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Research Article

# EFFECTS OF PLANTING SIZE AND INITIAL STOCKING DENSITY ON GROWTH AND SURVIVAL OF CULTURED CARPET SHELL CLAM (RUDITAPES DECUSSATUS L., 1758) IN THE AKARIT ESTUARY (GULF OF GABES, TUNISIA)

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**ABSTRACT**

The present study aimed to assess the effect of initial planting size classes (Experiment 1; 22, 24, 26 and 28mm) and initial stocking density (Experiment 2; 200, 300, 400 and 500 specimens/m²) on growth performance and survival rate of clam *Ruditapes decussatus*. Simultaneously two field experiments were conducted in the intertidal zone of Akarit (gulf of Gabès) over 31 months. Selected natural clam were sown in hard plastic net bag (0.5$m^2$) and buried into the soft bottom sediment. For the growth and survival evaluation, shell length and wet weight were measured individually every month throughout the experimental period.

At the end of growth trial, results demonstrated that initial seed sizes did not have a significant effect on clam growth and survivorship; in fact, clams of different initial size classes reached the legal commercial size (35 mm) in the same time period and average length did not differ significantly among treatments (P<0.05; ANCOVA). Also, results demonstrated that initial densities of 200 and 300 ind/m², did not have a significant effect on clam growth and survival rates. However, for the other initial densities, growth and survival rates were significantly dropped.



## INTRODUCTION

The carpet-shell clam *Ruditapes decussatus* is widely reared in major producing countries to satisfy market demand. This species is commercially very important in Mediterranean regions and has one of the highest rates of consumption of mollusk species in the world (Matias *et al*, 2009; Lucrezia *et al*, 2011). Indeed, among the 6324.34 tons produced in the world during 2014 (FAO, 2016), 63.3% were reared in the three following European countries: Portugal (35.34%), Italy (25.30) and Spain (2.65%). However, in Tunisia, the exploitation of this species (*R. decussatus*) is currently based only on fishing/harvesting activities of the natural stocks and annual production do not exceed 1635 tons in 2014 (DGPA, 2014). This exploitation is characterized by irregular activities; in fact, the authorized period of this activity do not exceed 7 months per year and can be more reduced when health status of the clam and harvesting area are affected.

The coastal area of the gulf of Gabès (South of Tunisia) is considered one of the most important zones of the natural exploitation of the clam *R. decussatus* in the Mediterranean region. This region represents also the most important zone in terms of people involved in harvesting clam *R. decussatus*. The letter becomes one of the most important commercial bivalves species in Tunisia together with the mussel *Mytilus galloprovincialis*, produced in the north part of the Tunisian coastal zones.

Typically, the commercial exploitation of clams involves either natural harvesting (Harbo *et al*, 1992), or planting seeds, originated from either naturally caught or hatchery reared, into the sediment for on growing (Gribben *et al*, 2002). In Tunisia as in many another country (Solidoro *et al*, 2003) the fishing activity is carried on illegally because often a significant part of the harvested clams are below the legally authorized size. Legal Tunisian exploitation of clam *R. decussatus* is based on setting a minimal authorized size of 35 mm and seasonal authorized period; from October to 15th May. Unfortunately *circa* 20 % of naturally collected clams is not suitable for legal marketing size (range: 18-30 mm) and rejected for sale after the hand grading process of production (Unpublished data). In this case, this quantity of small clams can be used for on-growing and, in this sense, are termed "seed". Thus collected clams below the authorized size can be valorized by planting artificially until reaching commercial size. Indeed, the combination of fishing and aquaculture of clams in the same exploitation area can contribute to the optimization of total revenue and in some case aquaculture gives better economic income than harvesting (Ojea *et al*, 2004). Also for social reasons, in some cases,

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aquaculture give higher economic income compared to harvesting clams (Melià *et al*, 2004).

The principal goal of shellfish aquaculture is to maximize yield per unit of time and space. The accomplishment of this goal requires the prediction of future production in terms of biomass growth and survival rate (Grant, 1996). Rapid growth to reach market size and low mortality are the two main characteristics determining the aquacultural potential of clams (Serdar, and Lok, 2007; Jurié *et al*, 2012). Therefore, the assessment of *R. decussatus*'s suitability for commercial culture depends on upon determining growth performance and survival rates under commercial culture conditions. This allows determining the required time for commercially harvested clams to reach market size which closely depends on the commercial authorized size and the environment in which they are grown.

Studies on growth and production in bivalve mollusks have identified different wide of variability and differ at spatial (rearing site) and temporal (seasonal environmental conditions) scales (Urrutia *et al*, 1999). Generally, this variability is attributed directly to the effect of environmental factors, particularly water temperature and food availability which have been considered the main factors affecting growth and production in bivalves. Thus, the assessment of rearing *R. decussatus* profitability for commercial scale depends on determining growth and survival parameters in a specific area. Thus, the extrapolation of results and conclusion from site to another causes a serious problem and experimental validation is necessary since each site offer it's particular characteristics.

The optimal fishing effort, in case of harvesting exploitation, and on optimal seeding size, seeding season, optimal stocking density, growth performance and survival rates, in case of aquaculture, are the most pertinent question should be answered in order to contribute in building reliable management bio-economic models to developing efficient and sustainable exploitation strategies of this species. Consequently, the present work is part of a larger study aimed to reach these goals. Specifically, the present study aims to evaluate the effect of different initial planting size and stocking density on growth performance and survival rates of the clam *Ruditapes decussatus* reared in intertidal areas of Zarat (Gulf of Gabes, Tunisia). Comparisons of growth performances of this species in other locations are discussed in the present work.

## MATERIALS AND METHODS

### *Study area*

This study was conducted in the gulf of Gabes (Tunisia) in the estuary of Akarit (34°5′12″ north latitude and 10°1′35″ east longitude). This location is characterized by an extended intertidal zone of 500 m in which carpet shell clam is highly exploited. Net bags were positioned near the low tidal line (Fig.1).

Hydrodynamic conditions in this zone are controlled by the semidiurnal tidal regime and tidal range varied from 0 to maximum depth of 1.5 m. In this site the substratum essentially consists by sand.

### *Experimental design and sampling*

For this study, two experiments were conducted from January 2010 to July 2012 (31 months). In both experiments, the growth trial was considered completed in July 2012 with the achievement of the average size of 35 mm, which is the legal authorized commercial size.

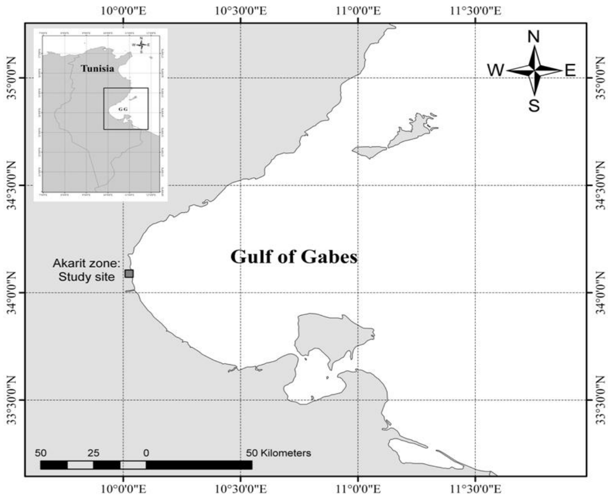


**Figure1** Map of the study area: intertidal zone of Akarit (Tunisia)

The experiments were carried out using specimens of clam *Ruditapes decussatus* from the natural population recuperated from fisherwomen because the length is lower than the legal commercial authorized size. For the first experiment, clam seed was graded into four size classes shell length (22, 24, 26 and 28 mm) according to the individual measurement (anterior-posterior axis) using digital caliper (± 0.01 mm). In each selected size class, shells were randomly allotted to 3 triplicates hard plastic net bags of 10 mm mesh size (0.5 $m^2$; 0.5 m × 1 m). For each treatment, bags were labeled. Thus, in our experiment, we had 12 net bags. The seeds were then sown at a density of 200 specimens/$m^2$, accordingly a total of 1200 specimens were used for this study. Initial average shell length (± SE) achieved for each treatment was 22.47 ± 0.03 mm, 24.54 ± 0.05 mm, 26.48 ± 0.04 mm and 28.42 ± 0.02 mm, respectively for the four size classes.

For the second experiment, conducted in parallel with the first one and related to stocking density, growth performance and survival rates effects of the following densities have been evaluated: 200, 300, 400 and 500 specimens/m². Seeding was done on 1 day (05 January 2010) with seeds of size class of 24 mm. Each treatment (*i.e.* density) was triplicated and bags were randomly arranged. As indicated above, the density used in the first experiment corresponds to the low density tested in this experiment.

In both experiments, efforts were made to reduce as much as possible the size heterogeneity within groups in each tested size class, it has been attempted to reduce individual variability by grading animals at the beginning of the growth trial as recommended by Fréchette *et al* (2005) which allows to minimize statistical uncertainty in comparisons among treatments.

Sediment was passed through a 5 mm sieve before used in bags. All experimental bags of the two experiments were disposed online parallel to low tide and set in the substrate by side. Bags distribution is randomly arranged. Particular attention has been reserved to the cleanness of farming nets to ensure normal respiration and adequate alimentation of the clams.

After sowing and every month, a sample of 30 animals was taken randomly from each bag to determine growth relevant parameters. During biometric monitoring, shell length, width, height and total wet weight were measured individually on 90 specimens for each treatment. Weight were measured to the nearest 0.1 g using a digital balance and other parameters such as length were measured using a digital caliper to the nearest 0.01 mm. The weight is important because the clams are sold live by weight. Length along the longest axis is the parameter used to determine the price category. For estimate mortality rates, the whole clam populations were observed and were obtained by counting the dead animals in each sample. Dead animals are characterized by open and empty bivalve. This procedure was repeated successively by two independent persons to reduce the uncertainty of estimating mean survival rates.

### *Environmental parameters*

Throughout the experimental period, water temperature and dissolved oxygen were monitored daily. These parameters were measured twice daily (8.00 and 17.00 hours) using an oxythermometer (WTW ⁄ OXI96). Levels of pH (WTW 586 pH meter MP) and water salinity (WTW 320 salinity meter) were measured monthly.

In addition, seawater samples were analyzed in the laboratory for phytoplankton biomass. The letter was estimated by chlorophyll-*a* concentration according to the spectrophotometric method of Lorenzen (1967).

### *Data analysis*

Statistical comparisons of shell length were made using one-way analysis of variance (ANOVA). Mean differences among treatments were tested for significance ($p < 0.05$) using Duncan's multiple range test. The procedure used was GLM of the software STATISTICA 5.1 (Statsoft, Tulsa, USA). Values are expressed as mean ± error standard of means (ESM) of three replicates. The Bartlett test (Snedecor and Cochran, 1989) was applied to test the homogeneity of variances before comparing samples.

Specific growth rate SGR (%/day) was analyzed by analysis of covariance (ANCOVA) with initial size as a fixed factor and SGR as the covariate.

Data on survival rates were arcsin-transformed before statistical analysis. The level for statistical significance was set at 5%.

Specific growth rate was calculated according to the following equation (Malouf and Bricelj, 1989): SGR = 100 Ln ($Lt_2/Lt_1$)/ $t_2$-$t_1$ where $Lt_1$ and $Lt_2$ are the shell length at the beginning and end of elapsed time, respectively.

Survival rate (%) was calculated as 100 ($Nt_2/Nt_1$), where $Nt_2$ is the number of live clams removed after $t_2$ and $Nt_1$ is the number of live clams at previous whole sampling.

## RESULTS

### *Environmental parameters*

The mean seawater temperatures in Akarit Estuary from January 2010 to July 2012 are presented in figure 2. The values of this parameter are ranged between 10 °C (late December 2010) and 36°C (late August 2010).

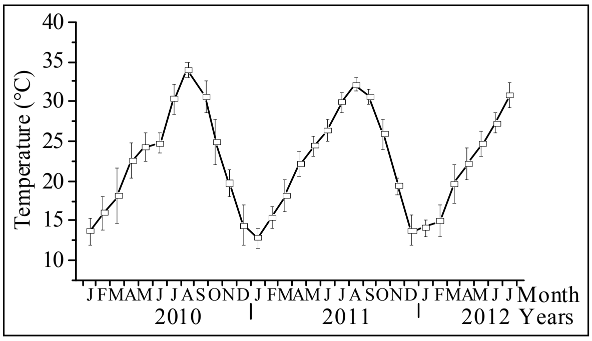


**Figure 2** Means (± DS) monthly seawater temperature at Akarit Estuary (gulf of Gabès, Tunisia) throughout the experimental period (*i.e.* January 2010 - July 2012).

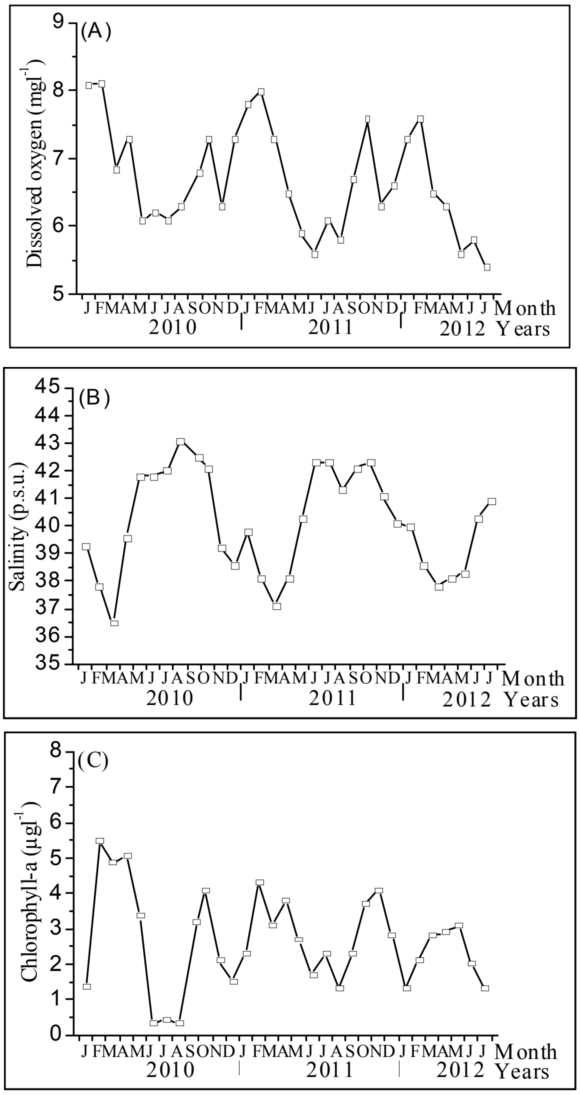


**Figure 3** Monthly variation of hydrological parameters: dissolved oxygen (A), salinity (B) and Chloropyhl-a (C) in Akarit Estuary (gulf of Gabès) during the experimental period (*i.e.* January 2010 - July 2012).

Temperature fluctuation shows always higher values in summer (> 30 °C) and lower values in winter and autumn (< 20 °C). Dissolved oxygen concentrations (Fig. 3) reached a maximum in February 2010 (8.1 mg $l^{-1}$) and minima in June 2012 (5.4 mg $l^{-1}$). Salinity values were recorded between 36 and 43 p.s.u.; the highest values were reported in summer months as indicated in figure 3.Chlorophyll-a concentrations are ranged between 0.32 and 5.48 µg $l^{-1}$; recorded respectively in February and Jun 2010 as indicated in figure 3.

### *Experiment I: The effect of initial size class*

### *Growth performance*

The increase in shell length of the four size classes of clam *R. decussatus* sowing in Akarit Esuary over 31 months is presented in Figure 4. For all treatments, the first phase is characterized by rapid growth, which maintained until June 2010. In this period, differences in sizes are maintained (P<0.05, ANCOVA). An increase of 5 mm was noted for the small size of 22 mm but the large class of 28 mm displayed relatively poor growth of 2 mm. The lengths of intermediate classes of 24 and 26 increase by 4 and 3.5 mm respectively. Then a relatively decrease of growth was observed until January 2011. So we note that shell lengths are similar among classes of 22 and 24 mm and among 26 and 28 mm which represent the second phase.

The third phase is characterized by significant better growth shell length until June 2011 but less important than June 2010 which is characterized by catch-up growth of small classes (22 and 24mm) than the larger ones (26 and 28 mm).

Indeed, all tested classes recorded similar sizes, *circa* 35 mm. By the end of study average shell lengths were 34.89, 35.04, 35.18 and 35.11 mm respectively for the populations starting with size classes of 22, 24, 26 and 28 mm. Statistical analysis shows no significant differences in shell length among groups at the end of the growth trial (P>0.05, ANCOVA, Table 1).

Overall, small clams grew faster than the large seed. At the start of the experiment, specific growth rate values are maximal for all tested classes, but steadily declined until late March 2010 (Fig. 5). Shell specific growth rates were 0.056, 0.042, 0.035 and 0.025 in the first months of rearing, respectively for size classes of 22, 24, 26 and 28 mm. Then a relatively decrease and settled period was observed where specific growth rate is minimal in winter; in second spring 2011, specific growth rates increase again but less important than the first year.

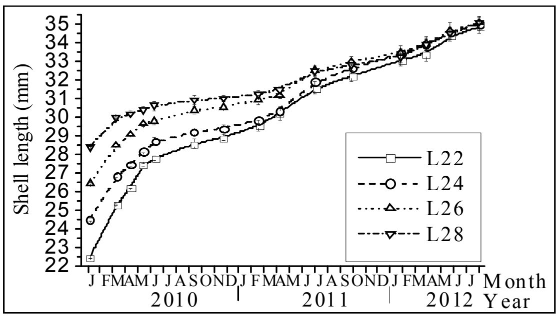


**Figure 4** Monthly increase of shell length (anterior-posterior axis) for the four size classes of cultured clam *R. decussatus* over 31 months in Akarit Estuary.

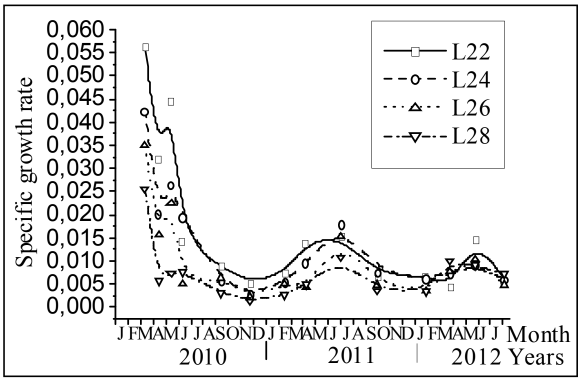


**Figure 5** Monthly specific growth rate for the four size classes of cultured clam *R. decussatus* over 31 months in Akarit Estuary.

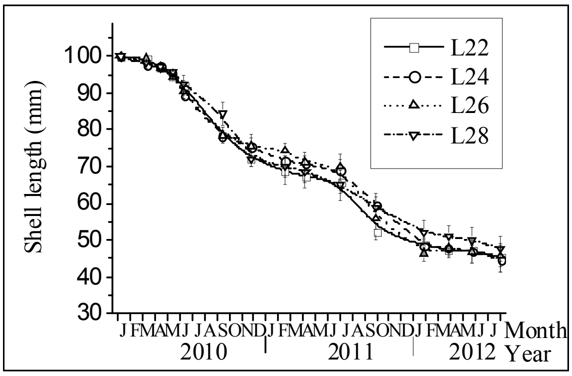


**Figure 6** Cumulative mortality for the four size classes of cultured clam *R. decussatus* over 31 months in Akarit Estuary.

### *Survival rate*

Survival rates over 31 months of rearing clams are presented in figure 6. At the end of the growth trial, survival rates were 45.33, 44.67, 46.00 and 48.33 %, respectively for the following size classes: 22, 24, 26 and 28 mm. There is no significant difference (P>0.05) among this values, which attest that initial size classes don't have any effects on final survival rates. Besides, mortality is higher in summer and autumn seasons.

### *Experiment II: The effect of initial stocking density*

The effects of stocking density (200, 300, 400 and 500 specimens per m²) on growth and survival rates of clams are presented in table 2.

At the end of the growth trial, results demonstrate that the mean length of clams reared at 200 and 300 specimen per m² was significantly larger (P<0.05) than those reared in the other densities. The same trend was also observed in the means wet weight. Indeed, clams grew an average of 11 mm over the duration of the experiment (an increase of 46 %), while clams reared at 400 and 500 specimens per m² grew an average of 8.5 mm (an increase of 35 %).

As indicated in table 2, survival rates were significantly dropped when clams reared at densities of 400 and 500 specimens per m², compared to other tested densities.

**Table 1** Mean shell length (±ESM), live wet weight at the beginning and at the end of the experiment and survival rate for the four size classes of cultured clam *R. decussatus*

| Date / shell class length | | L22 | L24 | L26 | L28 |
|---|---|---|---|---|---|
| Early January 2010 | Shell length (mm) | 22.47±0.03[a] | 24.54±0.05[b] | 26.48± 0.04[c] | 28.42±0.02[d] |
| | Live wet weight (g) | 2.49±0.02[a] | 3.19± 0.03[b] | 4.14±0.02[c] | 5.19±0.02[d] |
| Late July 2012 | Shell length (mm) | 34.89±0.39[a] | 35.04±0.31[a] | 35.18±0.36[a] | 35.11±0.33[a] |
| | Live wet weight (g) | 9.63±0.26[a] | 9.74±0.20[a] | 9.92±0.33[a] | 9.59±0.27[a] |
| | Survival rate (%) | 45.33±3.85[a] | 44.67±3.18[a] | 56.00±3.06[a] | 48.33±3.53[a] |

**Table 2** Mean shell length (±ESM), live wet weight at the beginning and the end of the experiment and survival rate of clams *R. decussatus* reared at different stocking densities.

| Date / rearing density | | D200 | D300 | D400 | D500 |
|---|---|---|---|---|---|
| Early January 2010 | Shell length (mm) | 24.54±0.05[a] | 24.67±0.03[a] | 24.51± 0.04[a] | 24.49±0.05[a] |
| | Live wet weight (g) | 3.19±0.03[a] | 3.21± 0.03[a] | 3.23±0.04[a] | 3.18±0.03[a] |
| Late July 2012 | Shell length (mm) | 35.04±0.31[a] | 35.31±0.38a | 33.23±0.43[b] | 32.39±0.37[b] |
| | Live wet weight (g) | 9.74±0.20[a] | 9.53±0.26[a] | 7.57±0.22[b] | 7.37±0.21[b] |
| | Survival rate (%) | 44.67±3.18[a] | 42.11±2.11[a] | 32.33±3.11[b] | 30.80±3.17[b] |
| | Yields (Kg/m$^2$) | 0.93±0.08 | 1.30±0.1 | 0.97±0.08 | 1.13±0.13 |

## DISCUSSION

Until now, Tunisian clams *Ruditapes decussatus* production has been based on fishery/harvesting from wild stocks exclusively from the gulf of Gabès. The present study is the first one to give some zootechnical parameters of its rearing in the intertidal zone, taking advantage of the tidal movement in akarit estuary.

As indicated above, initial seed sizes did not have a significant effect on clam growth and thus, clams of different initial size classes reached the legal commercial size (35 mm) in the same time. Global growth pattern remains similar among all classes in the second year of rearing and therefore small and medium classes caught up to large classes within 31 months. Thus, aquaculturists could use the small, medium or large seed to obtain legally marketable clams (35 mm) in a similar time. Therefore there is no advantage of selecting large size class to reduce the rearing period. This results is particularly important for aquaculturists to use all size classes of harvested clam, in which their sizes are blow the legal harvestable size. Besides, the rearing system used in the present study require low technology to the development of commercial aquaculture activity that could be transferred to fishermen. In fact, one of the priorities of the Tunisian five-year aquaculture development strategy is to give priority to the establishment of clam hatcheries. This allow us to use the hatchery-reared seed for on-growing in the gulf of Gabès as largely practiced in the Mediterranean regions. Also seeds can be used to enhance natural stock in some fishing areas where the natural density is low as the case of some zone in the north part of Gabès-gulf region (Sfax region in Tunisia) as reported by Derbali *et al.* (2016).

It is obvious that knowledge of growth performance and survival rates are necessary to suggest suitable sustainable management strategies of clam aquaculture. On the other terms, what is the time necessary for the seed to achieve the legal commercial sizes ? what is the gain in stock mass and what are the mortality losses? In fact, efficient operation of an aquaculture business requires forecasting product availability for a legal commercial in terms of stock growth and survival (Cigarría and Fernández, 2000). Environmental specificities of each area require local determination of theses parameters.

Especially because studies on growth and production in bivalve mollusks have identified different degrees of variability at spatial and temporal scales (Urrutia *et al*, 1999). The close relationship of growth rates and season have been well described (Melià *et al*, 2004; Urrutia *et al*, 1999; Lucrezia *et al*, 2011) with a peak of higher growth and periods which characterized by decreases of growth performance.

The evolutionary trend of *R. decussatus* shell growth for the four size classes was similar throughout the experimental period. The annual growth pattern is recorded, with relatively fast growth between January and June followed by a period of slow growth between July and December. This pattern have been explained in terms of seasonal changes of the environmental conditions, particularly water temperature and food availability. These factors are well reported in many studies (Puigcerver, 1996; Urrutia *et al*, 1999; Soudant *et al*, 2004).

As indicated in figure 5, which represent the dynamic variation of the specific growth rates, fast growth occurred simultaneously in all size groups from January to June, every year and decreases from June to November. This trend is apparently marked by season variations, and generally, each season characterizes the aquatic ecosystem by specific water temperature and food availability which in turn affect it's productivity. In Akarit zone (study area), the average water temperature reaches its peak during the summer season; and continues to decline till it reaches its minimum in December, January and February which correspond to the cold season.

As confirmed in our results, clam growth is dependent on temperature and food availability. Growth performance dropped in summer, may be due to negative effects of the temperature as explained by Urrutia *et al* (1999) who indicated that 50 % of the annual clam growth in an estuary in Spain occurred in the spring whereas growth dropped in summer. This is may be to negative effects on temperature, causing physiological stress (Shpigel and Fridman, 1990). This corroborate with our results, where greater growth was obtained in the spring, while clam growth was lower in the winter; due to lower water temperature and poor nutrition. Puigcerver (1996) and Soudant *et al* (2004) also reported continuous but slower growth in clam during the cold season. Serdar and Lok (2007) demonstrate that growth of *R.*

*decussatus* in Sufa Lagoon is better from April to October than from October to April and concluded that the spring season is more suitable for planting clam seed. At this time, clams benefit from faster growth and more suitable environmental conditions such as water temperature and food availability. However, the summer months are the period when there were more losses.

The potential effects of environmental conditions are also elucidated by Jurié *et al* (2012) when the growth assessment was determined from internal growth bands in the Pag-Bay-eastern Adriatic Sea. They demonstrate that growth lines are formed in February indicating that slowest growth corresponded with low sea temperature, indicating that reduced growth occurs mostly in winter months due to adverse environmental conditions; particularly declining of water temperature and lack of food. According to Walne (1976), growth trial conducted in the UK demonstrated that *R. decussatus* is very sensitive to decreases of water temperature (from 20 to 10 °C). In this situation, clams loss their filtration capacity by more than 45 %. When water temperature increases from 20 °C to 27 and 32 °C, the filtration rates reduced to 16 and 35 %, respectively (Walne, 1976). Therefore it appears that the optimum temperature for *R. decussatus* is *circa* 20 °C as its physiological performance is poorer when departed from 20°C. At the start of the experiment (three first months) low mortality was observed in all size classes. However, significant mortality was detected in summer season; this could be probably a result of desiccation due to high summer temperatures. In fact, as indicated in figure 2 during months of Jun, July, August, September and October, sea water temperatures are 25-36 °C which can affect physiological status of clams. In summer and during the ebb tides, water temperature can rise abnormal extreme value particularly in shallower zones (for example 36 °C in August 2010; Fig. 2).

The comparatively low growth performance of the clams reared in Akarit area can be attributed to the poor feeding conditions. In fact, these clams are daily exposed to the air for long periods of time; due to its high intertidal position. As demonstrated by Widdows and Shick (1985), air exposure may significantly affect growth in filter feeders. For *R. decussatus*, Breber (1996) and Vincenzi *et al* (2006) reported that very shallow water impair its growth by exposing them directly to air during low tide. Generally, animals living in the intertidal zone are exposed not only to seasonal fluctuations but also short-term daily variations of temperature (*i.e.* 10-25 °C) and are unable to maintain their feeding and respiratory rates relatively independent of these fluctuations in environmental temperature (Bayne *et al*, 1976). Intertidal bivalves also have to cope with hypoxia and the cessation of feeding during emersion periods and these are also likely to be reflected in long-term changes of metabolic response to temperature (Newell and Bayne, 1980). Median lethal times (LT 50%) were circa 48 h and 10 h at 28 and 35 °C, respectively. A common range temperature for Akarit waters during summer season (Fig. 2). Temperatures above 28 °C can therefore significantly decrease clams resistance to air exposure, cause significant physiological stress and affect growth performance. Indeed, as reported by Worrall and Widdows (1984) at relatively higher temperature, when exposed to air, clams valve gaping was observed. This induces the activation of aerobic metabolic pathways and thus the mobilization of energy reserves, desiccation and consequently losses by mortality.

Also, since at the end of the growth trial clams of all size classes reach the same size, small individual grew faster than larger ones. This size-dependent effect on growth is well documented in aquatic organisms (*e.g.* Azaza *et al*, 2010). This assumption suggests that individuals of different sizes displayed variable growth performance independent of environmental conditions. On the other hand, another physiological status can affect and modulate growth performance related to the size /age. For example, the shell growth profile of juvenile *versus* reproductively adult is influenced by the reproductive condition and metabolic level (Worrall and widows, 1984). Indeed, the growth and survival, generally reflect the synergistic effects of several environmental factors acting on various physiological processes such as reproductive status. In the study area of the present study, the population of *R. decussatus* reach its first sexual maturity at 24.37 mm (Derbali *et al*, 2016) which correspond of the first months of the start of the experiment. Also as demonstrated by Hamida (2004) spawning events for this species occurred irregularly from June to December in the gulf of Gabes.

As well demonstrated in earlier studies (see e.g. Ojea *et al*, 2004; Serdar and Lök, 2009; Matias *et al*, 2013) physiological reproductive status mobilize energy reserve for reproductive activity at the expense of somatic growth and thus can contribute to reducing growth efficiency and in some cases whole body composition such as proteins and lipids

Beyond environmental conditions discussed above, results demonstrate a significant effect of stocking density on growth and survivorship. Obviously, the general trend is identified between rearing efficiency (*i.e.* growth performances and survival rates) and crowding, in the aquatic organism. In fact, in the Akarit estuary, stocking density of clams above 300 specimens per $m^2$, reduce significantly their rearing performances. In our experimental conditions, results demonstrate that intermediate densities appear to provide best growth performance. However, yields increase when increasing seeding densities, since there is no effect of stocking density on survival rates for the first three stocking densities.

When growth performance of clams is affected by high-density conditions, one explanation is a combined effect of less food per individual (share of the meal) and stress from physical contact with neighbors (Hadley and Manzi, 1984); this increases the possibility of shell injury expenditure of energy to repair this damage (see *e.g.* Taylor *et al*, 1997). Same results were observed by Chávez-Villalba *et al* (2010). The letter authors showed that cultivated oysters *Crassostrea gigas* were sensitive to overstocking, since growth at high densities was less than at low densities. The negative correlation of survival and density was identified by Melià *et al* (2004) in clam *Ruditapes philippinarum* of Eo estuary in Spain using stochastic demographic model.

Besides physical environmental conditions, clam production is likely to be affected by a wide variety of predators and their potential impact vary depending on location and season

(Munroe *et al*, 2015). The impact of this factor is avoided in our study; because care is taken when using hard plastic mesh net bag as recommended by Serdar *et al* (2007) to protect clams from potential predators.

In conclusion, the present work shows that growth of *R. decussatus* in Akarit estuary is better from February to Jun (spring season) than from July to October (summer season). Thus, the spring season is more suitable for planting clam seeds; since Spring planting benefit from faster growth and more suitable environmental conditions, particularly water temperature and food availability. On the other hand, owing to that clams of different initial size classes reached the legal commercial size (35 mm) in the same time, aquaculturists can use all size classes of harvested clam, in which their sizes are blow the legal harvestable size, for ongrowing. For better efficiency of this operation, in terms of growth and survival rates, stocking density do not exceed 300 clams per m².

Further research is needed to characterize the effects of others parameters under local conditions such as culture system and planting season on the clam growth. These factors act synergistically and intricately on some physiological parameters *e.g.* health status, physiological stress, oxidative stress, whole body composition, growth performance, reproduction, and survivorship. Assessment simultaneously combined factors could give some realistic insight on the zootechnical performance of ongrowing clams in order to develop a bioeconomic model with scientific rigor to be useful as a tool to estimate yields and profits associated with different rearing scenarii.

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## References

Azaza, M.S., Legendre, M., Kraiem, M.M., and Baras, E. (2010): Size dependent effects of daily thermal fluctuations on the growth and size heterogeneity of Nile tilapia *Oreochromis niloticus*. *J. fish. Biol*., 76: 669-683.

Bayne, B.L., Thompson R.J. and Widdows J. (1976): 1. Physiology. In: Bayne, B.L. (ed.), Marine Mussels: Their Ecology and Physiology. Camb. Univ. Press, Cambridge, pp 121-206.

Breber, P. (1996): L'allevamento della vongola verace in Italia. Cleup, Padova, 157 pp.

Chávez-Villalba, J., Arreola-Lizárraga, A., Burrola-Sánchez, S. and Hoyos-Chairez, F. (2010): Growth, condition, and survival of the Pacific oyster *Crassostrea gigas* cultivated within and outside a subtropical lagoon. Aquaculture, 300: 128-136.

Cigarría, J. and Fernández, J.M. (2000): Management of Manila clam beds I. Influence of seed size, type of substratum and protection on initial mortality. Aquaculture, 182: 173-182.

Derbali, A., Hadj Taieb, A., Kammoun, W., Gouirah, J., Wannes-Ghorbal, A., Zamouri-Langar, N., Ghorbel, M. and Jarboui, O. (2016): Stock assessment, spatial distribution and biological parameters of the clam *Venerupis decussate* along the Sfax coasts (Tunisia, Central Mediterranean). *J. Mar. Biol. Assoc*. U.K, 96 (1): 177-184.

DGPA (2014). Direction Générale de la Pêche et de l'Aquaculture de la Tunisie, les statistiques de la pêche et de l'aquaculture de l'année 2014. 113 pp.

FAO, 2016. Global dataset, FishStatJ 2.1.1. Universal software for fishery statistical tile series, FAO, Roma Italy. http://www.fao.org/fishery/statistics/software/fishstatj/en. (accessed March 15, 2016).

Fréchette, M., Alunno-Bruscia, M., Dumais, J.F., Sirois, R. and Daigle G. (2005): Incompleteness and statistical uncertainty in completion/stocking experiments. Aquaculture, 246: 209-225.

Grant, J. (1996): The relationship of bioenergetics and the environmental to the field growth of culture bivalves. *J. Exp. Mar. Biol. Ecol*., 200: 239-256.

Gribben, P.E., Creese, R.G. and Hooker, S.H. (2002). Growth rates of the venus clam *Ruditapes largillierti* grown under experimental culture conditions in New Zealand. Aquaculture, 213 :187-197.

Hadley, N.H. and Manzi, J.J. (1984): Growth of seed clams, *Mercenaria mercenaria*, at various densities in a commercial scale nursery system. Aquaculture, 36: 369-378.

Hamida, L. (2004): Reproduction de la palourde *Ruditapes decussatus*, en milieu naturel (sud Tunisie) et en milieu contrôlé (écloserie expérimentale): relation avec le système immunitaire. Thesis. Université de Bretagne Occidentale. 198 p.

Harbo, R., Farlinger, S., Hobbs, K. and Thomas, G. (1992): A review of quota management in the geoduck clam fishery in British Columbia, 1976 to 1990, and quota options for the 1991 fishery. Can. Manuscr. Rep. Fish. Aquat. Sci., 2178, 135.

Jurié, I., Bušelić, I., Ezgeta-Balić, D., Vrgoč, N., Peharda, M. (2012): Age, Growth and Condition Index of Venerupis decussata (Linnaeus, 1758) in the Eastern Adriatic Sea. Turkish *J. Fish. Aquat*. Sic., 12: 613-618.

Lorenzen, C.J. (1967). Determination of chlorophyll and pheopigments: Spectrophotometric equations, Limnol. Oceanography, 12: 343-346.

Lucrezia, C., Scirocco, T., Specchiulli, A., Florio, M.F. and Breber, P. (2011). Bioindicators for siting the carpet clam Tapes decussatus L. farming in Mediterranean lagoons. Int. J. Fish. Aquac., 3 (3): 54-64.

Malouf, R.E. and Bricelj, V.M. (1989): Comparative biology of clams: environmental tolerance, feeding, and growth. In: Manzi, J.J., Castagna, M. (Eds.), Clam Mariculture in North America. Elsevier, Amsterdam: pp 23-73.

Matias, D., Joaquim, S., Leitao, A. and Massapina, C. (2009): Effect of geographic origin, temperature and timing of broodstock collection on conditioning, spawning success and larval viability of *Ruditapes decussatus* (Linné, 1758). Aquac. Int., 17: 257-271.

Matias, D., Joaquim, S., Matias, A.M., Moura, P., Teixeira De Sousa, J., Sobral, P. and Leitão, A. (2013): The reproductive cycle of the European clam *Ruditapes decussatus* (L., 1758) in two Portuguese populations:

Implications for management and aquaculture programs. Aquaculture, 406: 52-61.

Melià, P., De Leo, G.A. and Gatto, M. (2004): Density and temperature depending of vital rates in the Manila clam *Tapes philippinarum*: A stochastic demographic model. Mar. Ecol. Prog. Ser., 272: 153-164.

Munroe, M., Kraeuter, J., Brian Beal, B., Chew, K., Luckenbach, M. and Peterson, C.P. (2015): Clam predator protection is effective and necessary for food production. Mar. Pollut. Bull., 100: 47-52.

Newell, R.I.E. and Bayne, B.L. (1980): Seasonal changes in the physiology, reproductive condition and carbohydrate content of the cockle Cardium (Cerastoderma) edule (Bivalvia: Cardiidae). Mar. Biol., 56: 11-19.

Ojea, J., Pazos, A.J., Martinez, D., Novoa, S., Sanchez, J.L. and Abad, M. (2004): Seasonal variation in weight and biochemical composition of the tissues of *Ruditapes decussatus* in relation to the gametogenic cycle. Aquaculture, 238 (1-4): 451-468.

Puigcerver, M. (1996): Analysis on individual growth of juvenile carpet shell clams, *Tapes decussatus* (L.), in three different rearing conditions employed in the Ebro's Delta, Spain. Aquacult. Res., 27: 399-404.

Serdar, S. and Lok, A. (2007): Impact of Planting Season on Growth and Survival of the Carpet Shell Clam *(Tapes decussatus*, Linnaeus 1758). ISR *J. Aquacult-Bamid*., 59(1): 42-46.

Serdar, S., and Lök, A. (2009): Gametogenic cycle and biochemical composition of the transplanted carpet shell clam *Tapes decussat*us, Linnaeus 1758 in Sufa (Homa) Lagoon, Izmir, Turkey. Aquaculture, 293: 81-88.

Serdar, S., Lök, A., Kose, A., Köse, A., Yildiz, H., Acarli, S. and Goulletquer, F. (2007): Growth and survival rates of carpet shell clam (*Tapes decussatus* Linnaeus, 1758) using various culture methods in Sufa (Homa) Lagoon, Izmir, Turkey. Aquacult. Eng., 37: 89-99.

Shpigel, M. and Fridman, R. (1990): Propagation of Manila clam (*Tapes semidecussatus*) in the effluent of fish aquaculture ponds in Eilat, Israel. Aquaculture, 90: 113-122.

Snedecor, G.W. and Cochram, G.W. (1989): Statistical Methods. Iowa State University Press, Ames, USA, 503 pp.

Solidoro, C., Melaku Canu, D. and Rossi, R. (2003): Ecological and economic considerations on fishing and rearing of *Tapes philippinarum* in the lagoon of Venice. Ecol. Model., 170: 303-318.

Soudant, P., Paillard, C., Choquet, G., Lambert, C., Reid, H.I., Marhic, A., Donaghy, L. and Birkbech, T.H. (2004): Impact of season and rearing site on the physiological and immunological parameters of Manila clam *Venerupis* (*Tapes Ruditapes*) *philippinarum*. Aquaculture, 229: 401-418.

Taylor, J.J., Rose, R.A., Southgate, P.C. and Taylor, C.E. (1997): Effects of stocking density on growth and survival of early juvenile silver-lip pearl oysters, *Pinctada maxima* (Jameson), held in suspended nursery culture. Aquaculture, 153: 41-49.

Urrutia, M.B., Ibrarro, I., Iglesias, J.I.P. and Navarro, E. (1999): Energetics of growth and reproduction in high-tidal population of the clam *Ruditapes decussatus* from Urdaibai Estuary (Basque Country, N. Spain). *J. Sea. Res*., 42: 35-48.

Vincenzi, S. Caramori, G. Rossi, R. and De Leo, G.A. (2006): A GIS based habitat suitability model for commercial yield estimation of *Tapes philipinarum* in a Mediterranean coastal lagoon (Sacco di Goro, Italy). Ecol. Model., 193: 90-104.

Walne, P.R. (1976): Experiments on the culture in the sea of the butterfish *Venerupsis decussate* L. Aquaculture, 8: 371-381.

Widdows, J. and Shick, M. (1985): Physiological responses of *Mytilus edulis* and *Cardium edule* to aerial exposure. Mar. Biol., 85: 217-232.

Worrall, C. M. and Widdows, J. (1984). Investigation of factors influencing mortality in *Mytilus edulis* L. Mar. Biol. Lett., 5: 85-97.

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