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Morphological Differences Between two Populations of the Little Tunny, *Euthynnus alletteratus* (Rafinesque, 1810) in Tunisian Waters (Central Mediterranean Sea)

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HA and MT conceived and designed the study. HA collected and examined the samples, HA and ABF analyzed the data, HA, ABF, MR, SZ, AH, JPQ and MT wrote the article.

Key words
***Euthynnus alletteratus*, Morphological characters, Meristic characters, Morphometric differentiation, Tunisian waters.**

ABSTRACT

In this study we analyzed possible differences among the specimens of the little tunny *Euthynnus alletteratus (*Rafinesque, 1810) inhabiting Tunisian waters. Our investigation based on the analysis of morphological characteristics of *Euthynnus alletteratus* from two distant sampling sites (Mahdia and Zarzis) along the Tunisian coast using 11 morphometric and 3 meristic characters in order to investigate the morpholgical variation among them. Uni and Multivariate analysis of variance of 64 adult specimens showed significant differences among the means of the two studied sites for 8 standardized morphometric measurements out of 11 characters. The principal component analysis (PCA), scatter plot of individual component score between PC1 and PC2 showed two morphometric groups. The linear canonical variate analysis (CVA), the overall assignments of individuals into their original groups was 95.13%. The morphometric and meristic analysis were fully congruent and confirm the occurrence of two potential differentiated groups. This variation of morphometric and meristic characters in specimens from two populations could be caused by differences in genetic structure or environmental conditions.

INTRODUCTION

The Atlantic little tunny, *Euthynnus alletteratus* (Rafinesque, 1810) is the only member of the genus *Euthynnus* distributed in Atlantic and Mediterranean waters (Collette and Nauen, 1983; El-Haweet *et al*., 2013). This species is widely distributed in neritic inshore waters about 200 m depth in the both sides of the tropical and subtropical Atlantic Ocean, including the Mediterranean, Caribbean Sea and Gulf of Mexico (Colette *et al*., 2011). In the Mediterranean Sea, the maximum size attained is about 100 cm fork length and about 12 kg weight whereas in the Atlantic the maximum fork length is 90 cm (Collete and Nauen, 1983; Collete, 1986). This species occurs in schools by size together with other scombridae species, but has a tendency to scatter during certain periods of the year. Usually found in coastal waters with swift currents, near shoals and around the warmer waters of thermal fronts and upwelling.

The information on the migration pattern of small tunny such as *E. alletteratus* is much scarcer and more fragmented (ICCAT, 2006; di Natale *et al*., 2009) although its behavior is supposed to be less migratory than other tuna species (ICCAT, 2006). There is little information available to determine the stock structure of *E. alletteratus* as current information does not allow us to evaluate the status of their stock (ICCAT, 2006). In 2006, Tunisian little tunny catch was 2.221 tones (it represented 33.8% of all tuna species captured in Tunisia (ICCAT, 2006).

Despite the geographic distribution there are a few biological studies on *E. alletteratus* inhabiting Mediterranean regions especially Tunisia (Hattour, 1984; Hajjej *et al*., 2010, 2011; El-Haweet *et al*., 2013), Turkey (Kahraman, 2005; Kahraman and Oray, 2001) and Spain

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(Valeiras and Abad, 2007). Those studies mainly focused on length-weight and growth estimate. In addition, Garcia and Posada (2013) described some trophic and diet of *E. alletteratus* in Central Colombian Caribbean. However, very little genetic information is available for this species. In restricted study using mtDNA 35 COI sequences retrieved from the GenBank, the genealogical signal of *E. alletteratus* indicated recent population expansion (Kumar and Kunal, 2013).

Recently, Koched *et al.* (2013) analyzed the spatial distribution of *E. alletteratus* larvae in the Gulf of Gabes along Tunisian coast, and reported that these larvae were mainly found at the inshore stations covering the wide continental shelf of this region. In fact, in this region, the little tunny larvae were distributed at over depths between 51m and 129 m.

In the world, the first study of *E. alletteratus* populations, using morphometric and meristic parameters, were carried out in the Eastern Atlalantic Ocean reveal to identify two sub-populations (Gaykov and Bokhanov, 2008). In Tunisia, Hajjej *et al.* (2011) examined the morphological variation of *E. alletteratus* using morphometric and meristic characters and failed to have a clear subdivision between two populations from Teboulbah and Zarzis. This result could be explained by the large period of sampling having made essentially in the spawning period in which the migration and mixing population are relatively high (Hajjej *et al*., 2013). Hence, we make and conducted this study in order to overcome mentioned objections by sampling outside the spawning period.

The present study was undertaken to investigate the morphological variation of the little tunny *E. alletteratus* in Tunisia by using morphometric and meristic characters. This study different from previous ones by sampling beyond the spawning season hence we avoid possible populations interference.

MATERIALS AND METHODS

Sampling

Morphometric analyses were conducted on 64 collected little tunny specimens from commercial catches of two Tunisian locations, Mahdia in the Central coast (n = 40; November 2008 and May 2009), and Zarzis in the South coast (n=24; October 2008) (Table I). Their fork length varied from 36.7 cm to 97.5 cm.

Biological study

For each specimen, the following parameters were recorded: the fork length (FL), the total weight (Wt) and the eviscerated weight (We). The length-weight relationships were calculated following a logarithmic transformation of the exponential regression formula: $W = aL^b$ (Ricker, 1973), where W is body weight (g), L is fork length (cm), a is the intercept and b is slope. Student's t-test was used to determine whether the coefficient b was significantly different from 3.

Biometric analysis

We took eleven measurements of the 64 adult specimens using digital caliper (VERNIER) and values were approximated to the nearest 0.01 mm. These were : (1) Snout Length (SnL), (2) eye diameter (ED), (3) head length (HL), (4) distance of pectoral fin (DP), (5) distance of the first dorsal fin (DD1), (6) distance of the second dorsal fin (DD2), (7) distance of ventral fin (DV), (8) distance of anal fin (DA), (9) standard length (SL), (10) fork length (FL) and (11) total length (TL) (Fig. 2). Based on the obtained results, we calculated the ratio between all morphometric characters and the percentage of fork length (FL), except the fork length itself and eye diameter (ED), which was expressed as a percentage of total length (TL) and the head length (HL), respectively. All length-length relationships as well as relative relationships of each body dimension ratio in relation to fork length were established using linear, power and exponential regression analyses. The fork length of spécimens from two populations were first examined for normality with Kolmogorov-Smirnov (K-S) test.

Meristic analysis

Three meristic characters were also studied: number of dorsal finlets (DF), number of ventral finlets (VF) and the number of branchialspins (Br) (Fig. 1).

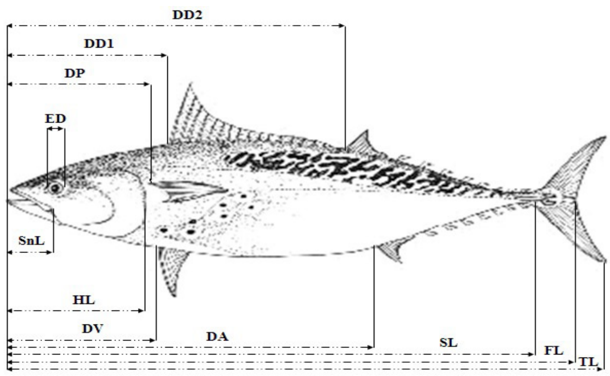

Fig. 1. Schematic drawing of Euthynnus alletteratus body with measured dimensions: snout sength (SnL), eye diameter, head length (HL), distance of pectoral fin (DP), distance of the first dorsal fin (DD1), distance of the second dorsal fin (DD2), distance of ventral fin (DV), distance of anal fin (DA), standard length (SL), fork length and total length (TL).

Table I.- Description of fork length and total weight of Mahdia and Zarzis samples.

Locality	Coordinate		N		FL (cm)		Wt (g)	
	Coordinate	N	Range	X	SD	Range	X	SD
Mahdia (Ma)	35°29'57"N 11°05'11"E	40	37.7-49.7	43.77	3.02	880-2100	1421.62	259.38
Zarzis (Za)	33°30'08"N 11°07'27"E	24	36.7-97.5	51.91	19.41	940-12500	3082.86	3568.89
All		64	36.7-97.5	47.99	14.63	880-12500	2282.26	2693.18

N is the sample size.

Statistical analyses

The associations of morphometric characters and populations were assessed by principal component analysis (PCA) and canonical variate analysis (CVA). All variables were transformed into logarithms (log_{10}) in order to eliminate the biased effect of large measurements in multivariate analysis (Vatandoust el al., 2014). Discriminant function analysis was used to portray relationships based on morphometric variables and to determine to which of two populations given individual should be assigned, based on the discriminant functions. Principal components analysis is basically based upon the variance-covariance matrix of the log-transformed variables. Morphological character variation was assessed using univariate (ANOVA-Scheffe´, 1959), multivariate analysis (MANOVA) and Student t-test.

For each morphological characteristic analyzed, the minimal and maximal value were determined, as well as the average arithmetic, the standard error and the coefficient of variation. The obtained results were interpreted by using the Student t-test.

Correlation analysis

The Possible relationships between each pair of characters were tested by Pearson's correlation analysis, using data from all the two sampling sites and for the whole period.

We used for this Statistical analysis the Statistica 10.0 software package and the statistical significance was considered for $P < 0.05$.

All statistical analyses of morphometric parameters were performed using Past1.81 (Hammer *et al*., 2001) and Statistica v.10 (StatSoft, Inc., www.statsoft.com).

RESULTS

Biological analysis

The fork lengths of specimens sampled from Zarzis and Mahdia populations and overall were distributed according to the normal distribution (Kolmogorov-Smirnov test: d= 0.0477 for Zarzis, d= 0.0356 for Mahdia and d= 0.0488 total; P<0.05).

The values of b which was <3 for Mahdia, Zarzis and all samples suggested that *E. alletteratus* don't follow the law of the cube (Table II). The R^2 value in all cases was higher than 0.927, indicating that for this species there is a strong positive correlation between Wt and FL. So for this fish, the length increased more rapidly than weight.

Table II.- Length-weight relationships for *Euthynnus alletteratus* (W = a FL^b).

Region	Parameters of the L-W relationship					
	a	b	R2	T	S'	Allometry
Mahdia	0.0817	2.5810	0.927	0.111	+	Negative
Zarzis	0.0512	2.7093	0.994	0.156	+	Negative
All	0.0502	2.7122	0.991	0.148	+	Negative

a, b, parameters of the length-weight relationship; S', significance for Mahdia, Zarzis and all (All) samples.

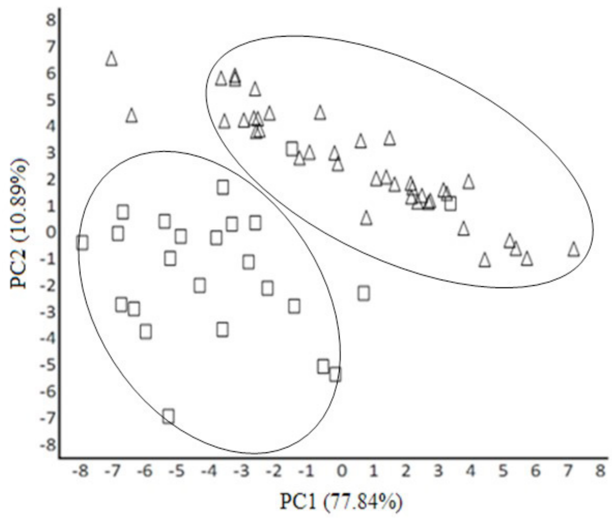

Fig. 2. The first (PC1) and second (PC2) principal component analysis for eleven morphometric characters in 64 individuals of *E. alletteratus* from Tunisia (□, Δ individuals belonging to Zarzis and Mahdia sampling sites, respectively).

Table III.- Length-weight relationship of *Euthynnus alletteratus* from various regions.

Geographical Region	Reference	N	FL	A	b	R^2
Senegal	Diouf (1980)	1808	20-90	0.014	3.035	0.980
Tunisia	Hattour (1984)	100	47.3-101.3	0.016	3	-
Western Mediterranean	Rodrigues-Roda (1966)	325	50-70	0.022	2.912	-
Aegean Sea (Turkey)	Kahraman and Oray (2001)	104	55-85	0.057	2.697	0.933
Mediterranean Sea (Turkey)	Kahraman and Oray (2001)	1085	52-97.5	0.048	2.723	0.961
Eastern Mediterranean	Kahraman (2005)	63	58-82.5	0.0001	2.4683	0.970
Southwest of Spain	Macias *et al.* (2006)	217	56-86	0.044	2.755	0.919
Northeastern Mediterranean	Kahraman *et al.* (2008)	96	43-87	0.0381	2.77	0.968
East of Atlantic	Gaykov and Bokhanov (2008)	3319	-	0.0153	3.0085	0.994
Tunisia	Hattour (2009)	989	6.5-108	0.00538	3.264	0.995
Spain	Macias *et al.* (2009)	439	-	1.6989-5	2.9667	0.987
Tunisia	Hajjej *et al.* (2009	536	19.2-97.8	0.0207	2.9264	0.984
Egypt	Hussain *et al.* (2014)	146	33-102	0.052	2.639	0.981
Tunisia	Present study	64	36.7-97.5	0.0502	2.7122	0.991

N, sample size; FL, fork length; a, constant; b, coefficient of allometry; R^2, coefficient of correlation.

Table IV.- Length- length relationship of *Euthynnus alletteratus* from Mahdia and Zarzis sampling sites.

Mahdia		Zarzis	
Equation	**R^2**	**Equation**	**R^2**
SnL=0.2016HL+2.169	0.6312	SnL=0.3085HL+0.3526	0.8745
ED=0.0845HL+0.7625	0.4249	ED=0.0921HL+0.6199	0.9099
HL=0.2454FL+0.8255	0.6673	HL=0.2681FL-1.6048	0.9927
DP=0.2537FL-0.511	0.7883	DP=0.2923FL-1.9875	0.9951
DD1=0.2766FL-0.1573	0.8559	DD1=0.2974FL-1.0794	0.9793
DD2=0.5564FL+0.5892	0.9521	DD2=0.5657FL+0.0793	0.9965
DV=0.2544FL+0.1196	0.7191	DV=0.2962FL-1.6759	0.9949
DA=0.587FL+2.2686	0.902	DA=0.6481FL-0.4657	0.9971
SL=0.9399FL-0.3933	0.9837	SL=0.9279FL+0.117	0.9996
FL=0.9798TL-1.8064	0.9819	FL=0.976TL-1.7221	0.9991

Biometric analysis

Morphometric study

Results of the morphometric characteristic ratios, length-length equations and relevant parameters are given in Tables III and IV. Linear regressions showed the best accuracy for all length-length relationships (Table IV). For Mahdia samples, the best fit was recorded between standard length (SL) and fork length (FL) (R^2= 0.984), while the lowest value of coefficient of determination was established between eye diameter (ED) and head length (HL) (R^2= 0.425). For Zarzis samples, the best fit was recorded also between standard length (SL) and fork length (FL) (R^2= 0.9996), while the lowest value of coefficient of determination was established between Snouth length (SnL) and head length (HL) (R^2= 0.875).

The maximum ratio range of all little tunny samples morphometric relationships was noted for SnL/HL (ΔSnL/FL = 22.89%) however the minimum ratio range was noted for DD1/FL (ΔDD1/FL = 4.52%). The ratio range from 3.22% (DD1/FL) to 9.69% (SnL/FL) for Mahdia samples and from 3.36% (SL/FL) to 15.80% (SnL/FL) for Zarzis samples (Table V).

The scatter plot of the first two principal components showed two clear groups (Fig. 2). As shown in the diagram, the first two factors explained 88.73 % of the total variation between the 11 morphometric variables for the specimens in Zarzis and Mahdia localities. Of this total intraspecific variation percentage, component 1 explained 77.84% of this percentage, and component 2 explained 10.89%. The distribution of the first two PCs showed a morphometric differentiation of *E. alletteratus* into two groups that correspond to Mahdia and Zarzis sampling sites (Fig. 2).

Nevertheless, in the canonical variate analysis (CVA), 66.12 % and 12.84 % of the total variation were expressed by the first and the second canonical variate axis, respectively. The scattergram showed a clear difference between the two mophometric groups (Fig. 3). The probability of correct classification is 95.31%. These groups were most differentiated (distance = 4.9; F = 15.3; p = 0.000) according to the Mahalanobis distance.

In addition, ANOVA and student's t test analysis indicated highly statistically significant differences between these two morphometric groups for eight morphometric and one meristic character. These were SnL, ED, HL, DP, DD1, DD2, DV, DA and VF for the meristic character. Indeed, Scheffe's post hoc tests showed that these morphological characters differ statistically significantly from Mahdia and Zarzis populations (*P*<0.05) (Table V). The significant difference was established in the relationships: SnL/HL (t= 11.43), ED/HL (t= 11.75), HL/FL (t= 11.53), DP/FL (t= 10.56), DD1/FL (t= 10.25), DD2/FL (t= 6.38), DV/FL (t= 10.43), DA/FL (t= 5.46). Finally, MANOVA's based on the 11 morphometric measurements, showed significant differences between these two morphometric groups (Wilk's lambda=0.21, F = 17.36, *P* = 0.000).

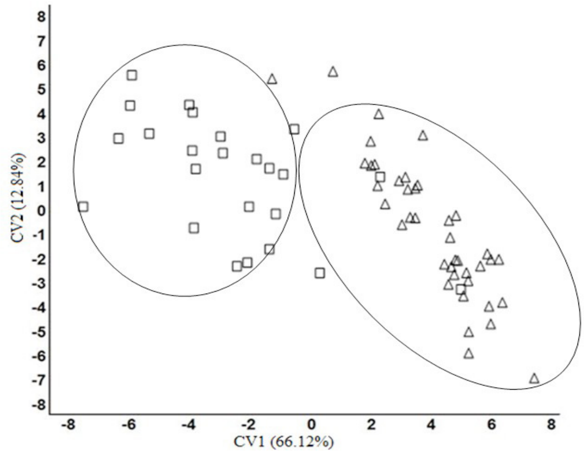

Fig. 3. Canonical variate analysis (CVA) of the 11 morphometric measurements examined between individuals of *E. alletteratus*, (□, Δ individuals belonging to Zarzis and Mahdia sampling sites, respectively (probability of the correct classification= 95.31 %)).

Table V.- Relative relationships of measured body proportion of *Euthynnus alletteratus* from Mahdia and Zarzis sampling sites (*: p<0.05).

Variable	Locality	N	Range (%)	Δ (%)	X	SD	Variance	t
SnL/HL	Mahdia	40	38.52 – 48.21	9.69	42.21	2.57	6.62	11.43*
	Zarzis	24	25.32 – 41.12	15.80	34.25	3.56	12.73	
	ALL	64	25.32 – 48.21	22.89	38.68	5.00	25.07	
ED/HL	Mahdia	40	11.51 – 18.69	7.18	16.05	1.38	1.93	11.75*
	Zarzis	24	10.75 – 18.60	7.85	15.20	1.80	3.25	
	ALL	64	10.75 – 18.69	7.94	15.68	1.63	2.66	
HL/FL	Mahdia	40	20.00 – 25.88	5.88	22.64	1.22	1.49	11.53*
	Zarzis	24	21.27 – 25.17	3.90	23.24	1.18	1.39	
	ALL	64	20.00 – 25.88	5.88	22.91	1.23	1.52	
DP/FL	Mahdia	40	21.90 – 25.80	3.90	24.19	0.92	0.86	10.56*
	Zarzis	24	23.16 – 27.32	4.16	24.70	1.06	1.14	
	ALL	64	21.90 – 27.32	5.42	24.40	1.01	1.02	
DD1/FL	Mahdia	40	25.71 – 28.93	3.22	27.29	0.77	0.60	10.25*
	Zarzis	24	26.04 – 30.23	4.19	27.27	1.04	1.08	
	ALL	64	25.71 – 30.23	4.52	27.24	0.81	0.78	
DD2/FL	Mahdia	40	54.28 – 58.45	4.17	56.99	0.86	0.74	6.38*
	Zarzis	24	54.95 – 59.21	4.26	56.75	0.91	0.84	
	ALL	64	54.28 – 59.21	4.93	56.89	0.88	0.78	
DV/FL	Mahdia	40	23.24 – 28.09	4.85	25.71	1.08	1.16	10.43*
	Zarzis	24	24.34 – 28.48	4.14	25.80	0.96	0.93	
	ALL	64	23.24 – 28.48	5.24	25.75	1.02	1.06	
DA/FL	Mahdia	40	61.24 – 68.39	7.15	63.90	1.39	1.94	5.46*
	Zarzis	24	61.26 – 65.95	4.69	63.74	0.99	0.99	
	ALL	64	61.24 – 68.39	7.15	63.84	1.24	1.54	
SL/FL	Mahdia	40	91.93 – 96.68	4.75	93.09	0.80	0.65	0.75
	Zarzis	24	91.40 – 94.76	3.36	93.04	0.59	0.35	
	ALL	64	91.40 – 96.68	5.28	93.06	0.70	0.50	
FL/TL	Mahdia	40	91.03 – 96.04	5.01	94.08	0.90	0.82	0.77
	Zarzis	24	91.28 – 97.17	5.89	94.15	1.41	2.00	
	ALL	64	91.03 – 97.17	6.14	94.11	1.17	1.37	

Table VI.- Meristic characters statistics of *Euthynnus alletteratus* from Mahdia and Zarzis sampling sites (*: P<0.05).

Meristical character	Locality	Range	Mode	X	SD	t
Dorsal finlets (DF)	Mahdia	8 – 9	8	8.07	0.26	0.70
	Zarzis	8 – 9	8	8.04	0.20	
Ventral finlets (VF)	Mahdia	7 – 8	7	7.07	0.26	2.56*
	Zarzis	6 – 8	7	6.87	0.33	
Branchiospin (Br)	Mahdia	36 - 40	38	38.37	1.16	1.55
	Zarzis	33 – 40	38	37.79	1.84	

Table VII.- Correlation coefficients between each pair of characters of Zarzis sample.

	HLz	SnLz	FLz	Edz	DPz	DD1z	DD2z	DVz	Daz	SLz	TLz	PDz	PVz	Bz
HLz	1.00													
SnLz	0.82	1.00												
FLz	0.79	0.58	1.00											
Edz	0.28	0.08	0.40	1.00										
DPz	0.93	0.69	0.90	0.33	1.00									
DD1z	0.76	0.55	0.92	0.36	0.88	1.00								
DD2z	0.75	0.60	0.97	0.34	0.87	0.92	1.00							
DVz	0.78	0.64	0.91	0.42	0.88	0.89	0.90	1.00						
Daz	0.79	0.57	0.97	0.33	0.89	0.93	0.96	0.91	1.00					
SLz	0.79	0.56	1.00	0.41	0.90	0.92	0.96	0.91	0.96	1.00				
TLz	0.77	0.55	0.98	0.41	0.89	0.93	0.97	0.89	0.96	0.98	1.00			
PDz	0.11	0.04	0.11	-0.08	0.14	0.17	0.12	0.07	0.08	0.11	0.12	1.00		
PVz	-0.31	-0.39	-0.30	-0.09	-0.29	-0.29	-0.35	-0.33	-0.37	-0.29	-0.32	0.08	1.00	
Bz	0.12	-0.09	0.10	0.41	0.07	-0.05	0.04	0.12	0.08	0.11	0.04	0.02	0.03	1.00

Numbers in bold are significant (P<0.05).

Table VIII.- Correlation coefficients between each pair of characters of Mahdia sample.

	HLm	SnLm	FLm	Edm	DPm	DD1m	DD2m	DVm	Dam	SLm	TLm	PDm	PVm	Bm
HLm	1.00													
SnLm	0.79	1.00												
FLm	0.82	0.90	1.00											
Edm	0.51	0.53	0.59	1.00										
DPm	0.96	0.84	0.89	0.53	1.00									
DD1m	0.80	0.86	0.93	0.57	0.88	1.00								
DD2m	0.82	0.89	0.98	0.62	0.88	0.93	1.00							
DVm	0.83	0.82	0.85	0.54	0.83	0.78	0.88	1.00						
Dam	0.81	0.86	0.95	0.50	0.88	0.92	0.93	0.80	1.00					
SLm	0.66	0.74	0.86	0.42	0.73	0.79	0.84	0.67	0.84	1.00				
TLm	0.80	0.90	0.99	0.56	0.87	0.92	0.97	0.84	0.95	0.84	1.00			
PDm	-0.10	-0.03	-0.04	-0.12	-0.04	-0.07	-0.10	0.02	-0.03	0.00	-0.01	1.00		
PVm	-0.03	0.09	0.09	0.07	0.08	0.04	0.02	0.12	0.02	0.11	0.09	0.64	1.00	
Bm	0.18	0.04	0.04	-0.05	0.06	-0.07	0.04	0.10	0.04	0.20	0.02	-0.26	-0.26	1.00

Numbers in bold are significant (*P*<0.05).

Meristic study

Meristic characters of *E. alletteratus*, their range, mode, mean, standard deviation values and t-student are presented in Table VI. Our results present the same variation in two localities (Mahdia and Zarzis) of the number of dorsal finlets (DF) (from 8 to 9) with 8 for the mode. For the ventral finlets (VF) we found a difference between the two localities, so the number ranged from 7 to 8 for Mahdia but for Zarzis it ranged from 6 to 8, with mode equal to 7 for the two localities, in addition, this character has a significant difference between Mahdia and Zarzis samples (t= 2.56).

The correlation coefficients between characters are presented in Tables VII and VIII. Generally, in the two studied sites, all the coefficients between morphometric coefficients were close to 1. For the meristic characters only in the Mahdia population, a significant correlation was observed between the number of ventral finlets (VF) and the number of dorsal finlets (DF), and there is no correlation between the meristic and morphometric parameters both in two sites. The correlation results revealed that all of the meristic variables studied were free from the influence of size.

DISCUSSION

Biological analysis

The results presented in this study show a negative allometric growth of fork length in function of the total and eviscerated weights for *E. alletteratus* both in Mahdia and Zarzis sites.

In fact, the little tunny grows more in length than in weight. Our result are in accordance with those reported in the Aegean Sea (Kahraman and Oray, 2001), in the Eastern Mediterranean Sea Kahraman (2005), in the North-Eastern Mediterranean (Kahraman *et al*., 2008), in the South-East of Spain (Macias *et al*., 2006), and in Tunisian waters (Hajjej *et al*., 2011). From previous studies, the allometry may be isometric or positive respectively in the Eastern Atlantic Ocean (Gaykov and Bokhanov, 2008) and in Tunisian waters (Hattour, 2000). Our study showed that the allometry in Tunisian waters varied in the time. In this way, Cort *et al*. (1995) showed that the *b* values changed from year to year within the same geographical region. Many authors indicated that the difference in the allometry between region were caused by environmental factors like salinity, temperature and food abundance, and biological factor like sex and stage of maturity (Andrade and Campos, 2002; Francicevic *et al*., 2005).

Moreover, Table III showed the differences between the regression coefficient values "b" of *E. alletteratus* in Tunisian waters for different sampling dates and between samples from various Mediterranean and Atlantic localities. According to literature, the « b » values are higher in the Western Mediterranean (Rodriguez-Roda, 1966; Macias *et al*., 2009) and in the Atlantic (Diouf, 1980; Gaykov and Bokhanov, 2008), while these values in the Eastern Mediterranean (Kahraman and Oray, 2001; Kahraman, 2005; Kahraman *et al*., 2008; Hussain *et al*., 2014) are relatively low and negative allometry was established (Table III).

In Tunisian waters the allometry is positive (Hattour, 1984, 2009) or negative (Hajjej *et al*., 2009 and this study). These differences can be explained by the fact that in Tunisian waters are lying between the two shores of the Mediterranean. In addition, *E. alletteratus* is a migratory fish (ICCAT, 2006; di Natale *et al*., 2009), and this species can be originated by populations from the Eastern or Western Mediterranean. In our study, we can postulate that the two sampling sites (Mahdia and Zarzis) should be influenced by populations coming from the Western Mediterranean and which are characterized by a relatively lower value of "b" and therefore allometry negative.

Morphometric and meristic analyses

Our results demonstrate the existence of morphometric variation between Mahdia and Zarzis samples. The morphological analysis among the *E. alletteratus* samples show a statistically significant differences (p=0.00) between Mahdia and Zarzis in all parameters except standard and fork length. The Snout Length mean (SnL), Eye Diameter mean (ED), Distance of the first dorsal fin mean (DD1), Distance of the second dorsal fin mean (DD2) and Distance of anal fin mean (DA) of Mahdia specimens were larger than those of Zarzis specimens, while Head Length mean (HL), Distance of pectoral fin mean (DP) and Distance of ventral fin mean (DV) were significantly higher in Zarzis individuals than in Mahdia. Among *E. alletteratus* examined populations (Mahdia and Zarzis), a clear differentiation morphometric and meristic characters is showed.

However, Hajjej *et al*. (2011) and (2013) failed to prove a differentiation between Teboulbah and Zarzis located in central and southern coast of Tunisia. The authors reported that this results to the large period of sampling (between January 2008 and December 2009) and that most of the samples from these two localities were taken in summer, during the spawning season migration of *E. alletteratus,* which runs from June to September (Hajjej *et al*., 2011), and accordingly, an inadvertent sampling between these two areas may have taken place. In fact, in this period, and because of this spawning migration, individuals on each of these two areas can be collected in the other, which may have implications for the results drawn about the structure of the stock. In our study we collected samples from Mahdia in two different periods (November 2008 and May 2009) and from Zarzis in one period (October 2008), so it's outside the spawning period migration of *E. alletteratus*, and so the populations may be stables and isolated, for this, our results converges to have a significant morphological differences. In the same way, Ryman *et al*. (1984) and Cheverud (1988) proved that morphological differentiation indicates that the majority of fish spend their entire lives in separate regions.

The morphometric differentiation between specimens from different populations could be caused by differences in genetic structure or environmental conditions (Francicevic *et al*., 2005). Indeed, the environmental factors prevailing during the early development stages, when individual's phenotype is more amenable to environmental influence is of particular importance. Also, the morphological differences revealed in this study may be solely related to body shape variation and not to size effects which were successfully accounted for by allometric transformation (Vatandoust *et al*., 2014).

CONCLUSION

In conclusion, this investigation focused on some biological characters of *E. alletteratus* showed a negative allometry, In addition, the variability of morphometric as well as meristic characters of *E. alletteratus* clearly demonstrated two differentiated groups that correspond to the two sampling sites analyzed. This morphological study of *E. alletteratus* in Tunisian waters report has proved to provide an insight into discrimination of marine stocks. In future research an extensive specimens and populations of *E. alletteratus* more enlarged in capture period, and genetic structure such as microsatellites markers are needed to confirm our results.

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Statement of conflict of interest

Authors have declared no conflict of interest.

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