First Data on Morphometric Parameters of The European Conger Eel (*Conger conger*, Linnaeus, 1758) in Béni-Saf Bay (Western Algerian Coasts)

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Abstract
A biometric study was conducted on a benthic fish of the family Congridae, the European conger eel (*Conger conger* Linnaeus, 1758), from the western coasts of Algeria, from Béni-Saf. This study was carried out due to the total absence of reliable and exploitable information concerning the morphometric characteristics of this fish along the Algerian coast. It was based on statistical processing of 18 morphometric variables measured on each sampled fish. the comparison between months using univariate ANOVA and multivariate MANOVA statistical tests showed significant differences in morphometric variables measured on the European conger eel (*Conger conger*). However, regarding the sex factor, no significant differences were observed between males and females.

Keywords: *Conger conger*, biometric study, morphometric variables, univariate and multivariate statistical tests, western coasts of Algeria.

1. Introduction

The European conger eel, *Conger conger* (Linnaeus, 1758), is a marine benthic carnivorous Anguilliform species living in rocky and sandy bottoms between 10 and 1000 m in depth (Culurgioni et *al*., 2006). It is widely distributed in the North-eastern Atlantic, from Norway to Senegal (including the Canary Islands, Azores and Madeira), in Mediterranean and western Black Seas (Correia et *al*., 2009; Tighe, 2015). European conger eel (*C. conger*) is of great importance in commercial and recreational fishery resource, being caught with bottom trawl, hook and line (Figueiredo et *al*., 1996; Morato et *al*.,1999; O'Sullivan et *al*., 2003).

Several studies have been devoted to the study of the biology of the European conger eel (*C. conger*) on several Mediterranean and Atlantic areas on different aspects: reproductive biology (Cau & Manconi 1983, 1984; Fannon et *al*., 1990; Sbaihi et *al*., 2001; Abi-Ayad et *al*., 2011a; Mazouz et *al*., 2014; Mazouz and Abi-Ayad, 2015), diet (Morato et *al*., 1999; O'Sullivan et *al*., 2004; Xavier et *al*., 2010; Abi-Ayad et *al*., 2011b; Anastasopoulou et *al*., 2013), age and growth (O'Sullivan et *al*., 2003; Correia et *al*., 2009; Matić-Skoko et *al*., 2012; Sallami and Ben Salem 2017; Daoudi et *al*., 2020). However, no scientific studies on morphometry and biometry of this species have been published except the study of Casadevall et *al*. (2017) and Sallami et *al*. (2020). The objective of this work is to characterize the morphology of the European conger eel *C. conger* caught in the western coast of Algeria, emphasizing the influence of sex and time on the morphology, and the search for possible morphological variations compared to other populations.

2. Materials and Methods

2.1. Data collection

Conger conger specimens used in this study were captured monthly from the Western coast of Algeria, from Béni-Saf (Figure 1), for 12 months. The Conger eel were caught by commercial trawlers, at a depth ranging between 100 and 150 meters, based on information provided by experienced fishermen who are aware of fishing grounds in the area. In total, 172 specimens, 92 females and 80 males were sampled and treated in detail at the laboratory (AQUABIOR).

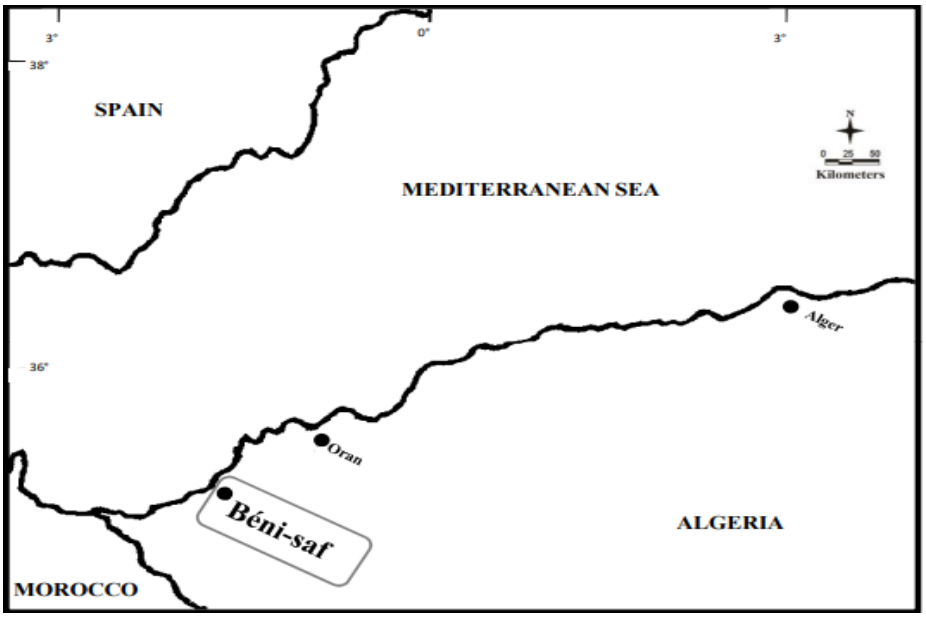

Fig 1: Study area: bay of Béni-saf (Algeria).

2.2. Morphometric measurements

A series of eighteen (18) morphometric measurements were carried out on each sampled fish. These measurements were made on the basis of previous studies cited by Tudela (1999) and Mezedjri (2004) to obtain maximum information about the studied fish. All measurements were taken with precision to the nearest millimeter (mm), using an ichthyometer and a caliper. Sex determination was performed after fish dissection. The morphometric variables measured for the individuals are shown in Table 1 and figure 2.

Table 1: Morphometric variables studied on European conger eel (*C. conger*).

No	Code	Description
1	Lt	Total length
2	Ls	Standard length
3	Lpdo	Length pre-dorsal
4	Lpan	Length pre-anal
5	Lcep	Cephalic length
6	Lppc	Length pre-pectoral
7	Doan	Distance dorsal /anal
8	Doca	Distance dorsal / caudal
9	Lman	Mandible length
10	Lmax	Maxillary length
11	Dor	Diameter orbital
12	Pror	Length pre-orbital
13	Lapc	Distance between pectoral insertions
14	Hpc	Pectoral Height
15	Hdo	Dorsal Height
16	Han	Anal Height
17	Hpdc	Peduncle Height
18	Dopc	Distance dorsal / pectoral

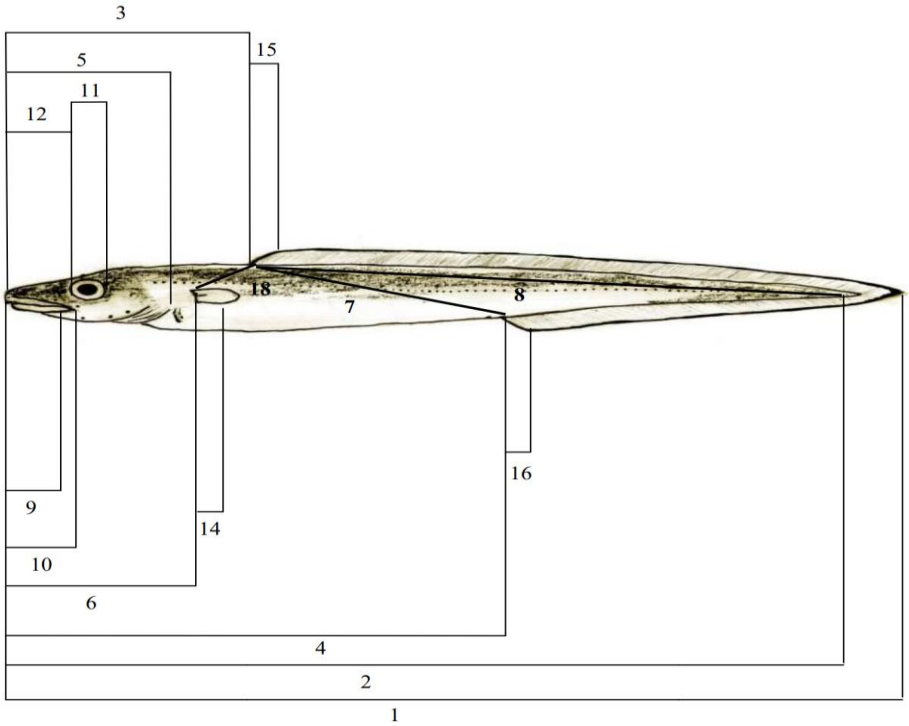

Fig 2: Morphometric measurements taken on each fish.

2.3. Statistical analysis of the data

To better describe the different morphometric variables characterizing the studied individuals (fish) in this study, we calculated some basic statistical parameters such as the arithmetic mean (x), which is a parameter of central position and central tendency, the standard deviation (s), which measures the dispersion of the data around the mean, the minimum (x_{min}) and maximum (x_{max}) values which both give an idea of the extent of the data, and finally the size or the number of samples (n) which informs us about the importance of the data processed.

Univariate statistical analyses

Morphometric data was analyzed using the analysis of the univariate variance (ANOVA). This test consists in comparing the averages of several populations at random, simple and independent sample data (Dagnélie, 1970, 2006). Univariate analysis of variance (ANOVA) was used in this study, to compare, on one hand, the means of the 18 variables between the 12 months, and on the other hand, between genders.

Multivariate statistical analyses

The multivariate variance analysis or the dispersion analysis aim to compare the averages of more than two populations for several variables. This method is an extension of the univariate variance analysis, in which we have several variables that were observed simultaneously on the same individuals.

The comparison of the 12 months and between sexes for all 18 studied variables, was performed by using MANOVA multivariate variance analysis using three statistical tests which are: Wilk's lambda, Lawley-Hotteling, and Pillai's trace (Dagnélie, 1970, 1986, 2006). The three tests cited above and proposed by Palm (2000) and Dagnélie (1970, 2006) are all asymptotically equal in power and no test can be recommended in a systematic way, in preference to others (Dagnélie, 1986). According to Huberty (1994), the Wilk's test is the most popular.

All calculations were performed by using the Minitab software GLM procedure (Minitab s.s., 2013) for each of the 18 variables.

3. Results

3.1. Statistical analysis of the data

The results obtained by sex, for the different statistical parameters using the Minitab software for statistical analysis and processing of data, were presented in table 2. Generally, averages for the different variables measured are slightly higher for female's conger eels compared to those of the males.

Table 2: Statistical description of males and females

	Males			Females		
Variables	**Mean**	**x_{min}**	**x_{max}**	**Mean**	**x_{min}**	**x_{max}**
Lt	57,16	39,10	93,80	59,70	36,00	89,50
Ls	56,96	38,90	93,50	59,51	35,80	89,20
Lpan	23,53	14,80	41,00	24,56	6,50	44,10
Lppc	8,22	3,70	20,60	8,75	2,50	14,50

Lcep	6,99	3,80	13,50	7,50	2,50	13,20
Lpdo	11,42	7,20	18,50	12,20	6,80	24,20
Doan	11,38	2,30	20,00	13,36	6,70	21,10
Doca	48,93	29,50	86,20	46,15	12,10	86,10
Lman	2,90	1,60	5,30	3,02	1,40	5,60
Lmax	2,56	1,30	4,80	2,65	1,10	4,80
Dor	0,99	0,60	2,30	1,05	0,40	2,20
Pror	2,11	1,20	3,80	2,31	1,20	3,80
Lapc	2,79	1,30	5,50	2,94	1,10	5,60
Hpc	0,52	0,20	1,30	0,52	0,20	1,70
Hdo	0,38	0,10	1,00	0,40	0,10	2,00
Han	0,33	0,10	0,90	0,37	0,10	1,00
Hpdc	0,74	0,20	2,10	0,76	0,20	2,00
Dopc	3,32	2,00	6,00	3,60	1,20	8,50

3.2. Univariate statistical analyses

All results were obtained by using the GLM command of the Minitab software. Results of the ANOVA applied to each of the 18 variables measured were included in table 3 to the comparison between the months and between the two sexes. Examination of table 3 showed the existence of significant differences between the twelve months for all 11 morphometric measured variables with the exception of seven variable: Total length (Lt), standard length (Ls), length pre-pectoral (Lppc), cephalic length (Lcep), distance dorsal /anal (Doan), distance dorsal / caudal (Doca) and Distance dorsal / pectoral (Dopc), where the differences were not significant. Moreover, the examination of table 3 showed the absence of significant differences between the two sexes for 16 out of 18 variables. The variables that showed significant differences at the α = 5% level were: Length pre-dorsal (Lpdo) and length pre-orbital (Pror).

Table 3: Results of the comparison sexes and the months between them obtained by ANOVA for each of the 18 studied variables.

		Factors			
		Months		**Sexes**	
N°	**Variables**	**F**	**P**	**F**	**P**
1	Lt	1,91	0,096 ns	1,98	0,161 ns
2	Ls	1,97	0,086 ns	1,98	0,161 ns
3	Lpan	2,64	0,026*	1,90	0,170 ns
4	Lppc	1,96	0,087 ns	2,19	0,140 ns
5	Lcep	0,80	0,549 ns	2,69	0,103 ns
6	Lpdo	2,76	0,020*	4,16	0,043*
7	Doan	0,21	0,958 ns	0,61	0,435 ns
8	Doca	1,10	0,365 ns	0,21	0,646 ns
9	Lman	4,77	0,000***	1,61	0,206 ns
10	Lmax	5,65	0,000***	1,04	0,309 ns
11	Dor	4,76	0,000***	1,22	0,270 ns
12	Pror	3,04	0,012*	5,60	0,019*
13	Lapc	3,74	0,003**	2,33	0,129 ns
14	Hpc	31,73	0,000***	3,35	0,069 ns
15	Hdo	10,27	0,000***	0,68	0,410 ns
16	Han	10,22	0,000***	0,82	0,368 ns
17	Hpdc	11,91	0,000***	1,68	0,197 ns
18	Dopc	0,56	0,734 ns	3,16	0,077 ns

Note: p >5% = not significant differences, *p = 5% significant differences,
**p = 1% significant differences, ***p = 0.1% significant differences,
F = value of observed F of the ANOVA, P = Probability.

3.3. Multivariate statistical analyses

The Minitab MANOVA command applied to the data obtained from the twelve months gave the results represented by tables 4 and 5. For each of the two tables, the three Wilk's, Lawley-Hotteling and Pillai's tests yielded the same results. The examination of table 4 showed that the 3 tests concluded that there were very highly significant differences between the twelve months, for the whole of the morphometric observed characters on the *C. conger*. Additionally, the examination of table 5 showed that the 3 tests led to the absence of significant differences between the two sexes for all 18 studied variables. In the first case as in the second case, the MANOVA tests completely confirmed the results of the univariate analysis of variance (ANOVA) obtained previously.

Table 4: Multivariate tests used to test the equality of the vectors of average between the months.

Critère	Test statistique	F	P
Wilk's	0,05	6,86	0,000***
Lawley-Hotelling	4,92	7,73	0,000***
Pillai's	2,11	5,95	0,000***

***p = 0.1% significant differences, F = value of the Fobs, P = Probability.

Table 5: Multivariate tests used to test the equality of the vectors of average between two sexes. ns: p >5%: not significant differences,

Critère	Test statistique	F	P
Wilk's	0,91	0,82	0,673 ns
Lawley-Hotelling	0,10	0,82	0,673 ns
Pillai's	0,09	0,82	0,673 ns

F = value of the Fobs, P = Probability.

4. Discussion

Biometric variations are important for species description. Morphological characteristics, such as body shape and meristic data, have long been employed for stock identification (Turan et *al*., 2004). Generally, specimens from different regions differ from each other in morphology (Franičevič et *al*., 2005).

According to Sallami et *al*. (2020), there are only a few international studies available on the biometry of conger species, especially *Conger conger*. Furthermore, there is no biometric data available on the European conger (*C. conger*) in the Algerian basin, making the comparison of our results with other authors impossible.

In this study, the results obtained for the description of data by sex showed that averages for the different variables measured are slightly higher for females compared to those of the males.

This is explained by the fact that males have a slower growth rate than females (Takai, 1959). The same observation was reported on *C. conger* by Cau and Manconi (1983) in the southern Sardinian Sea, by Flores-Hernandez (1990) in southern Brittany and by Casadevall et *al*. (2017) in the northwest Mediterranean. Also, it was observed in the European eel *Anguilla Anguilla* (Kushnirov and Degani, 1995) and in many teleosts species (Tudela, 1999; Mezedjri, 2004; Mezedjri and Tahar, 2007).

The use of univariate analysis (ANOVA) showed that among a set of 18 morphometric variables measured in the European conger eel (*C. conger*), 11 variables exhibited significant differences across months, 7 related to body measurements (Length pre-anal, Length pre-dorsal, Distance between pectoral insertions, Pectoral Height, Dorsal Height, Anal Height, Peduncle Height), while 4 to cephalic measurements (Mandible length, Maxillary length, Diameter orbital, Length pre-orbital). However, for the sex factor, there were no significant differences for 16 variables out of 18 variables. Moreover, multivariate statistical tests MANOVA confirmed the previous results obtained by the ANOVA and showed the absence of significant differences between the two sexes, for all months, and the existence of significant differences between months, for the whole of the morphometric observed characters on the *C. conger*. These significant differences found between the twelve months depend on several factors. It may be related to the growth. However, according to Warne and Kanazawa (1958) and Casadevall et *al*. (2017), certain conger body measures, such as head length, snout length, body length, and distance from tip of snout to origin of dorsal, increase directly with growth. The significant differences could also be attributed to the sexual cycle of the eel. Indeed, during sexual maturation, the body of the eel undergoes significant physical changes. Gonadal development causing swelling of the abdomen, to the detriment of other organs. The physiognomy of the fish is modified, especially in the head. This is observed in public aquariums that have mature individuals.

5. Conclusion

In conclusion, results presented in this study provide the first detailed information on the biometrical parameters of the European conger eel, *Conger conger* in the bay of Béni-saf, Algeria. Such information is crucial for the conservation and management strategy of this exploited Congridae species. Furthermore, it constitutes a useful regional reference for a potential search of different populations within the *C. conger* species in its geographical distribution area. Top of Form

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