labrax* = 10-12) (Table 1).

Aquaculture

The Black Sea trout *Salmo labrax* is not among the species farmed in Romanian aquaculture, although there is potential in this regard. The species is used in aquaculture in Turkey (Eastern Black Sea Coast and streams), from classical systems to recirculating aquaculture systems (RAS) with promising results (Nikandrov & Shindavina, 2007; Akhan *et al.*, 2010; Ramazan *et al.*, 2010; Çakmak *et al.*, 2018a; Çakmak *et al.*, 2018b; Çakmak *et al.*, 2019).

Can *Salmo labrax* inhabit rivers from inside the Carpathian Mountains Arch?

During August 2018 and July 2019 the ichthyofauna from Someșul Cald River (Figure 1) was inventoried from its springs to Tarnița Reservoir (Dam). Along with *Salmo trutta*, *Thymallus thymallus*, *Squalius cephalus*, *Barbus carpathicus*, *Barbatula barbatula*, *Rutilus rutilus*, *Phoxinus phoxinus*, *Cobitis elongatoides*, *Cottus gobio*, *Perca fluviatilis*, and *Eudontomyzon danfordi*, 5 specimens of *Salmo* sp. were caught. The length

Table 1. Meristic characters of brown trout *Salmo trutta* and the Black Sea trout *Salmo labrax*

Common name	Brown trout	Black Sea trout
<i>Species name</i>	<i>Salmo trutta</i>	<i>Salmo labrax</i>
Dorsal fin (D)	III-V 9-10(11) ^(a, d)	(III) ^(e) - IV 9-10 ^(a, c, e, h, i)
Anal fin (A)	II-IV (7) 8-9 ^(a)	III-IV 8 (10) ^(a, c, e, i)
Ventral fin (V)	I 7-9 ^(a, d)	I-8 ^(a, c, e, h, i)
Pectoral fin (P)	I 12-13 (14) ^(c)	I 11-12 ^(e, h)
Scales on lateral line (LL)	110-132 ^(c) 118-130 ^(d)	112-122 ^(a, h, i) ; 119-132 ^(c) 116-135 ^(e)
Scales above lateral line (Sc A)	25-26 ^(c)	25-31 ^(c)
Scales below lateral line (Sc B)	20-23 ^(c)	22-30 ^(c, e)
Scales D/LL	12-17 ^(a)	16-23 ^(a)
Scales Ad/LL	15 (17) ^(d)	18 (19) ^(c, d)
Vertebrae (Ver)	56-61 ^(d)	57-60 ^(a, c, h)
Gill rakers (GR)	13-18 (14-16) ^(d)	(16) 17-18 (19-21) ^(a, b, c, d, e, h, i)
Branchiostegal rays (Brs R)	10 ^(g)	10-12 ^(c)

Superscripts: *a*-Petru Bănărescu (1964); *b*-Kottelat & Freyhof (2007); *c*-Cărăușu (1952); *d*-Svetovidov (1984); *e*-Holčík & Stefanov (2008); *f*-Bușniță & d Alexandrescu (1963); *g*-Page & Burr (1991); *h*-Oțel (2007); *i*-Popescu-Gorj & Dimitriu (1956)

Legend: D-dorsal fin; A-anal fin; V-ventral fin; P-pectoral fin; LL-lateral line scales; Sc A-scales above the lateral line; Sc B-scales below the lateral line; D/LL-scales from dorsal fin to the lateral line; Ad/LL-scales in oblique row from the base of the adipose fin to the lateral line; Ver-Vertebrae; GR-gill rakers from the first arch; Brs R-branchiostegal rays.

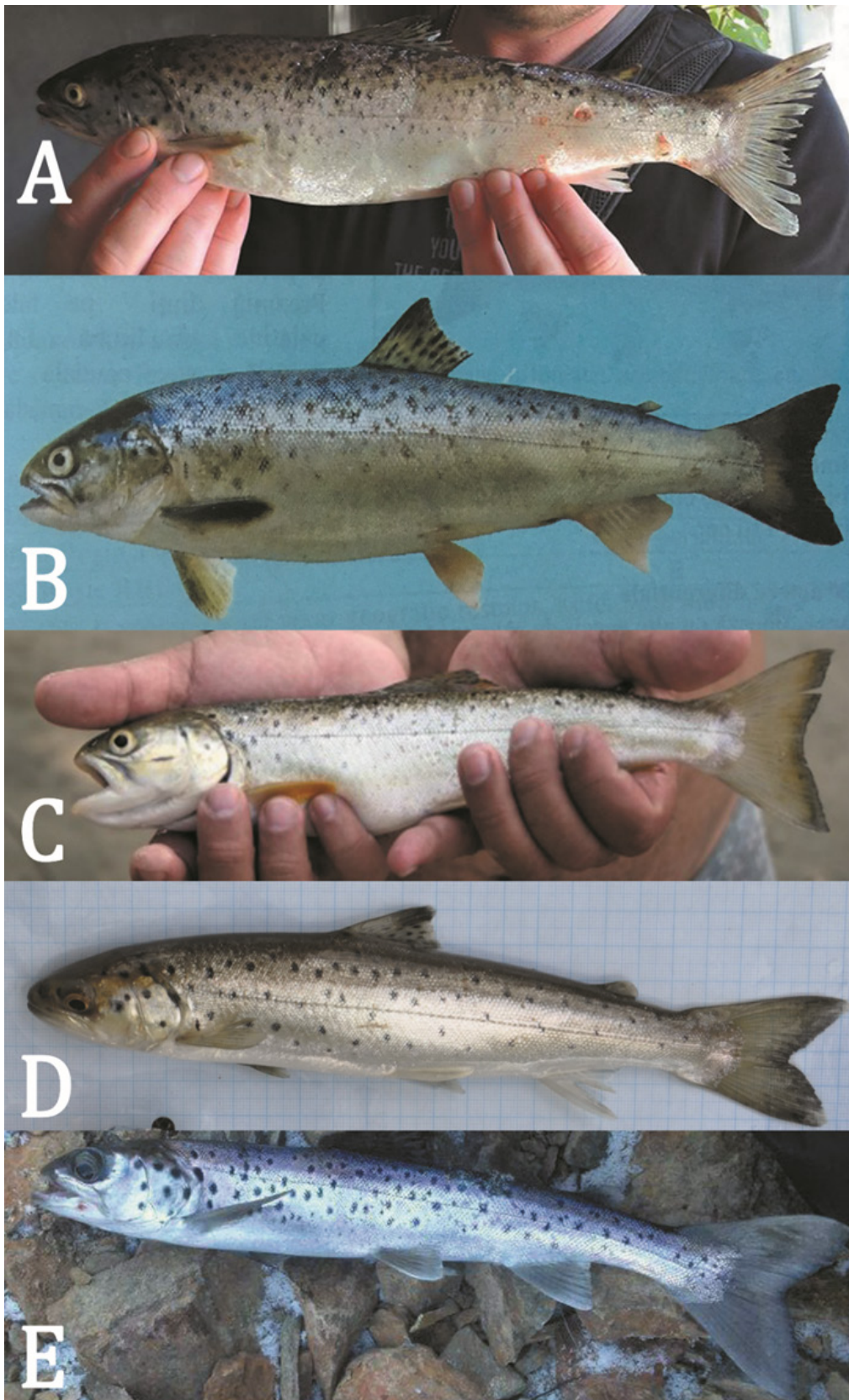


Figure 2. *Salmo labrax* from: A-Black Sea (photo credit: Daniel Cocan), B-Danube Delta, Sf. Gheorghe branch (photo credit: Vasile Oțel), C-Danube, Corabia (photo credit: Vasile Oțel), D-Someșul Cald River (photo credit: Călin Lațiu), E-Beliș Reservoir (photo credit: Ioan Rotar/Călin Lațiu)

Table 2. Chronological data mentions of *Salmo labrax* in and near Romanian waters

Year	Authors	Synonym used	Romanian habitat	Location	Frequency	Observations
1909	Antipa Grigore	<i>Salmo salar fario</i>	n/a	n/a	n/a	the name probably used for <i>Salmo labrax</i>
1948	Berg L.S.	<i>Salmo trutta labrax</i>	Black Sea, Danube basin	n/a	n/a	n/a
1952	Cărăușu Sergiu	<i>Salmo trutta labrax</i>	Black Sea, Danube, Lake Ialpuș	Black Sea coastal waters, Danube and Danube Delta	rare	Spawns at the end of April
1956	Popescu-Gorj Aurelian and Dimitriu Magdalena	<i>Salmo trutta labrax</i>	Black Sea, Danube, Danube Delta	Flooding lakes and ponds from the Danube Delta, Jirlia (Călărași), Măgureni, Sf. Gheorghe Branch	rare	Specimens around 27 cm were 3 to 4 years old
1964	Bănărescu Petru	<i>Salmo trutta labrax</i>	Black Sea, Danube, Danube Delta	The Black Sea, Danube (upper migration point - Călărași), Danube Delta, Razim-Sinoe lagoon complex	rare	n/a
1984	Svetovidov, A.N.	<i>Salmo trutta labrax</i>	Black Sea	n/a	n/a	n/a
1987	Lelek Anton	<i>Salmo trutta labrax</i>	Black Sea	n/a	n/a	Specimens from the Black Sea may reach 100 cm in length (total length)
1992	Oșel Vasile et al.	<i>Salmo trutta labrax</i>	Razim Lake	Razim-Sinoe lagoon complex		n/a
1997	Kottelat Maurice	<i>Salmo labrax</i>	Black Sea, Danube	Black Sea, Danube	n/a	n/a
2003	Vasilieva Ekaterina	<i>Salmo labrax</i>	Black Sea	n/a	rare	Lives in large rivers from northern coast of the Black Sea
2005	Bănărescu Petru	<i>Salmo trutta labrax</i>	Black Sea, Danube, Danube Delta	n/a	rare	It is found in the lower sectors of rivers emptying in the Black Sea
2007	Oșel Vasile	<i>Salmo labrax</i>	Black Sea, Danube, Danube Delta	The Danube, South of Sf. Gheorghe Branch, Razim-Sinoe Lagoon	rare	Caught in small numbers
2007	Milen Vassilev et al.	<i>Salmo labrax</i>	Danube	Ruse-Giurgiu	rare	Caught near Ruse town (Bulgaria)
2007	Vasilieva Ekaterina	<i>Salmo trutta labrax</i>	Black Sea (all coasts)	Black Sea	rare	Freshwater (potamodromous) are more widespread than saltwater (anadromous)
2007	Kottelat Maurice and Jörg Freyhof	<i>Salmo labrax</i>	Black Sea	Black Sea		Anadromous, lacustrine and resident forms
2008	Holčík J. and Stefanov T.	<i>Salmo labrax</i>	Danube	Bulgarian bank of Danube	rare	n/a
2010	Dudu Andreea et al.	<i>Salmo labrax</i>	Black Sea, Danube, Danube Delta, and tributaries	Danube Delta	n/a	n/a
2011	Muharrem Aksungur	<i>Salmo trutta labrax</i>	Black Sea	n/a	rare	the east coast of the Black Sea
2011	Georgescu Sergiu Emil et al.	<i>Salmo trutta labrax</i>	Black Sea, Danube, Danube Delta	n/a	rare	n/a

Table 2. Chronological data mentions of *Salmo labrax* in and near Romanian waters (continuation)

2012	Halasi-Kovacs B. and Harka A.	<i>Salmo labrax</i>	Black Sea, Danube, Danube Delta	Western Black Sea	rare	n/a
2015	Cocan Daniel	<i>Salmo labrax</i>	Danube Delta	Sfantu Gheorghe Branch	rare	Caught in August 2015/ Unpublished data
2017	Simonović <i>et al.</i>	<i>Salmo labrax</i>	Danube basin	n/a	rare	n/a
2018	Ninua Levan <i>et al.</i>	<i>Salmo labrax</i>	Black Sea	Northern and Western Black Sea	rare	n/a
2019	Lațiu Călin	<i>Salmo labrax</i>	Someșul Cald River, Beliș Reservoir	Doda Pili, Beliș-Fântânele Dam	rare	Unpublished data/Fig 1 (D,E) First record of <i>S. Labrax</i> inside the Carpathian Mountains Arch
2019	Anonymous fisherman	<i>Salmo labrax</i>	Danube Delta	Gorgova	rare	Unpublished data
2020	Dyldin Y. V. <i>et al.</i>	<i>Salmo labrax</i>	The Black Sea and Danube Basin	n/a	n/a	Anadromous and potamodromous (rivers and lakes) populations
2020	Oțel Vasile	<i>Salmo labrax</i>	Danube Delta	Maliuc	rare	Unpublished data
2020	FishBase	<i>Salmo labrax</i>	Rivers draining to the Black Sea	n/a	rare	Anadromous, lacustrine, resident forms

Legend: n/a- information not available

- Chilia Branch: the Romanian bank of Chilia Branch
- Lagoon Complex Razim-Sinoe: stray specimens
- Danube River: Călărași town (Călărași County), Giurgiu town (Giurgiu County), Corabia town (Olt County)-the highest migration point observed in the Danube River Romanian waters. In some cases, its presence was signaled near Nedeia Village (Dolj County), according to Popescu Gorj and Dimitriu in 1956. It is expected to find sporadic/stray specimens of the anadromous ecotype in lagoony lakes from the Danube Delta (Zmeica, Golovița, Leahova Mare).

The potamodromous ecotype of *Salmo labrax* could be found in Someșul Cald River catchment (Cluj County, N 46° 38.825'; E 022° 51.842'), Northwestern of Romania. There is a high probability to find potamodromous populations in other "river-reservoir" systems from inside and outside the Carpathian Mountains Arch (Drăgan River and Drăgan-Floroiu Reservoir; Sebeș River and Oașa Reservoir). The presence of this species in the Danube Delta Biosphere Reserve is not related to spawning migration (Bănărescu, 1964), but rather for food or new habitat. It is accidentally caught from Spring to Autumn

seasons by fishermen using gillnets designed for *Alosa immaculata*, or other fish species, and using seines while fishing in lagoony complexes. The potamodromous form is caught by fly fishing anglers (dry flies, nymphs) from April to September (legal trout fishing season in Romania) in Someșul Cald River and Beliș-Fântânele Reservoir.

The Black Sea Salmon *Salmo labrax* has the endangered species status in Romanian legislation and also in all the countries where it is extant but special measures for habitat restoration are necessary. It is also essential to identify the habitat and spawning grounds of the species (both anadromous and potamodromous ecotypes). Brown trout stockings may have a negative impact on Black Sea trout populations in this sense, and it is recommended that special attention for the waters where the two species live in sympatry like the presented area of Someșul Cald River, where *Salmo labrax* could be present. An example for our recommendation could be the *Salmo labrax* population we assume is living in Someșul Cald River and Beliș-Fântânele Reservoir (Cluj County, Romania). Genetic studies are also required to compare the isolated populations from Transylvania to those from the Black Sea coast. The potamodromous ecotype of *Salmo labrax* needs

further study regarding its reproductive migration behaviour (Pavlov *et al.*, 2018). It is not clear yet if the species reproductive migration behavior is fluvial, fluvial-adfluvial, lacustrine-fluvial, or allacustrine. Also, the spawning period of the species is unclear. Some authors mention that *Salmo labrax* spawns in spring (Bănărescu, 1964; Oțel, 2007), while other authors mention that it spawns in autumn and winter (Kottelat & Freyhof, 2007; Cakmak *et al.*, 2018). The distribution of fish species from the Salmonidae family (including *Salmo labrax*) in Romanian waters is still “an uncharted ground” and needs increased attention.

We also recommend that genetic studies on fish should be accompanied by morphological and meristic data, geographic coordinates, and period of fish sampling.

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