COMPARATIVE MORPHOMETRY OF A LOTIC AND A LENTIC POPULATION OF EUROPEAN CHUB (*SQUALIUS CEPHALUS*, LINNAEUS 1758)

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Abstract

The chub (Squalius cephalus) is a freshwater species that belongs to the cyprinid family (Cyprinidae). In Romania we find it in almost every river and stream located in the submontaneous region. This species is very important for the trophic integrity of freshwater ecosystems in the submontaneous region. The chub is very adaptable, this being the reason why we encounter it in non-characteristic freshwater ecosystems for chub, especially in the reservoirs built in the last decades in Romania. On the other hand, there are true chub waters in Romania that are not holding numerous populations anymore. Because of these reasons, studies on this species are required. In this study we used morphometric methods and techniques to analyse two chub populations: a population in a specific chub environment, the Crișul Repede river upper sector and the population in the Beliș-Fântânele reservoir. For this study we captured and studied 97 chubs from the Crișul Repede river and 66 chubs from the Beliș-Fântânele reservoir. The results we obtained show that the Crișul Repede population is dwindling, possibly due to anthropic factors. For the Beliș-Fântânele reservoir, the results show that the species is adapting to the environmental conditions of the reservoir.

Key words: allometry, morphology, scalimetry

INTRODUCTION

The European chub (*Squalius cephalus*, Linnaeus 1758) is a widespread cyprinid species across Romanian waters, especially in the submontaneous and the hillside region. *Squalius cephalus* is an omnivorous species and it is very resilient, thus adapting easily to new environments [3]. Scientific literature describes it as a riverine species, adapted to flowing water conditions, that only in isolated cases can be found in lakes and ponds [2]. In the last decades, tens of dams and artificial lakes were built in Romania [12] and chub is populating them on a large scale, including water bodies situated at higher altitude than the normal altitude range for this species [3]. The purpose of this study was to study from a morphometric point of view two different populations of *Squaliaus cephalus*: the chub population from the Crișul Repede River upper sector, and the population from the Beliș-Fântânele reservoir. By comparing the two populations morphometry we try to distinguish two aspects: what is the status of the lotic population and how well did the lentic population adapt to the reservoir environment.

MATERIAL AND METHOD

The research took place between 2016 and 2019. The first step in preparation for this research was to choose the locations from where we studied the chub populations. The lotic environment chosen was the Crișul Repede River upper sector, situated between Huedin and Vadu Crișului localities and this river sector is a typical environment for chub in the region of Transylvania, Romania. The Beliș-Fântânele reservoir is built on the Someșul Cald River, near the Beliș village, at

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approximately 1000 m altitude, in a mountainous region and since it has been built, a generous population of chub developed in its waters.

Using angling techniques, we captured 97 specimens of chub from the Crișul Repede River and 66 specimens of chub from the Beliș-Fântânele reservoir, which represented our study basis. After capture, each fish was weighed, photographed on a flat surface near a measuring tape and three scales were collected, then it was released in the best condition back into the water. In the laboratory we conducted a total of 33 somatic measurements based on the photo of each fish, using the AmScope Toupview software [9]. The following measurements were done (in mm): total length (TL), standard length (SL), maximum height (H), minimum height (h), caudal peduncle length (CpL), head length (HH), head height (HH), snout length (SnL), eye diameter (ED), upper jaw length (UjL), lower jaw length (LjL), pre-orbital distance (Pre-o-D), post-orbital distance (Post-o-D), pre-dorsal fin length (Pr-dL), post-dorsal fin length (Po-dL), pre-pectoral fin length (Pr-pL), post-pectoral fin length (Po-pL), pre-ventral fin length (Pr-vL), post-ventral fin length (Po-vL), pre-anal fin length (Pr-aL), post-anal fin length (Po-aL), dorsal fin -pectoral fin length (D-pL), dorsal fin - ventral fin length (D-vL), dorsal fin – anal fin length (D-aL), pectoral fin – ventral fin length (P-V), pectoral fin – anal fin length (P-A), ventral fin – anal fin length (V-A), dorsal fin height (DfH), pectoral fin length (PfL), ventral fin length (VfL), anal fin length (AfL), caudal upper fin length (CufL) and caudal lower fin length (ClfL). For each fish, its age was determined using scalimetry techniques, by counting under the microscope the accumulations of growth rings on the fish scales [4], to determine the age structure of the populations and the growth rate. Age was described as "Y+", in which Y represents how many full years the fish has and + represents the time passed during the year in which the fish was captured, thus obtaining an approximate age. For each age category we determined the number of specimens, the average weight, average total length, and their standard deviations. Growth rate regarding the weight and total length was determined by the difference between the mean values of weight and total length of two consecutive age categories.

Length-weight relationships were calculated, such as the Fulton condition factor (K) and the allometric growth equation. The Fulton condition factor was calculated using the following formula [4]:

$$K = \frac{W \cdot 100}{TL^3}$$

where K = Fulton condition factor, W = body weight (g) and TL = total length (mm). To assess a fish population growth pattern, the allometric growth equation is a very useful tool in determining if a fish grows with higher intensity in weight or in length [5, 6, 8]. The allometric equation was determined using the following formula [4]:

$$W = aTL^b$$

where W = body weight (g), TL = total length (mm), *a* = constant and *b* = slope.

For the Fulton coefficients we conducted the unpaired t test, and for the morphometric determinations we established the means with standard deviation and we also determined the Pearson r correlation between morphometric measurements, for each population.

Tabulation, statistical analysis, and graphics were done using Microsoft Office 365 Excel software [11] and the GraphPad Prism software [10].

RESULTS AND DISCUSSIONS

The following results were obtained regarding the age structure and growth rate of the studied chub populations. Age structure of the Crișul Repede population is presented in Table 1 and the growth rate is presented in Table 2.

Table 1 Age structure of the Crișul Repede population

Age category	1+	2+	3+	4+	5+
Specimens	7	40	36	12	2
W (g)	30.43±12.97	50.33±21.45	60.72±35.46	126.33±53.29	162.5±26.16
TL (mm)	148.36±14.73	169.57±17.68	177.61±27.25	215.97±32.77	232.71±7.73

Table 2 Growth rate of the Crișul Repede population

Category interval	1-2	2-3	3-4	4-5
Accumulated W (g)	19.90	10.39	65.61	36.17
Accumulated TL (mm)	21.21	8.04	38.36	16.74

Age structure of the Beliș-Fântânele population is presented in Table 3 and the growth rate is presented in Table 4.

Table 3 Age structure of the Beliș-Fântânele population

Age category	0+	1+	2+	3+	4+	7+
Specimens	14	12	32	4	3	1
W (g)	5.98±2.85	19.77±9.42	32.68±8.71	77.83±53.58	118.30±37.07	277.80
TL (mm)	80.54±13.80	121.07±18.55	145.55±13.82	179.96±48.11	228.86±24.51	271.84

Table 4 Growth rate of the Beliș-Fântânele population

Category interval	0-1	1-2	2-3	3-4
Accumulated W (g)	13.79	12.91	42.15	40.48
Accumulated TL (mm)	40.53	24.48	34.41	48.90

The absence of the “0+” age category and the small number of specimens in the “1+” age category for the Crișul Repede population in this study shows that there could be difficulties for the population to reproduce and this could be related to the anthropic activities that affect this river, such as pollution, gravel exploitation, regularization etc. The absence of the “5+”, “6+” age categories from this study regarding the Beliș-Fântânele population is due to the fact that the capturing method was limitative for such a big water body, not that they do not exist. The numbers regarding the age structure and the growth rate of this population point to a stable age structure and growth rate.

The Fulton condition factor (K) coefficients values for each population are put up to comparison in Fig. 1 and the estimation plot from the unpaired t test results are presented in Fig. 2.

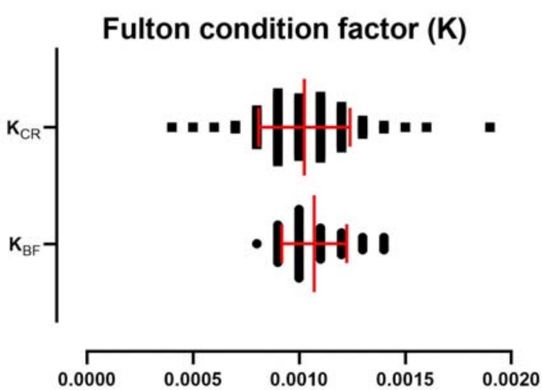

Fig. 1 Fulton condition factor (K) populations comparison

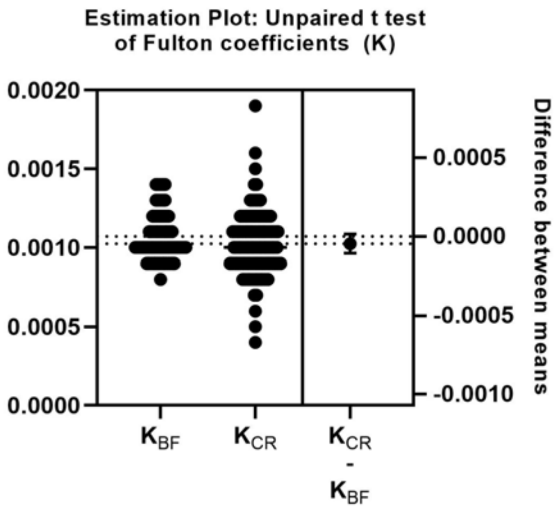

Fig. 2 Unpaired t test results of Fulton coefficients (K)

For the allometric growth equation we obtained the following values for the slope (b) and based on these results we determined each growth pattern for both populations. For the Crișul Repede population we obtained b=3.2585 (Fig. 3), thus b>3 and we have a positive allometric growth, where the fish grows with higher intensity in weight than in length.

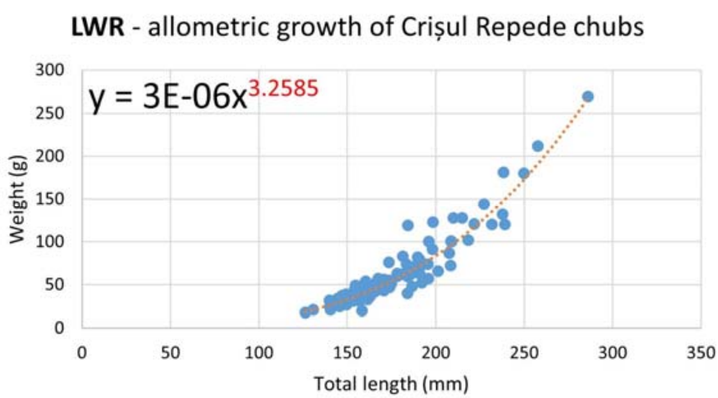

Fig. 3 Allometric growth equation of the Crișul Repede population

In the case of the Beliș-Fântânele population we obtained b=2.9519 (Fig. 4), thus b being very close to the value of 3 and we have an almost isometric growth pattern, in which the fish grows with almost the same intensity in weight as in length. Based on these results, we can assume that the Crișul Repede population grows according to the species typical growth pattern and the results from two other chub river populations in Transylvania obtained by Mireșan et al. in 2016 [7] both show a positive allometric growth pattern, just like the chubs from Crișul Repede.

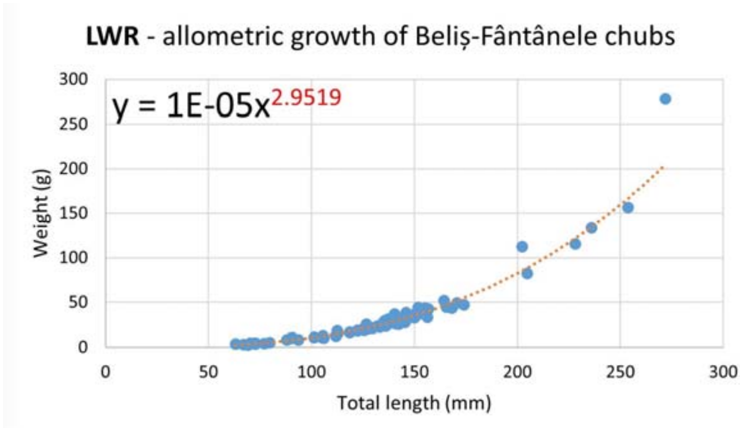

Fig. 4 Allometric growth equation of the Beliș-Fântânele population

In the case of the Beliș-Fântânele population we can assume that the population did not achieve yet the full potential of the species regarding the growth pattern and the species is still adapting to the lake conditions at this kind of altitude.

The morphometric analysis results are presented for each population as means and standard deviation for each determination. The results concerning the Crișul Repede population are presented in Fig. 5 and the results from the Beliș-Fântânele population are presented in Fig. 6.

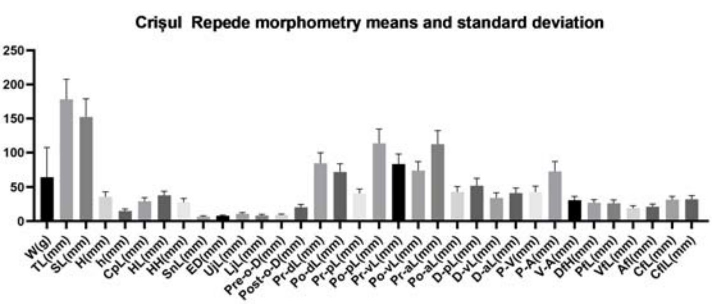

Fig. 5 Measured characters means and standard deviation for the Crișul Repede population

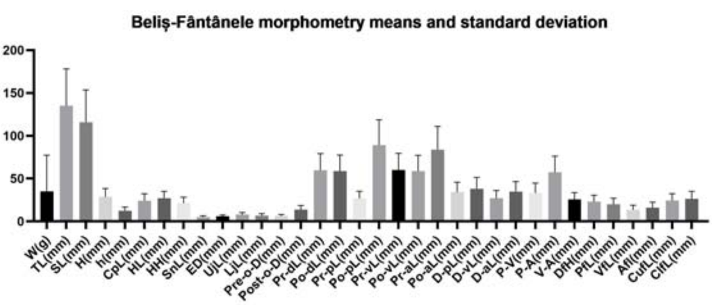

Fig. 6 Measured characters means and standard deviation for the Beliș-Fântânele population

By conducting the Pearson r correlation between morphometric measurements inside each population we can see how much different characters' influence each other. Two characters are positively correlated if the value is closer to 1 and they are negatively correlated if the value gets closer to -1 [1]. The correlations for the Crișul Repede population are presented in Fig. 7 and the correlations for the Beliș-Fântânele population are presented in Fig. 8. From these results we can assume that the pattern observed in the Crișul Repede population could be a standard for the species in lotic environments, where correlations exist, but they are only moderate to highly correlated. The results regarding the Beliș-Fântânele population display a much higher correlation between characters, which could show a much more uniform growth and could mean that the species is quickly adapting to the lacustrine environment.

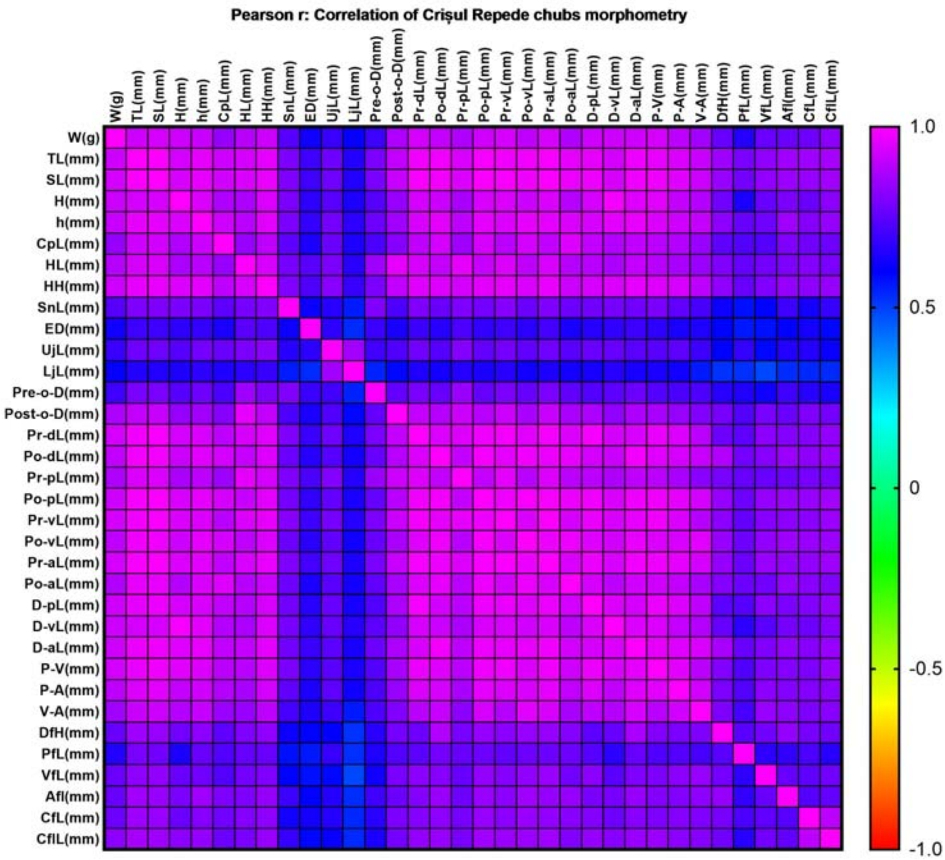

Fig. 7 Correlation between measured characters inside the Crișul Repede population

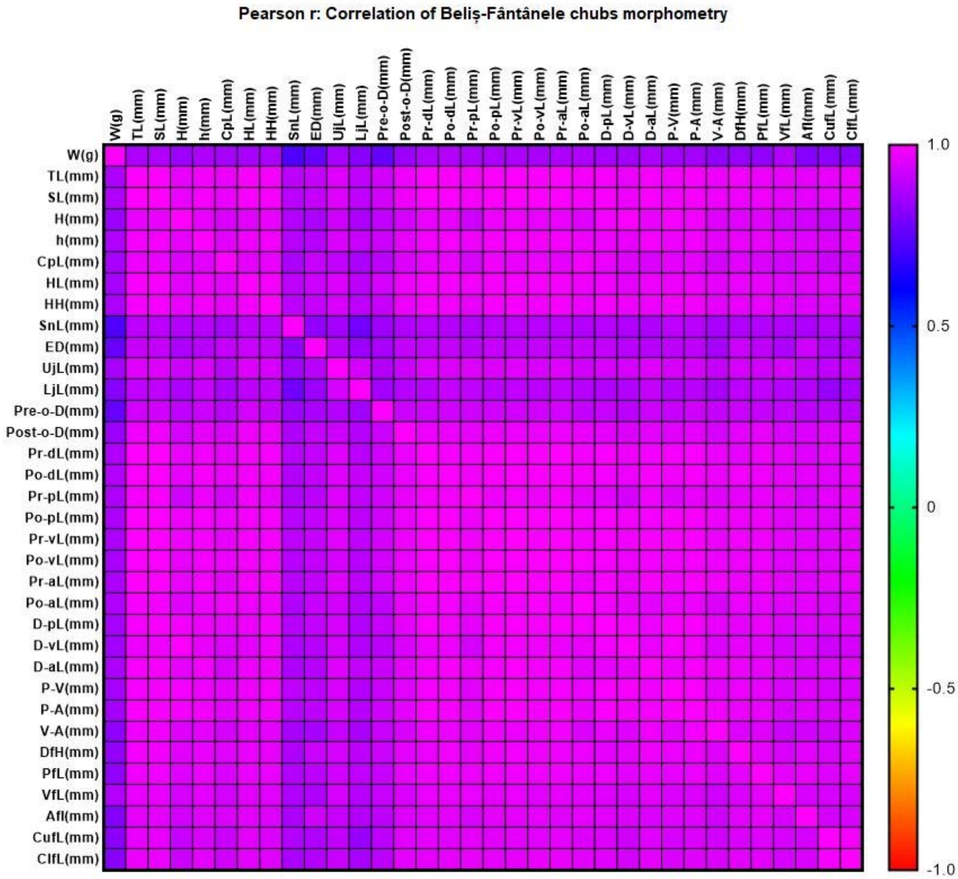

Fig. 8 Correlation between measured characters inside the Beliș-Fântânele population

CONCLUSIONS

By individually assessing each population the following conclusions arise. The Crișul Repede population age structure of *Squalius cephalus* shows that the population is not in its best condition and the main reason behind this could be the anthropic activities that affect this sector of river. The Beliș-Fântânele population looks stable by analysing the age structure and growth pattern.

From the morphometric point of view, we underlined the differences between lotic and lentic populations. This analysis shows us that the lentic population of the Beliș-Fântânele is adapting and stabilizing to lake conditions. These results can provide a basis for analysing other chub lake populations.

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