Scientific Papers. Series D. Animal Science. Vol. LXIII, No. 1, 2020
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

Alosa immaculata Bennet, 1835: A SHORT REVIEW OF THE SPECIES AND ITS BIOLOGY

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Abstract

Currently, in the continental and marine waters of the Earth, there are over 33,400 species of fish. Over time, naturalists, and specialists in ichthyology have proposed several variants of systematic classification of fish. Thanks to new methods and advanced scientific research equipment, 300-500 new species are discovered every year. This explains the fact that in just 20 years (1998-2017), 7,436 species were described. In 2004, the scientific organization Integrated Taxonomic Information System published ITIS Report, in which a complete taxonomic hierarchy of the genus Alosa is presented. Alosa immaculata (Pontic shad), is an important fish species in the ecological system of the Danube-Delta-Black Sea, with a significant economic value due to the high catches and to the nutritional qualities of meat. The knowledge of the essential elements regarding the biology and the exploitation of the species contributes to ensuring the necessary information for the conservation of the species and the management of the stocks. The current level of knowledge on the biology of the Pontic shad is known from the researches of the Romanian and Russian specialists from the years 1960-1970, but in the last 30 years, numerous changes have occurred in the environmental and exploitation conditions of the species. In this context, the aim of this paper is to present as updated information as possible regarding the biology and exploitation of the Pontic shad, under the new environmental conditions, to meet the current objective of species conservation in the requirements of the sustainable exploitation of the stocks.

Key words*: Alosa immaculata (Pontic shad), biology, stocks.*

INTRODUCTION

The Danube River covers a length of 2,857 km. Human activities have significantly influenced the flow of the Danube through flood prevention, navigation activities. The most important dams in the Danube at a distance of 943 km from the river, the Iron Gate I, and the Iron Gate II have formed an accumulation lake, which in turn represents obstacles for migratory fish species and Pontic shad.

Besides the negative impact of the dams and the regulation of the river flow, the common stocks of Pontic shad in the region of the Lower Danube have been affected by overfishing and the pollution. Some of the obstacles encountered in the standard effective management of these fish stocks may be the lack of harmonization and coordination of management.

Clupeidae is one of the world's most commercially essential families of fish. Despite their importance, little is known about the phylogenetic relationships within the genus *Alosa*, resulting in systematic and taxonomic uncertainty, which may undermine the establishment of adequate conservation measures (Faria et al., 2006).

The genus Alosa is present in the Northern hemisphere of the Earth. Many of the species representing this genus are in the Atlantic, Mediterranean, Black, and Caspian. In the Danube River and the Black Sea, are found *Alosa immaculata* (Bennett, 1838) - Pontic shad, *Alosa tanaica* (Grimm, 1901) - Azov shad, synonymous with subspecies *Alosa caspia nordmanni* (Antipa, 1906), and *Alosa maeotica* (Grimm, 1901) - Black Sea shad (Năvodaru et al., 2014).

According to IUCN Red List 2008, *Alosa immaculata* is a vulnerable species, and the current threat of the species is overfishing, at sea, and in the rivers during the migration runs, which is causing a population decline of unknown levels (Figure 1).

Figure 1. The geographic range of *Alosa immaculata* (IUCN, Red List 2008; Freyhof & Kottelat, 2008)

In the European Union, according to the Annex II of the Habitats Directive 92/43/EEC, the Pontic shad is a protected species, requiring protection under the Natura 2000 Network and site management, which is under its ecological requirements. Also, the species is listed in Annex IV, which obliges the Member States to ensure that their exploitation is compatible with maintaining a favorable conservation status. At the national level, the species is protected by the GEO no. 57/2007.

Pontic shad is a commercially important fish of the Danube Delta and the countries of the Lower Danube Region (Romania, Ukraine, and Bulgaria) (Ciolac & Patriche, 2004).

In this context, the purpose of this paper is to review some aspects regarding the biology and current status of the *Alosa immaculata* population along the Danube River and the Black Sea.

Taxonomy. Distribution. Morphology. Ecology and biology of the *Alosa immaculata*

Pallas (1811) made the first reports of the Pontic shad, under the name of western European shad, *Clupeonela pilchardus*. In the year 1835, Bennett describes the species under the name of *Alosa immaculata* - Pontic shad. *Alosa immaculata* is an anadromous fish species that inhabit the Black and Azov Sea, at varying depths and great distances from the coast of Ukraine, Romania, and Bulgaria (Bănărescu, 1964).

The *Alosa immaculata* is a marine, migratory, anadromous species, migrate for spawning from the Black Sea to the Danube River, and the average weight is around 240 g and the total length of 31 cm (Lenhardt et al., 2016) (Figure 2).

Figure 2. *Alosa immaculata* (Photo original)

The reproduction of *Alosa immaculata* takes place in the Danube, up to 80 km, between Brăila and Călărași county. Still, in the past, reproductive shad migrate upriver up to 1000 km, reaching only the Iron Gates II (863.55 km). The current of the Danube carries larvae and fry of Pontic shad to the sea (Cristea and Cristea, 1958).

Sexual maturation occurs at the age of 3 and 4 years old, and only a few individuals spawn two seasons (Năvodaru & Năstase, 2014; Țiganov et al., 2016).

Usually, a Pontic shad spawns only once or twice in its lifetime (Ciolac, 2004). Most spawning in the Danube River occurs between 180 and 743 km upstream (Kolarov, 1985; Schmutz, 2006). Individuals of two years have a low contribution among breeders being represented by individuals with growth and maturation accelerated. Also, fish with ages between 5 and 7 years are rarely found during migration (Năvodaru, 1997).

The migration is dependent on water temperature, and according to some authors begins in February - March when water temperatures reach 5-6˚C, with the highest rate in April, at water temperatures of 9-13˚C (Pavlov, 1953; Năstase et al., 2018). Năvodaru, in 1996 and 1998, said that the *Alosa immaculata* migration in the Danube River begins in spring at water temperatures of 3-7.5˚C, peaks in April and May between 9-17˚C, and is finished in June and July when water temperatures reach 22-26˚C.

Another critical factor that affects the entry of the *Alosa immaculata* into the Danube is turbidity and water level. According to Năvodaru (1997), higher water turbidity, and a high water level in the Danube slow down fish migration.

The sex structure of the migration population can vary depending on the seasonality and migration period. Several studies reported female dominance with the aging and a decrease of the males (Năvodaru, 1997; Năvodaru and Năstase, 2014; Țiganov et al., 2016).

Generally, the duration of the Danube shad migration is estimated at 100-150 days (Table 1).

Table 1. Size structure of *Alosa immaculata* in 2009, 2013, 2014 and 2016

Catch area/year	Catch period	Total weight (g)	Total length (cm)	The age of the fish caught	Sex ratio (M/F)	References
Danube River, 2009	April - June	100-400 g Average 276.72 g	24-39 cm Average 31.11 cm	-	-	Ibănescu et al., 2016
Black Sea coast, 2013	Spring season (March, April), summer (June, July) and autumn (September)	163-442 g Average 248 g	25.2-31.2 cm Average 28.2 cm	2 years -16% 3 years - 42% 4 years - 37% 5 years - 5 %	0.62, females dominant	Țiganov et al., 2016
Mouth of Danube River, 2014	January – May	163- 422 g Average 289 g	25.3 – 35.7 g Average 31.1 cm	3 years – 46% 4 years – 50% 5 years - 4 %	0.55, 64% - females, 36% of males	Năvodaru and Năstase, 2014
Mouth of Danube River, 2016	February – August	102-435 Average 236.8	22.7-36 Average 28.7 cm	Dominance 3-4 years	0.51, females dominant	Năstase et al., 2016

Generally, food consists of 70-75% of adult fish (Engraulis, Clupeonella, Sprattus) in the sea and Cyprinids in the Danube River, the rest being shellfish (Crangon, Upogebia, Idotheia), and other organisms according to their abundance and availability (Bănărescu, 1964; Cautiș et al., 1957).

Alosa immaculata has an elongated body, compressed laterally, and the mouth is terminal, broad, slightly oblique upwards. Well developed adipose eyelid, leaving a narrow, elliptical-shaped vertical opening. Laterally compressed abdomen from the tip of the snout to the base of anal. The hull is evident,

especially between ventral and anal. The dorsal fin is located towards the middle of the body, and the anal fin is located far behind. The backside of the body is colored in blue-green, silvery flanks, and sometimes white and sometimes darker head, fins are colorless (Antipa, 1909; Bănărescu, 1964).
Biological peculiarities of the species make it vulnerable to different threats, but the major ones are overfishing and loss of spawning grounds.
In the context of fishery management that takes ecological and ecosystem considerations, protected areas are highly relevant.
Recent data on shads stocks, distribution, population parameters, and genetics in the Black Sea area urgently are needed for the species conservation and management issues.

MATERIALS AND METHODS

The Danube is the most important stream in Romania. The Danube sector under study is of particular importance for fish populations, as it is a central wetland type (Ibănescu et al., 2016).
Several representative areas for each habitat type were chosen for fish sampling. The evidence comes from scientific and commercial fishing.
In order to study the biological parameters of the pontic shad species from the collected samples, samples were taken, which were analyzed in the laboratory.
Special fishing gear was used for Danube Pontic shad: driftnets and suitable boats operated by fishermen. The material was collected from different parts of the Danube, in the spring season (March, April), summer (June, July) and autumn (September) (Țiganov et al., 2016).
The main physiological parameters recorded for each individual were: total length, individual mass, age, and sex. Weight was determined in grams. The age was determined by reading the annual growth rings on the scales. The sex of each individual was determined by dissection.
The study of the species *Alosa immaculata* consisted in an ichthyological study of all the samples collected during the studied period, using both the samples collected from the experimental fishing and from the commercial fishing.

RESULTS AND DISCUSSIONS

In Romania, *Alosa immaculata* is a fish with high economic and socio-cultural value for the communities. Due to the highest nutritional quality of *Alosa immaculata* (has a big content of lipids 18-22% and a higher content of soluble vitamins), this fish is usually consumed in the Lent by the Christian population.
The fishery has a commercial value of about 1.5 million euros, with annual average catches of 200-500 tons. According to Năvodaru and Năstase (2014), *Alosa immaculata* has a cyclical evolution of catches, with minimums or maximums at 10-11 years, during the period 1960-1998, the minimum absolute was 200 t, and the maximum of 2,400 t.
Between years 2007 and 2010, according to data provided from FAO (2016) statistics regarding the catches in the Danube and the Black Sea, it is observed a dramatic decrease in 2014, of the level of catches in the Black Sea to approximately of 2 tons, while catches from the Danube in the last years are maintained around 400 tons per year (Figure 3).
Unfortunately, as much as the interest for the exploitation of the species, it is higher, as well as the danger of the drastic decline of the Danube and Sea populations Black is bigger. Also, the dramatic fall of Pontic shad migration in the Danube river for reproduction is a real issue that evidently should concern interested persons and involved institutions, companies, and organizations from both commercial and ecological point of view.
In this context, there it is recommended some management measures for the conservation of the *Alosa immaculata*, such as the introduction of bans, for example closing of certain fishing areas and seasons or protection of fish by regulating fishing methods and instruments for the Black Sea and Danube (Țiganov et al., 2016).
Knowledge of the essential elements of the biology and exploitation of the species contributes to ensuring necessary informatio for species conservation and management of stocks.

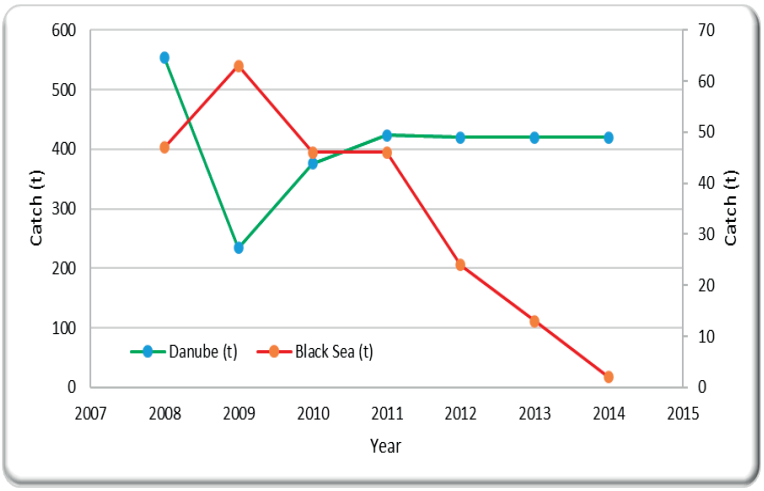

Figure 3. The level of catches of *Alosa immaculata* (Source FAO Statistics, 2016)

Control of fish stocks, including shad, is achieved by the interaction of three key compartments species - environmental - exploitation.

For better management, further investigation and more collaboration among countries in the Lower Danube River Region is needed: monitoring of stocks, studies on factors that influence change in shares, molecular genetic investigation of migrants, determination and protection of spawning and nursery places in the Danube River and its floodplains and delta as well as the costal shelf of the Black Sea.

CONCLUSIONS

Even if we consider the adverse changes of some ecological aspects related to environmental factors such as lower water level, water temperature, and pollution that could affect the success of the Danube shad reproduction. The most crucial cause of the decreasing of the stocks is the overfishing, mainly in Danube Delta area, which provides about 90% of total amount of capture in Danube River.

There are visible decreases in the Pontic shad population. The research is carried out only occasionally on the territory of Romania and Bulgaria. Changes resulting from human intervention in river systems affect migratory fish. Dams and river engineering structures will affect a species such as *Alosa immaculata* because their breeding areas have located in these river systems, as well as the adverse effects on the species that recur in the lower parts of this system are not very clear.

The monitoring of the migrating population of *Alosa immaculata* into the Danube River deserves further empirical study. Additional research is needed to quantify any changes in the number of individuals and their biometric variables and to validate if an upward trend in abundance is happening. The continuation of the study should provide the evidence necessary to determine possible changes in the conservation state of this species of community interest.

ACKNOWLEDGEMENTS

The principal author of the article thanks to "Dunărea de Jos" University of Galați which through the University Degree Program, the doctoral studies contract has supported the achievement.

REFERENCES

Antipa, G. (1909). *The ichthyological fauna of Romania*, XVI. Bucharest, RO: Vasile Adamachi Fund Publications, Romanian Academy Publishing House (In Romanian).

Bănărescu, P. (1964). *Pisces-Osteichthyes R.P.R. Fauna*, XVIII. Bucharest, RO: R.P.R. Academy Publishing House (In Romanian).

Cautiș, I., Iliescu, M., Maximov, A. (1957). Caspialose fund problem form Black Sea. *Bul ICP*, XV, 47-56.

Ciolac, A. (2004). Migration of fishes in Romanian Danube River. *Applied Ecology and Environmental Research*, 2(1), 143-163.

Ciolac, A., Patriche, N. (2004). Structure of Danube Shad (*Alosa pontica*, Eichwald 1838.) spawner flocks migrating for reproduction in Danube River. *Appl Ecol Env Res.*, 2(2), 53-58.

Cristea, A., Cristea, E. (1958). Some resulted obtained from prolificity of the Pontic shad (*Alosa pontica*). *Bul ICP*, XVII (3), 78-85.

FAO (2016). Fishery and Aquaculture Statistics. *FAO yearbook,* 125(7), Part 1.

Faria, R., Weiss, S., Alexandrino, P. (2006). A molecular phylogenetic perspective on the evolutionary history of *Alosa* spp. (Clupeidae). *Molecular phylogenetic and evolution,* 40, 298-304.

Freyhof, J., Kottelat, M. (2008). *Alosa immaculata.* The IUCN Red List of Threatened Species 2008: e.T907A13093654. Retrieved March 12, 2020, from https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T907A13093654.en.

GEO no. 57/2007 *on the regime of natural protected areas, the conservation of natural habitats, wild flora and fauna.*

Habitats Directive 92/43/EEC *Council Directive 92/43/EEC on the conservation of natural habitats and of wild Fauna and flora*.

Ibănescu, D., Popescu, A., Nica, A. (2016). Estimation of growth and mortality parameters of the Pontic shad (*Alosa immaculata* Bennett, 1835) in Romanian section of the Danube river. *Lucrări Ştiinţifice-Seria Zootehnie*, 285-289.

Kolarov, P. P. (1985). *Biological characteristics and population dynamic of anadromous fish specie.* PhD thesis, Varna: Institute for Fish Resources.

Lenhardt, M., Višnjić-Jeftić, Ž., Navodaru, I., Jarić, I., Vassilev, M., Gačić, Z., Nikčević, M. (2012). *Fish stock management cooperation in the Lower Danube region: A case study of sturgeons and Pontic shad*. In: Lagutov V. (eds) Environmental Security in Watersheds: The Sea of Azov. NATO Science for Peace and Security Series C: Environmental Security, Dordrecht, NL: Springer Publishing House.

Lenhardt, M., Navodaru, I., Vassilev, M., Kalauzi, A., Regner, S., Višnjić-Jeftić, Ž., Tošić, K., Smederevac-Lalić, M. (2016). Model of the Pontic shad *Alosa immaculata* (Bennet, 1835) and anchovy *Engraulis encrasicolus* (Linnaeus, 1758) catch in the Danube river and Black Sea for the period 1920-2008. *Acta zool. bulg.*, 68(4), 557-561.

Năstase, A., Năvodaru, I., Cernisencu, I., Ţiganov, G., Popa, L. (2018). Pontic shad (*Alosa immaculata*) migrating upstream the Danube river and larval drift downstream to the Black Sea in 2016. *Scientific Annals of the Danube Delta Institute*, 23, 57-68.

Năvodaru, I. (1996). *Exploitation of Alosa Pontica in the Danube Delta, Romania.* - In: Co W x i. G. (Ed.): *Stock Assessment in Inland* Fisheries, 448-453. Oxford, UK: Fishing News Books Publishing House.

Năvodaru, I. (1997). *The evolution of the Pontic shad effectives under conditions of ecological of the river and their maintenance measures.* PhD Thesis, "Dunărea de Jos" University of Galaţi.

Năvodaru, I. (1998). Migraţia scrumbiei de Dunăre (*Alosa pontica*) şi factorii de mediu. *Analele Ştiinţifice ale Institutului Delta Dunării-1997*, VI(1), 149-152.

Năvodaru, I., Năstase, A. (2014). *New data on pontic shad (Alosa immaculata Bennet 1835) migration and drifting larvae in Danube River,* Deltaica, 3: 48 pp. In: Torok, L. ed., Noi date asupra prezenţei marilor peşti migratory anadromi în Marea Neagră - Zona marină a Rezervaţiei Biosferei Delta Dunării (New data on presence of the great anadroumous migratory fishes in Black Sea - marine zone of Danube Delta Biosphere Reserve), ISSN 2286–0789; doi: 10.14590/DDI02.D03.

Pallas, P., S. (1811). *Zoographia Rosso-Asiatica, sistens omnium animalium in extenso Imperio Rossico et adjancetibus, domicilia, mores et descriptiones, anatomen atque icones plurimorum,* III, Petropoli: Academiae scientarium impress Publishing House.

Pavlov, P. I. (1953). *Biologhiceskaia I promislovaia harakteristika nerestovo stada dunaiskoi seldi.* In: Dunaiska seldi i biologhiceskie osnovi eio promisla, 118-174. Kiev, USSR: Acad. Nauk. Publishing House.

Schmutz, S. (2006). *Assessment of the potential transboundary effects of the construction of the 270 Bystre Deep Water Navigation Channel on fish and fisheries*. Report to the ESPOO Inquiry Commission Vienna, 56.

Ţiganov, G., Năvodaru, I., Cernişencu, I., Năstase, A., Maximov, V., Oprea, L. (2016). Preliminary data on the studies *Alosa immaculata* in Romania marine waters. *Scientific Annals of the Danube Delta Institute*, 22, 141-148.