Original Research Article

Biometric characteristics and condition factor of tropical freshwater *Atyascabra* Leach, 1815in the Bia river, South-East Region, Côte D'Ivoire

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ABSTRACT

The present study focused on 720 specimens of *Atyascabra*handcrafted captured in the Bia river, precisely in the localities of Aboisso and Biaka. This study was conducted to assess the adaptation and allometric of the species *A. scabra*in the Bia river. During the trial, data on the environmental parameters of the water were obtained using a multiparameter. As for the relative growth of the species *A. scabra* was determined from the individual measurements of the specimens. Then, Student's t-test allowed a comparison of allometric coefficients for the same sex in Aboisso and Biaka. Thus, the average air temperature was 26.92±1.33°C. In terms of rainfall, it fluctuated from 17.78 to 722.9 mm or an annual average of 155.96±191.21 mm. At Aboisso, the annual average temperature of water was 28.50 ± 1°C, 7.54 ± 0.1°C for the pH and 5.03 ± 0.8 for OD. For the locality of Biaka, the mean values recorded were 28.45 ± 1.9 °C, 7.39 ± 0.2, and 4.93 ± 0.9, respectively, for temperature, pH, and OD. The condition factor (k) estimated in Aboisso, ranged from 3.04 ± 0.05 to 3.29 ± 0.26 for males and from 2.85 ± 0.35 to 3.07 ± 0.12 for females of *Atyascabra*. As for the locality of Biaka, the estimated k values fluctuated between 3.1 ± 0.14 and 3.4 ± 0.31 for males and from 2.75 ± 0.07 to 3.10 ± 0.25 for females. The biometric study revealed a negative allometry in females and a positive allometry in males in both localities for the W/Lt and Lc/Lt relationships. *Atyascabra* freshwater shrimp has therefore shown a good adaptation in the Bia river. In addition, the results obtained could guide the choice of sex having economic interest in the event of possible aquaculture of this species.

Keywords: Atyascabra - Allometric - Condition factor - Bia river - Côte d'Ivoire.

1. INTRODUCTION

Decapod crustaceans play an important role with fish in controlling the structuring of the aquatic community (Covich et al., 1996; Konan, 2009). In addition, shrimps from the Atyidae and Palaemonidae family are an important resource for the artisanal fishery (Gooré Bi, 1998; Vanga, 2007; Almeida et al., 2010; Boguhé et al., 2011). Shrimp fishing is an activity practiced in most freshwater and brackish waters of West African countries (Enin, 1995; Etim and Sankare, 1998). In Côte d'Ivoire, shrimp are exploited artisanally by people along rivers (Vanga, 2007, Boguhé et al., 2011; Sankare et Amalachy, 2014; Konan et al., 2015). Freshwater shrimps are appreciated in human food especially in Ivorian. Nowadays, research focuses on species that carry out their reproductive cycle in their biotope for possible aquaculture. The aim is to ensure the food security of people. Thus, in the species *Atyascabra*, knowledge of environmental parameters would be an asset to lay the foundations for sustainable exploitation of this fishery resource and conservation of this biodiversity. The study of the relationship between linear and weight parameters is an indicator of the environmental quality (Yapi et al., 2017). Indeed, the environment is an important factor that influences the health, physiological development and distribution of shrimp (N'Zi, 2007). Previous studies on biometrics have been done on the species *Atyagabonensis*Giebel, 1875 of the Mu river (Okayi and Iorkyaa, 2004) and the Bandama river (Konan et al., 2015). This work focus on the characteristics of relative growth and condition factor of the *Atyascabra* freshwater shrimp caught in the Bia river, South-Comoé region in Côte d'Ivoire.

2. MATERIAL AND METHODS

2.1 Biological material

Freshwater shrimp specimens have been caught monthly on the main stem of the Bia river into two localities (Aboisso and Biaka)from August 2014 to July 2015. Thirty (30) individuals were collected monthly on each study site with a total of 720 individuals.

2.2 Study zone

Bia river is located between 5°0'7°5' North latitude and 2°6'3°3' West longitude. It takes origin in Ghana and measures 290 km within 120 km in Côte d'Ivoire. The coastal river covers 9650 km^2 basin and flows into the lagoon Aby in South East. Two dams (Ayamé I and Ayamé II) were built on the main courses, respectively 22 to 28.7 km from the Aby lagoon (Konan, 2009). The implementation of these

two works was held in 1959 for the dam Ayamé I and 1965 for dam Ayamé II. Our study was conducted in the main course of the river Bia, specifically at Biaka and Aboisso (Figure 1), both are located downstream of dam Ayamé. Thus, two stations: T 1 (5°27' N and 3°12' W) and T 2 (5°28' N and 3°12' W) in Aboisso, while stations T 3 (5°28' N, 3°11' W) and T 4 (5°30' N and 3°11' W) were identified at Biaka (Figure 1).

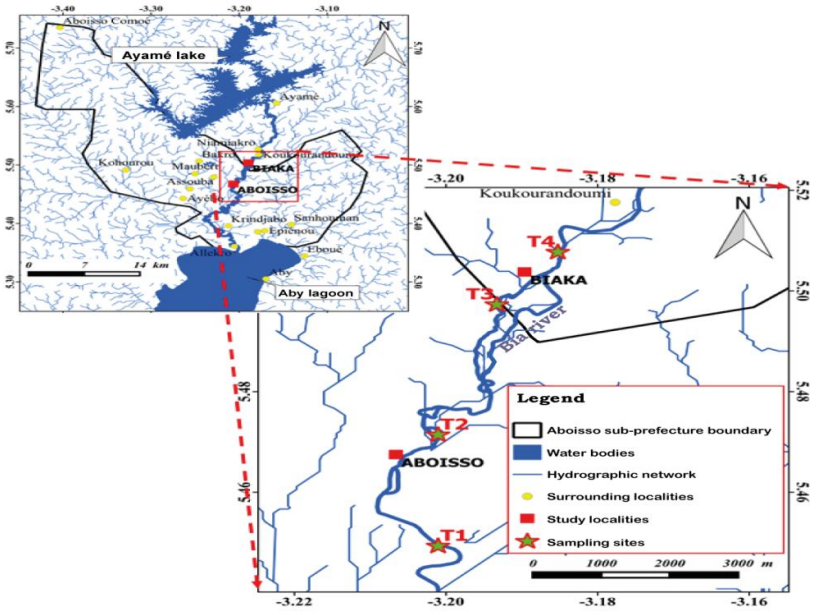

Fig.1.Geographical localization of the stations of Aboisso (T1 et T2) and Biaka (T3 et T4) (BNETD, 2016)

2.3 Measurement of physicochemical parameters of water

Measurements of the physicochemical parameters of water were carried out with the multi-parameter of mark BANTE 900P in situ in the morning (before 10 A.M.). Temperature (T), dissolved oxygen (OD), salinity, conductivity, pH, turbidity (TDS) and oxydo-reduction potential (ORP) were found at differents stations in each study area.

2.4 Morphometric surveys

The shrimps (30 individuals per month) were collected by hand and by diving (Kadjo et al., 2016a) in rocky bottoms areas of the sampling stations. In each site, animals were rapidly placed in coolers filled with ice and transported to laboratory. In the laboratory, shrimps were sexed based on the presence or absence of the appendix masculina on the 2nd pair of pleopods (Galvão and Bueno, 2000; Almeida et al., 2010). Then, individuals were measured and weighed. The following measurements were measured with a vernier caliper to the nearest 0.1 mm on each specimen. This is the total length (Lt), the length of the cephalothorax (Lc), the length of the rostrum (R), the width of the cephalothorax (lc), the length of the tergite (T), the width of the 2nd pleura (Pl), abdominal length (Lab), telson length (Tel), antenna lengths (Lantn) and antennules lengths (Lantl) of the 3rd, 4th and 5th pairs of pereopod. Morphometric data were standardized to avoid size variations related to age differences between individuals.

2.5 Seasonal determination of the condition factor

The Fulton condition factor (k) shows the overweight status of individuals in an aquatic environment. Individuals have a good adaptation when this factor is high. The Fulton condition factor (k) was determined seasonally in males and females in both communities by the following formula (Le Cren, 1951):

$k = \frac{W}{Lt^b} * 100$.

W: Total weight,
Lt: Total length

2.6 Allometric data processing

For the biometric study of the freshwater shrimp *Atyascabra* Leach, 1815, the following morphometric relationships were established: W = f (Lc), W = f (Lt) and Lc = f (Lt).The relations were expressed by a power function of the form $Y = aX^b$, which is transformed into a logarithmic function of the form Log Y = Log a + b Log X (Lawal-Are and Owolabi, 2012). This transformation is the simplest method to linearize the relationship, stabilize the variances and normalize the variables.

2.7 Statistical analysis of the biometric data

The allometric coefficient b of each equation was compared with the standard coefficient (1 for the length-length relationship and 3 for the weigth-length relationship). Then, Student's t-test allowed a comparison of these coefficients for the same sex in Aboisso and Biaka. The STATISTICA version 7.1 software was used to perform the tests. The significance level of these different tests is α = 0.05.

3. RESULTS AND DISCUSSION

3.1 Environmental parameters

3.1.1 Evolution of air temperature and rainfall

During the trial period, the air temperature varied between 24.70 and 28.70° C with an average of 26.92 ± 1.33° C. As for rainfall, it fluctuates from 17.78 to 722.9 mm, with an annual average of 155.96 ± 191.21 mm. In the short dry season (PSS), the average recorded air temperature is 24.90 ± 0.28°C and 41.53 ± 33.59 mm for precipitation. The temperature / precipitation pair obtained in PSP is 26.80 ± 0.71°C and 143.26 ± 79.01 mm. In GSS, the average values are 27.92 ± 0.65° C for air temperature and 85.30 ± 42.95 mm for precipitation. 26.66 ± 1.39° C and 358.49 ± 326.27 were recorded respectively for air, temperature and precipitation during GSP.

3.1.2 Evolution of physico-chemical parameters of water

Figure 2 shown the evolution of the physicochemical parameters of the water during the trial. At Aboisso, the water temperature has changed from 27.1 to 29.91 °C with an annual average of 28.50 ± 1 °C. The pH of the water fluctuated from 7.4 to 7.7 °C with an annual average of 7.54 ± 0.1. As for Dissolved Oxygen (DO), the values recorded varied between 4 and 6.5 with an average of 5.03 ± 0.8. In the locality of Biaka, recorded temperature values ranged from 27.3 to 29.6 °C with an average of 28.45 ± 1.9 °C. The pH fluctuated from 7.1 to 7.7, an average of 7.39 ± 0.2. OD values ranged from 4 to 6.4, averaging 4.93 ± 0.9.

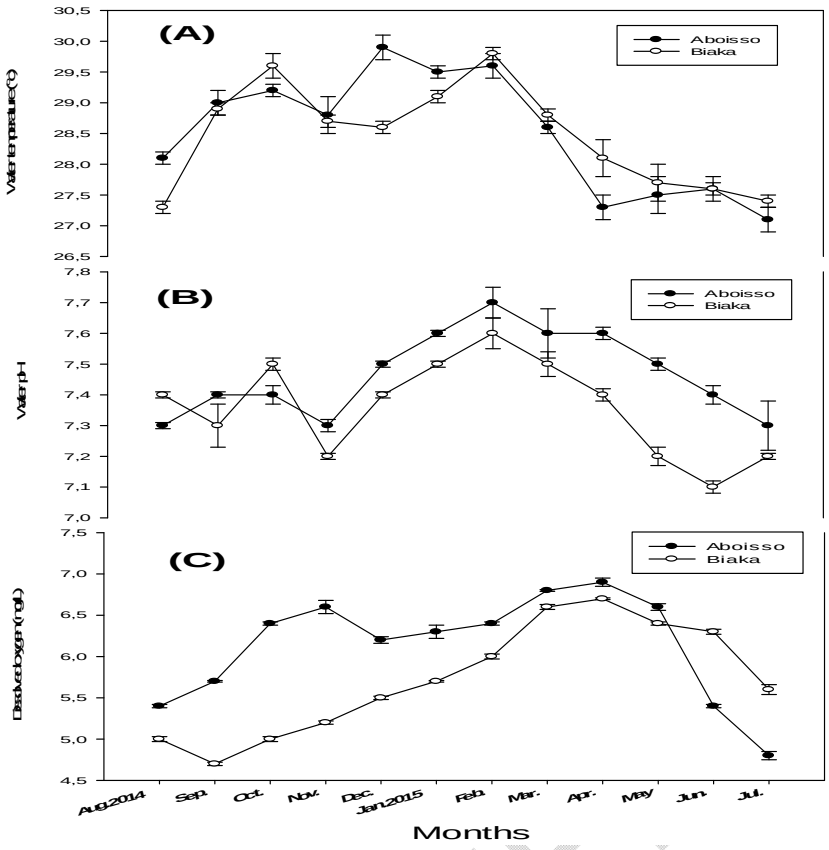

Fig. 2. Monthly variations of temperature (A), pH (B) and dissolved oxygen (C) of Bia

3.2 Biometric parameters

3.2.1 Seasonal variation of the condition factor

Figures 3 and 4 respectively show the seasonal evolution of condition factor (k) of freshwater shrimp in the localities of Aboisso and Biaka. In Aboisso, the estimated condition factor (k) ranged from 3.04 ± 0.05 to 3.29 ± 0.26 for males and from 2.85 ± 0.35 to 3.07 ± 0.12 for females of *Atyascabra* Leach, 1815. The peak k was observed in GSS in males (3.29 ± 0.26) and in females (3.07 ± 0.12). The lowest values of k were recorded in males (3.04 ± 0.55) and females (2.85 ± 0.35) in GSP. In the Biaka locality, estimated k values ranged from 3.1 ± 0.14 to 3.4 ± 0.31 in males and from 2.75 ± 0.07 to 3.10 ± 0.25 in females. In males, the peak of k was observed in GSS. The value of k was 3.40 ± 0.31. A decrease in k values (3.06 ± 0.05) was obtained during the PSP. On the other hand, in females, the peak of k was observed in GSS. The value of k was 3.10 ± 0.25. However, the low value of k (2.75 ± 0.25) was recorded in PSP.

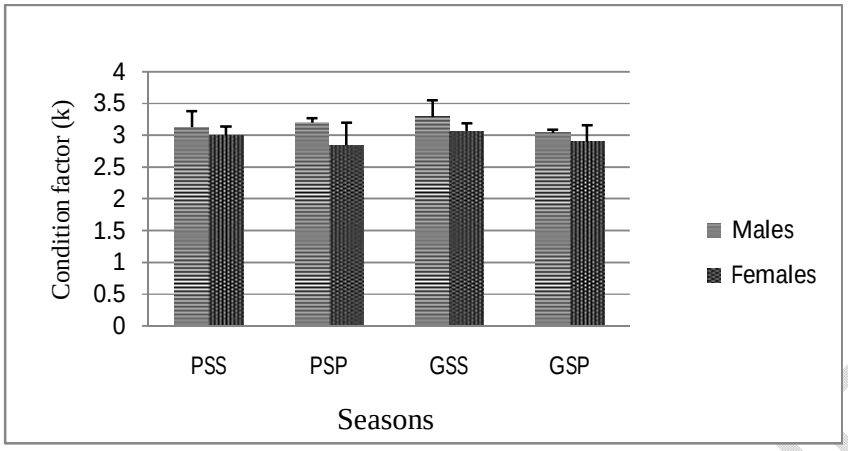

Fig. 3. Variation of condition factor (k) of males and females in Aboisso

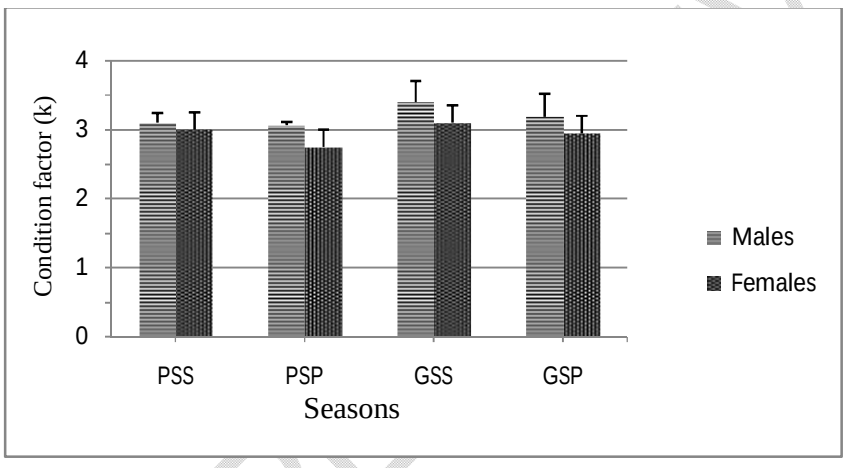

Fig. 4. Variation of condition factor (k) of males and females in Biaka

3.2.2 Total weight / length cephalothorax relationship of freshwater shrimp Atyascabra

Table 1 presents the annual evolution of the morphometric parameters of the Aboisso and Biaka samples. The t-test showed a negative allometry of the W-Lc ratios respectively in male and female individuals ($P < 0.05$). It is the same for both sexes combined in the localities studied.

3.2.3 Total weight / total length relationship of freshwater shrimp Atyascabra

Table 2 describes the variation between the total length (Lt) and weight (W) variables of Aboisso and Biaka shrimp. During the test, the t-test showed that the males recorded isometric allometry ($P = 0.343$). On the other hand, negative allometry was observed in females and sexes combined ($P < 0.05$) in the Aboisso locality. In Biaka, males and both sexes combined recorded positive allometry ($P < 0.05$). Females had negative allometry during the trial ($P < 0.05$).

3.2.4 Length cephalothorax / total length relationship of Atyascabra

Table 3 presents the seasonal evolution of the morphometric parameters of Aboisso and Biaka freshwater shrimps. During the trial, isometric allometry was observed in males and both sexes combined, while females recorded negative allometry ($P < 0.05$) in the Aboisso locality. In contrast, the t-test showed that positive allometry was recorded in males and sexes combined and negative allometry for females ($P < 0.05$) in the Biaka locality.

Table 1. Total weight / Cephalothorax length relationship of *Atyascabra* freshwater shrimp in the Aboisso and Biaka localities

Localities	sexes	Equation of regression	R^2	Allometry	N	Lc (mm)	W (g)	t	P>F
Aboisso	M	$W= 1,077Lc^{2,463}$	0,791	Negative	196	41,9±6,1	42,48±16,34	-13,41	< 0,05
	F	$W= 1,343Lc^{2,017}$	0,558	Negative	164	35,0±3,6	25,40±7,12	-61,38	< 0,05
	M+F	$W= 1,071Lc^{2,453}$	0,801	Negative	360	38,8±6,2	34,70±15,51	-36,92	< 0,05
Biaka	M	$W= 1,099Lc^{2,410}$	0,814	Negative	193	42,3±6,6	43,09±16,76	-32,30	< 0,05
	F	$W= 1,383Lc^{1,960}$	0,592	Negative	167	35,0±4,0	25,34±7,12	-33,92	< 0,05
	M+F	$W= 1,112Lc^{2,384}$	0,813	Negative	360	38,9±6,6	34,81±15,86	-46,10	< 0,05

**M: Males, F: Females, M + F: Combination of both sexes (males and females), W: Total mass, Lc: Cephalothorax length, a: Regression constant, b: Regression coefficient, R^2: Coefficient of determination, N: Number of freshwater shrimps, t: Student's t-test.*

Table 2. Total weight /total length relationship of *Atyascabra* freshwater shrimp in the Aboisso and Biaka localities

Localities	Sexes	Equation of regression	R^2	Allometry	N	Lt (mm)	W (g)	t	P>F
Aboisso	M	$W= 0,229Lt^{2,957}$	0,925	Isometric	196	110,1±14,5	42,48±16,34	- 0,95	0,343
	F	$W= 0,344Lt^{2,516}$	0,860	Negative	164	95,2±9,7	25,40±7,12	-26,29	< 0,05
	M+F	$W= 0,230Lt^{2,942}$	0,926	Negative	360	103,3±14,6	34,70±15,51	- 6,79	< 0,05
Biaka	M	$W= 0,200Lt^{3,100}$	0,917	Positive	193	109,4±14,2	43,09±16,76	15,82	< 0,05
	F	$W= 0,373Lt^{2,433}$	0,816	Negative	167	95,0±10,4	25,34±7,12	-23,19	< 0,05
	M+F	$W= 0,217Lt^{3,007}$	0,904	Positive	360	102,6±14,5	34,81±15,86	2,20	< 0,05

**M: Males, F: Females, M + F: Combination of both sexes (males and females), W: Total mass, Lt: Total length, a: Regression constant, b: Regression coefficient, R^2: Coefficient of determination, N: number of freshwater shrimps, t: Student's t-test*

Table 3. Cephalothorax length / total length of *Atyascabra* freshwater shrimp in the Aboisso and Biaka localities

Localities	Sexes	Equation of regression	R^2	Allometry	N	Lt (mm)	Lc (mm)	t	P>F
Aboisso	M	$Lc= 0,691Lt^{0,952}$	0,734	Isometric	196	110,1±14,5	41,9±6,1	-1,07	0,284
	F	$Lc= 0,848Lt^{0,724}$	0,519	Negative	164	95,2±9,7	35,0±3,6	-22,37	< 0,05
	M+F	$Lc= 0,676Lt^{0,965}$	0,748	Isometric	360	103,3±14,6	38,8±6,2	0,65	0,519
Biaka	M	$Lc= 0,618Lt^{1,065}$	0,778	Positive	193	109,4±14,2	42,3±6,6	5,26	< 0,05
	F	$Lc= 0,834Lt^{0,742}$	0,492	Negative	167	95,0±10,4	35,0±4,0	-35,84	< 0,05
	M+F	$Lc= 0,604Lt^{1,034}$	0,747	Positive	360	102,6±14,5	38,9±6,6	6,87	< 0,05

**M: Males, F: Females, M + F: Combination of both sexes (males and females), Lt: Total length, Lc: Cephalothorax length, a: Regression constant, b: Regression coefficient, R^2: Coefficient of determination, N: Number of freshwater shrimps, t: Student's t-test.*

4. DISCUSSION

The average values of the physicochemical parameters of the water recorded during the test are approximately equal in the two localities. The water pH values obtained at Aboisso (7.54) and Biaka (7.39) are closed to neutral (pH = 7) and between 7 and 8. These recorded pH comply with the standards recommended in breeding and would be linked to the presence of calcium ions emanating from the degradation of rocks (granitoids and green rocks).Calcium is a key element for exchange in the soil. In fact, in aquaculture, calcium is used to raise the pH of the water (Griessinger et al., 1990). Its action is reinforced by the decomposition of organic matter by bacteria, thus making particles of all sizes available to young shrimp. The temporal variations in water temperature observed in the two localities would be related to the time of day. During the day, the rise in water temperature is related to the sunshine that warms the surface layer while the bottom layers remain more stable (Griessinger et al., 1990).In addition, the rise in temperature would stimulate food intake in fish (Muller-Feuga, 1990). Dissolved oxygen (DO) is the result of air action, phytoplankton activity and water turnover. It is high in the day and falls in the evening. The results of our work are above the required value in freshwater shrimp culture in French Guyane (> 2 mg/l) (Griessinger et al., 1990).The condition index k values obtained in *Atyascabra* Leach, 1815; specimens are relatively low in the study areas. But there is no major variation in the seasonal values of k in both males and females. The peaks observed in both sexes correspond to the moments of sexual rest. During this period, the shrimp store the nutrients necessary for maintenance needs but also for reproduction. The gonad will therefore experience development. The lowest values of k could correspond to the emission times of gametes in individuals. This decrease in k is more pronounced in females of crustaceans that mobilize their energy (proteins, fats) stored in the hepatopancreas and in the muscles during the maturation stage for egg-laying (Dounia, 2008, Boguhé et al., 2016). These same observations were made on the species *Macrobrachiummalcolmsonii* Milne-Edwards, 1844, *M. rosenbergii* De Man, 1879 and *M. lammarei* Milne-Edwards, 1837 (Shanju and Geraldine, 2011). In *A. scabra* Leach, 1815, the breeding season is generally between the GSP and the PSP. The results obtained are in agreement with those (Konan et al, 2015) at *Atyagabonensis*Giebel, 1875 from the Bandama river and at *Macrobrachiumvollenovenii*Herklots, 1857 and *Macrobrachiummacrobrachion*Herklots, 1851 from Lekki and Lagos lagoons (Lawal-Are and Owolabi, 2012). However, the k values of our work are higher than those (Boguhé et al., 2016) on the *M. macrobrachion*Herklots, 1851 of the Bandama river. The biometric study shows a similarity between the W/Lc, W/Lt and Lc/Lt relationships of *A. scabra* Leach, 1815 freshwater shrimp of the Bia river in the Aboisso and Biaka localities. Apart from the W/Lc relationship, negative allometry was recorded in females. As for the males, a positive allometry was obtained. The results observed in *A. scabra* Leach, 1815, freshwater shrimp are related either to an ontogenetic or genetic aspect, or to the pressure of freshwater shrimp catches or to the stress of reproduction. The recorded isometric allometry cases could be related to the age effect of the specimens. Thus, the case of isometry of *Macrobrachiumvollenhovenii*Herklots, 1857 was attributed to the effect of age (Etim and Sankare, 1998). This is more noticeable during the breeding season as shrimps spend more energy on egg-laying. Our results corroborate those obtained (Okayi and Iorkyaa, 2004) in females *Atyagabonensis*Giebel, 1875. Apart from the males of *M. macrobrachion*Herklots, 1851 of the Lekki Lagoon (Nigeria) who had isometric growth, the females of *M. vollenhovenii*Herklots, 1857 and *M. macrobrachion*Herklots, 1851 of the Lekki and Lagos lagoons (Nigeria) have a negative allometry (Lawal-are and Owolabi, 2012). *A. gabonensis*Giebel, 1875 living in the Mu river, had isometric growth [13]. These results could be due to a sufficiency of nutrients and living space (Arenada et al., 2008).

5. CONCLUSION

This study provided important information on the species *A. scabra* caught artisanally in the Bia river. Recorded environmental parameters provide information on the ecology of this fishery resource. The study showed that the *Atyascabra* species have a good adaptation in the Bia river. Females have negative allometry while males have positive allometry. the information gathered will allow us to consider a possible aquaculture of this species. The choice of male individuals will be acclaimed for their good growth.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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