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Growth and assessment parameters of *Calappa granulata* (Crustacea ; Decapoda ; Brachyura) in the eastern Algerian coast (Southern Mediterranean Sea)

Paramètres de croissance et d'exploitation de Calappa granulata (Crustacés ; Décapodes ; Brachyoures) dans le bassin algérien oriental (Méditerranée Sud)

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Abstract. The shamefaced crab *Calappa granulata* (Linnaeus, 1758) is a species known from the Mediterranean Sea and east Atlantic from Portugal to Mauritania, including the Azores, Madeira, the Canary Islands, and the Cape Verde Islands. Recorded in Algeria by several authors, the shame-faced crab represents the main species of brachyuran crustaceans, found in the eastern Algerian fisheries. The growth study of the shame-faced crab's population, in the eastern part of the coast, is realized for the first time through this study. The latter was based on three years of sampling (2016-2018). The length-weight relationship shows that the growth of this species follows a negative allometry. The estimated growth parameters for this species using ELEFAN program are $L\infty$ = 102.5 mm and K = 0.31 yr^{-1}. According to the former, the asymptotic weight is 406.7 g. Mortality parameters calculated based on the growth parameters obtained for the population of *C. granulata* of the area are M = 0.41 yr^{-1}, Z = 1.94 yr^{-1} and F = 1.53 yr^{-1}.

Keywords: Growth parameters , mortality , Brachyura , *Calappa granulata* , Algerian coast.

Résumé. Le crabe honteux Calappa granulata (Linnaeus, 1758) est une espèce existante dans la méditerranée et l'atlantique Est allant du Portugal à la Mauritanie, comprenant les Açores, Madère, les îles canaries et le cap vert. Signalé en Algérie par plusieurs auteurs, le crabe honteux est la principale espèce de crustacés brachyoures débarqués dans les pêcheries algériennes de la région Est. L'étude de la croissance de la population du crabe honteux dans la partie orientale du bassin algérien a été réalisée pour la première fois et a été effectuée sur la base d'un échantillonnage qui s'est étalé sur une période de trois ans (2016-2018). La relation taille-poids montre que la croissance de cette espèce suit une allométrie minorante. Les paramètres de croissance estimés pour cette espèce à l'aide du programme ELEFAN sont ($L\infty$ = 102,5 mm, K = 0,31 an^{-1}). Le poids asymptotique a été estimé à partir de la longueur asymptotique à 406,7 g. Les paramètres de mortalité calculés sur la base des paramètres de croissance obtenus pour la population de *C. granulata* dans cette partie du bassin algérien sont (M = 0,41 an^{-1}, Z = 1,94 an^{-1}, F = 1,53 an^{-1}).

Mots Clés: Paramètres de croissance , Mortalité , Brachyoures , *C. granulata* , Bassin algérien.

INTRODUCTION

The shamefaced crab *Calappa granulata* (Linnaeus, 1758) is a sublittoral species known from the Mediterranean Sea and adjacent Atlantic Ocean from Portugal to Mauritania, including the Azores, Madeira, the Canary Islands, and the Cape Verde Islands (Manning & Holthuis 1981, Števcic 1990). It was recorded in Algeria by several authors (Santucci 1930, Délye 1957, Grimes 2004). This benthic species lives buried in sand or silt sediments (García Raso 1984). It is the main species of brachyuran crustaceans, found in Algerian fisheries related to the eastern area of the coast. No study of growth or mortality parameters of *C. granulata* belonging to the Mediterranean Sea's stock was carried out before. The purpose behind this study is to evaluate growth and mortality parameters of this crab species in this specific area. After prospecting fisheries along the Algerian coast, it was concluded that *Calappa granulata* is landed in large quantities in the east compared to the center and the west, and for that, the study was restricted to this area. The most recent descriptive study of *C. granulata* was conducted by P. Noël (2013). The description was achieved also by several authors including Fischer *et al.* (1987).

MATERIAL AND METHODS

Sampling and area Study

The related observations were made on collected samples from the eastern Algerian coast, between 2016 and 2018 (Fig. 1). A total of 233 specimens of *Calappa granulata* were examined. Specimens were sexed; also measurements of cephalothoracic length (CL) were recorded to the nearest millimeters (Fig. 2), as well as total weight (TW) to the nearest 0.01g.

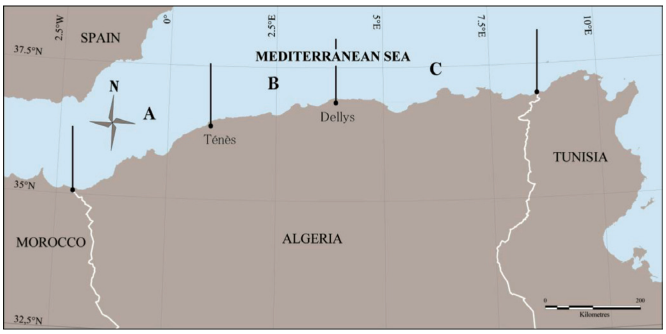

Figure 1. Map of the Algerian coast indicating western (A), central (B) and eastern (C) areas.

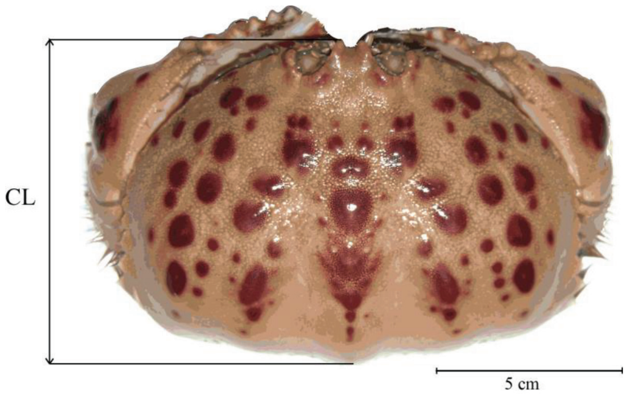

Figure 2. *C. granulata* Cephalothoracic length (CL) measurement.

Data analysis

The purpose of growth analysis is to project on a graph, the length evolution of the studied species as a function of time until reaching the asymptotic length. The parameters of the absolute growth model are presented in Von Bertalanffy equation as follows :

$$(CL = L\infty * [1 – e -k (t - t_0)])$$

CL : cephalothoracic length of crab at time ‘t’ in ‘mm’ ; K: growth coefficient ; t_0 : time (theoretical age) where the length is supposed to be zero ; L∞: asymptotic length when “t” tends to infinity (asymptotic length) in ‘mm’.

The most appropriate method of estimating growth parameters for crustaceans is ELEFAN, and it is recommended by Company (2000) for several reasons, such as, seasonal fluctuations by which crustaceans are characterized. According to Pauly and David (1981) and Pauly (1987), this program can be used to estimate growth parameters by analyzing length frequencies. This analysis can be carried out in two steps : (1) restructuring the length frequencies to smooth the irregularities of the data using the moving average ; (2) adjusting the growth curve through a modal progression analysis.

According to Pauly & David (1981), ELEFAN I considers the best fitting growth curve to be the one with the best ESP/ASP ratio, knowing that : ESP : Sum of explained peaks (the sum of the peaks that the growth curve crosses) ; ASP : Available sum of peaks. The growth parameters can be attained by the K-Scan label, which provides a different score curve for a ‘k’ varying in a range from 0.1 to 10. This option gives also the SL “Starting Length” and SS “Starting Sample”, to make possible the use of a second option named “Equal Responses Surface”. The latter provides an interval comprising pairs of L∞ and K values with the ESP/ASP ratio corresponding to each pair. A simplified description of this program was done by Sparre and Venema (1996). The comparison between the average lengths of males and females was performed using the following Student test (Schwartz 1963) :

$$\xi = \frac{|m1 - m2|}{\sqrt{\frac{\delta1^2}{n1} + \frac{\delta2^2}{n2}}}$$

Where m1 : mean length of sample 1 ; δ1 : variance of the sample 1 ; n1: sample 1 size. m2 : mean length of sample 2 ; δ2 : variance of sample 2 ; n2 : sample 2 size. In order to decide on the difference significance .between the two mean, ξ will be compared to 1.96 for a risk α = 5%

The ‘t’ test (Schwartz 1992) was also used to compare the curve slope with a theoretical value (b = 3) to determine the type of the growth followed by this species (positive allometry, isometry or negative allometry). The parameters of the ‘t’ test are as follows :

$$t = \frac{|P0 - P|}{SP0} \quad \text{With : } SPo^2 = \frac{\left(\frac{Sy}{Sx}\right)^2 - SPo^2}{n - 2}$$

Where P0 = b = slope calculated by the least squares method; SP0 : Standard deviation of the calculated slope ; n : sample size ; Sx : Standard deviation of the variable ‘CL’; Sy : Standard deviation of the variable ‘TW’; ddl = n-2 and α = 5%.

If t <1.96: the difference is not significant ; If t ≥ 1.96 : the difference is significant. According to Ricker (1979), the use of logarithm on lengths and weights avoids any kind of consistent bias, so that was adopted in this work.

The asymptotic weight was obtained using the length-weight relationship ($w = aL^b$) by replacing the value of cephalothoracic length (CL) with that of the asymptotic length (L∞).

The t0 used in this study was calculated using the following Pauly (1983) formula:

$$Log_{10}(-t_0) = -0.3922 – 0.2751 * Log_{10} L\infty - 1.038 * Log_{10} K$$

The mortality parameters (natural mortality, fishing mortality and total mortality) were assessed using the most common methods adapted to the Mediterranean stock. First, the instantaneous coefficient of natural mortality «M» is one of the most difficult parameters to evaluate, and that was mentioned by Pauly & Moreau (1997) and Sparre & Venema (1996). This parameter is calculated by the following Pauly’s equation (1980):

$$Ln M = -0.0152 - 0.279 Ln L\infty + 0.6543 Ln K + 0.463 * Ln T$$

It is based on three parameters namely L∞, K and the temperature that is considered stable in Mediterranean deep water (13°C). Second, there are several methods for estimating the total mortality «Z», among them, we opted for that of Pauly (1984) which consists of projecting on a graph the evolution of the natural logarithm of the sum of specimens according to the age, and which is represented by the formul :

$$t' = - [1 / K Ln [1 - (Li / L\infty)]]$$

Then, we have b = Z - K, knowing that b is the slope of the line, which implies: Z = b + K. Finally, Once Z and M are calculated, the direct application of the formula F = Z - M will provides the value of the fishing mortality F. It should be noted that the estimated parameters are relative to the population of *C. granulata* from the eastern area. The calculations were performed by FISAT II software version 1.2.0 (Gayanilo *et al*. 2005).

The probability capture curve was used to evaluate the selection parameters. The logistic function was applied to adjust the data and select the points to include in the analysis. That was recommended by Pauly (1984) because it better reflects seasonality than the moving average method. So, the logistic curve equation is :

$$\ln((1/P_L)-1) = S1- S2*Lc$$

and

$$L_{25}= (Ln(3)-S1)/S2 \; ; \; L_{50} = S1/S2 \; ; \; L_{75} = (Ln(3)+S1)/S2$$

S1 and S2 are variables used to calculate the probability of capture under the logistic model. PL : Probability of capture for length Lc.

RESULTS

Results reported on table 1 were calculated based on the aforementioned collected specimens of *C. granulata*. The results show that the calculated value of Student test for the two length averages (males and females) of this species ε = 0.28 is lower than the value provided by Student's table εt = 1.96 at a risk rate α of 5%. This means that there is no significant difference between the length averages of the two sexes. In the rest of this study, the data for both sexes will be treated in the same analysis.

Table 1. Student test for males and females of *C. granulata* species.

♀/♂	Mean (mm)	Var.	N	ε	A
♂	65.1	102.86	84	0.28	0.05
♀	65.2	75.02	149		

length frequency distributions

The seasonal length frequency distributions of the species *C. granulata* are represented on the polygons (Fig. 3). It is noticed that the peak 70 is repeated in the four seasons, the peak 54 is also repeated in the seasons : Spring, Autumn and Summer. It is also noticed that the youngest specimens of *C. granulata* (<46 mm) appear in Autumn season. The two seasons with most abundant specimens are summer and spring with respectively 75 and 74 specimens, followed by autumn with 45 specimens and winter with 39 specimens.

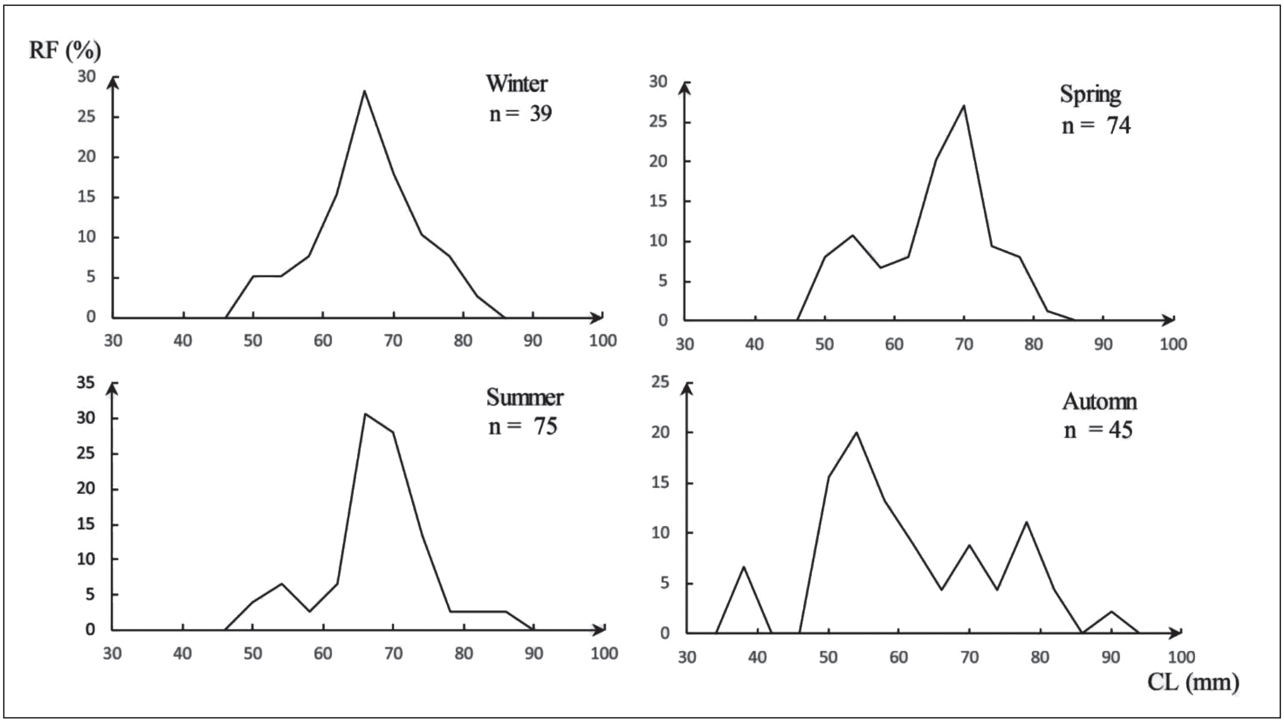

Figure 3. Seasonal *C. granulata* length-frequency polygons. CL : Cephalothoracic length ; RF : Relative frequency.

Length-weight relationship

As illustrated in figure 4, after the use of the 'power' type trend curve, the parameters obtained for *C. granulata* are: a = 0.0058 ; b = 2.41 with a correlation coefficient r = 0.85.

In order to see the growth type of this species, 't' test (Schwartz, 1992) was performed, and the results are represented in table 2.

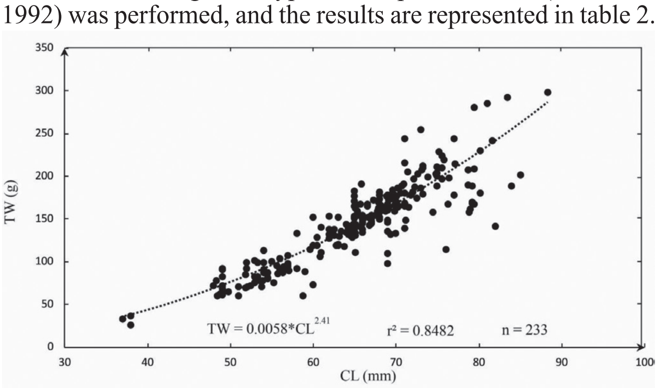

Figure 4. *C. granulata* length-weight relationship (Power-type trendline). TW : Total weight ; CL : Cephalothoracic length.

The tcalculated for *C. granulata* is 8.7 (Tab. 2), this value is higher than the one provided by the test table. This indicates that the growth of this species follows a negative allometry type, in other words, the weight grows at a low rate compared to the cube of the length.

Table 2. Estimated length-weight relationship parameters for *C. granulata*.

Parameters	n	a	b	r^2	t_{cal}	α
Values	233	0.0058	2.41	0.85	8.70	0.05

Growth parameters

In order to obtain the value of the starting length and the starting sample, L∞ calculated by the Powell-Wetherall method (99.55mm) was introduced into the program ELEFAN I - "K-scan label". The results presented on the K-scan label and the Equal Responses Surface subroutine are in table 3.

Table 3. Asymptotic weight and calculated parameters from the ELEFAN program.

Parameters	SS	SL (mm)	L∞ (mm)	K (yr^{-1})	Esp/Asp	W∞ (g)
Values	1	84	102.5	0.31	0.495	406.7

SS : Starting sample ; SL : Starting length

The K-scan label provides a starting length of 84mm and a starting sample numbered 1. The L∞/K couple with the highest score "Rn" is (L∞ = 102.5 mm and K = 0.31yr^{-1}) with a score of 0.495. This implies a W∞ valued 406.7g. Von Bertalanffy's linear equation of growth for this species is presented as follows : **Lc** = 102.5 * (1 – $e^{-0,31\ (t + 0,38)}$)

Mortality parameters

Growth parameters for this species were used as a basis for the calculation of mortality parameters. All of ; the natural mortality M calculated by Pauly's empirical equation (1980), the total mortality estimated by the Pauly's method (1984), and the fishing mortality deduced from these two indices, are shown in table 4.

Table 4. Calculated mortality parameters for the studied *C. granulata*.

Parameters	M (yr^{-1})	Z (yr^{-1})	F (yr^{-1})	F/Z
Values	0.41	1.94	1.53	0.78

None of these parameters related to the studied species has been carried out before, so it is impossible to make any comparison. The values mentioned in the table are specific to the studied area. They may vary from one area to another, and there are several factors that affect this variation such as fishing activities, predation and nutrition.

Selection parameters

The selection parameters of *C. granulata* are also estimated with the aim of having a view of the different lengths of captures probability.

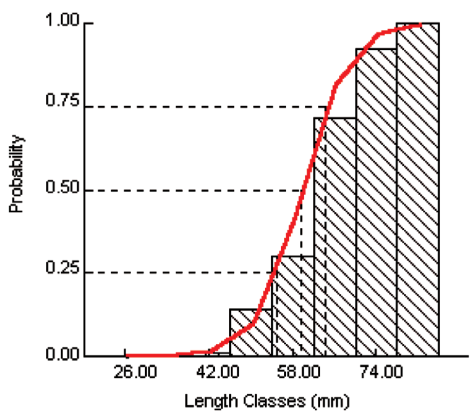

Figure 5. Probability capture curve of *C. granulata.*

The probability curve of catches, also known as the probability capture curve is represented in figue 5. The length at first capture L50 (50% of *C. granulata* entering the fishing gear is retained) is estimated at 59.6mm, whereas the lengths where the capture probability of *C. granulata* is about 25% and 75% are respectively 54.87mm and 64.32mm (Tab. 5).

Table 5. Selection parameters obtained from probability capture curve for *C. granulata.*

Parameters	L25 (mm)	L50 (mm)	L75 (mm)
Value	54.87	59.6	64.32

DISCUSSION

The length-weight relationship has shown that *C. granulata* has a negative allometry growth and that its weight increases at a low rate compared to the cube of length. It is often difficult to obtain a good length-weight relationship in the case of crabs : the structure of their gills allows the retention of water and creates a difference in weight of specimens of the same size. This difference depends on the time spent between capture and weight measurement. The growth and mortality parameters obtained reveal that this species has a relative slow growth with a 'k' of 0.31 yr-1. However, the asymptotic length that can be reached theoretically by this species, is 102.5mm, this length is important compared to the maximum observed length (88.34mm), or that of Pauly's approximation (Lmax/0.95) which is 92.88mm. As for the asymptotic weight, it is estimated at 406.7 g. The maximum measured weight is 298g. This type of slow and continuing growth to reach large sizes and weights is generally a characteristic of species that are subject to significant sensitivity towards fishing pressure. knowing that the state of a good species exploitation is represented by the ratio F/Z = 0.5, the current situation (F/Z = 0.78) suggests that this species is subject to fishing pressure more than the one recommended, so it is necessary to take precautions in order not to exhaust the *C. granulata* stock. The parameters calculated during this study concern only the case of *C. granulata* belonging to the eastern region of the Algerian coast, they might be inaccurate in another area.

CONCLUSION

The estimation of growth and assessment parameters of this crab species belonging to this zone, opens a new chapter on the study of a zoological group that has not yet received enough attention in the Algerian coast. A wider study along the entire Algerian coast would certainly provide additional information on the evolution of each population belonging to each region of the Algerian coast. Other experiments can also be conducted to gather more data on the growth of this species. These results can be integrated into marine resource management models in order to evaluate *C. granulata*'s exploitation in this area. Finally, the estimated parameters represent an interesting bibliography for any possible future study to be compared to this one.

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