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Comparative biometric study of sardine *Sardina pilchardus* (Walbaum, 1792) of the Algerian littoral (Actinopterygii Clupeiformes Clupeidae)

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ABSTRACT A compared biometric study of the sardine *Sardina pilchardus* (Walbaum, 1792) (Actinopterygii Clupeiformes Clupeidae) was carried on 471 specimens during the year 2015. These samples were taken from seven different sites of the Algerian coast going from the east to the west: El Kala, Annaba, Skikda, Collo, Jijel, Algiers, and Oran. The ANOVA test which was applied on each of the 36 variables morphometric and meristic shows that there is a highly significant difference between the seven sites for 35 variables out of 36. However, concerning the sex factor in the study area, we didn't note significant differences between sexes. The comparison of the seven sites with the MANOVA test confirms the results obtained by the ANOVA.

KEY WORDS Algerian coastline; compared biometric; MANOVA; *Sardina pilchardus*.

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INTRODUCTION

Fishing practiced on the Algerian basin targets a great variety of pelagic species, and among these species we find the sardine, *Sardina pilchardus* (Walbaum, 1792) (Actinopterygii Clupeiformes Clupeidae), which is the subject of this work by a disembarkation or landing of 40% to 50% of the overall national fish disembarkation. *Sardina pilchardus* has already been the topic of many studies, biologic and morphologic. We can cite those of Furnestin (1950), Lee (1961), (Aldebert & Tournier 1971), Ettahiri et al. (1998), Amenzoui et al. (2005), Khemiri (2006), Chlaida (2009), Kaidi (2011), and Nikolioudakis et al. (2011).

MATERIAL AND METHODS

This study was achieved during the year 2015, on the fish which was bought from fishmongers of the concerned regions: El Kala, Annaba, Skikda, Collo, Jijel, Algiers and Oran (Fig. 1).

According to the fishmongers, this fish is fished with the help of a fishing device, as fillet and mesh, and a sample of 30 individuals minimum is taken in to consideration, for every zone. Each individual is enveloped by a film in plastic immediately after the collection to avoid its damage, and then it is put in the freezer, at a temperature of -20 °C. In the laboratory, a set of 36 morphometric and meristic measures was obtained

on every fish (Fig. 2, Table 1). All the metric measures were realized in millimeters with the help of a dry compass. The meristic measures were done under a binocular magnifier with a reckoning; the fixing of the sex was realized after the dissection of the fish.

To describe better the various variables which characterize individuals, we calculated some basic statistical parameters such as the arithmetic average, the standard deviation (s) which measures the dispersion of the data around the mean, the minimal xmin and maximal xmax values which both give an idea of the extent of the data, and finally, the size which informs us about the handled importance of the data. To compare the averages for each of the 36 characteristics among the seven sites, we used the one-way variance analysis test or the fixed model classification factor. This test consists in comparing the averages of several populations from random, simple, and ample independent data (Dagnelie, 1970, 2006).

The comparison of the seven sites between them for the set of the studied variables, realized by means of the analysis of the multivariate variance by using three statistical tests, are: Wilk's, Lawley-Hotteling & Pillai's (Dagnelie, 2000). All the calculations were executed with the software statistical Minitab of analysis and treatment of the data, version 17 of the software (X, 2015).

RESULTS

According to the results obtained in the description of the data of 471 individuals, we noticed that the largest size is recorded in females of El Kala and Oran with a length of 19 cm. On the other side, the smallest size is noticed in the indeterminated sex with only 9.20 cm (see also Tables 2, 3). The females of El Kala, Jijel, and Oran have larger sizes than the males and it is the reverse in other sites, where the males are longer than females (Tables 3).

The comparison between the averages of the variables of the two sexes in each site tell us that the averages of the females in the gulfs of Algiers, El Kala, Jijel, and Oran, Collo, Skikda are slightly higher than those of the males. This is not the case for those of the Annaba who are a bit higher than females. This may suggest a possible sexual dimorphism in our species.

The results of the univariate fixed variance analysis test applied to each of the 36 variables measured appear in the Table 2 for comparison between sites and both sexes in each site show that

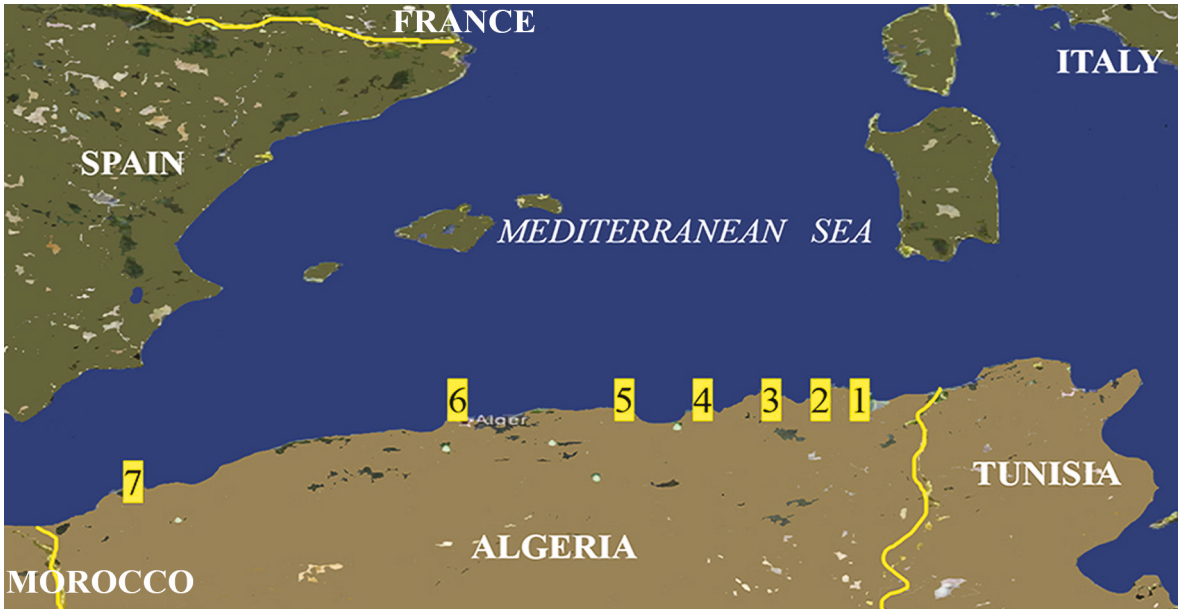

Figure 1. Study area, location of sampling sites: (1) El Kala Gulf, (2) Gulf of Annaba, (3) Gulf of Skikda, (4) Gulf of Collo, (5) Gulf of Jijel, (6) Bay of Algiers, (7) Gulf of Oran.

there is a highly significant meristic and morphometrical difference between the sites for 35 out of 36 variables, as well as very highly significant sex differences in the seven sites studied for: Lt, Lf, Dopv, at level α = 0.1%. Highly significant difference for Ls, Lpan, Lppv, Lpdo at level a=1% and differences just significant for Lppc, Doan. Lman, Lain, Lapc, Hpc, Hpd. Bado, Baan, pvan, brus at level α = 5%.The variables giving significant differences can be retained for the demonstration of sexual dimorphism of this species.

The test of MANOVA has been applied on 2 matrixes of data using three tests, Wilk's, Lawley-Hotelling and Pillai's) with the same results. This means that there are very highly significant differences between the 36 variables in the seven sites (Table 4). However, the three tests show the absence of any significant difference between the two sexes in each site for all the 36 variables (Table 5).

The noticed differences can be explained by the difference in sardine diet in each site, the physiological state of the individuals at the time of sampling and even the period of sampling as well as the pollution by the discharges of the different origins that change the physio-chemical parameters of the environment, which consequently deteriorate the aquatic ecosystem and the life cycle of its populations. According to Grimes (2010), most cities of the Algerian littoral suffer from a type of pollution that is related to the dominant activity in each city.

CONCLUSIONS

This work aims at a morphometrical comparison of the sardine of the Algerian littoral. The study is carried out on 471 specimens sampled in random manner. In this study it was possible to note by means of a comparison between the averages of the variables of both sexes in each site and the existence of an eventual sexual dimorphism in this species. The well determined statistical tests that were used show that there is a very highly significant difference between the 7 sites for the 35 biometrical variables upon 36 studied at our species, therefore our study constitutes a data base on which other studies are based in order to better understand the causes of this difference noticed in the sardine of the Algerian coast, for instance, a genetical study of the species.

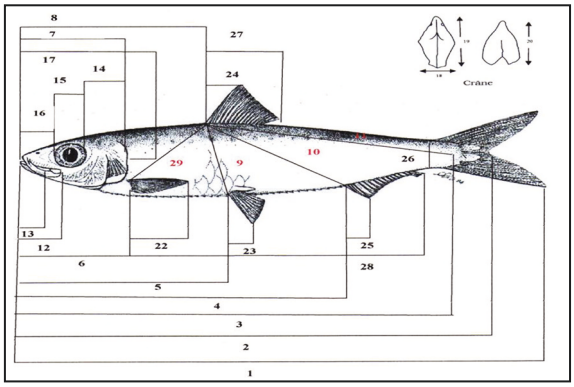

Figure 2. Morphometric measurements made on each fish.

Number	Code	Description
Morphometric measurements		
1	Lt	Total length
2	Lf	At fork length
3	Ls	Standard length
4	Lpan	Length pre-anal
5	Lppv	Length pre-pelvic
6	Lppc	Length pre-pectoral
7	Lcep	Cephalic length
8	Lpdo	Length pre-dorsal
9	Dopv	Dorsal / pelvic distance
10	Doan	Dorsal / anal distance
11	Doca	Dorsal / Caudal Distance
12	Lman	Mandible length
13	Lmax	Maxillary length
14	Poor	Distance post-orbitaire
15	Dor	Diameter Orbital
16	Pror	Length Pre-orbital
17	Lpop	Length pre-operculum
18	Lain	Inorbital Width
19	Lcra	Head width
20	Mist	Length mandible / isthmus
21	Lapc	Distance between pectoral insertions
22	Hpc	Pectoral Height
23	Hpv	Pelvic Height
24	Hdo	Dorsal Height
25	Han	Anal Height
26	Hpdc	Peduncle Height
27	Bado	Dorsal Height
28	Baan	Anal Height
29	Dopc	Distance dorsal/pectoral
30	Pcpv	Distance pectoral/pelvic
31	Pvan	Distance pelvic/anal
Meristic counting		
32	Cæc	Cæc Number of pyloric caeca
33	Brin	Number of lower gill rakers of the 1st left branchial arch
34	Brsu	Number of upper gills rakers of the 1st left branchial arch
35	Rypc	Number of rays of the left chest
36	Rypv	Number of left pelvic rays

Table 1. Morphometric and Meristic Studied Variables.

Factors					
		Site		Sex (sites)	
nº	Variables	F	P	F	P
1	Lt	1124.9	0.000***	3.66	0.001***
2	Lf	32.41	0.000***	3.94	0.000***
3	Ls	113.47	0.000***	3.35	0.002**
4	Lpan	113.75	0.000***	3.33	0.002**
5	Lppv	106.28	0.000***	3.23	0.002**
6	Lppc	52.13	0.000***	2.08	0.045*
7	Lcep	59.26	0.000***	1.77	0.091 ns
8	Lpdo	95.30	0.000***	3.24	0.002**
9	dopv	66.43	0.000***	4.53	0.000***
10	doan	85.19	0.000***	2.62	0.012*
11	doca	88.25	0.000***	1.65	0.119 ns
12	Lman	73.40	0.000***	2.16	0.036*
13	Lmax	48.49	0.000***	1.49	0.169 ns
14	Poor	75.91	0.000***	1.27	0.262 ns
15	Dor	23.93	0.000***	0.95	0.471 ns
16	Pror	54.59	0.000***	1.85	0.076 ns
17	Lpop	68.91	0.000***	1.85	0.076 ns
18	Lain	41.02	0.000***	2.42	0.019*
19	Lcra	77.55	0.000***	1.26	0.267 ns
20	Mist	57.36	0.000***	1.18	0.315 ns
21	Lapc	6.36	0.000***	2.31	0.025*
22	Hpc	78.75	0.000***	2.12	0.040*
23	Hpv	2.23	0.039*	0.08	0.999 ns
24	Hdo	62.40	0.000***	1.83	0.080 ns
25	Han	20.88	0.000***	0.87	0.532 ns
26	Hpdc	37.05	0.000***	2.16	0.318 ns
27	Bado	85.03	0.000***	2.16	0.036*
28	Baan	9.54	0.000***	2.06	0.047*
29	dopc	68.86	0.000***	1.87	0.073 ns
30	pcpv	63.25	0.000***	1.68	0.111 ns
31	pvan	66.14	0.000***	2.65	0.011*
32	cæc	37.25	0.000***	0.73	0.646 ns
33	brin	45.49	0.000***	1.00	0.433 ns
34	brsu	54.79	0.000***	2.14	0.039*
35	rypc	35.34	0.000***	1.08	0.375 ns
36	rypv	23.96	0.000***	0.63	0.730 ns

Table 2. Results of the analysis of variance at a fixed model classification criterion of the comparison, between sites and sexes (sites), of the means of each of the 36 variables. P>5%: not significant difference. *p=5%: significant difference. **P=1%: highly significant difference. ***p=0.1: very highly significant difference. F=value of F_{obs}. P=probability.

Sites	Males			Females		
	n	L max	L min	n	L max	L min
El-kala	40	16.10 cm	10.50 cm	29	19 cm	11.20 cm
Annaba	48	15.60 cm	10.50 cm	11	14.5 cm	9.50 cm
Skikda	53	15 cm	9.50 cm	23	14 cm	10 cm
Collo	44	15.40 cm	11.10 cm	67	15.10 cm	11.10 cm
Jijel	8	14.90 cm	9.70 cm	22	14.20 cm	10 cm
Alger	48	14.90 cm	9.70 cm	23	14.20 cm	10 cm
Oran	18	18.50 cm	16 cm	15	19 cm	14.50 cm

Table 3. Description of the data for each site.

Tests	Observed values of the test	Fobs	P
Wilks'	0.01150	12.598	0.000***
Lawley-Hotelling	9.07058	17.021	0.000***
Pillai's	2.73398	9.580	0.000***

Table 4. MANOVA for Sites. Multivariate tests used to test the equality of mean vectors between sites. P ≤ α= 0,001 : (***) very highly significant differences.

Tests	Observed values of the test	Fobs	P
Wilks'	0.51080	1.145	0.066 **ns**
Lawley-Hotelling	0.71231	1.146	0.065 **ns**
Pillai's	0.63468	1.144	0.067 **ns**

Table 5. MANOVA for sexes (sites). Multivariate tests used to test the equality of mean vectors between the two sexes in the sites. p > α= 0,05 : (ns) not significant.

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