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Socio-economic and cultural values of two species of crabs (*Cardisoma armatum* Herklots and *Callinectes amnicola* Rochebrune) in Southern Benin, Africa: Management of post-harvest losses and exoskeletons

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Crabs play an important economic and bio-ecological role in most aquatic ecosystems and occupy an important place in the variety of trophic niches. *Callinectes amnicola* Rochebrune and *Cardisoma armatum* Herklots are two edible species widely exploited in Benin. The present work aims to i) evaluate the socio-economic and cultural importance of those two crab species, ii) analyze the dynamics of the value chain, and iii) monitor the flow of their resources. Surveys were carried out during February 2018 to September 2019 among target groups in Ouémé, Atlantic and Littoral administrative Departments of Benin through structured and semi-structured interview methods as well as free interview. Results indicate that fishermen/catchers (12.76%), wholesalers/collectors (25.53%) and retailers (61.70%) are the actors involved in the crab value chain. Between 40 and 50% of fishery products are exported to markets in Togo and Ghana. Not all of the exoskeletons resulting from post-capture losses and those resulting from treatments for consumption, in particular *C. amnicola* (74.46%) and *C. armatum* (76.59%) are used, which poses an environmental management problem. The gains made in the sector vary from 8.000±2.828 Financial Community African Franc (FCAF) (*C. amnicola*) to 20.000±21.213 FCAF (*C. armatum*). The study found that crabs (*C. armatum* and *C. amnicola*) have remarkable socio-economic importance in Southern Benin, Africa.

Key words: Crab, economic analysis, monitoring, Benin.

INTRODUCTION

In Africa, lagoon and mangrove complexes play important ecological, economic and socio-cultural roles in

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the existence of coastal communities by providing a variety of plant products, fish and crustaceans (Sowman, 2006). Among a crustaceans group, crabs take an important place. Thirty-two crab species are reported in lagoons or different habitats ranging from the marine environment to the firm ground from Côte d'Ivoire to Nigeria. These species are divided into twenty-three genera and thirteen families (Dessouassi et al., 2018). According to available literature, the highest species richness of lagoon crabs is observed in Nigeria (twenty-three species) and the lowest is observed in Togo (two species). Regional surveys conducted during colonial times and around the period of the independence movement in West Africa have not included all the lagoons in such countries as Benin or Côte d'Ivoire (Dessouassi et al., 2018). Nowadays, in lagoon systems of South Benin, the exploitation of fishery resources constitutes an essential economic activity that contributes to the livelihoods of neighboring populations (Goussanou et al., 2017a). The lagoon systems of southern Benin contain a wide variety of crustaceans, including *Cardisoma armatum* Herklots and *Callinectes amnicola* Rochebrune (Goussanou et al., 2017a; Dessouassi et al., 2018). These two abundant aquatic species are extensively caught for own consumption and trade at the Lake Nokoué (Tohozin, 2012) and Porto-Novo lagoon (Goussanou et al., 2017b).

Crab fishing in Benin aquatic environments was considered as an accessory fishery compared to the fish that made up almost all the landings. Following the fishes decrease reflected by the decrease in captures, fishermen turned to crab fishing of which exploitation intensifies from day to day in Benin aquatic environments (Goussanou et al., 2017b). Crabs are an important source of protein and several species are caught and traded by local populations (Olalekan et al., 2015). The knowledge based on lagoon crabs is variable in Gulf of Guinea countries, namely from Côte d'Ivoire to Nigeria. Some works were conducted on *C. armatum* and *C. amnicola* species in West Africa and provided information on diversity (Dessouassi et al., 2018), ecological (Shahdadi and Schubart, 2017), biology (George and Abowei, 2009), reproduction (Jivoff et al., 2007), morphological description, structural characteristics, and the growth of the two main species of crab (Goussanou et al., 2017b). Information in relation with the socio-cultural importance of these species is not available.

In general, artisanal fishermen harvest a wide variety of fish, crustaceans and molluscs and use them for various domestic purposes. Therefore, wetland organisms such as plankton, crabs and fish are linked to the human food chain. It is evident that most of the coastal areas of West Africa depend on mangroves for their survival, subsistence and income. However, several aquatic resources such as crabs are today harvested in an unsustainable and uncontrolled manner, both on a commercial scale and by artisanal fishermen (Akegbejo-Samsons and Omoniyi, 2009).

In several countries, the use of crabs is essentially the consumption of their flesh, on the other hand the exoskeletons are often regarded as waste and do not make much use. The management and impact of this waste on the environment is no less. The crustacean shells provide a high proportion of lime carbonate and a nitrogenous material, chitin, analogous to the keratin of the hairs and nails of terrestrial animals, little or no digestible, only disintegrating with extreme slowness soil where it will be buried (Gustave, 1929). The biodegradation of the shell of crustaceans is very slow (Kandra et al., 2012). There is an urgent need to treat and use crustacean waste, which contains several bioactive compounds such as chitin, pigments, amino acids and fatty acids (Kandra et al., 2012).

Literature review on the exploitation and production of *Callinectes* sp. and *Cardisoma* sp. in West Africa (d'Almeida and Fiogbé, 2008) indicates an insufficient body of knowledge about these two species despite their socio-economic relevance. The authors have suggested that knowledge be improved relative to the estimation and exploitation of stocks as well as to the biological understanding necessary for a successful breeding of *Callinectes amnicola* Rochebrune and *Cardisoma armatum* Herklots. Indeed, in Southern Benin, information on the different uses and the socio-cultural importance of *C. armatum* and *C. amnicola* is not well understood. The same applies for the use and management of the exoskeletons of the two crab species in southern Benin for better environmental management. This study aims to assess the socio-economic and cultural importance of these two crab species, and to analyze the dynamics of their value chain, as well as monitor the flow of their resources. Achieving the objectives of this work will provide new knowledge about the resources of the study area. It is expected also to improve practices and management of aquatic resources, mainly crabs, and incomes of stakeholders in the value chain of these species.

MATERIALS AND METHODS

Identification of the study area

The study area was identified after a documentary study that made it possible to target the large crab production areas in Southern Benin. A prospective study was carried out during February 2018 to September 2019 in these areas through meetings with community leaders and actors involved in the crab value chain. This made it possible to select areas to be taken into account for the surveys and target groups to be surveyed. Additional criteria that were taken into account included accessibility of the area and the openness of the natives to participate in the study. At the end of the prospective study, 10 municipalities and 2 districts (Figure 1) belonging to three Departments (Atlantic, Littoral and Ouémé) were selected for surveying.

Study area

The study area belongs to the Guinean Zone between 6°25'-730'N

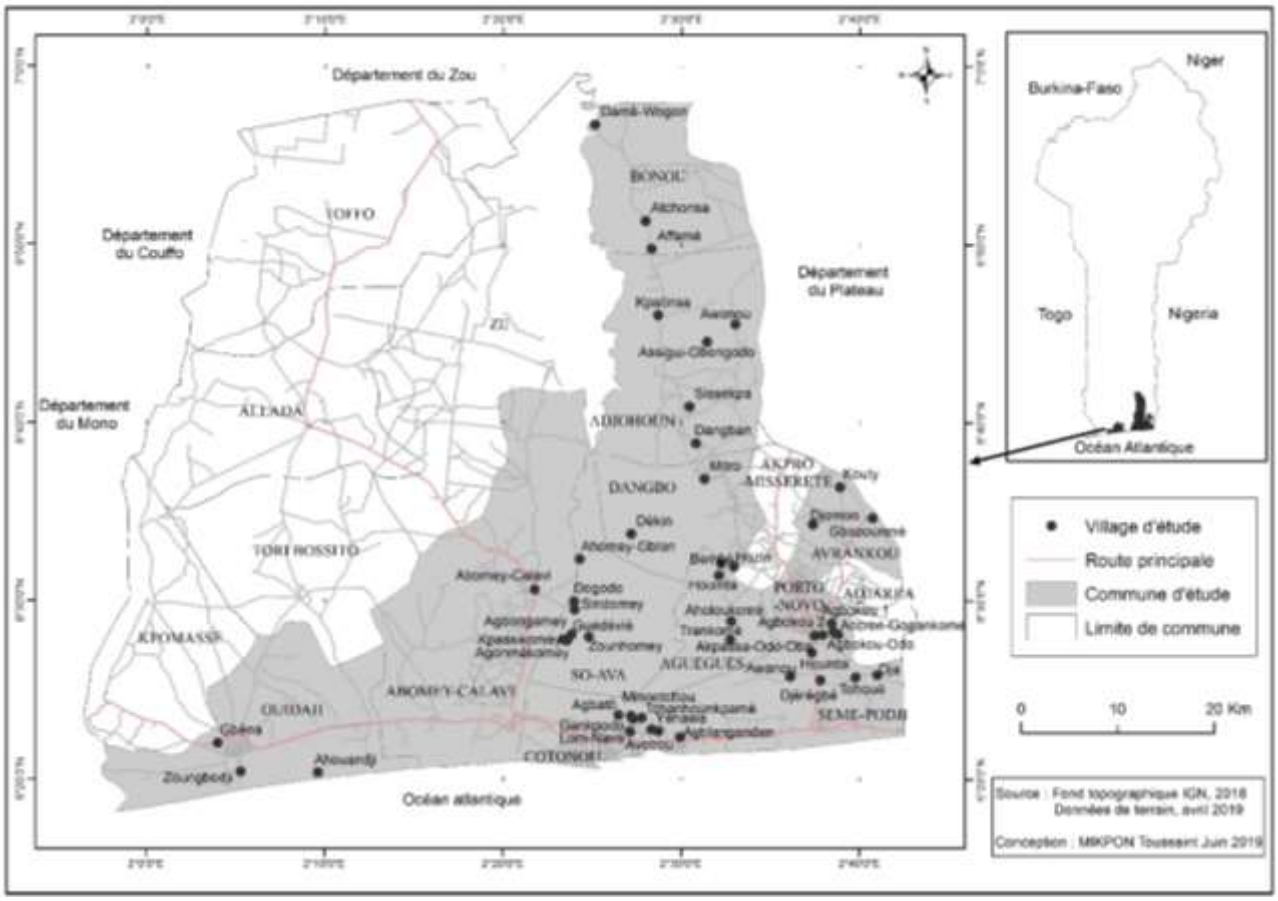


Figure 1. Location of the survey areas in Southern Benin, Africa.

and 2°33'-2°58'E (Figure 1) where the rainfall is bimodal (April to June and September to November) with a mean annual rainfall of 1200 mm (Assogbadjo et al., 2005). The Atlantic Department is located on a sandy coastal strip, 2 to 5 km wide and cut by lagoons and marshes that stretch along the coast. The lagoon complex of this department is increasingly salty in this case Lake Ahémé and Lake Nokoué. Lake Toho, on the other hand, contain fresh water which is mainly used for the irrigation of a 400 ha palm grove (INSAE, 2013). Average monthly temperatures range from 27 to 31°C. The months of February to April are the warmest months and the months of July to September are the coolest months (INSAE, 2013).

The Littoral Department is located on a coastal cordon whose homogeneous relief consists of a 200 km strip of alluvial sand articulated by a lagoon system. The plant cover consists of species characteristic of sandy clay and hydromorphic soils which are replaced in places by anthropogenic species. The Littoral Department does not have rivers, but Lake Nokoué (85 km²) and a few shallows constitute its water reservoirs (INSAE, 2013). The Ouémé Department belongs to the sub-equatorial region with a four season's climate. River Ouémé, Lake Nokoué and the Porto-Novo lagoon irrigate it. The vegetation has been strongly affected by various agricultural activities and now forms a mosaic of cultivated land and small relict forest patches (Assogbadjo et al., 2005). The Ouémé Department is characterized by reddish ferruginous, sandy-clay, alluvial and co-alluvial soils with vegetation which formed thicket, some relic forests, a grassland and raffia marshy formation and some mangroves (INSAE, 2013) (Figure 1).

Description and common use of *C. armatum* and *C. amnicola*

C. amnicola is the swimming species with lateral and sub-lateral spines and the last pair of legs transformed into a "paddle". *C. armatum* is the walking species that has 5 pairs of legs with hair, the first pair of which is transformed into pincers. This species can be found both in water (fresh and above all brackish) and on land (swampy regions) by digging the soil to make burrows where it takes refuge. Figure 2 shows the morphology of the two species taken into account in this study. In the study area, the two crab species are used in human and animal food, medicinally and in agriculture. They are widely used (100%) in human food and are of remarkable culturally particularly in the gastronomy of the populations of the study area in the preparation of several food

Data collection

The survey conducted during February 2018 to September 2019 used an approach based on the relationship of a population with its natural environment and the interactions therein. An organizational approach of the actors involved in the crab value chain was partially addressed. The method used for the surveys follows Dah-Nouvlessounon et al. (2015). The surveys were carried out with 3 target groups: fishermen/catchers (12), wholesalers / collectors (24) and retailers (58). Structured, semi-structured interviews as well as free interviews and observations were carried out with the

[a] *Cardisoma armatum* **[b] *Callinectes amnicola***

Figure 2. Morphology of the two crab species.

respondents using a socio-economic and cultural survey sheet designed for this purpose. The survey sheet contained 6 sections such as: Respondents' characteristics, crabs knowledge, socio-cultural importance and uses of the crabs species, dynamics and management in the value chain, crabs resource flow monitoring and socio-economic value of crabs' species. The sampling was carried out according to the method of Assogbadjo et al. (2012). It consisted of asking a question to 30 individuals in the study area. The question was whether the individual knew the two species of crab (*C. armatum* and *C. amnicola)* and was involved in the value chain. The size of the sample was determined by the formula of binomial distribution described by Dagnelie (1998):

$$n = \frac{U^2_{1-\alpha/2}\ x\ p(1-p)}{d^2} \quad (1)$$

With n the sample size; p the proportion of respondents who answered yes; d is the margin of error of the estimate; $U_{1-\alpha/2}$ is the value of the random variable at the probability value of 1-α/2. For the probability value of 0.975 (where α = 0.05), $U_{1-\alpha/2} \approx 1.96$.

Data analysis

Data from surveys carried out in the field were coded and entered into an Excel 2007 database. These data were analyzed with Statistical Package for the Social Sciences (SPSS) software Version 16.0 for the determination of descriptive statistics in terms of percentage and average. For socio-economic data, the GraphPad prism 7 software generated the graphs.

RESULTS

Socio-demographic characteristics of the actors involved in the crab value chain

A total of 94 respondents were included in the study. Indeed, the analysis of the results shows that several actors are involved in the crab value chain in the study area. These are fishermen/catchers, wholesalers/ collectors and retailers. Table 1 presents the distribution of actors according to the size of the sample and their socio-demographic characteristics relating to age, sex, level of education, religious affiliation and seniority in the field of sale and management of crabs. A rate of 54.25% of actors was enrolled in the Department of Ouémé, 19.14% in the Littoral and 26.59% in the Atlantic. Retailers (61.70%) are most involved in the chain while fishermen / catchers are the least represented in the chain (12.76%). Men (70.21%) in an age group below 30 years (60.63%) are the most represented in the value chain of the two crab species. They are mostly uneducated (54.25%) and have at least 20 years' seniority (56.38%) in the fishery resources management sector of Crabs (*C. armatum* and *C. amnicola*).

Socio-cultural importance of the two crab species

The socio-cultural importance of the two crab species lies in the various uses that people make of them. The species *C. amnicola* is more requested (65.22%) in culinary habits (variety of dishes) than the species *C. armatum* (34.78%). In addition, according to the interviews carried out and observations made in the field, 83.33% of the respondents do not appreciate the two species to the same degree against 16.66% of the respondents who appreciate them in the same way. However, some assess according to the economic power of the species, others according to the use they make of it. The study area is made up of several ethnic and religious groups. We note a prohibition, for certain followers of the "vodoun" cult which represent 02.12% of the study population, to have contact with species *C. armatum.* This limits the relationships of this part of the population with *C. armatum*. On the other hand, *C. armatum* is used for cultural rites by other followers (05.31%), which means that this species is subject to some protection. Unlike *C. armatum*, no cultural

Table 1. Distribution of actors and their socio-demographic characteristics.

Characteristics	Modality	Percentage		
		Ouémé	Littoral	Atlantique
Actors	Fisherman/catcher	7.44	2.12	3.19
	Wholesaler/collector	11.70	5.31	8.51
	Retailer	35.10	11.70	14.89
Sex	Woman	14.89	6.38	8.51
	Man	39.36	12.76	18.08
Age	<30 years	34.04	11.70	14.89
	Between 30 et 60 years	7.44	11.70	39.36
Education level	Uneducated	28.72	11.70	13.82
	Primary	10.63	7.44	8.51
	Secondary	12.76	00	4.25
	Higher	2.12	00	00
Seniority in the field	Between 0-20 years	19.14	12.76	11.70
	Between 21-40 years	35.10	6.38	14.89
Religion affiliation	Muslim	2.12	00	5.31
	Christian	40.42	12.76	11.70
	Animist	10.63	6.38	9.57
	Atheist	1.06	00	00

Table 2. Reported use of *C. amnicola* and *C. armatum* crabs in the study area.

Species	Used Part	Proportion (%) of different uses				
		Human food	Animal feed	Medicinal	Agricultural	No use
C. amnicola	Flesh	100	8.51	7.44	00	00
	Exoskeletons	2.12	18.08	00	5.31	74.46
C. armatum	Flesh	100	15.95	3.19	00	00
	Exoskeletons	3.19	6.38	10.63	8.51	76.59

prohibitions and rites have been reported for *C. amnicola* apart from the reasons of allergy and preferably mentioned by those who do not consume it regularly.

Table 2 shows that different parts (the flesh and the exoskeletons) of these crabs are used in varying proportions. So in human food, it is mainly the flesh (100%) of the two species that is used. In contrast, the exoskeletons of *C. amnicola* (18.08%) and *C. armatum* (6.38%) are used as a substitute for shells in the production of animal feed. Medicinally, the powder of dried *C. armatum* exoskeletons (10.63%) is used alone or in combination with other natural products in the treatment of wounds (burn victims and accident victims). Likewise, the exoskeletons of *C. amnicola* (5.31%) and *C. armatum* (9.57%) are used in agriculture for soil fertilization. Besides these, a large part of the study population does not use and does not recognize any use of the exoskeletons of *C. amnicola* (74.46%) and *C. armatum* (76.59%)

Dynamics and management in the value chain of *C. amnicola* and *C. armatum*

The actors involved in the value chain of the two species are fishermen/catchers, wholesalers/collectors and

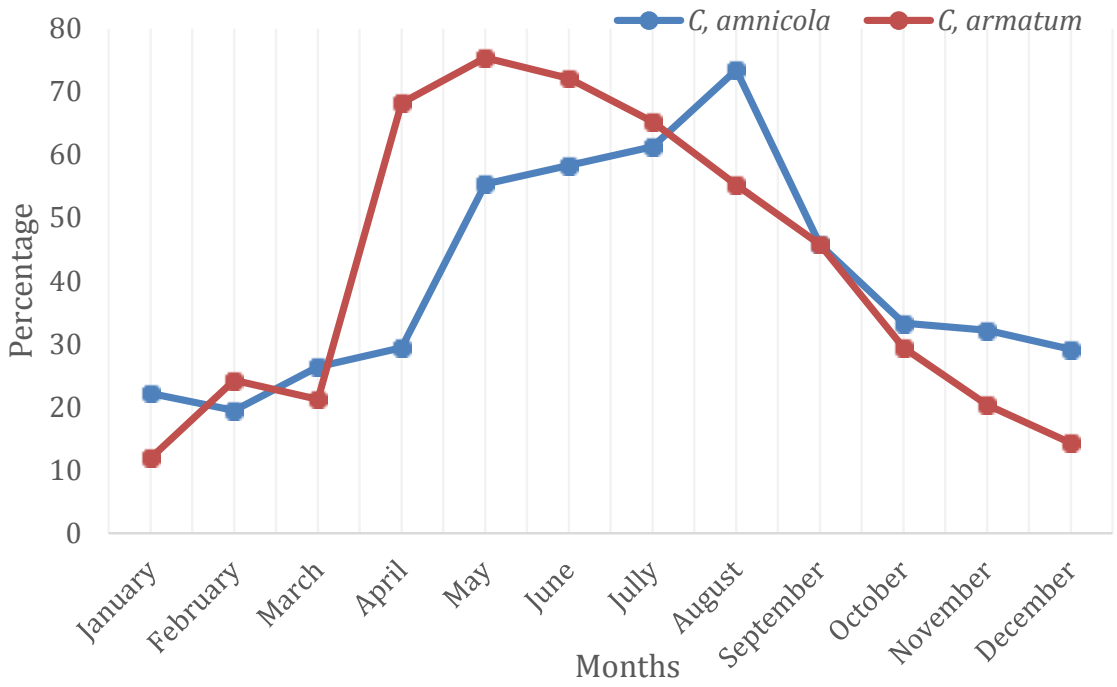


Figure 3. Periods of availability of the two crab species in the study area.

retailers. The fishermen/captors being the first actors in the chain use various engines in the fishing and the capture of the two species in the lagoon systems of the study area. These include wide mesh nets, the tyres and other traps made for this purpose. *C. armatum* is fished/captured in the lagoon systems of Lake Nokoué - Porto-Novo Lagoon, Ouémé valley and the mangroves. *C. amnicola* is much more fished in the lagoon system of Lake Nokoué - Porto-Novo lagoon. For the fishing/capture of *C. armatum*, the young men are the most numerous (58.33%) at this level of the chain. On the other hand, for the *C. amnicola* fishery, women are more involved (66.66%).

Products from fishing/capture are delivered to wholesalers/collectors who are at the second link in the chain. At this level of the chain, 40-50% of fishery products are exported to the markets of Togo and Ghana. The actors at this level of the chain (wholesalers/ collectors) are more or less organized and collaborate together to maintain their domination power over the other actors in the chain. Retailers are at the third level of the chain and are the most numerous (61.70%). They obtain their supplies from wholesalers/collectors and are most active at points of sale and markets in the neighboring localities of the study area. At all levels of the chain, from fishermen/captors to retailers, products are delivered fresh, which complicates post-catch management. There are many losses in post-catch management. *C. armatum* is more resistant than *C. amnicola*. However, each actor takes steps to minimize losses after capture. Both among the actors (fishermen/ captors and retailers) involved in the distribution of products (*C. armatum* and *C. amnicola*) as well as among consumers, 100% of the exoskeletons resulting from post-capture losses as well as those that are derived treatments for consumption, in particular 74.46% (*C. amnicola*) and 76.59% (*C. armatum*) are not used in any way.

Resource flow monitoring of *C. amnicola* and *C. armatum*

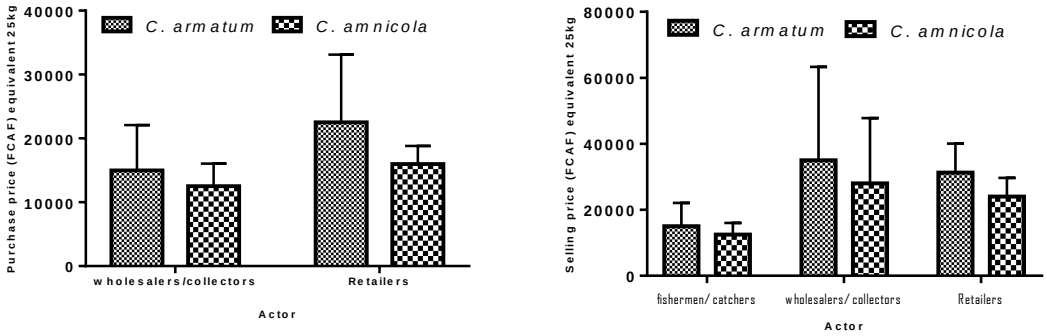
Both species are available throughout the year with a fluctuation in abundance depending on the season. Figure 3 shows the availability periods of the two species in the markets and points of sale. Analysis of the figure shows that the two species have an abundance between April and August. In addition, the availability of *C. armatum* is more noticeable (75.35%) in May while that of *C. amnicola* is more abundant (73.45%) in August. In addition, between September and March, demand is stronger than supply, which leads to soaring prices for the two species at these times of the year.

Socio-economic value of *C. amnicola* and *C. armatum*

Information gathered during market surveys on the crab trade has shown that the different actors involved in the industry do not use the same sales strategies in the value chain of fishery products. Indeed, the units of

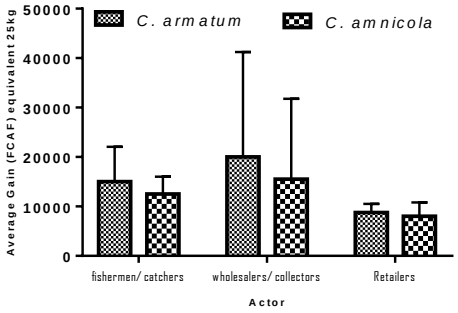
[a] Retailer of *C. amnicola* [b] Retailer of *C. armatum* [c] Fishermen and wholesalers

Figure 4. The units of measurement in the crab sales chain according to the actors.



[a] Purchase price

[b] Selling price



[c] Cost price

Figure 5. Variation in purchase, selling prices and average earnings depending on the actors involved in the sector.

measurement and the quantities sold vary greatly according to the species. For the two species (*C. amnicola* and *C. armatum*), fishermen/catchers as well as wholesalers/collectors use 25 kg equivalence baskets for trade (sale and purchase). However, for *C. amnicola*, retailers use smaller units of measure (basket and plastic) depending on the quantity desired by the buyer. In addition, for *C. armatum*, retailers use batches of 4 to 5 crabs tied in nets. For *C. armatum*, at the level of all actors in the chain, the quality and price of the product is linked to the size, sex and maturity of the crabs. The females crab engrained of eggs are very appreciated for consumption and are more expensive. Figure 4 shows the different units of measurement in the crab sales chain. The purchase and sale prices as well as the gains made vary depending on the actors involved in Crab value chain (Figure 5).

For *C. armatum*, the average purchase price of 25 kg equivalence varies from 15.000±7.071 FCAF (wholesalers/collectors) to 22.500 ± 10.606 FCAF

(retailers). In addition, the average selling prices vary from 15.00±7.071 FCAF (fishermen / catchers) to 35.000±28.284 FCAF (wholesalers/collectors). In fact, the gains made vary from 8.750±1.767 FCAF (retailers) to 20.000±21.213 FCAF (wholesalers/collectors). Wholesalers/collectors are those who make more profit with high added value in the sector. Note that the selling price of an equivalent of *C. armatum* to local retailers is two times lower than that of buyers in the sub-region (Togo and Ghana). For *C. amnicola*, the average 25 kg equivalence purchase prices vary from 12.500±3.535 FCAF (wholesalers/collectors) to 16.000 ± 2.828 FCAF (retailers). In addition, the average selling prices are 24.000 ± 5.656 FCAF at retailers and 28.000±19.798 FCAF at wholesalers/collectors. In fact, the gains made vary from 8.000±2.828 FCAF (retailers) to 15.500±16.263 FCAF (wholesalers/collectors). Along with the species, wholesalers/collectors are also those who make more profit in the sector. Actors can sell an equivalent of 50 kg of product per day on the market during periods of abundance.

DISCUSSION

Socio-demographic characteristics of the actors involved in the crab value chain

The lagoon systems of Southern Benin contain a wide variety of crustaceans including *C. armatum* and *C. amnicola* (Tohozin, 2012; Hinvi et al., 2013). Through a structured survey method, the study assessed the socio-economic and cultural importance of the two species and analyzed the value chain of these species as well as monitoring the flow of their resources. Socio-demographic characteristics of respondents show that at the first level of the chain, young people (21 to 30 years old) are the most represented, constituting 60.63% of the sample. This observation was also made in Ivory Coast by Sankaré et al. (2014b) and in Madagascar by Razafindralambo (1992) during a survey on the contribution of maritime and artisanal fishing in the socio-economics life of the fishermen. This phenomenon is common because the fishing activity requires young individuals suited to the physical strength and requirement. Experienced individuals aged between 31 and 45 years normally tend to then leave this level. Besides, in sex/gender aspect, Sankaré et al. (2014a) showed that individuals aged between 20 and 45 years, the proportion of young female (33.5%) was important compared to the young male proportion (29%). The same observation was made in our study for the *C. amnicola* fishery; women are more involved (66.66%). Others studies (Sankaré, 2007; Gnimadi et al*.,* 2008) showed that women play central role in crabs' chain value.

Among the constraints to the development of small-scale fishing, Horemans (1994) pointed out that socio-cultural constraints are linked to the generally low level of education and the social status of the small-scale fisherman who in many countries receive little consideration. In addition, some of them make fishing a subsistence activity or even divide their time between fishing and agriculture.

Socio-cultural importance of the two crab species

C. armatum and *C. amnicola* have a socio-cultural importance which appears through their various uses. Like other fishery products (fish and shrimp), *C. armatum* and *C. amnicola* are highly valued and constitute fundamental components of the culinary recipes of the populations of the study area and those of other countries such as Côte d'Ivoire (d'Almeida et al., 2014), Nigeria (Olalekan et al., 2015, Jerome et al*.,* 2020) and certain Latin American countries (Vasquez and Ramirez, 2015). Both species are highly valued and are sometimes substituted for other fishery products (fish, shrimp and others). This attitude of the study population is linked to the composition and nutritional value of crabs because crabs for the majority of species are a good source of protein and mineral compounds (Vigneshwari and Gokula, 2020). In many countries, crabs' meat has become a favourite food for many people replacing red meat and chicken due to the presence of high nutritive elements (Vigneshwari and Gokula, 2020). It is noteworthy that crab meat contains lower calories than beef, pork and poultry (Jimmy and Arazu, 2012). It is particularly rich in Omega-3 fatty acids, which are necessary to lower triglycerides and blood pressure, thereby reducing the risk of heart disease (Williams et al*.*, 2016). It is also an excellent source of many vitamins (B2, B3, B12 and C) and minerals like iron, calcium, potassium, phosphorus and zinc, which aids in reducing oxidative damage to cells and tissues and acts as an antioxidant by cancelling out the carcinogenic effects (Soundarapandian et al*.,* 2014). Proximate composition of *C. amnicola* showed more carbohydrate content in crunchy chest followed by in walking legs and in tissues (Moronkola et al*.,* 2011). Medicinally, the powder of dried *C. armatum* exoskeletons (10.63%) is used alone or in combination with other natural products in the treatment of wounds (burn victims and accident victims). Other authors also report the medicinal use of crabs. Dobson (2004) reports that crabs are put to various medicinal uses. One of the most interesting is the role of *Potamonautes raybouldi*, the tree hole crab of the East Usambara Mountains in Tanzania and the Shimba Hills in Kenya (Bayliss, 2002, Cumberlidge and Wranik, 2002). Here it is not the crab itself that is important, but the water from the tree hole in which it lives. Tree hole crab water is administered to pregnant women, and particularly those with a history of miscarriages. The value of this water may relate to the behaviour of the crab, which

neutralizes the naturally acidic water in tree holes by capturing snails and adding their crushed shells to the water, raising the pH and also enhancing levels of dissolved calcium (Bayliss 2002).

Likewise, the exoskeletons of *C. amnicola* (5.31%) and *C. armatum* (9.57%) are used in agriculture for soil fertilization. The reasons mentioned are related to the capacity of these shells (decomposed exoskeletons) to enrich the exhausted lands for better results. This attitude, based on unscientific experiences shows, that a part of the population of the study area has certain information on the stimulating power of substances contained in crab shells and their uses as biofertilizers. Kazemi and Salimi (2019) reported that chitosan, the linear polysaccharide obtained from crab exoskeletons, is good to improve productivity in agriculture. Chitosan is an effective organic molecule that improves productivity by supplying valuable nutrients to plant and due to site specific action of this nanoparticle it also enhances activity of protective enzymes that enables biotic and abiotic stress resistance in plants (Somdutt et al., 2019).

Dynamics and management in the value chain of *C. amnicola* and *C. armatum*

The actors involved in the management and dynamics and value chain of crabs are fishermen/captors, wholesalers/collectors and retailers. The same observation was made by Sankaré et al. (2014a) who propose management measures for swimming crab *C. amnicola* stock in Aby-Tendo-Ehy lagoon complex in Ivory Coast. Products from fishing/capture are delivered to wholesalers/collectors who are at the second link in the chain. At this level of the chain, 40-50% of fishery products are exported to the markets of Togo and Ghana. The reasons reported for this attitude are related to financial profitability. Indeed, the external market is more profitable for the sellers. Both among the actors (fishermen/captors and retailers) involved in the distribution of products (*C. armatum* and *C. amnicola*) as well as among consumers, 100% of the exoskeletons resulting from post-capture losses as well as those that are derived treatments for consumption, are not used in any way. These poorly formed exoskeletons are, therefore, pollutants and a problem for the environment because there is no system in the study area for effective management of crab exoskeletons.

Resource flow monitoring and socio-economic value of *C. amnicola* and *C. armatum*

Resource flow monitoring of *C. armatum* and *C. amnicola* shows the availability of both species throughout the year, but with higher levels of abundance between April and August. In the management of these resources, 40 to50% is exported to Togo and Ghana, likewise, post-capture as well as the exoskeletons of the crabs are not used in the study area. These exoskeletons can be used for the production of chitosan to improve crop yields. Chitosan is a biodegradable substance of natural origin obtained by the deacetylation of chitin, which is found in the exoskeletons of crustaceans such as lobsters, shrimps and crabs (Oanh et al., 2007).

The study also showed a very important socio-economic value of the crabs, *C. armatum* and *C. amnicola.* The actors involved in the crab value chain have incomes according to the species. Indeed, for *C. amnicola*, income range was from 8,000 ± 2,828 FCAF (retailers) to 15.500 ± 16.263 FCAF (wholesalers/ collectors). Besides, for *C. armatum*, income range was from 8750±1767 FCAF (retailers) to 20.000 ± 21.213 FCAF (wholesalers/collectors). Indeed, crabs management is a sector that provides significant income to the actors involved. Wholesalers/collectors are those who make more profit with higher added value 15.500 ± 16.263 FCAF in the sector. They are more or less organized and collaborate to maintain their power over the rest of the chain. The implementation of sustainable crab management strategies can significantly improve the income of actors involved in the crab sales chain.

Conclusion

This study shows the availability of *C. amnicola* and *C. armatum* crabs in the study area. Besides, there is lack of means and system for managing the losses and exoskeletons of these crustaceans. In addition, the two species of crabs (*C. armatum* and *C. amnicola*) have a varied socio-cultural importance that resides in the various uses that populations make of them. These species are used for food (human and animal), medicinal and agricultural purposes. The exoskeletons of these crustaceans are not used in most cases. The actors involved in the value chain of the two species are fishermen/captors, wholesalers/collectors and retailers. The study found that crabs (*C. armatum* and *C. amnicola*) have remarkable socio-economic importance. Wholesalers/collectors are those who make more profit with high benefit in the sector, are more or less organized, and collaborate to maintain their power over the rest of the chain.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Akegbejo-Samsons Y, Omoniyi IT (2009). Défis en matière de gestion des forêts de mangrove en Afrique: une évaluation critique de la zone du Delta du Niger au Nigéria. Nature and Faune 24(1):52-57.

Assogbadjo A, Glèlè Kakaï R, Vodouhê F, Djagoun C, Codjia J, Sinsin B (2012). Biodiversity and socioeconomic factors supporting farmers' choice of wild edible trees in the agroforestry systems of Benin (West Africa). Forest Policy Economics 14(1):41-49.

Assogbadjo AE, Sinsin B, Van Damme P (2005). Caractères morphologiques et production des capsules de baobab (*Adansonia digitata* L.) au Bénin. Fruits 60:327-340.

Bayliss J (2002). The East Usambara tree-hole crab (*Brachyura*: *Potamoidea*: *Potamonautidae*) a striking example of crustacean adaptation in closed canopy forest, Tanzania. African Journal of Ecology 40:26-34.

Cumberlidge N, Wranik W (2002). A new genus and new species of freshwater crab (Potamoidea, Potamidae) from Socotra Island, Yemen. Journal of Natural History 36:51-64.

D'Almeida MA, Koua HK, Ouattara-Soro SF, Fantodji A, Ehouman A, N'Diaye AS (2014). Caractères généraux et étude histologique du développement embryonnaire du crabe terrestre, *Cardisoma armatum*, herklots, 1851 (*decapoda gecarcinidae*) de Côté d'Ivoire. Afrique Science : Revue Internationale des Sciences et Technologies 10(2):338-355.

D'Almeida FMA, Fiogbé ED (2008). Revue documentaire sur l'exploitation et la production des crabes (*Callinectes* et *Cardiosoma*). Rapport final de mission de consultation. Programme pour les Moyens d'Existence Durables dans la pêche, Cotonou, Bénin, 108p.

Dagnelie P (1998). Statistiques théoriques et appliquées. Bruxelles: De Boeck et Larcier 39 p.

Dah-Nouvlessounon D, Adoukonou-Sagbadja H, Diarrassouba N, Adjanohoun A, Baba-Moussa F, Sezan A, Baba-Moussa L (2015). Indigenous knowledge and socio-economic values of three kola species (*Cola nitida*, *Cola acuminata* and *Garcinia kola*) used in southern Benin. European Scientific Journal 11(36):206-227.

Dessouassi CE, Chikou A, Lederoun D, Adandedjan D, Gangbe L, Laleye P (2018). Diversity, biology and exploitation of brackish water crabs in West Africa: A review. International Journal of Biology Chemical Science 12(5):2355-2370.

Dobson M (2004). Freshwater Crabs In Africa. Freshwater Biological Association 21:3-26.

George ADI, Abowei JFN (2009). The Composition, Ranking and Diversity of *Callinectes amnicola* (De Rochebrune, 1883) Food from Okpoka Creek, Niger Delta, Nigeria. Advance Journal of Food Science and Technology 1(1):12-18.

Gnimadi A, Egboou P, Dessouassi CE, Gbaguidi A (2008). Rapport final de l'analyse de la chaine de valeur sur la filière crabe (*Callinectes* et *Cardisoma*) au Sud du Benin. Ministère de l'Agriculture, de l'Elevage et de la Pêche/Direction des Pêches, Cotonou, Bénin 120 p.

Goussanou A, Bonou AG, Chikou A, Gandonou P, Mensah GA, Youssao AKI (2017a). Morphological, structural characteristics and growth relationship of crabs *Callinectes amnicola* and *Cardisoma armatum* in the complex Nokoué lake Porto-Novo lagoon in South Benin. Journal of Applied Biosciences 118:11803-11816.

Goussanou A, Chikou A, Ogni CA, Kassa KS, Houessionon B, Mensah GA, Youssao AKI (2017b). Synthèse des connaissances sur l'écologie et la biologie des crabes (Crustacés, Décapodes, Brachyoures). International Journal of Biological and Chemical Sciences 11(6):2990-3004.

Gustave H (1929). Traitement des déchets de poisson et utilisation des sous-produits. Recherches techniques 1:413-441.

Hinvi LC, Sohou Z, Agadjihouedé H, Laleye P, Sinsin B (2013). Domestication de *Portunus validus* et *Callinectes amnicola* au Bénin. Journal de la Recherche Scientifique de l'Université de Lomé 15(2):13-22.

Horemans B (1994). La situation de la pêche artisanale en Afrique de l'Ouest en 1993. Cotonou. 1994 Programme de Développement Intégré des Pêches Artisanales en Afrique de l'Ouest (DIPA), D]IPA/WP/54 40 p.

INSAE (2013). RGPH4 Cahier des villages et quartiers de ville, Département de l'Ouémé, Atlantique et Littoral, Institut National de Statistique et de l'Analyse Economique, Bénin 35 p.

Jimmy UP, Arazu VN (2012). The Proximate and Mineral Composition of Two Edible Crabs *Caflinectes amnicola* and *Uca tangeri* (Crustecea: Decapoda) of The Cross River, Nigeria. Pakistan Journal of Nutrition 11(1):78-82.

Jivoff P, Hines AH, Quackenbush LS (2007). Reproduction biology and embryonic development of *Callinectes sapidus*. In The Blue Crab *Callinectes sapidus*, Kennedy VS, Cronin LE (eds). Maryland Sea Grant College: Maryland pp. 255-298.

Jerome FC, Hassan A, Chukwuka AV (2020). Metalloestrogen uptake, antioxidant modulation and ovotestes development in *Callinectes amnicola* (blue crab): a first report of crustacea intersex in the Lagos lagoon (Nigeria). Science of the Total Environment 20(704):135235.

Kandra P, Challa M, Met K, Padma JH (2012). Efficient use of shrimp waste; present and future trends. Applied Microbiology of Biotechnology 93:17-29.

Kazemi NM, Salimi AA (2019). Chitosan Nanoparticle for Loading and Release of Nitrogen, Potassium, and Phosphorus Nutrients. Iranian Journal of Science and Technology 43:2781-2786.

Moronkola BA, Olowu RA, Tovide OO, Ayejuyo OO (2011). Determination of proximate and mineral contents of crab (*Callinectes amnicola*) living on the shore of Ojo river, Logos, Nigeria. Chemical Communications 1(1):1-6.

Oanh T, Hausler R, Monette F, Niquette P (2007). Valorisation des résidus industriels de pêches pour la transformation de chitosane par technique hydrothermo-chimique. Journal of Water Science 20(3):253-262.

Olalekan EI, Lawal-Are AO, Titilade PR (2015). Size and growth of *Cardisoma armatum* and *Cardisoma guanhumi* as ecological parameters for mangrove ecosystem. Journal of Marine Science: Research and Development 5(2):1-7.

Razafindralambo NY (1992). Contribution à l'étude socio-économique de la pêche maritime traditionnelle et artisanale à Madagascar : le cas de la région de Nosy-Be. Centre National de Recherches Océanographiques 44 p.

Sankaré Y (2007). Biologie, écologie et exploitation du crabe nageur *Callinectes amnicola*, de Rocherbrune, 1883 (Crustacea-Decapoda-Portunidae) du complexe lagunaire Aby-Tendo-Ehy (Côte d'Ivoire). Thèse de Doctorat, Université de Cocody, Cocody P 274.

Sankaré Y, Amalatchy NJ, Koffie-Bikpo CY (2014a). Etude comparative des captures de crabes nageurs *Callinectes amnicola* (Decapoda, Portunidae) dans les lagunes Ivoiriennes (Afrique de l'Ouest). Revue du CAMES 2(1):75-84.

Sankaré Y, Konan KJ, Amalatchy NJ, Soro MB (2014b). Swimming crab *Callinectes amnicola* (Decapoda-Portunidae): capture analysis of a Lagoon with high continental influence (Aby Lagoon, Côte d'Ivoire, West Africa). Wyno Academic Journal of Biological Sciences 2(2):9-19.

Shahdadi A, Schubart CD (2017). Taxonomic review of *Perisesarma* (Decapoda: Brachyura: Sesarmidae) and closely related genera based on morphology and molecular phylogenetics: new classification, two new genera and the questionable phylogenetic value of the epibranchial tooth. Zoological Journal of the Linnean Society 20:1-32.

Somdutt B, Himangini J, Rajawat KS, Choudhary J (2019). Controlled release action of chitosan nanoparticles to improve nutrient use efficiency. International Journal of Research in Agronomy 3(1):36-41.

Soundarapandian P, Varadharajan D, Ravichandran S (2014). Mineral composition of edible crab *Podophthalmus vigil* Fabricius (Crustacea: Decapoda). Arthropods 3(1):20-26.

Sowman M (2006). Subsistence and small-scale fisheries in South Africa: A ten-year review. Marine Policy 30(1):60-73.

Tohozin YA (2012). Pêcheries sédentaires, production et commercialisation des tourlourous des lagunes (*Cardisoma armatum*), des crabes bicornes (*Callinectes amnicola*) et des étrilles lisses (*Portunus validus*) dans l'ouest du lac Nokoué en République

du Bénin. Journal de la Recherche Scientifique de l'Université de Lomé 14(1):12-21.
Vasquez LH, Ramirez PT (2015). Aspects of growth in the terrestrial crab *Cardisoma crassum* Smith, 1870 (Crustacea: Brachyura: Gecarcinidae) from El Salado Estuary Puerto Vallarta, Jalisco, Mexico. Mitteilungen Klosterneuburg 65(2):81-99.
Vigneshwari S, Gokula V (2020). Proximate composition of fresh meat and exoskeleton of marine crab *Portunus pelagicus* (Linnaeus, 1758). International Journal of Life Science 8(2):383-390.
Williams IO, Ekpenyong E, Lawal OO, Essien NC, Edemumoh TO (2016). Nutrient and energy composition of flesh, limbs and carapace of *Callinectes amnicola* (Blue Crab) from Great Kwa river, South East Nigeria. African Journal of Food Science and Technology 7(3):060-065.