ESTIMATION OF GROWTH AND MORTALITY PARAMETERS OF THE PONTIC SHAD (*ALOSA IMMACULATA* BENNETT, 1835) IN ROMANIAN SECTION OF THE DANUBE RIVER

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Abstract

Features of the growth and mortality parameters were studied during 2009 on a total of 1011 specimens of Pontic shad, vulnerable specie of community interest whose population is in decline. The total length and weight migratory specimens ranged between 24 ÷ 39 cm and 100 ÷ 440 g. Using the ELEFAN program in FiSAT computer package, the calculated von Bertalanffy growth function parameters were L_∞ = 40.43 cm and k = 0.38 yr^{-1}, to = -0.08 years. The length - weight relationship (L - W) found is: $W = 0.0526 * L^{2.487}$ (r^2 = 0,85).

Total mortality (Z) was calculated using the length converted catch curve analysis method in FiSAT computer software package and has a value Z = 1.54.

Natural mortality was computed as M = 0.588 yr^{-1} at an annual average temperature of 12°C, hence, the fishing mortality was computed as F = Z – M = 0.952 yr^{-1}.

The exploitation rate (E) calculated as $E = F / Z$ for the Pontic shad population is 0.618.

Key words: the growth and mortality parameters, von Bertalanffy equation, L - W relationship (LWR)

INTRODUCTION

The *Alosa immaculata* is a pontic relict with great economic importance for the romanian Danube fishery and other countries such as Bulgaria, Ukraine, etc. The interest in this species is even more accentuated by its specific biology [2]. Biological peculiarities of the species make it vulnerable to different threats, but the major ones are overfishing and loss of spawning grounds [8].

The pontic shad (*Alosa immaculata*, Bennedett, 1835) is a migratory anadromous fish from Alosa genus, which lives in the Black Sea and Azov Sea. Currently, the adults migrate for reproduction upstream on the Danube, Dniester, Dnieper and Don. The population of the north - western part of Black Sea migrates up to the Danube at Giurgiu – Calarasi towns, rarely up to Iron Gate. In the past, exceptionally sporadic specimens reached Budapest (km 1650 of the Danube) [1]. The places where reproduction is conducted with higher intensity are located upstream of km 180, the maximum intensity being between Calarasi and Braila towns.

The spring reproduction migration triggers at a water temperature of 3 - 5ºC (February - March) with maximum intensity of 9 -17ºC (April - May) and ending at 22 - 26ºC (July) [7]. Due to over - fishing made on migratory routes, in spring, the numerical effectives of the shad population decreased considerably, becoming a vulnerable species.

MATERIALS AND METHODS

Study area

The Danube, the second longest river in Europe, is the most important stream of Romania. Romania is a Danube country in 99% because, excepting waters less important in Dobrogea Plateau (Taiţa and Casimcea), the rest of the country's water flows through the river systems that belong

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to the Danube. The Danube sector studied (Brăila - Gropeni) presents a particular importance for the fish populations because is a central wetland type, the Danube including between his arms, from north to south, the following islands (Harapu, Fundu Mare and Calia) (Figure 1). Due to the hydro - morphological conditions that are very different, the ichtiodiversity of the area is also very high. The samples were collected from the arms of the river.

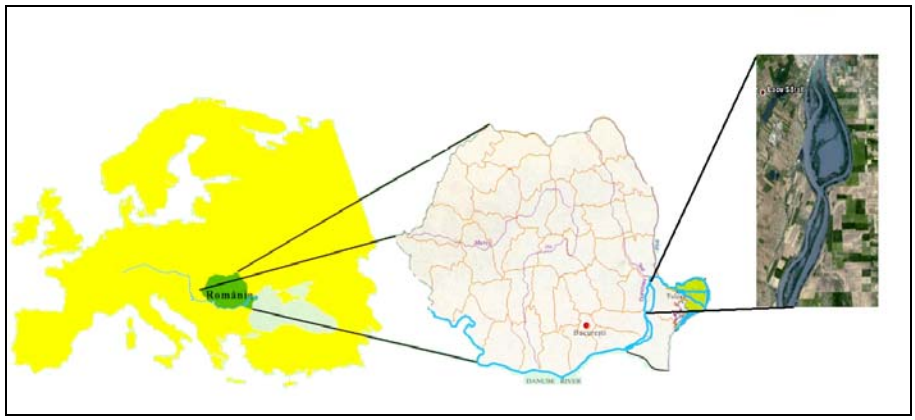

Figure 1 Area study

Sampling and data analysis

Fishing of specimens was achieved during migration in 2009 (April - June). The samples come from scientific and commercial fisheries conducted in the Brăila (km 170 of river) – Gropeni (km 197 of river), Romanian section of the Danube River. The fishing gear used were the shad gill nets, (double nets: a = 30 - 32 mm) with mesh size of 32 -70 mm. It was collected and sampled a number of 1011 individuals which the total biomass being ~ 280 kg. The main biological parameters registered for each individual were: total length (Lt ± 1 mm), individual mass (W ± 1 g).

Data analysis

For data analysis was used software package FiSAT II (FAO - ICLARM Stock Assessment Tool) based on length frequency distribution [3].

The length – weight relationship

The length - weight relationship (LWR) was estimated using the equation $W = a * L^b$, where: W - total body weight (g), L - total length (cm), b and a are the coefficients of the functional regression between W and L [11].

Were determined parameters b and a using the method of the least squares, using the logarithmic values of the total length (L) and the weight (W). The strength of the LWR was evaluated by means of regression coefficient (r^2).

The estimation of the growth parameters

The growth parameters (L_∞, k, t_0) were estimated by the length frequency analysis using the ELEFAN model implemented by the FiSAT II program. The general equation of the increase in length as a function of age (Von Bertalanffy) is:

$$L_t = L_\infty \left(1 - e^{-\left[K(t - t_o)\right]}\right)$$

([12]; [10]; [14]).

Where, Lt = length at age t, L_∞ = the asymptotic length of fish; k = curvature parameter that determines how fast the fish approaching to L_∞; t_0= the theoretical age at which the fish length is 0.

The theoretical estimation of t_0 age was performed using linear regression between the average lengths of individuals at successive ages by equation:

$$\ln(1 - L(t)/L_\infty = -k * t_0 + k * t \quad [14].$$

The mortality

The estimation of mortality rates represent an important component of fisheries management.

The **total mortality (Z)** can be divided into two types:

Natural mortality (M): the removal of fish from the stock due to causes not associated with fishing (competition, cannibalism, old age, predation, pollution or any other natural factor that causes the death of fish) In fisheries models natural mortality is denoted by (M).

Fishing mortality (F): the removal of fish from the stock due to fishing activities using any fishing gear.

Z = M+F

Total mortality (Z) was computed using the length converted catch curve analysis method in FiSAT II computer software package.

The natural mortality (M) was estimated by the Pauly's empirical formula [9] as:

$$\ln M = -0.0152 - 0.279 \ln L\infty + 0.6543 \ln k + 0.463 \ln T^0 C$$

Where: T^0C is the annual average temperature of Danube water at Braila ($T=12^0C$).

RESULTS AND DISCUSSIONS

Each generation of shad which participates at migration has its own characteristics regarding the dimensions body. This is due to the specific environmental conditions in which they were born and where the individuals lived, but is also due to the different response to these factors.

The main descriptive parameters of length and weight are shown in Table 1.

Table 1 Summarized Statistics of the variable

	L	W
Mean	31.11	276.72
S.E	0.25	5.93
S.D	3.027	71.38
Variance	9.16	5095.12
Min	24	100
Max	39	440

The total lengths of the fish studied are between 24 and 39 cm, with an average value of 31.11 cm. It can be observed that the specimens captured belong to seven classes of lengths, the most of them being in the classes 32.5 to 35 cm (26.8%) followed by 27.5 to 30 cm length class (25.71%) and 30 to 32.5 cm length class (14.24%) (Figure 2).

The weight specimens varies between 100 g and 400 g with a mean value of 276.72 g.

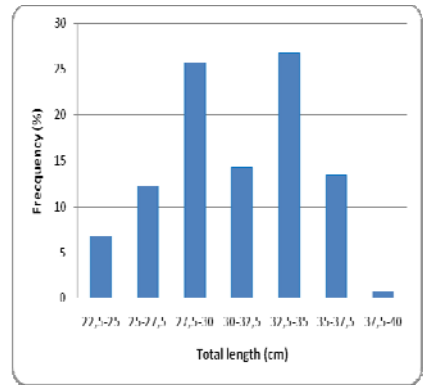

Figure 2 Length frequency distribution of Pontic Shad

The length - weight relationship (LWR)

The LWR has a great importance in the ecology and management of the fisheries stocks [13].

This relationship can also be helpful to assess the feeding rate, gonad maturity and metamorphosis of fish [5].

The coefficient b from the length – weight relationship according to Tesch [15], is a measure of the environmental conditions that can be useful to compare different environments conditions, the fatness or the well – being of fish.

The b coefficient in this study is 2.487, indicating allometric growth (that increased weight is slower than the length increase).

The length - weight relationship (LWR) for individuals of breeding shad during the study is: $Wt = 0.0526 * L^{2.487}$.

Between the two variables, length and weight (L - W), is a good correlation (r = 0.92) taking into account that in breeding period the individuals of different generations migrate (figure 3).

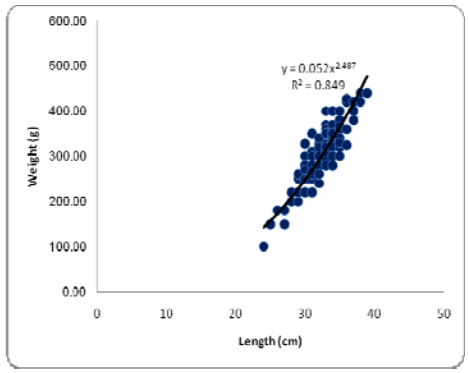

Figure 3 Length – weight relationship (LWR) of *Alosa immaculata*

This expression is close to the expressions determined by Năvodaru I., [6] ($Wt = 0.05625 * Lt^{2.457}$) and Iliescu M., [4] ($Wt = 0.0905 * Lt^{2.4}$) for the Pontic shad.

The determination of the growth parameters L_∞, k, t_0

The growth parameters L_∞, k and t_0 are constants in an equation we can predict the fish body size when it reaches a certain age.

The estimations of the growth parameters L_∞, k, t_0 obtained in this study are shown in table 2.

The asymptotic length (L_∞ = 40.43 cm) and the growth coefficint k (0.380) of the Pontic shad migratory captured in 2009, enclose in the values quoted in the literature [16].

The mathematical equation which shows the length (Lt) as a function of age (t) is of the form: $Lt = L_\infty * (1 - e^{-0.38(t+0.072)})$

Tabel 2 The values of growth parameters L_∞, k and t_o for Pontic shad

L_∞ (cm)	k	t_o
40,43	0,38	-0,072

Mortality

Estimating mortality rates is important for maintaining fish stocks at the desired level, so to avoid the overexploitation of fishery resources.

The estimate of the mortality rates (Z and M) for the Pontic shad population investigated was computed using the FiSAT II computer software package. The values are shown in table 3.

Tabel 3 The mortality rates of Pontic shad population

Species	Z	M	F	E
Alosa immaculata	1.54	0.588	0.952	0.618

The exploitation rate (E) of 0.618 for *Alosa immaculata* estimated from the mortality rates, is larger than 0.5. It shows that the stock of this species in this area is overexploited.

CONCLUSIONS

As a species with great commercial importance and threatened due to pollution and overfishing, knowing the elements from biology and the exploitation of these species, contributes at ensuring the basic information for the conservation and sustainable management of the shad stocks.

The study conducted on 1011 specimens of *Alosa immaculata* caught in the Romanian Danube sector in 2009 can be concluded:

✓ The pontic shad sampled in the studied period had the total length interval between 24 - 39 cm and weight values interval between 100 - 400 g.

✓ Relationship L – W established is $Wt = 0.0526 * L^{2.487}$

✓ Growth parameters (L_∞, k, t_0) have values similar to those from specialized literature.

✓ The high values of fishing mortality (F) and the rate of exploitation (E) shows that *Alosa immaculata* stock is not exploited in a sustainable conditions.

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