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Morphometric and length-weight relationships of the mussel *Perna perna* from the mamelles coast, Dakar, Senegal

Abdoulaye Diouf, Jean Fall, Abdoulaye Loum, Alioune Faye, Masse Diago and Malick Diouf

Abstract
This study focused on relationships between length-weights (length-total weight), sex ratio, size distribution, and the condition index of *Perna perna*. The length-weight relationship for the whole population of *P. perna* showed regression coefficients b=2.4467 an intercept with Y-axis, "a' = 0.2565, and R^2 = 0.871. The allometric coefficient of the specimens sampled in this study is b<3, implying the negative allometry shown by the tested specimens. The present study showed that the size of *P. perna* varied between 4-13 cm. The most common harvest size was between 7-10 cm. In *P. perna*, the gonads enter two distinct maturation periods, a very brief maturation phase from december to reach the maximum value of 36.36 in March. The second phase of laying begins in September, with an increase from 29.12 to 28.25 of the condition index (CI), which lasts 3 months, from December to February. Regarding the sex ratio, it is favorable to males for 9 months out of 12, against 3 months for females (February, March and November). Regarding the size of individuals, the sex ratio is in favor of females for individuals of large size, from 11 cm.

Keywords: Morphometric and length-weight, *Perna perna Dakar, Senegal*

1. Introduction
Bivalves play a vital role in the ecosystem equilibrium and constitute an essential member of the nearshore biota, contributing significant part in the food chain and the modification of sea bottom nature at their occurrence [1].
Scattered studies on distribution, ecology, the interaction between adults and recruitments, age structure, as well as reproduction in addition to length-weight relationships for *Perna perna* were treated in few articles in Senegal [2].
These are characteristic species of sublittoral zones where they often constitute dense populations on rocky substrata. Based on studies from Senegal, regular Mussel fishery is from May to July from the mussel beds in submerged or partially submerged rocks in the nearshore waters within a coastal stretch. The major mussel-fishing center is the peninsula of Cape Verde and Saloum Island. There are few studies conducted on the fishery, biology, and aquaculture potential of mussels from Senegal. *P. perna* is widely distributed in the Senegalese coastal regions from the peninsula of Cape Verde to Saloum Islands.
Studying on biometry of commercial species is essential because documentation of the fishery depends mainly on the field identification of the species. Stock characteristics, including the growth pattern, heavy metal content, and biochemical composition of the species from the habitat has to be monitored to maintain the fishery [2].
The specie *P. perna* is widely distributed in the world since, it is found on the East and West coasts of the tropical and subtropical Atlantic: Mauritania, Senegal, Congo, Angola, South America (Antilles, Guyana and Brazil) and on the shores of the Mediterranean (North African coasts: Tunisia, Morocco and Algeria) [3].
Growth is defined as the measure of the increase in height and weight of an individual, as a function of time and environmental variables. In a given population of mussels, the weight dynamics are closely linked to the reproductive activity of individuals; it is disturbed in bivalves by reproductive processes.
The government of Senegal has given high priority for the sustainable management of the wild

population and the possible development of mussel farming techniques to create income opportunities among the impoverished fishers and farmers. Therefore, an understanding of the reproductive biology of *P. perna* is an indispensable aspect of developing sustainable farming techniques and providing plausible scientific advice for the management of this valuable resource.

Senegalese waters, generally reputed to be very rich in fishery products, are becoming increasingly impoverished. Regarding this situation, aquaculture constitutes a palliative element. But whatever the origin of the products (fishing or aquaculture), the diversification of markets and the development of resources are becoming increasingly essential to boost exports.

Admittedly, Senegal has been approved for the export of fishery products since 1996, by decision n ° 96/355 / EEC of May 30, 1996, modified by decision n°2006/766 of 06 November 2006. Still, this approval does not cover bivalve mollusks. This constitutes a considerable shortfall, given the trend in exports, 18.35% of the volume of which (EU share in exports in 2018) corresponds to more than 43.89% of the total commercial value [4].

Faced with such situations, should Senegal always be satisfied with its approval for the export of fishery products other than bivalve mollusks, yet very appreciated by European tourists staying on its territory?

Even if the sub-sector occupies a predominant place in the contribution of the fishing sector to the national economy, the reduction of unemployment, especially for the ladies, the protein intake, and the aspects linked to biology (reproduction and growth) remain unknown.

Fishing is an essential pillar of the Senegalese economy because of the importance it plays at the economic, social and food levels, as evidenced by the following indicators: the first post of exportation, 2.3% of national GDP, 12.5% of GDP in the primary sector, 17% of the working population and more than 75% of the population's animal protein needs.

Senegal, behind Morocco, is the second country in Africa to be approved for the export of fishery products to the European Union. However, this authorization does not apply to all fishery products originating in Senegal. Indeed, live bivalve mollusks, because of their mode of food (filter feeder), constitute a potential danger for consumers, because they accumulate all the toxins filtered during their feeding.

Mussels are considered sentinel species and are used as biological indicators of anthropized ecosystems. They are used as biological indicators in biomonitoring programs to measure the degree of environmental pollution. Studies have shown that these species, if not treated well, lead to frequent and severe intoxications, in particular, PSP "Paralytic Shell Fish Poison," DSP "Diarrheic Shell Fish Poisoning", and ASP, "Amnesic Shell Fish Poison". This means that the EU, as a precaution and in the interests of consumer protection, requires all States wishing to export bivalve and gastropod mollusks to provide all the necessary guarantees that their production or collection sites are not polluted. Also, they should give information that an effective system of detoxification of the harvested products is in place.

Another no less important aspect is the study of the sustainability of the activity, especially in a context marked by the effects of climate change on aquatic flora and fauna. Such a study necessarily involves preliminary studies, in particular the study of the biology, growth and reproduction of these species. This is the context for this study, which focuses on the morphometric parameters of the Mussel (*P. perna*) of the Cape Verde peninsula, more precisely in the Mamelles area of Dakar.

The main objective of this study is to provide comprehensive knowledge about the biometrics (body size, gender) and ecological (surrounding water quality parameters and feeding behavior) of *Perna perna* collected from the Mamelles coast of Dakar, Senegal.

Specific objectives

- OS1: evaluate the abiotic parameters of the mussel's living environment (temperature, salinity);
- OS2: determine growth parameters (relation length-total weight and size-frequency distribution) ;
- OS3: determine the sex ratio;
- OS4: determine the condition index.

Materials and methods

Methods

Sampling Strategies

The Mamelles site (Figure 1) in the Cap Verde peninsula was selected for the study, which took place over 12 months (from March 2018 to February 2019). This ocean area is marked by a rocky bottom, which also serves as a fixation point for mussels.

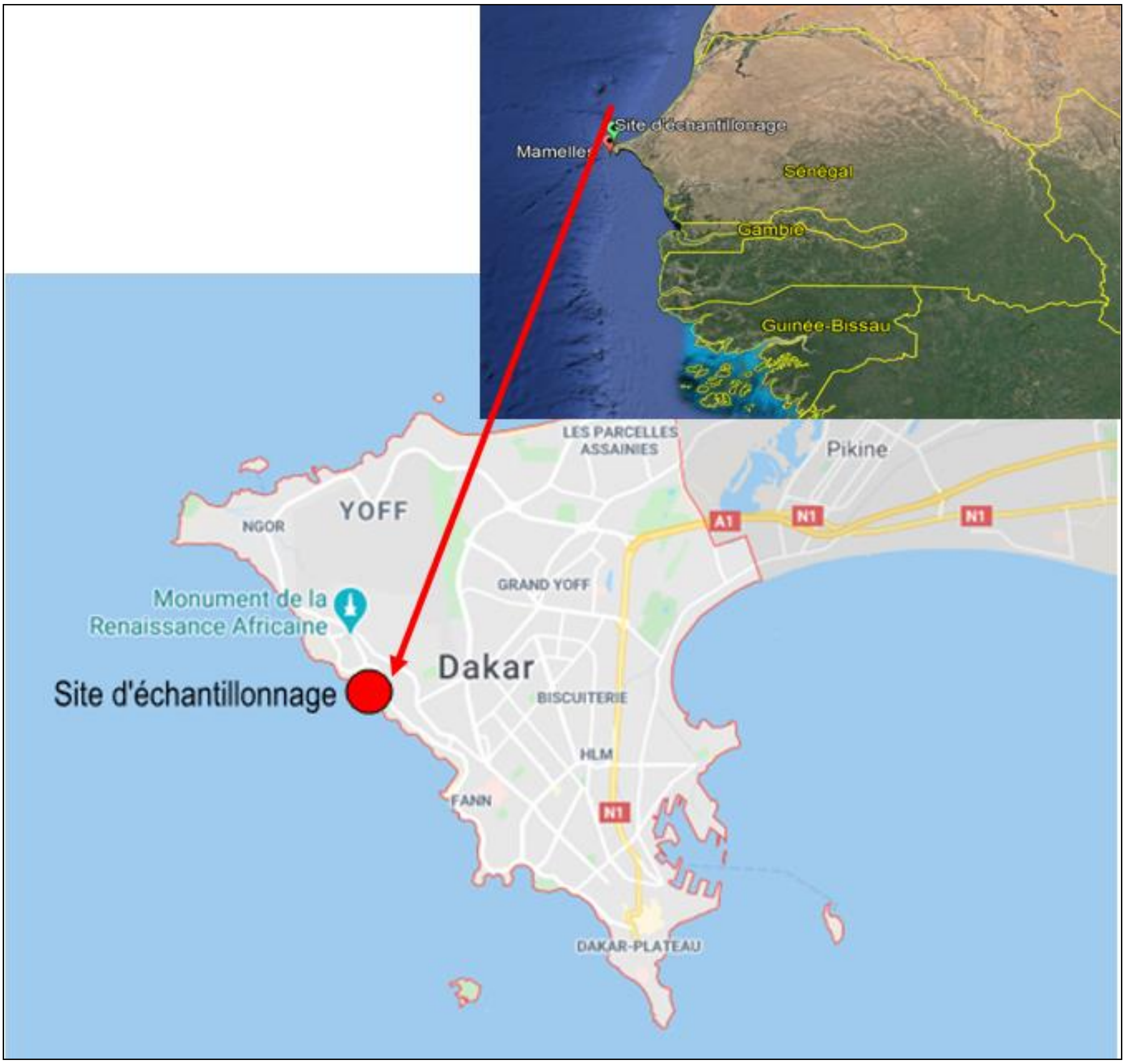

Fig 1: Sampling site

Each month, around fifty mussels (*Perna perna* Linne, 1758) were harvested by hand from the rocks by the local fishermen using diving equipment. The mussels were kept in seawater and transported to the laboratory in coolers. From these monthly collected samples of mussels, about 30 mussels were selected to identify the sex and to proceed biometric measurements.

Biometric measurements

For this purpose, a total of 600 mussels were collected from Mamelles, in which 30 mussels were used for each month. Biometric measurements such as length (maximum length along the anterior-posterior axis) of each individual were measured using a Vernier caliper with an accuracy of 0.01 mm. The total weight of each individual was recorded after draining the intervalval (or mantle) fluid to the nearest 0.1 g using an electronic balance. Both the male and female were dissected, and the meat was gently removed and weighed at 0.01 mg using the electronic balance. The sex of the individuals was determined by observing the coloration of the gonads. Females have a bright pinkish color, while in males, the gonads are whitish. As for immature individuals, this coloration is neither white nor pink.

Morphometric formulas

Allometry was examined (Pauly, 1983) for length-weight (length–total weight) relationships. The morphometric relationship was estimated using the linear equation Y = a+bX, where Y= body weight in mg, X = shell length in mm, a = constant and equal to the intercept of the straight line with Y-axis; b = the coefficient of allometry.

The allometric length-weight relationship $W = aL^b1$ was calculated, where a and b are constants. The correlation coefficient (r) was estimated for the relationships.

The condition index gives us an idea of the physiological state of individuals in a population ([5], [6]; [7]) and allows us to estimate the share of organic matter emitted during reproduction [5]. According to Pellerin – Massicotte [8], it is also a general indicator of stress and the health of organisms. The condition index (CI) chosen for this study is that proposed by Pellerin-Massicotte *et al.* [8]; it will allow us to follow the stages of gametogenesis and the periods of gamete emissions; the calculation of the flesh condition index was calculated as follows:

Condition Index = (Soft mass weight/ Total wet weight) x 100

Water quality assessments

For ecological factors analyses, two water quality parameters (collected from the same location of mussel collection sites) were recorded monthly to investigate how these factors are related to the growth and sex of *P. perna.* A multifunction environmental sensor (PCE-PHD1 brand.) was used to measure in situ the temperature (◦C), and a Refractometer-Salinometer was used to measure salinity (ppt).

Results and discussion

Results

Environmental parameters

The results of the present study showed two distinct periods: low temperature from November to May (temperature between 15 and 20°C) and a period of high heat from June to October (temperature in which revolves around 24 and 28°C). The water temperature varied from 15.4 to 28.7 ° C, with an average of 22.16 °C. Temperature increases were observed from May with maximums equal to 28.7°C during the winter period (August, September and October) **(**Figure 2).

The salinity, from January to May, was around 38 ‰ and a period of high salinity from June to December (41 ‰) was observed. During the rainy season, there is a slight decrease in salinity. The salinity varied from 38 to 41 ‰ during the experiment, with average of 39.58 ‰. Salinity increased at the end of the cold season (May) and reached a maximum in June and July (41 ‰), then decreases consecutively to the continental contributions of runoff water (Figure 2).

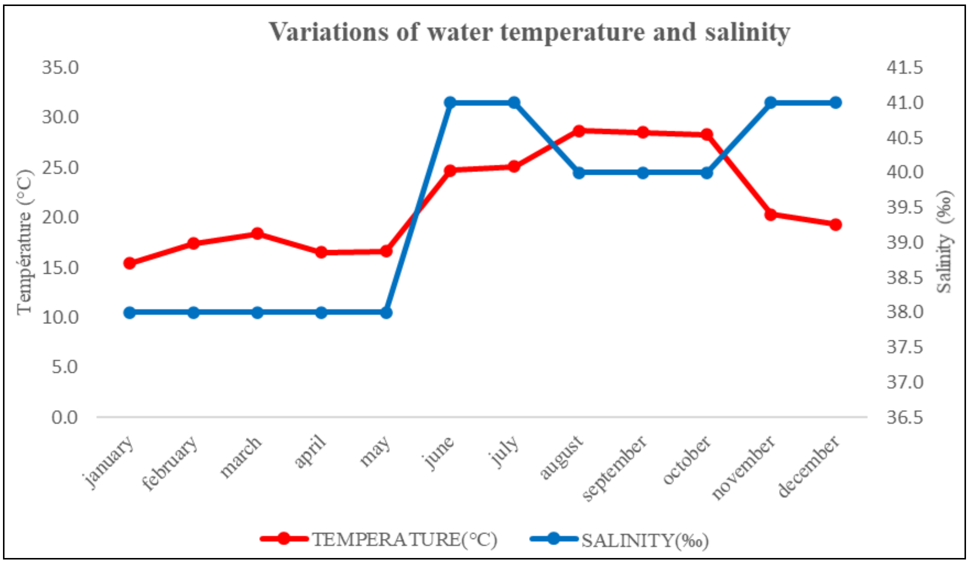

Fig 2: Variations of water temperature and salinity

Sex ratio

Regarding the sex ratio, it was favorable for males for 9 months out of 12, against 3 months for females (February, March and November) (Figure 3). Relative to the size of individuals, the sex ratio was in favor of females for individuals of large size, from 11 cm (Figure 4).

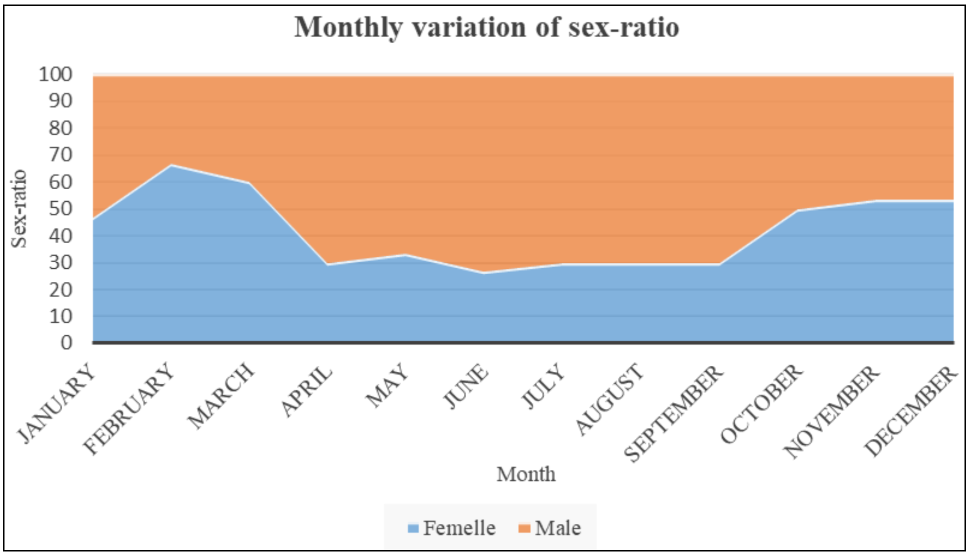

Fig 3: Monthly variation of sex ratio

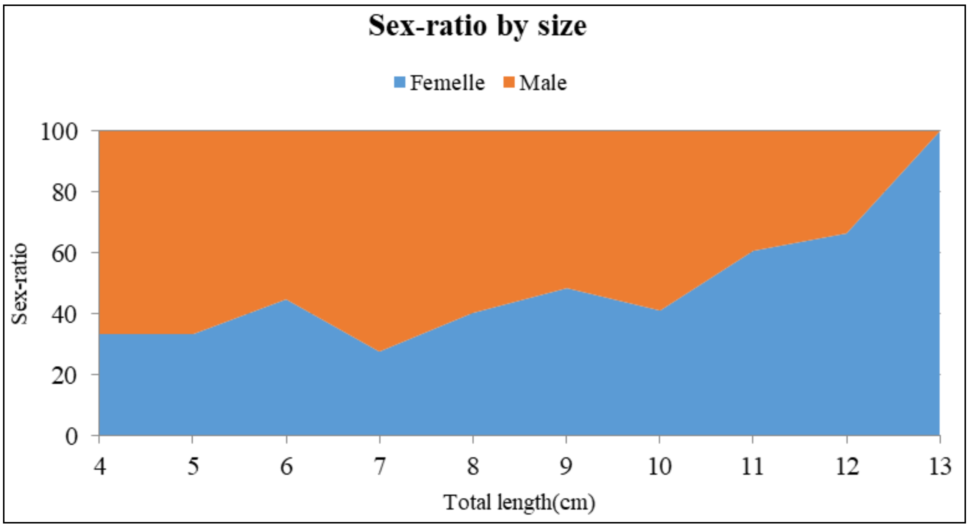

Fig 4: Variation of sex ratio by size

Condition index

In mussels, the gonads entered a very brief maturation phase from December (the condition index (CI) goes from 29.82 in February to reach the maximum value of 36.36 in March). The following egg-laying phase lasted from April to May (CI going from 30.05 to 28.23); the latter was followed by the second phase of maturation of the gonads, which extended from June to August. The second phase of laying began in September (CI increases from 29.12 to 28.25) and covered the period from December to February (Figure 5).

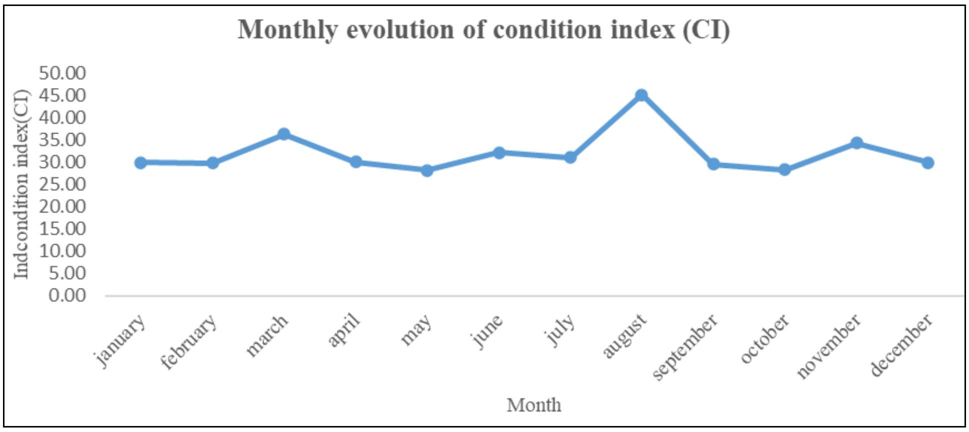

Fig 5: Monthly variation of the condition index

Length-weight relationships

The size-weight relationship is represented by the formula: W = 0.2565 * $L^{2.4467}$ with an R^2 = 0.871.

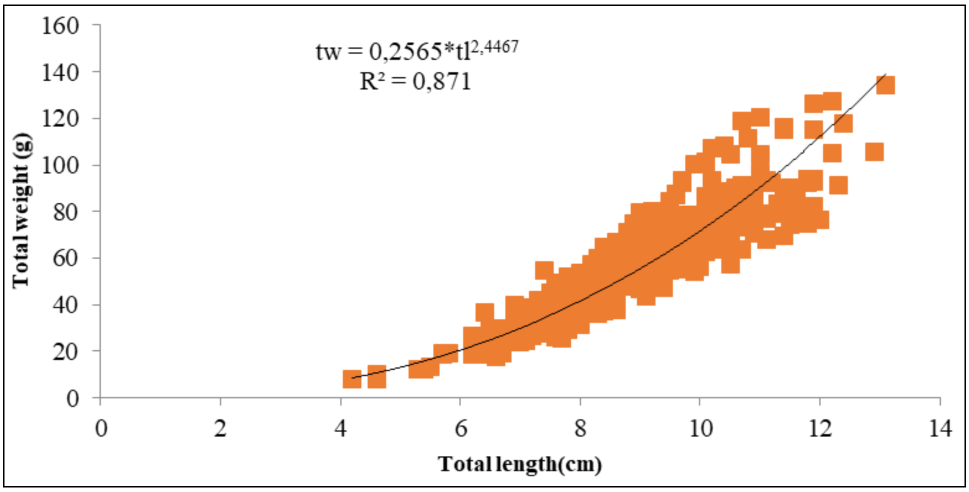

Fig 6: Length-weight relationships

The length-weight relationships of *Perna perna* are presented in Figure 6. The length-weight relationship for the whole population of *P. perna* showed regression coefficients b=2.4467 an intercept with Y-axis, “a’ = 0.2565. The allometric coefficient of the specimens sampled in this study was less than b=3, implying the negative allometry of the sampled specimens.

Size distribution

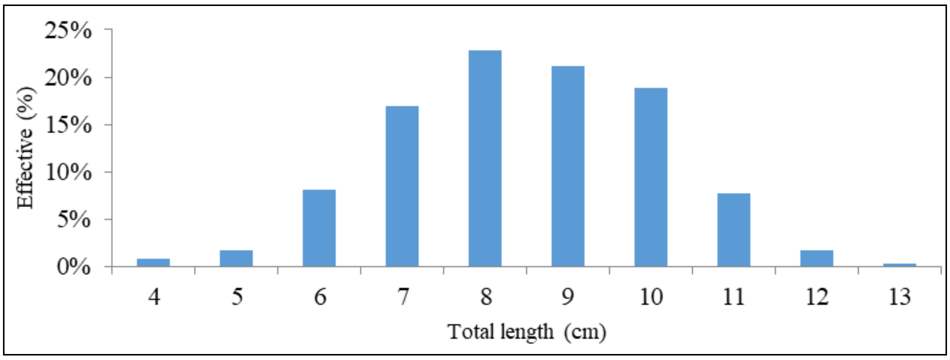

Fig 7: Size distribution

The present study showed that the size of *Perna perna* varied between 4-13 cm. The most common harvest size was between 7-10 cm (Figure 7).

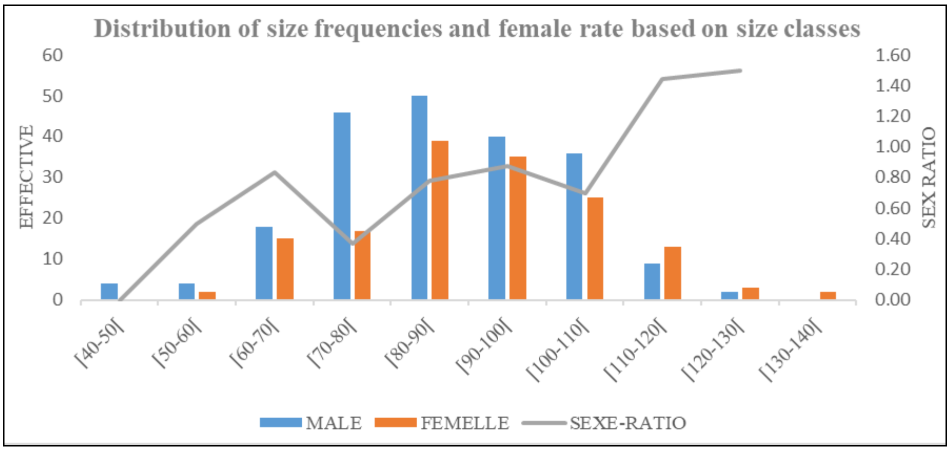

Fig 8: Distribution of size frequencies and female rate based on size classes

The collected individuals showed sizes varying from 40 to 140 mm. The lowest numbers (less than 10 specimens) were recorded in the size classes below 60 mm and above 120 mm for females. Individuals with a size between 60 and 120 mm represented the largest of the population of collected mussels (Figure 8). Concerning the sex ratio of the collected individuals, there was a clear predominance of males in the size classes ranging from 40 to 110 mm. Female individuals showed a slight predominance only in the size classes between 110 and 140 mm (Figure 8).

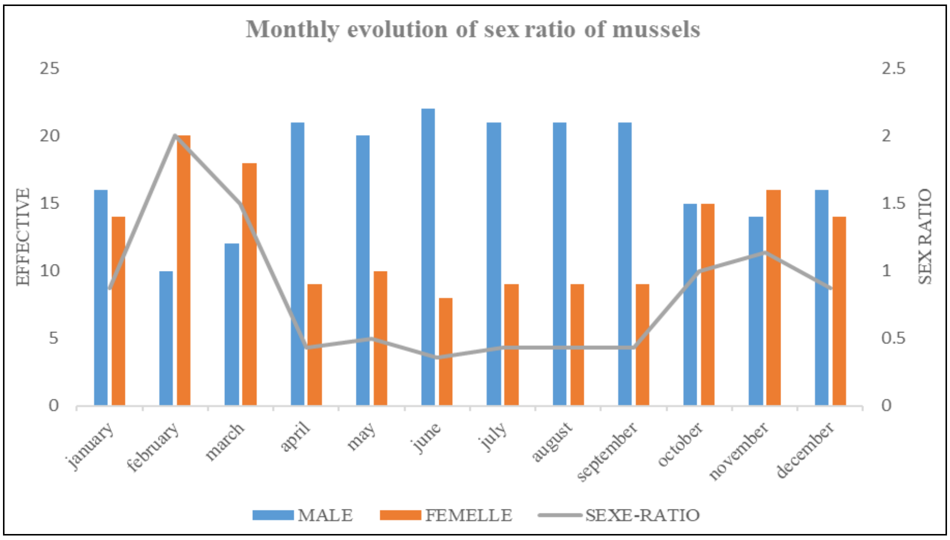

Fig 9: Monthly evolution of sex ratio of mussels (f/m)

The Sex ratio was in favor of females between October and December with a first peak in November and between January and March with a second peak in February (Figure 9).

Discussion

The results of the present study showed two distinct periods: low temperature from November to May (temperature between 15 and 20 °C) and a hot period from June to October (temperature between 24 and 28 °C). The water temperature varied from 15.4 to 28.7 ° C, with an average of 22.16 °C. An increase of the temperature was observed from May with a maximum equal to 28.7°C during the winter period (August, September and October).

The salinity varied from 38 to 41 ‰ during the experiment, with an average of 39.58 ‰. The salinity was around 38 ‰ from January to May. A period of high salinity from June to December (41 ‰) was observed. During the rainy season, there is a slight decrease in salinity. These results are slightly similar with those of Benchikh [3], who reported in 2009 that the monthly water temperature readings from the three sites (Cap de Garde, H`naya and Aouinate) show the existence of two very distinct periods: one cold from November to April, with a minimum from 12.5ºC, recorded in February, and the other hot, which spreads from May to October with a maximum of 28ºC recorded in July. This difference in temperature is a reflection of the Mediterranean character of the region where the contrasts between cold and hot seasons are very severe. Similar results were reported in the Gulf of Annaba by Khati-Hadj Moussa [9].

Regarding salinity, seasonal fluctuations were observed. The measurements carried out showed low salinities in winter and spring (between 36 and 38 ‰); this could be explained by the strong dilution of the water generated by the high inflows of freshwater, originating from the heavy precipitation, combined with the low evaporation of the water. The high water salinities, on the other hand, are recorded in summer and autumn, due to the combined action of high temperatures causing strong evaporation and the drop in precipitation at the origin of the drop in freshwater supplies [3]. According to Dufour and Merle [10], the large amplitude of thermal variations plays a direct role in the succession of planktonic species. Planktonic efflorescence represents an essential food intake for mussels; they would stimulate sexual maturation, as much by their importance as by the suddenness of their appearance [11].

Bivalve is a filter feeder, and weight growth is strongly influenced by the amount and quality of food available in the water column. When conditions are satisfactory, *P. perna* weight gain is consistent with growth in length. Indeed in bivalves, the growth in length and thickness of the shell is discontinuous and depends on the periodic secreting activities of the mantle. Composed of organic and inorganic substances, the shell is influenced by certain external factors such as pH, temperature, and salinity during its growth. This may be attributed to the occurrence of wide and extensive areas of rocky substrates, which accommodate suitable sites for escaping from hazard conditions particularly effects of temperature, salinity, radiations and predation at the upper littoral zones, in addition to providing vast spaces between individuals at reef flats [12].

According to variations in the condition index, there were two main breeding periods in the *Perna perna* mussel; the most important of these periods took place in July, August, and September. This period coincides with the winter season, where coastal waters benefit from nutrients supplied by rainwater. It is also characterized by a decrease in salinity following the water supply but also with the higher temperatures. The other period of reproduction corresponded with February, March and April, marked by the Upwelling (rise of cold waters, riched in micronutrients on the surface). However, it is less important than the first because the temperatures of the waters of surfaces were still low, so not too favorable. It would certainly coincide with the laying of small individuals.

The present study showed that the sex ratio is favorable for males for 9 months out of 12, against 3 months for females (February, March and November). Relative to the size of individuals, the sex ratio is in favor of females for individuals of large sizes, from 11 cm. The evaluation of the sex ratio revealed the dominance of the males compared to the females. This predominance of males was reported in the two species *P. perna* and *M. galloprovincialis* from Anza in Morocco [13].

The results of the evaluation of the *P. perna* mussel condition index showed that this index is much better in summer. This is similar to the results obtained by Benchikh [3]. These values are explained by the probable appearance of phytoplanktonic blooms that lead to an abundance of food. These are also explained by the probable achievement of the optimal physiological temperature that would promote better metabolization of the ingested products. According to Romeo *et al.* [14], the condition index would be associated with the water temperature and correspond to the rate of filling of the shell by soft tissue and would, therefore, provide information on the nutritional status and physiological of the animal. In the present study, the decrease in the condition index during the cold and hot periods would correspond to two laying phases. Similar observations have been reported by (Benchikh [3]; McQuaid and Lawrie [15]. Other authors explained the drop in the condition index is either due to poor trophic conditions or following a spawning, which led to weight loss [16].

In the studies of the biometric relationship, the constant “b”, also known as the coefficient of allometry or coefficient of regression expresses the rate of change of the relative animal body shape during the growth process [17]. The length-weight relationship for the whole population of *P. perna* showed regression coefficients b=2.4467 an intercept with Y-axis, “a’ = 0.2565. The allometric coefficient of the specimens sampled in this study is less than b=3, implying that the specimens showed negative allometry. *Perna perna* grows faster in size than in weight. Similarly, Benchikh [3] reported that the evaluation of the intensity of the relationship between the total length and the total weight in the *P. perna* mussel from all the sampled sites revealed the existence of negative allometry between these two parameters (b<3) reflecting the increase in the size of individuals faster than that of weight. According to Romeo *et al.* [14], this is related to the monthly fluctuations in the physiological state of the animal. Moreover, it has been reported a “b” values of length-total weight ranging from 2.67 [18] to 2.95 [19]. Our results are in line with those given by Hemachandra and Thippeswamy [19] and Thejasvi *et al.* [20], who studied the allometric relationships of shell dimensions and length-weight relationships of *P. viridis* from the intertidal regions of Coconut Island and Mukka of Karnataka state. This variation maybe because of the influence of ecological factors such as density, shore level [21]. Such ecological differences were shown by Hickman [22], who compared raft-grown populations of *P. canaliculus* with wild stocks of this same species.

The present study showed that the size of *P. perna* varied between 4-13 cm. The most common harvest size was between 7-10 cm. Our results are comparable to those reported by Rosińska *et al.* [23], who showed that the mean length measurements of the specimens from lakes Binowo and Wierzchowo (approximately 8 cm). The studies of other authors also indicated that the dominating specimens of swan mussel shells ranged from 7 to 9 cm. The study on biometrics and proximate composition of *P. indica* showed that the size varied between 6.15 and 15.41 cm total length and 18.7–225.8 g showing less size composition [24].
Many authors, who have studied the growth of mussels, have reported different types of growth. Jayalakshmy *et al.* [25] reported that *P. indica* collected from Vizhinjam ranged in length from 3.05 to 6.65cm, while for *P. viridis* collected from Calicut measured 2.43 to 10.6cm in length. In nature, some individuals of the same age or lengths show different weights, and the difference could be due to the physiological conditions and to the environmental factors [26].

Conclusion

The data obtained on the growth of the mussel *Perna perna* allow to better understanding its reproductive biology. It is essential for providing valuable models, sustainable management of the wild population, possible development of mussel farming techniques and plausible scientific advice for the management of this valuable resource to ensure profitability and the sustainability of their exploitation to create income opportunities among fishers and farmers. It emerges from this study that the measured physicochemical parameters show seasonal fluctuations. The increase in the size of individuals is faster than that of weight (negative allometry). The mussel *P. perna* has a sexual cycle spread out over the year with mainly two spawning periods, one in the dry season and the other in the rainy season. The gamete emission coincides with the decrease in the condition index and the restoration of the gonads. In perspective, it would be attractive to study the population dynamics of mussels from different natural mussels sites and determine the recruitment periods of the larvae. For food quality assessment it is necessary to détermine the biochemical composition of the flesh to interpret better the variations that may be caused by various contaminants present in the environment. Furthermore, it twill be necessary to détermine the impact of pollutants on the growth and sexual cycle of mussels. Lastly, it twill be valuable to investigate the gonado-somatic relationship and to conduct histological sections of the gonads of *P. perna.*

References

1. A-El-Sayed A, El-Mabrouk N, Ibrahim O, Amr M, Nassef M, El-Hammady A *et al*. Biometric Relationships for the Bivalve Mussel, *Brachidontes pharaonis* Populations from the North-Western Coast of Suez Gulf, Egypt. Egypt. Acad. J. Biolog. Sci. 2016; 8(1):61-73.
2. Diagne I, Ndiaye M, Ndiaye B, Diop A, Thiom M. Evaluation de la contamination métallique des moules *Mytilus galloprovincialis* et des sédiments marins au niveau des côtes de la région de Dakar (Sénégal). Int. J. Biol. Chem. Sci. 2013; 7(2):872-883.
3. Benchikh N. Etude de la croissance et du cycle de reproduction de la moule *Perna perna* dans le golfe d`Annaba et le littoral d`El Kala. Mémoire pour l'obtention du Diplôme de Magistère en Sciences de la Mer, 2009, 112p.
4. DITP. Rapport statistique des exportations de produits de la pêche, 2019, 32p
5. Bodoy A, Massé H. Quelques paramètres permettant de suivre la production organique d'un Mollusque Bivalve au cours d'un cycle saisonnier. Publ. Sci. Tech. CNEXO, Actes Coll. 1979; 7:753-766.
6. Bodoy A, Croissance et variation de la composition biochimique du bivalve *Spisula subtruntata* (Da Costa) dans le golfe de Marseille (Méditerranée occidentale). Tethys.1980; 11(1):57-66.
7. Lucas A, Beninger PG. The use of physicological condition indices in marine bivalve aquaculture. Aquaculture. 1985; 44:187-200.
8. Pellerin – Massicote J. Oxidative processes as indicators of chemical stress in marine bivalves Aquat. Ecosyst. Health. 1994; 3:101-111.
9. Khati Hadj moussa W. Etude de la qualité des eaux du golfe d'Annaba par l'utilisation d'un mollusque sentinelle, la moule *Perna perna:* essai *in vivo* et in situ. Application a la biosurveillance de l'environnement marin. Thèse de doctorat. Univ. Annaba. laboratoire écosystème marins et littoraux, 2009, 87p.
10. Dufour PH, Merle J. Station côtière en Atlantique tropilcal. Hydroclimat et production et production primaire. Doc. Sci. Center Orston Pointe-Noire, N.S. 1972; 25:48p.
11. Cayre P. Stocks de mollusques bivalves. In: Milieu et ressources halieutiques de la République Populaire du Congo, par Fontana, A., ed. Paros, Editions de l'ORSTOM, 1981, 313-322.
12. Diouf M, Faye A, Regala A, Cadot N, Fall EM, Karibuhoye C. Biometric Relationships and Evaluation of the Density of *Tagelus angulatus* Gray, 1847 (Mollusca, Solecurtidae) on the West African Coasts in three Villages of the Community Protected Area of Urok, Guinea-Bissau. Annual Research & Review in Biology. 2017; 13:1-9.
13. Idhallia M, Bouhaimi A, Zekhnini A, Narbonne JF, Mathieu M, Moukrim A. Etude du cycle de reproduction de deux espèces de moules *Perna perna* et *Mytillus galloprovincialis* dans la bais d'Agadir (Sud du Maroc). Laboratoire Eaux et environnement, Univ Ibnou Zohr. B.P. Maroc. British Librairy, 1997.
14. Romeo M, Garcia-Barrelli JP, Siddoumou Z, Nguyen PH. Variation spatiotemporelles des concentrations en métaux traces chez le mollusque *Donax rugosus* de la cote mauritanienne. Bull. Ecol., t. 1993; 24:83-86.
15. McQUAID CD, lawrie SM. Supply-side ecology of the brown mussel Perna Perrna ; an investigation of spasial and temporal variation in, and coupling between, goc, Camete release and larval supply. Mar. Biol. 2005; 147(4):955-936.
16. Barillé AL. Contribution à l'étude des potentialités conchylicoles de Prthuis Breton. Thèse de doctorat. Universirté d'Aix-Marseille II. 1996, 243p.
17. Laxmilatha P. Biometric relationships of Mactra violacea (Gmelin) from Kerala, south-west coast of India". Indian J. Fish. 2008; 55(4) :349-351.
18. Sundaram S, Josekutty CJ, Chavan BB. Length-weight relationship of Green mussel *Perna viridis* (Linnaeus, 1758) from Versova creek, Mumbai. Mar. Fish. Infor. ser. T. E. Ser. 2011; 207:33-34.
19. Hemachandra, Thippeswamy S. Allometry and condition

index in green Mussel *Perna viridis* (l.) From St. Mary's island off Malpe, near Udupi, India. Aqua. Res. 2008; 39:1747-1758.
20. Thejasvi A, Chandrakala Shenoy K, Thippeswamy S. Allometry of the green mussel *Perna viridis* (Linnaeus) from the intertidal rocky habitat of Mukka, Karnataka, India. J. Theor. Exp. Bio. 2013; 9(3-4):105-112.
21. Vakily JM. The biology and culture of mussels of the genus *Perna*. International Center for living aquatic resource management, Manila, Philippines, 1989, 1-63.
22. Hickman RW. Allometry and growth of the green lipped mussel *Perna canaliculus* in New Zealand. Mar. Biol. 1979; 51: 311-327.
23. Rosińska B, Chojnacki JC, Agnieszka L, Alicja M, Agnieszka S. Biometrics of swan mussels (*Anodonta cygnea)* from chosen lakes in the Pomeranian Region. Limnological review. 2008; 8:79-84.
24. Santhosh RB, Venu S, Malakar B, Swapna A, Kumar RR, Narayani S. Studies on Biometrics and Proximate Composition of *Perna Indica*, Kuriakose & Nair, 1976 Collected from Sippighat, South Andaman. Life Sciences Leaflets. 2016; 82:01-12.
25. Jayalakshmy KV, Maheswari N, Dileep Kumar R, Vijayan M. Biometric And Morphometric Studies Of *Perna Viridis* And *Perna Indica* Along The Southwest Coast Of India: A Statistical Approach. Journal of Experimental Biology and Agricultural Sciences. 2013; 1(4):285-296.
26. Gaspar MB, Santos MN, Vasconcelos P. Shell morphometric relationships of the most common bivalve species (Mollusca: Bivalvia) of the Algarve coast (southern Portugal). Hydrobiologia. 2002; 477:73-80.