Turkish Journal of Fisheries and Aquatic Sciences 6: 85-91 (2006)

Morphological properties of Horse mackerel, *Trachurus mediterraneus ponticus* Aleev, 1956 (Osteichthyes: Carangidae) from the Black Sea

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Received 18 April 2005
Accepted 24 May 2006

Abstract

Thirty two morphometrics and seven meristic characteristics were examined to evaluate the subpopulations from Varna Bay and Cape Igneada (Turkey, Black Sea coast) in 200 samples of horse mackerel (*Trachurus mediterraneus ponticus*).

Morphological differences between two samples were marked. The differences between samples from Varna Bay and Cape Igneada (Turkey) were possible due to diversities in the habitat. Difference coefficient of transgression in all of examined parameters was found less than 1.28. Some morphometric changes occurred as the total body length increased in the sample from Cape Igneada. There is not enough evidence to distinguish two different horse mackerel subpopulations.

Key words: morphometric, meristic analysis, *Trachurus mediterraneus*, Igneada, Varna, Black Sea

Introduction

The horse mackerel (*Trachurus mediterraneus ponticus* Aleev, 1956) is distributed in the Mediterranean, Azov Sea and Black Sea (Stoyanov *et al.*, 1963). Georgiev and Kolarov (1962) stated that this species is of great significance for Bulgarian Black Sea fishing.

The recent years' annual landings fluctuated from 1100.9 to 141.5 tons from 1989 to 2002 (Michailov and Prodanov, 2003).

The biology of this species has been well documented for the Black Sea (Maximov, 1913; 1914; Tihonov *et al.*, 1955). However, the morphometric and meristic characteristics have not yet been systematically studied.

The Black Sea horse mackerel is the subspecies of the Mediterranean horse mackerel, *Trachurus mediterraneus.* Aleev (1957; 1959) considers that in Black Sea, the species is represented by four local subpopulations: the south side of Crimean, the northern side of Crimean, the eastern (Caucasian) and the southern (Anatolian) each one with its own biological characteristics.

Some data on individual meristic characters (Cautis, 1966; 1979) in the western and north-western part of the Black Sea are available, but data on their morphometrics are very scarce (Cautis and Jonescu, 1979).

Dobrovolov and Dobrovolova (1983), using electrophoresis methods, assumed that no difference at species level can be found between *Trachurus mediterraneus ponticus* and *Trachurus mediterraneus mediterraneus*.

For this reason according to Dobrovolov (1986), the occurrence of large size type can be explained as a result of heterosis effect between the above mentioned subspecies.

This type being sterile does not produce further offspring, and became extinct after completing its life span.

According to Prodanov *et al.* (1997), the Black Sea horse mackerel represent a single population, as the environmental conditions are almost one and the same in the whole area inhabited, and there exists no positive evidence for the occurrence of two distinct subpopulations differing substantially in their biological parameters.

The goal of this paper is to investigate morphological properties of the Black Sea horse mackerel populations from two different habitats (Varna Bay and Cape Igneada) by analyzing morphometric and meristic characters.

Materials and Methods

Fish were collected in year of 2003 from two trawling grounds in the Black Sea: 100 specimens from Varna Bay and 100 specimens from Turkey Black Sea coast (Cape Igneada) (Figure 1).

The total body length (ab) of the first sample ranged from 11.7 to 15.0 cm. The total body length of second sample ranged from 12.2 to 17.4 cm. The samples were categorized into centimeter length classes.

Morphometric and meristic characters

Biometric measurements were performed on fresh fish. Thirty two morphometrics and seven meristic body characters were examined (Pravdin, 1966). The analyzed morphometrics and meristic characters are presented on Figure 2 and on Table 1, respectively.

The total and standard lengths were measured to the nearest 0.1 cm. The rest of the morphometric characters were measured to the nearest 0.01 mm. Measurements of the head were expressed as percentages of the head length whereas other body measurements were expressed as percentages of the standard length. The standard length was expressed as a percentage of the total length (ac/ab) and the minimum height was expressed as a percentage of the maximum body height (ik/gh).

Statistical analysis

Arithmetic means, standard deviations and variability coefficients were used to process the numerical data. The significance of differences in the studied characters between sample of Varna Bay and sample of Cape Igneada was tested with t - test (Sokal and Rohlf, 1981).

In the present paper, significant results at the 95% probability level tell us that our data is good enough to support a conclusion with 95% confidence. It was agreed P = 0.05 level of significance as being reasonable.

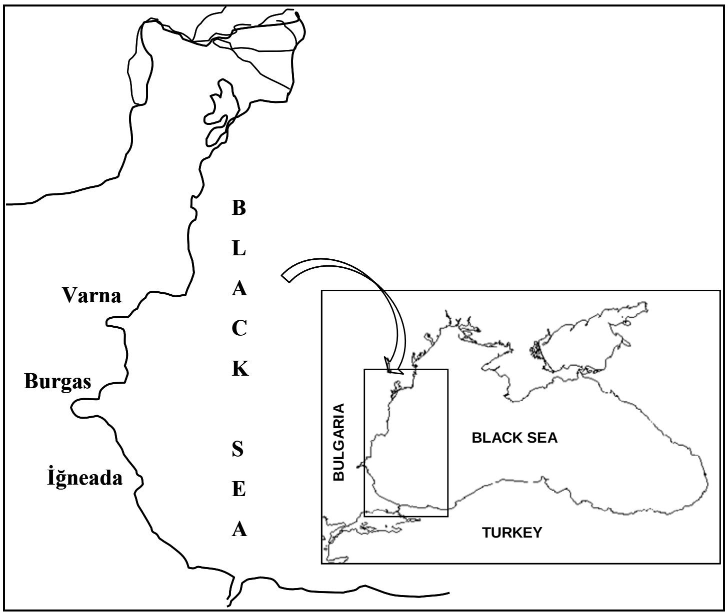

Figure 1. Location of the sampling stations.

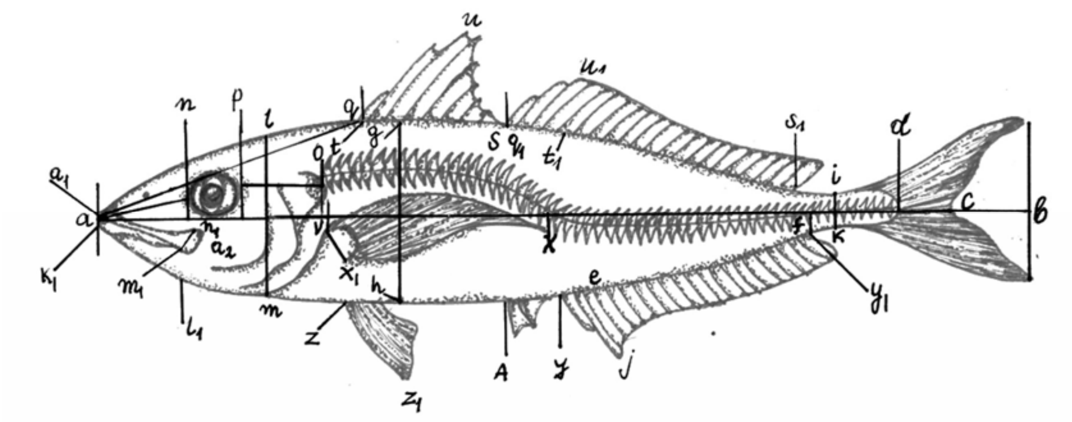

Figure 2. Stylized drawing of body proportions measured on horse mackerel :
ab-total length; ***ac***-fork length; ***ad***-standard length; ***od***-body length; ***an***-preorbital length; np-orbital diameter; **po**-postorbital distance; ***ao***-length head; ***lm***-height head ; a_1a_2- maxilla length; n_1m_1-maxilla width; k_1l_1- mandible length; ***gh*** -maximum body height ; ***ik*** -minimum body height; ***aq*** -pre-anterior dorsal length; ***rd*** -postdorsal length; ***az*** -prepectoral length; ***ay***-pre anal length; ***fd*** -distance of tail basis; ***qs*** -first part of dorsal fin length; q_1s_1-second part of dorsal fin length; ***tu*** -maximum height first part of dorsal fin; t_1u_1-maximum height second part of dorsal fin; yy_1-anal fin length ; ***ej*** -maximum anal fin height; ***vx*** -pectoral fin length(P); vx_1-pectoral fin width; zz_1-ventral fin length; ***vy*** -distance between P and A ; ***zy*** -distance between ventral and anal fin; ***ay*** -distance between anus and anal fin fin; sq_1-distance between ***qs*** and qs_1.

Table 1. Relative relationship of measured body proportions of horse mackerel from Black Sea coast of Turkey (Cape Igneada) and Bulgarian Black Sea coast (Varna Bay)

Body Proportions	Sample	Range	x±SD	Δ *x*	*t*	*V* (%)	Δ *V*
ac / ab	1*	84.96 - 94.08	88.24±0.2033	0.89	3.07	4.13	0.20
	2*	85.61-97.52	89.13±0.2081			4.33	
ao / ac	1	19.61-27.62	25.15±0.1825	1.34	4.48	3.33	2.24
	2	19.83-28.57	26.49±0.2359			5.57	
ad / ac	1	67.97-76.73	71.22±0.4815	1.43	1.29	3.33	0.91
	2	66.95-78.96	72.65±0.3682			4.24	
od / ac	1	59.85-77.40	67.44±0.3281	0.75	1.63	5.76	0.23
	2	63.12-75.96	68.19±0.3245			5.53	
an / ao	1	26.83-34.25	32.46±0.4571	0.75	5.82	10.8	0.20
	2	30-40	33.21±0.4540			10.6	
np / ao	1	20.83-30.5	27.32±0.3977	0.67	4.07	3.25	1.16
	2	19.51-29.5	26.65±0.4098			4.41	
po / ao	1	33.25-43.81	37.57±0.4869	0.79	1.93	5.55	0.89
	2	34.15-44.33	38.36±0.4069			6.44	
lm / ao	1	64.52-76.23	72.11±0.7740	1.65	3.93	5.15	0.45
	2	65.77-74.11	70.46±0.7927			4.7	
a_1a_2 / *ao*	1	27.03-34	31.26±0.4219	0.59	4.8	7.8	1.84
	2	29.05-33.17	30.67±0.3599			5.96	
n_1m_1 / *ao*	1	9.76-14.75	13.31±0.1987	1.29	4.47	3.95	0.46
	2	11.43-16.83	14.60±0.2102			4.41	
k_1l_1 / *ao*	1	29.73-31	30.48±0.4169	1.13	3.08	3.33	1.91
	2	28.26-30.5	29.35±0.4556			5.24	
gh / ac	1	15.78-26.02	20.46±0.1694	0.87	3.39	2.87	0.77
	2	16.8-26.01	21.33±0.1908			3.64	
ik / ac	1	2.61-6.57	3.55±0.0634	0.29	3.35	0.40	0.17
	2	3.10-5.08	3.84±0.0478			0.23	
aq / ac	1	26.45-44.25	33.39±0.3856	1.38	3.12	10.8	0.21
	2	26.77-37.39	32.01±0.2157			10.6	
rd / ac	1	31.96-40.08	36.51±0.5652	0.4	3.10	9.57	0.42
	2	33.89-40	36.91±0.3095			9.99	
az / ac	1	25.6-35.25	32.95±0.1409	0.42	6.86	4.58	0.40
	2	26.67-36.87	33.37±0.3225			4.98	
ay / ac	1	32.65-43.37	34.94±0.5625	0.99	4.40	6.46	0.14
	2	33.8-44.60	35.93±0.3802			6.32	
fd / ac	1	23.06-33.62	29.17±0.3085	1.06	2.67	6.32	3.20
	2	23.28-38.66	30.23±0.2027			9.52	
qs / ac	1	8.33-15.28	13.64±0.1727	1.86	7.01	4.11	1.13
	2	12.20-20	15.50±0.2683			2.98	
q_1s_1 / *ac*	1	8.33-19.24	13.61±0.2683	1.6	4.49	7.2	1.7
	2	10.83-24.11	15.21±0.2343			5.5	
tu / ac	1	8.33-16.94	12.58±0.1599	1.61	7.58	2.56	0.59
	2	10.66-18.8	14.19±0.1402			1.97	
t_1u_1 / *ac*	1	9.42-16.28	12.47±0.1192	0.9	4.88	1.42	0.59
	2	8.85-16.52	13.37±0.1416			2.01	
yy_1 / *ac*	1	11.71-27.27	17.20±0.2906	1.54	3.54	8.44	2.09
	2	11.21-26.83	15.66±0.3245			10.5	
jA / ac	1	6.80-16.22	11.46±0.1695	0.84	4.11	1.34	1.58
	2	9.45-15.32	12.30±0.1159			2.92	
vx / ac	1	18.85-26.81	23.36±0.1709	1.4	5.69	2.92	0.17
	2	16.81-25.44	21.96±0.1758			3.09	
vx_1 / *ac*	1	2.04-5.32	3.91±0.0614	0.05	0.59	0.38	0.15
	2	3.15-5.22	3.86±0.0478			0.23	
zz_1 / *ac*	1	12.07-17.12	14.35±0.099	0.04	0.19	0.99	1.04
	2	11.97-18.42	14.39±0.1424			2.03	
vy / ac	1	22.86-29.46	25.95±0.1284	2.4	7.95	1.64	5.82
	2	21.14-34.51	28.35±0.2732			7.46	
zy / ac	1	15.86-25.23	21.40±0.1651	3.0	9.3	2.73	4.94
	2	18.25-30.97	24.40±0.2769			7.67	
Ay / ac	1	2.13-4.55	3.390±0.0444	0.29	4.67	0.19	0.01
	2	2.70-4.63	3.677±0.0424			0.18	
sq_1 / *ac*	1	2.48-5.32	3.33±0.054	0.21	3.13	0.30	0.17
	2	3.01-4.32	3.54±0.036			0.13	

1* - Igneada; 2* - Varna.

Coefficient of difference CD (Mayr *et al*., 1956), which indicates transgression of the indication values of fishes from two samples, was also applied:

$$CD = \frac{\bar{x}_1 - \bar{x}_2}{S_{n_1} + S_{n_2}}$$

$\bar{x}_1, \bar{x}_2$ -Mean values; S_{n_1}, S_{n_2} - standard deviations

$CD < 1.28$ - Transgression is lower than 10% i.e., there are not two subspecies.

$CD = 1.28$ - Transgression is 10% i.e., it is possible to be two subspecies.

$CD > 1.28$ - Transgression is higher than 10% i.e., there are two subspecies.

Linear regression was used to examine the morphometric changes occurring with the increasing total length (Jardas *et al*., 2003).

Results

Comparison of the morphometric characteristics between two samples examined distinctively indicates statistically significant differences between most of the mean values, with exception of *ik*/*ac*; vx_1/ac; zz_1/ac; *Ay*/*ac*; sq_1/ac indication with small Δx values (Table 1).

Linear regression coefficient indicates that pectoral fin width vx_1 in both samples increases as a percentage from standard body length (vx_1/ac) (Table 2). Relative increase in *vy*/*ac* and in *zy*/*ac* from Varna Bay sample was observed. The closest statistical significances of differences in relationship were of the distance between *P* and *A,* and fork length (*vy*/*ac*) and distance between ventral and anal fin and fork length (*zy*/*ac*).

The variability coefficient of morphometrics relationship of sample from Varna Bay and sample from Turkey Black Sea coast (Cape Igneada) was relatively high.

There were insignificant differences in meristic characters between two samples (Table 3).

Discussion

The coefficient of linear regression in sample from Cape Igneada indicates that smaller specimens have a longer head (*ao*/*ac*) and longer post orbital distance (*po*/*ao*).

As to other morphometric relationships, smaller specimens of Varna Bay have bigger preorbital (*an*/*ao*) and postorbital (*po*/*ao*) distances and a smaller eye diameter (*np*/*ao*) than larger specimens of Igneada.

In previous investigations on *g.Trachurus* in the middle Adriatic Sea (Jardas *et al*., 2003), showed that specimens with smaller preorbital and postorbital distance have a bigger eyes diameter. The preorbital and postorbital distances increase as the size of the horse mackerel increases (Jardas *et al*., 2003).

Data from the literature on morphometric relations are comparable since they refer to total body length**.** Banarescu (1964) reported that the head constitutes 25% of the total body length in horse mackerel from the Black Sea. We determined that the head makes up 26.49% of the standard body length in sample of Varna Bay and 25.15% of the standard body length in sample of Cape Igneada. According to Stoyanov *et al.* (1963), eye diameter *np*/*ao* consists of 23.5-31.2% of the head length. In the present study, it was found that eye diameter in sample of Varna Bay is 19.51-29.5% and in sample from Igneada is 20.83-30.5% of the head length (Table 1).

In the sample of Igneada, we established that predorsal distance *aq*/*ac* is elongated and it is within the limits of 26.45-44.25%. It has been experimentally established that the body size increases in passing into waters with less salinity and higher temperature from the initial. Visceral part of the body shortens to a smaller extent in comparison with posterior part (Stoyanov, 1953).

Comparison of two samples showed relatively high values of t-test. Student t-test does not explain the morphological differences, i.e. very often shows differences in specimens that belong to one and the same subspecies.

CD coefficient of Mayr *et al*. (1956) was applied to evaluate differences between two subpopulations due to inefficiency of t-test.

Values of CD coefficient of transgression vary from 0.042 to 0.679, i.e., all of the indications were below critical value 1.28, which is significant that specimens from two samples do not belong to different subpopulations (Table 4). V% was used as relatively distraction measure. Coefficients of variation for most of the indications are less than 10%, which speaks for a small distraction i.e. examined samples are relatively homogeneous.

Meristic characters of horse mackerel were compared with data from literature (Table 5). Variations in the range of branched rays in dorsal (D) and anal (A) fins were small. Aleev (1957) found 26-34 branched rays in dorsal (D) and 21-31 branched rays in anal (A) fins.

The mean number of branchiospines (53), recorded by Stoyanov *et al*. (1963) is very close to the number recorded in the present study (52.5). The significance of the difference of scales of lateral line is difficult to establish since only ranges are reported in the literature (Jardas *et al*., 2003). Stoyanov *et al.* (1963) found that number of scales in the lateral line in horse mackerel from the Black Sea ranged (68-76), average 72. These data are in agreement with our results: range (66-74), mean 70.

Table 2. Regression (a, b) and determination coefficient (R^2) of linear regression

Body Proportions	Sample Place	Linear Regression		
		a	b	R^2
ac / ab	Igneada	88.242	0.0044	0.9547
	Varna	88.477	0.013	0.9451
ao / ac	Igneada	26.639	-0.0081	0.8913
	Varna	24.72	0.0086	0.9112
ad / ac	Igneada	91.241	0.0155	0.9422
	Varna	92.826	0.072	0.9641
od / ac	Igneada	66.768	0.0104	0.9255
	Varna	67.853	0.0066	0.9286
an / ao	Igneada	35.922	0.024	0.9480
	Varna	41.584	-0.0273	0.8871
np / ao	Igneada	27.412	0.0107	0.9525
	Varna	31.044	0.0277	0.9569
po / ao	Igneada	42.067	-0.0031	0.9475
	Varna	45.95	-0.071	0.9655
lm / ao	Igneada	70.506	0.0376	0.9711
	Varna	73.78	0.0531	0.9547
a_1a_2 / *ao*	Igneada	34.908	0.0306	0.9847
	Varna	38.052	0.036	0.9854
n_1m_1 / *ao*	Igneada	13.283	0.0066	0.9874
	Varna	15.119	-0.0103	0.9899
k_1l_1 / *ao*	Igneada	38.113	0.0374	0.9511
	Varna	43.326	0.0083	0.9584
gh / ac	Igneada	19.86	0.0104	0.9614
	Varna	20.292	0.0206	0.9658
ik / ac	Igneada	3.5028	0.0019	0.9544
	Varna	3.6609	0.0036	0.9521
aq / ac	Igneada	33.392	-0.0098	0.9145
	Varna	31.278	0.0146	0.9251
rd / ac	Igneada	42.586	-0.0107	0.8847
	Varna	40.29	0.0045	0.9256
az / ac	Igneada	30.279	0.0188	0.9325
	Varna	33.24	0.0026	0.9522
ay / ac	Igneada	50.929	0.0249	0.9411
	Varna	54.841	0.0017	0.9518
fd / ac	Igneada	28.487	0.0121	0.9647
	Varna	29.008	0.0242	0.9652
qs / ac	Igneada	12.92	0.0164	0.8755
	Varna	15.05	0.089	0.8956
q_1s_1 / *ac*	Igneada	12.537	0.0186	0.9121
	Varna	15.329	-0.0024	0.9156
tu / ac	Igneada	11.961	0.0142	0.8847
	Varna	13.809	0.0076	0.8911
t_1u_1 / *ac*	Igneada	11.941	0.0097	0.9244
	Varna	12.387	0.0194	0.9314
yy_1 / *ac*	Igneada	16.387	0.0004	0.9655
	Varna	13.357	0.0456	0.9611
jA / ac	Igneada	11.107	0.0077	0.9477
	Varna	11.811	0.0097	0.9481
vx / ac	Igneada	23.43	-0.0027	0.9623
	Varna	21.333	0.0125	0.9712
vx_1 / *ac*	Igneada	4.0043	-0.0012	0.9541
	Varna	3.9606	-0.0019	0.9518
zz_1 / *ac*	Igneada	14.186	0.0018	0.9366
	Varna	13.858	0.0105	0.9381
vy / ac	Igneada	25.629	0.0152	0.9111
	Varna	29.73	-0.0272	0.9521
zy / ac	Igneada	20.908	0.0198	0.9562
	Varna	26.385	-0.0393	0.9554
Ay / ac	Igneada	3.3827	0.0015	0.9422
	Varna	3.5559	0.0024	0.9514
sq_1 / *ac*	Igneada	3.334	0.001	0.9471
	Varna	3.4425	0.0019	0.9628

Table 3. Meristic characters of horse mackerel for sample from Cape Igneada and Varna Bay

Body Proportions	Sample	Range	x±SD	Δ x	t	V (%)	Δ V
D	Igneada	26-34	30.11±0.8841	0.01	0.08	2.48	0.28
	Varna	26-34	30.12±0.8522			2.20	
A	Igneada	21-31	26.44±0.6851	0.15	0.59	2.39	0.16
	Varna	21-31	26.59±0.7214			2.55	
P	Igneada	16-22	19.25±0.5219	0.02	0.34	2.53	0.17
	Varna	16-22	19.23±0.7615			2.36	
V	Igneada	6	6.00±0	0	0	0	0
	Varna	6	6.00±0			0	
Brsp (total)	Igneada	45-60	52.50±0.7436	0.02	0.61	2.52	0.25
	Varna	45-60	52.52±0.7586			2.77	
L.lat.	Igneada	66-74	70.22±1.014	0.01	0.29	3.56	0.32
	Varna	66-74	70.23±0.9613			3.88	
Vert.	Igneada	24	24.00±0	0	0	0	0
	Varna	24	24.00±0			0	0

Explanations: D – number of rays in dorsal fin; A – number of rays in anal fin; P – number of rays in pectoral fin; V – number of rays in ventral fin; Brsp – total number of branchiospines; L.lat – number of scales of linea lateralis; Vert. – number of vertebrae.

Table 4. Coefficient of transgression (CD) calculated for relative indexes

Indexes	CD	Indexes	CD
ac / ab	0.217	*az / ac*	0.521
ao / ac	0.319	*ay / ac*	0.317
ad / ac	0.093	*fd / ac*	0.190
od / ac	0.115	*qs / ac*	0.497
an / ao	0.411	q_1s_1 / *ac*	0.318
np / ao	0.287	*tu / ac*	0.537
po / ao	0.137	t_1u_1 / *ac*	0.346
lm /ao	0.278	yy_1 / *ac*	0.251
a_1a_2 / *ao*	0.482	*jA / ac*	0.296
n_1m_1 / *ao*	0.316	*vx / ac*	0.402
k_1l_1 / *ao*	0.430	vx_1 / *ac*	0.042
gh / ac	0.240	zz_1 / *ac*	0.013
ik / ac	0.260	*vy / ac*	0.60
aq / ac	0.229	*zy / ac*	0.679
rd / ac	0.443	*Ay / ac*	0.330
		sq_1 / *ac*	0.226

Table 5. Meristic characteristic of horse mackerel from Black Sea

Black Sea	D	A	P	V	L.lat.	Brsp.	Vert.
Svetovidov (1964)	VIII + I/28-34	II+I/25-29	-	-	68-76	-	24 (10+14)
Banarescu (1964)	VIII (IX) + I/28-35	II+I/26-30	-	-	69-79	-	24 (10+14)
Stoyanov *et al.* (1963)	VIII (IX) + I/28-32	II+I/25-29	-	-	68-76	45-61	24 (10+14)
Present study							
Cape Igneada	VII (IX) + I/26-34	II+I/21-31	16-22	6	66-74	45-60	24 (10+14)
Varna Bay	VII (IX) + I/ 26-34	II+I/21-31	16-22	6	66-74	45-60	24 (10+14)

We found the same number of vertebrae in sample of Varna Bay and Cape Igneada and these data are in agreement with results from previous studies (Table 3).

In the present study, it was established that there are no significant meristic differences between the horse mackerel population in the Bulgarian Black Sea coast and horse mackerel inhabit in the territorial waters of Turkey. All of the morphological differences are possible due to variability of the habitat and sample size of this study.

On the basis of examined biometric indexes, there was not enough evidence to distinguish two different horse mackerel subpopulations in terms of presented study.

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