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Biometric properties of damselfish, *Chromis chromis* (Osteichthyes: Pomacentridae) from the middle Adriatic

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Seventeen morphometric and seven meristic body characteristics were examined in 406 specimens of damselfish (234 females and 172 males) caught in the middle Adriatic (near the Korčula and Kopište Islands). The differences between the mean values of the measured morphometric characteristics in the males and females were not statistically significant. Modes were identical in males and females for most analyzed morphometric relationships. There were no differences in meristic characters between sexes. Thus, the male and female damselfish population in the middle Adriatic is homogeneous.

Key words: *Chromis chromis*, morphometric and meristic characteristics, Adriatic Sea

INTRODUCTION

The damselfish *Chromis chromis* (Linnaeus, 1758) is distributed in the eastern Atlantic along the coast of Portugal to the Gulf of Guinea (it may also reach Angola) and the Mediterranean Sea (QUIGNARD & PRAS, 1986). It is also distributed throughout the Adriatic Sea, living in schools in midwater, above or near rocky reefs, or above sea grass meadows, mainly at a depth of 3-35 m (JARDAS, 1996). It is the only representative of the family Pomacentridae in the Mediterranean Sea.

The biology of this species has been well documented for the Adriatic (SOFRADŽIJA, 1987; DULČIĆ & KRALJEVIĆ, 1994; DULČIĆ *et al*., 1994a, 1994b; DULČIĆ, 1996), Mediterranean (ABEL, 1961; CONTINI & DONATO, 1973; ARRUDA, 1977; DUKA & SHEVCHENKO, 1980), and eastern Atlantic (SALDANHA, 1966; MAPSTONE & WOOD, 1975; RÉ & GOMES, 1982). However, their morphometric and meristic characteristics have not been systematically studied. Some data on individual meristic characters are available (COLLIGNON *et al*., 1957; BANARESCU, 1964; SVETOVIDOV, 1964; SALDANHA, 1966; BINI, 1967; TORTONESE, 1975; ARRUDA, 1977; WOOD, 1977; RÉ & GOMES, 1982), but data on morphometry are very scarce. The goal of this paper was to investigate morphological properties of the Adriatic damselfish population by analyzing morphometric and meristic characters.

MATERIAL AND METHODS

Fish

Fish were collected with a beach seine (‘migavica’) in 1994 from the middle Adriatic (Fig. 1). A total of 406 damselfish specimens

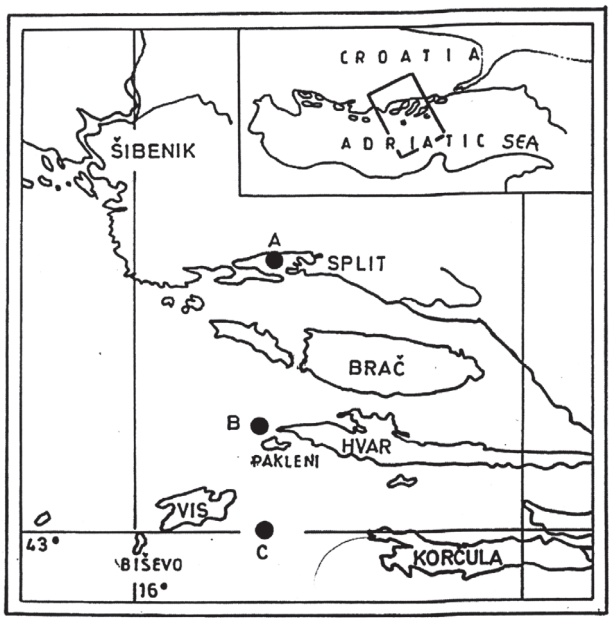

Fig. 1. Study area and sampling locations of Chromis chromis *in the middle Adriatic: A = Kaštela Bay, B = Pakleni Otoci Archipelago, C = Budikovac Islet*

(234 females and 172 males) were sampled from commercial catches and subjected to biometric analysis. The sample was categorized into length classes.

Morphometric and meristic characters

Biometric measurements were performed on fresh fish. Seventeen morphometric and seven meristic body characters were examined. Morphometric characters included total length, standard length, lengths of dorsal, anal, pectoral, and ventral fins, predorsal, preanal, preventral, and prepectoral lengths, maximum and minimum body heights, head length, eye diameter, and preocular, interocular, and postocular distances (Fig. 2). Meristic characters included number of spined and branched rays in dorsal, ventral, anal, and caudal fins, number of pectoral rays, number of gillrakers, and number of scales on linea lateralis.

Total and standard lengths were measured to the nearest 0.1 cm. The rest of the morphometric measurements were measured to the nearest 0.01 mm. Standard length was expressed as a percentage of the total length. Other body measurements were expressed as percentages of the standard length. Head measurements were expressed as percentages of the head length.

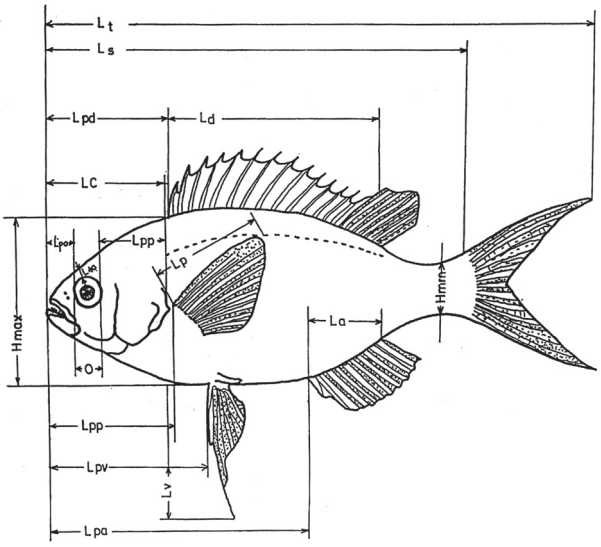

Fig. 2. Stylized drawing of body proportions measured on damselfish: total length (L_t), standard length (L_s), dorsal fin length (L_d), anal fin length (L_a), pectoral fin length (L_p), ventral fin length (L_v), predorsal length (L_{pd}), preanal length (L_{pa}), preventral length (L_{pv}), prepectoral length (L_{pp}), maximum body height (H_{max}), minimum body height (H_{min}), head length (L_c), eye diameter (O), preocular distance (P_o), interocular distance (L_{io}) and postocular distance (L_{po})

Statistical analysis

Data were processed by arithmetic means, standard deviations, and variability coefficients. The significance of differences between males

and females was tested by *t* test (SOKAL & ROHLF, 1981). Polynomial and linear regression analyses were used to examine the morphometric differences occurring as total length increased. Morphometric and meristic characters (between sites and sample sizes) were analyzed by ANOVA, followed by TUKEY-KRAMER's post-hoc test (SOKAL & ROHLF, 1981) for all possible pairwise comparisons.

RESULTS

Total length ranged 6.1-12.4 cm, with females ranging 7.4-12.4 cm and males 6.1-11.2 cm. Differences between mean morphometric measurements of males and females were not statistically significant but significant differences between males and females ($p<0.05$) were found in seven relationships: pectoral and ventral fin lengths, preanal, predorsal, and prepectoral lengths, and minimum body height to standard length, and the interocular distance to head length. The variability coefficients of morphometric relationships for males, females and the total sample were relatively low (Tables 1,2). Modes were identical in males and females for most morphometric relationships. The difference between modal values of males and females were mostly 1% or lower except for the relationships between the dorsal fin length, head length, and maximum body height to standard length.

Analysis of variance revealed no statistically significant differences in meristic characters between sites or sexes (TUKEY-KRAMER's test, $p>0.05$; Table 3). The coefficients of polynomial

Table 1. Relationships of measured body proportions (%) for female (n = 234) and male (n = 172) damselfish

Body proportion	Sex	Range	Mean±SD	ΔX	*t*	Variability coefficient (%)	ΔV
Standard length/total length	♂	72.58-75.69	73.92±0.857	0.07	0.56	1.16	0.10
	♀	72.58-75.83	73.99±0.930			1.26	
In relation to standard length							
Head length	♂	30.17-34.06	32.23±1.047	0.43	1.56	3.25	5.58
	♀	30.17-34.92	31.80±2.807			8.83	
Preanal length	♂	62.32-67.60	65.56±1.209	0.43	2.33	1.89	**0.03**
	♀	58.07-68.00	65.13±1.345			2.07	
Predorsal length	♂	30.51-35.14	32.83±1.164	0.46	2.70	3.55	**0.08**
	♀	30.64-36.00	33.29±1.155			3.47	
Preventral length	♂	31.43-36.49	33.32±1.646	0.39	1.37	4.94	**2.11**
	♀	30.88-37.84	33.71±2.373			7.05	
Pectoral fin length	♂	28.38-32.86	29.87±0.890	0.42	3.28	2.98	**0.06**
	♀	28.05-32.84	30.29±0.920			3.04	
Dorsal fin length	♂	53.33-58.11	55.60±1.394	0.40	1.92	2.51	0.33
	♀	52.47-58.89	55.20±1.568			2.84	
Ventral fin length	♂	22.39-28.95	25.94±1.455	0.74	3.44	5.61	**0.08**
	♀	24.37-30.86	26.68±1.599			5.59	
Anal fin length	♂	17.39-22.69	19.52±1.179	0.06	1.90	6.04	0.03
	♀	17.39-22.32	19.58±1.177			6.01	
Prepectoral length	♂	26.53-30.00	28.79±1.016	0.53	4.21	3.53	0.98
	♀	27.14-30.42	29.32±0.747			2.55	
Maximum body height	♂	45.20-54.20	49.07±2.806	0.04	0.11	5.72	1.42
	♀	45.00-52.61	49.03±2.109			4.30	
Minimum body height	♂	13.00-15.55	14.18±0.952	0.45	3.96	6.71	**2.50**
	♀	13.56-16.22	14.63±0.616			4.21	

Table 1. cont'd

Head length	♂	30.86-36.62	33.90±1.411	0.09	0.43	4.16	0.56
	♀	30.44-36.11	33.81±1.594			4.72	
In relation to head length							
Eye diameter	♂	27.92-33.33	30.05±1.658	0.27	1.10	5.52	0.66
	♀	26.20-33.33	29.78±1.841			6.18	
Interocular distance	♂	25.30-28.85	27.18±1.078	0.80	4.08	3.97	**2.31**
	♀	22.92-28.40	26.38±1.656			6.28	
Preocular distance	♂	20.00-22.22	21.46±0.724	0.01	0.07	3.37	1.09
	♀	18.80-23.15	21.45±1.172			4.46	
Postocular distance	♂	39.76-40.06	44.37±1.423	0.02	0.10	3.21	0.01
	♀	39.60-46.00	44.39±1.429			3.22	

ΔX = difference of mean values between males and females
ΔV = difference of variability coefficient between males and females

Table 2. Relative relationships of measured body proportions for total sample of damselfish (n = 406)

Body proportions	Range	Mean±SD	Variability coefficient (%)
Standard length/total length	72.58-75.83	73.96±0.894	1.21
In relation to standard length			
Head length	30.17-34.92	32.03±1.213	3.79
Preanal length	58.07-68.00	65.35±1.298	1.99
Predorsal length	30.51-36.00	33.06±1.174	3.55
Preventral length	30.88-37.84	33.51±2.125	6.34
Pectoral fin length	28.05-32.86	30.08±0.932	3.10
Dorsal fin length	52.47-58.89	55.40±1.496	2.70
Ventral fin length	22.39-30.86	26.32±1.572	5.97
Anal fin length	17.39-22.69	19.55±1.175	6.01
Prepectoral length	26.53-30.42	29.06±0.927	3.19
Maximum body height	45.00-54.20	49.05±2.466	5.03
Minimum body height	13.00-16.22	14.41±0.831	5.76
Head length	30.44-36.62	33.85±1.502	4.44
In relation to head length			
Eye diameter	26.20-33.33	29.92±1.754	5.86
Interocular distance	22.92-28.85	26.78±1.454	5.43
Preocular distance	18.80-23.15	21.46±0.948	4.42
Postocular distance	39.60-46.00	44.38±1.426	3.31

and linear regressions show that smaller specimens have a longer head (a = 30.670, b = -0.1812, c = 0.0014, R^2 = 0.9845) and longer anal (a = 38.907, b = -0.1658, c = 0.0011, R^2 = 0.9554), dorsal (a = 44.554, b = 0.5613, c = -0.077, R^2 = 0.9531), and ventral (a = 16.206, b = 0.0911, c = 0.001, R^2 = 0.9622) fins. At the same time, they have smaller maximum

Table 3. Meristic characters for females (n = 234) and males (n = 172) of damselfish

Peculiarity	Sex	Range	Mean±SD	ΔX	*t*	Variability coefficient (%)	ΔV
No. rays in dorsal fin	♂	XIV 9-11	10.05±0.217	0.02	0.09	2.16	0.05
	♀	XIV 9-11	10.07±0.223			2.21	
No. rays in anal fin	♂	II 9-11	10.04±0.118	0.08	0.67	1.18	0.75
	♀	II 9-11	10.09±0.195			1.93	
No. rays in pectoral fin	♂	17-18	17.10±0.133	0.00	0	0	0
	♀	17-18	17.10±0.131				
No. rays in ventral fin	♂	I 4-5	5.05±0.188	0.01	0.02	3.72	0.22
	♀	I 4-5	5.08±0.200			3.94	
No. rays in caudal fin	♂	III-17-IV	17.00±0	0	0	0	0
	♀	III-17-IV	17.00±0				
No. branchiospines	♂	28-30	29.34±0.887	0.03	0.04	3.02	0.08
	♀	28-30	29.41±0.911			3.10	
No. scales in linea lateralis	♂	24-26	25.38±0.567	0.17	0.44	2.23	0.42
	♀	24-26	25.21±0.667			2.65	

ΔX = difference of mean values between males and females
ΔV = difference of variability coefficient between males and females

(a = 22.172, b = -0.1222, c = 0.0010, R^2 = 0.9666) and minimum (a = 3.7453, b = -0.00857, c = 0.0012, R^2 = 0.8898) body heights. Smaller specimens have shorter preorbital and postorbital distances and smaller eye diameters than larger specimens. The preorbital and postorbital distances increase with the size of the damselfish.

DISCUSSION

The damselfish population of the middle Adriatic is relatively homogeneous although some morphological characters varied between sexes. The seven significant differences in morphometry could have resulted from phenotypic responses to the habitat in which they live, similar to those reported for *Syngnathus abaster* from the Danube River (CAKIĆ *et al*., 2002; MOVČAN, 1988). These authors indicated that differences may have been caused by varying features of the aquatic ecosystems. Modes of analyzed morphometric relationships were identical in males and females without a tendency toward bimodality in any characteristic, clearly indicating a homogeneous damselfish population in the Adriatic. Based on vertebra analysis, DULČIĆ *et al*. (1994) also reported that the damselfish population in the middle Adriatic is homogeneous.

Data from the literature on morphometric relationships are comparable since they refer to standard body length. RÉ & GOMES (1982) obtained standard lengths of 75.0-76.9% of the total body length for damselfish from the Azores, very close to the range found in this study (72.58-75.83%). BANARESCU (1964) reported that head length makes up 30.0-32.5% of the standard body length in damselfish from the Black Sea, COLLIGNON *et al*. (1957) that it constitutes 30% in damselfish from the Senegal coast, SALDANHA (1966) reported on 28.4-39.0% for damselfish from the Portuguese coast (Sesimbra, Cabo Afonso, D. Cralos, de Coimbra, Baia do Funchal), and DUKA & SHEVCHENKO (1980) recorded 27.4% in damselfish from the Black Sea and 27.0% for those from the Mediterranean. In this study, values were 30.17-34.06% of the standard body length, with a mean of 32.23%.

Data relating to maximum body height are also comparable. According to BANARESCU (1964), maximum body height constitutes 41.50-47.50% of the standard length. SALDANHA (1966) found that maximum body height is 48.8-

53.4% of the standard length in damselfish from several localities on the Portuguese coast. COLLINGON *et al*. (1957) reported a similar height from Senegalese waters (52.25%). All these reports are close to the range in the present study (45.20-54.20%). ARRUDA (1977) obtained mean maximum body heights of 50.8% for the Azores, 44.50% for Madeira, and 48.90% for the Mediterranean, very close to the means in our study (45.09%).

Eye diameters were also very similar to data from other reports. According to BANARESCU (1964), eye diameter constitutes 31.20-35.70% of the head length, close to the range in the present study (27.92-33.33%). TORTONESE (1975) and COLLINGNON *et al*. (1957) reported that eye diameter constitutes 33.33% of the head length in damselfish from the Mediterranean and Senegalese waters, respectively. ARRUDA (1977) obtained mean eye diameters of 33.8% for the Azores, 34.30% for Madeira, and 33.3% for the Mediterranean, very close to our means (29.92%).

Meristic characters of damselfish from the middle Adriatic are compared with data from other studies in Table 4. Data for the Mediterranean area from several authors agree with data from this study. The same number of ventral fin rays was recorded for damselfish from different locations. Variation in the ranges of branched rays in dorsal and anal fins was moderate. The number of spined rays in the dorsal fin of damselfish was between XIII and XIV, while the number of soft rays varied 8-11. The number of spined rays in the anal fin was constant in fish from different areas, while the

Table 4. Meristic characters of damselfish from the Atlantic, Adriatic, Mediterranean, and Black Seas

Area	Author	Dorsal fin (no. rays)	Anal fin (no. rays)	Pectoral fin (no. rays)	Ventral fin (no. rays	Caudal fin (no. rays)	Linea lateralis (no. scales)	Branchiospines (no.)
Adriatic	This study	XIV/10	II/10	17	I/5	IV-17-III	3/9 27	29
Naples Bay	FAGE (1918)	XIV/9	II/9	17	I/5	17	-	-
Senegal coast	COLIGNON *et al*. (1957)	XIV/11	II/12	-	-	-	27	22
Black Sea	SVETOVIDOV (1964)	XIV/9-11	II/10-11	-	-	-	18 3/8 19	-
Black Sea	BANARESCU (1964)	XIV/(8) 9-10(11)	II/(8)10-11	I/15-16	I/5	-	(24) 26-29	-
Portugal coast	SALDANHA (1966)	XIII-XIV/ 10-11	II/10-11	17	I/5	-	-	-
Mediterranean	BINI (1967)	XIV/10-11	II/10-12	17	I/5	IV-17-III	24-30	-
Mediterranean	TORTONESE (1970)	XIV/10-11	II/10-12	-	-	-	18-19 (8-9)	20
Mediterranean	WOOD (1977)	XIV/10	II/10	18(17)	-	-	16 3/8 19	7-8+18-21
Mediterranean	ARRUDA (1977)	XIV/10	II/10	18	-	-	3/9 25	29
Atlantic	ARRUDA (1977)	XIV/11	II/11	19	-	-	4/10 26	30
Azore Islands	RÉ & GOMES (1982)	XIV/11	II/11	18-20	-	19	16 3/8 19	-
Mediterranean Black Sea Atlantic	QUIGNARD & PRAS (1986)	XIII-XIV/ 10-11	II/10-11	-	-	-	24-30	30

number of soft rays varied 9-12. The number of soft rays in the pectoral fin varied 15-20 while only BANARESCU (1964) reported the presence of spined rays for damselfish from the Black Sea. The number from this study (17) is identical with those obtained by FAGE (1918), BINI (1967), and SALDANHA (1966).

No difference in number of branchiospines was recorded for the middle Adriatic, supporting the assumption that the middle Adriatic is inhabited by a homogeneous damselfish population. The number of branchiospines varied from 22 for the Senegal Coast to 30 for the Mediterranean, close to the value reported in this study (29). The number of branchiospines may indicate adaptation to environmental changes (ANDREU, 1969). Apart from the number of vertebrae, the number of rays in the dorsal fin and number of branchiospines define the level of homogeneity of a population (ALEGRÍA-HERNANDEZ, 1985). ARRUDA (1977) discovered differences in the number of scales above and below the lateral line and number of soft rays in the dorsal and anal fins between damselfish populations from the Marseille area of the Mediterranean and the Azores and Madeira in the northeastern Atlantic. He also discussed the possible existence of subspecies in the Azores and Madeira area, according to observed differences, explaining the geographical isolation of this area from the Mediterranean as the cause. The significance of differences in number of scales of the lateral line is difficult to establish, since only ranges are reported in the literature. The numbers of scales found in this study are mostly similar to those obtained for the Mediterranean.

In general, there are no significant morphological differences between the damselfish populations in the Adriatic and Mediterranean Seas, but there are some significant differences between these populations and populations from the Black Sea and the Azore/Madeira area.

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Biometrijska svojstva crnelja, *Chromis chromis* (Osteichthyes: Pomacentridae), u srednjem Jadranu

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SAŽETAK

Na 406 primjeraka crnelja (234 ženki i 172 mužjaka) ulovljenih u srednjem Jadranu (otok Korčula i otok Kopište) analizirano je 17 morfometrijskih i 7 merističkih karaktera. Srednje vrijednosti morfometrijskih vrijednosti za ženke i mužjake nisu statistički različite. Neke razlike u morfometrijskim vrijednostima između mužjaka i ženki postoje, no modalne vrijednosti tih odnosa su uglavnom iste te one kao i dobivene merističke osobine ukazuju da u srednjem Jadranu obitava homogena populacija ove vrste. Nisu izražene razlike koje bi ukazivale na postojanje subpopulacija. Također su uočene i promjene morfometrijskih odnosa u vezi s porastom tjelesne dužine.

Ključne riječi: *Chromis chromis*, morfomertrijski i meristički karakteri, Jadransko more