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MORPHOMETRIC AND MERISTIC CHARACTERS FOR AXILLARY SEABREAM *PAGELLUS ACARNE* FROM ANTALYA GULF (MEDITERRANEAN-TURKEY)

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ABSTRACT

Objective: The present study reports morphometric and meristic characteristics for *Pagellus acarne* caught by trawl from the Antalya Gulf (Mediterranean-Turkey). In addition, length-weight relationships are also estimated and compared with those estimated from other areas.

Methods: Individuals of *P. acarne* were collected during September - December 2011 from trawl surveys conducted in the Antalya Gulf (Mediterranean-Turkey). Morphometric characters were measured directly on the fish body (15 characteristics) and head (7 characteristics). Meristic characters were counted. Length-weight relationship was calculated using the equation $W = aTL^b$.

Results: Throughout the study period, a total of 360 specimens of *P. acarne*, ranging in size from 8.9 to 26.7 cm in total length and from 7.7 to 275 g in total weight, were collected. The length-weight relationship for all individuals was described by the parameters a = 0.0057 and b = 3.29. According to TL, from the twenty one morphometric characters, thirteen showed allometric growth, while eight showed isometric growth. The proportions of the examined morphometric characters ranged from 0.02 (for the lenght of the base of pelvic fin) to 0.51 (for the preanal distance).

Conclusion: The morphometric characters have shown strong correlation with TL. Length-weight relationship indicated that *P. acarne* populations exhibit positive allometric growth (weight increased allometrically with length).

1. Introduction

Pagellus acarne (Risso, 1827) (axillary seabream) is a widely distributed Sparidae species. Its distribution area encompasses both hemispheres, from Scandinavia to Senegal and Angola (1). The species shows relative importance in trawl catches along the entire Mediterranean (1, 6).

Growth, reproduction and ecological characteristics of axillary seabream have been documented throughout its geographical range (1-10). There are some studies conducted on biology of *Pagellus acarne* in Turkey. Akmirza (2013) determined monogenean parasites of this species (11). Soykan et al. (2015) studied growth of axillary seabream in east-central Aegean Sea (12). Oztekin et al. (2015) examined amino acid composition of this species caught from Dardanelles (13). Ilhan (2018) investigated the growth and feeding characteristics of this species in the Gulf of Izmir (14). Yedier et al. (2019) determined the length-weight and length-length relationships with condition factor values for *Axillary seabream* from coast of Tekirdağ in the Sea of Marmara (15).

Body size measurements of fish species have important implications for several aspects of fisheries science and fish population dynamics (16). Morphometric relationships can be very useful in fisheries management and research, especially for improving selectivity of towed gear types and using this information to estimate appropriate sizes and shapes (6).

Studies on the morphometry of axillary seabream are very limited. Wadie et al. (1999) analyzed the morphometric and meristic features of this species in the Egyptian Mediterranean waters (17). Dragicevic et al. (2012) studied the biometric properties of axillary seabream in the Eastern Adriatic basin (18).

Axillary seabream is of great commercial interest and is common in the small-scale fisheries in the Antalya Gulf. Even though few studies have already conducted on morphometric, meristic and length-weight relationship of axillary seabream , there is no report on morphometry of this species from Antalya Gulf. Hence, the current study aimed to describe the morphometric and meristic characteristics of axillary seabream from samples caught in the Antalya Gulf (Mediterranean-Turkey).

2. Material and Methods

Random samples of 360 individuals were collected during September - December 2011 from trawl surveys conducted in the Antalya Gulf (Mediterranean-Turkey). All individuals (preserved frozen) were measured for total length (TL, in cm) to the nearest mm and weighted (W, total wet weight in g) to the nearest 0.01 g. Morphometric characters from a random sub-sample of 50 individuals were measured directly on the fish body (15 characteristics) and head (7 characteristics) (Fig. 1) while counted. Also, the number of spine and soft rays of the dorsal, pectoral, ventral and anal fin (meristic characters) were recorded. Each morphometric character was represented as proportion (p) to TL. The mean values, the standard deviations and the coefficient of variations were

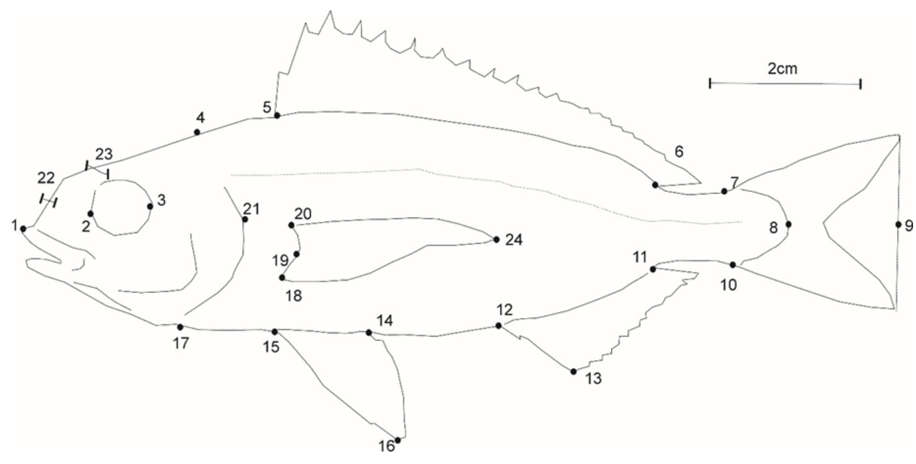

Figure 1. Measurements performed on the body of Axillary seabream specimens.

1-9) Total Length; 1-8) Standard length; 22) Distance of Internostril; 23) Distance of Interorbital; 2-3) Eye diameter ; 4-17) Head height; 1-21) Head length; 1-20) Prepectoral distance; 1-5) Predorsal distance; 1-15) Prepelvic distance; 14-15) Pelvic fin base length; 15-16) Pelvic fin depth; 18-20) Pectoral fin base length; 20-24) Pectoral fin depth; 5-6) Dorsal fin base length; 6-9) Postdorsal distance; 11-12) Anal fin base length; 7-10) Caudal fin depth; 7-9) Caudal peduncle length;1-2) preorbital; 3-21) postorbital estimated. The coefficient of variation (CV%) was computed for each character using the formula:

CV%=100 SD/p where SD is the standard deviation and p is the mean proportion of characters.

Also, in order to identify allometric growth of the morphometric characters in relation to total length (TL), the function $Y= aTL^b$ was calculated, where a and b are constants and Y is each one of the examinated morphometrical characters of fish. When the parameter b is equal to 1 the growth of the character Y in respect to TL is isometric, while when b is lower or higher to 1 value, the growth of the character Y shows negative or positive allomemetric growth in respect to TL, respectively (19). Length-weight relationship (LWR) was calculated using the equation $W = aTL^b$, where a is a coefficient related to body form and b is an exponent indicating isometric growth when equal to 3. When the b value in LWR was equal to 3 or did not show statistically significant deviation from 3, the growth was isometric, whereas the positive or negative allometric growth occurred when the b value deviated significantly from 3. Student's t-test (20) was applied to determine if there was a statistically significant difference between 1 and the value of b for each morphometric character and between 3 and the value of b for weight.

On the arcsine transformed squared ratios of the exanimated morphometric characters $[\mathrm{asin}\,(\sqrt{p})]$ (20) a principal component analysis (PCA) was applied to examine the contribution of each one of the 23 morphometric characters in the configuration of fish shape variance. PCA is a linear dimensionality reduction technique that replaces the original variables with a smaller number of uncorrelated variables (factors: Fi) while maintaining maximum variance and projecting the variables into a lower-dimensionality space. Each factor represents a group of correlated original variables which are uncorrelated by the the others original variables that form the others factors (21). All statistical analyses were performed using SPSS PC ver. 10.

3. Results

The following length–weight relationship for both sexes was calculated: $W=0.0057TL^{3.29}$ ($R^2=0.99$, SEest=0.077; SE b=0.017; n=360), where W is expressed in g and TL in cm. The length–weight relationship showed a positive allometry from the cube law (b>3) (t-test; $P<0.05$).

A sample of 50 individuals of axillary seabream was examined for morphometric and meristic characters. Their total length ranged from 88.85 to 151.55 mm (116.69 ±12.99mm). The summary statistic of the morfometric characters are shown in Table 1. The dorsal fin (D) composed from 12 spines and 12 soft rays (D: XII,12), the pectoral fin from 16-17 soft rays (P:16-17), the ventral fin (V) from 6 soft rays (V:6) and the anal fin (A) from 3 spines and 10 soft rays (A:III,10).

The morphometric characters showed strong correlation with the TL (Table 1: $R^2>0.65$; mean $R^2=0.83$). Out of 21 morphometric characters,13 showed allometric growth according to TL (5 positive and 8 negative allometry) (t-test; $p<0.05$) while 8 morphometric characters showed isometric growth according to TL (t-test; $p>0.05$) (Table 1).

The proportions of the examined morphometric characters ranged from 0.02 (for the lenght of the base of pelvic fin) to 0.51 (for the preanal distance). The CV% values of ratios were low (<10%, mean value 5.57%) (Table 1).

The PCA analysis extracted eight factors with eigenvalues higher than 1, explaining 76.8% of the variance (Table 2). Using a cut-off value of 0.50 for the factor loadings, factor 1 expressed characters associated with the lengthwise body length (pre-fin distances of pecto-ventral fins (P, V, A), head length, eye diameter and pre- and post orbital distances), factor 2 expressed variables associated with the fin height (pectoral and cadual), predorsal and postdorsal distances, factor 3 was associated with the base length of dorsal fin, factor 4 expressed variables associated with body heights (head and trunk), factor 5 was associated with the base length of anal fin and factor 7 with the base length of pectoral fin, respectively.

4. Discussion

The morphometric characters (phenetic characters) derived from the composite effect of genotype and environmental factors are under the influence of natural selection (22).

Table 1. Mean value (Xmean), standard deviation (SD), range, parameter b of the multiplicative equation among the each character (Y) and TL ($Y = a*TL^b$), standard error of b (SEb), t-test value coefficient of determination (R^2) and Coefficient of Variance x100 (CV%) for the morphometric character and their proportion according to TL. "*' marks the statistically significant differences of b from 1, "+" and "-"marked the positive and negative allometric growth respectively, and "0" isometric growth of character according to TL.

					allometric growth respect to TL						Proportions according to TL		
	Morphometric character	Xmean	SD	range	b	SEb	t-test			R^2	Xmean	SD	CV%
1	TOTAL LENGTH (TL)	116.7	12.99	88.85-151.55									
2	BODY DEPTH AT DORSAL FIN	24.52	3.38	17.93-34.58	1.18	0.05	7.31	*	+	0.92	0.21	0.009	4.38
3	PREDORSAL DISTANCE	33.6	3.76	26.62-45.56	0.93	0.05	2.56	*	-	0.86	0.29	0.012	4.21
4	POSTDORSAL DISTANCE	38.02	4.53	28.34-48.98	1.01	0.05	0.29		0	0.88	0.33	0.013	4.05
5	PREPECTORAL DISTANCE	30.85	3.41	23.08-40.8	0.95	0.05	2.15	*	-	0.89	0.26	0.01	3.7
6	PREPELVIC DISTANCE	34.42	3.7	26.69-46.1	0.91	0.05	3.89	*	-	0.88	0.3	0.011	3.78
7	PREANAL DISTANCE	59.55	6.86	46.19-82.82	0.97	0.05	1.46		0	0.9	0.51	0.018	3.48
8	CAUDAL PEDUNCLE DEPTH	7.38	1.01	5.28-9.98	1.15	0.07	4.52	*	+	0.86	0.06	0.003	5.31
9	CAUDAL PEDUNCLE LENGTH	25.94	3.4	18.76-34.08	1.03	0.08	0.71		0	0.77	0.22	0.014	6.21
10	DORSAL FIN BASE LENGTH	45.08	5.32	32.97-57.01	1.05	0.03	3.05	*	+	0.95	0.39	0.01	2.66
11	ANAL FIN BASE LENGTH	15.63	1.72	12.06-19.49	0.88	0.07	3.4	*	-	0.76	0.13	0.008	5.64
12	PECTORAL FIN BASE LENGTH	5.16	0.6	3.76-6.5	0.92	0.08	2.08	*	-	0.75	0.04	0.003	6.05
13	PECTORAL FIN DEPTH	23.93	3.32	15.24-31.74	1.15	0.08	3.58	*	+	0.8	0.2	0.013	6.59
14	PELVIC FIN BASE LENGTH	2.25	0.36	1.7-3.32	1.04	0.13	0.66		0	0.85	0.02	0.002	9.38
15	PELVIC FIN DEPTH	15.67	2.16	11.08-20.45	1.07	0.09	1.65		0	0.75	0.13	0.009	6.95
16	HEAD LENGTH	28.31	2.75	22.02-37.32	0.84	0.03	10.35	*	-	0.94	0.24	0.007	2.91
17	HEIGHT HEAD	21.29	2.53	16.09-29.4	0.99	0.05	0.26		0	0.88	0.18	0.007	3.98
18	EYE DIAMETER	9.53	1.09	7.32-14.04	0.68	0.1	6.31	*	-	0.78	0.08	0.007	8.22
19	İNTERORBITAL	7.01	0.89	4.92-9.73	0.92	0.1	1.59		0	0.63	0.06	0.005	7.98
20	PREORBITAL	8.3	1.08	6.48-11.78	1.04	0.07	1.02		0	0.81	0.07	0.004	5.74
21	POSTORBITAL	11.09	1.24	8.36-13.36	0.89	0.08	2.86	*	-	0.73	0.1	0.006	5.98
22	INTERNOSTRIL	4.12	0.66	2.78-5.87	1.14	0.13	2.16	*	+	0.82	0.04	0.003	9.87

It is certain that parameters related to the allometric type of growth in fishes and the sampling intervals could impose some major limitations for the morphological studies.

In this case, the use of the same period for collected specimens overcomes the problem but the findings are limited to the sampling season. On the other hand, the allometric growth of the most examined characters in the present research (Table 1) might impose limitations in the use of the body proportions for studying morphological relationships of fish species.

The results of the present study on the morphometry were not consistent with previous reports (17, 18). This fact could be attributed to various factors, such as the variability related to season differences in the observed length ranges of the studied specimen and possible differences in the body growth between different geographical areas. However, an important source of the above-mentioned disagreement could be related to the different definition of morphometric characters among the studies. In the present study the morphometric lengths were defined as the natural distances between the two landmarks, while in previous studies (17, 18) the morphometric lengths were defined as the projection of the natural distance between the two landmarks on the defined

Table 2. Results of Principal Components Analysis (PCA) and factor loadings for each morphometric character on the eight extracted PCA factors. With bold marked the important values (cut-off value of ±0.50).

		Factors							
		F1	F2	F3	F4	F5	F6	F7	F8
	Percentage of variance (PV)	0.203	0.135	0.117	0.078	0.070	0.061	0.056	0.048
	Cumulative PV	0.203	0.338	0.455	0.533	0.603	0.663	0.720	0.768
		Factor loadings							
		F1	F2	F3	F4	F5	F6	F7	F8
1	BODY DEPTH AT DORSAL FIN	-0.18	0.25	0.31	**0.73**	0.18	-0.04	0.07	-0.31
2	PREDORSAL DISTANCE	-0.28	**-0.63**	-0.37	0.30	-0.12	-0.26	-0.28	0.05
3	POSTDORSAL DISTANCE	0.40	**0.68**	-0.29	-0.08	0.23	0.17	0.28	0.13
4	PREPECTORAL DISTANCE	**-0.61**	0.09	-0.19	-0.45	-0.15	-0.01	-0.19	-0.34
5	PREPELVIC DISTANCE	**-0.75**	0.27	-0.35	0.07	-0.12	0.00	-0.07	0.04
6	PREANAL DISTANCE	**-0.57**	0.32	-0.35	0.16	0.18	-0.04	0.43	-0.07
7	CAUDAL PEDUNCLE DEPTH	-0.12	0.27	0.28	0.38	-0.35	-0.47	0.20	-0.20
8	CAUDAL PEDUNCLE LENGTH	0.36	**0.65**	-0.22	-0.07	0.13	0.01	-0.09	-0.11
9	DORSAL FIN BASE LENGTH	-0.18	-0.13	**0.81**	-0.26	-0.15	0.08	-0.03	-0.23
10	ANAL FIN BASE LENGTH	-0.31	0.11	0.33	0.09	**-0.60**	0.48	0.18	0.14
11	PECTORAL FIN BASE LENGTH	**-0.57**	-0.01	0.23	-0.20	0.00	-0.24	**0.50**	0.24
12	PECTORAL FIN DEPTH	0.16	**0.73**	-0.20	0.00	-0.26	-0.08	-0.05	-0.14
13	PELVIC FINBASE LENGTH	-0.45	0.17	0.37	0.00	0.46	-0.11	-0.23	0.30
14	PELVIC FIN DEPTH	0.25	0.28	-0.36	0.27	-0.38	-0.03	-0.43	0.11
15	HEAD LENGTH	**-0.73**	0.02	-0.38	-0.03	0.15	0.31	-0.04	0.18
16	HEIGHT HEAD	-0.43	0.02	0.23	**0.54**	0.33	0.35	-0.18	-0.05
17	EYE DIAMETER	**-0.53**	-0.30	-0.38	0.11	-0.09	-0.10	0.12	0.10
18	INTERORBITAL	-0.43	0.40	0.20	0.00	-0.39	-0.16	-0.13	0.41
19	PREORBITAL	**-0.58**	0.11	-0.12	-0.28	0.17	-0.37	-0.11	-0.35
20	POSTORBITAL	**-0.56**	0.28	0.14	-0.18	-0.04	0.39	-0.22	-0.23
21	INTERNOSTRIL	-0.05	0.46	0.45	-0.10	0.22	-0.30	-0.31	0.29

axis of the total length. Despite the usage of natural distances in the current report reduces the comparison ability by past studies, however it provides more morphometric information given that the natural distances embodied a part of body curvature.

The within-species variation of proportion was less evident as indicated by the relative low CV values (CV<10%) for each character and it suggests that the species consists of a phenotypicaly homogeneous group. Moreover, considering that there should be a negative correlation between CV and estimated heritability of morphological characters (23), the relatively low value of CV found in the present study indicates a high heritability for each character. On the other hand, the findings on the meristic characters were in agreement with previous studies (18 and references cited in 18).

Organisms are hypothesized to be constructed from distinct sub-units termed modules that are highly integrated internally and behave quasi-independently during ontogeny and evolution. Modularity is an abstract concept that seeks to capture the various levels and kinds of heterogeneity found in organisms, and it is considered a fundamental aspect of biological organization. A variational module is composed of features that vary together and are relatively independent of other such sets of features (24). In the present study PCA revealed eight variational modules (Table 2: factors) which are related to head, fin and lengthwise dimensions. The variational modules pattern of axillary sea bream body profile shows relative similarity by those of others Perciformes species such as *Sparus aurata* (25) and *Mullus barbatus* (26).

The slope (b) values of the length weight regression of both sexes combined of axillary seabream population was 3.288. The slope (b) values of the length weight regression of both sexes combined in axillary seabream populations were significantly different from 3. Length - weight relationship showed that the axillary seabream populations have an allometric type of growth (weight increased allometrically with length). The b value showed great variation from one population to another in the same species. Differences could be attributed to the combination of one or more of the following factors (27): (a) differences in the number of specimens examined, (b) area/season effect and (c) differences in the observed length ranges of the specimen caught.

The a and b values of axillary seabream in the current study are in the range estimeted in others regions. Based on 34 references it seems that for *Axillary seabream* the value of parameter a range from 0.00631 -0.01860, while b values lying within range 2.841-3.499 (28).

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