



# Commercial relationships between intermediaries and harvesters of the mangrove crab *Ucides cordatus* (Linnaeus, 1763) in the Mamanguape River estuary, Brazil, and their socio-ecological implications



Douglas Macêdo Nascimento <sup>a,\*</sup>, Rômulo Romeu Nóbrega Alves <sup>b</sup>, Raynner Rilke Duarte Barboza <sup>b</sup>, Anders Jensen Schmidt <sup>c</sup>, Karen Diele <sup>d,e</sup>, José Silva Mourão <sup>b</sup>

<sup>a</sup> Programa de Pós-Graduação em Etnobiologia e Conservação da Natureza, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos - CEP: 52171-900 - Recife, PE, Brasil

<sup>b</sup> Departamento de Biologia, Universidade Estadual da Paraíba, Av. Baraúnas, 351, Campus Universitário I, Bodocongó - CEP: 58109-753 - Campina Grande, PB, Brasil

<sup>c</sup> Universidade Federal do Sul da Bahia, Instituto de Humanidades, Artes e Ciências Paulo Freire, Praça Joana Angélica, 250, São José - CEP: 45988-058 - Teixeira de Freitas, BA, Brasil

<sup>d</sup> School of Applied Sciences, Edinburgh Napier University, Edinburgh, United Kingdom

<sup>e</sup> St Abbs Marine Station, St Abbs, United Kingdom

## ARTICLE INFO

### Article history:

Received 28 February 2016

Received in revised form 24 June 2016

Accepted 16 August 2016

Available online xxxx

### Keywords:

Production chain

Fishery

Sustainability

Conservation

Ethnozoology

## ABSTRACT

The large mangrove crab *Ucides cordatus* (“caranguejo-uçá”) is a key fisheries resource in Brazil, critical for the sustenance of livelihoods of thousands of people in coastal rural areas. Today's crab populations suffer from habitat degradation, disease, and increasing fishing pressure. Crabs are sold alive on local and regional markets, or traded as processed meat and the market chains typically involve intermediaries (i.e. traders). The present study examined the relationship between crab harvesters and the intermediaries, and the socio-ecological implications thereof. The research was performed between September 2013 and October 2014 in the Mamanguape River estuary, northeastern Brazil. Socioeconomic information and data regarding the catch (sex and carapace width of the crabs), the processing of *U. cordatus* meat and the commercial relationship between harvesters and intermediaries were obtained through structured (questionnaires) and semi-structured interviews and direct observations. The crab harvesters exist under precarious socioeconomic conditions that place them at the edge of society and therefore often seek loans offered by the intermediaries, generating loyalty and dependence that guarantees the intermediaries a stable supply of crabs needed to supply an avid market. Within this relationship, the intermediaries create pressure on natural crab populations by stimulating non-selective captures, as they buy specimens below the legal size limit (6 cm wide carapace) for meat processing. During crab meat processing, the intermediaries themselves report that the meat is often mixed with cooked and shredded of other marine vertebrates, such as spotted eagle ray (*Aetobatus narinari*) and nurse shark (*Ginglymostoma cirratum*), to increase the weight of the final product. As with the crab harvesters, the women involved in processing the crabmeat often accept loans, resulting in the same type of dependence and loyalty to the intermediaries. The intermediaries, with their strong influence on the crab harvesting, are directly linked to the commercial, social and ecological implications of these harvesting activities, together with the crab harvesters themselves. Hence, to ensure sustainability of the *U. cordatus* fishery and maintain (better improve) dependant livelihoods, all actors involved in the production chain of *U. cordatus* must be considered when developing management strategies, rather than the current approach of considering the crab harvesters only. We advise the development and implementation of fisheries associations to give the crab harvesters (and regulating bodies) greater control over and capital gains from their catches.

© 2016 Elsevier B.V. All rights reserved.

## 1. Introduction

The production chains of most artisanal fisheries around the world involve intermediaries who have direct commercial contacts with the fishers acquiring their catches and selling them to the final markets

(Gibbon, 1997; Pasquotto, 2007; Platteau and Abraham, 1987). Such commercial relationships have probably existed since the dawn of commercial trade (Platteau and Abraham, 1987; Platteau and Nugent, 1992; Merlijn, 1989; Russel, 1987).

Intermediaries represent a form of informal self-employment based on reciprocity and verbal agreements with fishers. They can be itinerant, work independently, and do not necessarily conform to legal directives, especially in terms of taxes, worker legislation, or fishing regulations

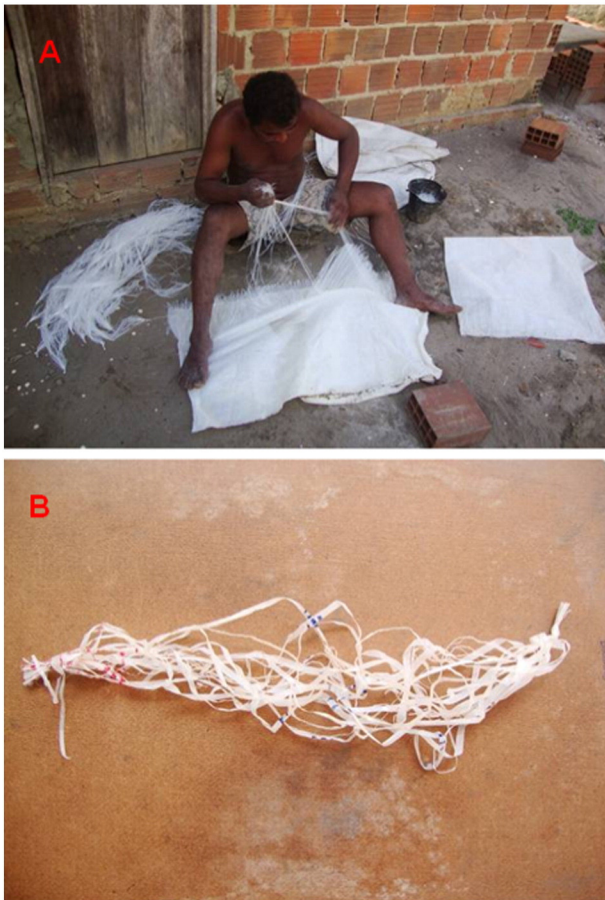
\* Corresponding author.

E-mail address: [douglasmacedo84@gmail.com](mailto:douglasmacedo84@gmail.com) (D.M. Nascimento).

(Crona et al., 2010; Merlijn, 1989; Platteau and Abraham, 1987). For the fishers, the key motivating factor for such informal agreements is the buffering of the uncertain nature of production volumes throughout the year (Wilson, 1980). In many developing countries, however, the commercial ties between fishers and intermediaries result in a dependence and reliability through accumulation of informal monetary loans (Crona et al., 2010).

In addition to the economic and social implications, the fishers-intermediaries relationship may also have considerable ecological implications, e.g. a direct influence upon yield and size of the captured animals (Wilson, 1980). The ecological effects and how these influence ecosystem services and health are however often understudied (Crona et al., 2010).

In Brazil, the large mangrove crab *U. cordatus* (“caranguejo-uçá”) is a key fisheries resource critical for the sustenance of livelihoods of thousands of people in coastal rural areas (Alves and Nishida, 2002, 2003; Alves et al., 2005; Nascimento et al., 2012; Nishida et al., 2006; Glaser and Diele, 2004). These crabs live in burrows in the mud up to 2 m deep and are harvested by so called “caranguejeiros” (mangrove crab harvesters) who capture them with their hands, hooked sticks, or with traps, such as tangle-netting (*redinha*) that are made from several loose polypropylene threads tied together (Fig. 1), placed onto the entrance of the crab burrows, secured by broken pieces of prop roots, to entangle and trap the animals when they emerge (Nascimento et al., 2012). Crab harvesters are generally socio-economically marginalized (Nordi et al., 2009), typically illiterate or functionally illiterate, and live in very simple houses with little infrastructure under conditions of poor hygiene (Alves and Nishida, 2003).



**Fig. 1.** Crab harvester shredding polypropylene bags for making the tangle-netting (A) and a tangle-netting manufactured in Tramataia community - PB (B). Photos: Douglas Nascimento.

Despite the socioeconomic importance of *U. cordatus* in Brazil (Diele et al., 2010; Brazilian Institute of the Environment and Natural Resources – IBAMA, 1995; Glaser, 2003; Kjerfve and Lacerda, 1993; Saint-Paul, 2006; Santos, 2002; Vieira et al., 2004; Wolff et al., 2000), especially in Paraíba State where the present research was undertaken (Alves and Nishida, 2003; Alves et al., 2005; Nascimento et al., 2011, 2012; Nordi et al., 2009), there are no comprehensive studies focused on the commercialization of this species and the socio-ecological implications of the relationships between the crab harvesters and intermediaries.

The present work was undertaken in an estuary in northeastern Brazil. It describes the steps in the processing (meat extraction) and commercialization of *U. cordatus* and elucidates the social ecological effects associated with that production. As such, the central question that oriented our study was: Do the intermediaries influence how the crab harvesters exploit the mangrove crab *U. cordatus* and create socio-ecological situations that threaten the sustainability of their harvests?

## 2. Methods

### 2.1. Study Area

The study was undertaken in the indigenous village Tramataia, part of the municipality Marcação, Paraíba State (PB), Northeastern Brazil. The village is situated on the banks of the Mamanguape River estuary, the second largest in the State, approximately 70 km north of the state capital of João Pessoa (06°43'02" – 06°51'54" S - 35°07'46" - 34°54'04" W) (Fig. 2). The mangrove-fringed estuary is oriented in a general East-West direction and is approximately 24 km long, with a maximum width of 2,5 km at the coast.

The area of influence of the Mamanguape River estuary is included within the Barra do Rio Mamanguape Environmental Protection Area – APA (Paludo and Klonowski, 1999). The mangrove forest, dominated by tree species such as *Rhizophora mangle*, *Avicennia germinans*, *A. schaueriana* and *Laguncularia racemosa*, is one of the best preserved in Paraíba State and is the second largest in that state, covering approximately 45,65 km<sup>2</sup> (Sociedade Internacional para Ecossistemas de Manguezal – ISME, 2005).

The APA incorporates the Mamanguape, Miriri, and Estivas rivers, and some small villages and agglomerations of houses within parts of the municipalities of Rio Tinto, Marcação, and Lucena along the coast of Paraíba State (Paludo and Klonowski, 1999).

Villagers of Tramataia (Potiguara ethnic group) regularly perform extractivist activities in the Mamanguape River estuary, harvesting crustaceans, mollusks and fish. The economically most important activity is harvesting of *U. cordatus* (Alves and Nishida, 2003; Alves et al., 2005; Nascimento et al., 2011, 2012; Paludo and Klonowski, 1999) (Fig. 3).

Tramataia community has a total population of 1.110, of which 877 (452 men and 425 women) are native Amerindians, comprising 243 families within 230 residences (SIASI - FUNASA/MS, 07/04/2011).

### 2.2. Research Authorizations and Methodological Procedures

The Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) authorized scientific research in the APA Barra do Rio Mamanguape through the System of Authorization and Information Concerning Biodiversity (SISBIO) (permit numbers: 36974-1 and 36974-2). The Research Ethics Committee (CEP) of the Universidade de Pernambuco (UPE) granted authorization for research with humans (authorization number: 359.093). The Instituto de Patrimônio Histórico and Artístico Nacional (IPHAN) granted authorization to investigate traditional knowledge without access to genetic heritage (authorization number: 019/2014). Finally, the Fundação Nacional do Índio (FUNAI) granted access to the indigenous lands of the Potiguara for scientific research (authorization number: 97/AEP/PRES/2014).

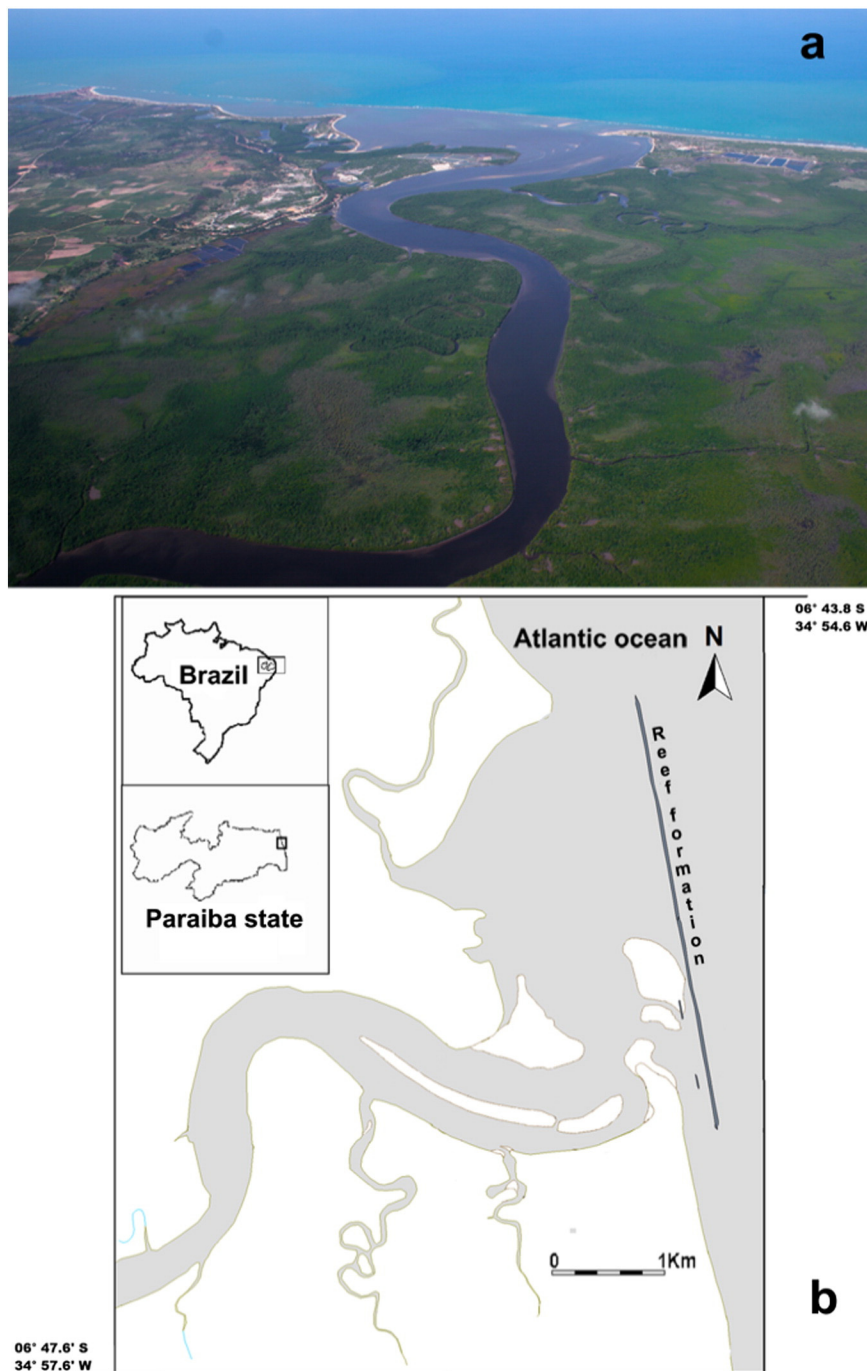


Fig. 2. The Mamanguape River estuary – PB, Brazil. a: Aerial view (Photo: Dirceu Tortorello); b: geo-referenced map (Figure adapted from Xavier et al., 2012).

Crab harvesters and their intermediaries were interviewed between September 2013 and June 2014. The first interviewed crab harvesters had been indicated by the president of the Z - 13 Fishing Colony at Tramataia; later on crab harvesters were selected via the “snowball” technique (Biernarcki and Waldorf, 1981), in which additional indications were provided by the initial interviewees. The intermediaries interviewed were indicated by the crab harvesters themselves. The research involved two data gathering techniques: 1) interviews, both structured and semi-structured (Huntington, 2000) and 2) direct observations (Sttebins, 1987). The semi-structured interviews with the crab harvesters ( $n = 106$ ) and all local intermediaries ( $n = 5$ ) contained pre-formulated questions concerning the commercialization of

*U. cordatus*; questions concerning the processing of the crabmeat (processing steps) were addressed only to the intermediaries. Structured interviews (questionnaires) with the crab harvesters were conducted to gather basic information concerning their socioeconomic situations, including their ages, sex, education, income, and housing and sanitary conditions. Recordings of the interviews, which were previously authorized by the interviewees, were made with a portable recorder and subsequently transcribed.

The direct observation technique, equivalent to the nonmember participant observer technique (Sttebins, 1987), was used in to describe aspects of the crab commercialization, such as the storage of yields in crab harvester residences and the processing of the crabmeat.





**Fig. 3.** Crab harvesters utilizing the braceamento technique to remove a mangrove crab from its burrow in the Mamanguape River estuary - PB. Photo: José Mourão.

The final price of the crabs in the supply chain was verified by information gathered from 31 pub and restaurant owners in the municipality of João Pessoa, Paraíba State - PB, the principal destination of the production of *U. cordatus* from the Mamanguape River estuary.

The specimens captured by the crab harvesters during 74 harvesting trips between September 2013 and October 2014 were analyzed in terms of their sex and carapace width – CW (transversal measurement of the carapace at its widest point). The sexes of the specimens were determined based on the shape of the abdomen, this structure being triangular in males and rounded in females. The CW (largest body dimension) was measured using a digital caliper (precision 0.01 mm).

### 2.3. Data Analysis

Qualitatively, the data analyses followed an emic/etic approach (Toledo, 1991). Emic approaches consider the manners in which the members of a given culture perceive, structure, classify, and articulate their universe, while an etic approach considers how the researcher views that universe as an outside observer (Posey, 1987). Quantitatively, the carapace width data (CW) of the *U. cordatus* specimens (maximum, minimum, median, and standard error) were analyzed using Excel 2007 software.

## 3. Results

### 3.1. Socio-economic Profiles of the Crab Harvesters and Dependency on *U. cordatus*

All of the crab harvesters interviewed in Tramataia village were men ( $n = 106$ ), with ages ranging from 15 to 62 years (median 36). The majority were literate 63.2% ( $n = 67$ ) or semi-literate 25.5% ( $n = 27$ ), with only 11.3% ( $n = 12$ ) being illiterate. 74.5% ( $n = 79$ ) of the interviewees with sons and daughters stated that these were attending school, while 25.5% ( $n = 27$ ) had no children or their children did not attend school.

In terms of habitation, all of the interviewees were homeowners, having built them around the perimeter of the mangrove swamp. The houses were of two types: bricks with ceramic roof tiles (60.4%;  $n = 64$ ); or mud and wattle with ceramic roof tiles (39.6%;  $n = 42$ ). The crab harvester households consisted of a median of 5.2 individual per habitation, with the majority of the households (71.7%;  $n = 76$ ) having a monthly income of one minimum Brazilian wage [US\$ 253,55/1 dollar (USD) = R\$ 3,47 reais (BRL); Quotation, June 14, 2016], while 28.3% ( $n = 30$ ) reported incomes of up to two minimum wages. Among these households, 44.5% ( $n = 42$ ) of all households were included in federal government assistance programs (such as *Bolsa Família*).



**Fig. 4.** Live crabs stored in polypropylene sacks at the Mamanguape River estuary, Paraíba State, Brazil. Photo: Douglas Nascimento.

All interviewed crab harvesters stated that capture of *U. cordatus* was their principal activity and main income source, however 58.5% ( $n = 62$ ) of the interviewees stated that they caught fish also. Most crab harvesters (86.8%;  $n = 92$ ) were dissatisfied with the infrastructure of the community where they lived, including its sanitary deficiencies.

### 3.2. Commercialization

Individual crab harvesters reported that they maintained a commercial relationship with one of the five intermediaries active in the region. All intermediaries were men. Most of the harvesters (85%) capture crabs five days the week, and their accumulated production is collected at their houses by the traders (intermediaries), normally twice a week (Wednesday and Friday).

Tramataia crab harvesters store the crabs loose in polypropylene sacks until they are sold (Fig. 4). The intermediaries collect the crab lots within relatively short time intervals to avoid excessive mortality after capture, especially in light of their extremely poor storage conditions.

The basic sales unit of mangrove crabs is a “corda” consisting of a dozen crabs. The fixed price of a dozen crabs which is agreed on by both parties, varies from US\$ 0.72 to US\$ 1.44 in 2014. A corda composed of large male crabs (carapace width of 6 cm or above) has the greatest commercial value, while a mixed corda (small males and females of varying sizes) will be traded for less. Most of the crab harvesters (87.3%) reported that they preferred to receive payment only once a week, on Fridays, arguing that this arrangement is more convenient to both parts.

After acquiring the crabs from the harvesters, the intermediaries separate them according to size and sex. Large males ( $\geq 6$  cm) are sold alive to the final buyers, while the smaller males and females are primarily processed for their meat. The production chain is outlined in Fig. 5.

According to the intermediaries, the principal markets for *U. cordatus* (live specimens and their meat) are pubs and restaurants in large northeastern Brazilian cities such as João Pessoa, Campina Grande, Natal and Recife. The intermediaries informed that without demand from those pubs and restaurants, crab harvesting would not be economically rewarding, as they absorb almost all production. The pub and restaurant owners in the city of João Pessoa (the principal commercial destination) purchase a dozen live crabs for US\$ 7.20. The

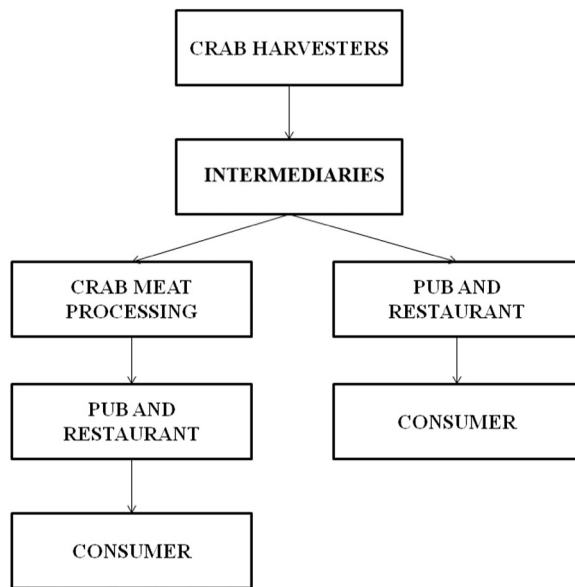


Fig. 5. Production chain of *U. cordatus* harvesting in the Mamanguape River estuary – PB.

clients of those bars and restaurants will then pay from US\$ 1.41 to US\$ 2.59 for a single crab, with an average price of US\$ 1.64.

The intermediaries maintain commercial infrastructures necessary for selling their products, consisting of (at least) transportation (an automobile) and polystyrene boxes to hold the crabs. In addition they bear operating costs to cover expenses for fuel, food, and daily wages for helpers to load and unload the merchandise. Most of the crab harvesters (94%) stated that they did not have access to such infrastructure, principally transport, but also money for the operational expenses, making it impossible to complete the later stages of commercialization. Additionally, 65% of the crab harvesters stated that they did not have the ability to commercialize their catches on their own, preferring to dedicate themselves only to harvesting – which does not leave sufficient time to carry out other activities.

The crab harvesters and intermediaries maintain a dependence within a “worker and boss” model. Confidence is established by the intermediaries by conceding favors to the crab harvesters. All intermediaries interviewed reported that they provide informal loans to the crab harvesters based on personal confidence – without any written document or interest charges. The loans were largely furnished to provide for the basic necessities of the crab harvesters (e.g. house expenses) in exchange for guaranteeing exclusive rights to their harvests.

All crab harvesters indicated that they feel exploited by the intermediaries due to the considerable physical effort required to capture the crabs and the low prices offered to them in return. However, this dissatisfaction is not externalized in their relationships with the intermediaries and in some cases they often establish bonds of considerable friendship with the intermediaries – with the latter occasionally becoming godparents to their sons and daughters.

### 3.3. Crab Meat Processing

Of the 8755 crabs captured by the crab harvesters during the course of the research project, 26.8% ( $n = 2346$ ) were below the legal size limit (60 mm) and, therefore, were processed for meat extraction (1,357 males [15.5%] and 989 females [11.3%]). The maximum and minimum carapace widths (CW) of these crabs for processing were 59.97 mm and 50.78 mm, with a mean of 57.57 mm (standard error = 1.978, Table 1).

The processing activities of *U. cordatus* crab meat are managed (and in part performed) by the intermediaries in the municipality of Marcação on a year-round basis. The process is composed of four

Table 1

Carapace widths (CW) of the mangrove crabs processed for their meat in the Mamanguape River estuary, Paraíba State, Brazil.

	Values (mm)	CW
Males ( $n = 1357$ crabs)	Maximum	59.96
	Minimum	50.78
	Mean	57.65 ( $\pm 1.929$ )
Females ( $n = 989$ crabs)	Maximum	59.97
	Minimum	51.41
	Mean	57.46 ( $\pm 2.037$ )

steps: a) cooking the crabs; b) dismembering them; c) washing the dismembered parts; and d) extracting the meat (Fig. 6). Remaining crab parts are not used for any other purpose and are discarded in the open air.

The place where the crabs are processed for their meat is called a “coapa”, and is provided with a rustic wood-burning stove built by the intermediaries in their own backyards. The intermediaries (with the help of their family) immerse the live crabs into boiling water inside large aluminum cauldrons, where they are left to cook for approximately 30 min. After cooking, the ventral section and the pereiopods (including the chelipeds) are dismembered and washed (Fig. 7). The intermediaries then deliver these parts to women living in the community who they have hired to extract the meat. Extraction itself is performed using a small knife (15 cm long), locally known as a *pinça*. The women are paid US\$ 1.15 for each kilogram of extracted meat. Each woman can extract a maximum of 4 kg per day, and can therefore earn up to US\$ 4.61/day. Due to the low earnings, the women often take out small loans with the intermediaries, thereby generating dependence and loyalty to them, much in the same way as the crab harvesters.

The processed crabmeat is presented to the intermediaries, who then weigh the yields, place them in plastic sacks holding 1 kg, and subsequently store them in a freezer, where they will be maintained until further transport. There are two distinct prices for processed crabmeat: meat extracted from the ventral region of the crab and the pereiopods is sold for US\$ 5.76/kg, while meat extracted from the chelas is more valuable and is sold for US\$ 10.08/kg. The intermediaries themselves report, however, that the crabmeat is often mixed with cooked and shredded meat of marine vertebrate. The most commonly used two local species of elasmobranchs are the spotted eagle ray *Aetobatus narinari* and the nurse shark *Ginglymostoma cirratum*. Ray meat, which has less value on the local market (averaging US\$ 1.01) but is more abundant than nurse shark meat, is more frequently utilized for adulterating the crabmeat. This adulteration is performed to increase profits. According to the intermediaries, this “fake” crab meat can represent more than half of the “crab” sold commercially.

## 4. Discussion

The entire production of the crab harvesters in the research area is readily acquired by intermediaries to supply a high-demand market in nearby cities. Within this context, the intermediaries establish informal agreements of credit and reciprocity, generating dependence and fidelity with crab harvesters. A similar situation was reported by Reis (2007) in Bragança, Pará State, Brazil. Various authors have noted that the credit offered to the artisanal fishers is a way of guaranteeing priority access to their catches, thus guaranteeing continuous and stable stocks (Platteau and Abraham, 1987; Russel, 1987; Merlijn, 1989) – although this has a strong effect on the social resilience of the fishers (Platteau and Abraham, 1987) who are generally very poor and have had little formal education (Madduppa et al., 2014). Our results reinforce these observations, revealing the persistence of socioeconomic situations similar to those reported by Alves and Nishida (2002). This recurrent situation reflects the strong dependence of crab harvesters on the intermediaries.





**Fig. 6.** Steps in the processing of *U. cordatus* meat at the Mamanguape River estuary, Paraíba State, Brazil: A) cooking the crabs; B) dismembering the crabs; C) washing the pereiopods; and D) extracting the meat. Photos: Douglas Nascimento.



**Fig. 7.** A) Coapa - typical processing site of specimens of *U. cordatus* crabs in the Mamanguape River estuary, Paraíba State, Brazil; B) separated parts of mangrove crabs: ventral portion (left) and pereiopods (right). Photos: Douglas Nascimento.

The practice of informal loans (which causes as well as reinforces loyalty and dependence, and suggests exploitation of the crab harvesters) has been observed among artisanal fishers and their intermediaries in other parts of the world, as reported by [Ochiewo et al. \(2010\)](#) in Kenya, [Madduppa et al. \(2014\)](#) in Indonesia, [Merlijn \(1989\)](#) in Malaysia, and [Rahman et al. \(2013\)](#) in Bangladesh. These situations of informal loans generally do not involve interest payments or any explicit payment deadline ([Platteau and Abraham, 1987](#); [Platteau and Nugent, 1992](#); [Merlijn, 1989](#)), being based exclusively on mutual confidence ([Crona et al., 2010](#)), as observed in the present work.

The relationships of dependence of the crab harvesters with intermediaries also involves the marketing of their harvests. The intermediaries provide secure and rapid sales, guaranteeing the purchase of their harvests in the crab harvesters own homes - which allows them to invest their time solely in harvesting activities. However, within this production chain, and due to the low prices that the crab harvesters obtain for their products, they must invest even greater efforts in harvesting activities if they wish to increase production and thus increase their income. More intense harvesting efforts, of course, imply greater pressure on natural populations of these mangrove crabs.

The links that *U. cordatus* harvesters have to intermediaries influence the type of exploitation of this natural resource, and drive cultural changes as to how crab harvesters capture their prey ([Alves and Nishida, 2003](#)). The quest for greater productivity (to improve their low incomes), for example, has led to the wide adoption of a more efficient harvesting techniques involving the use of tangle-netting ([Nascimento et al., 2016](#)), which, according to [Nascimento et al. \(2011\)](#) has caused a cultural rupture leading to the disuse of traditional capture techniques in the Mamanguape River estuary. The potential environmental impacts related to the utilization of this new capture technique include: less selective harvests (crab sizes and sexes), increased production, pollution (through plastic strings remaining in the mangrove), and the mutilation of the prop roots of *R. mangle* to help fix the tangle-netting above the burrow entrances ([Nascimento et al., 2012](#)).

The less selective capture with tangle-netting practiced by the crab harvesters ([Nascimento et al., 2016](#)) appears to be the consequence of the close relationships between the actors involved in crab harvesting.

The intermediaries use both male and female specimens of *U. cordatus* with carapace widths <6 cm for crab meat processing, which conflicts with the federal legislation (Decree IBAMA/PB no. 34 of 03 June 2003). The capture of small individuals can result in growth and recruitment overfishing and potentially reduce *U. cordatus* populations that are slow growing (Fiscarelli and Pinheiro, 2002; Diele and Koch, 2010).

Another ecological implication of the crab meat processing consists of the use of other marine species in the production chain of *U. cordatus* exploitation, such as *Ginglymostoma cirratum*, which appears on the List of Animals Threatened with Extinction under the vulnerable category (Portarias MMA n° 444/2014 and n° 445/2014). The incorporation of the meat of this species into products being sold as *U. cordatus* is a form of camouflaging the utilization and exploitation of a threatened species.

The social and economic dependence of the artisanal fishers in relation to the intermediaries may impact the sustainable use of marine resources (Crona et al., 2010). Additionally, there is a risk that any potential non-sustainability of long-term crab harvesting could be masked by production levels artificially maintained by technological improvements (Ludwig et al., 1993; Pauly et al., 2002), obscuring possible declines in stock levels (Capistrano and Lopes, 2012).

## 5. Final Considerations

Our results indicate that the principal actors involved in the production chain of *U. cordatus* (intermediaries and crab harvesters) must be considered when contemplating strategies for the sustainable management of this species – and not just the crab harvesters, who have heretofore been the sole focus of management plans developed by Brazilian environmental organs. Given the strong influence of intermediaries on the crab harvesting and commercialization process, these actors, as much as the crab harvesters themselves, are key drivers of social, economic, and ecological effects of this artisanal fishery.

Within this framework, we recommend that crab harvesters and the women involved in processing the crabmeat should organize themselves into cooperatives or associations, that could strengthen their social organization and create new forms of managing their harvests, generating alternatives for direct commercialization of their products. If there is interest from the intermediaries, they could also be part of the same cooperatives or associations. These professionals have experience with the dynamics of the market and a network of contacts previously established, which is useful in an organization of cooperative or association type. In this case, the intermediaries could become sales representatives (dealers).

The organization of cooperatives and associations would aggregate value to their products, guaranteeing greater economic profit for the crab harvesters. To do that, however, it will be necessary to establish links with public and/or private institutions (e.g. environmental organizations, universities, research institutes, non-governmental organizations) to provide infrastructure for storage and transport, as well as educational courses for crab harvesters in trading and basic economy. These partnerships could, for example, contribute to the dissemination of techniques guaranteeing the final quality of the processed crab meat; it should also be possible to develop further use of crab residues resulting from meat processing, such as organic fertilizer and animal rations, instead of simply discarding these by-products.

Additionally, the organization of crab harvesters into cooperatives would facilitate the monitoring of their catches by environmental organs, as the cooperative would be required to maintain registers of the quantities and sizes of the specimens captured, which would significantly aid in maintaining healthy natural stocks.

## Author Contributions

DMN participated in all of the research steps. RRNA, RRD and JSM contributed to the design of the work and data analysis. AJS e KD

contributed to the data analysis of the work. All authors were involved in manuscript preparation and have read and approved the final version.

## Conflicts of Interest

The authors declare that there were no conflicts of interests related to this work, and it has not been submitted to other journals for publication.

## Acknowledgments

The authors would like to thank the inhabitants of the Tramataia vilage, especially the crab harvesters, who kindly shared their valuable knowledge with us; the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) for awarding a study grant to the first author; and the administrators of the Barra do Rio Mamanguape Environmental Protection Area for their hospitality and housing in Barra de Mamanguape – PB during the data collection activities. Karen Diele received funding from the MASTS pooling initiative (The Marine Alliance for Science and Technology for Scotland) and its support is gratefully acknowledged. MASTS is funded by the Scottish Funding Council (grant reference HR09011) and contributing institutions.

## References

- Alves, R.R.N., Nishida, A.K., 2002. A ecdise do caranguejo-uçá, *Ucides cordatus* L. (Decapoda, Brachyura) na visão dos carangueiros. *Interciência* 27, 110–117.
- Alves, R.R.N., Nishida, A.K., 2003. Aspectos socioeconômicos e percepção ambiental dos catadores de caranguejo-uçá, *Ucides cordatus cordatus* (L. 1763) (Decapoda, Brachyura), no estuário do Rio Mamanguape, Nordeste do Brasil. *Interciência* 28, 36–43.
- Alves, R.R.N., Nishida, A.K., Hernandez, M.I.M., 2005. Environmental perception of gatherers of the crab caranguejo-uçá (*Ucides cordatus*, Decapoda, Brachyura) affecting their collection attitudes. *J. Ethnobiol. Ethnomed.* 1, 1–8.
- Biernarcki, P., Waldorf, D., 1981. Snowball sampling problems and techniques of chain referral sampling. *Sociol. Methods Res.* 10, 141–163.
- Brazilian Institute of the Environment and Natural Resources – IBAMA, 1995s. Os ecossistemas brasileiros e os principais macrovetores de desenvolvimento: subsídios ao planejamento da gestão ambiental. Ministério do Meio Ambiente, Recursos Hídricos e da Amazônia Legal, Programa Nacional do Meio Ambiente -PNMA. Brasília, MMA.
- Capistrano, J.F., Lopes, P.F.M., 2012. Crab gatherers perceive concrete changes in the life history traits of *Ucides cordatus* (Linnaeus, 1763), but overestimate their past and current catches. *Ethnobiol. Conserv.* 1, 1–21.
- Crona, B., Nyström, M., Folke, C., Jiddawi, N., 2010. Intermediaries, a critical social-ecological link in coastal communities of Kenya and Zanzibar. *Mar. Policy* 34, 761–771.
- Diele, K., Koch, V., 2010. Growth and mortality of the exploited mangrove crab *Ucides cordatus* (Ucididae) in N-Brazil. *J. Exp. Mar. Biol. Ecol.* 395, 171–180.
- Diele, K., Araújo, A.R., Glaser, M., Salzmann, U., 2010. Fishery of the mangrove crab *Ucides cordatus* in N-Brazil: First steps to successful co-management. In: Saint-Paul, U., Schneider, H. (Eds.), *Mangrove Dynamics and Management in North Brazil*. Ecological Studies Vol. 211. Springer, Berlin-Heidelberg, pp. 287–297.
- Fiscarelli, A.G., Pinheiro, M.A.A., 2002. Perfil sócio-econômico e conhecimento etnobiológico do catador de caranguejo-uçá, *Ucides cordatus* (Linnaeus, 1763), nos manguezais de Iguape (24° 41' S), SP, Brasil. *Actual. Biol.* 24, 129–142.
- Gibbon, P., 1997. Prawns and piranhas: the political economy of a Tanzanian private sector marketing chain. *J. Peasant Stud.* 25, 1–86.
- Glaser, M., 2003. Interrelations between mangrove ecosystem, local economy and social sustainability in Caeté Estuary, North Brazil. *Weit. Ecol. Manag.* 11, 265–272.
- Glaser, M., Diele, K., 2004. Asymmetric outcomes: assessing central aspects of the biological, economic and social sustainability of a mangrove crab fishery, *Ucides cordatus* (Ocyropidae), in North Brazil. *Ecol. Econ.* 49, 361–373.
- Huntington, H.P., 2000. Using traditional ecological knowledge in science: methods and applications. *Ecol. Appl.* 10, 1270–1274.
- Kjerfve, B., Lacerda, L.D., 1993. Management and Status of the Mangroves of Brazil. ISME/ITTO, Conservation and Sustainable utilization of mangrove forests in Latin America and Africa regions. Part I Latin Ameri, In, pp. 245–272.
- Ludwig, D., Hillborn, R., Walters, C., 1993. Uncertainty, resource exploitation, and conservation: lessons from history. *Science* 260, 17–36.
- Madduppa, H.H., Juterzenka, K.V.O.N., Syakir, M., Kochzius, M., 2014. Socio-economy of marine ornamental fishery and its impact on the population structure of the clown anemone fish *Amphiprion ocellaris* and its host anemones in Spermonde archipelago, Indonesia. *Ocean Coast. Manag.* 100, 41–50.
- Merlijn, A.G., 1989. The role of intermediaries in small-scale fisheries: a case study of Sarawak, Malaysia. *Dev. Chang.* 20, 683–700.



- Nascimento, D.M., Mourão, J.S., Alves, R.R.N., 2011. A substituição das técnicas tradicionais de captura do caranguejo-uçá (*Ucides cordatus*) pela técnica "redinha" no estuário do rio Mamanguape, Paraíba. *Sitientibus* 11, 113–119.
- Nascimento, D.M., Mourão, J.S., Ferreira, E.M., Bezerra, D.M.M.S.Q., Rocha, P.D., Alves, R.R.N., 2012. Capture techniques' of *caranguejo-uçá* crabs (*Ucides cordatus*) in Paraíba state (northeastern Brazil) and its socio-environmental implications. *An. Acad. Bras. Cienc.* 84, 605–608.
- Nascimento, D.M., Alves, A.G.C., Alves, R.R.N., Barboza, R.R.D., Diele, K., Mourão, J.S., 2016. An examination of the techniques used to capture mangrove crabs, *Ucides cordatus*, in the Mamanguape River estuary, northeastern Brazil, with implications for management. *Ocean Coast. Manag.* 130, 50–57.
- Nishida, A.K., Nordi, N., Alves, R.R.N., 2006. The lunar-tide cycle viewed by crustacean and mollusc gatherers in the State of Paraíba, Northeast Brazil and their influence in collection attitudes. *J. Ethnobiol. Ethnomed.* 2, 1–12.
- Nordi, N., Nishida, A.K., Alves, R.R.N., 2009. Effectiveness of two gathering techniques for *Ucides cordatus* in Northeast Brazil: implications for the sustainability of mangrove ecosystems. *Hum. Ecol.* 37, 121–127.
- Ochiewo, J., Torre-Castro, M., Muthama, C., Munyi, F., Nthuta, J.M., 2010. Socio-economic features of sea cucumber fisheries in southern coast of Kenya. *Ocean Coast. Manag.* 53, 192–202.
- Paludo, D., Klonowski, V.S., 1999. Barra de Mamanguape – PB: estudo do impacto do uso de madeira de manguezal pela população extrativista e da possibilidade de reflorestamento e manejo dos recursos madeireiros. São Paulo: MAB – UNESCO – MMA, n. 16, 1999. 54 p. (Série Cadernos da Reserva da Biosfera da mata Atlântica).
- Pasquotto, V.F., 2007. Comercialização, políticas públicas e reprodução social na pesca artesanal. In: Costa, A.L. (Ed.), *Nas redes da pesca artesanal, Segunda Edição IBAMA, Brasília, Brasil*.
- Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., 2002. Towards sustainability in world fisheries. *Nature* 418, 689–695.
- Platteau, J.P., Abraham, A., 1987. An inquiry into quasi-credit contracts: the role of reciprocal credit and interlinked deals in small-scale fishing communities. *J. Dev. Stud.* 23, 461–490.
- Platteau, J.P., Nugent, J., 1992. Share contracts and their rationale: lessons from marine fishing. *J. Dev. Stud.* 28, 386–422.
- Posey, D., 1987. Introdução – Etnobiologia: teoria e prática. In: Ribeiro, B. (Ed.), *Suma Etnológica Brasileira*. Vozes, Petrópolis, pp. 15–25.
- Rahman, M., Khatun, S., Hossain, M.B., Hassan, M.N., Nowsad, A.A.K.M., 2013. Present scenario of landing and distribution of fish in Bangladesh. *Pak. J. Biol. Sci.* 16, 1488–1495.
- Reis, M.R.R., 2007. Na Friadagem do Mangal: organizar e tirar caranguejos nos fins de semana em Bragança (Vila do Acarajó) (Dissertação de Mestrado) Universidade Federal do Pará (170p).
- Russel, D.N., 1987. Intermediaries and moneylending: relations of exchange in a highland Philippine economy. *J. Anthropol. Res.* 43, 139–161.
- Saint-Paul, U., 2006. Interrelations among mangroves, the local economy and social sustainability: a review from a case study in North Brazil. In: Hoanh, C.T., Tuong, T.P., Gowing, J.W., Hardy, B. (Eds.), *Environment and Livelihoods in Tropical Coastal Zones*, pp. 154–162.
- Santos, M.C.F., 2002. Drinking and osmoregulation in the mangrove crab *Ucides cordatus* following exposure to benzene. *Comp. Biochem. Physiol. A* 133, 29–42.
- Sociedade Internacional para Ecossistemas de Manguezal – ISME, 2005. *Estudo das áreas de manguezais do Nordeste do Brasil* (56 p.).
- Stebins, R.A., 1987. Fitting in: the researcher as leaner and participant. *Qual. Quant.* 21, 103–108.
- Toledo, V.M., 1991. *El Juego de la Supervivencia: Un Manual para la Investigación Etnoecológica en Latino-America*. California, Berkeley.
- Vieira, R.H.S.F., Lima, E.A., Sousa, D.B.R., Reis, E.F., Costa, R.G., Rodrigues, D.P., 2004. *Vibrio* spp. and *Salmonella* spp., presence and susceptibility in crab *Ucides cordatus*. *Rev. Inst. Med. Trop. Sao Paulo* 46, 179–182.
- Wilson, J.A., 1980. Adaptation to uncertainty and small numbers exchange: the New England fresh fish market. *Bell J. Econ.* 11, 491–504.
- Wolff, M., Koch, V., Isaac, V., 2000. A trophic flow model of the Caeté mangrove estuary (North Brazil) with considerations for the sustainable use of its resources. *Estuar. Coast. Shelf Sci.* 50, 789–803.
- Xavier, J.H.A., Cordeiro, C.A.M.M., Tenório, G.D., Diniz, A.F., Júnior, E.P.N.P., Rosa, R.S., Rosa, I.L., 2012. Fish assemblage of the Mamanguape Environmental Protection Area, NE Brazil: abundance, composition and microhabitat availability along the mangrove-reef gradient. *Neotrop. Ichthyol.* 10, 109–122.