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Some biological parameters of the peacock wrasse, *Symphodus (Crenilabrus) tinca* (L. 1758) (Pisces: Labridae) from the middle eastern Adriatic (Croatian coast)*

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SUMMARY: Data on sex ratio, length-weight relationship, age, growth and survival rate were analysed for peacock wrasse, *Symphodus (Crenilabrus) tinca* L., (total = 1443; males = 848, females = 595) collected in the eastern middle Adriatic island area during the reproductive period (April and May) from 1995 to 1999. The total length of sampled specimens ranged from 8.9 to 42.5 cm and the weight from 7.9 to 764.2 g. The overall sex ratio was 1.43:1 in favour of males. All individuals larger than 28.9 cm were males as an effect of faster growth. The oldest females were 12 and the oldest males 13 years old. The von Bertalanffy growth formula was estimated for females (L_∞ = 28.14; k = 0.294; t_o = - 0.775) and males (L_∞ = 42.24; k = 0.214; t_o = - 0.628). The slopes (b values) of total length - weight regressions indicated allometric growth for males (b = 2.7205) and both sexes (b = 2.8147) and isometric growth for females (b = 2.9901). Survival rate of males (S = 0.80) was slightly greater than that for females (0.756).0

Key words: *Symphodus tinca***,** eastern Adriatic, age, growth, sex ratio, survival rate.

RESUMEN: ALGUNOS PARÁMETROS BIOLÓGICOS DE LA SEÑORITA, *SYMPHODUS* (*CRENILABRUS*) *TINCA* (L. 1758) (PISCES: LABRIDAE) DEL ADRIÁTICO CENTRAL ORIENTAL (COSTA CROATA). – Datos sobre la proporción de sexos, relación talla-peso, edad, crecimiento y tasa de supervivencia se han analizado para la señorita, *Symphodus (Crenilabrus) tinca* L., (total = 1443; machos = 848, hembras = 595) capturados en la zona de islas del Adriático central oriental durante el periodo de reproducción (Abril y Mayo) entre 1995 y 1999. La talla total de los individuos muestreados osciló entre 8.9 y 42.5 cm y el peso entre 7.9 y 764.2 g. La proporción de sexos total fue 1.43:1 a favor de los machos. Todos los individuos mayores de 28.9 cm fueron machos, como efecto de un mayor crecimiento. Las hembras de más edad fueron de 12 años, y los machos de 13. La ecuación de crecimiento de von Bertalanffy fue estimada para hembras (L_∞ = 28.14; k = 0.294; t_0 = -0.775) y machos (L_∞ = 42.24; k = 0.214; t_0 = -0.628). Las pendientes (valores de b) de las regresiones longitud total - peso indicaron crecimiento alométrico para los machos (b = 2.7205) y para el conjunto de ambos sexos (b = 2.8147) y crecimiento isométrico para hembras (b = 2.9901). La tasa de supervivencia de los machos (S = 0.80) fue ligeramente mayor que la de las hembras (0.756).

Palabras clave: *Symphodus tinca*, Adriático oriental., edad, crecimiento, proporción de sexos, tasa de supervivencia.

INTRODUCTION

The peacock wrasse, *Symphodus (Crenilabrus) tinca* (Linnaeus, 1758) is one of the most abundant species of Labridae in the Adriatic Sea. It occurs in the whole Mediterranean, including the Black Sea, and the Eastern Atlantic from northern Spain to Morocco (Quignard and Pras, 1986; Bauchot, 1987). This gregarious littoral fish is found on rocky reefs covered by algae or in sea-grass (*Posidonia oceanica*) meadows,

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sometimes in salty lagoons, at depths ranging from 1 to 50 m (Quignard and Pras, 1986; Bauchot, 1987). Males build nests of seaweeds where one or more females spawn (Warner and Lejeune, 1985; Quignard and Pras, 1986). This species feeds on sea-urchins, ophiuroids, bivalves, shrimps and crabs (Quignard and Pras, 1986; Bauchot, 1987; Jardas, 1996). Reproduction takes place during spring time, in April-July on the French Mediterranean coasts (Quignard and Pras, 1986), in March-June on the North African coasts (Dieuzeide *at al.,* 1954) and in April-May along the Italian coasts (Bini, 1968; Tortonese, 1975) and in the Adriatic Sea (Grubišić, 1988; Jardas, 1996). The peacock wrasse is a gonochoric species which shows sexual dimorphism in body colour pattern, which is particularly visible during the reproductive period (Quignard, 1966; Warner and Lejeune, 1985; Guidetti, 2000). Although very common in the Adriatic, this species is of little commercial value along the Croatian Adriatic coast (annual catch hardly exceeds 10 t) (Grubišić, 1988; Jardas, 1996).

Published studies on its biology and ecology are limited, despite its wide distribution in the whole Mediterranean area. Some general biological and ecological data (species diagnosis, habitat, behaviour, food, reproduction, age and growth, etc.) are available for the Adriatic Sea (Poljakov *et al.*, 1958; Bini, 1968; Tortonese, 1975; Jardas, 1996), Italian coasts (Bini, 1968; Tortonese, 1975), Black Sea (Svetovidov, 1964; Banarescu, 1964), coasts of Turkey (Aksiray, 1954), north African coasts (Dieuzeide *at al.,* 1954) and for the whole Mediteranean and the north-eastern Atlantic (Quignard and Pras, 1986; Bauchot, 1987). More detailed literature on Mediterranean labrid fishes (including *Symphodus tinca*) has dealt with their reproductive behaviour and population distributions (Warner and Lejeune, 1985; Dufour *et al.,* 1995; Warner *et al*., 1995; Budaev and Zworykin, 1998; Relini *et al.*, 1998; Lutbeg and Warner, 1999; Guidetti, 2000), growth preformance (Gordoa *et al*., 2000), parasitism (Campos and Carbonell, 1994; Bray and Bartoli, 1996) and some physiologic and metabolic activities (Colin, 1972; El-Tawil *et al.,* 1987).

This paper deals with some aspects of age and size population structure, growth, length-weight relationship, sex ratio and survival rates of the peacock wrasse (males, females and both sexes) in the middle eastern Adriatic area (Croatian waters). It was a part of research into labrid species population dynamics and trammel bottom net selectivity in the Adriatic Sea.

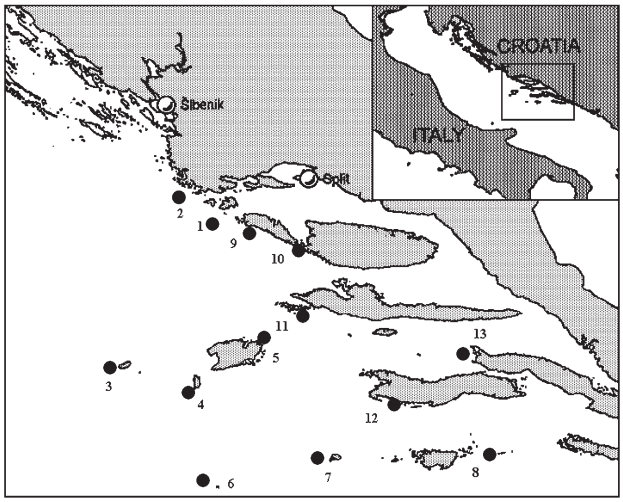

FIG. 1. – *Symphodus tinca*: Map showing the sampling locations in the middle eastern Adriatic (islands of: 1, Veliki Drvenik; 2, Mali Drvenik; 3, Sv. Andrija; 4, Biševo; 5, Vis and its eastern islets; 6, Palagruža; 7, Sušac; 8, Lastovo and its eastern islets; 9, Šolta and its western islets; 10, Brač; 11, Hvar; 12, Korčula; 13, the Peninsula of Pelješac).

MATERIALS AND METHODS

All specimens of peacock wrasse were collected during the reproductive period (April and May) of 1995-1999 at different stations in the middle eastern Adriatic area located on Figure 1.

All specimens collected were sampled by trammel bottom nets of 28, 30, 32, 35 and 40 mm mesh-size stretched (for individuals larger than 13 cm) (n = 1192)) and by beach seine of 22 mm mesh-size (for smaller specimens between 9 and 14 cm) (n = 251) (Nédélec, 1975; Cetinić and Swiniarsky, 1985; Cetinić *et al*., 1999). Locations, sampling gears and depth of fishing are shown in Table 1.

Total length was measured to the nearest 0.1 cm and body weight to the nearest 0.1 g. Although this species has very markedly expressed sex dimorphism evidenced in different body colours between males and females (particularly in the reproductive period), gonads were examined to confirm sex determination. Age was determined by reading otoliths (n = 1443). After dissection, sagitta otoliths were stored dry in paper envelopes, and later used for age determination (Chungova, 1963). After the otoliths had been cleaned and made transparent, the age of specimens was determined under a binocular microscope illuminated from above. The number of opaque zones (summer rings) and the presence of marginal translucent zones (winter rings) were checked by two readers for corroboration. Fish were then assigned to a 1 cm class size, from class 8.6-9.5

TABLE 1. – *Symphodus tinca*: Locations of sampling, gears used (TBS = trammel bottom set, BS = beach seine), depth of sampling and number of fish collected.

Stations	Locations	Gear	Depth (m)	Nunmber of fish
1 + 2	V. and M. Drvenik	TBS + BS	5-33 + 3-25	148 + 42
3 + 4	S.Andrija, Bisevo	TBS	4-42	35
5	Vis	TBS	2-39	113
6	Palagruža	TBS	5-43	39
7	Sušac	TBS	4-35	43
8	Lastovo	TBS	2-32	116
9	Šolta	TBS + BS	3-29 + 4-33	239 + 74
10	Brač	TBS + BS	3-32 + 2-27	182 + 64
11	Hvar	TBS + BS	2-27 + 4-36	145 + 38
12	Korčula	TBS + BS	2-38 + 2-33	93 + 33
13	Pelješac	TBS	3-29	39

cm to class 28.6-29.5 cm for females and from class 8.6-9.5 cm to class 41.6-42.5 cm for males and, within these size classes, to an age class.

The commonly used length-weight relationship was applied (Ricker, 1975):

$$W = a\ LT^{b}$$

where W is weight (g), LT is total length (cm), and a and b are constants. Parameters a and b were obtained by a linear adjustement to the lesser rectangles performed on the logarithmic transformation of the equation. The program STATGRAPHICS (Version 3.0) was used to estimate length-weight relationship and also the growth parameters L_∞, K and t_o in the ordinary von Bertalanffy equation: $Lt = L_\infty (1 - e^{-k(t-to)})$. This program uses a nonlinear least squares procedure, where the estimates L_∞, K and t_o are determined by minimising the sum of squared deviations between the observations and the estimated growth curve. The procedure is iterative and requires an initial guess of the parameters which is provided by the program. We used the data for all analyzed specimens. Difference in total length-weight relationship between sexes was tested by ANCOVA, and the hypothesis of isometric growth (Ricker, 1975) by the *t*-test.

A chi-square (χ^2) test was used to detect differences in sex ratios of sampled fish.

The survival rate (S) was estimated for each sex separately using the equation:

$$S = \frac{T}{\sum N + T - 1},$$

where $T = N_1+2N_2+3N_3+4N_4+ \cdot \cdot \cdot$, $\sum N = N_0+N_1+N_2+N_3+ \cdot \cdot \cdot$, and N_i is the abundance of each age class. This value is not really S, but the best estimate of S.

The variance of S values was calculated from the following equation (Chapman and Robson, 1960):

$$V(S) = S\ (S - \frac{T - 1}{\sum N + T - 2}).$$

RESULTS

The length-frequency distribution

Among the 1443 measured specimens, 848 were males (58.8%) and 595 females (41.2%). The total body length (LT) (cm) of males ranged from 9.4 to 42.5 cm ($\bar{x}$ ± SD = 23.4 ± 7.57). The range was smaller for females and ranged from 8.9 to 28.9 cm ($\bar{x}$ ± SD = 18.7 ± 4.71) (Fig. 2). Mean total body length of males was larger than that of females (ANOVA, $F = 6.3978$; $p < 0.05$).

Length-weight relationship

Weight (W) (g) of collected fish ranged from 7.9 to 764.2 g (Table 2). The length-weight relationship was calculated separately for males and females and for both sexes together (Table 3; Figs. 3A and B).

The slopes (b values) of the total length-weight relationships, which differ significantly between sexes (ANCOVA, $p < 0.05$), indicate allometric growth for males ($b = 2.7205$) and both sexes ($b = 2.8147$) and isometric growth for females ($b = 2.9901$). The value of b was significantly different from 3.0 for males ($t = 24.91$, $t_{crit} = 2.576$; $p < 0.05$; $N = 848$) and not for females ($t = 0.578$, $t_{crit} = 2.576$; $p > 0.05$; $N = 595$).

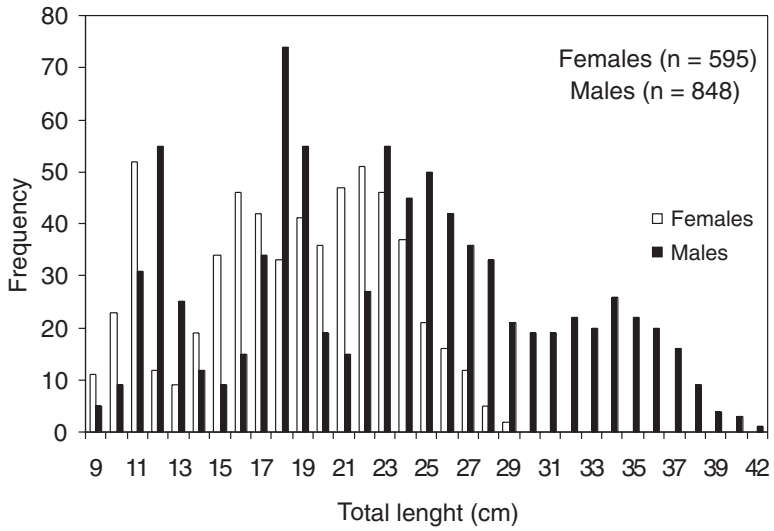

FIG. 2. – *Symphodus tinca*: Length-frequency distribution for females and males from the middle eastern Adriatic area

TABLE 2. – *Symphodus tinca*: Weight range (g) and mean weight ($\bar{w}$ ± SD) for males (n = 848) and females (n = 595) from the middle eastern Adriatic area

Length (cm)	N	Males weight range(g)	mean ± SD	N	Females weight range(g)	mean ± SD
8.6-9.5	5	9.1-9.5	9.3 ± 0.15	11	7.9-10.5	9.2 ± 0.66
9.6-10.5	9	10.6-13.8	11.6 ± 0.62	23	10.1-13.2	11.6 ± 0.87
10.6-11.5	31	13.2-18.0	15.6 ± 0.96	52	12.9-17.2	14.5 ± 0.99
11.6-12.5	55	16.9-24.1	19.5 ±1.29	12	15.7-20.8	18.1 ± 1.25
12.6-13.5	25	22.1-26.5	24.9 ± 1,68	9	19.7-27.8	23.5 ± 1.65
13.6-14.5	12	24.6-32.5	28.7 ± 2,09	19	26.8-32.5	29.1 ± 1.99
14.6-15.5	9	30.1-41.4	36.4 ± 2,44	34	30.9-45.2	38.1 ± 2.57
15.6-16.5	15	37.2-56.1	46.4 ± 3,04	46	39.8-57.2	46.9 ± 3.66
16.6-17.5	34	47.2-62.9	53.9 ± 4,48	42	49.4-70.9	58.3 ± 4.68
17.6-18.5	74	52.1-76.4	64.4 ± 6.25	33	54.8-92.1	66,5 ± 6.95
18.6-19.5	55	61.9-91.1	74.2 ± 7.43	41	68.3-100.9	79.4 ± 8.17
19.6-20.5	19	66.9-105.3	82.8 ± 8.24	36	79.7-119.1	90.9 ± 9,68
20.6-21.5	15	83.7-111.6	97.02 ± 10.39	47	80.1-129.2	106.3 ± 11.35
21.6-22.5	27	96.9-130.4	111.2 ± 12,03	51	95.1-140.3	120.5 ± 13.62
22.6-23.5	55	104.5-155.4	131.9 ± 13.74	46	100.5-161.2	139.6 ± 15.90
23.6-24.5	45	135.2-176.2	152.8 ± 15.53	37	124.6-180.1	157.8 ± 17.59
24.6-25.5	50	149.2-189.6	170.4 ± 17.02	21	142.2-208.5	179.8 ± 19.08
25.6-26.5	42	165.3-225.3	189.9 ± 19.10	16	165.3-254.3	202.8 ± 20.11
26.6-27.5	36	180.1-255.8	210.1 ± 22.22	12	187.6-264.3	228.4 ± 22.51
27.6-28.5	33	199.6-272.5	235.7 ± 25.75	5	210.9-280.1	253.9 ± 24.20
28.6-29.5	21	214.3-302.2	252.7 ± 27.65	2	237.8-316.8	277.3 ± 55.86
29.6-30.5	19	242.8-355.3	290.9 ± 33.55	-	-	-
30.6-31.5	19	269.8-389.5	327.0 ± 36.85	-	-	-
31.6-32.5	22	296.4-402.1	347.4 ± 39.12	-	-	-
32.6-33.5	20	330.5-418.9	366.3 ± 40.34	-	-	-
33.6-34.5	26	366.3-474.5	415.7 ± 42.80	-	-	-
34.6-35.5	22	389.6-535.7	444.3 ± 45.38	-	-	-
35.6-36.5	20	448.5-605.8	499.6 ± 47.17	-	-	-
36.6-37.5	16	483.4-635.4	522.5 ± 48.42	-	-	-
37.6-38.5	9	519.7-648.4	556.8 ± 40.22	-	-	-
38.6-39.5	4	570.2-650.3	589.8 ± 43,29	-	-	-
39.6-40.5	3	596.3-679.8	634.6 ± 42.17	-	-	-
40.6-41.5	-	-	-		-	-
41.6-42.5	1	764.2	764.2 ± 0			
-						
Total	848	9.1-764.2	192.4 ± 145.04	595	7.9-316.8	110.4 ± 75.11

TABLE 3. – *Symphodus tinca*: Parameters of the regression ($W = aLT^{b}$) between total length (*LT, cm*) and gross weight (*W, g*) for males, females and both sexes.

Sex	a	b	SE (b)	n	r^2	r
Males	0.0296	2.7205	0.01247	848	0.9850	0.9925
Females	0.0131	2.9901	0.02536	595	0.9808	0.9904
Both sexes	0.0220	2.8147	0.01182	1443	0.9829	0.9914

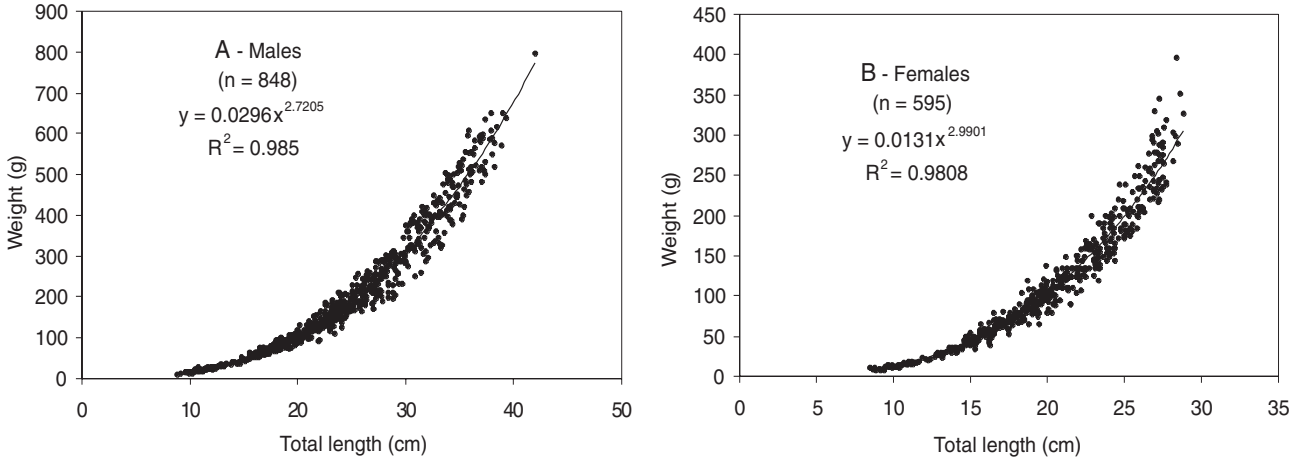

FIG. 3. – *Symphodus tinca*: Length-weight relationship for males (A) and females (B) from the middle eastern Adriatic area

Growth and age

The results of otolith reading for males and females are given in Table 4 (males) and Table 5 (females) and Figures 4A and B. The mean total length ($\bar{x}$ LT) of individuals assigned to each age class in each size class were used to fit the von Bertalanffy growth curve. The parameters are pre-

TABLE 4. – *Symphodus tinca*: Age length key for males (n = 848) in the middle eastern Adriatic based on otolith reading.

Size class (cm)	Age class												
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°
8.6-9.5	5	-	-	-	-	-	-	-	-	-	-	-	-
9.6-10.5	9	-	-	-	-	-	-	-	-	-	-	-	-
10.6-11.5	31	-	-	-	-	-	-	-	-	-	-	-	-
11.6-12.5	55	-	-	-	-	-	-	-	-	-	-	-	-
12.6-13.5	25	-	-	-	-	-	-	-	-	-	-	-	-
13.6-14.5	9	3	-	-	-	-	-	-	-	-	-	-	-
14.6-15.5	-	9	-	-	-	-	-	-	-	-	-	-	-
15.6-16.5	-	15	-	-	-	-	-	-	-	-	-	-	-
16.6-17.5	-	34	-	-	-	-	-	-	-	-	-	-	-
17.6-18.5	-	74	-	-	-	-	-	-	-	-	-	-	-
18.6-19.5	-	55	-	-	-	-	-	-	-	-	-	-	-
19.6-20.5	-	12	7	-	-	-	-	-	-	-	-	-	-
20.6-21.5	-	-	15	-	-	-	-	-	-	-	-	-	-
21.6-22.5	-	-	26	1	-	-	-	-	-	-	-	-	-
22.6-23.5	-	-	49	6	-	-	-	-	-	-	-	-	-
23.6-24.5	-	-	32	13	-	-	-	-	-	-	-	-	-
24.6-25.5	-	-	27	23	-	-	-	-	-	-	-	-	-
25.6-26.5	-	-	8	29	5	-	-	-	-	-	-	-	-
26.6-27.5	-	-	-	25	11	-	-	-	-	-	-	-	-
27.6-28.5	-	-	-	11	21	1	-	-	-	-	-	-	-
28.6-29.5	-	-	-	2	15	4	-	-	-	-	-	-	-
29.6-30.5	-	-	-	-	11	8	-	-	-	-	-	-	-
30.6-31.5	-	-	-	-	9	10	-	-	-	-	-	-	-
31.6-32.5	-	-	-	-	6	13	2	1	-	-	-	-	-
32.6-33.5	-	-	-	-	1	9	6	3	1	-	-	-	-
33.6-34.5	-	-	-	-	-	7	9	7	3	-	-	-	-
34.6-35.5	-	-	-	-	-	5	6	4	6	1	-	-	-
35.6-36.5	-	-	-	-	-	3	5	3	4	3	1	1	-
36.6-37.5	-	-	-	-	-	1	3	2	3	4	3	-	-
37.6-38.5	-	-	-	-	-	-	1	2	2	2	2	-	-
38.6-39.5	-	-	-	-	-	-	-	1	1	1	1	-	-
39.6-40.5	-	-	-	-	-	-	-	-	-	1	1	1	-
40.6-41.5	-	-	-	-	-	-	-	-	-	-	-	-	-
41.6-42.5	-	-	-	-	-	-	-	-	-	-	-	-	1
N	134	202	164	110	79	61	32	23	20	12	8	2	1
%	15.8	23.8	19.3	13.1	9.3	7.2	3.8	2.7	2.4	1.4	0.9	0.2	0.1
$\bar{x}$ LT	11.9	18.3	23.3	26.9	29.1	32.7	34.3	35.2	35.9	37.1	37.8	38.4	42.5
± SD	0.94	1.21	1.35	1.57	1.71	2.02	1.76	1.58	1.71	1.33	1.44	3.04	0

TABLE 5. – *Symphodus tinca*: Age length key for females (n = 595) in the middle eastern Adriatic based on otolith reading.

Size class (cm)	Age class											
	1º	2º	3º	4º	5º	6º	7º	8º	9º	10º	11º	12º
8.6-9.5	11	-	-	-	-	-	-	-	-	-	-	-
9.6-10.5	23	-	-	-	-	-	-	-	-	-	-	-
10.6-11.5	52	-	-	-	-	-	-	-	-	-	-	-
11.6-12.5	12	-	-	-	-	-	-	-	-	-	-	-
12.6-13.5	1	8	-	-	-	-	-	-	-	-	-	-
13.6-14.5	-	19	-	-	-	-	-	-	-	-	-	-
14.6-15.5	-	34	-	-	-	-	-	-	-	-	-	-
15.6-16.5	-	44	2	-	-	-	-	-	-	-	-	-
16.6-17.5	-	29	13	-	-	-	-	-	-	-	-	-
17.6-18.5	-	11	22	-	-	-	-	-	-	-	-	-
18.6-19.5	-	-	38	3	-	-	-	-	-	-	-	-
19.6-20.5	-	-	22	10	2	2	-	-	-	-	-	-
20.6-21.5	-	-	15	20	8	4	-	-	-	-	-	-
21.6-22.5	-	-	6	25	12	7	1	-	-	-	-	-
22.6-23.5	-	-	-	19	15	9	2	1	-	-	-	
23.6-24.5	-	-	-	12	9	7	6	2	1	-	-	-
24.6-25.5	-	-	-	2	5	5	5	3	1	-	-	-
25.6-26.5	-	-	-	-	2	4	4	2	2	2	-	-
26.6-27.5	-	-	-	-	1	3	1	2	1	2	1	-
27.6-28.5	-	-	-	-	-	1	1	1	1	1	1	-
28.6-29.5	-	-	-	-	-	-	-	-	-	-	1	1
N	99	145	118	91	54	42	20	11	6	5	3	1
%	16.6	24.4	19.8	15.3	9,0	7.1	3.4	1.9	1.0	0.8	0.5	0.2
$\bar{x}$ Lt (cm)	10.9	16.1	19.5	22.0	22.6	23.7	24.9	25.6	26.1	26.9	27.7	28.7
± SD	0.81	1.17	1.34	1.44	1.51	1.85	1.60	1.44	1.35	0.94	0.63	0

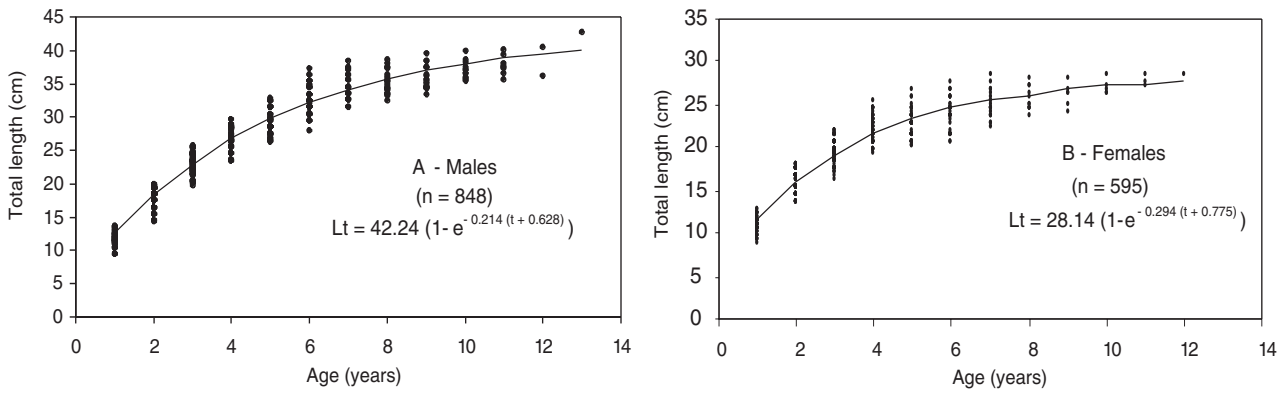

FIG. 4. – *Symphodus tinca*: Von Bertalanffy growth curve for males (A) and females (B)

sented in Table 6. The theoretical maximum lengths, L_∞ = 42.24 cm of males and L_∞ = 28.14 cm of females are not unrealistic since the largest specimens sampled during the survey were 28.9 cm for females and 42.5 cm for males. The oldest female collected was 12 years old and the oldest male 13 years old.

Sex ratio

The overall male : female ratio (1.43 : 1) was significantly different from the expected 1 : 1 ratio (χ^2 = 44.36, $p < 0.05$). The male : female ratio and corresponding chi-square (χ^2) value for each age class are presented in Table 7. Males were dominant in all

TABLE 6. – *Symphodus tinca*: Von Bertalanffy growth parameters for males and females from the middle eastern Adriatic.

Sex	L_∞ (cm)	± SE	k	± SE	t_0	± SE	r^2	N
Males	42.24	1.3253	0.214	0.2648	- 0.6291	0.2692	0.98655	848
Females	28.18	0.5316	0.293	0.0309	- 0.7821	0.2342	0.98806	595

TABLE 7. – *Symphodus tinca*: Number (N) and percentages of males and females within each age class and results of the chi-square (χ^2) tests.

Age (years)	Length range (cm)	Males		Females		Female/male significance	χ^2	Total
		N	%	N	%			
1 º	8.6-14.5	134	57.5	99	42.5	+	5.26	233
2 º	12.6-20.5	202	58.2	145	41.8	+	9.36	347
3 º	15.6-26.5	164	58.2	118	41.8	+	7.50	282
4 º	18.6-29.5	110	54.7	91	45.3	-	1.80	201
5 º	19.6-33.5	79	59.4	54	40.6	+	4.70	133
6 º	19.6-37.5	61	59.2	42	40.8	-	2.96	103
7 º	21.6-38.5	32	61.5	20	38.5	-	2.77	52
8 º	22.6-39.5	23	67.4	11	32.6	+	4.24	34
9 º	23.6-39.5	20	76.9	6	23.1	+	7.54	26
10 º	25.6-40.6	12	70.6	5	29.4	-	2.88	17
11 º	26.6-40.6	8	72.7	3	27.3	-	2.72	11
12 º	28.6-40.6	2	66.7	1	33.3			3
13 º	42.5	1	100	-	-			1
Total		848	58.8	595	41.2	+	44.36	1443

age classes, whereas the difference is generally not significant. All individuals larger than 29.0 cm were males.

Survival

The survival rate (S) was calculated using the equation of Chapman and Robson (1960). Its values for males was slightly greater than that for females: males, S = 0.80, $\nu(S) = 4.18 \times 10^{-5}$; females, S = 0.756, $\nu(S) = 6.95 \times 10^{-5}$.

DISCUSSION

The largest recorded total length of the peacock wrasse in its entire distribution area is 44.0 cm (Grubišić, 1959; 1988; Bauchot, 1987; Jardas, 1996) which confirms the results of the present study (maximum 42.5 cm LT). These values are higher than the maximum values recorded by other authors from different parts of the Mediterranean: 35.0 cm (SL) (Quignard and Pras, 1986), 35.0 cm (LT) (Palombi and Santarelli, 1953; Tortonese, 1975), 33.0 cm (Bini, 1968), and 30.0 cm (Dieuzeide *et al*., 1954; Svetovidov, 1964; Banarescu, 1964). These differences could be due to a biogeographic difference in growth rate, but also to differences in local fishing pressure.

The exponents of length-weight relationship (*b* value) of the peacock wrasse, estimated in the middle eastern Adriatic island area, show that growth is allometric in males ($b = 2.7205$) and both sexes ($b = 2.8146$) and isometric in females ($b = 2.9901$). These values of *b* from our study do not differ greatly from those estimated by Dulčić and Kraljević (1996) and Gordoa *et al.* (2000) (Table 8). Variations are attributed to different stages in ontogenetic development, as well as to differences in condition, sex and maturity. Geographic location and associated environmental conditions, such as seasonality (date and time of capture), stomach fullness, disease and parasite loads (Le Cren, 1951; Bagenal and Tesch, 1978) can also affect the value of *b*. The peacock wrasse collected in April and May were predominantly mature (except one-year-old and half of two-year-old specimens), indicating that the population had been sampled during the reproductive season. We therefore suppose that allometry of males and isometry of females were caused by gonadal

TABLE 8. – *Symphodus tinca*: Parameters of the length-weight relationship (b) and growth (L_∞, k, t_o) from eastern Adriatic, middle eastern Adriatic and northwestern Mediterranean

Authors	Study area	Age (years)	N	b	L_∞	k	t_o
Dulčić and Kraljević (1996)	Eastern Adriatic	-	-	2.726	-	-	-
Gordoa *et al* (2000)	Northwestern Mediterranean	1º-8º	292	2.795	30.65	0.808	0.323
Present study	Middle eastern Adriatic	1º-13º (M)	848	2.7205	42.24	0.214	0.629
		1º-12º (F)	595	2.9901	28.18	0.293	0.782
		1º-13º (M+F)	1443	2.8146	-	-	-

maturity. Grubišić (1988) and Jardas (1996) also noted that peacock wrasse spawned in the second half of spring in the Adriatic Sea. Bini (1968) and Tortonese (1975) observed that this species spawned in April and May in Italian waters and Banarescu (1964) reported a similar reproductive period for the peacock wrasse on the Romanian Black Sea coast.

The peacock wrasse is a relatively long-lived species. The maximum observed life span in our study was 13 years for males and 12 years for females. Quignard and Pras (1986) and Bauchot (1987) reported that life span for both sexes reached 14 to 15 years and rates of growth were slow: 7-year-old females measured 20 cm and males 26 cm. These authors also mentioned that females reached sexual maturity in their second year of life (10 cm) and males in their third to fourth years (10.5 cm). Gordoa *et al*. (2000) found the maximum age to be 8 years for the peacock wrasse population (sex combined) in an area of the northwestern Mediterranean coast. The lack of extensive studies does not allow comparison of growth parameters for males and females. However, Gordoa *et al.* (2000) presented individual age categories for combined sexes of four labrid fish species of northern Spain, including *Symphodus tinca,* according to parameters calculated from von the Bertalanffy growth curve (Table 8): age 1=20.17; age 2=25.99; age 3=28.58; age 4=29.73; age 5=30.24; age 6=30.47; age 7=30.57 and age 8=30.61. These results differ considerably from ours. Gordoa *et al*. (2000) also mentioned that the growth pattern was well described by the von Bertalanffy growth equation for all analysed species (*S. roissali, Coris julis, Labrus merula*) with the exception of *S. tinca,* which showed an extremely high dispersion in the length-at-age distribution. The comparison of the growth parameters (L_∞, k, t_o) of the peacock wrasse from the middle eastern Adriatic to those estimated in the northwestern Mediterranean also showed considerable differences (Table 8). Regional differences in growth probably depend on the ecological conditions in the areas of investigation. Water temperature can directly affect fish growth by influencing the physiology of the fish (Weatherley and Gill, 1987). However, water temperature is also directly related to rates of biological production and hence to food availability (Elizarov, 1965) and benthos species composition, both of which influence fish growth. Difference in growth of peacock wrasse between the Adriatic Sea and the coast of northern Spain could thus be attributed to differences in temperature and trophic resources in these areas.

Studies on the growth of Labridae in Europe are few (Quignard, 1966) and recent data are available only for a few species: *Xyrichthys novacula* from the Mediterranean Sea (Cardinale *et al.,* 1998) and *Ctenolabrus rupestris*, *Centrolabrus exoletus*, *Labrus bergylta*, *Labrus mixtus* and *Crenilabrus melops* from the west coast of Scotland (Treasurer, 1994; Sayer *et al*., 1995).

According to Warner and Lejeune (1985), four Mediterranean labrid species (genus *Symphodus*) from Corsica (France) were investigated under natural conditions to test the idea that extensive male mating-investment limited the extremes of male reproductive success, and thus reduced selection for protogynous sex change. In *S. tinca* males construct only a rudimentary nest, do not ventilate the eggs, and experience less spawning interference. Large males are relatively more successful in mating in this species, and sex change appears to occur occasionally (Warner and Lejeune, 1985).

The proportion of males and females in the population of peacock wrasse in the Adriatic appeared to depend on size and age. There were significant differences in the ratio of males to females in the total number of fish sampled and in all age classes. The percentage of females was highest in small size classes and lowest in large size classes (Table 7). The reason could be different survival rates of males and females. Survival rate value was slightly higher for males than for females. The slightly selective predation and slightly higher mortality rate of females may result from their slower growth and lower length size, which make them more easily attacked by predators. Peacock wrasse have been found in stomachs of *Scorpaena porcus* (Pallaoro and Jardas, 1991), *Phycis phycis*, *Conger conger*, *Muraena helena* (Maričević, pers. comm.) and *Scorpaena scrofa* (author's unpublished data). These predators were all found in our study area (Županović and Jardas, 1989), suggesting that predation may be a decisive factor in controlling variations in female population parameters in the middle eastern Adriatic. As the difference between males and females was in length and not in age, it is also possible that the slower female's growth could be related to energetic investment in gonad development during the reproductive cycle. It is also possible that part of the peacock wrasse population changes sex (protogynous hermaphroditism) during its life time, although some authors (Warner and Lejeune, 1985) do not agree with this hypothesis.

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