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*Dragana MILOŠEVIĆ and Drago MARIĆ¹***LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF
Cyprinus carpio FROM SKADAR LAKE (MONTENEGRO) DURING
SPAWNING PERIOD****SUMMARY**

The present study investigates the length-weight relationship (LWR) of the carp (*Cyprinus carpio*) in Skadar Lake, Montenegro. The samples for the study were collected from Skadar Lake during the spawning period. The value of the exponent 'b' in the LWR was equal or less than 3 (2.72 to 3.05). LWR in five groups (juveniles, mature males, mature females, males and females after spawning) of carp showed negative allometric and isometric (juveniles = 3.02, mature females = 3.05) growth patterns. Estimates of the average condition factor (K) ranged from 1.12 as shown by the male after spawning, to 1.35 as shown by the mature female. Significant differences were found between juveniles and males and females after spawning and between males and females after spawning. There was no difference in K between mature males and females. The mature females gonosomatic index (GSI) ranged from 8.1 to 24.5. The coefficient of correlation between K and GSI was not significant in mature females. No significant differences were found in the ratio between sexes from the hypothetical distribution of 1:1 ($P > 0.05$). The study presented here represents an additional contribution to the better understanding of biology of *C. carpio* from Skadar Lake. Moreover, our research provides the first references on LWR and K for the *C. carpio* from Skadar Lake.

Key words: Carp, spawning period, condition, sex ratio, growth.

INTRODUCTION

Cyprinus carpio is one of the most important commercial fish species on Skadar Lake. Forty years ago carp was fished in quantities of up to 300 tonnes and represented a different percentage (20-30%) of commercial catch (Drecun and Miranović 1962, Stein et al. 1975). More significant changes in the structure of the catch of commercial fish were registered for the period of 1970 to 1980. The catch of commercial species in this period declined by more than 30% over the previous period (Drecun, 1980, Marić and Krivokapić 1997). The biology of this species is relatively well studied. It is estimated that in the last decade, about 100 tonnes of carp has been caught. Spawning begins in late March, intensifies in

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April and May and ends in June. Sexual maturity occurs between 2 to 4 years (Drecun, 1962, Janković, 1971, Drecun and Ristić 1972, Ivanović, 1967 and 1973, Janković, 1981 and 1983).

The length-weight relationship is widely used in fishery studies as it allows conversion of growth-in-length equations to growth-in-weight for use in stock assessment models and estimation of biomasses from length observation (Moutopoulos and Stergiouk 2002). These relationships are also frequently used to follow seasonal variations in fish growth and to estimate condition indexes (Anderson and Gutreuter 1983, Richter et al. 2000). The condition of fish (K) and the related length-weight relationships are widely used parameters and help us understand the general well-being of fish, its growth, survival, maturity and reproduction (Le Cren, 1951). These parameters are also broadly used in the estimation of weight from length, conversion of growth in length equations to growth in weight equations in stock assessment models, estimation of biomass from length, indication of sex and between-region differences and for comparison of the individuals of the same species (Wootton, 1990, Tsoumani et al. 2006).

The aim of the present paper was to gather precise information of the sex ratio, length-weight relationship and carp condition during spawning period in Skadar Lake.

MATERIAL AND METHODS

A total of 226 specimens of *C. carpio* from Skadar Lake were collected from March to April 2009 using electro-aggregate. During the spawning period all specimens were sampled from the littoral region. Sex of the fish was determined by examination of the gonads after dissection. All fresh individuals were measured for total length (TL, in cm) and weight (W, total wet weight in g) to the nearest 0.01 g. The TL of each fish (measured to the nearest 0.02 mm) was taken from the tip of the anterior part of the mouth to the end of the caudal fin. The condition factor (K) was estimated from the mathematical function:

$$K = 100WL^{-3}$$

where K is the condition factor, W is the total weight of body and L is the total length of body (in cm).

The following mathematical function was used for estimation of LWRs (Ricker, 1975):

$$W = aL^b$$

where W is the total body weight (in gr), L is the total length (TL) of the body (in cm) and *a* and *b* are the coefficients of the functional regression between W and L. An allometric coefficient *b* value larger or smaller than 3.0 shows an

allometric growth, or isometric growth when it is equal to 3.0 (Bagenal and Tesch 1978).

The values of parameters a and b were estimated by linear regression analysis based on log transformed equation: $\log w = \log a + b (\log l)$ (Ricker, 1975). The determination coefficient (r^2) was used as an indicator of the quality of the regressions. Sex ratio (male: female) was calculated and significant differences from the expected ratio (1:1) were tested by means of χ^2 test (25). In order to test differences between groups the t-test was conducted ($p = 0.05$).

Studied area

The Skadar Lake drainage basin is located between 18°41' and 19°47' East and between 42°58' and 40°10' North. The lake is located in a karstic area in the outer part of the southeastern Dinaric Alps and is the largest of the Balkan lakes. It has a surface area which fluctuates seasonally from approximately 370 to 600 km². The lake's water level also varies seasonally from 4.7 to 9.8 m above sea level. The lake extends in the NW-SE direction, and it is approximately 44 km long. The southern and southwestern sides of the lake are rocky, barren and steep, having bays in which the sublacustrine springs ("oka"), are usually found. On the northern side there is an enormous inundated area, the boundaries of which change as water levels fluctuate. The climate at the Skadar Lake drainage basin is typically Mediterranean, with a long, hot summer at lower and medium altitudes and a short winter with heavy and abundant rainfalls.

The macrophyte vegetation is found through the littoral zones of the lake and has a significant role because they provide habitat, shelter, food and a spawning zone for a large number of fish species. Macrophyte vegetation in Skadar Lake is characterised by the presence of emergent, floating and submerged macrophytes and it is distributed in zones (belts). Skadar Lake has a highly productive ecosystem inhabited by many fish species. The largest number of species in association with carp, in the investigated area (scientific and common names according to Kottelat and Freyhof 2007, Marić and Milošević 2011) were Ohrid nase, *Chondrostoma ohridanus* Karaman, 1924, Skadar chub, *Squalius platiceps* (Župančić et al. 2010), Prussian carp, *Carassius gibelio* (Bloch, 1782), Skadar rudd, *Scardinius knjezevici* Bianco Kottelat, 2005, Prespa roach, *Rutilus prespensis* (Karaman, 1924), Scoranza-Bleak, *Alburnus scoransa* (Heckel and Kner 1858), European eel, *Anguilla anguilla* (L., 1758).

Those species are in competition with carp, but carp is in significant competition with the *C. gibelio* (Marić, 2000).

RESULTS AND DISCUSSION

Length-weight relationships

Table 1 gives the sample size, the minimum, maximum, and mean lengths and weights, the values of a and b , the coefficient of determination r^2 and condition factor for *C. carpio*. Estimates of the coefficient b ranged from 2.72 as

shown by the female after spawning to 3.05 as shown by the mature female. According to Carlander (Froese, 2006), the exponent b should normally fall between 2.5 and 3.5 but can vary between 2 and 4 (Tesch, 1971, Bagenal and Tesch 1978). LWR in five groups of carp showed negative allometric and isometric growth patterns (Table 1). According to Abdoli et al. (2008) the exponent (b) ($b = 3.052$, males; $b = 3.050$, females) indicated that weight growth of *C. c. capoeta* was isometric. We concluded that no single regression would adequately describe the length-weight relationship for the carp in the spawning period. Le Cren (1951) also compared length-weight relationships for perch in Lake Windermere for different life stages, sexes, stages of gonad development and different seasons. He found significant differences and concluded that no single regression will adequately describe the length-weight relationship for the perch. Values of the correlation coefficient (r^2) varied from 0.93 as shown by males after spawning, to 0.98 as shown by the juveniles (Table 1). Similar values (b and r^2) are also given by Prpa et al. (2007) for several carp populations in waters in Croatia.

Table 1. Summary table of condition factor (K) and estimated parameters of the length-weight relationship ($W = aL^b$) for *Cyprinus carpio* from Lake Skadar

	N	TL range		Total weight		L-W relationship			K
		Min -max	Mean	Min -max	Mean	A	b	r^2	
Juveniles	32	9.8-28.5	18.94	11.8-378.0	102.16	0.012	3.02	0.98	1.30
Before spawning period (♀)	52	40.1-83.0	54.97	844-9500	2446.38	0.011	3.05	0.96	1.35
Before spawning period (♂)	84	34.0-58.0	46.20	572-2490	1328.76	0.031	2.77	0.94	1.32
After spawning period (♀)	35	44.0-65.6	53.74	1174-3784	1993.50	0.037	2.72	0.95	1.24
After spawning period (♂)	23	42.0-66.8	51.19	882-2925	1554.21	0.021	2.73	0.93	1.12

* Shown are sample size (N); the minimum, maximum and mean values of total length (TL, in cm) observed; the minimum, maximum and mean values of total weight (in gr) observed; parameters of the relationship (a and b); coefficient of determination (r^2).

Condition factor (K)

Investigations of five Carp groups during spawning period from Skadar Lake showed variations of K between 0.94 and 1.63. Estimates of the average K ranged from 1.12 as shown by the male after spawning, to 1.35 as shown by the mature female (Table 1). Average K (1.12 to 1.35) show that Skadar Lake is

inhabited by wild form (according to Prpa et al. (2007) $K = 1.50$ to 2.08). While the relative condition factor is useful in certain studies, it is not suitable for comparisons among populations and it assumes that the length-weight relationship remains constant over the period of the study.

Comparison of K between the five-studied groups demonstrated that mature carp female in a spawning period had greater condition factor ($K = 1.35$) than other groups. Significant differences were found between male and female after spawning and between juvenile specimens and specimens after spawning ($P < 0.05$). No significant differences were found between mature males and females ($P > 0.05$). The coefficient of correlation found between weight or length and K of any group had no significance ($P > 0.05$ in all cases), which meant that the coefficients of correlation between K and GSI (8.1-24.5) was of no significance in mature females. That means that during spawning period, length and weight of individuals does not affect the K value, but does affect the level of sexual maturity. Coefficient of condition indicates its size dependence – small fish specimens were in better condition than the bigger ones. At the same time, gonad growth depressed the fish digestive tract and prevented food consumption. Decrease in condition factors during an inactive phase in reproductive cycle could be explained by reserves used for sexual products. The energy normally used for maintenance and growth of the individual is diverted toward gonadic maturation and spawning.

According to Janković (1981) the carp (in Skadar Lake) showed the best growth in the first and second year of life. Males mature a year earlier, sometimes into their second year. Our results show that the carp becomes sexually mature at a length of about 35 cm (TL) and at a weight of about 600 grams. Only 10% of mature individuals found were less than 40 cm long (TL). Males usually become sexually mature at the weight of 1 kg (TL = 45 cm), while females matured over 1.5 kg (TL = 50 cm). These values are significantly higher than the value specified by the Drecun & Ristić (1972).

Structure of population in the spawning period – sex ratio

Out of the total carp specimens analysed during the study, 90 (44.1%) specimens were males, 82 (40.2%) were females and 32 (15.7%) were undetermined, juvenile specimens. No significant differences were found between the sex ratios from the hypothetical distribution of 1:1 ($P > 0.05$). The sex ratio found in the carp population from Skadar Lake was very close to 1:1, which suggests a well-balanced population. During the spawning period, carp in three stages of maturation were found: juvenile in stage I were not yet prepared for instant spawning, the signs of approaching spawning were apparent in the carp in stage IV or V, and the carp in stage VI were partially spent. At the beginning of the spawning period (end of March or early April), a rapid increase in ovary weight took place, which increased the GSI sharply. The GSI ($n = 35$) were: max: 24.5; mean: 18.6 (SD ± 3.03). In study period, the first spawning occurred after 20 March.

CONCLUSION

Length-weight relationship (LWR) in five groups (juveniles, mature males, mature females, males and females after spawning) of carp showed negative allometric and isometric (juveniles = 3.02, mature females = 3.05) growth patterns.

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DUŽINSKO-TEŽINSKI ODNOS I KONDICIONI FAKTOR *Cyprinus carpio* IZ SKADARSKOG JEZERA (CRNA GORA) ZA VRIJEME MRIJESNOG PERIODA

SAŽETAK

Predstavljeno istraživanje daje podatke o dužinsko-težinskom odnosu (LWR) populacije krapa (*Cyprinus carpio*) iz Skadarskog jezera, Crna Gora. Uzorci korišteni u ovom istraživanju sakupljani su u toku mrijesne sezone. Zabilježene vrijednosti regresionog koeficijenta "*b*" bile su manje ili jednake od 3 (2.72 do 3.05). LWR unutar pet grupa krapa (juvenili, zreli mužjaci, zrele ženke, mužjaci i ženke nakon mrijesta) pokazuju negativni alometrijski i izometrijski model rasta (juvenili = 3.02, zrele ženke = 3.05). Zabilježene prosječne vrijednosti K bile su u rasponu 1.12 kod mužjaka nakon perioda mrijesta, do 1.35 kod zrelih ženki. Statistički značajne razlike registrovane su između juvenilnih jedinki i mužjaka i ženki nakon perioda mrijesta, kao i između mužjaka i ženki nakon mrijesta. Nisu registrovane razlike u K između zrelih mužjaka i ženki. Registrovane vrijednosti GSI kod zrelih ženki bile su u rasponu od 8.1 do 25.5. Vrijednost koeficijenta korelacije između K i GSI kod zrelih ženki nije statistički značajna. U odnosu na hipotetičku distribuciju polova 1:1 nije nađena statistički značajna razlika ($P > 0.05$). Predstavljeno istraživanje daje značajan doprinos boljem poznavanju biologije *C. carpio* iz Skadarskog jezera, Crne Gora. Takođe, ovo istraživanje daje i prve podatke o LWR i K za *C. carpio* iz Skadarskog jezera.

Ključne riječi: Krap, mrijesni period, kondicija, odnos polova, rast