



**LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTORS OF THE BOGUE (*Boops boops*) (LINNAEUS, 1758) (Pisces, Sparidae) IN THE SOUTH ADRIATIC SEA (MONTENEGRO)**

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**Ključne riječi:**

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**SYNOPSIS**

Seasonal changes in length-weight relationships and condition factors (Fulton's and Le Cren's) of bogue, *Boops boops* (Linnaeus, 1758) were studied. Samples were collected monthly from the commercial landings during the period from September 2007 to August 2008 on Montenegrin shelf. A total of 933 individuals were measured and weighed. The total length of all analyzed specimens ranged from 10.0 to 25.9 cm and weights ranged between 9.35 g and 156.28 g, respectively. In the total sample, 55.2% were females, 43.3% were males and 1.5% were individuals of undetermined sex. Sex ratio (M / F+M) was different from 1:1, in favour of females (0.44). The length-weight relationship of females, males and all sampled specimens was described by the expression:  $W = 0.0192 \cdot L^{2.7443}$ ,  $W = 0.0218 \cdot L^{2.6864}$ ,  $W = 0.0203 \cdot L^{2.7184}$ , respectively. The *b* values of LWRs varied during the year with season and condition. During the winter, the length-weight relationship indicated isometric growth ( $b=3.0283$ ), while in other seasons showed negative allometric growth. Average Fulton's condition factor ranged from 0.9065 to 0.99 and average Le Cren's condition factor ranged from 1.0024 to 1.0051.

**SINOPSIS**

**DUŽINSKO-TEŽINSKI ODNOS I KONDICIONI FAKTORI BUKVE, *BOOPS BOOPS* (LINNAEUS, 1758) U JUŽNOM JADRANU (CRNA GORA)**

Sezonske promjene dužinsko-težinskog odnosa i kondicionih faktora (Fulton i Le Cren) bukve *Boops boops* (Linnaeus, 1758) su proučavane. Uzorci bukve su sakupljeni mjesečnom dinamikom iz komercijalnih ulova sa područja šelfa Crnogorskog primorja u periodu od septembra 2007. do septembra 2008. Ukupan broj obrađenih jedinki je bio 933, pri čemu su najveći udio sačinjavale ženke (55.2%), 43.3% su bili mužjaci i 1.5% je bilo nedeterminisano. Ženke su dominirale u populaciji tako da je odnos polova bio različit od očekivanog odnosa 1:1. Totalna

dužina svih analiziranih jedinki se kretala u rasponu od 10.0 do 25.9 cm, a težina od 9.35 g do 156.28 g. Vrijednosti parametra *b* dužinsko-težinskog odnosa variraju sezonski i u zavisnosti od kondicije. Tokom zime je zabilježen izometrijski rast dok je u ostalim sezonama zabilježen negativan alometrijski rast. Srednja vrijednost Fultonovog kondicionog faktora svih analiziranih jedinki je bila u rasponu od 0.9065 do 0.99 a Le Crenovog od 1.0024 do 1.0051.

## INTRODUCTION

The bogue, *Boops boops* (Linnaeus, 1758) belongs to the family Sparidae, which is represented by 10 genera and 18 species in the Adriatic Sea (Jardas, 1996). According to the same author, bogue is widely distributed throughout the Adriatic Sea; commonly inhabits waters over various types of bottoms and mainly found at about 50-150 m depth. Sparidae species belong to benthopelagial, a fact that determines the type of fishing gears used to fish them (Jardas et al., 1998). In Montenegrin waters (south Adriatic Sea) bogue is frequently caught by gillnetters and seine netters although significant quantities are caught by trawlers (Kasalica et al., 2011). In spite of its commercial importance, current data regarding this species in Montenegrin waters is rather poor.

This aim of this paper is to provide the length-weight relationships as well as relative (Le Cren's) and cubic Fulton's condition factor of *B. boops*. The findings of this study are important because the estimates of length-weight relationships are necessary for stock assessment and management (Pauly, 1983). The length-weight relationship also helps in predicting the condition, reproductive history, and life history of fish species (Nikolsky, 1963; Pauly, 1993), and also important for comparative growth studies (Moutopoulos & Stergiou, 2002).

## MATERIALS AND METHODS

A total of 933 individuals of *Boops boops* were collected from monthly commercial landings using various types of fishing gears: gill nets, trammel nets, beach seines as well as trawls in the south Adriatic Sea (Figure 1). Landings were taken in three different Montenegrin ports (Bar, Budva and Herceg-Novi), but each month from the different port. Sampling was conducted from September 2007 to September 2008 in the framework of the FAO AdriaMed Pilot Study on biological and economic data collection and monitoring system of fisheries in Montenegro.

Collected fish were preserved with ice in a cooler box and immediately transported to the laboratory. *Boops boops* individuals were counted, measured and

sexed. For each individual the following parameters were taken: total length (TL) was taken from the tip of the snout to the extended tip of the caudal fin using a measuring board and body weight was measured using electronic digital balance (Sartorius Extend ED42002S). Total length and body weight were measured to the nearest 0.1 cm and nearest 0.01 g, respectively. Sex was determined according to the external appearance of gonads even though hermaphroditism is quite common in sparids. The sex ratio was expressed as the fraction of males over the total of males and females combined. A chi-squared test ( $\chi^2$ ) was used to detect differences in the sex ratio of sampled fish. The relationship between total length and body weight was determined using the equation:  $W = a \cdot TL^b$  (Le Cren, 1951), where  $W$  is the body weight (expressed in g),  $TL$  is the total length (expressed in cm),  $a$  is the intercept, and  $b$  is the slope of the curve. The parameters  $a$  and  $b$  were calculated by linear regression on the transformed equation:  $\log(W) = \log(a) + b \cdot \log(TL)$  for females, males, individuals of undetermined sex as well as the total sample. These parameters were also calculated seasonally (spring, summer, autumn and winter). The coefficient of determination ( $r^2$ ) was used as an indicator of the quality of the linear regression (Scherrer, 1984). The hypothesis of isometric growth was tested using the  $t$ -test (Ricker, 1975). If the coefficient  $b$  is larger or smaller than 3.0, there is indication of allometric growth. Specifically, values of  $b$  greater than 3 indicate a positive allometric growth and values lower than 3 indicate negative allometric growth. When  $b$  equals 3.0, isometric growth is indicated.

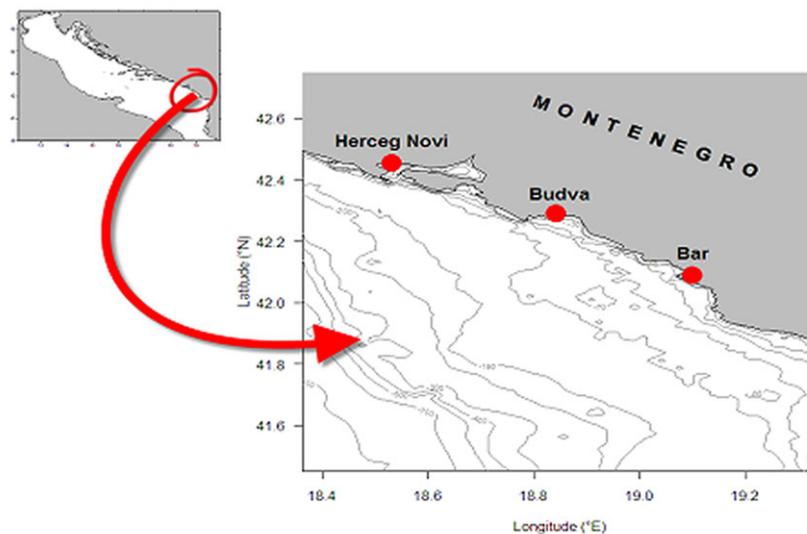


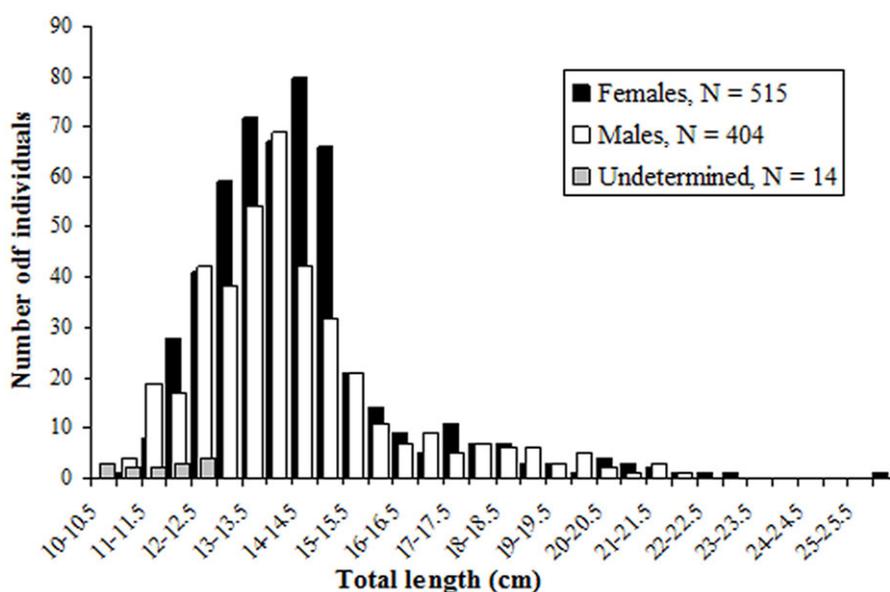
Figure 1. Sampling area and main ports (commercial landing sites) in Montenegro.

Fulton's condition factor ( $K = 100 \cdot W \cdot TL^{-3}$ ) (Fulton, 1904) and Le Cren's relative condition factor ( $K_n = 100 \cdot W \cdot a^{-1} \cdot TL^{-b}$ ) (Le Cren, 1951) were calculated for each individual and for each season (autumn, winter, spring and summer). Length-weight parameters,  $a$  and  $b$ , which had been used in calculation of relative condition

factor were the same as those obtained for the whole sampling period. The relationship between values of  $b$  with  $K$  and  $K_n$  were tested by Pearson's correlation ( $P < 0.05$ ).

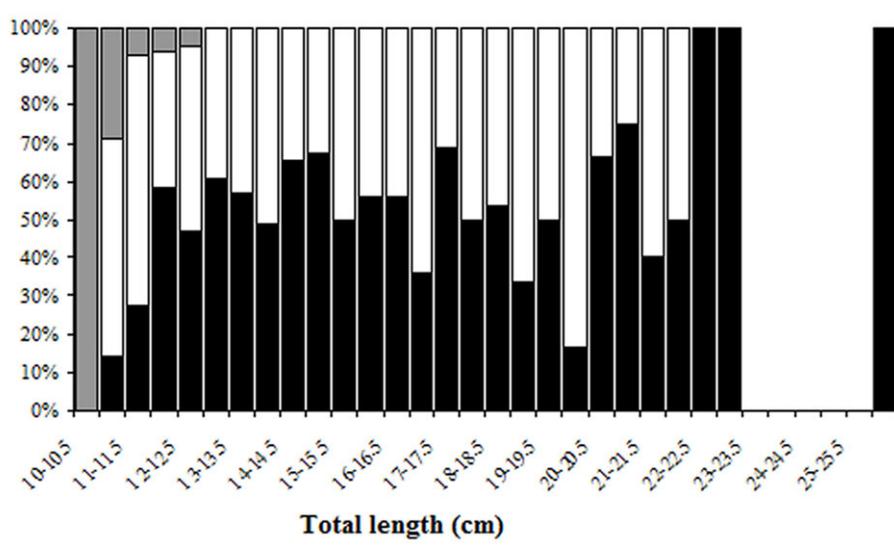
## RESULTS

A total of 933 individuals were sampled during the study period. The shortest individual, 10.0 cm, was obtained in September and the longest, 25.9 cm TL, in June. Sex determination was difficult in fish of smaller lengths but easier at larger sizes. In the total catch, the smallest fraction (1.5%) was of undetermined sex, 43.3% were males and 55.2% were females. Total length of the sampled fish ranged from 10.0 to 25.9 cm TL with the mean length of  $13.96 \pm 1.98$  cm TL and weights ranged between 9.35 g and 156.28 g ( $27.80 \pm 13.50$ ). Length-frequency distribution is presented in Graph 1. The total length of females ranged from 10.6 to 25.9 cm, with a mean of  $14.02 \text{ cm} \pm 1.91$ , and weights from 12.46 to 156.28 g ( $28.32 \pm 13.53$ ). The total length of males ranged from 10.5 to 21.9 cm ( $13.98 \text{ cm} \pm 2.05$ ), and weights from 12.89 to 110.0 g ( $27.58 \pm 13.47$ ). No statistically significant difference was observed between the means of total length and body weight of both sexes ( $z=0.30$ ,  $p=0.76$ ;  $z=0.83$ ,  $p=0.41$ ). The female individuals were statistically larger and heavier than males (Mann-Whitney test,  $p < 0.05$ ).



Graph 1. Length frequency distribution for *Boops boops* females, males and undetermined from the south Adriatic Sea.

The overall sex-ratio value in the total number of fish in which sex was successfully determined, was 0.44. This ratio was significantly different from the expected value of 1:1 ( $\chi^2=13.407$ ,  $P < 0.05$ ). The sex ratio varied with season. Females dominated during spring and summer while males dominated during the autumn and winter. The sex ratio by size showed female predominance in greater length classes while males were predominant in smaller length classes (Graph 2).



**Graph 2: Sex ratio variations according to size classes of *Boops boops* during the 2007-2008 sampling period. White bars = males; black bars = females; gray bars = undetermined.**

The length-weight relationships of bogue in Montenegrin waters for females, males, undetermined and the total sampled population were determined as  $W=0.0192*TL^{2.7443}$ ,  $W=0.0218*TL^{2.6864}$ ,  $W=0.0101*TL^{3.0096}$ ,  $W=0.0203*TL^{2.7184}$ , respectively (Table 1.). All relationships were highly significant ( $r^2 > 0.85$ ,  $P < 0.001$ ). The LWR of this species indicates negative deviation from ideal allometric growth ( $b < 3$ ) except for the undetermined specimens. The exponents of the estimated LWR for male and female bogue significantly differed between the sexes ( $t$ -test,  $P < 0.05$ ). The number of individuals, parameters  $a$  and  $b$  of the LWRs, standard error of  $b$ , coefficient of determination  $r^2$  and  $t$ -values for each season are presented in Table 2. When the seasonal variations were considered, the  $b$  value reached its maximum value of 3.0283 ( $N = 146$ ,  $r^2 = 0.96$ ) during winter (December, January and February) and its minimum value of 2.5089 ( $N = 200$ ,  $r^2 = 0.97$ ) during autumn (September, October and November). The  $b$  value recorded in the winter did not show statistically significant deviation from 3 indicating an isometric growth during this season.

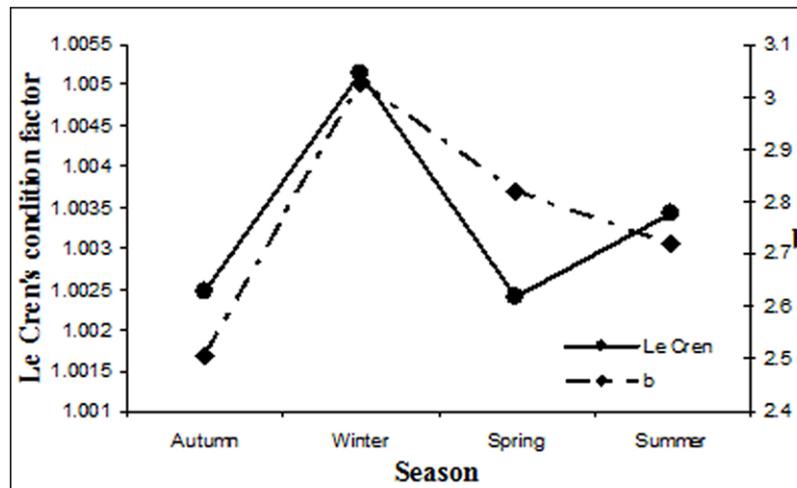
**Table 1: Parameters of length-weight relationship of *Boops boops* in the south Adriatic Sea (N, sample size; TL, total length; *a*, intercept of the relationship; *b*, slope of the relationship; CI, confidence limits,  $r^2$ , coefficient of determination).**

<i>Boops boops</i>	N	TL range (cm)	<i>a</i>	<i>b</i>	95 % CI of <i>b</i>	$r^2$
Females	515	10.6-25.9	0.0192	2.7443	2.6881-2.8001	0.95
Males	404	10.5-21.9	0.0218	2.6864	2.6221-2.7506	0.94
Undetermined	14	10.0-12.3	0.0101	3.0096	2.4577-3.5614	0.92
TOTAL	933	10.0-25.9	0.0203	2.7184	2.6767-2.7601	0.95

**Table 2: Parameters of length-weight relationship of *Boops boops* in the south Adriatic Sea according to the seasons including all collected specimens (N, sample size; *a*, intercept; *b*, slope; SE, standard error;  $r^2$ , coefficient of determination; *t* values).**

Season	Sex	N	<i>a</i>	<i>b</i>	SE of <i>b</i>	$r^2$	<i>t</i>
Autumn	M	101	0.0374	2.4806	0.0418	0.973	-6.0299
	F	85	0.0370	2.4899	0.0592	0.955	-4.1776
	U	14	0.0101	3.0096	0.2532	0.922	0.0301
	Total	200	0.0349	2.5089	0.0328	0.967	-5.5050
Winter	M	96	0.0091	2.9932	0.0698	0.951	-0.0372
	F	50	0.0075	3.0683	0.0694	0.976	0.3542
	Total	146	0.0083	3.0283	0.0494	0.963	0.2148
Spring	M	114	0.0166	2.7938	0.0813	0.913	-1.3251
	F	246	0.0159	2.8167	0.0486	0.932	-1.9513
	Total	360	0.0157	2.8194	0.0416	0.928	-2.2531
Summer	M	93	0.0223	2.6843	0.0884	0.911	-1.5930
	F	134	0.0198	2.7324	0.0783	0.902	-1.1789
	Total	227	0.0205	2.7183	0.0587	0.905	1.7748
All seasons	M	404	0.0217	2.6863	0.0327	0.943	-4.0427
	F	515	0.0191	2.7443	0.0286	0.950	-3.6473
	U	14	0.0101	3.0096	0.2532	0.920	0.0301
	Total	933	0.0203	2.7184	0.0212	0.946	-5.4516

The monthly variations of parameter *b* and condition factors are presented in Graph 3. Mean Fulton's condition factor ranged from 0.9065 in winter to 0.991 in spring while Le Cren's condition factor ranged from 1.0024 in spring to 1.0051 in winter. Pearson's coefficient showed significant negative correlation between values of *b* and Fulton's condition factors ( $r = -0.80$ ;  $P < 0.05$ ) and positive correlation between values of *b* and Le Cren's condition factor ( $r = 0.77$ ;  $P < 0.05$ ). Between two condition factors, Pearson's coefficient showed significant negative correlation ( $r = -0.98$ ;  $P < 0.05$ ).



Graph 3: Bogue, *Boops boops*. Variation of  $b$  values with Fulton's condition factor and  $b$  values with Le Cren's condition factor throughout the season.

## DISCUSSION AND CONCLUSIONS

The maximum length of bogue observed in this study (TL = 25.9 cm) was lower than the maximum record value of 36.0 cm from the Portuguese coast (Gordo, 1995). In this study, bogue total length ranged between 10.0 and 25.9 cm TL. Bogue from the wider estuarine area of the River Cetina, in the middle Adriatic, had lower range, from 9.7 cm to 16.7 cm TL (Dulčić & Glamuzina, 2006) while in the territorial waters of Greece (Naxos Island) their total length was greater and ranged from 10.4 to 28.1 cm (Stergiou et al., 2004). A wide range of this species total length was recorded along the Portuguese coast, between 6.0 and 36.0 cm TL (Gordo, 1995). These regional differences in total length probably depend on the ecological differences in the areas of investigation (Šantic et al., 2006).

The sex ratio by size showed female predominance in greater length classes while males were dominated in smaller length classes, which is in agreement with the Alegria-Hernández (1990) data on biological aspects of bogue population inhabiting channel areas of the middle Adriatic. We may stress that even though the bogue is a protogynous hermaphrodite, sex change may not only be related to individual determinism, but could also depend on the environmental and social conditions (Happe & Zohar, 1988). Females dominated in the total sample but in seasonal aspects males were dominant in autumn and winter. Alegria-Hernández (1990) found that the larger number of males is associated with the period of reproduction.

Values of the parameter  $b$  of the length-weight relationship were mostly within the expected range of 2.3-3.5, according to Bagenal & Tesch (1978). In the present study, bogue generally showed negative allometric growth. The similar growth was observed for *B. boops* in Montenegrin waters (south Adriatic) (Kasalica et al., 2011), Croatian waters (middle Adriatic) (Dulčić & Glamuzina, 2006) as well as in Spanish (Valle et al, 2003) and Tunisian waters (Anato & Ktari, 1986). Our results diverged from the results of Campillo (1992), Karakulak et al. (2006) and Kara & Bayhan (2008) who suggest positive allometric growth. According to Bagenal & Tesch (1978), the parameters of the fish LWRs are affected by a series of factors including season, habitat, gonad maturity, sex, diet, stomach fullness, health, preservation techniques and locality. According to Kapiris & Klaoudatos (2011) the observed differences between allometric coefficient values could be attributed to the different fishing gear used.

In this study, the estimation of parameter  $b$  values for *Boops boops* showed seasonal variation. Negative allometric growth was recorded in autumn, spring and summer while in winter isometric growth was observed. The values of the parameter  $b$  in the length-weight relationship were statistically different from three ( $t$ -test,  $P < 0.05$ ) during almost the entire sampling period (except in winter). The reproduction process (spawning and gonad activity) and changes in food uptake could cause monthly variations in length-weight relationship parameters (Andrade & Campos, 2002). The seasonal variation of  $b$  values was probably connected with the reproductive cycle of this species which is in accordance with Kasalica et al. (2011) who found, based on GSI values that the spawning season in Montenegrin waters occurred between January and March. Maximum values of  $b$  was observed during the winter months, the period when Kasalica et al. (2011) noted that the GSI showed the pronounced peak for females and males in February. The causes of  $b$  variations could be explained by the fact that during the spawning season the parameter  $b$  changed due to the increase in gonad weight of the matured individuals (Zorica et al., 2006).

When comparing parameter  $b$  of the length-weight relationship with Fulton's and Le Cren's condition factors, the negative relationship between Fulton's condition factor and parameter  $b$  in autumn and winter suggests an effective transference of somatic energy to the gonads during reproduction. This factor was significantly higher in autumn and spring while the value of parameter  $b$  was significantly higher in winter than in all other seasons. In terms of seasonality, Fulton's condition factor follows the reproductive cycle of the species, decreasing during the spawning period and increasing after this period (Graph. 3). This is in line with the seasonal fluctuations of condition, with minimum values (lower energy reserves) occurring during spawning (winter) and maximum values (higher energy reserves) during the post-spawning period (spring). Increased feeding in the post-spawning period and

recovery phase of gonads can probably explain the highest condition of fish obtained in spring.

Le Cren's condition factor and parameter *b* showed the same pattern and positive relationship (Graph. 3) so it seemed that this factor was not affected by the sexual cycle as Gordo (1995) suggested.

In conclusion, seasonal variation of length-weight relationship and condition factors of bogue in the south Adriatic Sea were probably connected with the gonadal changes.

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