

Analysis of the Affinity between Anadromous Salmon and Catadromous Trout of the Black Sea Kumzha

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There are two species of Kumzha and 2 species of trout in Georgia: anadromous salmon and freshwater catadromous trout of the Black Sea. Kumzha inhabit the Black Sea Georgian coastal and landscape water bodies, while anadromous salmon and catadromous river trout of the Caspian Sea Kumzha are common in water bodies of the East Georgia. They should not be confused during the reproductive manipulations. For a long time, scientists recognized anadromous salmon and freshwater trout as two independent species. Today, many experiments have proved the transformation of anadromous salmon into river trout and vice versa, the transformation of river or lake trout into true salmon. Anadromous salmon and freshwater catadromous trout of the Black Sea Kumzha are two ecological forms of Black Sea Kumzha, a species of the *Salmonidae* family. Through diadromous migrations, there is constant exchange and complementation of genetic and paratypic elements between the catadromous river and anadromous metapopulations. The life cycle of salmon is divided into two periods: sea (fattening) and river (genital products maturation and spawning). Adults typically make annual anadromous migrations to their native river for spawning and spend 6 months there, i.e. as long as in the sea. Conditionally resident trout in rivers and streams live there for only one or two years, then undergo internal osmoregulation, acquire silvery appearance and migrate to the sea. Black Sea salmon population size and area totally depend on the generations obtained by reproduction of salmon and trout in a spawning river, most of which, after reaching the age of one year, migrate to the sea from early spring to late autumn, thus permanently replenishing and increasing the salmon population. The total of 60-70% of salmon – trout subpopulation in the Georgian coastal rivers are the underyearlings – the single reproduction fund of migrating and resident eco-types of the Black Sea Kumzha. © 2023 Bull. Georg. Natl. Acad. Sci.

Black Sea salmon, anadromous salmon, river trout, reproduction fund, smolts, osmoregulation

There are two Kumzha and two trout species common in Georgia: anadromous salmon (*Salmo labrax*) and catadromous river trout (*Salmo labrax fario*) of Black Sea Salmon species (*Salmo trutta labrax* Pallas 1811; *Salmo labrax* (new name)) are

common in the rivers and lakes of West Georgia; anadromous Caspian salmon (*Salmo trutta caspius*) and catadromous river trout (*Salmo trutta caspius fario*) of Caspian Sea Kumzha species (*Salmo trutta caspius Kessler*) are common in the rivers and lakes

of East Georgia. Therefore, when studying the salmonid fishes of Georgia, these two species should be clearly distinguished and not to be confused during reproduction. For a long time, scientists considered anadromous salmon, river trout and lake trout as completely different species. Today transformation of migrating Kumzha into river trout and conversely, transformation of river and lake trout into true salmon are proven facts. An important role in clarifying the confusing and intertwined kinship of salmonid fishes by scientists was played by acclimatization and breeding of Kumzha in artificial conditions, when it was found that river trout reproduced in fish farms, as they enter a river, migrate to the sea and transform into salmon. European river trout, following their conserved instinct, sometimes migrate 300-700 km to coastal estuaries, aspiring to transform into salmon, but are forced to migrate back due to high sea temperature. Duly adapted river trout, which we transferred to the sea many times from Batumi Fish Farm of the Black Sea Scientific-Research Institute of Ecology and Fish Breeding, adapt well to marine environment and transform into salmon.

Materials and Methods

The studies of Black Sea salmon and river trout have been conducted since the 1970s [1] at the Scientific-Research Institute of Marine Fisheries and Oceanography, but exceptionally intensive research and collection of comprehensive data was carried out with EU TACIS funding in 1998-2000, when international project "Black Sea Salmon Strategy" was implemented [2, 3]. Anadromous salmon and trout were caught in the river with hand drifts and special push nets (L=40-50 m). At the same time, large sexually mature adult salmon were collected for morphological, anatomical and gonadotropic studies and for scales collection from the individuals legally seized from anglers and poachers and bought on shadow markets. Representative studies of marine habitats and rivers to grow salmon were conducted by using the

available data at the institute as well as new data and exceptionally intensive and comprehensive studies were conducted on the example of the unique coastal and salmon rivers of Ajara rich in salmon and trout. Fish morphometric features were treated by I. Pravdin's method [4] and biological indicators were analyzed and interpreted by U. Riker's methods [5]. Fish species in the sea and rivers were identified and live fish were released into the habitat [1-3]. Grant-based salmon and trout surveys were conducted in the rivers of Khobistskali, Tekhura and Tskhenistskali in 2001-2004, during the construction of Kulevi Terminal. The trout in the middle and upper reaches of the Supsa River were studied in 2014 with future HPP grant. In 2016-2021, we conducted new studies of the *Salmonidae* family under the Biodiversity Action Plan of Ajaristskali HPP Cascade.

Results and Discussion

Anadromous salmon (*Salmo labrax*) and catadromous river trout (*Salmo labrax fario*) of the Black Sea Kumzha are two ecological forms of the same species of the *Salmonidae* family - Black Sea Kumzha. The life cycle of salmon, the natural life cycle of salmon in terms of unchanged functioning of (spawning) rivers is divided into two periods: sea fattening and river genital products maturation and spawning.

SM producer was caught in the River Machakhela during its anadromous migration in April of 2016.

Adults usually make annual anadromous migrations for gonade maturation and spawning to their native river and spend 6 months there, i.e. as long as in the sea. Conventionally resident river trout live in rivers and streams for only one or two years, then undergo internal osmoregulation, acquire silvery appearance and migrate to the sea. Black Sea salmon population size and area depend entirely on the number of fry and juveniles (which are biologically indistinguishable) born from roe laid by salmon in the spawning river, most of

which, after reaching the age of one year, migrate to the sea from early spring to late autumn and thus constantly replenish and increase the anadromous salmon population [1-3,6-9].

Our long-term studies (1970-2022) demonstrate that 60-70% of the salmon and trout subpopulation of Georgian coastal rivers are the underyearling of a single reproduction fund of migrating and resident eco-types of the Black Sea Kumzha. The proportion of two-year and older individuals in the subpopulation is 30-40%, 50% of which acquire a silvery color in autumn and depart to estuaries. The other half (15-20% of the total river population) consists almost entirely of second-year individuals, some of which also get a silvery color and migrate to the sea. Older fish make up no more than 1%. The negligible proportion of fish older than two years in the total population in the Black Sea coastal rivers is due not only to over-fishing, but also to their transformation into smolts and migration to the sea [1-3,6-10].

The sex ratio in this year's (0+) subpopulation of the river is almost uniform, but from the second year (1+), as the trout are distributed into two shoals: the ones migrating to the sea (average 82-88% of females and average 18-23% of males) and the ones temporarily staying in the river (17-21% of females and 81-87% of males), it becomes non-uniform. Migration of significant part (78-93 %) of female trout to the sea is determined by sex, ecology and reproductive physiology. Ovarian development of salmon requires a great store of energy, while the food supply of the river is very scarce for them, but is sufficient for dwarf males [6, 8, 9, 11].

Due to rich and diverse marine nutrition, stable high oxygen content in saline water, abundance of iodine, microelements and other environmental factors, migrants grow rapidly and reach 5-8kg at the age of 2 or 3 years. Their growth rates are stably high, even after sexual maturity during their habitation in the sea. The reproductive potential of females consequently increases manifold. Through diadromous migrations, there is a continuous exchan-

ge and complementation of genetic and paratypic elements between catadromous and anadromous metapopulations of the river, if it is not limited by anthropogenic factors that can sever the connection between them and lead them to extinction, what is not uncommon in current complicated political, economic and social conditions of the Black Sea region [6, 8-11].

In 2016-2021, we thoroughly studied the ecology and biology of anadromous salmon and river trout of Black Sea salmon and conditions for their reserves growth. Ecology of their habitats was assessed and analyzed. The karyotype of Kumzha's anadromous salmon and trout of Black Sea salmon: $2n=80$, $NF=98-100$ is homogeneous and according to their high variability and plasticity (polymorphism); their body shape, coloration and biological parameters are highly variable in different reservoirs following their high variability and plasticity (polymorphism). Very brightly colored individuals and almost black individuals with very mottled, shortened, thickened and elongated bodies are encountered.

The back of salmon found in rivers is brownish and their sides have silvery metallic sheen. In large lakes and estuaries, silver coloration predominates. Mottled trouts are very beautiful, with their bodies covered with red, black and white dots.

Trout from different water bodies in Georgia differ significantly morphologically and biologically. Their different forms are found in nature, differing greatly in appearance, coloration, habitats and ecology. The coloration of the trout of Black Sea Kumzha varies greatly depending on the color of river water and bed soil, surrounding vegetation and shading, abundance of food and time of year. Trout in waters containing lime are always bright and silvery, while they have dark coloration in rivers with a peaty and muddy bottom.

It is very important that Black Sea salmon is the only and unique species in the whole Black Sea region and a breeding population is preserved only in Georgian coastline and surrounding landscapes.

It needs protection, care and proper management. The abundance of trout in rivers and streams and the stability of their stocks is one of the ways to increase salmon population. High densities in rivers and streams and lack of nutrients and iodine force trout to become smolts by oxygenation and head down to the sea for intensive feeding and rapid growth [1-3, 6, 8-11].

During the implementation of the Black Sea Salmon Rehabilitation and Management Plan since 2006, our main objectives have been to protect Kumzha's habitats, significantly improve their ecological conditions, create the necessary conditions for natural reproduction of salmon and recognize it as a universal priority in the entire Black Sea region; ensure the growth of the stocks of anadromous salmon and river trout; raise the awareness of general public; create incentives for the protection and conservation of natural environment and valuable fish; manage each salmon river basin individually (11,12); establish long-term monitoring practices for salmon and trout fishing and control their stocks and further expand, develop and internationalize biological and ecological research and ecological monitoring of Black Sea Kumzha [1-3,7-9, 11].

Our thorough studies of the current state and bioecology of the Black Sea salmon and trout prove that the following measures are much more efficient than the complex of reproductiv-breeding measures for their protection and rehabilitation realized in the past [11]: maximum promotion and stimulation of natural reproduction of salmon and trout, protection of marine habitats, spawning population and breeding and reproduction rivers, establishment of relevant reserves; general improvement of the ecology and efficient monitoring; restriction of fishing and effective control of marine and river metapopulations of Black Sea salmon, elimination of artificial and natural barriers hampering the diadromous fish migration in the rivers and construction of fish passes using the model of Larnier et al. [12], which were installed on the River

Chirukhistskali Dam of Ajaristskali HPP cascade as per our advice, as well as introduction of spawning-ameliorative and biotechnical innovations [2, 3, 8, 9, 11].

In terms of the current changed ecology we have realized new environmental approach, the novelty of which consists in a balanced combination of artificial reproduction and the priority of natural reproduction of salmonid fish. The common reproductive stock of migrating and resident flocks of Black Sea Kumzha creates the basis for effective raiding trout breeding with efficient use of the river's forage base. This approach excludes long-term breeding of trout hatchlings in an artificial environment and is limited to breeding of juveniles (2-3-month-old mottled species) in protected rivers – natural fish farms, in which the growth and development of the mottled species into the smolts with complete osmoregulation proceeds smoothly, with a high probability of survival. An excellent example of this is the rich experience of the USA and Canada in salmon cultivation biotechnology [2, 3, 8, 9,11].

Conclusions

Anadromous salmon and catadromous freshwater trout of the Black Sea Kumzha are two ecological forms of the same salmonid species of the *Salmonidae* family the Black Sea Kumzha. Through diadromous migrations, there is constant exchange and complementation of genetic and paratypic elements between the catadromous river and anadromous metapopulations. The Black Sea salmon population size and area entirely depend on the generations obtained by reproduction of salmon and nearby found trout in a spawning river, most of which, having reached the age of one year, migrate to the sea from early spring to late autumn, thus permanently replenishing and increasing the salmon population. The total of 60-70% of the salmon and trout subpopulation of Georgian coastal rivers are the udneryearlings, making a single reproduction fund of migrating and resident eco-

types of the Black Sea Kumzha. The proportion of two-year and older individuals in the subpopulation is 30-40%, 50% of which acquire a silvery color in autumn and head for estuaries. The other half (15-20% of the total river population) consists almost entirely of second-year individuals, some of which

also get a silvery color and migrate to the sea. The negligible proportion of older adults (1-2%) in the total population of rivers is due not only to overfishing, but also to their transformation to smolts and migration to the sea.

ფიტოპათოლოგია

შავი ზღვის კუმჟას ანადრომული ორაგულისა და კატადრომული კალმახის ურთიერთობათა ანალიზი

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საქართველოში გავრცელებულია ორი სახეობის კუმჟა და ორი სახეობის კალმახი: შავი ზღვის საქართველოს სანაპიროსა და ლანდშაფტურ წყალსატევებში ბინადრობს შავი ზღვის კუმჟას ანადრომული ორაგული და მტკნარი წყლის კატადრომული კალმახი; აღმოსავლეთ საქართველოს წყალსატევებში გავრცელებულია კასპიის ზღვის კუმჟას ანადრომული ორაგული და მდინარის კატადრომული კალმახი. სარეპროდუქციო მანიპულაციებისას დაუშვებელია მათი აღრევა. დიდი ხნის განმავლობაში მეცნიერების მიერ ანადრომული ორაგული და მტკნარი წყლის კალმახები დამოუკიდებელ სახეობებად იყო აღიარებული. დღეისათვის მრავალი ექსპერიმენტით დამტკიცებულია გამსვლელი ორაგულის გარდასახვა ნაკადულის კალმახად და, პირიქით, ნაკადულისა და ტბის კალმახების გარდაქმნა ნამდვილ ორაგულებად. შავი ზღვის კუმჟას ანადრომული ორაგული და მტკნარი წყლის კატადრომული კალმახი ორაგულისებრთა ერთი სახეობის კუმჟას ორი ეკოლოგიური ფორმაა. დიადრომული მიგრაციების გზით მდინარის მკვიდრ და გამსვლელ მეტაპოპულაციებს შორის მუდმივად მიმდინარეობს გენეტიკური და პარატიპული ელემენტების მიმოცვლა და ურთიერთშეცვლა. ორაგულის სასიცოცხლო ციკლი ორ – ზღვის სანასუქო და მდინარის სასუქო პროდუქტების მომწიფებისა და

ტოფობის – პერიოდად იყოფა. ედულტები, როგორც წესი, ყოველწლიურად ახორციელებენ ანადრომულ მიგრაციას ტოფობისთვის მშობლიურ მდინარეში და ატარებენ იქ 6 თვეს – იმდენს, რამდენსაც ზღვაში. მდინარეებსა და ნაკადულებში არსებული, პირობითად, რეზიდენტი კალმახები ცხოვრობენ იქ მხოლოდ ერთი ან ორი წელი, შემდეგ შინაგანად განიცდიან ოსმორეგულაციას, გარეგნულად შეივერცხლებიან და მიგრირებენ ზღვაში. ორაგულის პოპულაციის მოცულობა და არეალის სიდიდე მთლიანად დამოკიდებულია სატოფო მდინარეში ორაგულებისა და კალმახების რეპროდუქციით მიღებულ თაობებზე, რომელთა უმრავლესობა ერთი წლის ასაკის მიღწევის შემდეგ, ადრე გაზაფხულიდან გვიან შემოდგომამდე მიგრირებს ზღვაში, ავსებს და ადიდებს ორაგულის პოპულაციას. საქართველოს სანაპირო მდინარეების ორაგულ-კალმახის სუბპოპულაციის 60-70% წლეგანდებია – კუმქას გამსვლელი და მკვიდრი ეკოტიპების აღწარმოების ერთიანი სარეპროდუქციო ფონდი.

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