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Study of the Relative Growth of Bivalve *Cardium costatum* (Linné, 1758) of the Exclusive Economic Zone of Côte d'ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KF and KFKI designed the study, performed the statistical analysis, wrote the protocol, and first draft of the manuscript. Authors AJB and YN managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study was to determine growth parameters in order to provide important data for better planning of the sustainable management of maritime resources and initiate shellfish farming.

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A total of 540 individuals from the exclusive economic zone of Côte d'Ivoire were sampled from November 2012 to October 2014. The measurements were carried out in order to study the allometric relationships concerning the height-length, height-thickness relationships, thickness-length, weight-length, weight-height and weight-thickness. The results reveal that linear growth exhibits negative allometry (b < 1) in *Cardium costatum*. This species grows faster in length than in height and thickness. The weight growth of *Cardium costatum* presents a positive allometry (b > 3). Which means that this species grows faster than it lengthens.

Keywords: Bivalve; metric parameters; allometry; growth.

1. INTRODUCTION

Bivalve molluscs play an important ecological role in the ecosystem by stabilizing the seabed by the formation of clumped shell beds that protect loose sediments against erosion [1]. They contribute to the increase in benthic biodiversity [2]. They intervene at lower trophic levels in marine ecosystems by transferring energy through the links of the food chain. Due to their filtering role, bivalves play a role in purifying water. They purify the water, and thus reduce turbidity [3]. Bivalves constitute an important component of the benthos, both in the epifauna with fixed species (oysters and mussels) or vagile species (scallops) and in the endofauna with burrowing bivalves (cockles, clams, etc.) [4].

In Côte d'Ivoire, the only study to date on bivalve landings [5] shows that *Cardium costatum* is the most common species (65.1%) in landings at the fishing port of Abidjan. It is the most abundant species (73.37%, 48.63%, 66.49% and 48.34% respectively in the short hot and cold seasons, the long hot and cold seasons) in all landings. It is present all year round in large quantities and also has the largest shell dimensions [5]. This presence in catches in quantity makes it a potentially economic species and a significant source of animal protein for populations. However, fishing for marine bivalve molluscs is still considered incidental and is not mentioned in the reports of the Department of Fisheries and Aquaculture.The absence of management measures could therefore inevitably lead to an often irreversible degradation of the ecosystems involved in the event of intense exploitation of the natural stock. Certain biological parameters, in particular growth, are necessary for a better knowledge of stocks. This work provides information on the linear growth and the weight growth of *C. costatum* in order to make available to decision-makers, data likely to help in the development of an optimal and sustainable management policy of the stock.

2. MATERIALS AND METHODS

2.1 Determination of metric Characteristics of *Cardium costatum* Landed at the Fishing Port of Abidjan

Fishing takes place in the coastline of Côte d'Ivoire, also known as the exclusive economic zone (EEZ). This fishing area (Fig. 1), 550 km long, is located between 8 ° and 3 ° west longitude. It starts from Cap “des Palmes” (8 ° W) in the West to Cap “des Trois Pointes” (2 ° 30 W) in the East. The continental shelf is narrow and the slope is steep. It is characterized by a series of sandy and rocky areas. The seawater of the exclusive economic zone of Côte d'Ivoire has four marine seasons. The small cold season occurs during the months of January to February. The great cold season, for its part, takes place from July to October. The short hot season sets in from November to December and the great hot season from March to June [6]. A monthly sampling of 22 individuals taken randomly from the landings of the commercial trawler fishery of the fishing port of Abidjan was carried out from November 2012 to October 2014.. The individuals landed are transported under ice from the fishing port to the laboratory, where the measurements are carried out. The various metric parameters recorded were measured using an electronic caliper at 1 mm. The weighings were carried out using a precision balance 0.01 g. For each individual studied, the following parameters were measured (Fig. 2).

- Total length (L): It corresponds to the greatest distance separating the anterior edge from the posterior edge of the shell;
- Height (H): It is the distance which goes from the dorsal hinge to the ventral edge. As for the total length;
- Thickness (T): It is the maximum distance of the convexity of the two united valves.

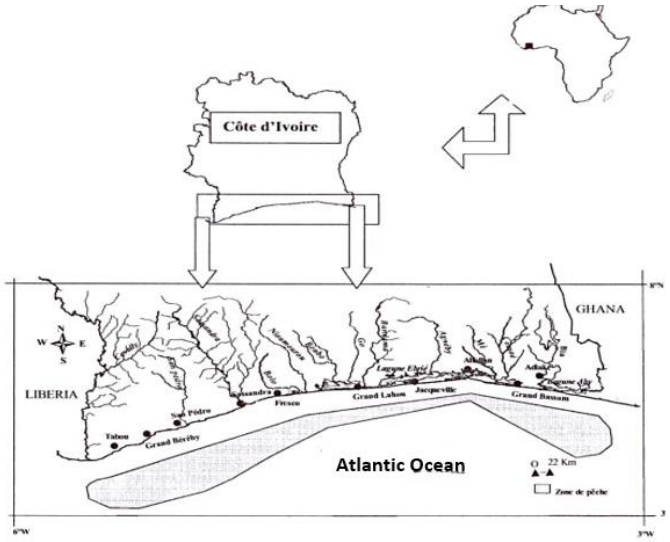


Fig. 1. Fishing zone for bivalve molluscs [7]

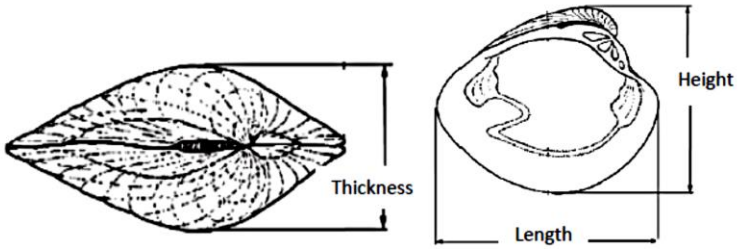


Fig. 2. Different measurements of *C. costatum*

2.2 Expression of Results and Analysis of Statistical Data

The measurements obtained made it possible to study the overall allometric relationships linking the various linear and weight parameters. The allometric relationships retained in this study concern the height-length, height-thickness, thickness-length, weight-length, weight-height, weight-thickness relationships. The relations were expressed by a power function of the form:

$$Y = aX^b \quad (1)\ [8]$$

With: Y: dependent variable, dimension or weight of the studied body.

X: independent variable, it represents the reference length.
a: constant.
b: allometric coefficient.

After a logarithmic transformation, equation (1) is written:

$$Ln\ y = Ln\ a + b\ Ln\ x \quad (2)$$

In order to determine the nature of allometry, we compared the observed value of the slope (b) with the theoretical value 1 (if it is allometric relations linking two linear parameters), or 3 (if it is a linear measure and a weight measure).

When using linear animal measurements, three cases may arise:

If b = 1: the growth is isometric
If b <1: the growth is a lower bound
If b>1: growth is major.

Regarding the relative growth of mass over a measure of length, it has been shown that weight generally increases in proportion to the cube of length. For the weight relationship, three cases can arise:

If b = 3: the growth is isometric
If b<3: the growth is lower.
If b>3: growth is major.

The correlation coefficient (r) is determined from the square root of the coefficient of determination (R^2). It made it possible to measure the intensity of the linear relationship that exists between two biometric variables.

The statistical significance of the coefficient of determination (R^2) was estimated and the student's t-test was used to check whether the values of b were significantly different from the isometric value b = 3 at the 5% threshold.

3. RESULTS AND DISCUSSION

The analysis included a total of 540 individuals ranging in size from 41 to 91 mm and weight from 5.6 to 114 g.

3.1 Height-length Relationship, Height-thickness Relationship and Thickness-length Relationship

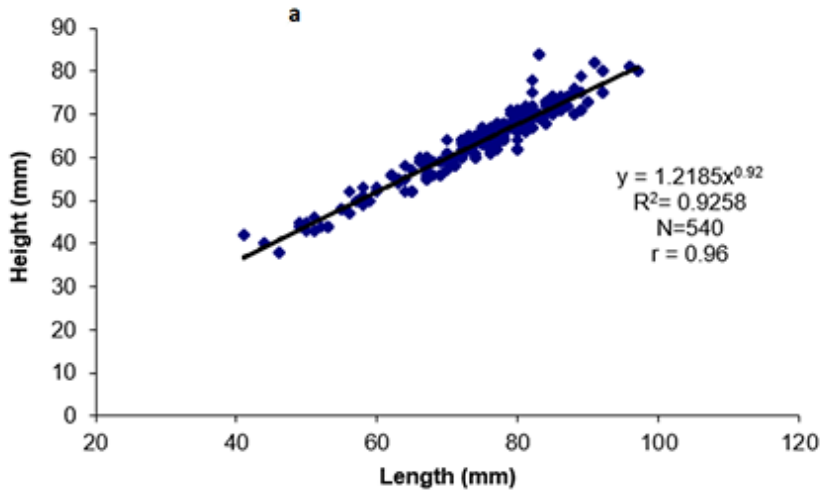
In the study of the height-length, height-thickness, thickness-length relationship, the regression lines obtained from the logarithmic coordinates are presented respectively in Figs. 3, 4, 5. The allometric coefficient (b = 0.91) which is less than 1 (Student t-test: p = 0.02) and the correlation coefficient (r = 0.95) show that *C. costatum* has a proportionally greater growth in length than in height.

Concerning the height-thickness relationship, the correlation value (r) is 0.95 and the allometric coefficient (b = 0.87) is statistically less than 1 (Student t-test: p = 0.01). These results indicate that the growth in thickness is proportionally faster than that in height.

Concerning the thickness-length relationship, the allometric coefficient 0.98 is statistically less than 1 (Student t-test: p = 0.02). The increase in length is proportionally faster than that of thickness. The correlation value is 0.94.

The height-length, height-thickness, thickness-length pairs show that this species grows faster in length than in height and thickness.This significant negative allometry has also been reported for other bivalve species (*Cerastoderma glaucum* and *Ruditapes decussatus*) from the El Mellah lagoon in Algeria [9,10] ; (*Cerastoderma glaucum*) from the Gulf of Gabes [3]. This negative allometry would be related to the improvement of the efficiency of burial in order to avoid dislodgement by hydrodynamics and predation. Indeed, in general, variations in bivalve allometry have been associated with latitude, species, physiological traits and local environmental conditions [10, 11].

The growth in length could be explained by the fact that the length (the greatest distance separating the anterior edge from the posterior edge of the shell) represents the zone of dehiscence. The Bivalve will therefore tend to lengthen the opening area in order to feed, breathe and emit its gametes to the outside. Indeed, bivalves are known for their remarkable morphological diversity and the phenotypic plasticity which perceived as a key mechanism for enabling organisms to survive [12].



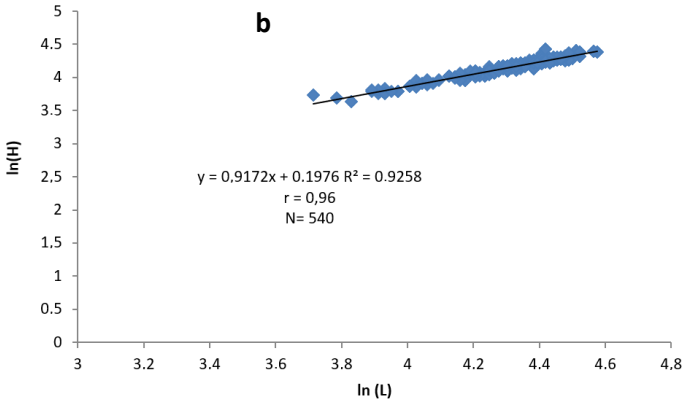


Fig. 3. Height-length relationship in *Cardium costatum*

a- Power trend curve; b- Linear trend curve; R^2: Regression; N: number of individuals; L: length; H: height

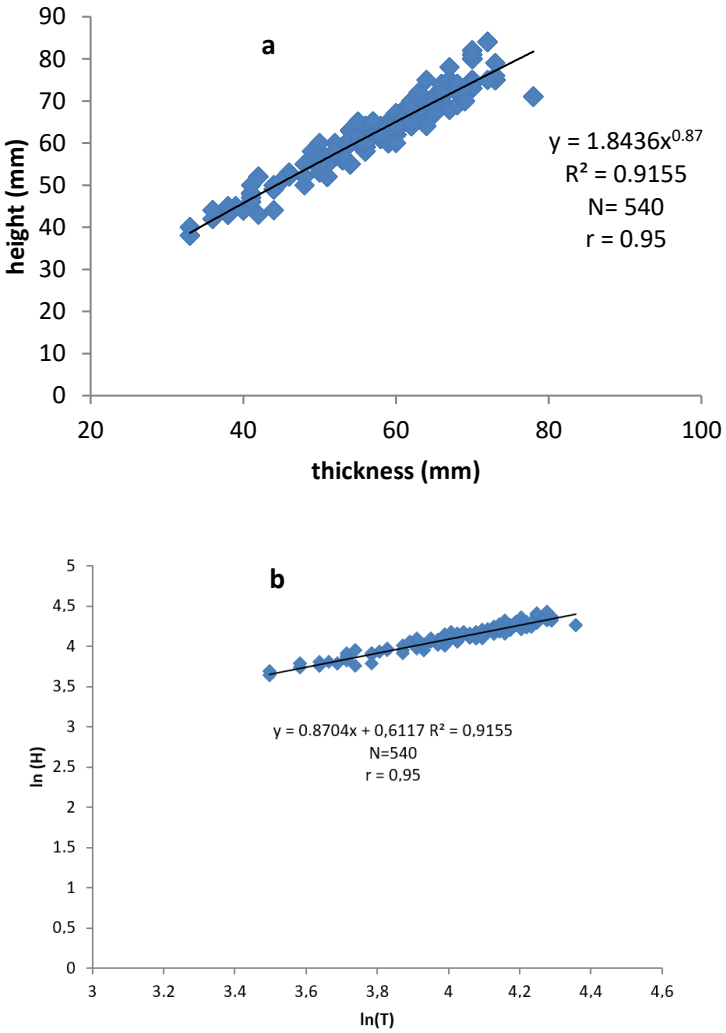


Fig. 4. Height-thickness relationship in *Cardium costatum* caught in the exclusive economic zone of Côte d'Ivoire

a- Power trend curve; b- Linear trend curve; R^2: Regression; N: number of individuals; T: thickness

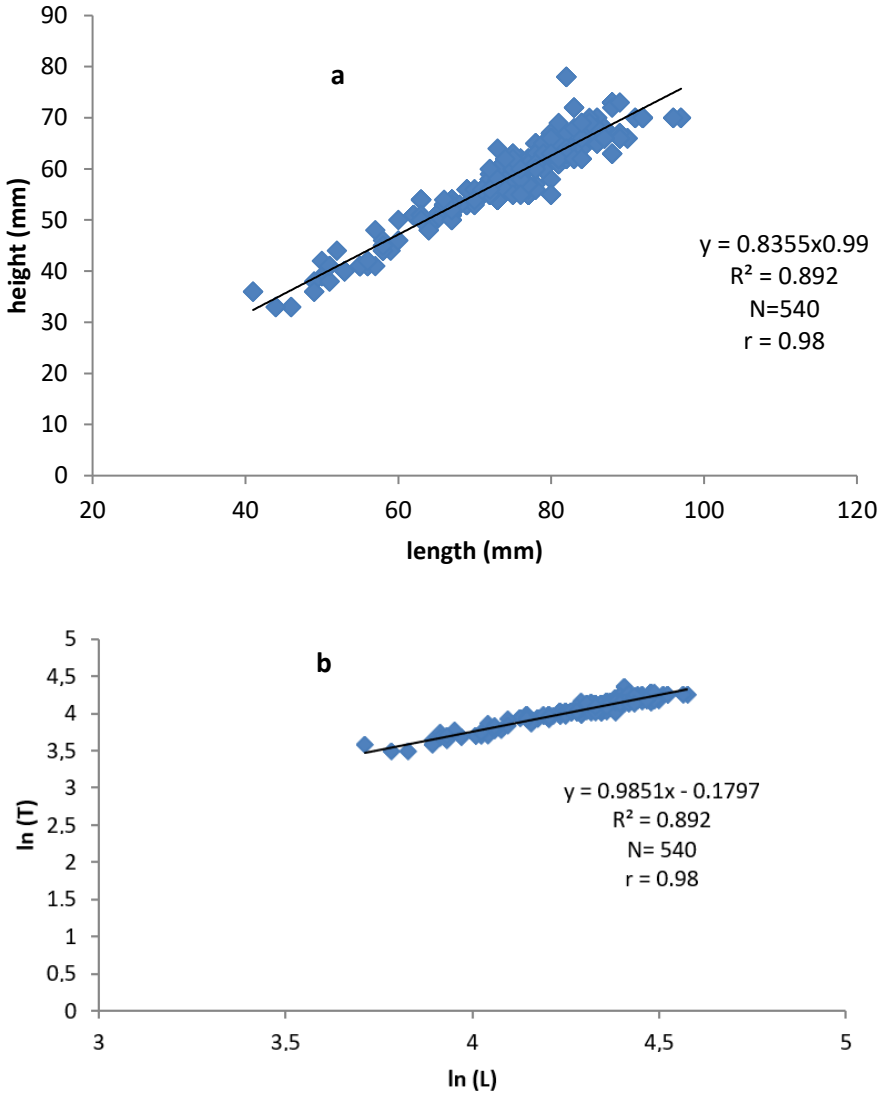


Fig. 5. Thickness-length in *Cardium costatum* caught in the exclusive economic zone of Côte d'Ivoire

a- Power trend curve; b- linear trend curve. R^2: Regression; N: number of individuals

3.2 Weight-length relationship, Weight-height Relationship, Weight-thickness Relationship

In the study of the weight-length, weight-height, weight-thickness relationship, the regression lines obtained from the logarithmic coordinates are presented respectively in Figs. 6, 7, 8.

The allometric coefficient 3.19 is statistically greater than 3 (Student's t-test: p = 0.00). The increase in mass is proportionally faster than that of the length. The correlation value is 0.83.

Regarding the weight-height relationship, the allometric coefficient 3.13 is statistically greater than 3 (Student's t-test: p = 0.01). The increase in mass is proportionally faster than that of height. The correlation value is 0.82.

Concerning the weight-thickness relationship,the allometric coefficient 3.32 is statistically greater than 3 (Student's t-test: p = 0.02). The increase in mass is proportionally faster than that of the thickness. The correlation value is 0.85.

The weight-length, weight-height and weight-thickness pairs show that the weight growth of *C. costatum* is allometric major (b> 3). Which means that this species grows faster than it elongates. This could be explained by the fact that it has access to the calcium necessary for

the constitution and solidification of these shells [13]. This calcium could be obtained through food or through absorbed marine sediments. This result does not agree with those of certain authors who have studied the growth of mussels and oysters in farming [14], of mussels in the Gulf of Annaba [15, 16], and the *Cerastoderma glaucum* shell [17]. According to these authors, the evaluation of the intensity of the bond between the total length and the total weight reveals a negative allometry between these two parameters (b <3). This difference in idea could be explained by the difference in the biotope of burrowing and fixed molluscs. Mussels and oysters attach themselves to a substrate during their development. They will therefore not be able to take advantage of the calcium contained in the sediments, unlike the family of cardiids which live in the sediments. This difference in idea could be explained by the difference in the biotope of burrowing and fixed molluscs.

Also, there are strong correlations between the different couples with regard to the high values of the correlation coefficient r. For all the graphical representations, the experimental points are ordered around the theoretical curve as demonstrated by the values of the correlation coefficients which are all high. This result means that the elongation of the shells and the enlargement of *C. costatum* are closely related and occur in the same direction.

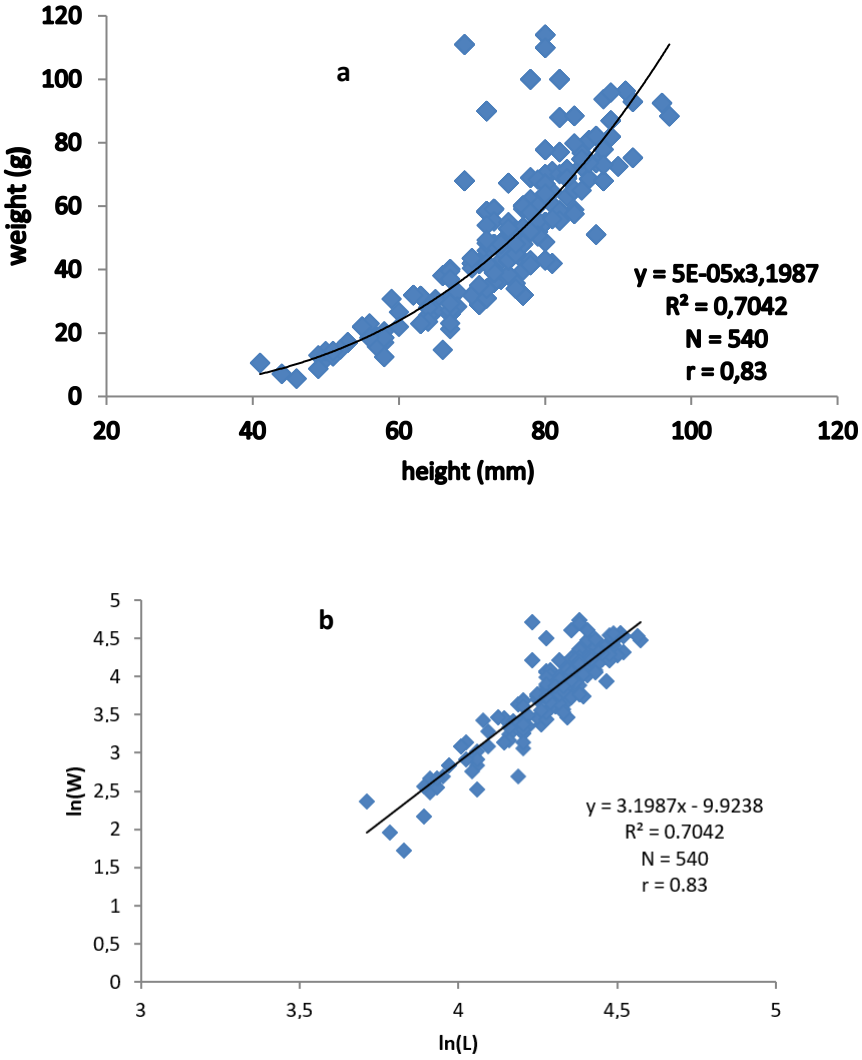


Fig. 6. Weight-length relationship in *Cardium costatum*

a- Power trend curve; b- Linear trend curve. R^2: Regression; N: number of individuals; W: weight

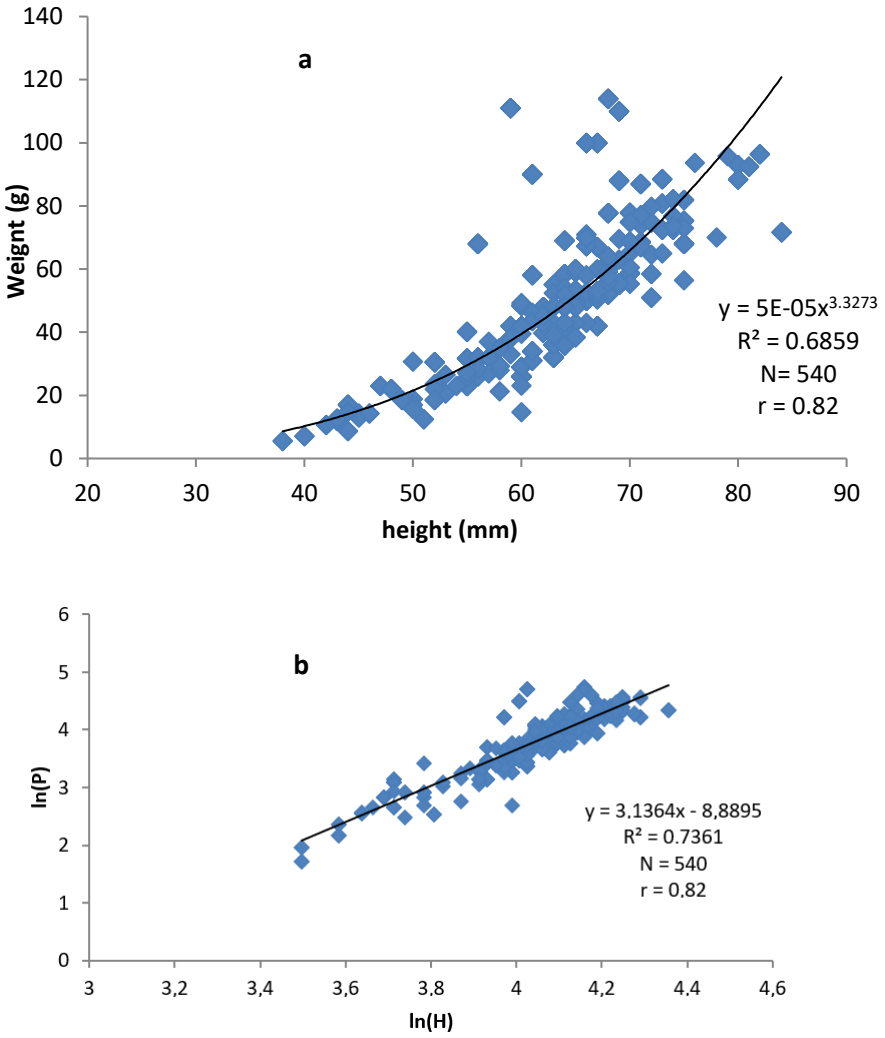
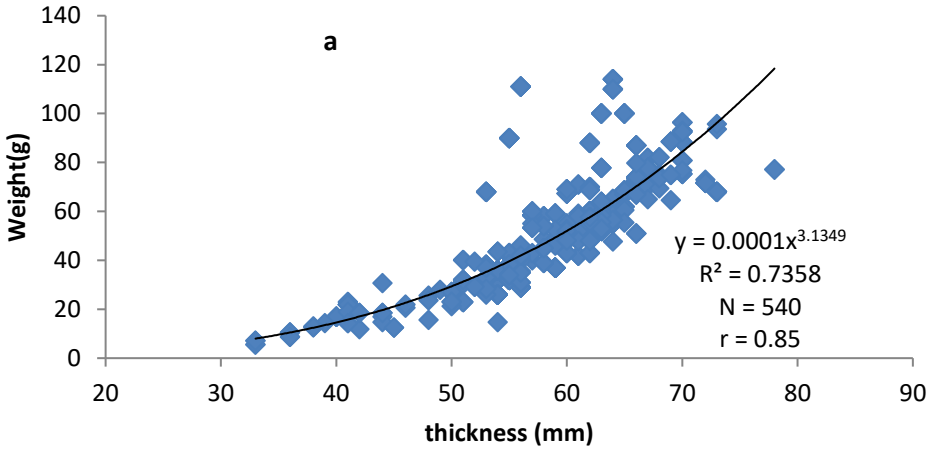


Fig. 7. Weight-height relationship in *Cardium costatum* caught.
a- Power trend curve; b- Linear trend curve; R^2: Regression; N: number of individuals.



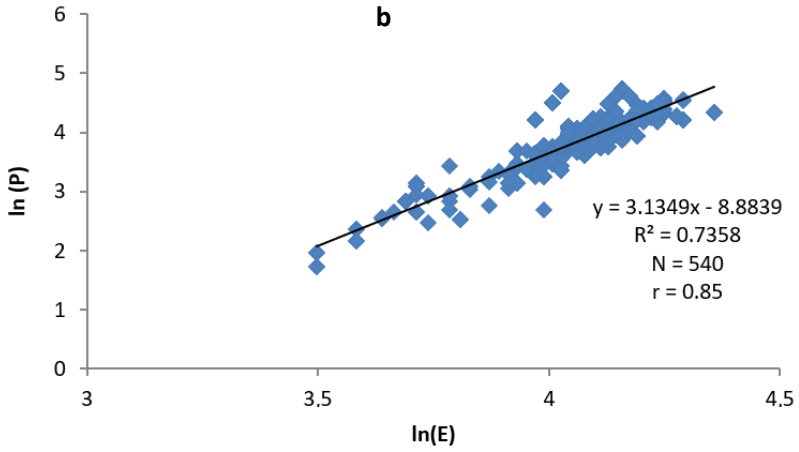


Fig. 8. Weight-thickness relationship in *Cardium costatum* caught in the exclusive economic zone of Côte d'Ivoire

a- Power trend curve; b- linear trend curve; R^2: Regression; N: number of individuals.

4. CONCLUSION

The species *Cardium costatum* of the Exclusive Economic Zone of Côte D'Ivoire grows faster in length than in height and thickness, and it grows faster than it elongates. These data could constitute a basic tool for the rational management of marine bivalve molluscs in the Exclusive Economic Zone of Côte d'Ivoire.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby declare that no generative artificial intelligence technologies such as large language models (ChatGPT, COPILOT, etc.) and text-image generators were used during the writing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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