Age and growth determination of Lower Danube sturgeon species *Huso huso* and *Acipenser stellatus*

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**Abstract.** In the Lower Danube, sturgeon populations have declined dramatically in recent decades. Although efforts have been made at the legislative level since 2006, by forbidden commercial fishing, an assessment of stocks and conservation status of sturgeon species has not yet been made [1]. In this context, it is necessary to estimate the age and growth rate of sturgeon species in order to establish their current conservation status, with a high level of confidence. This article presents the long-term results obtained by INCDPM during 6 years of research in which were captured and released 108 specimens of beluga (*Huso huso*) and 193 specimens of stellat sturgeon (*Acipenser stellatus*). Thus, before the ultrasonically tagging of the sturgeon specimens, informational volumes regarding the biometric parameters were collected simultaneously with the gender determination [1]. Based on the collected data and the calculus hypotheses, it was possible to determine the ages of the sturgeon specimens and to perfect the method of improving the confidence level of the data obtained from the *in-situ* investigations. In order to foster sustainable management of Danube sturgeon populations, it is essential to carry out assessments with a high degree of confidence of the age of anadromous sturgeon species. The quantification of the population depends on species spawning cycles taking into account that they are characterized by high longevity.

1. Introduction

Sturgeons are one of the most valuable resources on Earth [2], the Lower Danube being one of the last areas where these species grow and reproduce naturally. Although they are long-lived fish with delayed maturity, sturgeon stocks worldwide have declined dramatically recently. A century ago there were 6 species of sturgeons in the Lower Danube basin, nowadays three of them being considered critically endangered, one vulnerable and two extinct [3]. In order to know the current status of sturgeon species and to improve their situation, it is necessary to have as complete information as possible about existing stocks and future evolution, depending on the conservation status of habitats and species and the pressures exerted on them.

The study of growth parameters is significant for the assessment of populations and for making comparisons on the development of species in different aquatic environments [4]. Growth parameters, processed by analytical and statistical methods, provide information on the causes of the endangerment of different aquatic ecosystems, specimens development, cyclical and seasonal reproduction, and the general conservation status of the species [5,6]. According to information from the literature, the age of sturgeon specimens can be estimated by several methods, the most frequent
being represented by observing certain parts of the body (otoliths, shields, etc.) or statistical analysis of data on length and body mass [7,8,9]. The determination of the growth rate and the age of the beluga and stellate specimens was made starting with the relationship between length and mass [10] of a number of 108 beluga specimens (Huso huso) and 193 stellate sturgeon specimens (Acipenser stellatus).

2. In-situ investigations and data processing

2.1. Biometric determinations

The biometric parameters analyzed in this paper are: total and standard length (cm), head circumference (cm), trunk circumference (cm), tail circumference (cm) and body mass (kg). Length and circumference measurements were made by using a roulette. To determine the body weight, an electronic scale was used for specimens weighing less than 10 kg and a mechanical one with lower accuracy for large specimens. Figure 1 presented the determination of biometric parameters.

![Figure 1. Biometric determinations[1].](image)

2.2. Determining the relationship length - body mass

Following the in-situ investigations, the length-body mass relationships were determined for the captured beluga and stellite sturgeon specimens by analyzing the growth model based on the allometry of the species. Growth parameters were determined in order to estimate the age of the specimens and calculate the frequency of catches by age categories so that based on the results obtained to be possible to assess the conservation status of the species and the impact caused by the anthropogenic pressure. The length-body mass ratio for the captured specimens was determined on the basis of the statistical-mathematical relationship (1) which expressed the increase of the sturgeon specimen (represented by units of mass and units of length) as a function of proportionality coefficient (a) and allometry (b) [11].

\[ W_t = a \cdot L_t^b. \] (1)

where:
- \( W_t \) – total mass of the specimen (kg);
- \( a \) – coefficient of proportionality, indicating the intersection of the regression line;
- \( L_t \) – total length of the specimen (cm);
- \( b \) – allometry coefficient, indicates the slope corresponding to the growth rate, respectively how the body mass varies according to the length.
Figure 2 represents the correlation of body mass and length for beluga and stellate specimens captured and analyzed in the spring and autumn campaigns of the period 2011-2017.

The value of the correlation coefficients of the regression equations (2 and 3) of length-body mass (R = 0.97-beluga and R = 0.98 - stellate) ensure a strong interdependence between the total length and body mass of the analyzed specimens.

\[ W_t = 7 \cdot 10^{-6} \cdot L_t^{3.0137}. \] (2)

\[ W_t = 8.6 \cdot 10^{-6} \cdot L_t^{2.8119}. \] (3)

From the allometric point of view, when \( b = 3 \) means an isometric increase in weight. When the value of \( b \) is other than 3, the weight increase is allometric, (positive allometric if \( b>3 \), negative allometric if \( b<3 \)) [12]. From the regression equations (2) and (3) positive allometry was found (\( b = 3.013691 \)), for the beluga specimens, through which the increase is made more in body mass, than in length and negative allometry (\( b = 2.8118 \)) specific to the stellate specimens from the Lower Danube, through which the growth is achieved more in length than in body mass.

2.3. The method used to determine the growth rate and age

In this paper, the estimation of the age of the specimens was made starting from the method developed by Von Bertalanffy [13,14] which is based on samples of length/body mass and the evolution of these over time, depending on which the growth parameters \( k \) and \( t_0 \) are determined. The relationship based on the evolution of length over time is:

\[ L(t) = L_\infty \cdot \left(1 - e^{-k(t-t_0)}\right). \] (4)

where:
- \( L(t) \) – length at age \( t \) [cm]
- \( L_\infty \) – length at which growth is supposed to stop [cm];
- \( k \) – growth coefficient or curve parameter. Depending on the value of \( k \), information is obtained about the dynamics of the growth of specimens in the ecosystem and can help to evaluate and compare the populations of the same species, which live in different areas;
- \( t_0 \) – vârsta teoretică la care lungimea este 0, nu are semnificație biologică [15];

\( L_\infty \), can be considered the maximum length of the analyzed sample or the maximum known length of the previous catches [7]. The age of the specimens, determined by the evolution of the body mass in time, is given by the relation (5).

\[ W(t) = W_\infty \cdot \left(1 - e^{-k(t-t_0)}\right)^3 \] (5)
where:
\( W_t \) - total body mass [kg]
\( W_\infty \) - asymptotic mass represented by the corresponding value when the specimen reached \( L_\infty \) [kg]

The constant \( W_\infty \) can be considered the maximum body mass of the analyzed sample or the maximum body mass known from the previous catches [7].

3. Results and Discussions

3.1. Analysis of the population structure by length classes

The distribution of catch frequencies by length classes for the analyzed period is presented in figure 3.

![Figure 3. Frequency of sturgeon lengths captured during 2011÷2017 period [1].](image)

Throughout the analyzed period, the 193 captured stellate specimens were grouped into 9 length classes, ranging from 19 ÷ 144 cm. The highest frequencies in catches were recorded in the length classes of 97 ÷ 127 cm.

The 108 specimens of beluga were grouped into 12 length classes, ranging from 20 ÷ 310 cm. The most frequent catches were recorded in the length classes of 191 ÷ 230 cm. From the literature, it results that this length interval corresponds to the specimens aged between 12 ÷ 17 years, being at the first or second spawning period. [16].

3.2. Improving the informational volume of sturgeons body mass

Following further verifications, certain deviations on the body-mass determined by weighing of some beluga specimens from the sample of 104 adult specimens were found (Figure 4). Due to the frequent deviations, the weighing accuracy was improved and it was considered necessary to correct the weighing errors. Thus, the correction coefficient of beluga specimens body masses was developed (\( C_{RD} \)). At the same time, there was introduced a procedure of electronic weighing in order to eliminate the weighing errors. The determination of the (\( C_{RD} \)) coefficient presented in the present study represents a novelty in the field, taking into account the fact that it allows the estimation of the body mass depending on the measured length and circumferences. This coefficient is applicable in research studies involving large specimens of beluga for which weighing could be very difficult, especially in the absence of adequate infrastructure to allow proper handling of specimens.

Determination of the (\( C_{RD} \)) coefficient was made based on the informational volume obtained over the years 2018÷2019. For a sample of 15 specimens of beluga for which the body mass has been accurately measured using an electronic weighing system with a measurement deviation of less than 100 g (Figure 4) the body mass correction coefficient of each specimen was determined according to the total length and the three of the measured circumferences.
The regression equation for the corrected mass depends on the \((C_{RD})\) coefficient and expressed through the relationship (6), (Deak & Raischi, 2018):

\[
W_e = 2.3413 \cdot 10^3 \cdot C_{RD}^{2.2421},
\]  

(6)

where:

\(W_e\) – total body mass of the specimen (kg),

\(C_{RD}\) – body mass correction coefficient.

In order to determine the age of the specimens with a high confidence level, the body masses for the 104 specimens of beluga which was initially weighing with large deviations were corrected.

3.3. Analysis of the age of sturgeons from the Lower Danube

Based on the methodology, the age of the sturgeon specimens from the Lower Danube was determined \((Huso huso\) and \(Acipenser stellatus\)) depending on their body mass and their length, figure 5.

According to the presented graphs, the age of the mature beluga specimens of analyzed varies between 14 ÷ 29 years. According to most authors \([16,17]\), maturity in the case of \(Huso huso\) (beluga) is evident around the age of 10 ÷ 16 years. Regarding the age distribution of the investigated beluga specimens, it results that 78% of the evaluated specimens were at the first or second spawning period. 15% were at the third spawning period. 3% were at the fourth or fifth cycle of spawning and the remaining 4% were juveniles. From the obtained results it can be observed that for the most stellate specimens, the age between 7-11 years represents, with a high probability, the second spawning cycle. Regarding the age distribution of the investigated stellate specimens, it results that 2% of them were
juveniles, 66% at the first or second spawning period, 27% at the third spawning period, and only 5% being at the fourth or fifth spawning period.

4. Conclusions

Between May 2011 and December 2017, 108 specimens of Huso huso and 193 specimens of Acipenser stellatus were captured, ultrasonically tagged, and released into the Danube. Biometric data on the length and weight of the captured specimens were considered as a starting point for assessing the conservation status of anadromous sturgeon species. The distribution of catches by frequencies of lengths and weights have helped to identify the age of the specimens after applying the correction coefficient ($C_{RD}$) to the beluga specimens’ weight. The determination of the coefficient ($C_{RD}$) was possible with the help of data from the information volume obtained in 2018 ÷ 2019, for a sample of 15 specimens of beluga, for which the weight was measured with high precision, respectively the length and the circumferences.

Coefficient ($C_{RD}$) determination represents a novelty that allows estimates of fish body mass by length and circumference, with applicability in research studies involving large specimens of beluga and for which weighing is difficult.

In the case of Huso huso, by interpreting the results regarding the number of specimens and their age in the analyzed sample, the abundance in catches of young specimens was observed, 4% juveniles, 78% being at the first and second spawning period, 15% at the third and only 3% of them at the fourth or fifth spawning period.

In the case of Acipenser stellatus, due to the smaller dimensions of the specimens, their weighing could be performed with high precision, without requiring corrections. Age estimation was performed based on lengths and body masses measured in the field using the statistical-mathematical methodology for processing the information volume. Also was maintained a very high percentage of 66% of young specimens at the first and second spawning period, 27% at the third spawning period, 5% at the fourth or fifth spawning period and only 2% juveniles.

Taking into account that sturgeons are long-lived species, the low frequency in catches of specimens being at higher spawning cycles highlighted the effect of certain pressures on their conservation status and indicated the need to develop an estimation methodology of populations specific to these species. An important aspect resulting from the processing of informational volumes is that there is clear evidence of spawning of the two of the species given that over 65% of the captured specimens were young but there is a quantitative uncertainty regarding the volume of the sturgeon population if there is a satisfactory density of the species in order ensure the sustainable conservation status of sturgeons in the Lower Danube.

In conclusion, it is imperative to identify and apply measures to reduce the pressures that affect the conservation status of sturgeons in the Lower Danube proved by the fact that the percentage of specimens with more than 3 spawning cycles is less than 10%.

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