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Research Article **Araştırma Makalesi**

Morphometric and Meristic Characteristics of Four Scorpaenoid Species from Antalya Bay, Türkiye

Antalya Körfezi (Türkiye) Dört Scorpaenoid Türünün Morfometrik ve Meristik Özellikleri

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Abstract: In this study, fifteen morphometric and nine meristic traits have been examined of the *Scorpaena scrofa*, *Scorpaena elongata*, *Scorpaena notata*, and *Helicolenus dactylopterus* species from the Antalya Bay. The results showed that the *S. scrofa* total length ranged from 109.29 to 271.12 mm and was characterized by dark spots on its spinous dorsal spines between the 6th and 11th. In the *S. elongata* total length was 153.61 to 248.67 mm. On the other hand, *S. notata* is characterized by a total length of 131.28 to 305.24 mm and supraocular tentacle. In the *H. dactylopterus* total length was 110.87 to 306.23 mm. The linear length-length relationships and the allometric growth pattern were also investigated. For all species, correlations between fifteen different morphometric measurements showed a significant difference (p <0.05). R^2 correlation coefficient was between 0.752 to 0.988 for the *S. scrofa*, 0.485 to 0.959 for the *S. elongata*, 0.207 to 0.975 for the *S. notata*, and, 0.417 to 0.926 for the *H. dactylopterus*, respectively. Thus, this study may provide useful information for the conservation and sustainable management of these important fish species.

Keywords

- *Scorpaena scrofa*
- *Scorpaena elongata*
- *Scorpaena notata*
- *Helicolenus dactylopterus*
- Mediterranean Sea

Özet: Bu çalışmada, Antalya Körfezi (Türkiye)'nden avlanan *Scorpaena scrofa*, *Scorpaena elongata*, *Scorpaena notata* ve *Helicolenus dactylopterus* türlerinin onbeş morfometrik ve dokuz meristik özelliği incelenmiştir. Toplam uzunluklar, *S. scrofa*'da 109,29 – 271,12 mm, *S. elongata*'da 153,61 – 248,67 mm, *S. notata*'da 131,28 – 305,24 mm ve *H. dactylopterus*'da 110,87 – 306,23 mm arasında değişirken, *S. scrofa* 6. ve 11. sırt dikeni arasındaki koyu leke, *S. notata* ise supraokuler tentakül ile karakterize edilmiştir. Uzunluk-uzunluk ilişkileri ve allometrik büyümede incelenmiş, tüm türler için onbeş farklı morfometrik ölçüm arasındaki korelasyonlar önemli farklılık göstermiştir (p < 0,05). R^2 korelasyon katsayısı sırasıyla *S. scrofa* için 0,752-0,988, *S. elongata* için 0,485-0,959, *S. notata* için 0,207-0,975 ve *H. dactylopterus* için 0,417-0,926 olarak tespit edilmiştir. Bu nedenle, mevcut çalışmamız, bu önemli balık türlerinin korunması ve sürdürülebilir yönetimi için yararlı bilgiler sağlayabilir.

Anahtar kelimeler

- *Scorpaena scrofa*
- *Scorpaena elongata*
- *Scorpaena notata*
- *Helicolenus dactylopterus*
- Akdeniz

1. INTRODUCTION

Scorpaenidae and Sebastidae are typically the two families in the Mediterranean Sea that constitute the Scorpionfishes (Turan et al., 2009). Four genus and nine species make up the commercially significant demersal fish family Scorpaenidae, which is found across the Mediterranean Sea (Nelson, 1994). The red scorpionfish *Scorpaena scrofa* Linnaeus, 1758 is a widely dispersed species in the eastern Atlantic coast from Biscay to Senegal and the Mediterranean basin (except from the Black

Sea) (Hureau and Litvinenko, 1986). A deep-sea fish found in the eastern Atlantic and Mediterranean Seas, from the shelf edge to the upper slope, is the slender rockfish *Scorpaena elongata* Cadenat, 1943 (Bauchot, 1987). The small red scorpionfish *Scorpaena notata* Rafinesque, 1810, is a benthic and small sized scorpion fish inhabiting the depth range of 30 - 700 m (Hureau and Litvinenko, 1986). It inhabits the Mediterranean Sea and the eastern Atlantic from the Bay of Biscay to Madeira, the Azores, the Canary Islands, and the north-western coast of Africa as far south as Senegal (Eschmeyer, 1969). In the Mediterranean Sea, the family Sebastidae is represented by one genera and one species, *Helicolenus dactylopterus* (Delaroche 1809). The bluemouth, *H. dactylopterus*, is a deep sea scorpionfish widely distributed in the eastern Atlantic from the Norwegian coasts to the southwestern coast of Africa (Hureau and Litvinenko, 1986).In the Mediterranean Sea, it is distributed along the continental shelf edge and slope (Bauchot, 1987).

Ichthyologists frequently employ the examination of morphometric and meristic traits to distinguish between several species and among various populations within a species (Hassan et al., 2020; Hassan et al., 2021; Islam et al., 2020; Khatun et al., 2021; Washim et al., 2022; Jawad et al., 2022). Morphological variation between populations may result from interpopulation variations in genetic makeup or environmental factors (Sheller et al., 2023; Guo et al., 2023; Cermakova et al., 2023). The presence of a genetic basis for such diversity is crucial from an evolutionary perspective since it is necessary for selection driven population divergence, which may eventually lead to speciation (Hermida et al., 2005).

Numerous research has provided comprehensive details with distinguished characteristics regarding the distribution and physiology of Scorpaena species (Porcu et al., 2022; Bayhan et al., 2022). Yedier and Bostancı (2021), in the study, have supplied comprehensive information with diagnostic details on the biology and distribution of Scorpaena species in the marine waters of Turkey.

Therefore, this study aims to contribute to the knowledge of the different morphometric and meristic measurements and their relationships to *S. scrofa*, *S. elongata*, *S. notata* and *H. dactylopterus* inhabiting Antalya Bay from Turkey.

2. MATERIALS and METHODS

A total of 323 specimens of the four Scorpaenoid species were collected monthly by use of a commercial bottom trawl operated from Antalya Bay (Figure 1) from October 2020 to September 2021. The total catch of the four Scorpaenoid species included 70 samples of *S. scrofa* (40 males and 30 females), 62 samples of *S. elongata* (39 males and 23 females), and 35 samples of *S. notata* (20 males and 15 females), as well as 156 samples of *H. dactylopterus* (97 males and 59 females) (Figure 2), respectively. The fish were then immediately placed in ice boxes and transported to a laboratory for further analysis. The method of Bauchot (1987) was followed for morphometric measurements and meristic counts. Fifteen morphometric measurements were measured for each specimen to the nearest 0.1 mm using a dial calipe as follows: standard length (SL) (A), total length (TL) (B), maximum body height (BH) (C), minimum body height (Bh) (D), head length (HL) (E), pectoral fin length (PecFL) (F), pelvic fin length (PlvFL) (G), anal fin length (AFL) (H), caudal peduncle length (CPL) (I), snout length (SnoL) (K), maxilla length (ML) (L), preorbital height (Poh) (M), eye diameter (ED) (N), interorbital distance (IoD) (O) and supraocular tentacle length (STL) (P) (Figure 3) and, nine meristic characters: number of dorsal fin rays (DFR), minimum dorsal fin rays (MinDFR), maximum dorsal fin rays (MaxDFR), number of anal fin rays (AFR), minimum anal fin rays (MinAFR), maximum anal fin rays (MaxAFR), pelvic fin rays (PlvFR), pectoral fin rays (PecFR) and caudal fin rays (CFR).

Figure 1. Sampling area

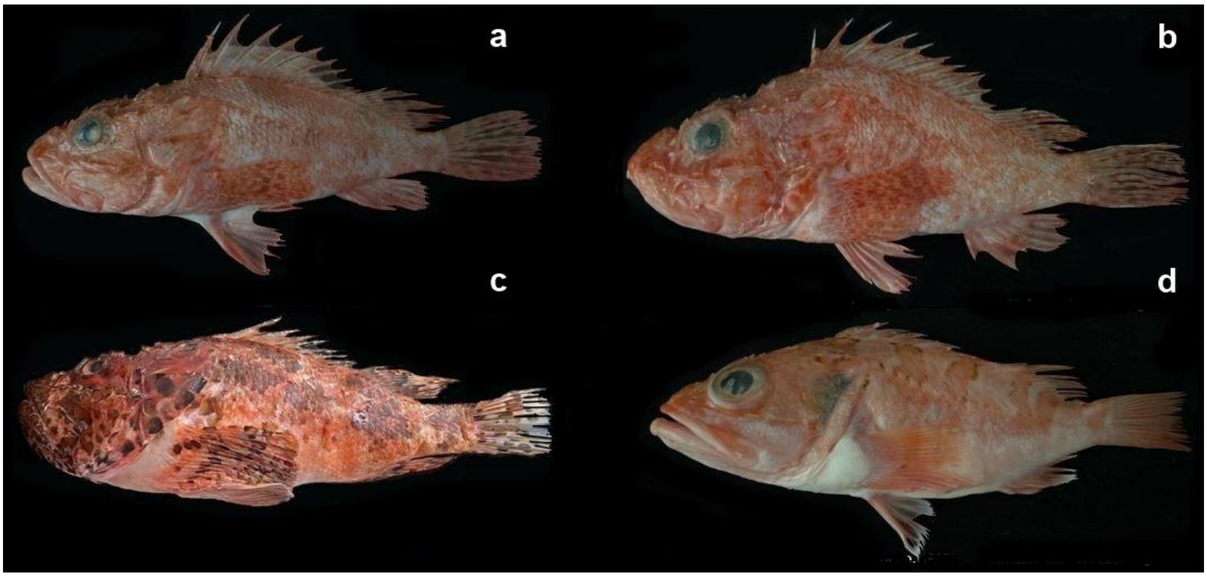

Figure 2. (a) *Scorpaena scrofa*, 23.1 cm TL; (b) *Scorpaena elongata*, 23.9 cm TL; (c) *Scorpaena notata*, 30.5 cm TL; (d) *Helicolenus dactylopterus*, 22.9 cm TL.

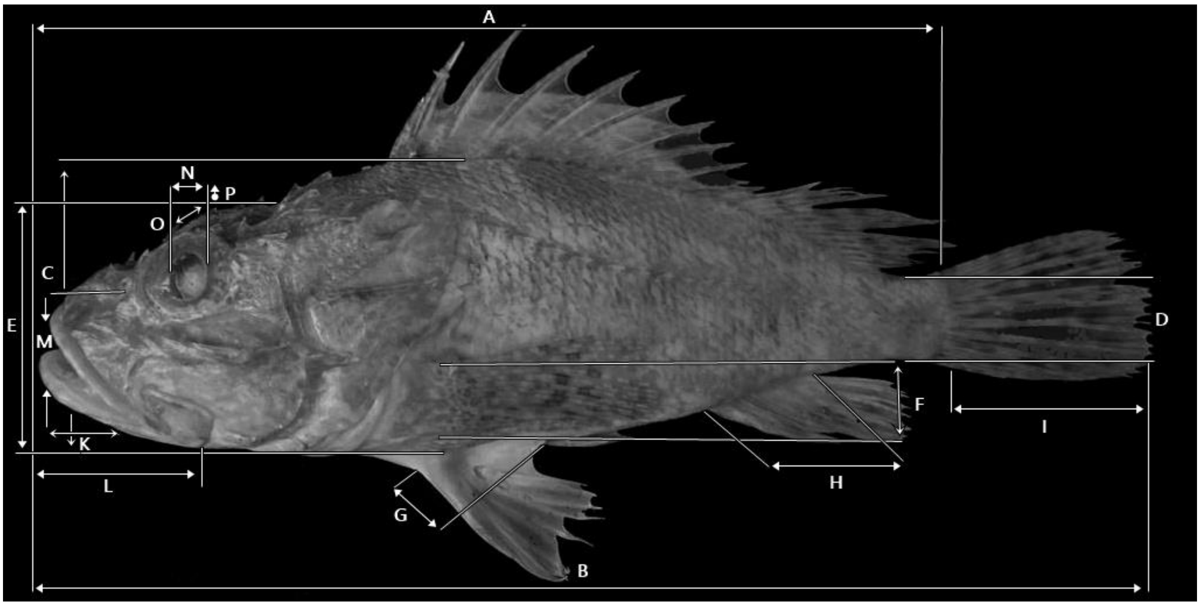

Figure 3. Morphometric measurements of four Scorpaenoid species of the Antalya Bay (standard length (SL) (A), total length (TL) (B), maximum body height (BH) (C), minimum body height (Bh) (D), head length (HL) (E), pectoral fin length (PecFL) (F), pelvic fin length (PlvFL) (G), anal fin length (AFL) (H), caudal peduncle length (CPL) (I), snout length (SnoL) (K), maxilla length (ML) (L), preorbital height (Poh) (M), eye diameter (ED) (N), interorbital distance (IoD) (O) and supraocular tentacle length (STL) (P))

All morphometric measurements and counts for two dorsal, pectoral, pelvic, and anal fin rays were taken from both sides of each fish sample. Rimzhim et al., (2015) used a linear regression equation to determine the relationship between total length and each of the morphometric and meristic characters. In the regression formula: $Y = a + bX$, all morphometric and meristic parameters were assumed as Y, while X was the assumed standard length of fish, a was the intercept and b was the regression slope, which was in accord with Zubia et al., (2015). For the allometric coefficients (b), the type of allometric growth was identified as $b = 1$ for isometric growth, $b > 1$ for positive allometric growth, and $b < 1$ for negative allometric growth. To determine the relationship between standard length and all of these morphometric and meristic characteristics, a linear regression relationship and coefficient of correlation (*r*) were calculated. The significance of regression was determined using a *t*-test with a *p*-value of 0.05. These *t*-test values were obtained during linear regression analysis., which provides a method for determining the statistical significance of correlations between standard length and all selected morphometric and meristic characteristics at the 5% level ($p < 0.05$).

Microsoft Excel and SPSS v26 were used for statistical analysis the Kolmogorov-Smirnov test ($p > 0.05$) was used to evaluate the normality of data. Levene's test was adopted to test the homogeneity of variances ($p > 0.05$).

3. RESULT

The morphometric and meristic characteristics of the male and female sexes of the four Scorpaenoid species were calculated and are shown in Figure 3. Except for *H. dactylopterus*, the overall results of the current study revealed that most relationships between TL versus morphometric and meristic characters of male and female sexes of each selected Scorpaenoid species were found to be strong ($r = 0.70 - 0.99$) and statistically significant (*t*-test; $p > 0.05$), as shown in Tables 2; 5; 6; and 7, respectively. Furthermore, except for *H. dactylopterus*, the analysis of the variations between the means obtained for each morphometric and meristic character of male and female sexes of four selected Scorpaenoid species was found to be mostly insignificant by using a two-sample *t*-test at a 5% level ($p < 0.05$), revealing that both male and female fishes of *S. scrofa*, *S. elongata,* and *S. notata* were showing extreme similarities in their all external morphological characteristics observed in the present study. *S. scrofa*, *S. elongata*, *S. notata* and *H. dactylopterus* species selected for this study displayed any distinguishing characteristics that could aid in distinguishing the male from the female fish, no sexual dimorphism was observed for each Scorpaenoid species in this study.

3.1. Morphometric and meristic analysis

3.1.1. *S. scrofa* - Morphometrics

The variation between the means of each morphological character among the male and female sexes of *S. scofa* was subjected to the two samples *t*-test analysis at the 5% level ($p < 0.05$), as shown in Table 2. According to the findings, the differences between the means of the most morphometric characters among the male and female sexes of *S. scofa* were statistically significant ($p < 0.05$), except for two morphometric characters such as TL/SL and TL/Bh, which showed statistically insignificant variations ($p > 0.05$). As a result, the male and female sexes of this species were discovered to have different external morphology based on their most morphometric characteristics, which may be useful in sexual dimorphism. The levels of correlation coefficient (*r*) obtained for the following relationships between TL and various morphometric variables such as SnoL, ML, and Poh of males were found to be varied from that of females in *S. scofa*. This could be because the growth rates of these body parts in relation to the increase in TL of fish were discovered to differ between the sexes. The relationships between TL versus SL, BH, HL, PecFL, SnoL, ML and PoH in both sexes had the highest correlation coefficient values ($r > 0.90$), indicating that all of these morphometric variables were strongly correlated with TL. Table 2 revealed that in male *S. scofa*, all relationships between TL and various selected morphometric characters were statistically significant ($p < 0.05$), whereas, in female *S. scofa*, most relationships between TL and various morphometric characters were statistically significant ($p < 0.05$), except for TL versus SnoL that showed insignificant ($p > 0.05$) type of relationship.

The linear regression parameters between the morphometric characters and SL measurements were shown in Table 3. The linear equations were best described for the morphometric characters, as the R^2 correlation coefficient showed higher values: between 0.87 to 0.99 for the *S. scrofa*. The best fit was recorded for the *S. scrofa* between the TL to SL ($R^2 = 0.99$); while the lowest value of the coefficient of determination was established for the *S. scrofa* between the ML to SL ($R^2 = 0.87$). The coefficients of linear regression point to the fact that smaller specimens have a longer TL/SL, Bh/SL, and IoD/SL for the *S. scrofa*.

The isometric growth models were watched for the TL, BH, PecFL, PvlFL, AFL, CPL, SnoL, PoH, ED, and IoD (0.969 to 1.082) for the *S. scrofa*. The BH, HL, and ML (1.127 to 1.144) were defined by the positive allometric relationship for *S. scrofa* (Table 4).

3.1.2. *S. scrofa* - Meristics

DFR (XII/9), MinDFR (I-XII), MaxDFR (III-IV); AFR (III/5), MinAFR (I), MaxAFR (II-III); PlvFR (I/5); PecFR (18-19) and CFR (17-20). *S. scrofa* was characterized by a dark spot on its spinous dorsal spines between the 6th and 11th.

Table 2. In male and female *Scorpaena scrofa*, there is a linear regression relationship between total length (TL, mm) and head length (HL, mm), and various morphological characteristics (mm).

Morphometric characteristics	**Male (N= 40)**								**Female (N= 30)**								**Two samples *t*-test**	
	Min.	**Max.**	**Mean±SD**	**Regression coefficient**			***p***	**CT**	**Min.**	**Max.**	**Mean±SD**	**Regression coefficient**			***p***	**CT**	***t* test**	***p***
				a	***b***	***r***						***a***	***b***	***r***				
TL	109.29	228.13	156.60±39.63						117.45	182.24	167.67±54.53						2.00	0.34[NS]
TL/SL	111.15	125.51	123.25±3.99	0.91	1.29	0.99	0.0[a]	SC	118.53	125.17	123.97±2.37	0.99	0.86	0,99	0.0[a]	SC	2.02	0.00*
TL/BH	315.75	388.04	410.23±29.77	1.06	0.18	0.93	0.0[a]	SC	297.48	388.04	398.72±36.27	1.13	0.13	0.90	0.0[a]	SC	2.00	0.15 [NS]
TL/Bh	1137.26	1345.90	1340.90±48.03	1.03	0.06	0.98	0.0[a]	SC	1298.90	1416.01	1366.11±46.50	1.01	0.07	0.99	0.0[a]	SC	1.99	0.02*
TL//HL	226.52	274.59	315.53±60.37	1.48	0.03	0,80	0.0[a]	SC	195.43	290.42	313.17±50.13	1.17	0.13	0.82	0.0[a]	SC	1.99	0.86 [NS]
TL/PecFL	404.86	430.11	443.98±26.28	1.07	0.16	0.97	0.0[a]	SC	408.90	477.94	448.58±26.40	0.89	0.38	0.97	0.0[a]	SC	2.00	0.46 [NS]
TL/PlvFL	431.78	488.92	500.36±32.73	1.04	0.16	0.94	0.0[a]	SC	460.94	531.93	504.22±28.51	0.89	0.33	0.97	0.0[a]	SC	1.99	0.59 [NS]
TL/AFL	380.17	543.81	5537.55±27.32	1.06	0.14	0.92	0.0[a]	SC	477.69	477.70	541.52±11.72	1.01	0.18	0.99	0.0[a]	SC	2.00	0.41 [NS]
TL/CPL	801.01	949.75	958.27±69.78	0.90	0.17	0.90	0.0[a]	SC	772.53	772.55	943.41±75.53	0.95	0.14	0.94	0.0[a]	SC	1.99	0.39 [NS]
TL/SnoL	706.15	723.30	749.40±106.2	0.78	0.40	0,73	0.0[a]	SC	698.45	1175.7	749.82±105.5	0.96	0.17	0.91	0.1[NS]	SC	1.99	0.99 [NS]
TL/ML	387.79	647.36	630.63±51.74	1.06	0.12	0.86	0.0[a]	SC	533.20	650.16	662.53±90.73	0.83	0.36	0.72	0.0[a]	SC	2.01	0.08 [NS]
TL/PoH	570.31	950.15	928.60±77.18	1.09	0.07	0.79	0.0[a]	SC	802.02	802.82	944.95±46.82	1.02	0.09	0.97	0.0[a]	SC	1.99	0,27 [NS]
TL/ED	1213.56	1712.69	1702.55±81.78	1.02	0.05	0.92	0.0[a]	SC	1246.51	1246.50	1690.43±91.94	1.02	0.05	0.95	0.0[a]	SC	1.99	0.56 [NS]
TL/IoD	1855.34	2254.25	2240.53±66.32	1.02	0.04	0.98	0.0[a]	SC	2203.63	2203.48	2251.78±10.10	1.00	0.04	0.99	0.0[a]	SC	2.02	0.30 [NS]
HL	28.62	83.08	52.71±19.93						28.49	62.75	55.58±21.11						1.99	0.56[NS]
HL/ED	411.49	623.72	558.91±109.41	0.57	0.97	0.79	0.0[a]	SC	415.45	429.21	554.83±105.69	0.70	0.61	0.77	0.0[a]	SC	2.00	0.87 [NS]
HL/IoD	541.61	820.95	736.17±143.96	0.57	0.75	0.80	0.0[a]	SC	546.82	758.77	739.28±134.19	0.68	0.49	0.81	0.0[a]	SC	1.99	0.92 [NS]

Note: N: No. of samples examined; Min.: Minimum; Max.: Maximum; SD: Standard Deviation; SE: Standard Error; *p*: *p*-value; CT: Correlation Type; SC: shows the Strong Correlation (when $r>0.70$); MC: shows Moderate Correlation ($r= 0.51-0.69$); RC: Represant Weak Correlation (when $r<0.50$); NC: shows Negative Correlation; * shows t-test significant at 5% level ($p<0.05$); NS: Not significant correlation (when $p>0.05$); a: shows relationship significant when $p>0.05$.

Table 3. The linear relationship between some parameters of morphometric characters and SL of *S. scrofa*, *S. elongata*, *S. notata*, and *H. dactylopterus.*

Linear equation	**R^2 ***	**Linear equation**	**R^2 ***
S. scrofa		***S. elongata***	
TL= -3.747+1.267*SL	0.99	TL= 3.625+1.248*SL	0.98
BH= -8.085+0.373*SL	0.90	BH= -2.201+0.279*SL	0.94
Bh= -0.445+0.095*SL	0.98	Bh= 0.173+0.088*SL	0.96
HL= -9.699+0.488*SL	0.95	HL= -1.468+0.419*SL	0.95
PecFL= 2.243+0.261*SL	0.93	PecFL= 0.736+0.261*SL	0.96
PlvFL= 2.515+0.227*SL	0.93	PlvFL= 1.651+0.243*SL	0.98
AFL= -1.010+0.238*SL	0.94	AFL= 2.322+0.223*SL	0.99
CPL= 0.848+0.124*SL	0.93	CPL= 1.418+0.089*SL	0.93
SnoL= 1.102+0.158*SL	0.89	SnoL= 0.809+0.103*SL	0.85
ML= 2.945+0.171*SL	0.87	ML= 1.983+0.182*SL	0.87
PoH= -0.680+0.139*SL	0.88	PoH= -0.031+0.157*SL	0.90
ED= -0.217+0.075*SL	0.92	ED= 0.072+0.097*SL	0.86
IoD= -0.173+0.057*SL	0.97	IoD= 1.061+0.056*SL	0.99
S. notata	R^2 *	*H. dactylopterus*	R^2 *
TL= 9.202+1.252*SL	0.98	TL= 3.779+1.211*SL	0.98
BH= -2.855+0.298*SL	0.91	BH= 1.198+0.289*SL	0.96
Bh= 0.972+0.097*SL	0.97	Bh= 2.019+0.083*SL	0.96
HL= -1.138+0.409*SL	0.95	HL= 0.571+0.396*SL	0.96
PecFL= -3.017+0.249*SL	0.96	PecFL= 0.001+0.232*SL	0.98
PlvFL= -3.792+0.248*SL	0.87	PlvFL= 2.575+0.201*SL	0.96
AFL= 1.855+0.233*SL	0.91	AFL= 1.684+0.199*SL	0.90
CPL= 0.392+0.111*SL	0.93	CPL= 1.839+0.102*SL	0.92
SnoL= 0.711+0.116*SL	0.95	SnoL= 0.224+0.091*SL	0.90
ML= 2.421+0.195*SL	0.97	ML= 2.683+0.175*SL	0.90
PoH= 2.083+0.155*SL	0.92	PoH= 2.998+0.101*SL	0.89
ED= -0.463+0.088*SL	0.89	ED= 0.856+0.131*SL	0.88
IoD= 0.982+0.053*SL	0.88	IoD= -0.019+0.051*SL	0,90
STL= 1.131+0.051*SL	0.86		

* Significance value is less than 0.01 level for all correlation

Table 4. Parameters of the allometric regression for *S. scrofa*, *S. elongata*, *S. notata*, and *H. dactylopterus* morphometric characters related to the standard length.

Allometric equation				Allometric equation			
S. scrofa	**a**	**b**	**R^2**	***S. elongata***	**a**	**b**	**R^2**
In standard length				**In standard length**			
TL	1.007	1.042 I	0.989	TL	1.327	0.992 I	0.980
BH	0.152	1.144 +	0.903	BH	0.271	1.005 I	0.941
Bh	0.069	1.057 I	0.969	Bh	0.091	0.995 I	0.859
HL	0.039	1.483 +	0.803	HL	0.374	1.018 I	0.948
PecFL	0.269	1.006 I	0,921	PecFL	0.357	0.938 -	0.894
PlvFL	0.249	0.997 I	0.913	PlvFL	0.286	0.976 I	0.877
AFL	0.166	1.067 I	0.951	AFL	0.294	0.957 I	0.891
CPL	0.151	0.969 I	0.905	CPL	0.111	0.984 I	0.903
SnoL	0.131	1.056 I	0.910	SnoL	0.119	0.982 I	0.898
ML	0.106	1.127 +	0.909	ML	0.233	0.964 I	0.894
PoH	0.089	1.082 I	0.913	PoH	0.147	1.012 I	0.907
ED	0.054	1.061 I	0.935	ED	0.094	1.008 I	0.892
IoD	0.043	1.051 I	0.976	IoD	0.041	1.089 I	0.881
S. notata	**a**	**b**	**R^2**	***H. dactylopterus***	**a**	**b**	**R^2**
In standard length				**In standard length**			
TL	2.208	0.894 -	0.922	TL	1.384	0.977 I	0.956
BH	0.169	1.098 I	0.893	BH	0.304	0.994 I	0.886
Bh	0.157	0.918 -	0.886	Bh	0.138	0.926 -	0,863
HL	0.346	1.029 I	0.971	HL	0.429	0.985 I	0.876
PecFL	0.078	1.218 +	0.884	PecFL	0.222	1.007 I	0.884
PlvFL	0.037	1.368 +	0.832	PlvFL	0.324	0.920 -	0.915
AFL	0.356	0.925 -	0.852	AFL	0.228	0.982 I	0.861
CPL	0.142	0.956 I	0.861	CPL	0.179	0.908 -	0.859
SnoL	0.151	0.956 I	0.962	SnoL	0.094	0.994 I	0.889
ML	0.338	0.906 -	0.879	ML	0.230	0.977 I	0.845
PoH	0.271	0.905 -	0.859	PoH	0.266	0.839 -	0.851
ED	0.062	1.061 I	0.894	ED	0.164	0.963 I	0.833
IoD	0.113	0.872 -	0.867	IoD	0.046	1.015 I	0.894
STL	0.149	0.804 -	0.893				

(I): isometric growth, (+): positive allometric growth, (-): negative allometric growth

3.2.1. *S. elongata*-Morphometrics

The analysis of variations between the means obtained for most morphometric measurements of this species male and female sexes was found to be statistically insignificant (*t*-test, $p > 0.05$), however, the variations between the means of very morphometric measurements such as TL/BH, TL/HL and HL/IoD of both sexes were found to be statistically significant ($p < 0.05$) as shown in Table 5. As a result, the external morphology of both the male and female sexes of this species was similar, except for maximum body height, head length, and interorbital distance. In general, most relationships between morphometric characters of two sexes with TL were strong and highly significant ($p < 0.05$), except TL/CPL, TL/IoD, and HL/IoD in males and females of this species that moderate correlation.

The linear equations were best described for the morphometric characters, as the R^2 correlation coefficient showed higher values: between 0.85 to 0.99 for the *S. elongata*, The best fit was recorded for the *S. elongata*: the AFL to SL and the IoD to SL (R^2 = 0.99), while the lowest value of the coefficient of determination was established for the *S. elongata*: the SnoL to SL (R^2 = 0.85). The coefficients of linear regression point to the fact that smaller specimens have a longer the AFL/SL, IoD/SL, TL/SL, and PlvFL/SL for the *S. elongata* (Table 3).

Among all characters following this study for the *S. elongata*, the TL, BH, Bh, HL, PlvFL, AFL, CPL, SnoL, ML, PoH, ED, and IoD (0.938 to 1.089) were defined by ısometric growth, while the only PecFL (0.938) watched negative the negative allometric relationship (Table 4).

3.2.2. *S. elongata*-Meristics

DFR (XII/10), MinDFR (I-XII), MaxDFR (III-IV); AFR (III/5), MinAFR (I), MaxAFR (II-III); PlvFR (I/5); PecFR (19) and CFR (18-20).

Table 5. In male and female *Scorpaena elongata*, there is a linear regression relationship between total length (TL, mm) and head length (HL, mm), and various morphological characteristics (mm).

Morphometric characteristics	**Male (N= 39)**								**Female (N= 23)**								**Two samples *t*-test**	
	Min.	**Max.**	**Mean±SD**	**Regression coefficient**			***p***	**CT**	**Min.**	**Max.**	**Mean±SD**	**Regression coefficient**			***p***	**CT**	***t* test**	***p***
				a	***b***	***r***						***a***	***b***	***r***				
TL	144.08	332.36	192.99±35.47						144.87	332.36	189.67±36.80						1.67	0.34 [NS]
TL/SL	122.66	133.61	127.13±3.24	0.98	0.88	0.98	0.0[a]	SC	122.66	133.61	127.49±3.15	1.00	0.75	0,98	0.0[a]	SC	2.01	0.67 [NS]
TL/BH	436.18	487.18	456.05±18.01	1.01	0.21	0.96	0.0[a]	SC	436.18	487.18	462.52±18.35	1.03	0.19	0.95	0.0[a]	SC	2.01	0.01 *
TL/Bh	1286.50	1656.03	1442.26±114.2	0.94	0.09	0.85	0.0[a]	SC	1286.50	1656.03	1435.13±88.78	1.06	0.05	0.89	0.0[a]	SC	2.00	0.78 [NS]
TL//HL	286.25	343.42	309.63±14.73	0.95	0.41	0,94	0.0[a]	SC	286.25	343.42	314.64±16.42	1.11	0.18	0.94	0.0[a]	SC	2.02	0.02 *
TL/PecFL	413.62	547.43	481.09±43.58	0.96	0.78	0.97	0.0[a]	SC	413.62	547.31	487.30±41.86	1.10	0.12	0.80	0.0[a]	SC	2.01	0.57 [NS]
TL/PlvFL	433.42	558.64	505.42±39.16	0.98	0.22	0.85	0.0[a]	SC	433.42	558.64	503.09±43.66	0.98	0.22	0.76	0.0[a]	SC	2.02	0.83 [NS]
TL/AFL	490.57	647.01	540.45±51.21	0.98	0.20	0.81	0.0[a]	SC	490.57	647.01	534.69±45.28	0.91	0.30	0.80	0.0[a]	SC	2.01	0.64 [NS]
TL/CPL	902.82	1454.64	1254.18±158.7	0.83	0.19	0.56	0.0[a]	MC	1237.73	1454.64	1265.97±150,7	1.16	0.03	0.63	0.0[a]	MC	2.01	0.77 [NS]
TL/SnoL	1019.97	1288.33	1177.16±67.29	0.99	0.09	0.91	0.0[a]	SC	1019.97	1288.33	1172.48±74.28	1.03	0.07	0.87	0.0[a]	SC	2.01	0.80 [NS]
TL/ML	595.03	710.77	655.98±38.79	1.04	0.12	0.91	0.0[a]	SC	593.03	710,75	654.36±34.11	0.94	0.22	0.90	0.0[a]	SC	2.00	0.86 [NS]
TL/PoH	739.60	865.43	816.12±35.78	0.99	0.13	0.95	0.0[a]	SC	737.60	863.43	815.01±40.83	1.10	0.07	0.94	0.0[a]	SC	2.02	0,91 [NS]
TL/ED	1180.10	1549.73	1323.91±128.2	1.03	0.06	0.83	0.0[a]	SC	1179.13	1548.45	1303.71±112.0	0.95	0.10	0.80	0.0[a]	SC	2.00	0.51 [NS]
TL/IoD	1434.36	2532.94	2025.44±321.8	0.91	0.08	0.54	0.0[a]	MC	1432.25	2531.98	2021.78±357.8	1.21	0.02	0.57	0.0[a]	MC	2.02	0.97 [NS]
HL	46.36	112.86	61.32±12.08						43.27	85.76	63.45±12.14						2.01	0.50 [NS]
HL/ED	378.69	541.40	429.24±53.89	0.95	0.29	0.73	0.0[a]	SC	376.54	540.38	415.92±48.26	0.78	0.60	0.69	0.0[a]	MC	2.01	0.02 *
HL/IoD	474.61	805.96	653.99±98.17	0.96	0.18	0.57	0.0[a]	MC	472.51	804.66	640.56±95.57	1.16	0.08	0.56	0.0[a]	MC	2.01	0.59 [NS]

Note: N: No. of samples examined; Min.: Minimum; Max.: Maximum; SD: Standard Deviation; SE: Standard Error; *p*: *p*-value; CT: Correlation Type; SC: shows the Strong Correlation (when r>0.70); MC: shows Moderate Correlation (r= 0.51-0.69); RC: Represent Weak Correlation (when r<0.50); NC: shows Negative Correlation; * shows t-test significant at 5% level (p<0.05); NS: Not significant correlation (when p>0.05); a: shows relationship significant when p>0.05.

3.3.1. *S. notata* - Morphometrics

The mean values of morphometric variables in *S. notata* were compared between sexes, and the differences between the means of most morphometric measurements of this species male and female sexes were found to be statistically insignificant (p > 0.05), as shown in Table 6. However, the variations between the means of few morphometric measurements i.e., TL/BH, TL/PlvFL, TL/SnoL, TL/STL, and HL/STL of both sexes were found to be statistically significant (p < 0.05), hence, both male and female sexes of this species were similar in their external morphology. The mean values of morphometric variables in *S. notata* were compared between two sexes, which revealed that the variations between the means of most morphometric measurements of male and female sexes of *S. notata* were showing strong and significant relationships (r = 0.70 - 0.99; p< 0.05) with total length and head length in both male and female sexes of *S. notata*, except the relationships between TL and HL versus ten variables i.e., SL, Bh, HL, AFL, CPL, SnoL, ML, PoH, IoD and ED, which was found to be strong (r > 0.70) in both sexes, while the correlation between TL/STL and HL/STL was found to represent weak correlation (r < 0.50) in males but moderately correlation (r = 0.51 - 0.69) in females, whereas TL/ED showed moderate correlation in males, while strong in females. As a result, the levels of relationship for TL/STL, HL/STL, and TL/ED between male and female sexes were found to be significantly different, indicating that these two characters could be useful in distinguishing *S. notata* males from females.

The linear equations were best described for the morphometric characters, as the R^2 corelation coefficient showed higher values: between 0.87 to 0.98 for the *S. notata*. The best fit was recorded for the *S. notata*: the TL to SL (R^2= 0.98), while the lowest value of the coefficient of determination was established for the *S. notata*: the STL to SL (R^2= 0.86); and for the *H. dactylopterus:* the EL to SL (R^2 = 0.88), respectively. The coefficients of linear regression point to the fact that smaller specimens have a longer TL/SL, Bh/SL, and ML/SL for the *S. notata* (Table 3).

For the *S. notata*, the TL, Bh, AFL, ML, PoH, IoD and STL (0.804 to 0.925) were defined by the negative allometry. The PecFL, and PlvFL (1.218 to 1.368) were defined by the positive allometric relationship, other four characters watched isometric growth (0.956 to 1.098) (Table 4).

3.3.2. *S. notata* - Meristics

DFR (XII/9), MinDFR (I-XII), MaxDFR (III-IV); AFR (III/5), MinAFR (I), MaxAFR (II-III); PlvFR (I/5); PecFR (16-18) and CFR (18-19). *S. notata* was characterized by a supraocular tentacle.

Table 6. In male and female *Scorpaena notata*, there is a linear regression relationship between total length (TL, mm) and head length (HL, mm), and various morphological characteristics (mm).

Morphometric characteristics	Male (N= 20)								Female (N= 15)								Two samples *t*-test	
	Min.	Max.	Mean±SD	Regression coefficient			*p*	CT	Min.	Max.	Mean±SD	Regression coefficient			*p*	CT	*t* test	*p*
				a	*b*	*r*						*a*	*b*	*r*				
TL	131.28	302.33	203.71±49.62						158.43	305.24	226.44±43.16						2.04	0.16[NS]
TL/SL	122.02	149.55	128.32±9.37	0.96	0.96	0.92	0.0[a]	SC	122.00	139.31	135.09±12.30	0.98	0.81	0,79	0.0[a]	SC	2.05	0.09 [NS]
TL/BH	416.24	658.27	455.30±87.52	0.93	0.33	0.66	0.0[a]	MC	416.23	658.25	515.63±120.57	0.95	0.26	0.63	0.0[a]	MC	2.06	0.01 *
TL/Bh	1215.61	1335.57	1271.31±42.53	1.00	0.08	0.98	0.0[a]	SC	1215.60	1335.55	1266.14±51.87	1.02	0.07	0.96	0.0[a]	SC	2.05	0.76 [NS]
TL//HL	293.45	400.10	317.66±36.37	0.94	0.44	0,82	0.0[a]	SC	293.43	400.08	343.46±48.18	0.97	0.34	0.58	0.0[a]	MC	2.05	0.09 [NS]
TL/PecFL	467.69	917.74	562.39±154.10	0.89	0.33	0.51	0.0[a]	MC	467.68	917.71	661.99±216.83	0.91	0.25	0.54	0.0[a]	MC	2.06	0.14 [NS]
TL/PlvFL	480.14	1049.66	579.65±203.23	0.85	0.39	0.51	0.0[a]	MC	480.13	1049.65	718.89±279.82	0.91	0.24	0.53	0.0[a]	MC	2.06	0.02 *
TL/AFL	503.28	576.63	543.02±27.43	1.05	0.14	0.96	0.0[a]	SC	503.28	576.63	533.88±32.54	1.01	0.17	0.92	0.0[a]	SC	2.05	0.39 [NS]
TL/CPL	1093.48	1240.37	1150.83±52.27	1.03	0.08	0.97	0.0[a]	SC	1092.46	1241.36	1164.07±53.05	1.01	0.08	0.95	0.0[a]	SC	2.04	0.47[NS]
TL/SnoL	1017.60	1159.73	1073.51±54.03	0.95	0.12	0,96	0.0[a]	SC	1017.62	1159.71	1101.70±57.18	0.99	0.09	0.92	0.0[a]	SC	2.04	0.01 *
TL/ML	597.40	662.52	626.95±29.99	0.97	0.18	0.96	0.0[a]	SC	597.39	662.50	624.43±27.92	1.02	0.14	0.95	0.0[a]	SC	2.03	0.80 [NS]
TL/PoH	736.10	855.72	783.89±50.40	0.95	0.17	0.93	0.0[a]	SC	736.09	855.69	782.84±39.52	1.01	0.12	0.94	0.0[a]	SC	2.03	0,95 [NS]
TL/ED	1253.04	1979.50	1551.74±241.2	0.99	0.07	0.68	0.0[a]	MC	1253.03	1979.50	1629.46±321.4	0.91	0.10	0.71	0.0[a]	SC	2.05	0.44[NS]
TL/IoD	2048.59	2494.94	2248.39±171.9	0.96	0.06	0.90	0.0[a]	SC	2047.55	2454.25	2192.18±169.6	1.02	0.04	0.89	0.0[a]	SC	2.03	0.34[NS]
TL/STL	1783.13	2997.72	2501.93±451.4	0.96	0.05	0.48	0.0[a]	RC	1925.60	2997.72	2282.78±434.1	0.98	0.05	0.58	0.0[a]	MC	2.04	0.02 *
HL	36.27	82.56	64.52±15.50						39.60	87.19	66.94±13.99						2.04	0.63 [NS]
HL/ED	407.47	565.54	489.57±63.00	1.02	0.19	0.78	0.0[a]	SC	407.44	565.51	472.58±52.32	1.03	0.18	0.76	0.0[a]	SC	2.04	0.39[NS]
HL/IoD	512.01	801.05	716.67±94.62	0.82	0.29	0.64	0.0[a]	MC	526.82	800.49	653.62±123.50	0.56	0.98	0.63	0.0[a]	MC	2.06	0.11[NS]
HL/STL	445.67	962.48	802.20±183.70	0.71	0.42	0.49	0.0[a]	RC	510.98	962.48	683.81±192.46	0.46	1.46	0.56	0.0[a]	MC	2.04	0.01 *

Note: N: No. of samples examined; Min.: Minimum; Max.: Maximum; SD: Standard Deviation; SE: Standard Error; *p*: *p*-value; CT: Correlation Type; SC: shows the Strong Correlation (when r>0.70); MC: shows Moderate Correlation (r= 0.51-0.69); RC: Represant Weak Correlation (when r<0.50); NC: shows Negative Correlation; * shows t-test significant at 5% level (p<0.05); NS: Not significant correlation (when p>0.05); a: shows relationship significant whwn p>0.05.

3.4.1. *H. dactylopterus* - Morphometrics

The current study found that, while most morphometric characteristics of male fish differed from female fish, such differences were statistically insignificant (*t*-test; $p > 0.05$), as shown in Table 5. Thus, male and female individuals of this species were discovered to have almost identical external morphology. All linear regression relationships between TL and HL and various morphometric variables (except TL/CPL, TL/IoD, and HL/IoD) for *H. dactylopterus* demonstrated strong and significant correlations, with r-values ranging from 0.73 to 0.98. However, morphometric variables such as Bh, CPL, ML, and PoH of males and females of this species exhibited a moderate level of relationship with TL of fish, while IoD of all individuals of *H. dactylopterus* represents a weak correlation with TL and HL. Females correlation coefficients for the relationship between TL and three morphometric characters (SL, PlvFL, and ED) were found to be highly significant, with *r*-values greater than 0.90, while males showed a strong correlation between SL, HL, SnoL, and ED, but weak correlation for both TL/IoD and HL/IoD. Females had higher *r*-values for the following relationships SL, BH, PecFL, PlvFL, and SnoL than males, indicating a significant superiority of females over males. The t-test analysis revealed that the relationships between all morphometric characters of both male and female individuals of *H. dactylopterus* were found to be statistically insignificant ($p > 0.05$).

The linear equations were best described for the morphometric characters, as the R^2 correlation coefficient showed higher values: between 0.88 to 0.98 for the *H. dactylopterus.* The best fit was recorded for the *H. dactylopterus:* the TL to SL and the PecFL to SL (R^2= 0.98), while the lowest value of the coefficient of determination was established for the *H. dactylopterus:* the EL to SL (R^2 = 0.88), respectively. The coefficients of linear regression point to the fact that smaller specimens have a longing for the *H. dactylopterus* (Table 3).

In the *H. dactylopterus* species the negative allometric relationship of the Bh, PlvFL, CPL, and PoH (0.839 to 0.926) was typical, other in nine morphometric characters (0.963 to 1.015) watched isometric growth (Table 4). Correlations between 15 different morphometric measurements showed a significant difference ($p < 0.01$) among the population of all Scorpaenoid species.

3.4.2. *H. dactylopterus*-Meristics

DFR (XII/12-13), MinDFR (I-XII), MaxDFR (III-IV); AFR (III/5), MinAFR (I), MaxAFR (II-III); PlvFR (I/5); PecFR (18-19) and CFR (20-21).

Table 7. In male and female *Helicolenus dactylopterus*, there is a linear regression relationship between total length (TL, mm) and head length (HL, mm), and various morphological characteristics (mm).

Morphometric characteristics	Male (N= 97)								Female (N= 59)								Two samples *t*-test	
	Min.	Max.	Mean±SD	Regression coefficient			*p*	CT	Min.	Max.	Mean±SD	Regression coefficient			*p*	CT	*t* test	*p*
				a	*b*	*r*						*a*	*b*	*r*				
TL	110.87	298.54	179.13±45.90						122.54	306.23	180.36±47.33						1.98	0.87 NS
TL/SL	112.31	186.48	125.26±10.89	0.97	0.97	0.92	0.0 a	SC	116.20	128.60	122.52±3.75	0.99	0.85	0,99	0.0 a	SC	1.98	0.62 NS
TL/BH	358.31	521.08	419.93±54.08	1.00	0.24	0.79	0.0 a	SC	358.31	521.08	425.61±54.89	0.99	0.25	0.89	0.0 a	SC	1.98	0.53 NS
TL/Bh	855.56	1776.89	1305.81±240.4	0.94	0.11	0.59	0.0 a	MC	855.54	1775.43	1322.85±209.1	0.89	0.14	0.67	0.0 a	MC	1.97	0.64 NS
TL//HL	236.87	351.34	314.00±23.38	0.97	0.37	0,90	0.0 a	SC	235.77	350.04	308.56±31.26	1.00	0.33	0.82	0.0 a	SC	1.98	0.25 NS
TL/PecFL	475.05	658.04	542.13±59.25	1.08	0.12	0.88	0.0 a	SC	474.03	657.12	540.00±56.52	1.03	0.16	0.95	0.0 a	SC	1.97	0.82 NS
TL/PlvFL	480.33	627.45	568.60±50.71	0.95	0.23	0.87	0.0 a	SC	480.31	627.43	567.53±44.98	0.97	0.21	0.96	0.0 a	SC	1.98	0.89 NS
TL/AFL	409.75	755.50	594.65±97.69	1.07	0.12	0.72	0.0 a	SC	409.71	755.50	610.15±96.66	1.05	0.13	0.73	0.0 a	SC	1.97	0.63 NS
TL/CPL	763.49	1382.38	1127.16±179.2	0.99	0.09	0.65	0.0 a	MC	763.47	1381.24	1086.16±191.1	0.87	0.19	0.63	0.0 a	MC	1.98	0.34 NS
TL/SnoL	1197.07	1747.52	1356.24±124.0	1.01	0.07	0,91	0.0 a	SC	1197.05	1746.51	1354.19±131.8	0.96	0.09	0.98	0.0 a	SC	1.98	0.19 NS
TL/ML	349.81	1149.88	601.79±113.58	1.04	0.14	0.57	0.0 a	MC	349.76	1148.97	590.13±117.96	0.82	0.43	0.51	0.0 a	MC	1.98	0.55 NS
TL/PoH	654.25	1415.45	1038.94±197.4	0.89	0.17	0.54	0.0 a	MC	654.22	1414.54	1060.77±184.2	0.84	0.22	0.58	0.0 a	MC	1.97	0,49 NS
TL/ED	762.14	1019.75	903.55±58.81	1.04	0.09	0.93	0.0 a	SC	762.11	1019.73	915.48±68.43	0.99	0.12	0.92	0.0 a	SC	1.98	0.27 NS
TL/IoD	1433.23	3693.79	2584.20±621.7	0.87	0.08	0.35	0.0 a	RC	1433.20	3693.75	2629.85±565.3	1.15	0.02	0.32	0.0 a	RC	1.98	0.65 NS
HL	35.14	107.59	57.30±14.95						36.11	129.28	59.16±17.49						1.98	0.50 NS
HL/ED	236.04	430.50	290.41±39.76	0.91	0.49	0.76	0.0 a	SC	236.36	430.52	301.88±54.97	0.75	0.92	0.65	0.0 a	MC	1.99	0.17 NS
HL/IoD	481.99	955.95	786.51±152.3	0.90	0.19	0.45	0.0 a	RC	481.99	1072.49	827.70±161.5	1.09	0.09	0.45	0.0 a	RC	1.98	2 NS

Note: N: No. of samples examined; Min.: Minimum; Max.: Maximum; SD: Standard Deviation; SE: Standard Error; p: p-value; CT: Correlation Type; SC: shows the Strong Correlation (when $r>0.70$); MC: shows Moderate Correlation (r= 0.51-0.69); RC: Represent Weak Correlation (when $r<0.50$); NC: shows Negative Correlation; * shows t-test significant at 5% level ($p<0.05$); NS: Not significant correlation (when $p>0.05$); a: shows relationship significant when $p>4$.

4. DISCUSSION

Resuts presented in this study were compared with the length data found in the literature, for the *S. scrofa*: the maximum TL, 39.1 cm (Karakulak et al., 2006) in the northern Aegan Sea; whereas 30.1 cm (Özaydın and Taşkavak, 2006) in the İzmir Bay, Turkey; 42.1 cm (Deval et al., 2014) in the Antalya Bay; 58.2 cm (Matic-Skoko et al., 2015) in Adriatic Sea; 40.5 cm (Shahrani et al., 2015) in the western Libyan coast; 38.3 cm (Miled-Fathalli et al., 2019) in the Gulf of Tunisia; 370.0 mm (Jaramillo-Londono et al., 2019) in the Cullera Coast, Iberian Peninsula; 30.2 cm (Arslan and Bostancı, 2019) in the İzmir Bay, Aegean Sea and 33.4 cm (Yedier and Bostancı, 2021) in the Aegean, Black, Mediterranean and Marmara seas; for the *S. elongata*: the maximum TL, 24 cm; 42.1 cm; 41.5 cm; 50 cm and 23.6 cm as given by Edelist (2014) in the Southeastern Mediterranean Sea; Deval et al. 2014 in the Antalya Bay; Lelli et al. 2017 in the Lebanese marine waters, eastern Mediterranean; Miled-Fathalli et al. 2019 in the Gulf of Tunisia and Yedier and Bostancı 2021 in the Aegean, Black; respectively; for the *S. notata:* the maximum TL, 15.1 cm; 24.3 cm; 17.5 cm; 15.2 cm and 22.9 cm with respect to Karakulak et al. 2006 in the northern Aegean Sea, Turkey; Özaydın and Taşkavak 2006 in the İzmir Bay, Turkey; Akalın et al. 2011 in the İzmir Bay, Turkey; Miled-Fathalli et al. 2019 in the Gulf of Tunisia and Yedier and Bostancı 2021 in the Aegean, Black, Mediterranean and Marmara seas; and for the *H. dactylopterus* specimens: the maximum TL was 30 cm; 36 cm; 44.9 cm; 38.0 cm; 27 cm; 19.3 cm; 30.6 cm and 24 cm according to Massuati et al. 2000 in the western Mediterranean; Massuati et al. 2000 in the Alboran Sea; Sequeira et al. 2009 in the Portuguese; Munoz et al. 2010 in the north-western Mediterranean; Consoli et al. 2010, in the central Mediterranean (southern Tyrrhenian Sea); Demirhan and Akbulut 2015, in the North-Eastern Mediterranean Sea, Turkey; Sami et al. 2016, in the Northern Waters of Tunisia (Central Mediterranean) and Miled-Fathalli et al. 2019, in the Gulf of Tunisia. With regard to four Scorpaenoid species previous studies give a similar comparative picture for the length ranges of this species from different references.

In this study, 15 morphometric and 9 meristic characters were examined and compared for each Scorpaenoid species to determine the phenotypic differentiation between male and female populations of each selected Scorpaenoid species. The morphological measurements of the four species of the Scorpaenoid showed enough variation to distinguish the males and females of each Scorpaenoid species. Male and female individuals of each *S. scrofa*, *S. elongata*, *S. notata* and *H. dactylopterus* studied in this study exhibited morphological similarities with each other in nearly all aspects. The current study also revealed that, while some differences in the means obtained for each morphometric character were observed between male and female sexes of the four Scorpaenoid species, all such differences were found to be mostly insignificant (*t*-test; $p < 0.05$) in the selected Scorpaenoid species, indicating a negligible effect of sex on observed variation in morphometric characters, which was consistent with Turan et al. (2005). However, significant variations (*t*-test; $p < 0.05$) were observed in the standard length and minimum body height in *S. scofa*, in the maximum body height, head length, and eye diameter in *S. elongata*, in the maximum body height, pelvic fin length, snout length and supraocular tentacle length in *S. notata*, while in case of *H. dactylopterus*, significant variations (*t*-test; $p < 0.05$) were noted in the distance between the standard length and anal fin length. As a result, sexual dimorphism was observed in only a few morphometric characters in these two Scorpaenoid species. Turan et al. (2009) compared *S. elongata*, *S. maderensis*, *S. notata*, *S. porcus*, and *S. scrofa* from Iskenderun Bay (Mediterranean Sea) based on the number of spines and soft rays on the anal, ventral, and dorsal fins, the number of soft rays on the pectoral and caudal fins, the number of scales. They concluded that caudal fin rays, pectoral fin rays, vertebrae numbers, and lateral scale numbers are crucial for species differentiation. Akaln et al. (2011) compared 19 metrics and 7 meristic properties of *S. porcus* and *S. notata* from the Aegean Sea. Although they claimed that the black spot on the dorsal fin and the supraocular tentacle is useful for distinguishing these two species, they had difficulty distinguishing juvenile individuals. Though growth rates of Scorpion fishes were found to vary with combinations of various biotic and environmental factors such as food availability, stocking density, sex, fish size, and habitats (Massuati et al., 2000; Karakulak et al., 2006; Özaydın and Taşkavak, 2006; Sequeira et al., 2009; Consoli et al., 2010; Deval et al., 2014; Edelist, 2014; Demirhan and Akbulut, 2015; Matic-Skoko et al,. 2015; Shahrani and Shakman, 2015; Sami et al., 2016; Lelli et al., 2017; Miled-Fathalli et al., 2019; Jaramillo-Londono et al., 2019; Arslan and Bostancı, 2019 and Yedier and Bostancı, 2021) they mostly varied along the different geographical gradients in which they lived. Thus, in the current study, differences in the morphological characteristics of the male and female populations of four Scorpaenoid species may be the result of differences in the habitat used or the conditions of their habitats, geographical isolation, availability of food, size range, health condition, and sexual maturity stages of fish, fish preservation techniques, sampling procedure, and sample size are the factors that may lead to the phenotypic differences. Furthermore, Fricke (2020), reported that the growth performance and survival rate of any fish species can also be affected by the water depth. This could be since certain parameters such as dissolved oxygen, temperature, salinity, turbidity, and pH of water could vary depending on water depth. Characters were found to vary significantly due to the impact of different environments in which they lived. Thus, the current study's findings revealed that the pattern of differences in morphological characteristics between male and female populations of each selected Scorpaenoid species of the current study could be attributed to the aforementioned factors.

According to Vladykov (1934), the fish with limited distribution exhibited a narrow range of differences in its morphometric characters, which were mostly caused by genetic variability, and thus the tendency of sub speciation was found to be low. However, fish species with a wide geographical distribution showed significant differences in their most morphometric characteristics, which are strongly influenced by the environment and have a high proclivity for subspecies formation. Scorpanoid species fell into the widely distributed category in the current study, so all of these morphological characteristics were found to vary significantly due to the impact of different environments in which they lived.

It shows that in the present study, the meristic counts are independent of body size and there is no change in meristic counts with the increase in body length. This corroborates with the studies in other fishes by Torcu and Aka (2000), Turan et al. (2009), Akalın et al. (2011), and Fricke et al. (2020). The study of morphometric and meristic characters is important for the identification of specimens and for experimental studies. Collectively, these results show that the collected fish specimens represented a homogenous group. Our findings also indicate that DFR, PlvFL, PecFL, and CFL are common and non-variable characters of all four species.

The linear equations were optimal for the morphometric characters, as the coefficients of determination showed higher values (R^2>0.90). The morphometric characters for the *S. scrofa, S. elongata*, *S. notata* and *H. dactylopterus* were calculated to find a relationship, with the TL indicating a linear relationship with all "R^2" values of morphometric characters within the range of 0.752 to 0.988, 0.485 to 0.959, 0.207 to 0.975 and 0.417 to 0.926, respectively The value of correlation coefficient was higher for the *S. scrofa* (0.988) and *S. elongata* (0.959) in SL meaning SL highly correlated with TL. These values are for the *S. notata* (0.975) in minimum body height and for *H. dactylopterus* (0.926) in the ED. High values of correlation coefficient "R^2" indicated a high degree of positive correlation with the reference length (TL) (Dasgupta et al. 1991). Arslan (2017), reported that some morphometric regression and correlation relationships for the *S. scrofa*, HL = 0.337TL + 1.090 (R^2 = 0.91), PoD = 0.224TB + 4.688 (R^2 = 0.90), DFL= 0.417TB + 6.693 (R^2 = 0.89), ML = 0.172TB + 0.131 (R^2 = 0.87), CPH = 0.086TB - 1.533 (R^2 = 0.87), POM = 0.162TB + 2.997 (R^2 = 0.81), BH = 0.262TB - 2.564 R^2 = 0.81) and SnoL= 0.110TB - 2.784 (R^2 = 0.75). Results obtained from the Aegean Sea were generally in agreement with the results presented in this paper.

The rate of allometric equations was found to be of taxonomic interest (Gould 1966). Moreover, the type of allometry was used to study the Scorpaenid species (Massuati et al., 2000; Özaydın et al., 2006; Karakulak et al., 2006; Consoli et al., 2010; Akalın et al., 2011; Deval et al., 2014; Edelist, 2014; Demirhan and Akbulut, 2015; Matic-Skoko et al., 2015; Sami et al., 2016; Lelli et al., 201; Arslan and Bostancı, 2019; Miled-Fathalli et al., 2019). The present study, confirms this explanation and emphasizes the taxonomic significance of allometric equation relationships in the explanatory of morphometric characters of the four Scorpaenoid species, Antalya Bay considered.

The four Scorpaenoid species were characterized by clear variations in the external features. For the *S. scrofa* species was characterized by a dark spot on its spinous dorsal spines between the 6th and 11th and the *S. notata* species supraocular tentacle. In addition, the morphometric ratios with standard length declared the difference of each species from each other as the HL, AFl, SnoL, and PoH in the *H. dactylopterus* were smaller than in the *S. scrofa*, *S. elongata* and, *S. notata*; the PecFL in the *S. notata* were smaller than in the three Scorpaenid species; the CFL were smilar in the four Scorpaenid species; the BH in the *H. dactylopterus* were higher than in the *S. scrofa*, *S. elongata*, and *S. notata*, whereas with head length as the ED in the *H. dactylopterus* were higher than in three Scorpaenid species, with the IoD are smaller than in others. Temporal trends in morphometric characters/SL and HL of the four Scorpaenid species were determined by non-parametric Spearman correlation. Results of correlation coefficient analysis indicated that the mean Antalya Bay distance (0.83) between the four species in all morphometric measurements were significant ($p < 1$). Arslan (2017), reported that was found to be the highest coefficient of the head length to total height ($R^2 = 0.91$) and the lowest coefficient of the head length to snouth length ($R^2 = 0.75$). The coefficient of correlation with total height was found as preopercular distance ($R^2 = 0.90$), dorsal fin base length ($R^2 = 0.89$). Akalın et al. (2011), reported important differences among the PYB, KPY, UCB, GC, SOTB, DYEUDB, AYEKDB, AYEUDB, and PYDB characters in the *S. notata* and *S. porcus* species from the İzmir Bay.

The fins formula were as follows: *S. scrofa* - D (XII 9), A (III 5), Plv (I 5), Pec (18-19), C (17-20) similar to Fricke et al. 2020; Turan et al. 2009 and Torcu and Aka 2000, *S. elongata* - D (XII 10), A (III 5), Plv (I 5), Pec (19), C (18-20) similar to Turan et al. 2009, *S. notata* - D (XII 9), A (III 5), Plv (I 5), Pec (16-18), C (18-19) similar to Akalın et al. 2011, Turan et al. 2009; Torcu and Aka 2000 and *H. dactylopterus* - D (XII 12-13), A (III 5), Plv (I 5), Pec (18-19), C (20-21) similar to Turan et al. 2009. It shows that the fish specimens so collected were of a homogenous group and XII dorsal fin rays, III anal fin rays and I pelvic fin rays were found to be a common and non-variable character in all four species.

5. CONCLUSION

The current study concluded that all selected morphometric and meristic characters were useful in observing phenotypic variations among the male and female populations of the four selected Scorpaenoid species. As a result, the present study will provide useful information on the morphometric and meristic characteristics of all four selected Scorpaenoid species and their sexes, allowing us to compare and contrast growth patterns and body measurements.

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CONFLICT OF INTEREST

The author declares no competing interests.

ETHICAL STATEMENTS

No ethical approval was required because the fish were obtained from commercial fisheries

DATA AVAILABILITY STATEMENT

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

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