POPULATION GROWTH AND THE STATE OF WESTERN BALKAN BARBEL (*BARBUS REBELI*) STOCK OF OHRID LAKE

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ABSTRACT

Western Balkan barbel (*Barbus rebeli*, Koller, 1926) is a cypriniform fish of the Family *Leuciscidae* of the Eastern Adriatic drainages, including big Balkan Lakes of Ohrid and Skadar. Although the barbel population is considered abundant and in general not threatened, in large lakes, activity is more intensive, there is suspicion that the population is impacted by overfishing. This study aimed to estimate the growth and state of the Western Balkan barbel (Barbus rebeli) stock in Lake Ohrid. A total of 133 specimens were collected monthly during 2023 from local small-scale fishermen. Total length (TL±0.1cm) and weight (W±1 g) were recorded, and growth parameters were calculated through length frequency analysis. The results showed that growth for the Western Balkan barbel was expressed with a length-related growth function L_t = 29.80 cm TL/ (1 + exp (-1.01 yr^{-1} (t - 0.0001 yr^{-1}))) and weight--length relationship was expressed with the equation $W=0.0001*L^{3.2}$. The length at first capture was estimated L_c=21.04 cm, which is shorter than the minimal allowable catch size (25 cm) set in the Regulation for the implementation of Albanian Fishery Law (no. 64, 2012) for *Barbus* spp. Length at first maturity was estimated L_m=19.5 cm. The growth performance index was Ø'=2.98. The exploitation rate of the western Balkan barbel stock is within the limit for sustainable fishing. However, increasing the mesh size of the gear that would allow the catch of individuals with a size no smaller than 25 cm (L_c/L_∞ = 0.84), as required by the fishery regulations, would decrease the relative yield per recruit (Y'/R) by 0.006 and increase the relative biomass per recruit (B'/R) by 0.032.

Keywords: Barbus rebeli, Ohrid Lake

1. INTRODUCTION

Western Balkan barbel *(Barbus rebeli*, Koller, 1926) is a temperate freshwater fish that inhabits the rivers and streams of the Ohrid Lake - Drin River - Shkodra Lake - Buna River watershed, as well as the two large lakes of this watershed, Ohrid and Shkodra Lake (Kottelat and Freyhof, 2007). The species is locally abundant, but populations are greatly fragmented, and some of them are facing potential threats as many small streams turn dry during summer (Kottelat and Freyhof, 2007). With 23 barbel species living in European waters (Kottelat & Freyhof, 2007), the genus Barbel constitutes one of the genera with the largest number of species. The presence of *B. rebeli* in River Drin basin was reported by Rakaj (1995), Kottelat and Freyhof (2007), Marić *et al.* (2010; 2012), Milošević & Talevski (2015)**,** Dhora (2020) and Shumka *et al*. (2023). While the scientific information on the morphology and morphometry of western Balkan barbel is limited, the data on its biology is even scarcer. Most of the publications are focused on the distribution of the species *B. rebeli* and the speciation of the genus *Barbus* (Machordom & Doadrio, 2001; Cake & Miho, 2005; Kottelat & Freyhof, 2007; Dhora, 2010; Marić *et al*., 2010, Marková *et al*., 2010; Grapci-Kotori *et al*., 2013; Velkova - Jordanoska *et al*., 2013; Dhora, 2020; Shumka et al. 2023). However, Rakaj (1995) reports some data on the biology of the species: Western Balkan barbel reproduce in the time-period May-June in gravel and sand bottom. Female fertility is reported to be 15 - 25 thousand eggs. The eggs hatch within 4-5 days within the temperature range 18-20^{0}C.

In Europe, barbel fishery is more commonly practiced as a sport or recreational activity rather than for commercial purposes. Both species of *Barbus* found in the large lakes of the Balkans, *Barbus rebeli* in Lake Ohrid and Lake Shkodra and *Barbus prespensis* in Lake Prespa, are of economic interest and are mainly exploited for human consumption by small-scale fisheries. In Ohrid Lake, assessments have been conducted on the variety of species and their frequency in different areas and depths (Spirkovski *et al*., 2017). However, in recent years, there has been a lack of data on the stocks of fishery target species. As high-value fish stocks such as of salmonids decrease, it is recommended that fishing activity in Ohrid Lake shift towards targeting cypriniform species, particularly those that are believed to be less exploited, as Ohrid roach (*Leucos basak*), western Balkan barbel (*Barbus rebeli*), Italian chub (*Squalius squalus*) and Albanian roach (*Pachychilon pictum*). The development of effective fishery management measures and the

promotion of certain types of fisheries in Ohrid Lake should be based on reliable data on the growth and condition of the stocks. In line with the previously mentioned considerations, this study aimed to estimate the growth and state of Western Balkan barbel stock in Lake Ohrid.

2. MATERIAL AND METHODS

Fish samples were collected from the local traditional fishermen at five main fishing boats landing sites along the Ohrid Lakeshore: Lin, Piskupat, Udënisht, Mëmëlisht and Pogradec. The sampling method was adapted by Sparre and Venema (1992). The fish were caught using 500 to 1000 m length nets with two different mesh size 26-32 mm and 45-90 mm.

Over a four-month period in 2023, a total of 133 specimens were collected on a monthly basis. Total length (TL) was measured to the nearest 0.1 cm, and the wet weight (W) to the nearest 1 g. The length frequency data were grouped into 2 cm class intervals sequentially arranged as monthly time series.

The estimation of growth parameters of western Balkan barbel population was performed based on length frequency analysis (Pauly and David 1981; Pauly and Morgan, 1987). Growth parameters L_∞ (asymptotic length) and K (growth coefficient) were estimated through the ELEFAN I procedure, while t_0 (theoretical age at length 0 cm) was calculated using the formula: $\ln(-t_0) = -0.3922 - 0.2752 \cdot \ln(L_\infty) - 1.038 \ln(K)$ (Pauly 1979). Length at the first maturity (L_m) was predicted based on the maximum theoretical length (L_∞) through the empirical relationship: $\ln(L_m) = 0.8979 \ln(L_\infty) - 0.0782$ (Froese and Binohlan 2000), while length at first capture (L_c) was estimated through length at 50% captures using length converted catch curve incorporated in FiSAT II tool (Jr. Gayanilo *et al*., 2005).

Growth performance index related to TL (Ø') was calculated according to the formula of Pauly and Munro (1984): $Ø' = \ln(K) + 2 * \ln(L_\infty)$. The length-weight relationship was established based on the function $W = a*L^b$.

The monthly recruitment pattern was constructed using the length frequency data set and the growth parameters using FiSAT II (2005) software package.

Total mortality rate (Z) was estimated by length converted catch curve analysis (Pauly, 1983). The natural mortality rate was calculated according to Pauly's empirical formula (Pauly, 1980) for the average annual Lake Ohrid temperature of 13.7^0C. The fishing mortality rate was obtained by subtraction of natural mortality rate (M) from total mortality rate (Z). The exploitation rate (E) was calculated from the relationship E=F/Z (Gulland, 1971).

The prediction of the stock production as relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) was evaluated after the model developed by Beverton and Holt (1966) and adapted for FiSAT II (2005). The calculations were done using the knife edge method and the values of the ratio L_c/L_∞ and M/K. The biological target reference values of exploitation were compared with the current exploitation rate and utilized to assess the status of the *B. rebeli* stock in Lake Ohrid.

3. RESULTS AND DISCUSSIONS

The sample was composed of 133 individuals of *B. rebeli* ranging in total length from 7.6 to 27 cm. The most common length groups of western Balkan barbel were those with an average class-length of 8.5 and 10.5 cm, representing respectively 19.6% and 18.2% of the total catch and were particularly dominant in the spring months. In addition, those with an average class-length of 22.5 and 24.5 cm represented respectively 18.2% and 14.0% of the total catch and were particularly dominant in the summer months.

The growth parameters of the species were estimated as L_∞= 29.80 cm (TL), K = 1.01 yr^{-1} and t_0 = -0.0001yr. Kottelat and Freyhof (2007) specify that the maximum standard length (SL) for B. rebeli is 25.0 cm. The scientific literature lacks data on the growth parameters and condition of *B. rebeli* populations, as the species is only found in the river Drin watershed. This is also true for other species such as *Barbus prespensis*, *Barbus balkanicus*, *Barbus graecus*, and *Barbus peloponnesius*. While some data on growth parameters exist for *Barbus barbus* (Kraiem, 1982), these values cannot be compared with those obtained in this study for *Barbus rebeli* due to differences in habitat and growth rate.

Using the estimated growth parameters (L_∞, K and t_0) the Von Bertalanffy Growth Function for length at time (t) for *B. rebeli* was expressed as:

L_t = 29.80 cm TL/ (1 + exp(-1.01 yr^{-1} (t - 0.0001 yr^{-1}))).

The restructured length frequency distribution with superimposed growth curves generated from ELEFAN I procedure are shown in Figure 1.

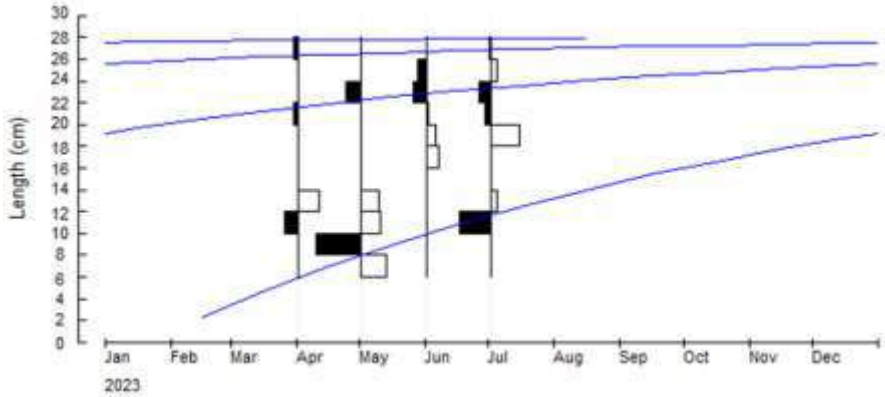

Fig. 1: Restructured length frequency distribution with superimposed growth curves for *B. rebeli* (n=133).

The length at first capture was estimated L_c=21.04 cm, which is shorter than the minimal allowable catch size (25 cm) set in the Regulation for the implementation of Albanian Fishery Law (no. 64, 2012) for *Barbus* spp. Length at first maturity for *B. rebeli* (Figure 2) was estimated L_m=19.5 cm and length at first catch was L_c = 21.04 cm. The small difference between the length at first catch and the length at first maturity of *B. rebeli* may be due to a fast growth rate and maturation at a smaller size.

Fig. 2: Western Balkan barbel (*B.rebeli*) caught in Ohrid Lake (photo:V. Kolaneci, July, 2023).

Length and weight measurements ranging from 7.6 cm to 27 cm in total length (TL) and from 4 g to 240 g used to describe the length – weight relationship (Figure 3). The obtained equation of the relationship was:

$W=0.0001*L^{3.2}$ ($r^2=0.946$), indicating positive allometric growth. The season in which the samples were collected may have influenced the value of b=3.2. Jordanova *et al.*, (2020) report a value of b=2.99 for the riverine form of *Barbus rebeli* found in the Black Drin River. For *Barbus barbus* the indicator "b" of the length-weight relationship is within the limits of 2.6 – 3.2 (Blanck & Lamouroux, 2007). The length weight relationship function is graphically plotted in Figure 3. The growth performance index (Ø) it's a useful tool for evaluating the health and condition of the fish population and can be used to compare the growth performance of different populations or of same population in different time periods. The growth performance index related to length for the *B. rebeli* population was calculated as Ø'=2.98. This indicates good growth performance with less variability in size and generally healthy conditions.

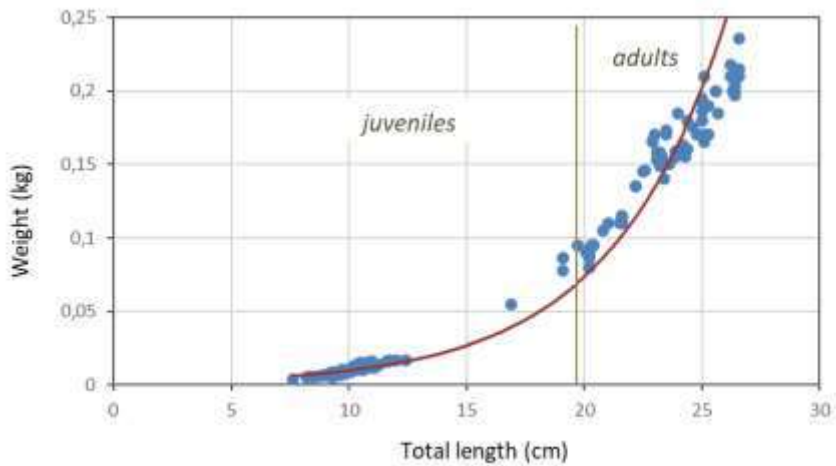

Fig. 3. Length-weight relationship function of *B. rebeli* (n=133).

From the recruitment pattern shown in Figure 4, it was found that *B. rebeli* recruitment occurs mostly in the first half of the year from February to June, with the recruitment peak in May with 31.25% of the total recruitment.

The knife-edge selection routine in Beverton and Holt (1966) analyses was adopted to predict relative yield per recruit and relative biomass per recruit of *B. rebeli* population. Using the values of M=1.26 yr^{-1}, M/K=1.25 and L_c/L_∞=0.69 derived from the previous estimations the calculated values of $E_{0.1}$, $E_{0.5}$ and E_{max} were 0.857, 0.418 and 0.960 respectively (Figure 5). The relative yield per recruit (Y'/R) and the relative biomass per recruit (B'/R) were respectively 0.052 and 0.490.

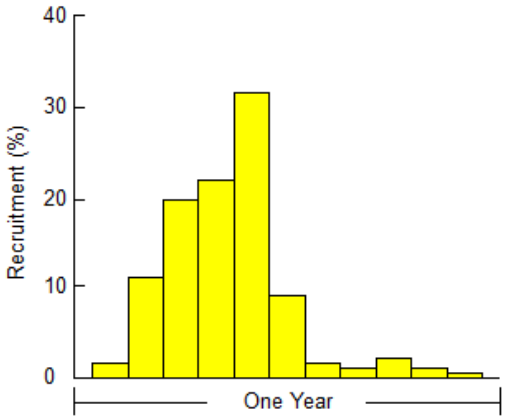

Fig. 4: Recruitment pattern of *B.rebeli* (n=133).

The exploitation rate of the western Balkan barbel stock, with a present value of E=0.39, is lower than the biological target points $E_{0.1}$, $E_{0.5}$ and E_{max}. This indicates that the fishing of this stock is within sustainable limits. However, increasing the mesh size of the gear that would allow the catch of individuals with a size no smaller than 25 cm (L_c/L_∞ = 0.84), as required by the fishery regulations, would decrease the relative yield per recruit (Y'/R) by 0.006 and increase the relative biomass per recruit (B'/R) with 0.032.

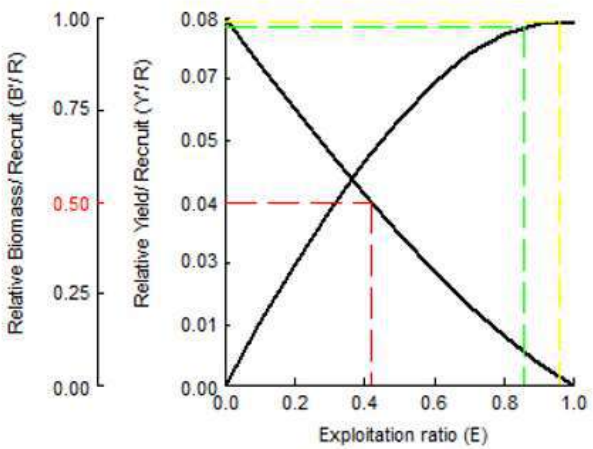

Fig. 5: Relative yield per recruit (Y'/R) and the relative biomass per recruit (B'/R) analysis of *B. rebeli* stock.

According to the results, the stock of *Barbus rebeli* in Ohrid Lake is underexploited, as it does not reach the maximum sustainable yield. The productivity of *B. rebeli* stock suggests that it can support long-term fishing in Lake Ohrid. However, since the species has a limited distribution, it is recommended that beside implementation of management measures, the stock status should be periodically monitored to avoid future conservation concerns.

The increase in production by maintaining the minimum allowable size at catch of 25 cm in the *B. rebeli* fishery can only be ensured if there is an increase in the fishing effort. It is recommended that the increase of exploitation rate should not exceed the biological limit of maximal sustainable yield of 0.97 for the species stock.

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