

Size Frequency Distribution and Sexual Dimorphism of Tropical Freshwater *Atya Scabra* Leach, 1815 in The Bia River, South-East Region, Côte d'Ivoire

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Abstract

The freshwater shrimp *Atya scabra* Leach, 1815 is traditionally captured in the Bia river, in the area of the South-Comoé, precisely in Biaka and Aboisso. The aim of this study was to investigate if sexual differences could affect external morphology in freshwater shrimp *Atya scabra*, to determine sexual dimorphism related to morphological differences during the maturation in this species. Thus, morphometric measurements in 360 specimens of *A. Scabra* were examined at each study site for sexual dimorphism from August 2014 to July 2015. In Aboisso, mean values recorded at lpp, Lantn and Lantl were 8.5 ± 7.8 ; 78.5 ± 84.1 and 47.5 ± 47.4 mm in males. The average values obtained were respectively 6.5 ± 4.9 ; 58.5 ± 46 and 25 ± 24 mm for lpp, Lantn and Lantl in females. In Biaka, Mean values in males were 7.5 ± 7.8 ; 71.5 ± 55.9 and 37.5 ± 31.8 mm. In females, mean values recorded were 6 ± 5.7 ; 60 ± 50.9 and 27.5 ± 21.9 mm. Concerning the sexual dimorphism index, the χ^2 test showed that there is no significant difference ($P > 0.05$) between the SDI determined at the level of the width of cephalothorax and the 3rd pair of pereopod (lpp) in the specimens of *Atya scabra* of Aboisso and those of Biaka. Analysis of the data shows two modal of distribution in males, females and in both sexes combined. When considering the sexes combined, the young recruits have an average size (Lt) of 83 ± 3.8 mm while the latter was 107.6 ± 12.1 mm in the oldest freshwater shrimps of the species *A. scabra* captured in Aboisso. But in Biaka, the young individuals had an average size (Lt) of 81.4 ± 4.3 mm. As for the oldest individuals, the value of the estimated average size is 107.0 ± 11.2 mm in the sexes combined. The present study was made in order to have data on the size frequency distribution and the sexual dimorphism index of this species.

Keywords: *Atya scabra* – Size frequency distribution - Sexual dimorphism - Côte d'Ivoire.

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INTRODUCTION

Decapod crustaceans play an important role with fish in controlling the structuring of the aquatic community [1, 2]. In addition, shrimps from the Atyidae and Palaemonidae family are an important resource for the artisanal fishery [3-6]. Three species of the genus *Atya* are found in the freshwater ecosystems of Côte d'Ivoire. The shrimp *Atya gabonensis* Giebel, 1875; has been reported in the Bandama river [7, 8]. This species has been found in the Sassandra river and the Tanoé river [9]. The other two species are well known in the Bia river: *Atya Africana* Bouvier, 1904 and *Atya scabra* Leach, 1815. The genus *Atya* is commonly called “cocobé” by the people living near the Bia river (South-Comoé region) because it is devoid of clamps.

Previous studies have revealed that in Atyidae, the male sex is located at the 5th pair of pereopods and at the 3rd pair of pereopods in the female. Females are distinguished from males by the width of the 2nd pleura [5, 10]. The present work aims to describe some distinctive characteristics of the sexes in *Atya scabra* from the shrimps caught in the Bia river. A structure analysis of the fished population was also carried out. The basic data obtained will provide a better understanding of the study on the reproduction of *Atya scabra*. The aim of this study was to investigate if sexual differences could affect external morphology in freshwater shrimp *Atya scabra*, to determine sexual dimorphism related to morphological differences during the maturation in this species. 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.

This work will focus on the size frequency distribution and sexual dimorphism of the *Atya scabra* freshwater shrimp caught in the Bia river, South-Comoé region, Côte d'Ivoire.

MATERIAL AND METHODS

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.

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 the Côte d'Ivoire. The coastal river covers 9650 km² basin and flows into the lagoon Aby in South East. Two dams (Ayame I and Ayame II) were built on the main courses, respectively 22 to 28.7 km from the Aby lagoon [2]. 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 Bia river, 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).

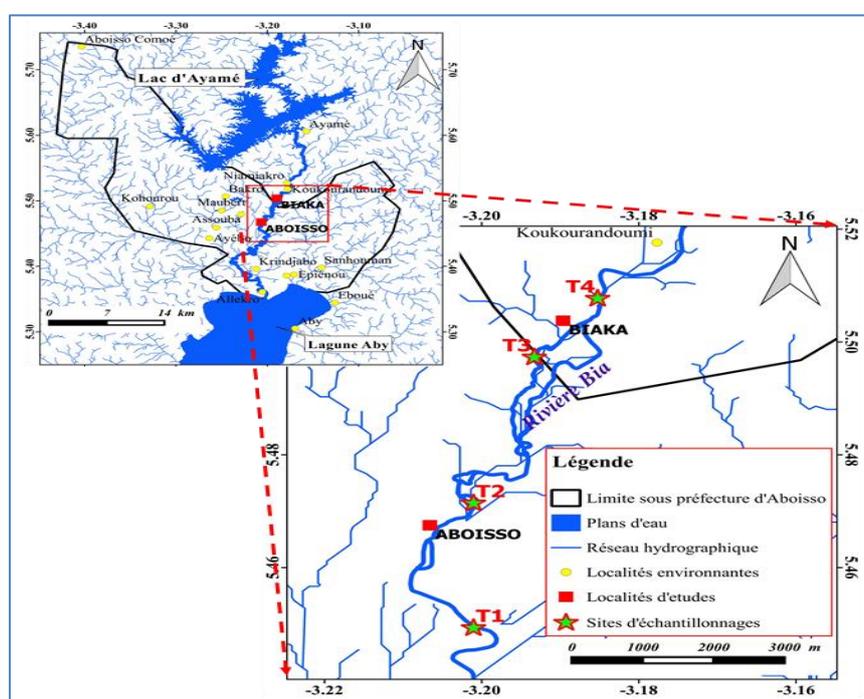


Fig-1: Geographical localization of the stations of Aboisso (T1 et T2) and Biaka (T3 et T4) (BNETD, 2016)

Morphometric surveys

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.

Sexual dimorphism index

The sexual dimorphism index (SDI) was determined from distinctive traits in males and females.

These traits are part of the freshwater shrimp's morphometric measurements. The SDI is the ratio of the length (width) of the appendix of the dominant sex to that of the weak sex. The SDI was calculated by the method used by [11] according to the formula:

$$SDI = \frac{X_1}{X_s} - 1$$

X_1 : Average value of the length (width) of the appendix of the dominant sex (male sex)

X_s : Average value of the length (width) of the appendix of the weak sex (female sex)

Statistical analysis of the biometric data

Student's t-test allowed a comparison of these coefficients for the same sex in Aboisso and Biaka. The SDIs determined in the specimens in the two localities

were compared in pairs using a G test which is the equivalent of the Chi-square test (χ^2). The R version 2.12.2 software was used to perform these tests. The significance level of these different tests is $\alpha = 0.05$.

RESULTS

Biometric parameters

Sexual dimorphism index

The table I presents the morphometric data of the appendages found in the *Atya scabra* Leach, 1815 specimens. The morphometric measurements concerned 196 males and 164 females at Aboisso. In males, mean values recorded at lpp, Lantn and Lantl were 8.5 ± 7.8 ; 78.5 ± 84.1 and 47.5 ± 47.4 mm. The average values

obtained were respectively 6.5 ± 4.9 ; 58.5 ± 46 and 25 ± 24 mm for lpp, Lantn and Lantl in females. In Biaka, morphometric measurements were performed on 193 males and 167 females. Mean values in males were 7.5 ± 7.8 ; 71.5 ± 55.9 and 37.5 ± 31.8 mm. In females, mean values recorded were 6 ± 5.7 ; 60 ± 50.9 and 27.5 ± 21.9 mm. Correspondingly, the χ^2 test showed no significant difference ($P > 0.05$) between sexually dimorphic indices (SDIs) determined at the large level of the cephalothorax and at the 3rd peripheral pair (lpp) in the specimens of *Atya scabra* Leach, 1815 of Aboisso and these of Biaka (table II). In addition, the χ^2 test revealed a significant difference in the length of antennae (Lantn) and antennules (Lantl) in the specimens of the localities studied ($P < 0.05$).

Table-I: Comparison of dimorphisms in *Atya scabra* specimens in the localities studied (measurements are in mm)

	Aboisso						Biaka					
	lpp		Lantn		Lantl		lpp		Lantn		Lantl	
	M	F	M	F	M	F	M	F	M	F	M	F
N	196	164	196	164	196	164	193	167	193	167	193	167
Maximum	14	10	138	91	81	42	13	10	111	96	60	43
Minimum	3	3	19	26	14	8	2	2	32	24	15	12
Average	8,5	6,5	78,5	58,5	47,5	25,0	7,5	6,0	71,5	60,0	37,5	27,5
Ecart-type	7,8	4,9	84,1	46,0	47,4	24,0	7,8	5,7	55,9	50,9	31,8	21,9

N: Number of freshwater shrimp, M: Male, F: Female, lpp: Width of the 3rd pair of pereopods, Lantn: Length of the antennae, Lantl: Length of the antennules

Table-II: Comparison of SDI in *Atya scabra* specimens in localities studied

Morphometric variables	Aboisso			Biaka				
	M	F	SDI	M	F	SDI	χ^2	$P > \chi^2$
Cephalothorax width (lc)	+	-	0,187	+	-	0,203	0,066	0,798
Width 3rd pair pereopod (lpp)	+	-	0,31	+	-	0,25	0,64	0,420
Length of antennae (Lantn)	+	-	0,34	+	-	0,19	4,30	0,038
Length of antennules (Lantl)	+	-	0,90	+	-	0,36	23,91	< 0,05

(+): Individual with the highest average, (-): Individual with the lowest average, χ^2 : Chi-square value, P: Probability, N: Number of freshwater shrimp, M: Male, F: Female, lpp: Width of the third pair of pereopods, Lantn: Length of the antennae, Lantl: Length of the antennules

Size frequency distribution analysis

Table III shows the average sizes (Lt) of *Atya scabra* Leach, 1815 males, females and sexes combined in the two study areas. In the locality of Aboisso, males and females have respective average sizes of $104.0 \pm$

1.5 mm and 95.0 ± 9.2 mm. An average size of 103.3 ± 1.5 mm was obtained in the sexes combined. The minimum and maximum size obtained in Aboisso males was 59 and 145 mm, respectively. As for females, the minimum size recorded was 66 mm and 117 mm for the maximum size. For the locality of Biaka, the average sizes recorded were 109.4 ± 1.4 mm in males, 95.0 ± 1.0 mm in females and 102.6 ± 1.4 mm in the sexes combined. In males, the minimum size was 74 mm and 144 mm for the maximum size. As for females, the minimum and maximum size obtained was 67 and 133 mm.

Tableau-III: Average sizes (Lt) of *Atya scabra* males, females and sexes combined in the two study areas (in mm)

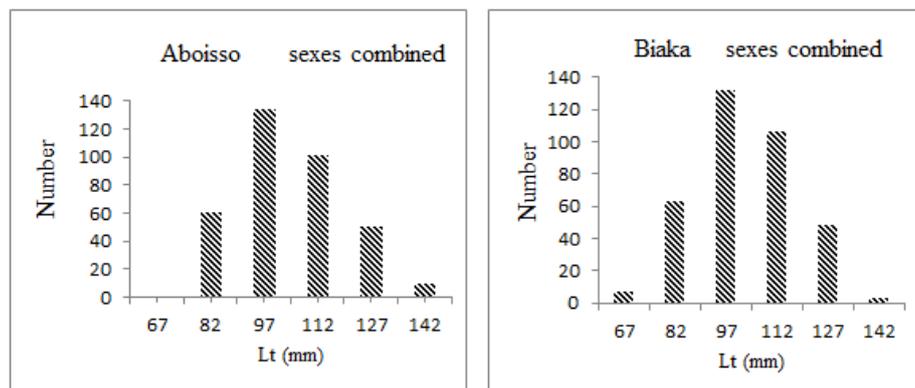
Localities	Males	Females	Sexes combined
Aboisso	$104,0 \pm 1,5$	$95,0 \pm 9,2$	$103,3 \pm 1,5$
Biaka	$109,4 \pm 1,4$	$95,0 \pm 1,0$	$102,6 \pm 1,4$

Table-IV: Modal composition of the size frequency distribution (Lt) in mm of *Atya scabra* males, females and sexes combined in the two study areas

Localities	Modal	Males	Females	Sexes combined
Aboisso	1	83,1±4,1	82,9±3,7	83,0±3,8
	2	102,6±5,1	99,4±7,3	107,6±12,1
Biaka	1	80,2±3,5	81,9±4,1	81,4±4,3
	2	112,6±10,6	100,0±7,1	107,0±11,2

Figure 2 shows the size frequency distribution of the *Atya scabra* freshwater shrimp obtained during sampling. Analysis of the histograms shows two modal of distribution in males, females and in both sexes combined. In Aboisso, the average sizes (Lt) observed in the first modal in males are greater (83.1 ± 4.1 mm) compared to those recorded in females (82.9 ± 3.7 mm) (Table IV). This modal is made up of young recruits of similar average size. Mode 2 consists of older individuals with an average length (Lt) of 102.6 ± 5.1 mm for males and 99.4 ± 7.3 mm for females. The males therefore have a larger average size (Lt) than that of the females. In all the freshwater shrimps of the species *A. scabra* captured, the young recruits have an average size (Lt) of 83 ± 3.8 mm while the latter was

107.6 ± 12.1 mm in the oldest (figure 5). In Biaka, two modes have been identified. The first mode is composed of male specimens of average size of 80.2 ± 3.5 mm and 81.9 ± 4.1 mm in females (Table IV). In this mode, females have a similar strength to males. Females have a longer average length than that of males. The second mode groups the majority of elderly individuals with average sizes estimated at 112.6 ± 10.6 mm in males and 100.0 ± 7.1 mm in females (Table IV). The average length (Lt) of males was greater than that of females in this mode. When considering the sexes combined, the young individuals had an average size (Lt) of 81.4 ± 4.3 mm. As for the oldest individuals, the value of the estimated average size is 107.0 ± 11.2 mm (Table IV).

**Fig-2: Histograms of freshwater shrimp size frequencies of *Atya scabra* Leach, 1815**

DISCUSSION

The study of the population structure is generally based on the age criterion [12]. In the case of our work, there is no clue on the specimen allowing to determine it with precision. The estimate on population structuring is based on the size frequencies taken individually. In both locations, the average size of the *Atya scabra* Leach, 1815 males was between 104.0 and 109.4 mm. In contrast, in females, the mean size recorded was 95.0 mm. As for the two sexes combined, the size obtained fluctuated from 102.6 to 103.3 mm. The population structure that includes two modes in the size class for each sex and for both sexes is the result of the fishing technique used which is diving. The hand used to collect the specimens between the rocks, opts rather in the choice of the larger individuals, having a great commercial value. This fishery would tend to target mature individuals. In the species *Atya scabra* Leach, 1815, small individuals would be released in their natural environment or reserved for the

fishermen's household. This capture technical is opposed to the method of trawls or nets or even gillnets, which depending on the mesh size can take all layers of the shrimp population [6, 12]. In addition, the size distribution of individuals could provide information on the exploitation state of shrimp. Indeed, the rise in fishing effort and anthropogenic pollution lead to a reduction in the size of the specimens [5-13]. This observation was made in Brazil where the *Atya scabra* shrimp is overexploited in the northern states [5].

Concerning sexual dimorphism, it is of capital interest for ecologists and aquaculturists. It helps to establish a balance or proportion of the sexes. In *A. scabra* Leach, 1815, sexual dimorphism is very pronounced. Observations had been made on the importance of the width of male cephalothorax relative to females and the width of the female pleura compared to males by [5] and [14]. Except for the other dimorphic parameters in *Atya scabra* Leach, 1815, a significant difference was observed in the sexual dimorphism

index (SDI) of the lengths of the antennas and antennules. This difference may be due to fishing pressure on specimens in the Biaka locality [14]. The diving technique used to capture freshwater shrimp is believed to be the cause of the mutilation of these organs.

CONCLUSION

This study provided basic information on the species *A. scabra* caught artisanally in the Bia river. In Aboisso as in Biaka, the specimens of captured *Atya scabra* were dominated by aged freshwater shrimps. Sexual dimorphism is pronounced between sexes with larger average sizes in males. The information collected will lay the groundwork for potential aquaculture of *A. scabra* freshwater shrimp. It would be interesting to study of this species.

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