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Biometry analysis of the whiting, *Merlangius merlangus* (Linneaus, 1758) from the northern Adriatic Sea

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Biometry analysis was conducted on 282 specimens of whiting, Merlangius merlangus *(Linneaus, 1758) from the northern Adriatic Sea. The total length of all specimens ranged from 16.6 to 33.7 cm. There were twenty one morphometric and nine meristic characteristics measured. Sexual dimorphism was observed in 15 morphometric measurements. The number of rays in the first anal fin is the only meristic character that showed differences between sexes. Relative growth was studied by comparing morphological characters with standard and head length. The results provide the first complete biometric description of this species in the Adriatic Sea. Data were compared with other biometric information available for this species; however it is not possible to fully discriminate the Adriatic population from those in other areas.*

Key words: *Merlangius merlangus*, biometry, Adriatic Sea

INTRODUCTION

The whiting, *Merlangius merlangus* (Linneaus, 1758) is one the most common fish species in the northern Adriatic and is also found in the middle, and rarely in the southern, part of the Adriatic Sea (JARDAS, 1996). This species is distributed in the Atlantic Ocean (from Norway and Iceland to the northern coast of Portugal), the Mediterranean Sea (the Adriatic and Aegean Seas), the Black, the Azov and the Marmara Seas. In the Adriatic, whiting is commonly found near muddy or sandy bottoms in waters mostly up to 50 m deep, and up to 100 m in the northern Adriatic channel waters (FRATTINI & CASALI, 1998). Whiting is caught almost entirely with trawl nets.

The analysis of some metric and meristic characteristics of whiting specimens from the Mediterranean Sea suggests the existence of a certain differentiation, and two subspecies have been described. *M. merlangus euxinus* (Nordmann, 1840) from the Black, Marmara and Azov Seas is distinguished from *M. merlangus merlangus* (L., 1758) from the Atlantic, by the presence of a barbel on the chin, the length of the pectoral fin, and the numbers of fin rays, gillrakers and vertebrae (TORTONESE, 1970; SVETOVIDOV, 1986). The population in the Adriatic has been assigned both to subspecies *M. m. merlangus* (BINI, 1970) and *M. m. euxinus* (SVETOVIDOV, 1964; TORTONESE, 1970; 1986). UNGARO *et al.* (1995) presented metric and meristic data on only 33 specimens of whiting

collected in the Adriatic and 15 specimens from the Black Sea and found differences between the two populations.

Although some data on morphometric and meristic characters of the Adriatic whiting are available (BINI, 1970; UNGARO *et al.*, 1995; JARDAS, 1996), they are incomplete and insufficient due to a small number of specimens described. A review of the published morphological characters of whiting is presented in the Discussion.

The aim of this study was to investigate the morphological properties of the Adriatic whiting population, as well as species relative growth. Results provide the first complete biometric description of this species in the Adriatic Sea.

MATERIAL AND METHODS

Whiting specimens from the eastern part of the northern Adriatic were taken from commercial trawl catches, from January to May 2010. Bottoms at sampling sites were mostly muddy and sandy, with depths between 30 and 40 m (Fig. 1). There were 282 whiting specimens analysed.

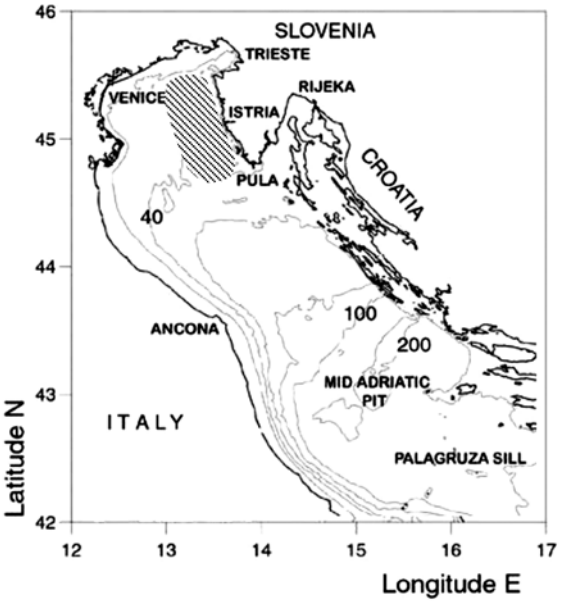

Fig. 1. Sampling area of whiting, Merlangius merlangus *in the eastern northern Adriatic*

All morphometric measurements were taken to the nearest 0.1 cm. Sex was determined macroscopically according to the shape and appearance of the gonads (BOWERS, 1954). There were 21 morphometric and 8 meristic characters measured. Morphometric characters included total length (TL), standard length (SL), lengths of three dorsal (LD1, LD2, LD3) and two anal (LA1, LA2) fin bases, lengths of pectoral (LP), ventral (LV) and caudal fins (LC), predorsal (PD), preanal (PA), preventral (PV) and prepectoral (PP) distances. Also, maximum (H) and minimum (h) body heights, head length (CL), eye diameter (O), preocular (PO), interocular (IO) and postocular distances (OLO) were measured (Fig. 2). The barbel on the chin was present; however its length has not been measured as it was very small and delicate. Meristic characters included number of rays in dorsal (D1, D2, D3), pectoral (P), ventral (V) and anal (A1, A2) fins, number of gillrakers (Brsp) and number of vertebrae (Vert). Urostyle was not included in the vertebrae count (Fig. 3). Scales on linea lateralis have not been counted because they are very small and easily fall off during handling of the fish. Rays on the caudal fin were very difficult to count and error during measuring was higher than the variability. Standard length was expressed as a percentage of total length while other body measurements were expressed as percentages of standard length. Head measurements were expressed as a percentage of head length.

The sex ratio was tested by a simple Chi-square test. Biometry data were analysed by arithmetic means, standard deviations and variability coefficients. Student's *t* test ($p<0.05$) was used to determine statistical differences between mean values of morphometric and meristic characters of males and females. In order to describe relative growth, linear regression analysis was used to correlate morphometric relationships with standard length of the specimens.

RESULTS

The sample of 282 *M. merlangus* specimens was composed of 120 males and 162 females. The sex ratio in the sample differed statistically from the expected 1:1 ($\chi^2=9.692$; $p<0.05$).

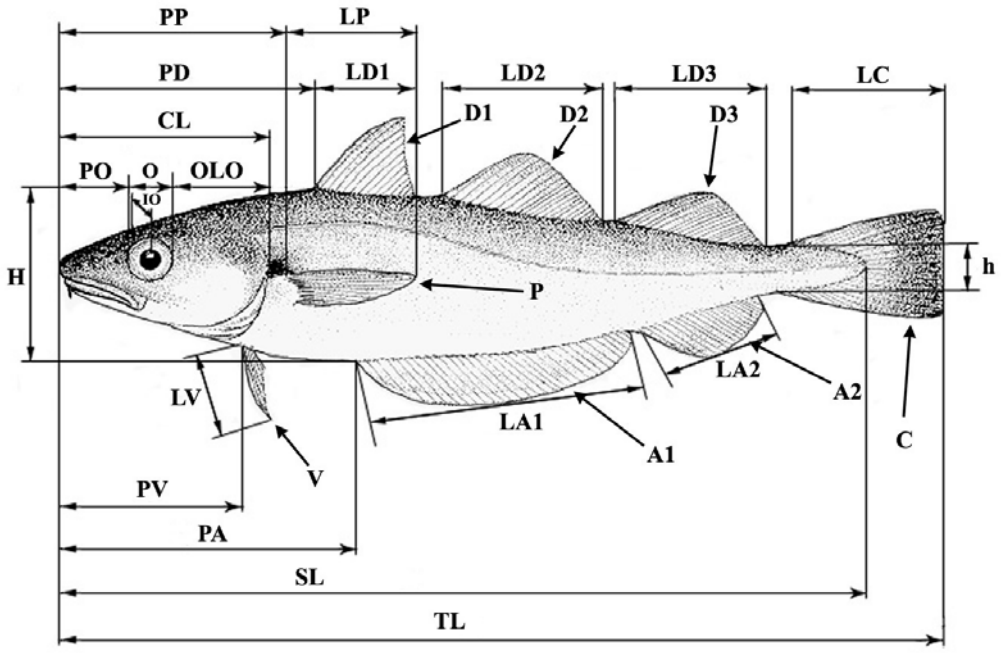

Fig. 2. Morphometric characters of whiting, Merlangius merlangus*: total length (TL), standard length (SL), dorsal fin base lengths (LD1, LD2, LD3), anal fin base lengths (LA1, LA2), pectoral fin length (LP), ventral fin length (LV), caudal fin length (LC), predorsal distance (PD), preanal distance (PA), preventral distance (PV), prepectoral distance (PP), maximum body height (H), minimum body height (h), head length (CL), eye diameter (O), preocular distance (PO), interocular distance (IO), postocular distance (OLO)*

Fig. 3. Caudal Vertebrae of whiting, Merlangius merlangus*: vertebrae (V) and urostyle*

Total length (TL) ranged from 16.6 to 33.7 cm (22.17±3.45) for all specimens, with females ranging from 16.6 to 33.7 cm (23.55±3.52) and males from 17.3 to 25.7 cm (19.95±1.77). Mean values of all 21 morphometric characters (including total and standard body length) of females were significantly higher than those of males ($p<0.05$). 15 morphometric relationships (Table 1, **) showed statistically significant ($t \geq 1.96$; $p \leq 0.05$) differences between the sexes. Variability coefficients varied from 0.68 to 10.88% for the SL/TL and LV/SL relationships, displaying a relatively wide range.

Meristic data are shown in Table 2. Whiting has only soft rays in all the fins and their number varies, except in the ventral fin, which had 6 rays in all the specimens. Student's *t* test showed statistically significant differences in number of rays in the first anal fin, which is lower in females.

Linear regression analysis showed that bigger *M. merlangus* specimens have a shorter head in comparison to standard body length (B = -0.070%; $R^2 = 0.076$), shorter preanal (B = -0.123%; $R^2 = 0.055$), prepectoral (B = -0.128%; $R^2 = 0.153$) and preventral (B = -0.064%; $R^2 = 0.030$) distances, smaller base length of second anal fin (B = -0.088%; $R^2 = 0.082$) and smaller lengths of pectoral (B = -0.096%; $R^2 = 0.160$), ventral (B = -0.171%; $R^2 = 0.169$) and caudal (B = -0.115%; $R^2 = 0.126$) fins. Preocular (B = 0.087%; $R^2 = 0.053$), postocular (B = 0.273%; $R^2 = 0.333$) and interocular (B = 0.240%; $R^2 = 0.199$) distances are larger in bigger fish; however, eye diameter (B = -0.311%; $R^2 = 0.471$) is smaller. Maximum body height in comparison to body size (H/SL) (B = 0.096%; $R^2 = 0.036$) is also larger in bigger fish. Minimum body height

Table 1. Relationships of morphometric characters (%) for males (n=120), females (n=162) and total sample (n=282) of whiting, Merlangius merlangus *from the northern Adriatic Sea; SD= standard deviation; V=variability coefficient*

*Relationship**	*Sex*	*Range (%)*	*Mean ± SD*	*t*	*V (%)*
SL/TL	♂	85.93 – 98.33	90.82 ± 1.38	1.51	1.52
	♀	89.69 – 92.61	91.05 ± 0.62		0.68
	total	85.93 – 98.33	90.96 ± 0.98		1.08
CL/SL	♂	23.24 – 34.61	27.89 ± 1.11	3.17**	2.47
	♀	24.86 – 28.93	27.44 ± 0.84		3.07
	total	23.24 – 34.61	27.61 ± 0.97		2.92
LD1/SL	♂	10.66 – 14.55	12.68 ± 0.81	2.65**	6.29
	♀	10.05 – 15.02	13.01 ± 0.79		6.10
	total	10.05 – 15.02	12.88 ± 0.81		6.27
LD2/SL	♂	16.61 – 23.54	20.52 ± 1.53	0.80	7.44
	♀	17.69 - 23.45	20.36 ± 1.18		5.80
	total	16.61 – 23.54	20.42 ± 1.32		6.47
LD3/SL	♂	12.93 – 17.65	15.82 ± 0.97	2.02**	6.04
	♀	12.96 – 17.83	15.53 ± 0.98		6.32
	total	12.93 – 17.83	15.64 ± 0.98		6.26
LA1/SL	♂	29.38 – 37.58	34.42 ± 1.57	1.08	4.41
	♀	30.28 – 38.78	34.17 ± 1.71		5.02
	total	29.38 – 38.78	34.27 ± 1.66		4.80
LA2/SL	♂	15.12 – 19.59	16.81 ± 0.89	3.47**	5.31
	♀	14.21 – 19.78	16.30 ± 0.99		6.09
	total	14.21 – 19.78	16.50 ± 0.99		5.98
LP/SL	♂	14.38 – 17.38	16.03 ± 0.72	4.50**	4.42
	♀	13.63 – 17.24	15.54 ± 0.73		4.70
	total	13.63 – 17.38	15.73 ± 0.76		4.83
LV/SL	♂	8.15 – 15.76	12.87 ± 1.15	5.20**	8.88
	♀	6.77 – 14.52	11.89 ± 1.29		10.88
	total	6.77 – 15.76	12.26 ± 1.33		10.81
LC/SL	♂	16.64 – 21.51	19.33 ± 0.97	2.27**	4.89
	♀	14.61 – 20.95	18.98 ± 1.06		5.60
	total	14.61 – 21.51	19.12 ± 1.04		5.39
PD/SL	♂	27.39 – 35.44	31.73 ± 1.13	1.24	3.39
	♀	28.57 – 34.90	31.94 ± 0.98		3.08
	total	27.39 – 35.44	31.86 ± 1.04		3.20
PA/SL	♂	28.92 – 40.70	36.82 ± 1.69	4.08**	4.45
	♀	27.22 – 40.68	37.84 ± 1.59		4.19
	total	27.22 – 40.70	37.45 ± 1.70		4.47

PP/SL	♂	23.65 – 34.18	29.38 ± 1.12	2.83**	3.60
	♀	25.84 – 31.23	28.95 ± 1.00		3.47
	total	23.65 – 34.18	29.12 ± 1.07		3.59
PV/SL	♂	20.33 – 26.20	23.66 ± 1.19	1.14	4.91
	♀	19.82 – 26.60	23.47 ± 1.20		5.10
	total	19.82 – 26.60	23.54 ± 1.19		5.03
H/SL	♂	17.45 – 24.58	20.09 ± 1.51	3.59**	7.44
	♀	16.48 – 26.35	20.96 ± 1.61		7.66
	total	16.48 – 26.35	20.63 ± 1.62		7.83
h/SL	♂	3.99 – 5.28	4.68 ± 0.30	1.35	6.33
	♀	3.87 – 5.42	4.61 ± 0.35		7.49
	total	3.87 – 5.42	4.64 ± 0.33		7.08
O/CL	♂	19.93 – 25.23	22.53 ± 1.27	6.86**	5.65
	♀	18.82 – 24.69	21.18 ± 1.30		6.12
	total	18.82 – 25.23	21.70 ± 1.44		6.65
IO/CL	♂	14.78 – 23.24	19.18 ± 1.53	5.94**	7.96
	♀	17.14 – 25.78	20.60 ± 1.60		7.74
	total	14.78 – 25.78	20.06 ± 1.53		8.54
PO/CL	♂	31.46 – 37.80	35.50 ± 1.12	3.71**	3.17
	♀	32.22 – 40.30	36.16 ± 1.18		3.27
	total	31.46 – 40.30	35.91 ± 1.12		3.34
OLO/CL	♂	40.42 – 46.19	43.46 ± 1.23	7.22**	2.84
	♀	42.24 – 48.97	44.93 ± 1.39		3.09
	total	40.42 – 48.97	44.37 ± 1.51		3.40
h/H	♂	18.40 – 27.19	23.39 ± 1.97	4.17**	8.44
	♀	17.78 – 26.87	22.11 ± 2.04		9.21
	total	17.78 – 27.19	22.60 ± 2.10		9.30

*abbreviations as in Fig. 2
**statistically significant ($t \geq 1.96$; $p \leq 0.05$)

in comparison to maximum body height (h/H) is smaller in larger fish (B = -0.141%; $R^2 = 0.046$).

DISCUSSION

The sex ratio in whiting depends on sampling location, because larger fish prefer deeper waters (COOPER, 1983) and size frequency in the sample, due to sexual dimorphism in growth (BOWERS, 1954). In the Adriatic Sea GIOVANARDI & RIZZOLI (1984) found that in the winter females were dominant in the population (1.18:1.00). However VALLISNERI *et al.* (2006) calculated a sex ratio that did not differ from 1:1. In the Sea of Marmara GÖKSUNGUR & ERDEM (2005) reported that while overall there was 39.13% of females in the population, in groups III and older females were dominant. The same was determined by COOPER (1983) in the area off the west coast of Scotland and by GERRITSEN *et al.* (2003) in the Irish Sea. COOPER (1983) suggested that the metabolic strain is greater in older males leading to higher mortality. This was also true for other gadoids (*Trisopterus minutus* and *T. esmarkii*) (COOPER, 1983). The sex ratio calculated in this study is in accordance with the aforementioned studies, as samples obtained from trawl nets included only fish that were more than 16 cm long.

Table 2. Meristic characters for male (n=120) and female (n=162) whiting, Merlangius merlangus *from the northern Adriatic Sea; SD=standard deviation; V=variability coefficient*

Meristic character	*Sex*	*Range (%)*	*Mean ± SD*	*t*	*V (%)*
No. rays in first dorsal fin	♂	12-15	13.69 ± 0.76	1.06	5.54
D1	♀	12-15	13.82 ± 0.77		5.59
	total	12-15	13.77 ± 0.77		5.57
No. rays in second dorsal fin	♂	16-22	19.00 ± 1.26	0.94	6.62
D2	♀	16-22	18.81 ± 1.28		6.78
	total	16-22	18.89 ± 1.27		6.72
No. rays in third dorsal fin	♂	18-22	19.76 ± 1.07	1.31	5.40
D3	♀	18-22	19.98 ± 1.08		5.40
	total	18-22	19.90 ± 1.08		5.41
No. rays in first anal fin	♂	26-34	30.67 ± 1.88	3.04*	6.12
A1	♀	26-34	29.80 ± 1.83		6.14
	total	26-34	30.13 ± 1.89		6.28
No. rays in second anal fin	♂	19-24	21.49 ± 1.13	0.05	5.24
A2	♀	19-24	21.48 ± 1.08		5.01
	total	19-24	21.48 ± 1.09		5.09
No. rays in pectoral fin	♂	16-21	18.66 ± 1.11	0.98	5.94
P	♀	16-21	18.83 ± 1.12		5.95
	total	16-21	18.76 ± 1.12		5.95
No. rays in ventral fin	♂	6	6.00 ± 0	0	0
V	♀	6	6.00 ± 0		0
	total	6	6.00 ± 0		0
No. branchiospines	♂	16-22	19.05 ± 1.55	0.80	8.12
	♀	16-22	19.22 ± 1.24		6.45
	total	16-22	19.15 ± 1.36		7.11
No. vertebrae	♂	51-53	51.79 ± 0.66	0.45	1.27
	♀	51-53	51.86 ± 0.61		1.18
	total	51-53	51.84 ± 0.63		1.22

*statistically significant ($t \geq 1.96$; $p \leq 0.05$)

Data from this study present the first report on the existence of morphometric variations between male and female whiting other than body length. Many authors (BOWERS, 1954, Irish Sea; GIOVANARDI & RIZZOLI, 1984, Adriatic Sea; ISMEN, 2002, Black Sea) reported that female whiting grow faster, especially after the second year of life. In other gadoids, females that spawn for the first time have lower fecundity and produce smaller eggs (TRIPPEL, 1998) and for reproductive success it is important that females grow bigger (ISMEN, 1995). There is evidence of sexual dimorphism regarding other morphological characteristics in the Gadidae family. For instance, in cod (*Gadus morhua*) males have significantly larger pelvic fins (SKJÆRAASEN *et al.*, 2006) which are used during spawning and male rivalry, and may be the result of sexual selection.

No detailed information on the morphometry

of whiting from the Atlantic Ocean has been found. SVETOVIDOV (1964), BANARESCU (1964) and UNGARO *et al.* (1995) published data on some morphometric relationships in whiting from the Black and Adriatic Seas (Table 3). Data presented by UNGARO *et al.* (1995) has not been included in this table because they expressed all measurements as a percentage of standard length which was, according to the diagram included in that scientific paper, measured differently than in this study. SVETOVIDOV (1964) used total body length for comparison with other morphometric characters so, in order to compare with data from this study, the same relationships were calculated and added to Table 3.

Table 3. Morphometric characters of whiting, Merlangius merlangus *from the Black Sea and northern Adriatic. Abbreviations for the morphometric relationships as in Fig.2.*

Author	BANARESCU 1964	SVETOVIDOV 1964	This study
Area	Black Sea	Black Sea	Adriatic Sea
Sp. or Spp.	*M. m. euxinus*	*M. m. euxinus*	*M. merlangus*
No. of specimens measured	-	-	282
CL/SL	27.3-31.1%	-	23.2-34.6%
CL/TL	24.6-27.1%	23.7-25.8%	22.7-26.9%
LD1/SL	13.8-16.3%	-	10.1-15.0%
LD1/TL	-	12.3-15.8%	9.1-13.7%
LD2/SL	17.9-21.3%	-	16.6-23.5%
LD2/TL	-	17.3-19.9%	15.2-21.6%
LA1/SL	31.2-34.3%	-	29.4-38.8%
LA1/TL	-	29.0-31.6%	27.8-35.5%
LA2/SL	14.4-17.5%	-	14.2-19.8%
LP/SL	17.2-21.6%	-	13.6-17.4%
LP/TL	-	15.4-18.2%	12.5-15.6%
LV/SL	13.0-15.6%	-	6.8-15.8%
LV/TL	-	8.1-11.3%	6.3-14.2%
LC/SL	12.5-13.8%	-	14.6-21.5%
LC/TL	-	10.5-12.5%	13.3-19.4%
PD/SL	30.7-33.8%	-	27.4-35.4%
PD/TL	-	27.6-30.2%	26.1-32.2%
PA/TL	-	35.6-38.2%	27.2-40.7%
H/SL	17.2-21.6%	-	16.5-26.4%
H/TL	15.4-19.5%	-	15.0-24.3%
O/CL	20.1-25.8%	22.8-26.5%	18.8-25.2%

All ranges for morphometric relationships overlap, except for caudal and pectoral fin lengths. Caudal fin length is significantly smaller in studies from the Black Sea; however, this can probably be attributed to different measuring points. Pectoral fin length was, in the present study, less than 17.4% of standard, or 15.6% of total, body length, while BANARESCU (1964) and SVETOVIDOV (1964) reported that in the whiting from the Black Sea it is more than 17.2% of

standard, or 15.4% of total, body length. Some authors (SVETOVIDOV, 1986; UNGARO *et al.*, 1995) suggested that whiting subspecies could be differentiated by the pectoral fin to body length ratio. According to SVETOVIDOV (1986) in *M. m. merlangus* the pectoral fin is 13.8-15.6% of body length and in *M. m. euxinus* 15.4-18.2%. From this it can be concluded that the Adriatic whiting population is different from the Black Sea whiting and similar to the *M. m. merlangus* from the Atlantic Ocean. UNGARO *et al.* (1995) also noted that in the sample from the Black Sea (15 specimens measured) the pectoral fin was significantly longer than in the sample of Adriatic whiting (33 specimens measured). They found that two samples also statistically differed in head length, preocular length, eye diameter and length of second dorsal fin. Authors discussed whether these differences could be attributed to the spatial segregation of whiting in the areas considered, with the southern Adriatic and the Ionian Seas, with higher salinities and average temperatures, representing ecological barriers.

Other authors presented only some morphometric relationships for the whiting from the Adriatic Sea. BINI (1970) calculated that total length was 5-6 times the maximum height of Adriatic whiting, and similar values were found in this study (4.1-6.7, average 5.4), with larger variation probably due to our bigger sample. The same author reported the total length to head length (3.5-4.0) and head length to eye diameter ratio (4.0-4.5), which in our study were 3.7-4.4 (average 4.0) and 4.0-5.3 (average 4.6), respectively. JARDAS (1996) and TORTONESE (1970) reported that standard length was 4.5-5.0 times the maximum height, but in the present study it was 3.8-6.1 (average 4.8). JARDAS (1996) also reported that standard length to head ratio was 3.5 (this study 3.4-4.1, average 3.6). It is difficult to draw any conclusions from this data as sample size is different and values in the cited literature were obviously approximated. Still, the larger ranges in the present study could be the result of a larger sample or larger specimen length range.

Meristic characters of the whiting were compared with published data from the Adriatic and other Seas (Table 4). Cited literature is mostly based on books that describe fauna of certain areas, with the exception of a scientific paper by UNGARO *et al.*, 1995. Therefore there are no sample sizes or exact research areas defined. In this review it can be noted that the Adriatic population of whiting is sometimes named as the subspecies *M. m. merlangus*, and other times *M. m. euxinus*. Moreover, some authors described populations from Adriatic and Black Sea as one, although UNGARO *et al.* (1995) later showed that they differ in morphometric and meristic characteristics.

The most conservative meristic character measured in whiting was the number of rays in the ventral fin, which is reported to be 6 by all authors. Only BANARESCU (1964) noted that there may also be 7 rays.

The number of rays in the pectoral fin is defined by only three authors (BANARESCU, 1964; BINI, 1970; JARDAS, 1996) and it varies from 19 to 21. In this study the range is greater, from 16 to 21 rays.

The numbers of rays in the first and third dorsal and second anal fins are reported to be similar by all authors, including this study.

In whiting there are between 51 and 54 vertebrae. However, BANARESCU (1964) and SVETOVIDOV (1986) noted that in the Atlantic population this number can be bigger (53-57).

The number of gillrakers is mostly found to be from 20-23, except for SVETOVIDOV (1986) who stated that in the Atlantic population this number is from 19-26, contrasting with the present study where this range was lower, from 16-22.

The most variable meristic characters in whiting are the numbers of rays in the second dorsal and first anal fins. Two groups of data can be identified from Table 4. The first group can be characterized by 16-19 rays in the D2 fin and 28-32 rays in the A1 fin, and it includes whiting from the Black Sea (BANARESCU, 1964; SVETOVIDOV, 1964; 1986; TORTONESE, 1970) and from the Adriatic Sea (SVETOVIDOV, 1986; TORTONESE, 1970; JARDAS, 1996). The second group is described by having 18-23 (25) rays in the D2 fin and 30 – 35 (36) rays in the A1

Table 4. Meristic characters of whiting, Merlangius merlangus *from the Atlantic, Mediterranean with Black Sea, and the Adriatic*

Author	Area	Sp. or Spp.	No. of specimens measured	D1	D2	D3	A1	A2	P	V	Brsp.	Vert.
BANARESCU 1964	Black Sea	*M. m. euxinus*	-	14-17	16-19	18-22	28-32	19-22	20-21	6(7)	20-23	53
	Atlantic and Adriatic	*M. m. merlangus*	-	12-15	18-25	19-22	30-35	21-23	-	-	20-23	53-57
SVETOVIDOV 1964	Black Sea	*M. m. euxinus*	-	14-17	16-19	18-22	28-32	19-22	-	-	20-23	53
TORTONESE 1975	Adriatic and Black Sea	*M. m. euxinus*	22	13-17	16-19	18-22	28-32	19-22	-	-	-	52-53
	Atlantic	*M. m. merlangus*	-	13-17	18-23	18-22	30-35	19-22	-	-	-	-
BINI 1970	Adriatic	*M. m. merlangus*	-	12-16	18-25	19-22	30-36	21-23	19-20	6	-	-
SVETOVIDOV 1986	Adriatic and Black Sea	*M. m. euxinus*	-	14-17	16-19	18-22	28-32	19-22	-	-	20-23	51-54
	Atlantic	*M. m. merlangus*	-	12-15	18-25	19-22	30-35	21-23	-	-	19-26	53-57
UNGARO *et al.* 1995	Adriatic	*M. merlangus*	33	10-16	14-21	14-20	22-29	13-21	-	-	-	-
	Black Sea	*M. merlangus*	15	13-16	14-18	15-19	23-32	14-20	-	-	-	-
JARDAS 1996	Adriatic	*M. merlangus*	-	14-17	16-19	18-22	18-32	19-22	19-20	6	20-23	-
Present study	Adriatic	*M. merlangus*	282	12-15	16-22	18-22	26-34	19-24	16-21	6	16-22	51-53

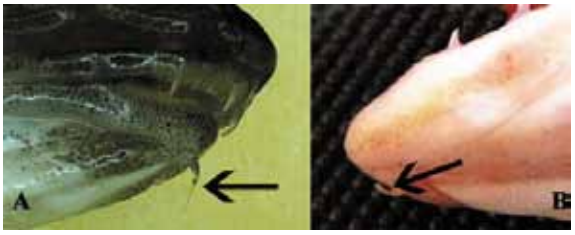

Fig. 4. Barbel on the chin of whiting, Merlangius merlangus*: A –from the Black Sea, B – from the Adriatic Sea*

fin. This group includes Atlantic (BANARESCU, 1964; TORTONESE, 1970; SVETOVIDOV, 1986) and Adriatic whiting (BINI, 1970; BANARESCU, 1964). The problem is that although Atlantic and Black Sea populations can be differentiated, the Adriatic population is, depending on the author, assigned to both groups. The number of rays in the D2 and A1 fins from this study show higher variability which can be attributed to a larger number of specimens analysed. This result could also be interpreted as intermediate between Atlantic and Black Sea populations. It is, however, significant that the numbers of rays in the D2 and A1 fins are higher than in the Black Sea whiting described, suggesting that the two populations are different. UNGARO *et al.* (1995) also found that the number of rays in the second dorsal fin is significantly different in the Adriatic and Black Sea whiting.

Most authors note that the subspecies *M. m. merlangus* has no barbel on the chin or it is microscopic (BINI, 1970; TORTONESE, 1970; SVETOVIDOV, 1986: UNGARO *et al.*, 1995), and also that the subspecies *M. m. euxinus* has a barbel visible to the naked eye. Only UNGARO *et al.* (1995) measured its length in *M. m. euxinus* and found that it is longer than 2mm (Fig. 4A.). In the present study the barbel was visible but smaller than 2mm (Fig. 4B.).

CONCLUSIONS

This study showed the existence of morphometric differences between sexes and sexual dimorphism in whiting; however, the investigated characters are not sufficient to discriminate sex for each specimen due to relatively large overlap in their range. Differences in meristic and morphometric characters between whiting populations in the Atlantic Ocean, Black Sea and the Adriatic exist and could be the result of spatial segregation and different environmental conditions. Data from this study suggest that the population of whiting from the Adriatic Sea is different from the Black Sea population. Further research is required to determine the status of subspecies of whiting and their area of distribution. The phylogeny of this species should be investigated through genetic analysis techniques, which are less prone to subjective interpretation.

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Analiza biometrijskih svojstava pišmolja, *Merlangius merlangus* (Linneaus, 1758) iz sjevernog Jadrana

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Analizirana su biometrijska svojstva na 282 jedinke pišmolja, *Merlangius merlangus* (Linneaus, 1758), iz sjevernog Jadrana. Ukupna je dužina svih jedinki bila od 16.6 do 33.7 cm. Izmjerena je dvadeset i jedna morfometrijska značajka i devet merističih značajki. U 15 morfometrijskih i jednoj merističkoj osobini (broj šipčica prve analne peraje) je uočeno postojanje spolnog dimorfizma kod ove vrste. Usporedbom svih morfoloških značajki sa standardnom dužinom tijela i dužinom glave je izračunat relativni rast. Dobiveni rezultati predstavljaju prvi potpuni opis ove vrste u Jadranskom moru, te su uspoređeni s ostalim dostupnim biometrijskim podacima o njoj. Pomoću dosadašnjih spoznaja o biometriji ove vrste, nije bilo moguće u potpunosti razlikovati jadransku populaciju od onih iz ostalih područja.

Ključne riječi: *Merlangius merlangus*, biometrija, Jadransko more