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MATHEMATICAL MODELING OF BODY MASS FOR SPECIMENS OF *HUSO HUSO* SPECIMENS TAGGED AND MONITORED IN THE LOWER DANUBE

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Abstract

The Lower Danube Basin has an important role in the biogeography of European rivers and represents a refuge for numerous important fish species. Sturgeons are distributed exclusively in the northern hemisphere of the Earth and are an important group in the evolution and classification of fish, being a longlived group of vertebrates, which have successfully maintained their morphological characteristics for over 200 million years, but now, according to the IUCN Red List of Endangered Species (IUCN), sturgeon species around the world are threatened with extinction. The family Acipenseridae comprises five genera with 25 species and of these 6 are native in the Lower Danube. As knowledge on the behavior and ecology of sturgeon species is limited this study analyzes the information volume accumulated during 2011-2020 by the team of experts of the National Institute for Research and Development for Environmental Protection (INCDPM) and proposes a model for calculating the body mass of the beluga (Huso huso) specimens tagged and monitored according to morphobiometric parameters. Studies are limited in time due to the alarming decline of these species; out of the 6 species of native sturgeon, only 4 are currently found in the Lower Danube.

Keywords*: Acipenseriformes; Beluga sturgeon; Danube River; Monitorig; IUCN Red List of Endangered Species*

Introduction

Starting with the middle of the XIX century, sturgeon population numbers have started to decrease [1-6], and in the context of the large number of sturgeon species threatened with extinction worldwide [7], experts from the National Research and Development Institute for Environmental Protection have been conducting research on native sturgeon species in the Lower Danube since 2011 [8]. The Lower Danube Basin is known to play an important role in the biogeography of European rivers and is a refuge for many important fish species, including species belonging to the Acipenseridae family [9]. Acipenseriformes are considered *"living fossils"* due to the few morphological changes they have undergone over time [9-12], and at

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present, of the 6 native sturgeon species, only 4 have been identified in expert research, the European sea sturgeon and the fringebarbel sturgeon being considered extinct [13-15].

Although numerous legislative measures have been imposed including International Union for Conservation of Nature Red List of Threatened Species, Appendix II of the Convention on International Trade in Endangered Species, Bern Convention population decline still exists and is attributed to anthropogenic factors such as poaching, dam constructions, fragmented ecosystems, habitat destruction [16].

In Romania the competent authorities have issued a series of legislative measures on the conservation of sturgeon populations in natural waters since 2006 [17]. Legislative measures have been renewed over time so that they are still in force today, however wild sturgeon populations are still considered to be threatened with extinction [18-20].

During the 10 years of research, 475 specimens of *H. huso*, *A. ruthenus*, *A. gueldenstaedtii* and *A. stellatus* were captured, measured, tagged, released and monitored, of which 27.79% were belugas, which is a significant amount of information, unique worldwide, used in this study.

The main aim of the study is to estimate the body mass of *H. huso* specimens, based on the volume of information accumulated over 10 years of study by INCDPM experts.

Experimental

Method

Experts from the National Research and Development Institute for Environmental Protection in Bucharest have developed a theoretical calculation method for estimating the body mass of *H. huso* specimens based on morphobiometric measurements and their relationships. Measurements were carried out by experts *in situ* on the 132 specimens caught, tagged, released and monitored during 10 years of research. After weighing each captured specimen, the researchers measured circumference at head, trunk and tail level. They also measured total length (Lt), standard length (Ls), length from rostrum tip to head circumference (L1), length from head circumference to trunk circumference (L2), length from trunk circumference to tail circumference (L3), and length from tail circumference to tail tip (L4) (see Table 1).

Table 1. Values of morphobiometric measurements carried out *in situ* by the INCDPM expert team for 6 of the *H. huso* specimens caught, tagged, released and monitored in the Lower Danube

Individuals	Weight (kg)	Øhead (cm)	Øtrunk (cm)	Øtail (cm)	L_1 (cm)	L_2 (cm)	L_3 (cm)	L_4 (cm)
H_1	50	76	80	26	36	30	99	33
H_2	55	74	78	24	39	37	111	44
H_3	90	87	101	29	45	35	122	43
H_4	100	93	104	26	46	42	123	24
H_5	101	94	105	28	39	41	125	51
H_6	135	95	119	30	41	50	128	46

The calculation method used to estimate the body mass (annotated with m) of the beluga was based on the formula $m = \rho * V$, where the density (annotated with ρ) was calculated using a sample of *H. huso* specimens whose body mass was precisely known and resulted in a constant value of 0.0011 and the volume (annotated with V) was adapted to the conformation of the fish. Hypothetically, the specimen was divided into 4 segments (Fig. 1) and the volume of each was

calculated separately, finally summing the values obtained from the calculations to obtain the volume of the whole beluga (Fig. 2).

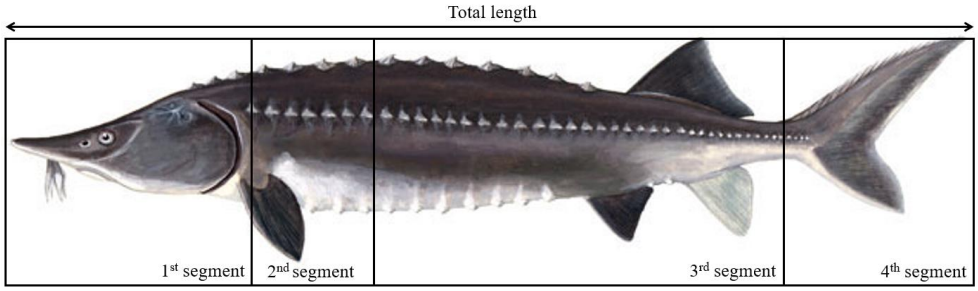

Fig. 1. Hypothetical division of a specimen of the species *H. huso* for calculating volume

$m=\rho*(V_1+V_2+V_3+V_4)$, where:

$V_1=0.33*3.14*(R_{head}\text{^}2)*L_1;$

$V_2=(3.14*L_2*((R_{trunk}\text{^}2)+(R_{head}\text{^}2)+(R_{trunk}*R_{head})))/3;$

$V_3=(3.14*L_3*((R_{trunk}\text{^}2)+(R_{tail}\text{^}2)+(R_{trunk}*R_{tail})))/3;$

$V_4= 0.33*3.14*(R_{tail}\text{^}2)*L_4;$

Fig. 2. Calculation formula applied to estimate the body mass of *H. huso* specimens

Results and discussion

To verify and validate the results obtained from the body mass estimation calculations, these were compared (Table 2) with the body mass of specimens weighed *in situ*, using a weighing instrument with accurate values within 100 grams.

Subsequently, it was found that the difference between the body mass estimated by the above calculation model and the body mass measured *in situ* is between 0.5 and 3.1kg (Fig. 3), which is an error of maximum 3.1% of the body mass of the sturgeon analysed. Thus, the relationships established between morphobiometric measurements made *in situ* prove useful in the process of estimating body mass.

Table 2. Estimation of body mass of *H. huso* specimens using the formula and comparison between calculated and measured body mass *in situ*.

Individuals	R_{head} (cm)	R_{trunk} (cm)	R_{tail} (cm)	V_1 (cm^3)	V_2 (cm^3)	V_3 (cm^3)	V4 (cm^3)	V (cm^3)	ρ	Calculated Weight (kg)	Weight (kg)
H_1	12.1	12.7	4.1	5463.3	14535.0	24056.4	586.1	44640.8	0.0011	49.1	50
H_2	11.8	12.4	3.8	5611.2	17019.2	25134.1	665.9	48430.3	0.0011	53.3	55
H_3	13.9	16.1	4.6	8949.0	24668.1	45235.2	950.1	79802.5	0.0011	87.8	90
H_4	14.8	16.6	4.1	10453.2	32477.5	46340.4	426.3	89697.4	0.0011	98.7	100
H_5	15.0	16.7	4.5	9054.1	32350.6	48928.5	1050.5	91383.7	0.0011	100.5	101
H_6	15.1	18.9	4.8	9722.0	45768.3	63290.0	1087.7	119868.1	0.0011	131.9	135

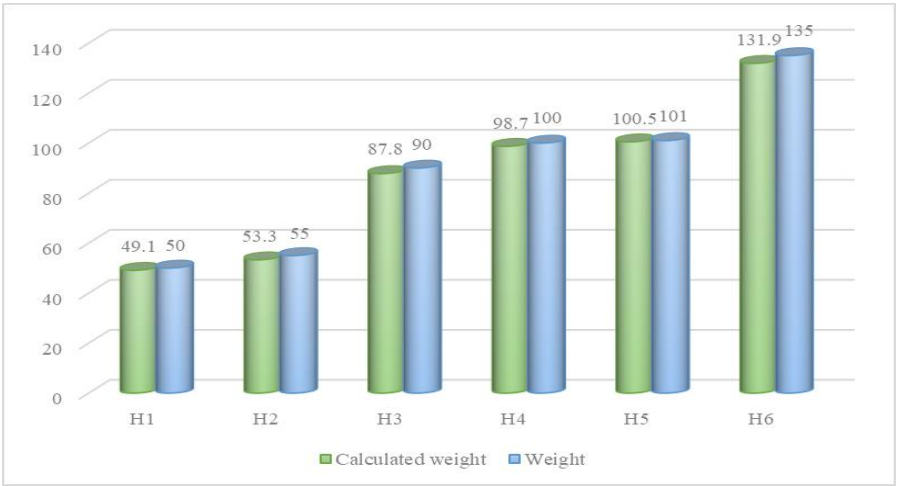

Fig. 3. Comparison between weight values calculated by the formula and weight values acquired by weighing

Conclusions

Because of the size, weighing the belugas *in situ* is difficult and especially in the absence of appropriate weighing instruments, so this mathematical model aims to estimate body mass using morphobiometric measurements and their relationships.

Subsequently, with the help of the body mass, the age of the individuals caught, tagged, released and monitored on the lower Danube by the INCDPM research team can be estimated by means of a mathematical model.

In conclusion, this initial study offers a possibility of estimating body mass based on a series of morphobiometric measurements carried out *in situ*.

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