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Bosiljka Mustać
E-mail: bmustac@unizd.hr
Gabrijela Zoja Cukar
Anita Vidović
University of Zadar, Department of Ecology, Agronomy and Aquaculture
Trg Kneza Višeslava 9, 23000 Zadar, Croatia

Comparison of Growth Parametres Between Sardine *Sardina Pilchardus* (Walbaum, 1792) and Anchovy *Engraulis Encrasicolus* (Linnaeus, 1758) from the Eastern Adriatic Sea

Abstract

Sardine *Sardina pilchardus* (Walbaum, 1792) and anchovy *Engraulis encrasicolus* (Linnaeus, 1758), besides being ecologically very important pelagic resources, are also the most numerous fish species in Croatian fisheries landings. Hence, the aim of this study was to compare sardine and anchovy growth parameters: length, length-weight relationship, condition and age population structure. All samples (N=3313) were collected from purse seine catches of eastern Adriatic Sea, during period June 2015 – August 2016. Total lengths of sardine and anchovy ranged from 10.5 to 17.5 cm (average ± SD: 13.94 cm ± 1.07) and from 10.0 to 17.5 cm (average ± SD: 14.09 cm ± 0.88), respectively. Both sardine and anchovy length-weight relationship indicated positive allometry, although allometric coefficient was higher in anchovy (b=3.201) than in sardine (b=3.069). In general, condition of both species grew with fish length. Sardine and anchovy age composition varied from one to five years, while most of the analysed samples belonged to the 3 year class. Growth parameters were for anchovy: $L\infty$=18.36cm; K=0.317; t_0= -1.89 and for sardine $L\infty$=19.71 cm; K=0.286; t_0= -1.82.

Keywords: sardine, anchovy, length-weight relationship, condition, age structure

1. Introduction

Sardine *Sardina pilchardus* (Walbaum, 1792) and anchovy *Engraulis encrasicolus* (Linnaeus, 1758), besides being ecologically very important pelagic resources as a link between planktonic production and higher trophic levels, are also the most numerous fish species in Croatian fisheries landings [1, 2].

Fluctuations of small pelagic fish have been observed worldwide and over time. Analysis of fish scales in sediment cores from different locations indicated that anchovy and sardine fluctuated prior to climate change and fishing. However, due to climate

change, their distribution, nutrient supply, habitat, fishing, and adaptation may be affected by ocean warming, acidification, deoxygenation, and altered hydrology [3].

Biometry, the length-weight relationship, condition indexes are commonly used in fishery science and management: in stock assessment models, estimation of biomasses, and comparison between regions and/or seasonal variations in fish [4, 5]. In addition, knowledge about age structure of certain fish population allows us to better understand the dynamics of fish stocks and how fish populations react to exploitation and environmental stresses, and enables us to provide improved fisheries management [6].

Furthermore, these data are also important considering the need for small pelagic fish conservation, since their stock supports predator populations of many larger fish and other marine organisms, playing an important part in the trophic structure of marine ecosystem [3, 5].

In the different parts of the Adriatic Sea fluctuations of small pelagic fish biomass and caches, as well as variability of their biological parameters, have been reported trough time [7]. Hence, the aim of this study was to analyse and compare sardine and anchovy growth parameters: length, length-weight relationship, condition and age population structure.

2. Material and methods

All samples (N=3313) were collected from commercial purse seine catches (8 mm mesh used under artificial light) in the eastern Adriatic Sea, during period June 2015 – August 2016. Sardine (N=2453) were taken during whole study period, while anchovy (N=860) samples were present only during spring-summer months when this species is usually caught in the eastern Adriatic Sea. All samples were analysed for biometry parameters; total length size was measured for each fish by ichthyometer with an accuracy of 1.0 mm and mass (weight) was weighed in grams, immediately after landing.

The relationship between total length (L) and weight (W) was examined using functional regression: log W= log a + b log L; a- regression constant, b- regression coefficient, W- bodyweight, and L- total length of fish.

The Fulton's equation ($K=100\ W\ L^{-3}$) was used for estimation of monthly fish condition, where W was bodyweight, and L was total length of fish, respectively.

After sampling and determination of morphometric parameters, cca 15 fish of each species were randomly separated to determine their age. The age structure of population, both sardine and anchovy, was determined by otolith analysis, i.e. reading of hyaline and opaque rings on the otolith *Sagitta* which reflects the periodicity of the growth. The otoliths were cleansed in 96% ethanol solution, to be observed by the Olympus binocular microscope (magnification 0.5 x 3.5) with reflected light. Both sides (concave and convex) of otoliths were observed to determine age more accurately. One

opaque ring that was wider and came from the summer period and one hyaline, dark and narrow ring that derived from the winter period were counted as one year of fish life.

The von Bertalanffy equation [8], which was modified according to Beverton and Holt [9] in STATISTICA (Stat Soft 7), was used to describe growth of sardines and anchovies: $Lt=L_{\infty}(1-e^{-k(t-t_0)})$, where L_{∞} represents the asymptotic value of the length, K stands for the growth coefficient of the species, and t_0 represents the theoretical age of the fish at the length of the lo, i.e. the length at which otoliths begin to form.

3. Results and discussion

3.1. Length-weigh and condition

Overall, the total length of sardines (N=2453) ranged from 10.5 (June and February) to 17.5 cm (April). The mean total length (LT ± SD) was 13.94 cm ± 1.07. The modal length class was 14 cm. The smallest average monthly length was recorded in January 2016 and the largest in July 2015. The total body weight of sardines varied from 6.14 to 45.73 g. Mean weight value (W ± SD) was 19.89 g ± 5.03.

Regarding sardinelength-weigh relationship, the regression coefficient b was 3.069, while the regression constant a equalled 0.0057 (Figure 1).

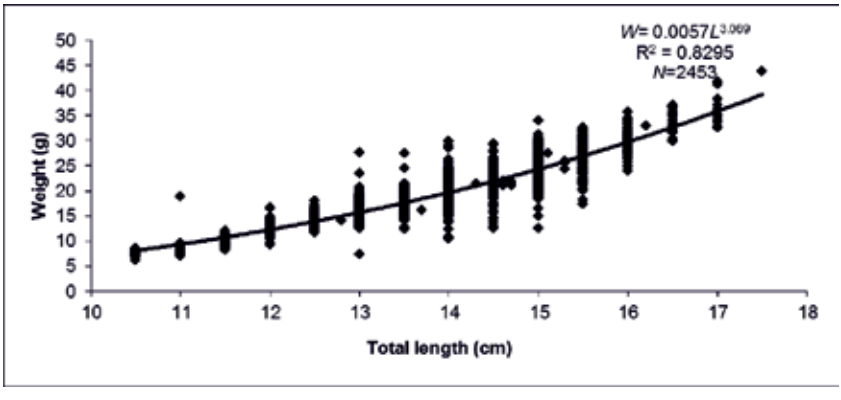

Figure 1: Length-weight relationship of sardine from the eastern Adriatic Sea during June 2015 – August 2016.

The Fulton's condition factor (K) ranged from K=0.641 (10.5 cm; 7.42 g) to K=0.816 (17.5 cm; 43.75 g); Mean Fulton's condition factor value for sardine (K ± SD) was 0.718 ± 0.043 (Figure 2).

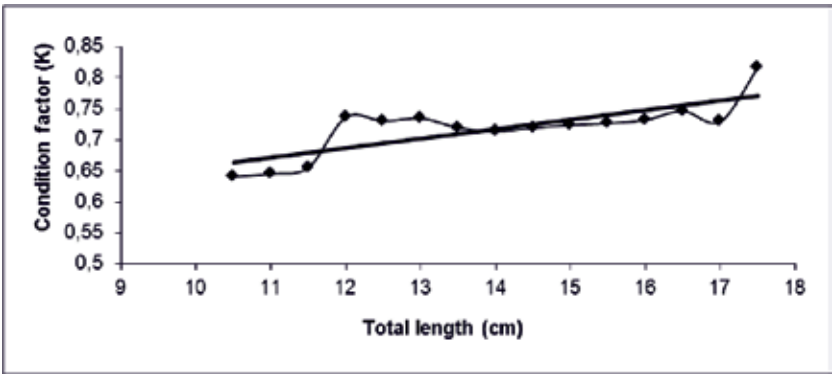

Figure 2: The Fulton's condition factor (K) of sardine from the eastern Adriatic Sea during June 2015 – August 2016.

Anchovies length (N=860) ranged from 10 cm (September) to 17.5 cm (April). The mean total length (LT ± SD) was 14.09 cm ± 0.88. The modal length class was 14 cm. The smallest average monthly length of anchovy was observed in June 2016, and the largest in July 2015. The total body weight of anchovy varied from 5.93 to 35.30 g, while mean weight value (W ± SD) was 18.01 g ± 4.08.

The regression coefficient b of anchovy length-weigh relationship was 3.201, while the regression constant a was 0.0037 (Figure 3).

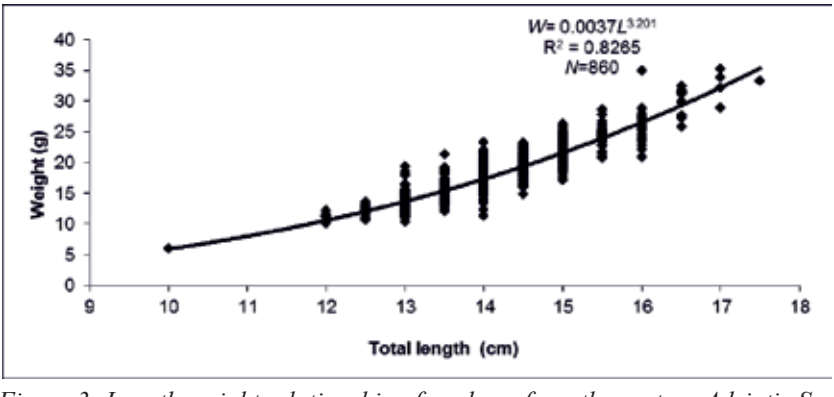

Figure 3: Length-weight relationship of anchovy from the eastern Adriatic Sea during June 2015 – August 2016.

The Fulton's condition factor (K) of anchovy ranged from K = 0.593 (10.0 cm; 5.93 g) to K = 0.664 (16.5 cm; 29.85 g), with a mean value (K ± SD) K = 0.635 ± 0.02 (Figure 4).

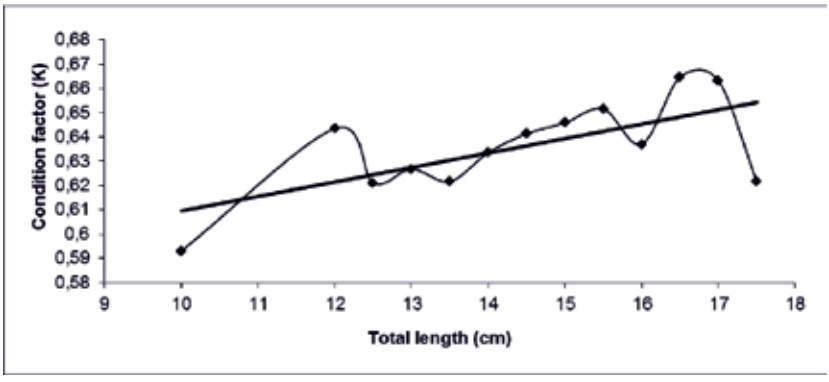

Figure 4: The Fulton's condition factor (K) of anchovy from the eastern Adriatic Sea during June 2015 – August 2016.

If the average length of sardine (13.94 cm) and anchovy (14.09 cm) from this survey from the Adriatic Sea is compared with the results obtained from the other parts of the Mediterranean Sea, overall, they have reported greater lengths for both species [10, 11].

Both sardine and anchovy length-weight relationship indicated positive allometry, although allometric coefficient was higher in anchovy (b=3.201) than in sardine (b=3.069).

The positive allometric growth of sardines and anchovy from the Adriatic Sea was also determined earlier [12]. However, length-weight relationship of sardines from the offshore (Dugi otok) and inshore waters (Virsko more) of Mid Adriatic Sea during 2004-2005 showed negative allometric growth [5]. Although, during this study sardines regression coefficient b was 3.069, the regression constant 0.0057, indicating positive allometric growth, i.e. weight growth was greater than length grow, value of slope b was close to isometric growth. Different slope b values were found between seasons for sardine from Portugal [13].

In sardines from the northern Mediterranean, the females had positive allometric growth (b = 3.21), and males negative (b = 2.91), while anchovy from the north-western Mediterranean revealed positive allometric growth (b = 3.41) [13, 14].

Fulton's condition factor for sardine (K=0.718) was greater than for anchovy (K=0.635). Also, for both species condition generally grew with fish length, although in largest anchovy condition value decreased. Sardine and anchovy from inshore waters were in better condition than those from offshore waters in the Adriatic Sea, probably due to food, i.e. zooplankton abundance [5, 15].

3.2. Age and growth

The total length of sardines (N=89) whose otoliths were analysed for the age structure ranged from 10.5 to 17.0 cm. Most specimens were 3 years old, i.e. their total length ranged from 13.0 to 15.5 cm (Table 1). The smallest numbers of individuals were 5 years old, and these were also the largest sardines observed.

Table 1: Age and length structure of sardine population, eastern Adriatic Sea, June 2015 – August 2016.

Age	Sardine		
	N	Length range LT (cm)	$\overline{x} \pm SD$ (LT)
1	8	10.5-11.5	11.00 ±0.27
2	24	12.0-14.5	13.06 ± 0.84
3	49	13.0-15.5	14.78 ± 0.64
4	6	15.0-16.5	15.92 ± 0.58
5	2	16.5-17.0	16.75± 0.35
Total	89	10.5-17.0	14.09 ± 1.49

Growth parameters for sardine were: L∞=19.71 cm; K=0.286; t_0= -1.82 (Figure 5).The greatest length overlap was found in length class 13.5 -14.5 cm, within age group of 2 and 3 years and in sardines with total length 15.0 cm belonging to 3 and 4 years age group.

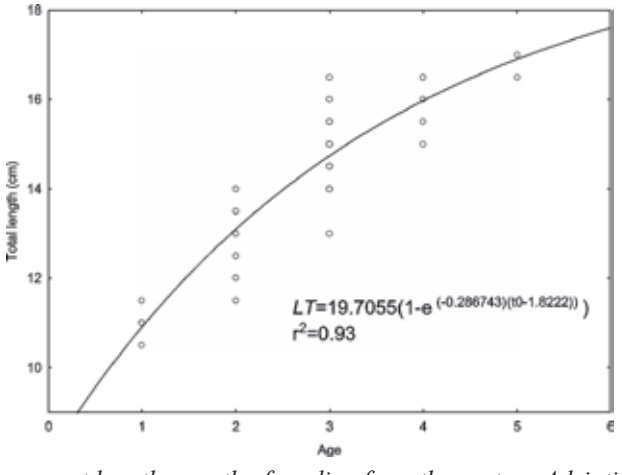

Figure 5: The age at length growth of sardine from the eastern Adriatic Sea during June 2015 – August 2016.

The total length of anchovy (N= 96) used for age determination ranged from 10.0 to 17.5 cm. The largest number of anchovy belonged to the length class 13.5 - 14.5 cm, and most of them were 3 years old (Table 2).

Table 2: Age and length structure of anchovy population, eastern Adriatic Sea, June 2015 – August 2016.

Age	Anchovy		
	N	Length range LT (cm)	$\overline{x}$ ± *SD* (LT)
1	1	10	-
2	31	12-0-14.0	13.13 ±0.58
3	51	13.0-15.5	14.40 ± 0.62
4	12	15.0-17.5	15.54 ± 0.94
5	1	17	-
Total	96	10.0-17.5	14.11± 1.4

Growth parameters for anchovy were: L∞=18.36 cm; K=0.317; t_0= -1.89 (Figure 6). The greatest length overlap was found in anchovies belonging to length class 14.0 cm, within age group of 2, 3 and 4 years.

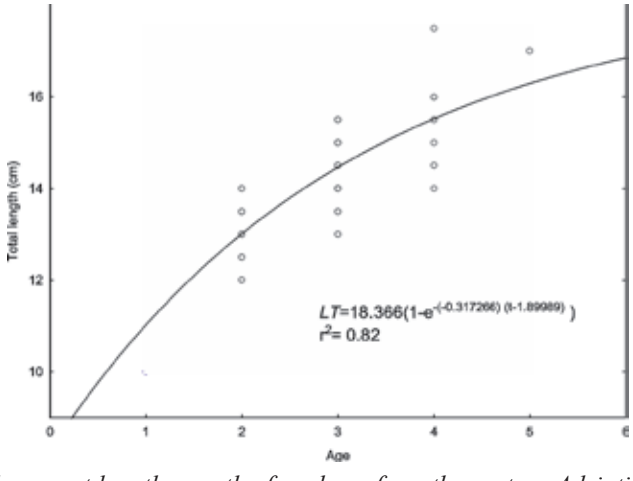

Figure 6: The age at length growth of anchovy from the eastern Adriatic Sea during June 2015 – August 2016

Both sardine and anchovy age composition varied from one to five years, while most of the analysed samples were 3-year-old. Most of the sardines from Algerian

eastern coasts belonging to length class 14.0 - 15.0 cm were also 3 and 4 years old [16]. Sardine populations across the Atlantic and Mediterranean showed large variation in Von Bertalanffy growth parameters and maximum age, and both parameters were higher for sardine in the Atlantic than in the Mediterranean area [16]. Hence, more similar to present study, were results of growth parameters (L_∞=19.50; K=0.39 and t_0= -0.48) in sardine samples from the Aegean Sea [17]. In addition, similar values of anchovy growth parameters as in this study, were found in samples caught in south Italy, in the area of Sicily (L_∞=18.60cm; K=0.29; t_0 = -2.01) [18].

4. Conclusions

Similar sardine and anchovy total length range (10.5 to 17.5 and 10.0 to 17.5 cm, respectively) and average lengths (13.94 and 14.09 cm) were found during this study in the eastern Adriatic Sea, from June 2015 to August 2016, although sardine (N=2453) were more abundant in samples than anchovy(N=860).

Allometric coefficient was higher in anchovy (b=3.201) than in sardine (b=3.069), but length-weight relationship of both species revealed positive allometry. On the other hand, average value of condition factor was greater for sardine (K=0.718) than for anchovy (K=0.635). Condition of both species grew with fish length.

Regarding age population structure, both sardine and anchovy were from one to five years old; most of the samples were 3 years old. Sardine asymptotic length (L_∞=19.71 cm) was greater than anchovy (L_∞=18.36 cm), while growth coefficient was higher for anchovy (K=0.317) than for sardine (K=0.286).

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