International Journal of Fisheries and Aquaculture Research
Vol.8, No.1, pp.1-28, 2022
Print ISSN: ISSN 2397-7507,
Online ISSN: ISSN 2397-776

Comparative Study on Morphology of *Sarpa Salpa* and *Dentex Gibbosus* (Perciformes) From the Southern Mediterranean Coast (Eastern Libya)

Amnnah khalid khalleefah[1], Sayed Mohamed Ali[2, *], Ramadan A. S. Ali[1]
[1] Department of Zoology, Omar Al-Mukhtar University, Albaida, Libya
[2] Department of Marine Sciences, Omar Al-Mukhtar University, Albaida, Libya
*: Corresponding author <sayed.mohaned@omu.edu.ly>

Citation: Amnnah khalid khalleefah, Sayed Mohamed Ali and Ramadan A. S. Ali (2022) Comparative Study on Morphology of Sarpa Salpa and Dentex Gibbosus (Perciformes) From the Southern Mediterranean Coast (Eastern Libya), *International Journal of Fisheries and Aquaculture Research*, 8, (1) , 1-28

ABSTRACT: *Eighteen Sarpa salpa and fifteen Dentex gibbous fish collected randomly from the artisanal catch of Benghazi landing site, eastern Libya (32°36' N 20°03' E), during fall and winter of 2019 were used in the present study. Morphogenic features, and 21 key morphometric and 6 key meristic parameters were established for each fish. S. salpa was fusiform with a terminal mouth, narrow caudal peduncle and bifurcate caudal fin. The body was silvery white at the belly side, grading into silvery black at the dorsal side, and horizontal yellow to black stripes extended from the head region to the caudal peduncle. D. gibbosus was less fusiform with large eyes and a lunate caudal peduncle, the mouth was almost terminal, and the body was silvery but slightly pinkish and lighter at the belly side. S. salpa was heavier and longer than D. gibbosus, all its morphometric parameters were significantly higher than those of D. gibbosus except for the eye diameter and the mouth gape. This trend existed even when the parameters were related to total fish length as a ratio to eliminate the effect of size. The majority of binary pairs of morphometric parameters of S. salpa, and D. gibbosus, correlated strongly and positively with each other. Morphometric parameters located within the head region were related to the head length by linear and power regressions, and parameters located outside the head region were related to total fish length by similar regressions. Almost all regressions for both fish were positive and highly significant, indicating that all the parameters increased as the fish grew. The "b" value of the power length-weight regression indicated negative allometric growth for both fish; that of S. salpa was 2.715, and that of D. gibbosus was 2.246. The differences in morphometric traits of both fish were discussed in relation to modes of feeding and swimming, camouflage, and habitat. The Fulton condition factors were 1.733 and 1.247 in order. These factors did not change significantly during fish growth. Almost all the meristic parameters did not correlate with fish length, meaning that they were conservative features and can be used to establish meristic forms. The meristic forms derived were:*

D, X-XI (XI) + 14-17 (16); A, III + 13-15 (14); P, 14-16 (15); V, I + 5; LL, 70-80 (76) for S. salpa, and,

D, XI-XII (XII) + 10-11 (10); A, III + 8-9 (9); P, 14-15 (15); V, I + 5; LL, 60-65 (62) for D. gibbosus. The numbers between parenthesis are the modes.

KEYWORDS: morphology, morphometry, meristic, Sarpa salpa, Dentex gibbosus, Mediterranean.

INTRODUCTION

Many approaches are used for characterization and differentiation between fish. These approaches are based on morphological and molecular traits, anatomical traits such as sagittal morphology, physiological characters, ecology and distribution, and image recognition systems (IRS). Among these tools, morphological approaches stand as the simplest, easiest, direct, efficient, and most powerful (Mohammed, 2018). Morphological traits can be subdivided into morphogenic, morphometric, and meristic. Morphogenic traits are based on descriptive characteristics that cannot be measured or counted, such as body form and color, retractability of the snout, shape of the caudal fin, and type of scales. Morphometric traits are measurable parameters such as total weight and length of the fish, length of the head and the different fins, and eye diameter. Meristic traits are countable parameters such as the number of spine and rays of fins, the number of scales on, above, and below the lateral line, and the number of gill rackers (Mohammed, 2018). The length-weight relationship of fish is usually expressed as power, linear, or logarithmic regressions. The power expression is $W = aL^b$, where W and L are fish weight and length, and "a" and "b" are the regression constants. The regression enables calculating the fish weight expected for a given fish length, and vice versa, and is usually a necessary component in many of the population dynamics equations. The values of "a", the intercept of the regression line on the y axis, and "b", the slope of the regression line, differ inter and intra species spatiotemporally. Fish grow isometrically when the value of "b" equals 3 meaning that both weight and length increase at similar rates, negative allometrically when "b" < 3 indicating that length increases at a faster pace than weight and the fish tends to be slimmer as it grows, or positive allometrically when "b" > 3, here, weight increases at a faster pace than length and the fish tends to be stouter as it grows (Froese, 2006). Fulton's (K) condition factor is a length-weight ratio ($K=100W/L^3$) that indicates fish health. Presumably fish with higher K is chubbier. It is a handy tool for comparing fish conditions spatiotemporally (Fulton, 1902; Froese, 2006). Morphology are believed to be an adaptation on the evolutionary scale and plasticity on the short term scale to continuously changing environment.

Members of the family Sparidae inhabit tropical and temperate waters and are the most dominant group of demersal fish in coastal Mediterranean waters (Osaman and Mahamoud, 2009), including the Libyan coast (Al-Hassan and El Siliny, 1999), where they constitute a major component of the artisanal catch. Adult *Sarpa salpa* and *Dentex gibbosus* are two "look-alike" medium sized Sparid that are common in inshore waters of the eastern Libyan Mediterranean Sea. The main apparent difference between the two fish is their mode of feeding, which is probably reflected in other traits such as habitat prefrence, details of the morphology, mode of feeding and swimming, and bio-mineralization. Juveniles of *S. salpa* feed on small invertebrates, mainly crustaceans; later, however, they are almost exclusively herbivorous. *D. gibbosus* is exclusively carnivorous on crustaceans, mollusks, and small fish (Golani *et al*., 2006; Ben-Abdalla *et al*., 2009).

The objective of the present work is to establish and compare the morphological traits of *Sarpa salpa* and *Dentex gibbosus* from the Benghazi coasts, eastern Libya (southern Mediterranean Sea) and relate the differences, when possible, to differences in habitat and fish biological traits. The morphology of either fish has not been studied in Libya. In addition, in previous studies, morphological traits of fish were usually established as an identification tool, and rarely correlated with fish habitat and biological traits.

METHODS

The study area:

The study area: Benghazi coast, Benghazi city, Juliana Port and its vicinities, is located on the eastern coast of Libya (Fig. 1). Benghazi is the second largest city in Libya, a major deep-sea harbor, and an industrial and commercial center. The coast is characterized by the presence of many small seasonal estuaries, lagoons, wetlands, and tidal marshes of brackish water. Benghazi Natural Reserve (marine and terrestrial) is located close to Benghazi City. Benghazi City is a permanent fishing and landing site with a major fish market (Reynolds *et al*., 1995).

Fig 1. Benghazi city and harbor, the site from which the study fish were collected.

Sample collection and identification:

Eighteen *Sarpa salpa* and fifteen *Dentex gibbous* were collected randomly from the artisanal catch of the Benghazi landing site during the fall and winter of 2019 and transported in ice boxes to the Marine Laboratory of the Department of Zoology of Omar Al-Mukhtar University. Identification was confirmed according to Whitehead *et al*. (1984); Golani *et al*. (2006), and Ben-Abdalla *et al.* (2009).

Establishing the morphogenic traits of *S. salpa* and *D. gibbosus*

Morphogenic characters	Morphometric parameters	Meristic parameters
1- Body-shape	1- Total Weight (TW)	1- Number of Dorsal fin Rays (DR) and Spines (DS)
2- Body-color	2- Gutted weight (GW)	2- Number of Pectoral fin Rays (PR) and Spines (PS)
3- Presence or absence of spots and strips	3- Total Length (TL)	3- Number of Ventral fin Rays (VR) and Spines (VS)
4- Shape of mouth position, retractability	4- Fork Length (FL)	4- Number of Anal fin Rays (AR) and Spines (AS)
5- Shape of caudal fin	5- Standard Length (SL)	5- Number of Caudal fin rays (C)
	6- Body Depth (BD)	6- Number of Scales on Lateral Line (SLL)
	7- Head Length (HL)	
	8- pectoral fin Lengths (PFL)	
	9- Dorsal fin Length (DFL)	
	10- Ventral fin Length (VFL)	
	11- Anal fin Length (AFL)	
	12- Caudal peduncle length(CPL)	
	13- Caudal Peduncle Width	
	14- Cauda fin Gape (CFG)	
	15- Pre-dorsal fin length (PFDL)	
	16- Pre anal fin length (PFAL)	
	17- Eye Diameter (ED)	
	18- Pre orbital Length (POL)	
	19- Post orbital Length (POSL)	
	20- Mouth Width (MW)	
	21- Mouth Gape (MG)	

The morphogenic features of *S. salpa* and *D. gibbosus* (Table 1) were observed and recorded.

Establishing the morphometric traits of *S. salpa* and *D. gibbosus*

Twenty-one morphometric parameters (Table 1 and Figs. 2 and 3) were measured for individuals of both fish, with weights to the nearest 0.1g and corresponding lengths to 0.1cm. The individual morphometric parameters of both fish were related to fish length as a percentage ratio.

Table 1. The morphogenic, morphometric, and meristic traits established for *Sarpa salpa* and *Dentex gibbosus* in the present study.

Morphometric parameters located outside the head region of the fish were related to total fish length by linear and power regression equations. Morphometric parameters located within the head region were related to head length by similar equations.

Pearson's binary correlations between the morphometric parameters were established.

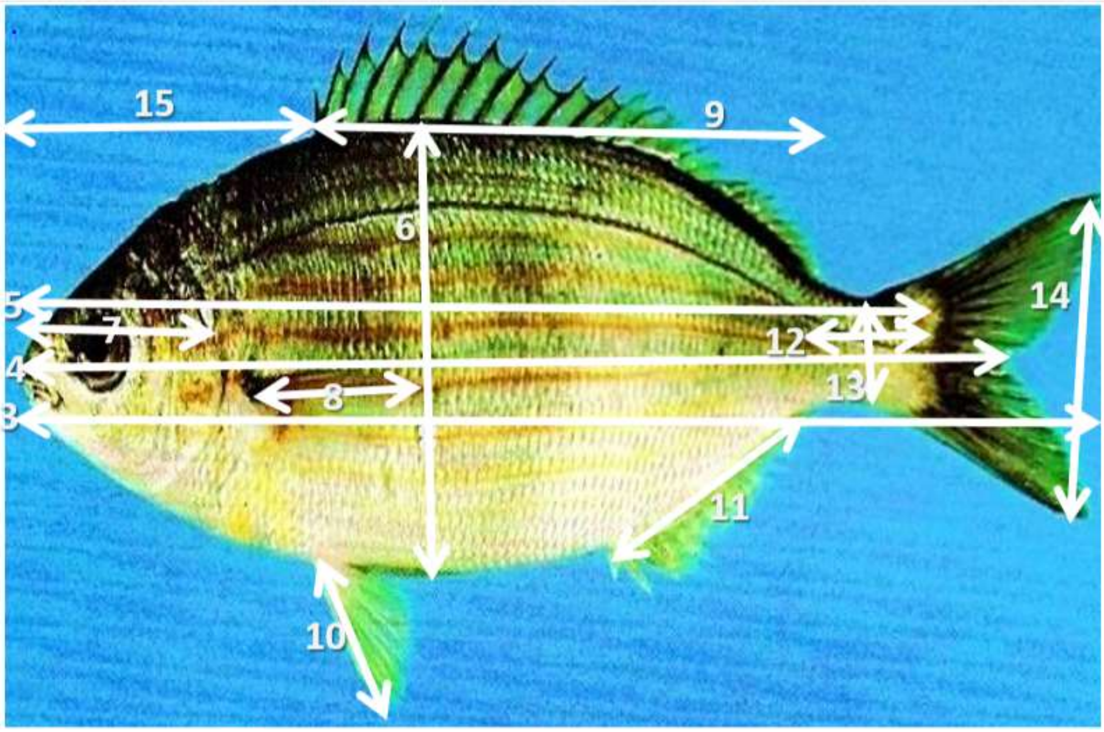

Fig 2. Some of the morphometric measurements taken for *S. salpa* (above) and *D. gibbosus* (Fig. 3).

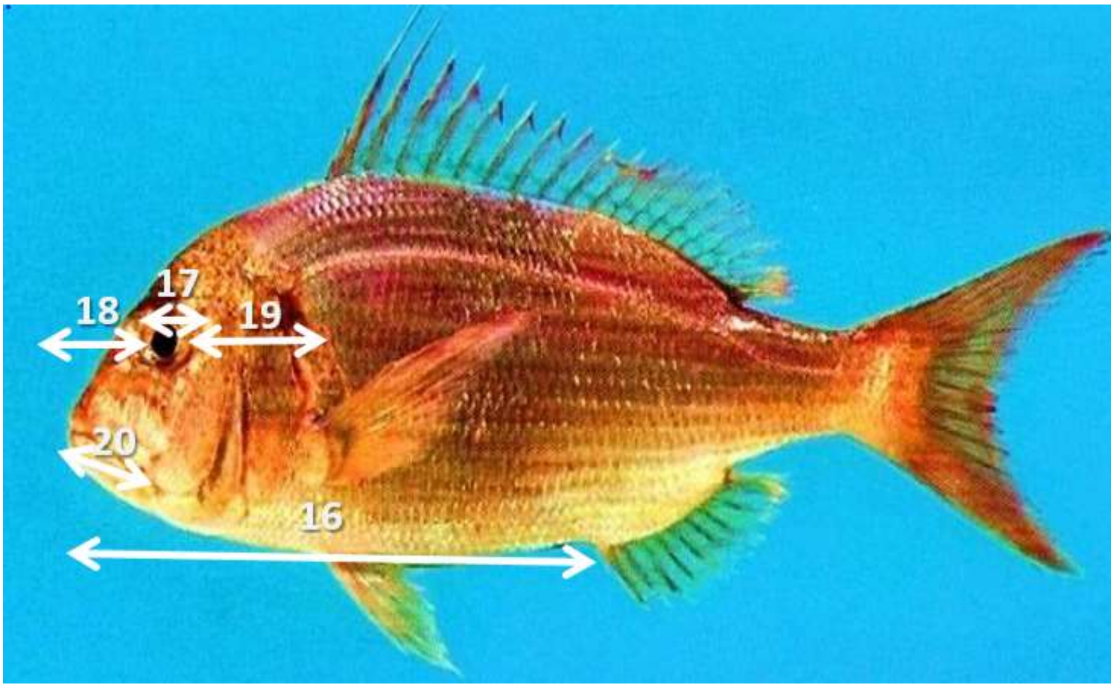

Fig. 3. Some of the morphometric measurements taken for *D. gibbosus* (Fig. 3) and *S. salpa* (Fig. 2).

The length-weight relationship (LWR):

The LWR was calculated for both fish according to Le Cren, (1951) and Ricker, (1975) as follows:

$TW = aTL^b$, where TW is total weight (gm), TL is total length (cm), and “a” and “b” are constants.

The condition factors:

Fulton (K_F) and Clark (K_C) condition factors were calculated for both fish according to Fulton (1902), as $K_F = 100 * TW / TL^3$, and (Clark, 1928) as $K_C = 100 * TWg / L^3$, where TWg is fish gutted weight in grams.

Establishing the meristic traits of *S. salpa* and *D. gibbosus*

Six meristic parameters were counted for each fish (Table 1), Maximum, minimum, and mode of the count of each parameter were established. The meristic parameters were not related to fish length by percentage ratios or by regression equations because Pearson’s correlations between possible meristic pairs, and between the 6 meristic parameters and the fish length indicated no correlations.

Statistical analysis:

Descriptive statistics of the morphometric and the meristic parameters were established using Excel 2010 and the SPSS and Minitab packages. These parameters were correlated with each other using Pearson's binary correlation. The morphometric parameters were related to total fish length and head by percent ratios (to minimize variations due to differences in the size of both fish) and linear, and power regression equations. The morphometric parameters of both fish were examined for the significance of differences between means by student t-tests.

RESULTS

The morphogenic traits

Sarpa salpa:

Fusiform body (Fig. 2), lower terminal mouth, narrow caudal peduncle, bifurcate caudal fin, body silvery white at the belly side grading into silvery black at the dorsal side, distinct lateral line extending to the base of the caudal peduncle, and horizontal yellow to black stripes extending from the head region to the caudal peduncle.

Dentex gibbosus:

The body is fusiform, but to a lesser extent than in *S. salpa* (Fig. 3); the eyes are large; the caudal peduncle is narrow and ends in the lunate caudal fin; the body is silvery, slightly pinkish, and lighter on the belly side, with no horizontal or vertical stripes; and the lateral line is distinct.

The morphometric traits of both fish

Sarpa salpa of the present study was larger than *Dentex gibbosus*. The mean total weight (± standard error) of both fish in order was 1071.9±68.7 and 231.73±9.02gm, corresponding to a mean total length of 39.289±0.934 and 26.467±0.399cm. All the other morphometric parameters of *S. salpa* were significantly ($P \leq 0.05$) higher than those of *D. gibbosus* except ED, PFL, MG, and MW (highlighted green in Table 2). The difference between means of POL of both fish was not significant, but the percentage ratio of POL from total fish length was significantly higher for *D. gibbosus*. HL, ED, POL, POSL, PFL, VFL, CPL, CFG, PFDL, MG, MW percentage ratios of *D. gibbosus* were significantly higher than those of *S. salpa* (highlighted turquoise in Table 2). Converting the measured morphometric parameters to percentage ratios from total length removed the effect of fish size and enables comparison between the two fish even though *S. salpa* was much larger than *D. gibbosus*.

Table. 2. Means of morphometric parameters (± standard error) and percentage ratios of these parameters from the total length of *Sarpa salpa* (SS) and *Dentex gibbosus* (DG). Means with different superscripts were significantly different. Means of morphometric parameters that have higher magnitudes in DG compared to SS are highlighted green and turquoise for percent ratios.

Morphometric characters	Species	Mean ± SE	%
TW	**SS**	1071.9±68.7 a	
	DG	231.73±9.02 b	
TL	**SS**	39.289±0.934 a	
	DG	26.467±0.399 b	
FL	**SS**	35.833±0.909 a	91.170±0.538 a
	DG	23.573±0.349 b	89.059±0.547 b
SL	**SS**	33.072±0.801 a	84.176±0.389 a
	DG	21.027±0.311 b	79.466±0.432 b
BD	**SS**	11.988±0.369 a	30.480±0.562 a
	DG	7.2649±0.0980 b	27.471±0.234 b
HL	**SS**	8.122±0.210 a	20.670±0.209 b
	DG	7.0479±0.0979 b	26.644±0.184 a
ED	**SS**	1.6704±0.0893 b	4.276±0.0823 b
	DG	2.0564±0.0288 a	7.782±0.111 a
POL	**SS**	2.9253±0.0893 a	7.443±0.138 b
	DG	2.9529±0.0633 a	11.153±0.114 a
POSL	**SS**	3.938±0.100 a	10.027±0.109 b
	DG	2.7560±0.0435 b	10.43±0.132 a
DFL	**SS**	17.854±0.438 a	45.520±0.680 a
	DG	10.558±0.171 b	39.892±0.232 b
PFL	**SS**	6.788±0.218 b	17.255±0.329 b
	DG	7.434±0.161 a	28.1150.547 a
VFL	**SS**	5.283±0.120 a	13.483±0.220 b
	DG	4.2627±0.0860 b	16.107±0.210 a

AFL	**SS**	7.245±0.136 a	18.499±0.219 a
	DG	3.912±0.106 b	14.764±0.268 b
CPL	**SS**	3.601±0.138 a	9.163±0.256 b
	DG	2.896±0.111 b	10.934±0.370 a
CPW	**SS**	2.6552±0.0634 a	6.7698±0.096 a
	DG	1.6655±0.0474 b	6.292±0.149 b
CFG	**SS**	11.830±0.557 a	30.32±1.50 b
	DG	10.398±0.332 b	39.31±1.17 a
PFDL	**SS**	11.703±0.368 a	29.794±0.618 b
	DG	8.438±0.224 b	31.980±0.949 a
PFAL	**SS**	21.962±0.603 a	55.843±0.442 a
	DG	13.701±0.183 b	51.798±0.281 b
MG	**SS**	2.1822±0.0527 b	5.582±0.132 b
	DG	3.0105±0.0593 a	11.391±0.218 a
MW	**SS**	1.9807±0.0706 b	5.0255±0.089 b
	DG	2.6481±0.0470 a	10.007±0.105 a
GW	**SS**	772.5±45.9 a	1940.5±81.4 a
	DG	203.67±7.68 b	766.6±19.7 b

The length-weight relationship

The power and linear regressions of the length-weight relationship of *S. salpa* and *D. gibbosus* were highly significant and had high R^2 (Table 3, Figs. 4 and 5). The power regressions were slightly stronger than the linear ones, but both regressions expressed the relation very well. The "b" value of the power regression of both fish indicated negative allometric growth; that of *S. salpa* was 2.7148, and that of *D. gibbosus* was 2.2457, which was more negatively allometric than the former.

Table 3. The power and linear length-weight regressions of *Sarpa salpa* and *Dentex gibbosus*.

Species	**Regression**	**a**	**b**	**R^2**	**P**
S. salpa	Linear	- 1605.6	68.151	0.8591	0.000
	Power	0.0444	2.7418	0.8854	0.000
D. gibbosus	Linear	- 275.98	19.183	0.7202	0.000
	Power	0.1469	2.2457	0.7372	0.000

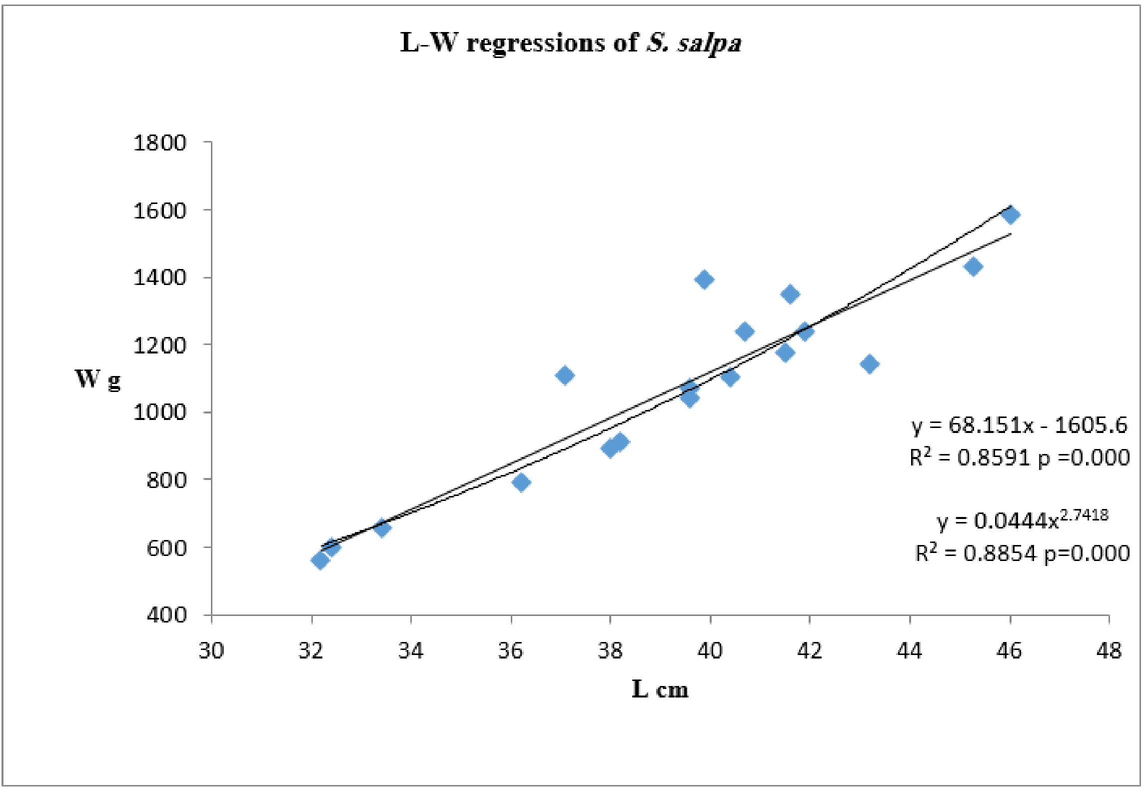

Fig. 4. Power and linear length-weight regressions of *Sarpa salpa*.

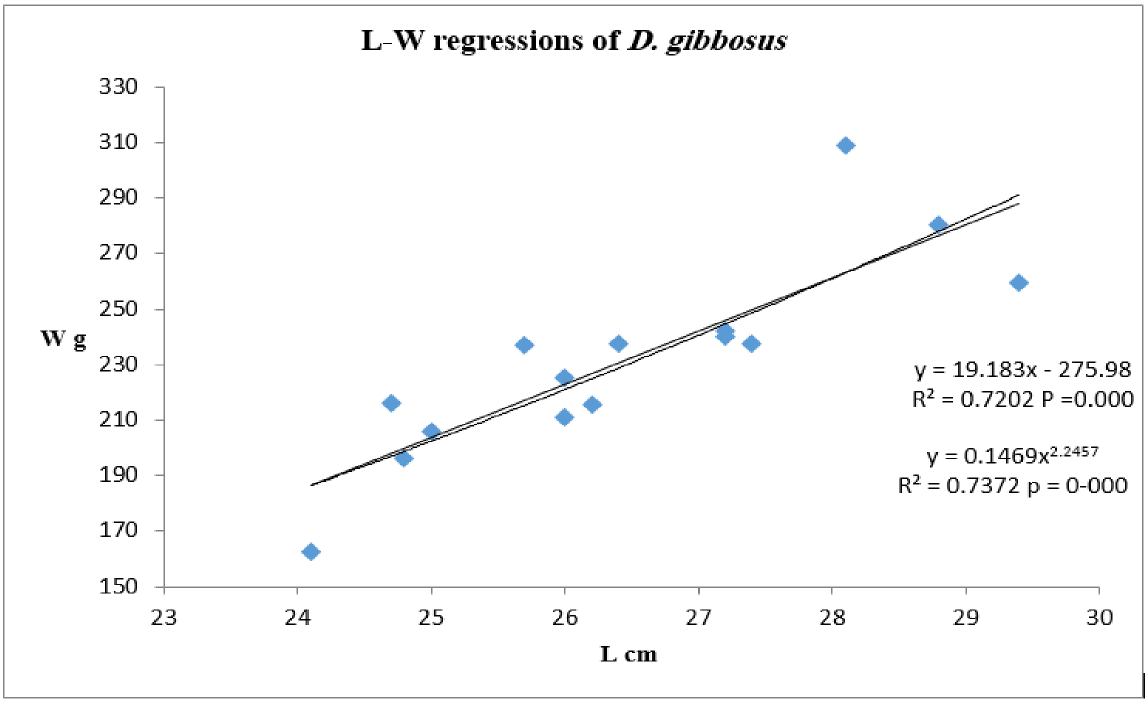

Fig. 5. The power and linear length-weight regressions of *Dentex gibbosus*.

The condition factors

The Fulton condition factors of *S. salpa* and *D. gibbosus* were 1.733 and 1.247 (Table 4). Linear and power regressions of these factors with fish length had low R^2 and P values > 0.05, indicating that the condition of both fish did not change significantly during the growth (increase in length is taken as an indicator of growth) of the fish, although an insignificant trend was observed (Table 4, and Figs 6 and 7).

Table 4. Fulton condition factor (K_F) of *Sarpa salpa* and *Dentex gibbosus*.

Species	K	Regression	a	b	R^2	P
S. salpa	1.733	Linear	2.2057	- 0.01	0.0617	0.320
		Power	4.4419	-0.258	0.0641	0.311
D. gibbosus	1.247	Linear	2.16	-0.035	0.2332	0.068
		Power	14.688	-0.754	0.2404	0.064

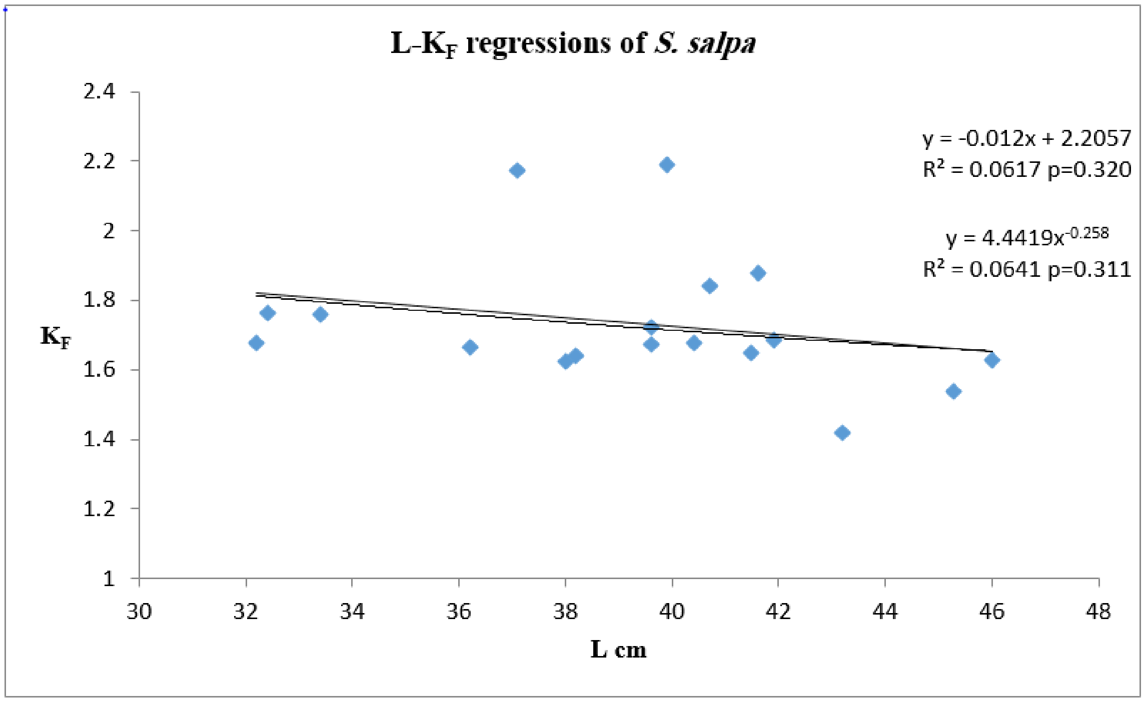

Fig. 6. Total length-condition factor regressions of *S. salpa*.

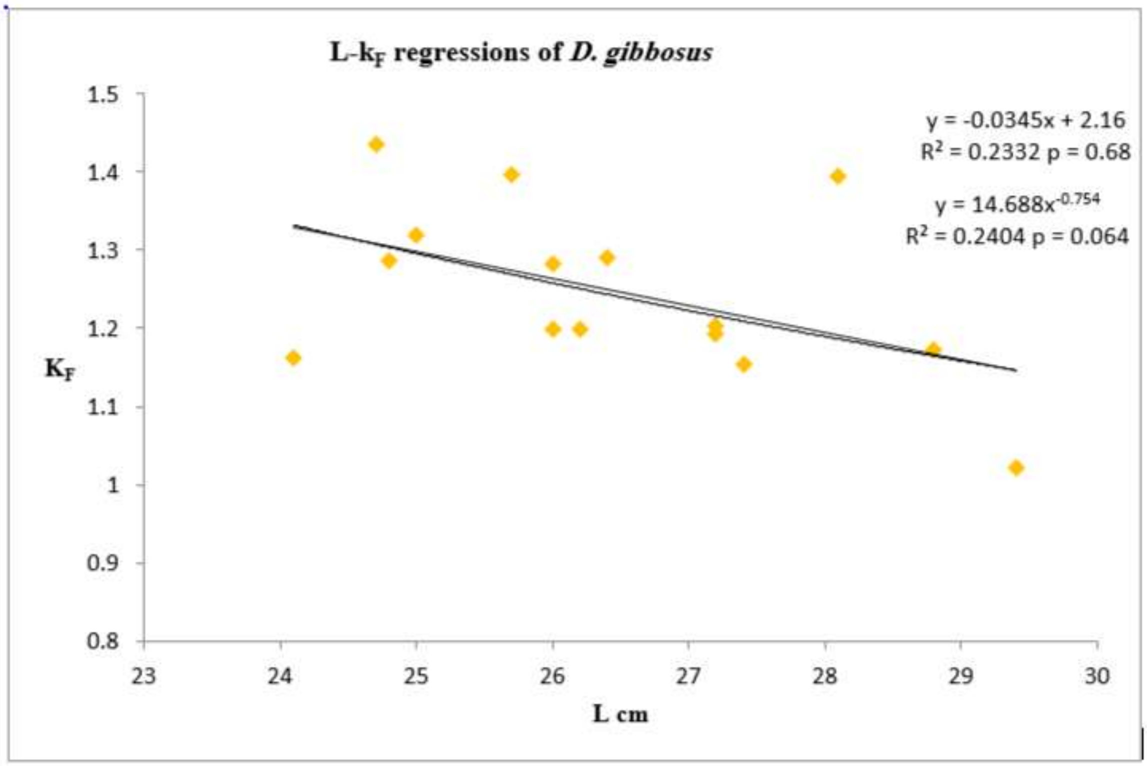

Fig. 7. Total length-condition factor regressions of *D. gibbosus*.

Binary correlation between the morphometric parameters of *Sarpa salpa* and *Dentex gibbosus.*

Pearson's binary correlations between the morphometric parameters of *S. salpa* (Table 5) were strong, positive, and significant for almost all possible pairs. CPL correlated moderately with the other parameters, CFG and MG showed weak or no correlations. MG, however, correlated strongly with CPL (highlighted turquoise in Table 5). Most morphometric pairs of *D. gibbosus* also correlated strongly or moderately with each other (Table 6), except ED, CFG, PFDL, and MG, which correlated, more or less, weakly with the other parameters.

Table 5. Binary correlations between morphometric parameters of *S. salpa*.

	TW	TL	FL	SL	BD	HL	ED	POL	POSL	DFL	PFL	VFL	AFL	CPL	CPW	CFG	PFDL	PFAL	MG	MW
TL	.927**																			
FL	.960**	.973**																		
SL	.953**	.982**	.991**																	
BD	.883**	.820**	.838**	.842**																
HL	.977**	.91**	.93**	.93**	.89**															
ED	.708**	.64**	.71**	.72**	.52*	.64**														
POL	.871**	.78**	.80**	.80**	.88**	.93**	.51*													
POSL	.974**	.89**	.91**	.90**	.89**	.97**	.67**	.90**												
DFL	.784**	.79**	.83**	.83**	.64**	.71**	.66**	.61**	.681**											
PFL	.876**	.82**	.86**	.86**	.82**	.88**	.78**	.82**	.882**	.71**										
VFL	.865**	.746**	.808**	.795**	.777**	.801**	.731**	.738**	.834**	.791**	.801**									
AFL	.863**	.870**	.897**	.911**	.753**	.818**	.725**	.702**	.781**	.944**	.762**	.816**								
CPL	.584*	.659**	.663**	.645**	.410	.577*	.473*	.440	.566*	.492*	.438	.457	.508*							
CPW	.905**	.815**	.846**	.861**	.918**	.891**	.634**	.862**	.874**	.750**	.850**	.838**	.817**	.350						
CFG	.11	.15	.22	.19	.21	.08	.05	.03	.060	.01	.13	-02		-.1	.10					
PFDL	.791**	.746**	.763**	.737**	.666**	.749**	.383	.601**	.747**	.649**	.636**	.641**	.725**	.309	.688**	.089				
PFAL	.969**	.958**	.982**	.978**	.819**	.927**	.717**	.777**	.913**	.811**	.830**	.813**	.877**	.671**	.847**	.195	.767**			
MG	.433	.532*	.468	.459	.277	.494*	.220	.433	.442	.241	.296	.241	.272	.822**	.256	-.280	.207	.489*		
MW	.856**	.870**	.864**	.876**	.849**	.892**	.547*	.831**	.857**	.644**	.856**	.635**	.725**	.380	.889**	.233	.695**	.825**	.351	
GW	.934**	.901**	.900**	.896**	.816**	.919**	.547*	.822**	.902**	.733**	.768**	.786**	.786**	.686**	.798**	.028	.741**	.925**	.573*	.735**

***: Significant at 0.05 level. **: significant at o.o1 level.**

Table 6. Binary correlations between morphometric parameters of *D. gibbosus*.

	TW	TL	FL	SL	BD	HL	ED	POL	POSL	DFL	PFL	VFL	AFL	CPL	CPW	CFG	PFDL	PFAL	MG	MW
TL	.849**																			
FL	.844**	.929**																		
SL	.891**	.933**	.963**																	
BD	.794**	.825**	.831**	.796**																
HL	.900**	.888**	.821**	.847**	.786**															
ED	.364	.517*	.379	.310	.423	.558*														
POL	.842**	.792**	.711**	.692**	.653**	.889**	.496													
POSL	.636*	.664**	.578*	.639*	.714**	.817**	.385	.549*												
DFL	.890**	.938**	.931**	.941**	.790**	.866**	.385	.735**	.676**											
PFL	.525*	.480	.356	.331	.317	.628*	.456	.756**	.391	.430										
VFL	.777**	.746**	.724**	.764**	.573*	.769**	.303	.669**	.516*	.757**	.568*									
AFL	.706**	.781**	.805**	.752**	.682**	.691**	.261	.642**	.416	.824**	.421	.745**								
CPL	.604*	.510	.592*	.539*	.703**	.590*	.449	.504	.505	.490	.319	.267	.358							
CPW	.522*	.551*	.623*	.555*	.442	.643**	.312	.638*	.315	.498	.494	.646**	.745**	.370						
CFG	.380	.393	.410	.350	.341	.505	.448	.464	.294	.345	.153	.546*	.481	.244	.658**					
PFDL	-.239-	.014	-.050-	-.051-	.015	-.030-	.367	-.318-	.289	.009	-.257-	-.298-	-.153-	.221	-.242-	-.057-				
PFAL	.926**	.933**	.919**	.935**	.772**	.888**	.413	.844**	.589*	.913**	.512	.818**	.719**	.553*	.549*	.425	-.184-			
MG	.361	.441	.360	.424	.392	.253	-.282-	.251	.202	.448	.021	.447	.492	-.137-	.055	-.012-	-.376-	.437		
MW	.764**	.809**	.650**	.705**	.611*	.847**	.488	.810**	.700**	.743**	.586*	.751**	.481	.254	.358	.457	-.150-	.820**	.376	
GW	.977**	.880**	.878**	.913**	.850**	.897**	.310	.806**	.685**	.935**	.477	.771**	.793**	.597*	.532*	.357	-.168-	.918**	.467	.730**

***: Significant at 0.05 level. **: significant at o.o1 level.**

Regressions of *Sarpa salpa* and *Dentex gibbosus* morphometric parameters with total fish length.

The morphometric parameters located outside the head region were related to fish length by linear and power regressions (Table 7). All the regressions were highly significant, except for *S. salpa* CFG, and CFG, and PFDL, and MG of *D. gibbosus* (highlighted yellow in the table). Both the linear and the power regressions of both fish described the relationship well, R^2 was strong for most parameters, but in general, was slightly stronger for *S. salpa* parameters than for *D. gibbosus* parameters. All regressions were positive indicating that all the morphometric parameters increased as the fish grew.

The morphometric parameters located within the head region were related to head length by linear and power regressions (Table 8). All the regressions were highly significant, except MG of *D. gibbosus* (highlighted yellow in the Table). Both the linear and the power regressions of both fish described the relationship well, R^2 was strong for all parameters (highlighted green) Except for MG for *D. gibbosus* (highlighted yellow in the Table), all of the regressions were highly significant. Both the linear and the power regressions of both fish described the relationship well, R^2 was strong for all parameters (highlighted green) except ED and MG; in general, R^2 of *S. salpa* parameters was slightly higher than that of *D. gibbosus* parameters. All the regressions were positive, indicating that all the morphometric parameters studied increased as the fish grew.

Graphical presentation of some of these regressions is shown in Figs 8 to 11.

Table. 7. Linear (L) and power (P) regression of *Sarpa salpa* and *Dentex gibbosus* morphometric parameters located outside the head region vs. total length. Regressions that were not significant at 0.05 are highlighted yellow.

parameters	Regression	*S. salpa*				*D. gibbosus*			
		a	b	R^2	P	a	b	R^2	P
TW	**L**	-1605	68.151	0.8591	0.000	-275.9	19.183	0.7202	0.000
	P	0.0444	2.7418	0.8854	0.000	0.1469	2.2457	0.7372	0.000
FL	**L**	-1.381	0.9472	0.9464	0.000	-0.733	0.9184	0.8627	0.000
	P	0.793	1.038	0.9497	0.000	0.8076	1.0298	0.8624	0.000
SL	**L**	0.011	0.8421	0.9643	0.000	1.7681	0.7277	0.8703	0.000
	P	0.8379	1.0012	0.9656	0.000	1.0351	0.9192	0.87	0.000
BD	**L**	-0.743	0.324	0.6725	0.000	1.8996	0.2027	0.6806	0.000
	P	0.1805	1.1421	0.6877	0.000	0.6279	0.7474	0.6815	0.000
HL	**L**	0.0043	0.2066	0.8418	0.000	1.279	0.218	0.789	0.000
	P	0.1958	1.0145	0.8598	0.000	0.4735	0.8243	0.7886	0.000
ED	**L**	0.9205	0.0191	0.4153	0.004	1.0686	0.0373	0.2676	0.048
	P	0.3508	0.4251	0.3973	0.004	0.4106	0.4916	0.2715	0.048
POL	**L**	-0.006	0.0746	0.6092	0.000	-0.372	0.1256	0.6269	0.000
	P	0.0642	1.0397	0.6556	0.000	0.0755	1.1186	0.6354	0.000
POSL	**L**	0.1589	0.0962	0.8073	0.000	0.8428	0.0723	0.4403	0.007

	P	0.111	0.9705	0.8276	0.000	0.2735	0.7051	0.447	0.007
DFL	**L**	3.2477	0.3718	0.6276	0.000	-0.074	0.4017	0.8799	0.000
	P	0.8731	0.8218	0.6305	0.000	0.3787	1.0158	0.8724	0.000
PFL	**L**	-0.77	0.1924	0.6804	0.000	2.289	0.1944	0.2308	0.070
	P	0.0981	1.1532	0.6726	0.000	0.7882	0.6843	0.2163	0.070
VFL	**L**	1.5326	0.0955	0.5564	0.000	0.0041	0.1609	0.5565	0.001
	P	0.3693	0.7245	0.5884	0.000	0.1786	0.9681	0.5521	0.001
AFL	**L**	2.2778	0.1264	0.7569	0.000	-1.603	0.2084	0.6107	0.001
	P	0.5878	0.6843	0.7685	0.000	0.0405	1.3945	0.5681	0.001
CPL	**L**	-0.21	0.097	0.4339	0.003	0.8591	0.1419	0.2597	0.052
	P	0.0894	1.0049	0.4399	0.003	0.038	1.3201	0.2377	0.052
CPW	**L**	0.4809	0.0553	0.6636	0.000	-0.069	0.0655	0.304	0.033
	P	0.1265	0.8289	0.6874	0.000	0.0599	1.0134	0.2406	0.033
CFG	**L**	8.2871	0.0902	0.0229	0.549	1.7402	0.3271	0.1545	0.147
	P	4.1301	0.2794	0.0113	0.549	0.6982	0.8225	0.1297	0.147
PFDL	**L**	0.1628	0.2937	0.5563	0.000	8.2286	0.0079	0.0002	0.960
	P	0.3412	0.9618	0.4838	0.000	9.6612	-0.043	0.0005	0.960
PFAL	**L**	-2.359	0.619	0.9179	0.000	2.3795	0.4278	0.8699	0.000
	P	0.3933	1.0955	0.9281	0.000	0.9351	0.8195	0.8719	0.000
MG	**L**	1.0021	0.03	0.2835	0.023	1.2751	0.0656	0.1947	0.100
	P	0.3602	0.4901	0.2482	0.023	0.4813	0.5591	0.1768	0.100
MW	**L**	-0.606	0.0658	0.7575	0.000	0.1272	0.0952	0.6541	0.000
	P	0.0162	1.3073	0.8074	0.000	0.1144	0.9589	0.6463	0.000
GW	**L**	-967.1	44.277	0.812	0.000	-244.5	16.934	0.7744	0.000
	P	0.083	2.4837	0.8509	0.000	0.7719	2.2409	0.7719	0.000

Table. 8. Linear (L) and power (P) regression of *Sarpa salpa* and *Dentex gibbosus* morphometric parameters located within the head region vs. head length. Regressions that were not significant at 0.05, or had low R^2, are highlighted yellow.

parameter	**Regressions**	***Sarpa salpa***				***Dentex gibbosus***			
		a	**b**	**R^2**	**P**	**a**	**b**	**R^2**	**P**
ED	L	0.9775	0.0853	0.4207	0.004	0.8996	0.1641	0.3116	0.031
	P	0.7318	0.3941	0.4088	0.004	0.675	0.5702	0.3116	0.031
POL	L	- 0.28	0.3945	0.864	0.000	-1.098	0.5749	0.7904	0.000
	P	0.2894	1.1037	0.8843	0.000	0.2095	1.3543	0.8026	0.000
POSL	L	0.1783	0.463	0.9483	0.000	0.2005	0.3626	0.667	0.000
	P	0.537	0.9505	0.9505	0.000	0.4429	0.936	0.6788	0.000

MG	L	1.177	0.1238	0.2441	0.037	1.9294	0.1534	0.0642	0.362
	P	0.8855	0.4295	0.2282	0.037	1.5661	0.3335	0.0542	0.362
MW	L	-0.452	0.2996	0.7952	0.000	-0.218	0.4066	0.7178	0.000
	P	0.1536	1.2192	0.8407	0.000	0.3213	1.0798	0.7061	0.000

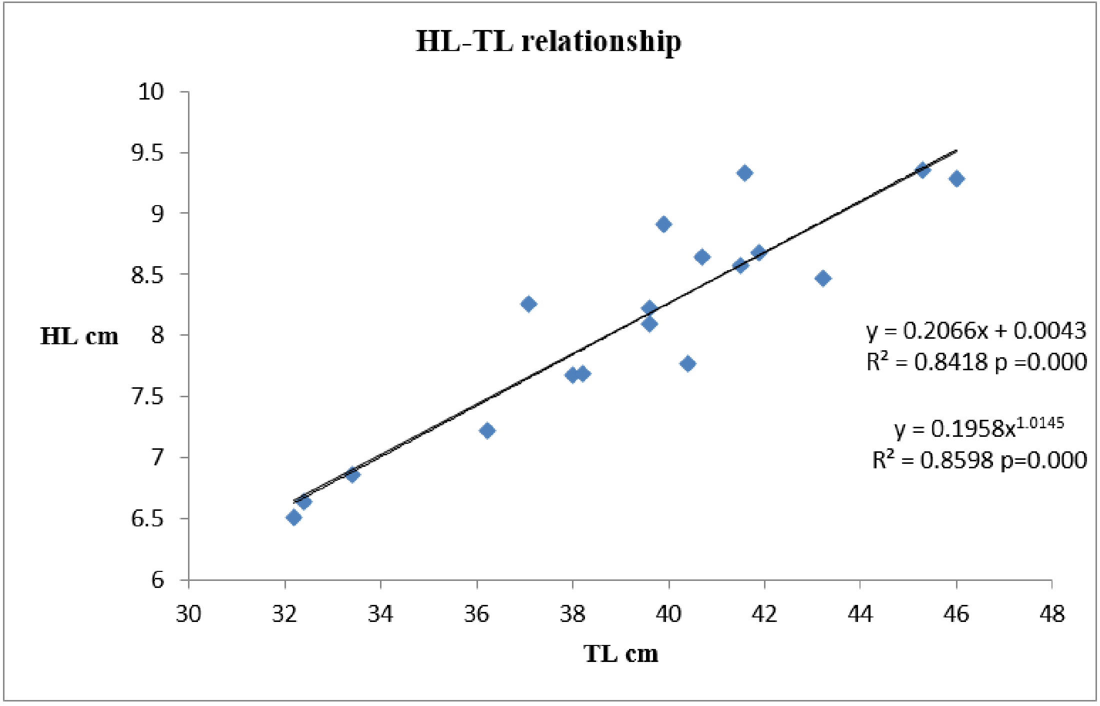

Fig. 8. Head length-total length of *Sarpa salpa*.

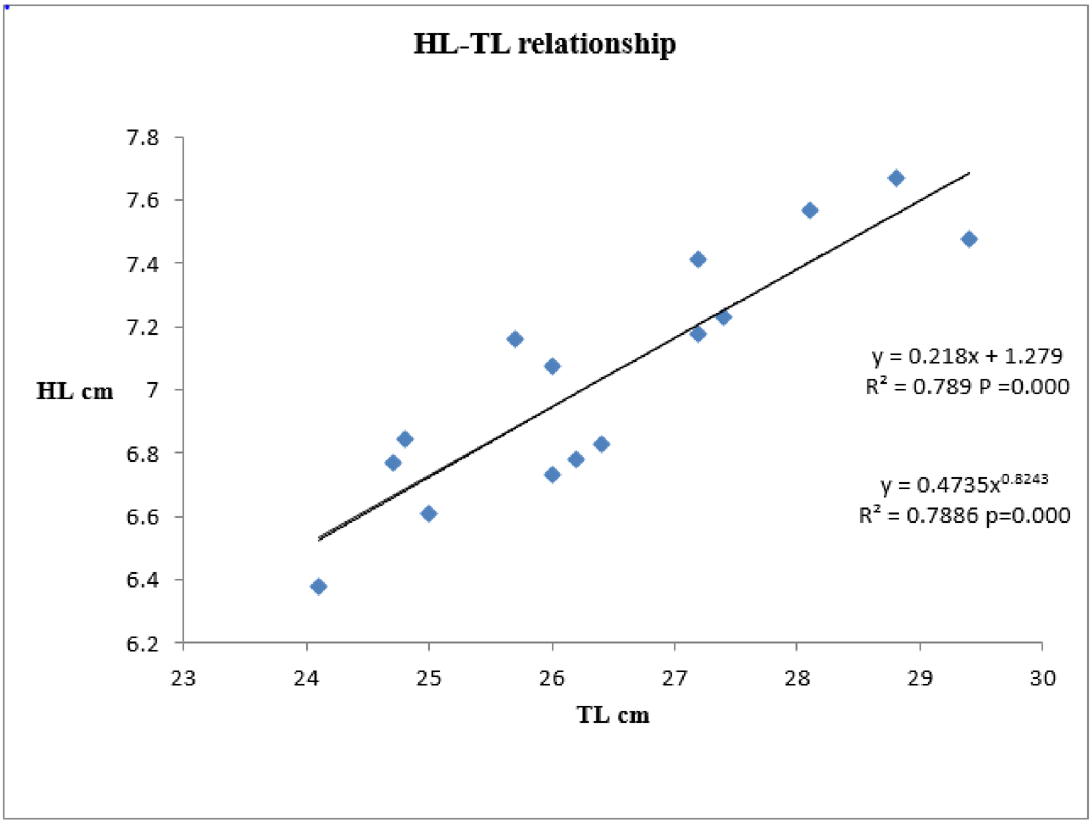

Fig. 9. Head length-total length of *Dentex gibbosus*

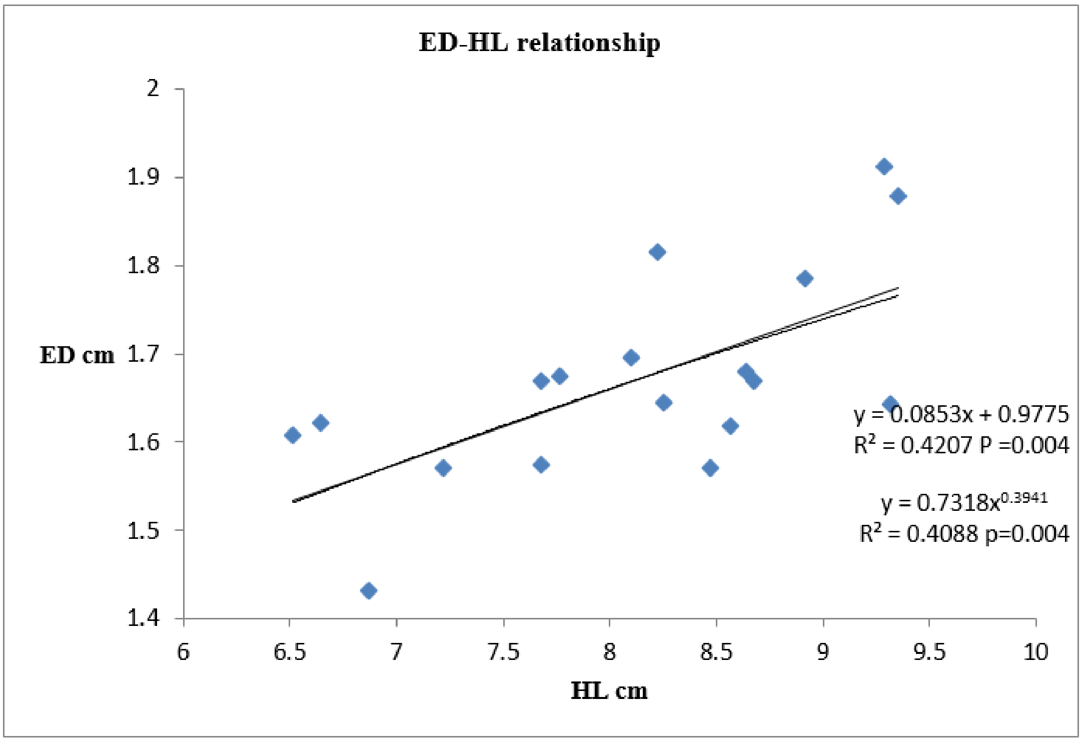

Fig. 10. Eye diameter-head length of *Sarpa salpa*.

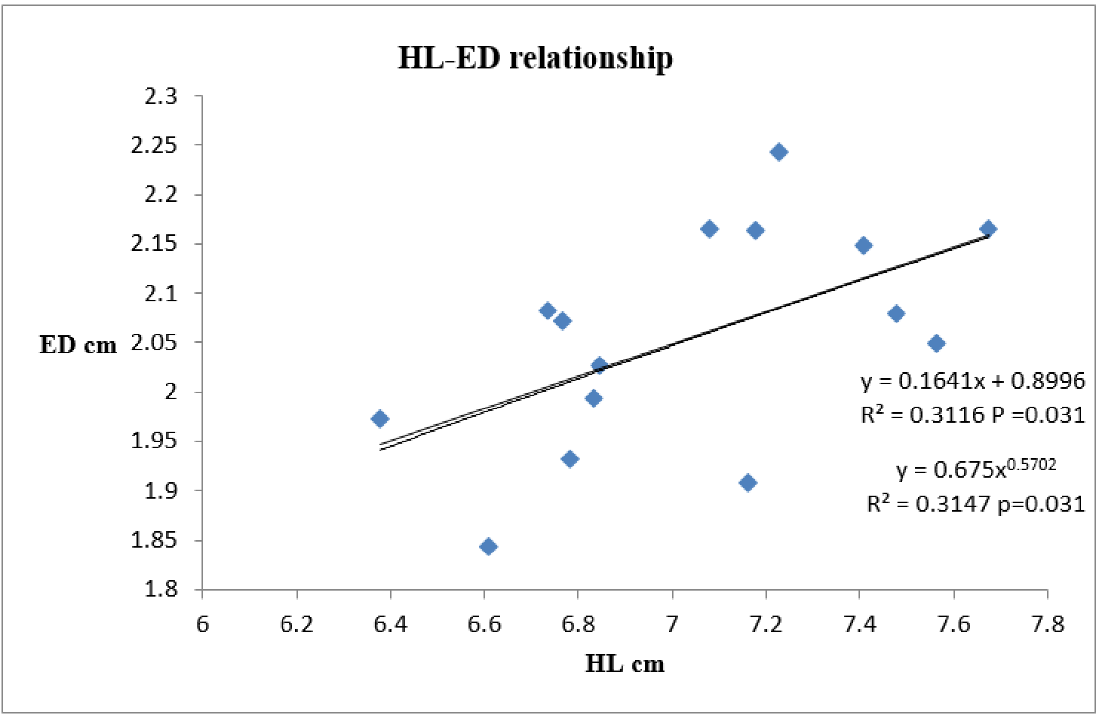

Fig. 11. Eye diameter-head length of *Dentex gibbosus.*

The binary correlations between meristic counts

The pectoral fin of both fish had rays but no spines, all the other fins had spines and rays. In general, meristic parameters of both *S. salpa* and *D. gibbosus* did not correlate with each other or with fish length (Tables 9 and 10), indicating that meristic traits are conservative throughout the life of both fish, and hence, could be used as rough fingerprints for individual species. The meristic formulae drawn from them (Table 11) are shown below. The formulae of both fish, however, show an appreciable degree of overlap:

D, X-XI (XI) + 14-17 (16); A, III + 13-15 (14); P, 14-16 (15); V, I + 5; LL, 70-80 (76) for *S. salpa*, and,

D, XI-XII (XII) + 10-11 (10); A, III + 8-9 (9); P, 14-15 (15); V, I + 5; LL,60-65 (62) for *D. gibbosus*.

Modes are presented between parenthesis, as was advised by Mohammed, (2018).

Table 9. Pearson's correlation of meristic parameters of *S. salpa* with each other, and with fish length. Only the cell highlighted in green correlated moderately.

	DR	DS	PR	AR	CR	SLL
DS	.572*					
PR	-.177	.081				
AR	-.395	-.420	-.192			
CR	-.590**	-.198	.272	.354		
SLL	-.551*	-.321	.232	.060	.391	
TL	-.104	-.020	.183	-.022	.325	.145

Table 10. Pearson's correlation of meristic parameters of *D. gibbosus* with each other, and with fish length.

	DR	DS	PR	AR	CR	SLL
DS	.071					
PR	-.443	-.161				
AR	.161	.443	-.023			
CR	.071	-.071	.443	.443		
SLL	.015	-.015	.349	-.034	.211	
TL	-.012	-.167	-.084	.118	.084	.108

Table 11: Data from which the meristic formulae of *Sarpa salpa* and *Dentex gibbosus* were derived. (S: spine, R; ray).

Meristic characters	***S. salpa***			***D. gibbosus***		
	Min	**Max**	**Mode**	**Min**	**Max**	**Mode**
DR	14.00	17.00	16.00	10.00	11.00	10.00
DS	10.00	11.00	11.00	11.00	12.00	12.00
PR	14.00	16.00	15.00	14.00	15.00	15.00
PS	0	0	0	0	0	0
VR	5.00	5.00	5.00	5.00	5.00	5.00
VS	1.00	1.00	1.00	1.00	1.00	1.00
AR	13.00	15.00	14.00	8.00	9.00	9.00
AS	3.00	3.00	3.00	3.00	3.00	3.00
CR	16.00	24.00	20.00	18.00	20.00	20.00
SLL	70.00	80.00	76.00*	60.00	65.00	62.00

DISCUSSION

Sarpa salpa and *Drntez gibbosus* are modern acanthopterygian fish. Relating the morphological traits established in the present study to the habitat and the biological traits of the fish, such as modes of feeding and swimming, habitat, camouflage, etc., was difficult because of the interactions between the traits, and the inadequate presence of generalizations derived by previous studies. *Sarpa salpa* of the present study was fusiform with a terminal mouth, narrow caudal peduncle, and bifurcate caudal fin. These traits indicate that the fish is a relatively fast swimmer (compared to *D. gibbosus*), suggesting that it escapes from predators by fast swimming. The body was silvery white at the ventral side, grading into silvery black at the dorsal side, indicating that the fish, although benthic, did not live in direct contact with the bottom substratum while grazing blades of seaweeds and seagrass, which grow a few centimeters above the bottom. Viewed from above, the black dorsal side blends the fish with the dark bottom substratum; viewed from below, the silvery white ventral side blends the fish with the silvery white sea surface, an appropriate camouflage from predators in both cases. The role of the horizontal yellow to black stripes extending from the head region to the caudal peduncle is not clear, but fish strips and spots are often explained as a tool of distraction.

Dentex gibbosus was a slow swimmer than *S. salpa*. The body was less fusiform, the head was less symmetrical dorsoventrally, the mouth was terminally bottom, the caudal peduncle was broader, and the caudal fin was lunate. These features suggest that fast swimming is not the priority strategy for escaping from predators. The slightly pinkish color matches the color of the bottom substratum, indicating the importance of camouflage from predators while digging in the bottom soil in search of covered invertebrates.

Sarpa salpa in the present study was larger than *Dentex gibbosus*. The mean total weights (±SE) of both fish were 1071.9±68.7 and 231.73±9.02gm, corresponding to a mean total length of 39.289±0.934 and 26.467±0.399cm, Golani (2006) reported 15-30cm. Max: 45cm for *D. gibbosus*, and 30-60cm. Max: 80cm for *S. salpa*, IGFA (2001) and Bauchot and Hureau (1990) reported Max length: 106 cm FL male/unsexed *D. gibbosus*, common length: 60.0 cm total length male/unsexed, and maximum weight of16.4 kg. Bauchot (1987) and Bauchot and Hureau (1990) reported D. gibbosus has a maximum length of 106 cm FL male/unsexed, a common length of 60.0 cm total length male/unsexed, and a maximum weight of 16.4 kg. According to Bauchot (1987) and Bauchot and Hureau (1990), the maximum length of S. salpa for males and unisex is 51.0 cm SL, with a common length of 30.0 cm SL for males and unisex. Differences between our study and the cited studies may be due to environmental differences. Most of the other morphometric parameters of *S. salpa* were higher than those of *D. gibbosus* except for ED and MG, which were significantly and noticeably larger in the latter. These differences existed even after the transformation of the parameters to the percentage ratio from the total length of the fish to lessen the effect of size, indicating that these differences are genuine and did not result from the unequal sizes of both fish. It may be that the larger terminal and semi-bottom mouths of *D. gibbosus* are more suitable for penetrating the bottom substratum and dislodging attached invertebrates and that the large eyes enable the fish to see better near the bottom substratum, where turbidity is expected to be high and visibility low. *S. salpa*, on the other hand, grazes on seaweed and seagrass. Seaweeds grow a few centimeters above the sea bottom, so the fish does not need to dig in the bottom. Seaweeds grow on rocky bottoms, a less turbid environment, while buried invertebrates predominate in soft bottoms.

The head length (HL) of *S. salpa* was significantly larger than that of *D. gibbosus* (8.12 and 7.05 cm long), but this is an artifact of the former fish being larger than the latter. On converting HL to percent ratio from TL, *S. salpa* scored 20.67% compared to 26.64% for *D. gibbosus*. Probably the larger head of the latter enabled the housing of the larger MG and ED and the bulkier mussels required to move the larger mouth and jaws—an adaptation for a more benthic life. The same argument applies to the pre-orbital length (POL) and the post-orbital length (POSL). The former was about the same length in both fish, but the latter was larger in *S. salpa*. The scene is reversed on the transformation to percent ratio; both parameters were now higher for *D. gibbosus* (POL: 7.44 and 11.15%; POSL: 10.027 and 10.43% in order). The dorsal fin (DFL) of *S. salpa* was longer than that of *D. gibbosus*, both as an absolute measurement and as a percent ratio. The dorsal fin stabilizes fish against rolling and assists in sudden turns, a trait that is more important in fast swimming. Pelvic and pectoral fins allow fish to fine-tune their movements. These paired fins keep the fish leveled and prevent side-to-side rolling. In the present study, the pectoral fin (PFL) of *S. salpa* was shorter than that of *D. gibbosus* (6.788 and 7.43 cm). However, the percent ratio of this fin to fish length was much higher in the latter fish (17.25 and 28.11% in order). The ventral fin of *S. salpa* (5.28 cm) was longer than that of *D. gibbosus* (4.26 cm); however, based on the percent ratio from total length, *D. gibbosus* has the longer fin (13.48 and 16.11% consecutively). One can conclude that the paired longer pectoral and ventral (pelvic) fins are needed for the fish, which needs to continuously balance itself while digging and searching for invertebrates within the bottom substratum. On the other hand, the faster *S. salpa* can do well with shorter pectoral and ventral fins as the higher speed provides the thrust needed to operate the fins and hence compensates for the smaller fin size. Anal fins are unpaired; they stabilize fish by acting like the bottom and keel of a boat. *S. salpa* had a longer anal fin than *D. gibbosus*, both in absolute value and as a percent ratio. This fin is more important for faster-swimming fish. The caudal fin gape (maximum length of the dorso-ventrally stretched caudal fin) ratio of *D. gibbosus* was much higher than that of *S. salpa*, as this fin is needed to provide downwards thrust that enables the fish to dig into the bottom. In percent ratio to the fish length, the caudal peduncle length (CPL) of *S. salpa* was shorter than that of *D. gibbosus*, but the caudal peduncle width (CPW) followed the opposite trend. The significance of this contrast is not clear from the data of the present study. neither the difference nor the contrast in pre dorsal fin length (PFDL) and pre anal fin length (PFAL) between both fish; generally, a shorter CPW is associated with faster fish. The mouth gape correlated poorly to moderately with the morphometric parameters but very strongly with the caudal peduncle length (CPL).Not so for *D. gibbosus*. Again, the cause is not clear. In conclusion, it could be said that a larger head, eye diameter, pre-orbital length, post-orbital length, pectoral fin, ventral fin, caudal peduncle, and mouth gape and width characterize highly benthic fish that need to borrow in the substratum in search of food. Such fish need to have larger eyes to account for the more turbid habitat, a larger mouth, and a head to accommodate the eyes and the mouth, in addition to the strong muscles needed to move the jaws. These fish also need large caudle fins to provide the downward thrust needed for the digging and larger pectoral and pelvic fins to tune their activity while digging. Relatively faster benthic fish need to have a border body depth (BD) to accommodate the muscles needed for fast swimming and a longer dorsal fin and anal fin (unpaired single fins).

The binary correlations between most morphometric parameters of *S. salpa* and *D. gibbosus* were positive and significant. Regressions of these parameters with total fish length or head length were presented; both linear and power regressions described the relationship very well and on equal footing.

The power and linear regressions of the length-weight relationship of *S. salpa* and *D. gibbosus* were highly significant and correlated strongly. The "b" value of the power regression of both fish indicated negative allometric growth; that of *S. salpa* was 2.7148 and that of *D. gibbosus* was 2.2457, which was noticeably more negative allometric than the former. The significance of this difference cannot be deduced from the data obtained in the present study. Negative allometry means that growth in length proceeds at a faster rate than growth in weight. It may be that *S. salpa* needs a body with more muscles to propel the fish. There have been few studies on the length-weight relationships of S. salpa.Bayhan and Kara (2015) calculated $W=aL^b$ for males, females, hermaphrodites, and the total sample of *S. salpa* from Izmir Bay (Aegean Sea of Turkey) as $W=0.0294L^{2.750}$, $W=0.0216L^{2.840}$, $W=0.0115L^{3.058}$, and W=0.0189L2.894, respectively; Abdallah (2002) calculated "b" of the length-weight relationship of *S. salpa* caught by trawl off Alexandria, Egypt, as 2.90. Many of these results, which range from negative allometry to isometry, are close to the one obtained in the present study. Most previous studies recorded isometric or near isometric growth for *D. gibbosus*; for example, Grubii *et al.* (2008) found that *D. gibbosus* from the Adriatic Sea, Croatia, had positive allometric growth for mixed male/female populations (b = 3.0943) and males (b = 3.1759), and isometric growth for females (b = 3.0272) and immature (b = 3.00) specimens; Duli and Glamuzina (2006) obtained the value of b = 3.13 for pink dentex from Croatian estuarine systems; Pajuelo and Lorenzo (1995) calculated the length-weight relationship of *D. gibbosus* from the Canary Islands, with a resultantly lower b value (b = 3.0812); and Nguyen-Xuan and Wojciechowski (1972) found b = 3.0 for up to five-year-old pink dentice from the northwest African coast. The season, habitat, gonadal maturity, sex, stomach fullness, health, and preservation methods are just a few of the variables that can affect a fish's growth. Differences between the length-weight association found in the current study and the prior studies may also be due to these variables (Tesch, 1971; Bagenal and Tesch, 1978; Froese, 2006). According to Moutopoulos and Stergiou (2002), variations in "b" values can be attributed to factors such as the number of the specimens studied, the region and season, the length ranges of the fish caught, and the time spent collecting samples.

Fulton condition factors of *S. salpa* and *D. gibbosus* in the present study were 1.733 and 1.247, indicating that the former is more stout than the latter, a trait that possibly reflects the need for more muscles for propulsion. Linear and power regressions of these condition factors with fish length had low R2, indicating that these parameters did not change significantly with fish growth. However, the trend of factors decreasing with growth (statistically insignificant) observed for both fish suggests that it could be significant if larger fish samples were used. The condition factor of both fish was rarely reported in previous literature, however, Matic-Skoko *et al.* (2004) studied the growth of juvenile *Sarpa salpa* in the Kornati Archipelago, eastern Adriatic Sea; the condition factor C_F was 1.41. Grubii *et al.* (2008) found that the condition factor of *D. gibbosus* from the Adriatic Sea, Croatia, ranged from 1.307 to 1.661 in males and from 1.335 to 1.653 in females, but the difference between the two sexes was not significant. Matic-Skoko *et al*. and Grubii *et al*. condition factors were close to the ones obtained in the present study.

In the present study, meristic counts of both fish did not correlate with total length; therefore, these parameters were conservative (did not change as the fish grew) and can be used as rough fingerprints specific to each fish. The following meristic formulae were derived:

D, X-XI (XI) + 14-17 (16); A, III + 13-15 (14); P, 14-16 (15); V, I + 5; LL, 70-80 (76) for *S. salpa*, and,

D, XI-XII (XII) + 10-11 (10); A, III + 8-9 (9); P, 14-15 (15); V, I + 5; LL, 60-65 (62) for *D. gibbosus*.

These forms were similar, but not identical, to those presented by Golani *et al*., (2066):

An important observation to be made here is that the differences between the two studies are in the number of rays on individual fins, but the number of spines on individual fins tended to be similar. This was also observed in other studies under publication. A conclusion could be drawn that rays are more plastic than spines; further, the plasticity in spines occurred only in those of the dorsal fin and not the other fins. In the present study, modes of counting rays and spines are presented between two parentheses to reduce the effect of counting errors as recommended by Mohamed (2018). Differences in meristic traits within separate populations of the same fish species were reported by many workers. For example, Bilici *et al*. (2016) studied morphological and meristic differences among freshwater fish, *Cyprinion kais* populations, in the Tigris River of southeast Turkey. According to the morphometric and meristic characteristics, they found that there is high variation between the locality groups belonging to the samples of *C. kais*. Rawat *et al*. (2017) studied the meristic characteristics and their variations among the population of splendid pony fish, *Eubleekaria splendens,* along the Indian coast. They claimed that depending on their locations and the coast, fish had different numbers of pectoral fin rays. Additionally, the fish varied depending on the coast in terms of the number of rackers on the first gill arch. Environmental conditions, particularly temperature during early development, salinity, light, and dissolved oxygen, can have a significant impact on meristic numbers (Lindsey, 1988). Lindsey (1958) and Fowler (1959) both observed that several species experienced variations of this type (1970).

THE IMPLICATION TO RESEARCH AND PRACTICE

To maximize benefits from morphological studies of fish, an effort should be made to relate established inter- and intra-species differences in morphometric parameters to fish biological traits, in particular, food and feeding, mode of swimming and concealment, and habitat. This is usually a difficult job, but general conclusions could be drawn after such studies accumulate with time. As of today, not enough such studies are available.

Comparing morphometric traits within and between species becomes easier when the morphometric parameters are related to fish length as ratios (e.g., length of the dorsal fin to length of the fish) to remove the effect of size. This procedure will enable comparing the parameters between fish of different sizes. Without this, the comparison might be useless.

Attention should be paid to the binary correlations of the morphometric parameters; they may tell a lot.

Modes of meristic counts (e.g., number of spines and rays of individual fins, gill rackers, scales on lateral lines, etc.) should always be included (between two parentheses) in the meristic form of the fish to reduce the effect of counting error, as was first recommended by Mohamed (2018).

THE IMPLICATIONS FOR RESEARCH AND PRACTICE

To maximize benefits from morphological studies of fish, an effort should be made to relate established inter- and intra-species differences in morphometric parameters to fish biological traits, in particular, food and feeding, mode of swimming and concealment, and habitat. This is usually a difficult job, but general conclusions could be drawn after such studies accumulate with time. As of today, not enough such studies are available.

Comparing morphometric traits within and between species becomes easier when the morphometric parameters are related to fish length as ratios (e.g., length of the dorsal fin to length of the fish) to remove the effect of size. This procedure will enable comparing the parameters between fish of different sizes. Without this, the comparison might be useless.

Attention should be paid to the binary correlations of the morphometric parameters; they may tell a lot.

Modes of meristic counts (e.g., number of spines and rays of individual fins, gill rackers, scales on lateral lines, etc.) should always be included (between two parentheses) in the meristic form of the fish to reduce the effect of counting error, as was first recommended by Mohamed (2018).

CONCLUSIONS

- *S. salpa* and *D. gibbosus* are two “look-alike-fish, but closer examination revealed many differences.
- *S. salpa* is an herbivore while *D. gibbosus* is a carnivore.
- *S. salpa* is larger in weight and length than *D. gibbosus*.

- The length-weight relationship and K_F show that the growth of both fish was negatively allometric, and that of *D. gibbosus* was more negative.
- The condition of both fish did not change significantly during growth, but an insignificant trend of decreasing condition with growth was observed for both fish.
- The body of *S. salpa* was fusiform, the caudal fin was forked, the caudal peduncle was narrow, the mouth was terminal, and the dorsal side of the fish was dark while the ventral side was silvery, these traits are adaptations for relatively fast swimming and that the fish have less contact with the bottom as it feeds on weeds and grasses. This trend was less pronounced in *D. gibbosus*, in addition, the mouth was bottom terminal, and the color of the fish was a faint rose; therefore, probably this fish spends more time in contact with the bottom than *S. salpa* as it needs to dig in the bottom in search for gastropods, bivalves, crustaceans, and other vertebrates.
- It may be that coloration and fast swimming are the strategy developed by *S. salpa* for avoiding enemies. *D. gibbosus* coloration matches that of the bottom substratum, making it less conspicuous.
- Larger paired fins are adaptations for highly benthic, digging fish, while larger single fins are adaptations for faster fish.
- Meristic forms of individual fish species may show mild plasticity within the same species. Plasticity is more likely to occur in the number of rays than the number of spines.

RECOMMENDATIONS

We recommend the execution of studies similar to the present one but using other fish of different habitats, modes of feeding, modes of swimming…etc. (e.g. benthic/pelagic, fast/slow swimmers, herbivores/carnivores, cold water/warm water fish…) to find out how these traits are related to the morphometry of the fish.

Reviews and meta-analyses will also be very useful.

CONFLICT OF INTEREST

No conflict of interest is claimed. The present work is part of a thesis executed at the Department of Zoology of Omar Al-Mukhtar University, Albaida, Libya.

REFERENCES

Abdallah, M. (2002). Length-weight relationship of fishes caught by trawl off Alexandria, Egypt. Naga, the ICLARM Quarterly, 25(1), pp. 19-20.

Al-Hassan, L. A. and El-Silini, O.A. (1999). Check-list of bony fishes collected from the Mediterranean coast of Benghazi, Libya. Revista de Biologia Marina Oceanografia, 34: 291-301

Bagenal, T. B. and Tesch, F. W. (1978). Age and Growth. In: Bagenal, T. (Ed.), Methods of Assessment of Fish Production in Fresh Waters. Oxford Blackwell Scientific Publicayion, pp: 101-136.

Bauchot, M.-L. and J.-C. Hureau, (1990). Sparidae. p. 790-812. In J.C. Quero, J.C. Hureau, C. Karrer, A. Post and L. Saldanha (eds.) Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris. Vol. 2.

Bauchot, M.-L., (1987). Poissons osseux. p. 891-1421. In W. Fischer, M.L. Bauchot and M. Schneider (eds.) Fiches FAO d'identification pour les besoins de la pêche. (rev. 1). Méditerranée et mer Noire. Zone de pêche 37. Vol. II. Commission des Communautés Européennes and FAO, Rome.

Bayhan and Kara. (2015). Length-Weight and Length-Length Relationships of the Salema *Sarpa salpa* (Linnaeus, 1758) in Izmir Bay (Aegean Sea of Turkey). kistan J. Zool., vol. 47(4), pp. 1141-1146, 2015.

Ben-Abdalla, A. R.; Al-Gmati, H.; Kasim, A. A.; Al-Turkie, A. A. and Ben-Moussa, M. N. (2009). Guide to bony fishes in Libyan waters, Marine biology Research Center (MBRC) - Tajoura'a, 180 pp.

Bilici, Serbest; Arif Baysal; Tarik Cicek; Ersin Uysal; Erhan Unlu. (2016). Morphological and meristic differences among freshwater fish, *Cyprinion kais* (Cyprinidae) populations in Tigris River of southeast Turkey. Fresenius Environmental Bulletin. Volume 25 ± No. 10/2016, pages 4045-4051.

Bond, K. I. (1986). Fish life. University of Organ. Pp. 475. USA.

Clark, F. N. (1928). The weight-length relationship of the California sardine (*Sardinella caerulea*) at San Pedro, Division of Fish and Game. Fish Bull, No. 12, 59pp.

Fowler J. A. (1970). Control of vertebral number in teleosts-an embryological problem. Q. Rev. Biol. 45, 148-167.

Froese R. (2006): Cube law; condition factor and weight length relationship: history, meta-analysis and recommendations. *Jour. Appli, Icthyol.* 22: 241-53.

Fulton, F. 1902. Rate of growth of sea fishes. Scient. Invest fish. Div. Scot Rep. 20. 123 – 145.

Golani, D. Öztürk, B. and Basusta B. (2006). Fishes of the Eastern Mediterranean, Turkish Marine Research Foundation, 264 pp.

Grubišić, Leon; Tanja šegvić; Neda Skakelja; Vjekoslav Tičina & Ivan Katavić. (2008). Condition and length-weight relationship of *Dentex gibbosus* from Adriatic Sea, Croatia. Cybium: International Journal of Ichthyology. 2008, 32(4): 335-338.

IGFA, (2001). Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, USA.

Le Cren, E. D. (1951). "The Length Weight Relationship and Seasonal Cycle in gonad weight and Condition in the Perch (*Perca fluviaittlis*)." *J. Anim. Ecol.* 20: 201-19.

Lindsey C. C. (1958). Modification of meristic characters by light duration in kokanee (*Oncorhynchus nerka*). Copeia, 134-136.

Matic´-Skoko, Sanja; Miro Kraljevic´; Jakov Dulcˇic´ and Armin Pallaoro. (2004). Growth of juvenile salema, *Sarpa salpa* (Teleostei: Sparidae), in the Kornati Archipelago, eastern Adriatic Sea. SCI. MAR., 68 (3): 411-417.

Mohammed, W. E. (2018). Morphological Study to identify tilapia species (Cichlidae) in Ain Um Hufayan Lagoon, Eastern Libya Coast. MSc thesis. Omar AL-Mukhtar University, Albaida, Libya.

Moutopoulos D. K., Stergiou K. I. (2002). Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). Journal of Applied Ichthyology, 18: 200-203.

Nguyen-Xuan L. and J. Wojciechowski, (1972). - Comparative biology of fish from genus *Dentex* (Sparidae) of north-west African coast. Acta Ichthyol. Piscicult., 2: 77-79.

Osman, A. M. and Mahmoud, H. H. (2009). Feeding Biology of *Diplodus sargus* and *Diplodus vulgaris* (Teleostei, Sparidae) in Egyptian Mediterranean Waters. World Journal of Fish and Marine Sciences 1 (4) 290 – 296.

Pajuelo J. G. & J. M. Lorenzo (1995). Biological parameters reflecting the current state of the expliotated pink dentex *Dentex gibbosus* (Pisces: Sparidae) population off the Canary Islands. South African Journal of Marine Sciences 16: 311-319.

Rawat, Shobha, Benakappa, S, Kumar, Jitendra, Soman, Chitra, Sonwal, Mahesh, Pandey, Gayatri. (2017). Study on the meristic characteristics and their variations among the population of splendid ponyfish, *Eubleekaria splendens* (Cuvier, 1829) along the Indian coast. Journal of Experimental Zoology, India, Vol. 20, Supplement 1549-1552.

Reynolds, J. E. and A. Abukhader and A. Ben Abdallah. (1995). The marine wealth sector of Libya: a development planning overview, Food and Agriculture Organization (FAO), Division of Fishery and Aquaculture Economics and Policy Division, Tripoli/Rome.

Ricker, W.E. (1975). Computation and interpretation of biological statistics of fish populations. Bulletin of fisheries research board of Canada 191. 382 pp.623-625.

Tesch, F. W (1971). Age and growth. In Methods of Assessment of Fish Production in Freshwaters (ed). Ricker, W.E Oxford Scientific Publications Pp 99-130.

Weisel G. F. (1955). Variations in the number of fin rays of two cyprinid fishes correlated with natural water temperature. Ecology 36, 1- 6.

Whitehead, P. J. P.; Bauchot, J. C.; Hureau, J. C.; Nielsen, J.; and Tortonese, E. (1984). Fishes of the North eastern Atlantic and Mediterranean. Published by the United Nations Educational, Scientific and Cultural Organization. United Kingdom. UNESCO, 1473 pp.