

SOME BIOLOGICAL PARAMETERS OF BLACK-BELLIED ANGLER FISH (*LOPHIUS BUDEGASSA* SPINOLA, 1807) IN MONTENEGRIN WATERS (SOUTH-EAST ADRIATIC)

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NEKI BIOLOŠKI PARAMETRI GRDOBE (*LOPHIUS BUDEGASSA* SPINOLA, 1807) U VODAMA CRNE GORE (JUGOISTOČNI JADRAN)

Apstrakt

U ovom istraživanju obrađene su 264 jedinke grdobe (*LophiusbudegassaSpinola*, 1807), od kojih su 128 (ili 48,5%) bili mužjaci, 114 (43,2%) ženke, dok kod 22 jedinke (8.3%) nije bilo moguće odrediti spol. Odnos ženki i mužjaka bio je 1:1,12. Omjer spolova (SR) procijenjen je na 47,1. Testiranje uzorka χ^2 -testom pokazalo je da ne postoji statistički značajna razlika između broja mužjaka i ženki u uzorku ($\chi^2 = 0.8099$, $p > 0.05$).

Totalna dužina (TL) jedinki u uzorku kretala se od 15,6 do 67,0 cm, sa prosječnom vrijednošću od $29,2 \pm 8,1$ cm (prosječna dužina \pm standardna devijacija). Shapiro-Wilkesov test normalnosti pokazao je da distribucija dužinskih frekvencija ukupnog uzorka nije pratila normalnu distribuciju ($W = 0,9003$; $p < 0,05$), kao ni distribucija mužjaka ($W = 0,9563$; $p < 0,05$) ni ženki ($W = 0,8959$; $p < 0,05$). Raspon dužina kod ženki varirao je 18,8 do 67,0 cm TL, sa prosjekom od $31,9 \pm 9,6$ cm TL. Prosječna dužina mužjaka bila je $82,3 \pm 5,7$ cm TL, dok su minimalna i maksimalna dužina bile 16,6 cm i 48,4 cm TL.

Prosječna masa jedinki u uzorku bila je $444,15 \pm 427,24$ g, sa rasponom od 57,14 g do 3000,00 g. Masa ženki kretala se od 114,50 g do 3000,00 g, sa srednjom vrijednošću od $584,10 \pm 557,15$ g. Najmanja izmjerena masa mužjaka bila je 66,70 g, a najveća 1791,96 g, sa prosjekom od $372,40 \pm 249,28$ g.

Analiza dužinsko-masenog odnosa pokazala je vrijednost parametra b manju od idealne izometrijske vrijednosti 3, što znači brži rast jedinki u dužinu od povećanja mase, odnosno da jedinka sa rastom dobiva izduženiji oblik tijela. Vrijednosti parametra b po spolovima su također bile manje od 3. Studentov t -test pokazao je da se parametar b dužinsko-masenog odnosa kod ukupnog uzorka i ženki statistički značajno razlikovao od vrijednosti 3, dok kod mužjaka to nije bio slučaj.

Dužina prve spolne zrelosti ($L_{m50\%}$) ukupnog uzorka procijenjena je na 26,37 cm TL, odnosno 30,50 cm TL kod ženki i 26,26 cm TL kod mužjaka. Procijenjene su i dužine pri kojima 25% ($L_{m25\%}$), odnosno 75% ($L_{m75\%}$) populacije dosegne spolnu zrelost, kao i parametri α i β krivulje zrelosti.

Ključne riječi: grdoba, *Lophius budegassa*, dužinsko-maseni odnos, spolnazrelost, Jadransko more

Keywords: Black-bellied angler fish, *Lophius budegassa*, length-weight relationship, sexual maturity, Adriatic Sea

INTRODUCTION

Black-bellied angler fish, *Lophius budegassa* (Spinola, 1807) (Figure 1) is a demersal-dwelling species of bony fishes (Teleostei) that is distributed in the entire Mediterranean and the eastern Atlantic, from Ireland, Great Britain and the North Sea to the western coasts of West Africa (Sierra Leone), but also in Namibia (Jardas, 1996; Bianchi *et al.*, 1999; Vrgočet *et al.*, 2004). It is widespread in the entire Adriatic Sea (Jardas, 1987; Vrgočet *et al.*, 2004). It is one of the two species of angler fish found in the Adriatic (the other being *L. piscatorius*), but is the more abundant one (Vrgočet *et al.*, 2004).



Figure 1. Black-bellied angler fish (*L. budegassa*) (photo by A. Joksimović)

L. budegassa lives on soft bottoms, but shows no preference for any specific type of sediment. (Jardas, 1996; Vrgočet *et al.*, 2004). It is found at depths between 13 and 404 m (Jardas, 1987; Vrgočet *et al.*, 2004), but the majority of fished individuals come from depths between 90 and 170 m (Jardas, 1987; 1996). Depth, and not the type of sediment, seems to be decisive for the distribution of species (Jardas, 1987; Vrgočet *et al.*, 2004).

In Montenegrin waters, Merker & Ninčić (1973) reported *L. budegassa* in the open waters of the South Adriatic at depth strata from 25 to 500 m.

MATERIALS AND METHODS

The *L. budegassa* samples were taken in period from 2007 to 2014, obtained upon landing from trawlers operating in Montenegrin territorial waters (ports of Herceg Novi, Budva and Bar), and then analysed in laboratory. The length was measured to the nearest mm, and the total body weight (using a precise electronic balance) to the nearest 0.01 g.

Shapiro-Wilkes test was used to test whether the length frequency distribution of *L. budegassa* followed the normal (bell-curve) distribution.

Sex ratio (SR) was given as a proportion of females in the sample, according to the formula: $SR = \frac{N_f}{N_f + N_m} \cdot 100$, where N_f is the number of females and N_m number of males in the total sample.

The χ^2 -square (chi-square) test was used to test whether there was a statistically significant difference between the number of females and males.

Length-weight relationship was determined for the entire sample, according to the formula $W = a \cdot L^b$. Parameters a and b were estimated using ordinary least-square regression after transforming the data in natural logarithms ($\ln W = \ln a + b \cdot \ln TL$) (Huxley, 1924; Jensen, 1976).

Modified Student's t -test was used to test whether there was a statistically significant difference between the value of slope (parameter b) of the length-weight relationship and the ideal, isometric value of 3.

Maturity stages were determined according to the MEDITS Instruction manual V.6 (2012). Maturing and mature individuals were used to determine the length of first sexual maturity (MEDITS stages 2B, 2C, 3, 4A and 4B). Logistic model was used to estimate the length of first sexual maturity ($L_{m50\%}$): $P = \frac{1}{1 + e^{-(\alpha - \beta \cdot TL)}}$, where P is the estimated ratio of sexually mature individuals of a given total length, α and β are constants, and TL is the total length of the fish.

Based on parameters α and β , it is possible to estimate lengths at which 25% ($L_{m25\%}$), 50% ($L_{m50\%}$) and 75% ($L_{m75\%}$) of the population reaches sexual maturity: $L_{m50\%} = \frac{\alpha}{\beta}$, $L_{m25\%} = \frac{\alpha - \ln 3}{\beta}$, and $L_{m75\%} = \frac{\alpha + \ln 3}{\beta}$.

RESULTS AND DISCUSSION

There were 264 individuals in the total sample of *L. budegassa*, of which 128 (or 48.5%) were male, 114 (43.2%) female and 22 (8.3%) were individuals of undetermined sex. Female-to-male ratio was 1:1.12, while the sex ratio (SR) was estimated to 47.1. The χ^2 -test performed on the sample showed that there was no statistically significant difference between the number of males and females ($\chi^2 = 0.8099$, $p > 0.05$).

Total lengths of individuals are presented in Table 1. Shapiro-Wilkes normality test showed that the length frequency distribution of the total sample did not follow the normal (Gaussian) distribution ($W = 0.9003$, $p < 0.05$) (Figure 2), and neither did females ($W = 0.8959$, $p < 0.05$) nor males ($W = 0.9563$, $p < 0.05$).

Maximum length reported for the species was 100 cm (Caruso, 1986), and Ungaroet al. (2002) report lengths of up to 95 cm during the MEDITS survey. Jardas (1996) gives maximum size for *L. budegassa* 70 cm, with lengths from 20 to 40 cm being the most common. This is in line with present findings, and it could be that this species in the Adriatic doesn't reach maximum lengths reported in the Atlantic and Mediterranean.

Table 1. Total length (TL) and weight (W) of analysed specimens of *L. budegassa*

Sex	TL (min – max, cm)	TL (mean ± SD)	W (min – max, g)	W (mean ± SD)
Total sample	15.6 – 67.0	29.2 ± 8.2	57.14 – 3000.00	444.15 ± 427.24
Female	18.8 – 67.0	32.0 ± 9.6	114.50 – 3000.00	584.10 ± 557.15
Male	16.6 – 48.4	28.3 ± 5.8	66.47 – 1791.96	372.40 ± 249.28

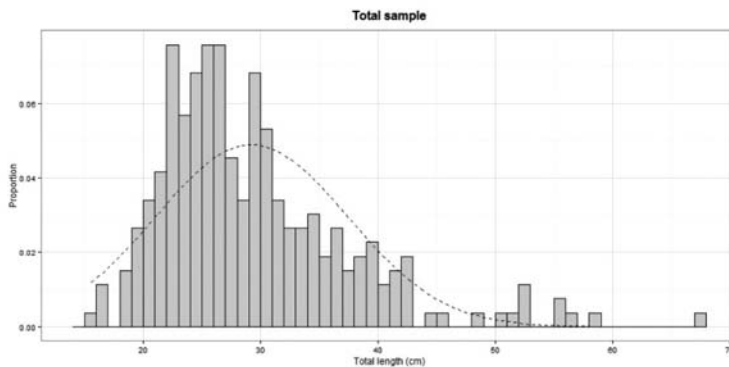


Figure 2. Length frequency distribution of *L. budegassa* in Montenegrin waters (gray bars – actual length frequency categories, dashed line – theoretical normal distribution of the sample)

The predominance of smaller individuals appears to be a common occurrence in *L. budegassa* trawl fisheries, and is reported by other authors (Jardas, 1987; Ungaroet al., 2002; Vrgočet al., 2004; Piccinettiet al., 2012; Ikicaet al., 2013).

The average body weights of the total sample, and separately for females and males are presented in Table 1.

The length-weight relationship parameters for the total sample show that the parameter b (slope) has a value lower than the ideal, isometric value of 3, implying a faster growth in length compared to the gain in weight, or, alternatively, the body assuming a more elongated shape with growth. Likewise, values of the b coefficient for both sexes show values of b lower than 3 (Figure 3).

For females and the total sample, Student's t -test showed a statistically significant difference between the estimated value of coefficient b and the isometric value of 3, $t = 0.2161$ ($p = 0.05$) and $t = 0.2426$ ($p = 0.05$), respectively. The b value of males was not statistically different from 3, $t = 0.1248$ ($p = 0.05$).

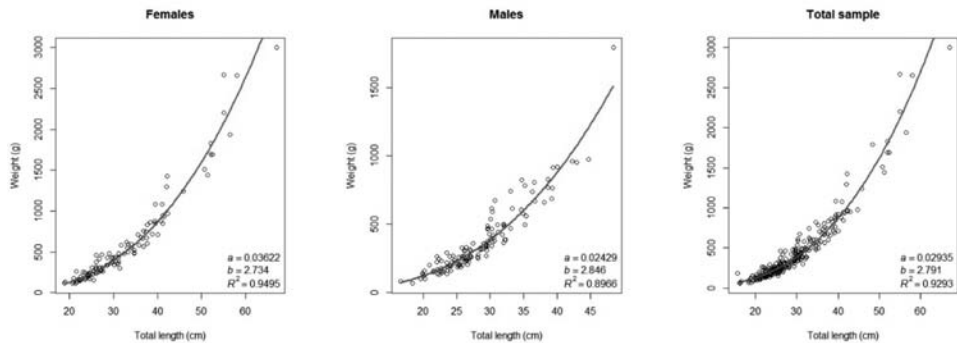


Figure 3. Length-weight relationship of females, males and total sample of *L. budegassa* in Montenegrin waters

Jardas (1987) gives $b = 2.089$ for juvenile *L. budegassa* in the Adriatic, and $b = 3.024$ for adult individuals (sexes combined), and states that juveniles were predominant in the sample. In this study, parameter b of the juvenile *L. budegassa* (TL < 27 cm), also dominant in the sample, was estimated to 2.697, which agrees with Jardas’s findings. Previous study by Ikica *et al.* (2013) also listed $b < 3$ for the area, which is different from data reported by other authors for the Adriatic (Jardas, 1987; Dulčić&Glamuzina, 2006), who report values of b parameter above 3. However, several authors (Stergiou&Moutopoulos, 2001; Torres *et al.*, 2012; STECF, 2013; Stergiou*et al.*, 2014) consistently report values of b lower than 3 in Greek and Spanish waters.

Length at first maturity ($L_{m50\%}$) for the total sample was estimated at 26.37 cm TL, for females at 30.50 cm TL and 26.26 cm TL for males (Figure 4, Table 2). Lengths at which 25% ($L_{m25\%}$) and 75% ($L_{m75\%}$) of the population reach maturity, as well as the maturity range ($L_{m75\%} - L_{m25\%}$; MR) are given in Table 2.

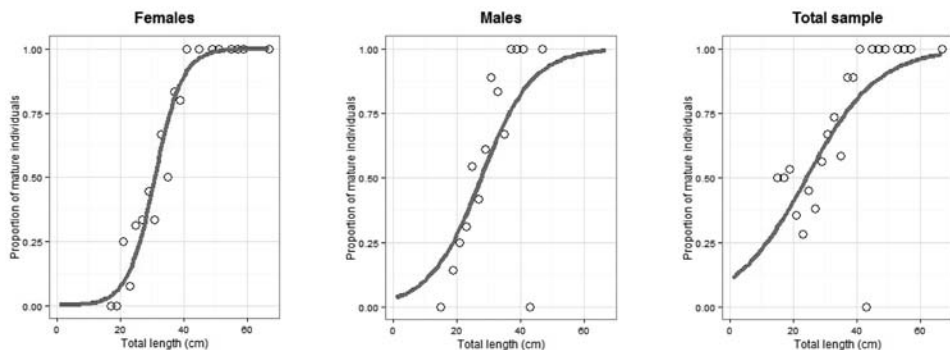


Figure 4. Maturity ogives and length at first maturity for *L. budegassa* females, males, and total sample (circles – observed values, red line – predicted values)

Table 2. Estimation of maturity ogive parameters (α , β) and lengths at which 25% ($L_{m25\%}$), 50% ($L_{m50\%}$) and 75% ($L_{m75\%}$) of population reach sexual maturity and maturity range (MR) for males, females and total sample of *L. budegassa*

Sex	α	β	$L_{m25\%}$	$L_{m50\%}$	$L_{m75\%}$	MR
Males	4.8054	0.1830	20.25	26.26	32.26	12.01
Females	6.0783	0.1993	24.99	30.50	36.01	11.02
Total sample	3.0516	0.1157	16.87	26.37	35.86	18.99

Previous data for the Adriatic give the estimated length of first maturity (with no mention of sex) at 33-34 cm (Jardas, 1987; Jardas 1996; Vrigoč *et al.*, 2004), and 25.72 cm for Montenegrin waters (total sample; Ikica *et al.*, 2013). Estimations of $L_{m50\%}$ for Atlantic Iberian Coast were significantly higher at 44.7 cm for both sexes and 53.6 cm for females (Duarte *et al.*, 2001), and higher still for the Mediterranean (66.2 cm, females only; Ungaroet *al.*, 2002).

Various differences between the data from Montenegrin waters compared to other areas of the Adriatic and, especially, the Mediterranean and/or Atlantic waters can be explained by the fact that the Adriatic Sea is a part of the Central Mediterranean (Jardaset *al.*, 2008; Piccinettiet *al.*, 2012) with inflow of water masses from the Eastern Mediterranean (Zore-Armanda, 1963, 1968), and according to the MEDITS data, the smallest individuals (TL < 30 cm) of *L. budegassa* are more represented in the catches in the Central and Eastern Mediterranean (Ungaroet *al.*, 2002). This fact would then influence any analysis based on length frequencies. Additionally, trawling in Montenegro is limited mostly to the shelf area, which makes for about 43% (or about 3500 km²) of Montenegrin territorial waters and epicontinental belt combined, and majority of the hauls are performed at the same locations over and over again, likely influencing the length frequency distribution of catches, favouring the smaller individuals.

CONCLUSIONS

The results in this study could indicate that the population of *L. budegassa* in the Adriatic Sea shows different patterns of growth and sexual maturity than the populations studied in the Mediterranean and the eastern Atlantic Ocean. However, even though the specimens used in the present study were obtained over a number of years, the total sample was still relatively small and heavily biased towards individuals of smaller lengths, a fact that could influence the final results of the analyses. Therefore, a deeper study on a more representative sample would be advisable in the area, in order to obtain a better and more detailed of the various biological parameters.

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