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# Age, growth, mortality and condition index of an unexploited *Ruditapes decussatus* population from El Mellah lagoon Algeria

**Lamia Bensaad-Bendjedid*, Saber Belhaouas, Asma Kerdoussi, Naoual Djebbari, Mardja Tahri, Mourad Bensouillah**

*Laboratory of Ecobiology for Marine Environment and Coastlines, Faculty of Science, Badji Mokhtar University, Annaba, Algeria*

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## Abstract

Between May 2016 and April 2017, *Ruditapes decussatus* (Linnaeus, 1758) population from El Mellah lagoon was investigated to collect information about several biological parameters before it upcoming re-operating after 13 years of discontinued exploitation. Total length ranged from 22.15 to 62.53 mm, while weight varied between 2.16 and 46.83g. The allometric relationships between body sizes and length were determined; the length-weight one indicated an isometric growth and expressed as $TW = 0.0002\ SL^{2.9853}$. The age was ranged from the first to the sixth, individuals 2 to 4 years old dominated the population; von Bertalanffy growth parameters were undertaken using the software recommended by FAO (FISAT II, VONBIT for Excel) and estimated to $K=0.38\ year^{-1}$ and $L\infty= 63.924$ mm. The longevity ($t_{max}$), the growth performance index ($\Phi'$) and mortality rate (Z) were 7.81 years, 3.61 and 0.65 $year^{-1}$, respectively. Condition Index was monthly determined for this population as a tool to identify optimal and sustainable harvesting periods which correspond to the period between October and January.

* **Corresponding Author:** Bensaad-Bendjedid Lamia ✉ lamiabendjedid@gmail.com

## Introduction

*Ruditapes decussatus* is widely distributed species; the habitat of this venerid clam ranges from North Atlantic coasts to Congo and the Mediterranean; in Algeria, the only coastal lagoon El Mellah supports a natural bed of this valuable species (Bakalem & Romano, 1979; Refes, 1994) which have been extensively exploited from 1980 to 1999; however from the beginning of 2000s a gradual disappearance of this population was noted inducing the interruption of fishing activities from 2004 (MPRH, 2011), but since 2015, *Ruditapes decussatus* come back on El Mellah's shores and the return to its operation is imminent.

To avoid a further stock decline, a future exploitation needs to be planned and aproper study on *R. decussatus* from El Mellah lagoon should be carried out first, but while there are numerous researches on ichthyofauna, benthic macrofauna, diversity and biomass of El Mellah lagoon (Semroud, 1983; Grimes, 1994; Draredja, 2005; Chaoui *et al*, 2006; Draredja *et al*., 2012), only one deals with ecology and biology of *Ruditapes decussatus* (Refes, 1994) although the knowledge of the both is considered essential for dynamic, management and conservation of marine bivalves populations.

The overall goal of the present study is to update information and provide new data about some population parameters of *R. decussatus* from El Mellah lagoon by estimating: age, growth, mortality, performance index, longevity and condition index as a preliminary basis and a suitable guide for a sustainable management of this natural resource.

## Materials and methods

*Study Site*

El Mellah lagoon is located in the extreme eastern of Algerian coasts (36°54' N – 8°20' E) near the Algerian- Tunisian border (Fig. 1); it covers an area of 865 ha and communicates with the sea by a long and narrow channel of 900 m; temperature and salinity vary respectively between 11.40-30.50°C and 15.90-37.10 psu (Draredja *et al*., 2012).

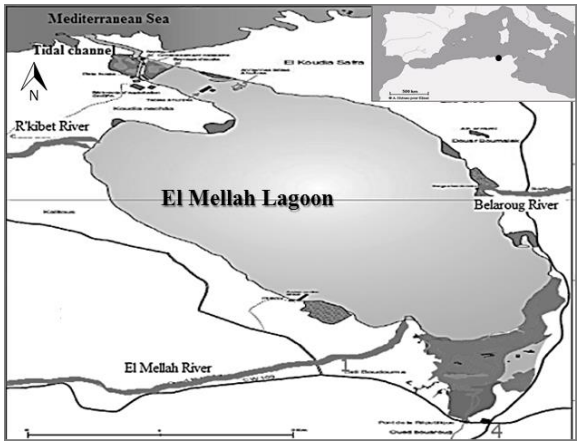


**Fig. 1.** Geographical location of El Mellah lagoon.

*Sampling and laboratory procedure*

From May 2016 to April 2017, the clams were monthly sampled at a mean water depth of 40 cm by hand or using a clam rake, and then transferred to the laboratory for processing. Shell length (SL, mm, maximum anteroposterior distance considered as reference length), shell height (SH, mm, maximum distance from hinge to ventral margin), shell width (SW, mm, maximum distance between the closed shell valves), were measured with Vernier caliper (± 0.01 mm). Total wet weight (TW, g), shell weight (sW, g), tissue wet weight (tWW, g) were also measured using an analytical balance sensitive to 0.01 g.

*Relative growth*

The morphometric relationships between shell dimensions and shell length with weights were investigated using the allometric equation:

$$Y = a X^{b}$$

This equation can be expressed in the logarithmic form:

$$\text{Log } Y = \text{Log } a + b \text{ Log } X$$

Where "Y" is the dependent variable, "X" the independent variable, "a" the intercept of the regression line, the allometry coefficient "b" (the slope) expresses the type of allometry which depends if the two variables (X, Y) have the same units of measurement (isometric: b= 1, negative allometric: b < 1, positive allometric: b > 1); or different ones (isometric: b= 3, negative allometric: b < 3, positive allometric: b > 3).

*Age and absolute growth*

Length-Frequency Distributions: In order to estimate age, the Bhattacharya's method (Bhattacharya, 1967) available in the fish-stock assessment tool FISAT II 1.2 (Gayanilo *et al.*, 2005) was used, for that purpose clams were grouped into shell length classes and divided into cohorts at 2 mm intervals.

The von Bertalanffy Growth Parameters: asymptotic length (L∞ mm) and growth coefficient (K, $yr^{-1}$) of the von Bertalanffy growth function (VBGF) (1938) $Lt = L\infty (1-e^{-K(t-to)})$, were obtained by using FISAT II and the software package VONBIT for Excel (www.fao.org/fishery/topic/16078/en), the growth performance index Φ′ was determined according to the equation: $\Phi' = \log10\ K + 2\ \log10\ L\infty$ . Pauly and Munro (1984), this index enables a meaningful comparison of growth performances of *Ruditapes decussatus* at different sites sampling.

The theoretical maximum age ($t_{max}$) was calculated as: $t_{max} = (3/k) + t_o$(Gayanilo and Pauly, 1997; Scalici *et al*, 2015).

Mortality rate: Mortality is an important aspect in the dynamic population of bivalves, indeed total mortality coefficient Z (year $^{-1}$), is composed of two components: natural mortality (M year $^{-1}$); due to predation, disease, cannibalism, competition, etc..., and fisheries mortality (F year $^{-1}$), due to fishing activities, Z= M + F. Mortality is estimated from the slope of the right descending arm of a length-converted catch curve (Pauly, 1983) using FiSAT II which outputs Z $year^{-1}$ as well as the 95% confidence intervals surrounding Z based on the goodness of fit of the regression.

In cases where there is no fishing pressure on a species as it's the case for *Ruditapes decussatus* from El Mellah lagoon , it can be assumed that Z=M (i.e. F = 0).

*Condition index*

For the determination of the condition index (CI), 15 individuals ranging from 30-45 mm were taken randomly from each monthly sample, the CI proposed by Walne 1976, was applied: (tissue dry weight (tDW, g)/shell dry weight (sDW, g)) *100). tDW and sDW were obtained by oven drying at 80°C for 24 h.

## Results

*Population structure*

Data on descriptive statistics size variables of *Ruditapes decussatus*from El Mellah lagoon is given in Table 1, the majority of this population (71.81 %) is part of the size classes included between 32 to 52 mm (Fig. 2), while the smallest (22-26 mm) and the largest (58-64 mm) ones, are the less represented with respectively only 2.5% and 3.89% from the entire sampling.

**Table 1.** Size parameters and descriptive statistics of *R. decussatus* from El Mellah lagoon (n: number of individuals, SE: standard error of mean values).

| Size Parameters | n | Mean ± SE | Size range |
|---|---|---|---|
| SL | 720 | 42.34 ± 0.33 | 22.15-62.53 |
| SH | 707 | 35.34 ± 0.28 | 19.2-55.34 |
| SW | 707 | 18.35 ± 0.15 | 10-28.44 |
| TW | 720 | 16.06 ± 0.36 | 2.16- 46.83 |
| sW | 504 | 9.40 ± 0.21 | 1.96-28.1 |
| tWW | 504 | 4.73 ± 0.10 | 1.29-12.62 |

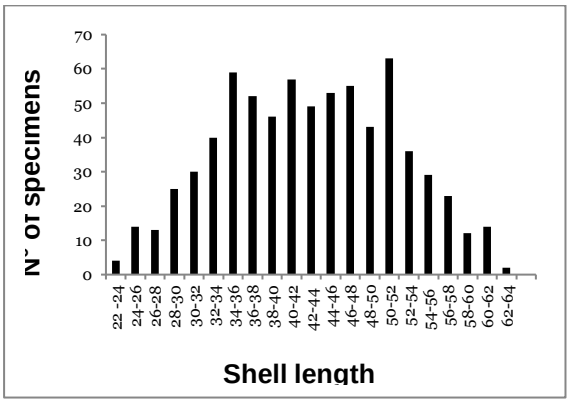


**Fig. 2.** Size-frequency distributions of *R. decussatus* from EL Mellah lagoon.

*Relative growth*

Biometric data of *Ruditapes decussatus* from El Mellah lagoon (Table 2) showed a strong significant correlation between shell length/other dimensions and shell length/weights ($R^2 \geqslant 0.91$; $P < 0.001$); indeed the morphometric relationships between shell length/shell height and shell length/shell width reflected a negative allometry as well as the

relationship between tissue wet weight against shell length; however, a positive allometric growth was identified in the relationship between shell length and shell weight while an isometric one was recorded in the relation: shell length/ total weight.

**Table 2.** Length-lengths and length - weights relationships of *R. decussatus* from El Mellah Lagoon (n: number of pairs of values, $R^2$: determination coefficient, P<0.001 for all regressions).

| Y | X | a | b | $R^2$ | n | Allometry |
|---|---|---|---|---|---|---|
| SH | SL | - 0.6365 | 0.8428 | 0.97 | 707 | allometric - |
| SW | SL | - 0.1944 | 0.4351 | 0.94 | 707 | allometric - |
| TW | SL | 0.0002 | 2.9853 | 0.98 | 720 | isometric |
| sW | SL | 0.00006 | 3.0981 | 0.96 | 504 | allometric + |
| t WW | SL | 0.0001 | 2.7439 | 0.91 | 504 | allometric - |

*Age, absolute growth and mortality rate*

The application of Bhattacharya's method brings out six cohorts; data on the estimated mean length at age is disclosed in the table 3; it is noteworthy that *Ruditapes decussatus* from El Mellah lagoon presents a rapid growth during the first year of life with a data value of 25.89 ± 1.74, then declines during subsequent years; the majority of specimens (74.05 %) were recorded in age range 2 to 4.

**Table 3**. Mean length at age using Bhattacharya's method (FISAT II 1.2.0) of *R. decussatus* of El Mellah lagoon. (CM: computed mean ± standard deviation, n: number of individuals).

| Age (year) | CM (mm) | n | % | Growth rate |
|---|---|---|---|---|
| 1 | 25.89 ± 1.74 | 31 | 5.06 | 9.62 |
| 2 | 35.51 ± 2.79 | 151 | 24.63 | 6.45 |
| 3 | 41.96 ± 2.02 | 152 | 24.79 | 5.38 |
| 4 | 47.34 ± 2.56 | 151 | 24.63 | 6.32 |
| 5 | 53.66 ± 3.82 | 100 | 16.31 | 7.36 |
| 6 | 61.02 ± 0.81 | 28 | 4.56 | - |

Based on the age–length key the VBGF (Fig. 3) describing the growth of *R. decussatus* was estimated as: $Lt = 63.924\ (1\text{-}e^{-0.38\ (t\ +\ 0.086)})$, growth performance index (Φ′) and theoretical maximum age ($t_{max}$) were 3.61 and 7.81 years respectively.

The length-converted catch curve analysis (fig. 4) using $L\infty$= 63.924 mm and K= 0.38 $yr^{-1}$, showed a low rate mortality: Z= 0.61(confidence interval CI= 0.47-0.75).


**Fig. 3.** Von Bertalanffy growth curve of *R. decussatus* from El Mellah lagoon.

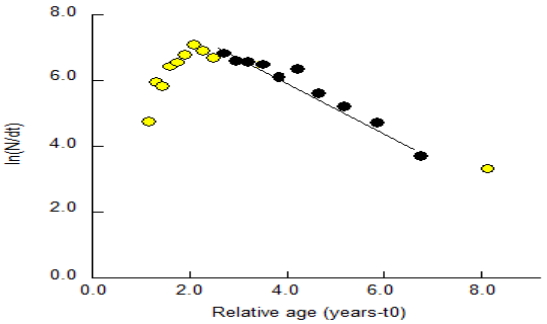


**Fig. 4.** Length-converted catch curve of *R. decussatus* from El Mellah lagoon.

*Condition index*

CI of *Ruditapes decussatus* from El Mellah lagoon showed temporal variations (Fig. 5), the highest value was recorded during June (12.89) then decreased sharply in the following months until September when CI reaches its minimum value (10.23), an increasing in the CI level was observed between October and January, then CI declined 12.07% in February to reach a value of 10.86.

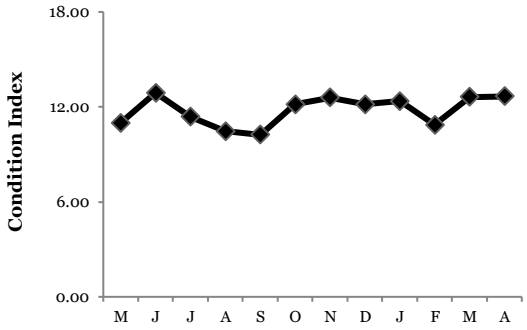


**Fig. 5.** Monthly variations in condition index (CI) of *R. decussatus* from El Mellah Lagoon (May 2016 to April 2017).

**Discussion**

The present study analyzed some population parameters of *Ruditapes decussatus* from El Mellah lagoon as a baseline for sustainable stock management before it upcoming back into operation after more than 10 years of discontinuation, subsequently to the almost complete disappearance of this population following an irrational exploitation.

The biometric characteristics of *Ruditapes decussatus* shell form revealed a negative allometries between shell length/shell height and shell length/shell width, suggesting that the shell form was elongated and narrow, similar results were observed in Egypt (Mohammad *et al*., 2014), in Tunisia and Italy (Costa *et al*., 2008). These authors suggested that this shape form was related to the improvement of the burrowing efficiency in order to avoid dislodgement by hydrodynamics and predation. Indeed generally, variations in allometry of bivalves have been associated with latitude, species, physiological traits and local environmental conditions (Beukemaand Meehan, 1985; Stirlingand Okumus, 1994; Gosling, 2003; Caill-Milly *et al*., 2012). An isometric allometry was noted between shell length and total weight revealing a homogeneous growth between size and weight, Kandeel (2008) and Gaspar *et al*. (2001) report similar observations respectively for *Ruditapes decussatus* from Lake Timsah (Egypt) and 11 bivalve species from Algarve coast (Portugal).

The VBGF parameters L∞ and K obtained using length–frequency distribution were 63.924 mm and 0.38 $y^{-1}$ respectively. Comparing our data with those of previous studies in various Mediterranean regions, it appears that it's close to that it was recorded in the Gulf of Fos, France (Garcia 1993) but remain lower than the values obtained in Araxos lagoon, Greece (Chryssanthakopoulouand Kaspiris, 2005). However, growth performance index (Φ′) displayed the greatest value (3.61); this is probably related to the favrable environmental conditions (mainly temperature and food availability) on the growth of *Ruditapes decussatus* population of El Mellah lagoon.

Regarding the low mortality rate registered (Z=0.61 $y^{-1}$), it can be only related to natural causes (aging, pathogens, predation, environmental conditions, …) as there is not yet fishery for *R. decussatus* from El Mellah lagoon, however according to Aranguren *et al.* (2014) mortality rates in *Ruditapes populations*, especially in natural beds may results from a complex synergy of biotic and abiotic factors.

Condition index analysis have provided preliminary database on the reproduction cycle of the *Ruditapes decussatus* population of the El Mellah lagoon, indeed if we refer to several authors (Beningerandlucas, 1984; Lucas and Beninger, 1985; Laruelle *et al*., 1994; Ojea *et al*., 2004) who agree that sharp falls of the CI values correspond to a spawning events, we can assume that this population presented three periods of gamete release; two partial emissions in February and May, and a main one from June to September (a histological study not yet published confirms these results). Our results are similar to those obtained in *R. decussatus* population from Gulf of Gabès, Tunisia (Trigui-El Menif, 1995), moreover in bivalves, the number of spawning and the duration of breeding season were often be related to temperature as it has a positive effect on those both physiological events (Lubet, 1970; Partridge, 1977; Laruelle *et al*., 1994); on the other hand, the highest condition index values were recorded between October and January revealing the best period to harvesting *Ruditapes decussatus* of El Mellah lagoon.

In conclusion, the results obtained in this study may contribute initially to put in place a sustainable and profitable exploitation and then to consider the possibility to farm this population.

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