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RESEARCH ARTICLE

TAXONOMIC INVENTORY OF SHRIMPS OF CAVALLY RIVER IN COTE D'IVOIRE

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ABSTRACT

Background: The present study is the first of the genre in the upper course of Cavally. **Objectives:** It aims to make a systematic inventory of shrimps. Methods: Samplings were made on the upper portion of the river in a mining environment and then upstream and downstream of this area between September 2015 and August 2016. Shrimps were caught monthly using dip nets and keep nets. **Results:** Totally 1051 individuals were harvested. They belong to the families of Palaemonidae and Atyidae. Five valid species (*Macrobrachium vollenhovenii, M. macrobrachion, M. felicinum, M. thysi and M. dux*) and five invalid species (*Caridina sp, Macrobrachium sp1, M. sp2, M. sp3* and *M. sp4*) have been identified. Their distribution along the river seems to be negatively influenced by the mining area where fewer numbers species were recorded than those of the upstream and downstream sites. **Conclusion:** This study revealed the existence of new taxa for Côte d'Ivoire.

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INTRODUCTION

Shrimps are a zoological group of the branching of arthropods and sub-branching of crustaceans. Their interests for humanity are diverse and varied. They are of socio-economic importance to the populations (Fischer *et al*., 1981; CSAO, 2006; FAO, 2008; Mahyao *et al*., 2010; De Grave & Fransen, 2011; Boucharel, 2012; Traoré, 2013; Mahyao *et al*., 2014) because they provide dietary protein and generate employment and income for the population (Gooré Bi, 1998; Boghué, 2015). They intervene in the regulation of aquatic ecosystems through their role in the food network (Fossati *et al*., 2002 ; March *et al*., 2002 ; Konan, 2009). In Côte d'Ivoire, research works have been carried out in the large basins (Comoé, Bandama and Sassandra rivers) (N'Zi, 2007), in small basins (Bia River, Agnébi River, etc.) (Gooré Bi, 1998), in the lakes (Taabo, Kossou etc.) (Boghué, 2015) and in the lagoons (Aby, Ehy, etc.) (Djiriéoulou, 2017) The Cavally River, one of the four major rivers that cross the Côte d'Ivoire shelters many species of fauna including shrimp species, but this river has not been studied by the previous authors on shrimp fauna. The present work mainly aims to shrimps systematical inventory of Cavally River for contribuating to the updating databases of national and global biodiversity.

MATERIALS AND METHODS

Study area: Cavally is a River in West Africa running from north of Mont Nimba in Guinea at an altitude of 600 m, through Côte d'Ivoire, to Zwedru in Liberia, and back to the border with Côte d'Ivoire. It forms the southern two-thirds of the international boundary between Liberia and Côte d'Ivoire (Girard, 1974). Long of 700 km, it catchment area is 30 600 km^2. The Ivorian part of the Cavally River is 515 km long with a catchment area of 15000 km^2. Four sampling stations were selected on the Cavally River and its tributaries on both sides of the industrial and mining zone "Ity": one station Z1 (7°05′43.0′′N - 8°06′28.4′′) is an upstream; one station Z2 (6°52′33.52′′N - 8°06′29.21′′W) an intermediate stream and two stations [Z3 (6°50′30.12′′N - 8°06′59.03′′W) and Z4 (6°40′22.1′′N - 8°16′18.9′′W)] in downstream **(**Figure 1). The choice of stations were made to measure impact of the ''Ity'' gold mine operation on shrimps population and the environment of the area.

Shrimp sampling: Shrimps were sampled monthly from September 2015 to August 2016 using a dip net (25 cm opening diameter and 2 mm mesh size). Fishing is done by one person according to Djiriéoulou (2017). The dip net is immersed in water and then removed after a period of time sufficient to optimize shrimp capture. At each site, the same catch effort (15 min of fishing) was applied. In addition to the dip net, keep nets baited with fresh or precooked cassava residues were used. The captured shrimps were kept in jars containing 10% titrated formaldehyde and labeled. The tag shows the date and time of the harvest, the name of the sampling station, the type of catching gear and the type of fishing practiced Voir légende et titre de la carte Voir légende et titre de la carte.

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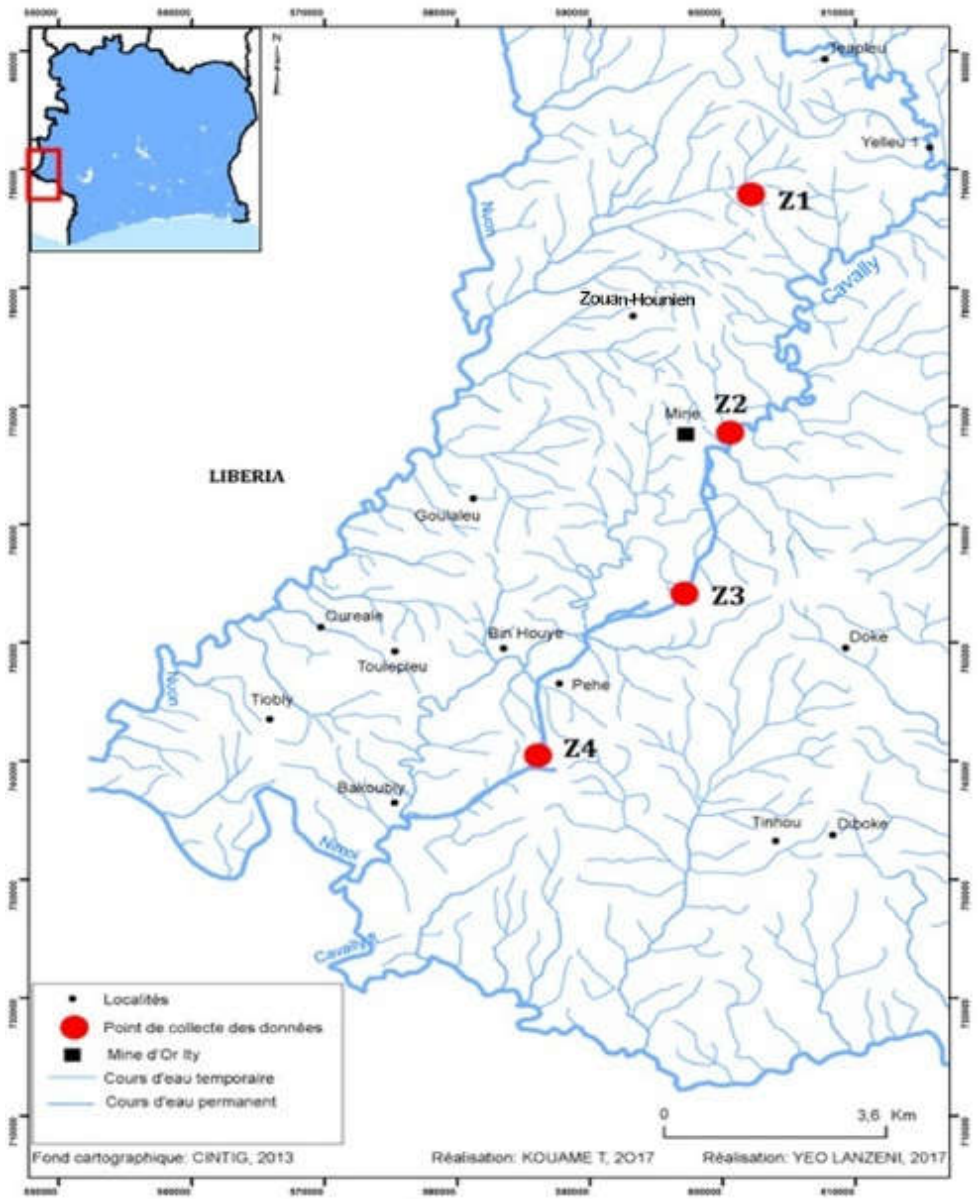


Figure 1. Stations sampled (●) and mining zone "Ity" (■) in the upper Cavally River (Cote d'Ivoire) from September 2015 to August 2016

Measurement and identification of shrimps: A vernier calliper of the MITUTOYO DIAL CALIPER type (0-300 mm) with a precision of 0.01 mm and an entomological needle were used respectively for the collection of metric and meristic characters. The number and types of descriptors considered are identical to those of Konan (2009). During the measurements, the shrimp is lying on the ventral side, the head turned to the left of the observer. A sensitive balance of the Sartorius TE153S type (precision 0.001g, 150 g capacity) and another of the type DENVER SI-4002 (accuracy 0.01g, reach 4000 g) were used for the weighing of individuals. A binocular loupe Vision SX25 type was used to observe small individuals. Drawings were also made to highlight the most discriminating characters in the different specimens. Finally, shrimps identification was made using determination's keys of Monod (1966 and 1980), Powell (1982), Gooré Bi *et al*. (2002) and Konan (2009).

Data Analysis: Reports were made between some metric descriptors (Carapace Length by. Standard Length: LC / LS, Rostrum Length by Carapace Length: LR / LC, Carp Length by Length of the Merus: LCA / LM, etc.). These ratios were then expressed as a percentage. "Species-without-dimension" methodology of Mayr (1970) was used in the identification of different groups of shrimps. The use of this methodology is due to the fact that it has already been used in systematic shrimps (Gooré Bi, 1998 & Konan 2009). According to these authors, this method is more suitable for solving identification problems. Thus, its application has been very successful in the systematic reviews of many species, particularly african fish (Thys van den Audenaerde, 1970; Teugels, 1986; Gourène, 1988; Tshibwabwa, 1997). All analyzes were done using Excel and Word software.

RESULTS

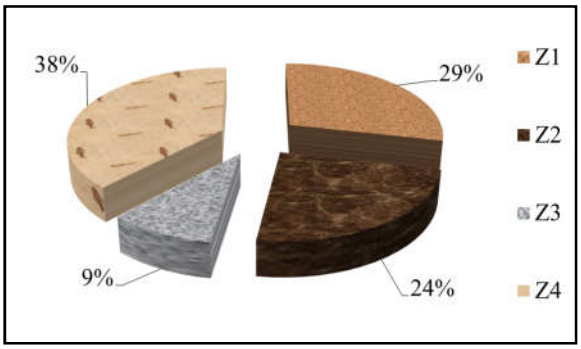
A total of 1051 individuals were examined. They belong to two families separating individuals into two groups: Atyidae (G1 group) and Palaemonidae (G2 group) (Table 1). Atyidae are represented by 66 individuals or 6.28% of the specimens collected. They have all been attached to the genus *Caridina*. They constitute a homogeneous group at the meristic, metric and morphological level;That means that they are individuals

of the same species. However, in the current state of the available keys, the identification stopped at the genus. So it is about species *Caridina* sp. For the Palaemonidae (G2 group), 985 individuals or 93.72% of the samples were attached to them. They all belong to the *Macrobrachium* genus. Considering the morphological, metric and meristic characteristics, this lot is heterogeneous and therefore consists of several homogeneous groups.

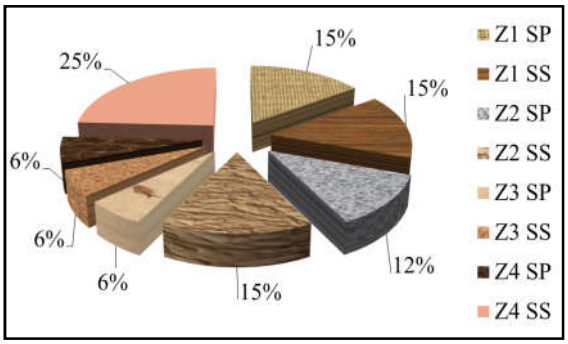
At the current state of available identification keys, 5 species have been identified in this group. These are *Macrobrachium vollenhovenii* (383 individuals), *M. macrobrachion* (175 individuals), *M. felicinum* (14 individuals), *M. dux* (321 individuals) and *M. thysi* (11 individuals) representing a total of 904 individuals. The rest of the individuals (147 individuals) could not be identified until the species.

Table 1. List of shrimps inventoried in the upper Cavally River

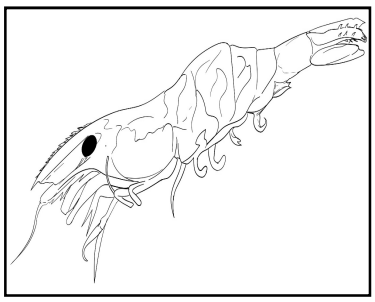
			Sampling stations			
Families	Genres	Species	Z1	Z2	Z3	Z4
Atyidae	*Caridina*	*Caridina* sp				+
Palaemonidae	*Macrobrachium*	*Macrobrachium dux* (Lenz, 1910)	+	+		+
		Macrobrachium felicinum, Holthuis,1949	+			
		Macrobrachium macrobrachion (Herklots, 1851)	+	+	+	+
		Macrobrachium thysi Powell, 1980		+		
		Macrobrachium vollenhovenii (Herklots, 1857)	+	+	+	+
		Macrobrachium sp1	+	+		+
		Macrobrachium sp2				+
		Macrobrachium sp3	+			+
		Macrobrachium sp4				+
Total 2	2	10	6	5	2	8



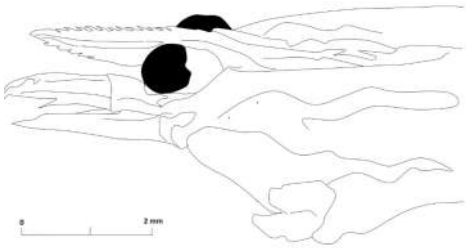
A: Percentage of number of species by station



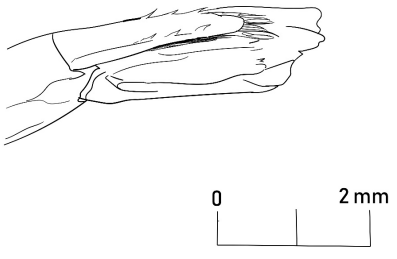
B : Percentage of species by season



a



B



c

d

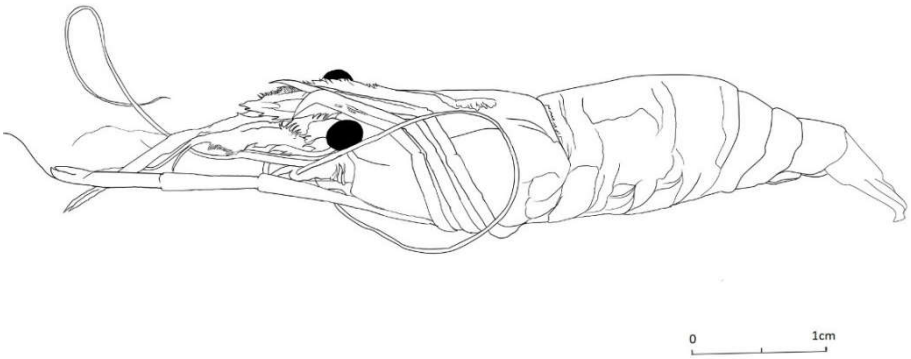
Figure 2. General morphology of *Caridina* shrimps caught in Cavally between September 2015 and August 2016. A. Whole individual; b. Morphology of the rostrum; c. Morphology of the telson; d. Photo of an individual

To clarify their systematic position, these individuals were subdivided into four affinity subgroups corresponding to the species *Macrobrachium* sp1, *M*. sp2, *M*. sp3 and *M*. sp4.Thus, the species richness of the shrimps of the upper Cavally River consists of 10 species, 5 valid and 5 invalid. It varies according to the stations (Table1) and seasons (Figure 2). Pending the determination until the species of the invalid's species, a diagnosis of each of these species is made in this study.

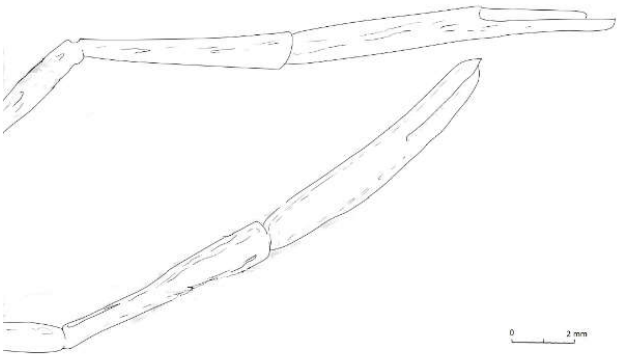
Diagnosis of unidentified individuals: It concerns individuals or groups of individuals that have not been attached to any of the known species to that day.

Shrimp of the family Atyidae *Caridina* sp

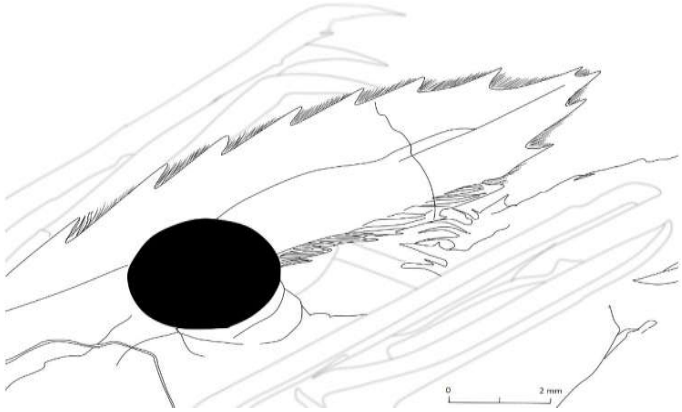
Description: rostrum with teeth on both sides with a short, smooth distal portion; 15 to 23 teeth on the dorsal surface against 5 to 10 on the ventral side hence the dental formula:



a: whole individual of *Macrobrachium* sp1



b: homogeneous legs of *Macrobrachium* sp1



c: rostrum of *Macrobrachium* sp1

d: photo of an individual

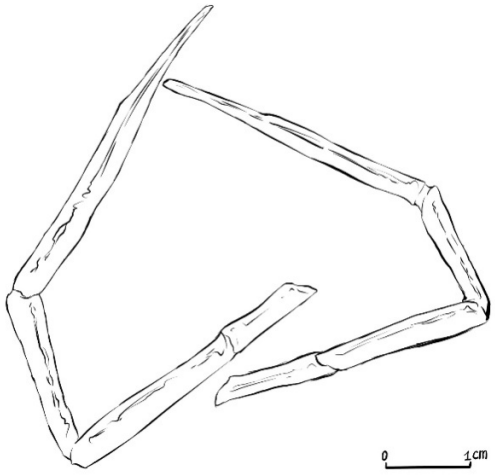
Figure 3. Different discriminant descriptors of *Macrobrachium* sp1 captured in the Cavally River September 2015 and August 2016

15-23 / 5-10, 2 to 3 post-orbital teeth, rostrum longer than the carapace and measuring approximately 3 and a half times the length of the carapace (LR / LC: 376%) and indented in its distal portion to the apex. Carp shorter than carapace (LCA / LC = 51%) and merus (LCA / LM = 67%), longer than palm (LM / LPA = 172%), two rows of 3 to 4 spines on the telson (Figure 2) Sixty-six individuals were observed in the samples taken. Maximum total length (LT) observed = 21.41 mm with total weight (TW) = 0.086 g Shrimp of the family Palaemonidae.

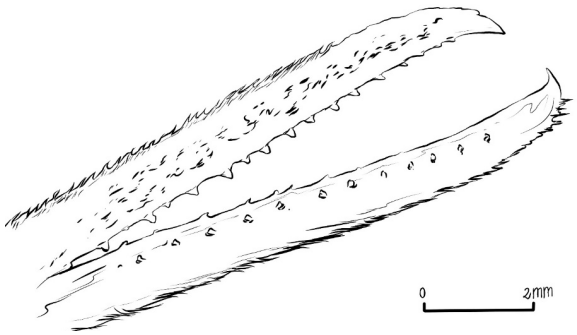
Macrobrachium sp1

Description: legs of the second pair homogeneous and hail with articles (ischion, merus, carp and palm) of flared form towards the anterior vertex; pubescent legs especially on the outer edge of the palm and fingers. Carp less longer than merus (94% to 98% times that of the merus) and that of the carapace (LCA / LC = 56.52% to 59.61%); palm length greater than that of the merus (LM / LPA = 93%), ischium and finger. Ischion shorter than the merus but longer than the fingers; fingers of the claws coated with fine bristles and bearing teeth on their inner edge: 2 to 10 on the fixed finger and 4 to 5 on the movable finger. Latero-external side of the different articles of the second pair of legs traversed by a gutter, well marked on the palms. Lamellar and curved rostrum with its apical tip oriented in the prolongation of the antennal peduncle; rostrum shorter than carapace (LR / LC = 87.90% to 95.71%) and longer or equal to the peduncle antennular but inferior to the antennal scale with 8 to 9 teeth on the dorsal edge against 3 to 5 on the ventral edge giving the dental formula: 8-9 / 3-5. Presence of 2 post-orbital teeth but no thorns, teeth of the upper border of the rostrum slightly separated in the basal part of the rostrum, apical portion of the

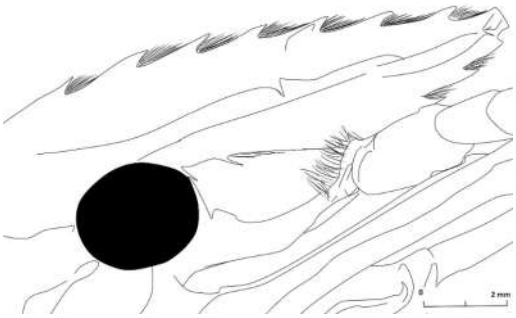
a : whole individual of *Macrobrachium* sp2



b : heterogeneous legs *Macrobrachium* sp2



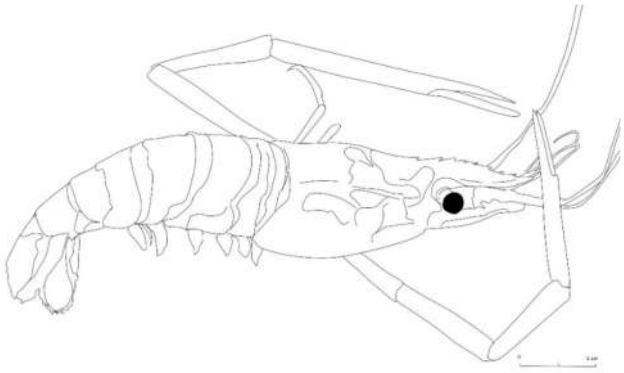
c: fingers of the second pair of legs with multiple teeth



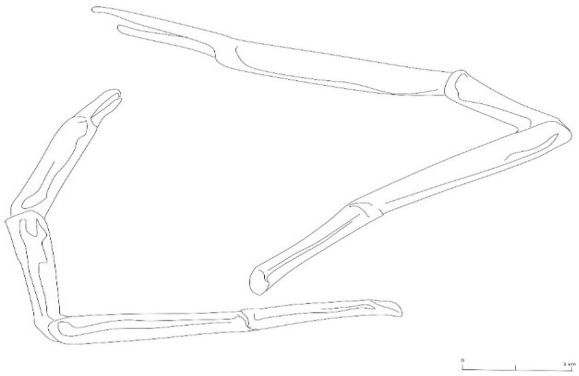
d: rostrum of *Macrobrachium* sp2

e: photo of an individual

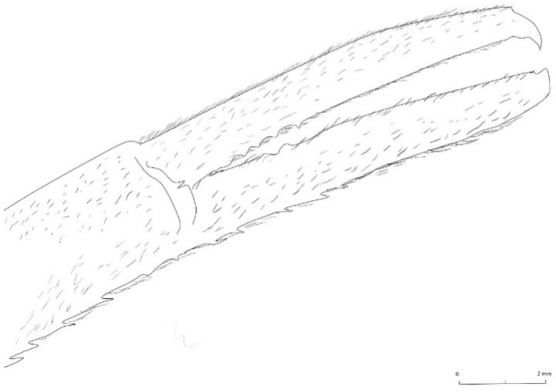
Figure 4. Different discriminant descriptors of *Macrobrachium* sp2 captured in the Cavally River September 2015 and August 2016



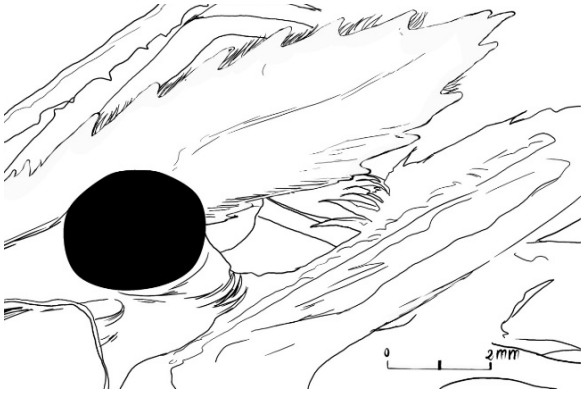
a: whole individual of *Macrobrachium* sp3



b : heterogeneous legs *Macrobrachium* sp3



c: fingers of the second pair of legs



d : rostrum of *Macrobrachium* sp3

e. photo of an individual

Figure 5. Different discriminant descriptors of *Macrobrachium* sp3 captured in the Cavally River September 2015 and August 2016

rostrum smooth on the dorsal surface, presence of a pair of two spines on the telson; distance between the two pairs of spines of the telson superior to that of the spines of the previous pair, telson terminated by a pair of movable spines at the lateral edges (Figure 3). Thirty-two individuals were obtained after sampling

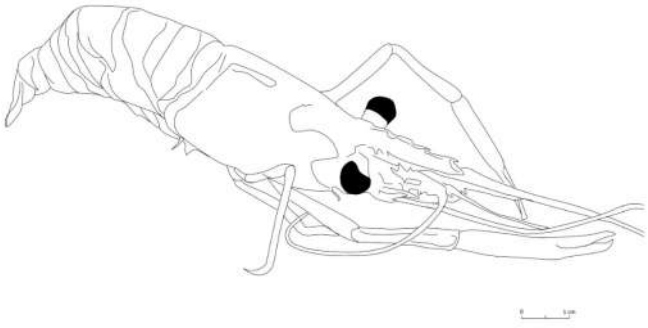
Maximum total length (LT) observed = 53.26 mm with total weight (TW) = 3.845 g

Macrobrachium sp2

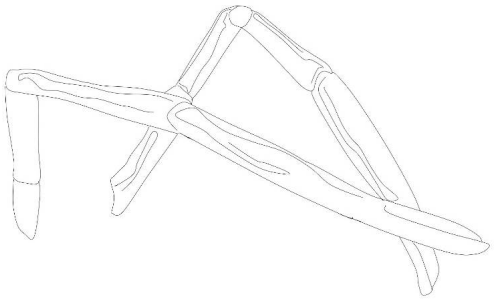
Description: second pair of heterogeneous legs with the articles (carp, merus and palm) elongated, covered with spines much more erected on the inner side than external, finger more pubescent than other articles; carp shorter than carapace (LCA / LC = 67%), the merus (LCA / LM = 98%) and the palm (LCA / LPA = 83%); palm making about one and a half times the length of the finger (LPA / LDO = 166%); presence of numerous conical teeth on the inner face of the fingers (18 to 23 on the fixed must against 16 to 20 on the mobile finger). Rostrum lamellar and exceeding the antennal foot but shorter than the antennal scale, rostrum longer than the carapace (LR / LC = 101%) with 8 to 10 teeth on the dorsal surface against 3 to 4 on the ventral side, hence the dental formula: 8-10 / 3-4, 1 to 2 post-orbital teeth, identical teeth on both rostral edges; teeth of the dorsal margin slightly separated at the base of the rostrum, two rows two spines on the telson (Figure 4). Twenty-three individuals were observed during surveys. Maximum total length (LT) observed = 85.74 mm; total weight (TW) = 5.729 g

Macrobrachium sp3

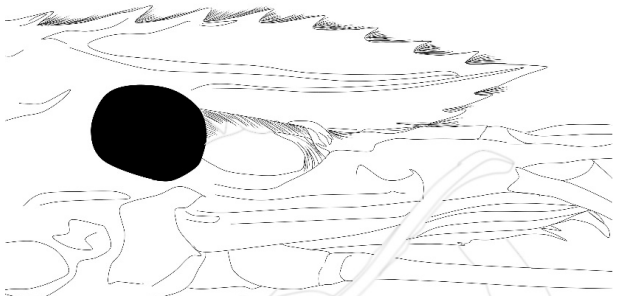
Description: second pair of asymmetrical legs with elongated articles (carp, merus and palm) covered with spines much more



a: whole individual of *Macrobrachium* sp4



b: second pair of homogeneous legs of *Macrobrachium* sp4



c : rostrum of *Macrobrachium* sp4

d: photo of an individual

Figure 6. Different discriminant descriptors of *Macrobrachium* sp4 captured in the Cavally River September 2015 and August 2016

erect on the inner side than on the outer side, finger more pubescent than other articles, carp shorter than carapace (LCA / LC = 57%) and merus (LCA / LM = 93%), merus shorter than palm (LM / LPA = 89%), length of the palm making about one and a half times that of the finger (LPA / LDO = 1.55), presence of 5 to 6 teeth on the fixed finger and the movable finger, rostrum shorter than the carapace (LR / LC = 79%) and inferior to the antennal scale but equal to the antennal peduncle, lamellar and bearing 8-10 on its dorsal edge against 3-5 on the ventral edge, two post-orbital teeth, the dental formula is: 8-10 / 3-5, two rows of two spines on the telson (Figure 5) Sixteen individuals were counted in the samples collected.

Maximum total length (LT) observed = 65.47 mm; total weight (TW) = 4.504 g

***Macrobrachium* sp4**

Description: second pair of homogeneous legs and hail, carp longer than the merus (LCA / LM = 101%) but less longer than the carapace (59.52% LC), merus shorter than palm (LM / LPA = 91%), claws with shorter fingers than the merus (LM / LDO = 164%), carp (LCA / LDO = 194%) and palm (LPA / LDO = 137%), presence of 4 teeth on the inner edge of the fixed finger and 5 on the movable finger; lenticular rostrum, tip of rostrum appreciably at the same level as that of antennal scales. Rostrum having 7 teeth on its dorsal edge against 3 to 4 on the ventral one; the dental formula is 7 / 3-4, presence of one post-orbital tooth, and 3 to 4 spines on the telson (Figure 6).

Ten individuals were observed in the samples.

Maximum total length (LT) observed = 60.34 mm with a total weight (TW) = 3.482 g.

DISCUSSION

In the upper Cavally River, we counted ten species, whom five were valid (Kouamé *et al.,* 2018) and five invalid ones ranked into two large families. This taxonomic diversity at the family level is identical to that obtained by Gooré Bi (1998), N'Zi (2007) and Konan (2009). In addition, our results differ from those obtained by Djiriéoulou (2017) who obtained four families. This difference could be explained by the fact that this author, contrary to our studies, worked in three different types of ecosystems (marsh, fluviatile and lagoon). Specifically, the number of species in this study is significantly lower than that reported by N'Zi (2007) and Djiriéoulou (2017) (13 species) and Konan (2009) (9 species). But superior to those of the works of Camara *et al.* (2009) (3 species). The difference between our results and those of previous works could be explained by the diversity of habitats visited and the techniques used for sampling (dip net and keep nets). Reduction of the volume of water during the dry season increases the performance of these techniques. According to Didier (1997), environmental heterogeneity ensures a higher species richness than that likely to be encountered under homogeneous environmental conditions. In addition, for Graça *et al.* (2004), large study areas offer a diversity of habitats to exploit. Spatially, the upstream (6 species) and downstream (8 species) areas of the mining domain recorded the greatest diversity. Contrary, the areas within the domain have a relatively low diversity (2 species). This reduction in wealth is certainly due to mining activity. A similar finding was made by Kouamélan *et al*. (2003), N'Zi *et al.* (2008), Yao *et al.* (2005) and Aboua (2012) during their works on the Boubo River, Comoé and Bandama Rivers, respectively. According to these authors, irregular distributions of species richness in these rivers are due to human activities.

Conclusion

A total of ten shrimp species of which five were valid (*Macrobrachium vollenhovenii*, *M. macrobrachion*, *M. dux*, *M. thysi* and *M. felicinun*) were sampled on all the stations explored. The lowest species richness was recorded at stations in the vicinity of the mining area. This study focused on the upper Cavally River. Other studies covering the rest of this watercourse should be considered. For invalid species, genetic studies should also be considered for identification until the species.

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