

Monitoring mangrove crab *Ucides cordatus* Linnaeus, 1763 (Crustacea: Ucididae) landing in the Parnaíba River Delta: fishing characteristics, social and economic aspects

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ABSTRACT

The century-old mangrove crab *Ucides cordatus* Linnaeus, 1763 harvesting is a traditional activity of Northeastern Brazilian coastal communities, who use it as food, source of income and cultural reference. The extractivism and marketing of this crustacean is essential for the socio-economic development of the states of Maranhão, Piauí and Ceará. The aim of this study was to carry out the monitoring of harvesting and landing of the mangrove crab in Ilha Grande, PI. Interviews were conducted with crab gatherers and transporters to obtain information about harvesting, landed volume, market price and destination of commercialized crab. The main capture spots were located at the Maranhão part of the Parnaíba River Delta. Crab gatherers are active 5.07 times a week and spend an average of 6 hours in mangrove. The average number of crabs collected per gatherer/day was 77.0. The quantity landed in daytime period was 63,628 crabs/month, totalizing 714,543 crabs/year. The average price traded was USD 0.19/crab. The production chain

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of mangrove crab harvesting requires planning for maintain the natural stocks and aggregation of value to the product, benefiting the appreciation of crab gatherers.

KEY WORDS

Crab gatherers, fishing effort, planning.

INTRODUCTION

Located between the states of Piauí and Maranhão, the Parnaíba River Delta is the third largest delta in the world and the only one in the open ocean of the Americas, and presents great importance for the flora and as a nursery to the fauna of the Northeastern Brazilian coast (Ministério do Meio Ambiente, 2002), because it harbors extensive mangroves areas. These mangroves form a complex food web which is essential for the health of coastal ecosystems (Schaeffer-Novelli, 1995).

The crab *Ucides cordatus* Linnaeus, 1763 inhabits mangroves, excavates burrows in the sediment of the tidal zone (Schmidt, 2012) and plays an important ecological role in soil oxygenation and nutrient cycling (Melo, 1996). This crustacean has a socio-economic importance for the communities of gatherers from the Parnaíba River Delta, as an income font and the local market is refreshed by its harvesting and marketing (Legat *et al.*, 2005), thus it can be considered as the symbol species of the Parnaíba Delta region.

The extractivism of mangrove crab is one of the oldest traditional activities in Brazil, occurring in several states, but on a larger scale in Pará, Maranhão, Piauí and Bahia (Dias-Neto, 2011). According to fisheries statistics, the annual production of this species ranged from 9,577.2 t in 2007 (IBAMA, 2007) to 8,607.5 t in 2011 (Ministério da Pesca e Aquicultura, 2011). Of this amount, Pará contributed with approximately 50.0%, Piauí with 10.0% and Maranhão with 18.0% of the total volume of mangrove crab captured. From 2011, there are no official production data, but the reduction observed between 2007 and 2011 (around 10.0%) worries gatherers, environmental agencies and researchers, who have since then carried out studies aimed at the sustainability of mangrove crab in Brazil (Araújo and Calado, 2008; Castro *et al.*, 2008; Wunderlich *et al.*, 2008; Góes *et al.*, 2010; Castiglioni *et al.*, 2013; Oliveira *et al.*, 2013).

Among the researches carried out, the evaluation of capture methods and the development of transport

techniques have the least impact on the populations of mangrove crab. The harvesting is traditionally carried out by the “braceamento (putting the hand and arm inside the burrow)” combined with the “cambito” or hook, an instrument that serves to force the crab out of the whole (Legat and Puchnick-Legat, 2009). There are also techniques such as “redinha” that consists in a trap placed in the opening of the burrows, which is extremely predatory, besides being prohibited by the Brazilian legislation (IBAMA, 2003a; Jablonski *et al.*, 2010).

In this sense, experts proposed management plans for the sustainable use of crabs in the document “Proposal of a National Management Plan for the sustainable use of the mangrove crab, guaiamum and siri-azul” (Dias-Neto, 2011). Concurrently with the management of harvesting, the Empresa Brasileira de Pesquisa Agropecuária (Embrapa) developed a technology that demands the transport of untied (free) crabs in plastic boxes, which drastically reduced their mortality (Legat and Puchnick-Legat, 2009), becoming a law in force in 2014 by the Normative Instruction n.9 of July 2, 2013 (Ministério da Pesca e Aquicultura, 2013).

However, it is difficult to evaluate the efficiency of the proposed technologies, when there is no monitoring of the mangrove crab extractivism or quantification of the volume landed annually. This is a problem involving small-scale fishing. Their contribution, role and importance traditionally have often been described separately on thematic terms (economic, social, employment and food source), when it should be analyzed in synergism and interconnection between these sectors (Béné, 2006). Small-scale fishing involves concepts of food security, rural and economic development, environmental and cultural dimensions. It demands local and regular monitoring of the activity; new science methodologies for analyzing available data; constant small-scale fishing information updating; and insertion of the activity in the nation’s development context, in order to promote changes in societal priorities and values, with consequence improvements in policy and governance (Andrew *et al.*, 2007).

Due to the small-scale fishing importance and the need for constant monitoring of this activity; to socioeconomic importance of the crab extractivism for the communities of the Parnaíba River Delta and its surroundings; and to contribute to the rational use of coastal natural resources, the objective of this work was to monitoring the mangrove crab landed in Ilha Grande, between the states of Maranhão and Piauí, with special relevance to its social, economic and environmental aspects.

MATERIAL AND METHODS

Ilha Grande de Santa Isabel is located in the municipalities of Parnaíba and Ilha Grande, in the state of Piauí. It has a population of 8,914 inhabitants, and a municipal human development index (IDHM) of 0.563, occupation of the territory index of 66.36 inhabitants/km² and altitude of 10 m. Its economy is based on public services and extractivism of natural resources (Instituto Brasileiro de Geografia e Estatística, 2015). It has an extension of 134.31 km², being the largest coastal fluvial island of the Parnaíba River Delta, an area of Union domain within the Environmental Protection Area (APA) in Parnaíba River Delta (Crespo, 2007).

The climate is tropical humid or coastal, with temperatures varying between 23°C and 35°C, summer rains and average annual rainfall of 800 mm (Instituto Brasileiro de Geografia e Estatística, 2015). The sandy, shallow, nutrient-poor soils of the region are classified as marine quartz sands, solonetz-solodized and indiscriminate mangrove soils (Empresa Brasileira de Pesquisa Agropecuária, 2016).

It is formed by transitional biomes between the caatinga, savana (cerrado) and marine coastal systems, and presents great biodiversity mainly in mangroves that provide vegetation, shelter and subsistence for different fauna groups, such as mammals, birds, reptiles, fish, crustaceans and molluscs (Instituto Chico Mendes de Conservação da Biodiversidade, 2016).

The monitoring of the extractivism was carried out by the monitoring of the landing at the Tatus Harbor (2°45'58.68"S 41°50'59.94"W), the main place of distribution and commercialization of the mangrove crab in Ilha Grande; and by the application of monthly

interviews to the gatherers and merchants of crab, between December 2014 and November 2015.

The dates of field trips followed the lunar calendar: new moon is considered bad for harvesting and full moon is considered better, according to the testimony of the gatherers. There were performed 24 field trips (approximately two/month), totalizing 832 interviews.

In order to collect the data, were created field worksheets containing: name of the harbor, name of canoe or boat, species captured, fishing gear used, place of capture, quantity obtained, duration of harvesting, number of gatherers, periodicity of harvesting, sale price and destination of crab marketed. The catch per unit of fishing effort (CPUE) was calculated using as effort unit the number of crabs caught by gathereres per day (Lima *et al.*, 2010). The total volume landed monthly was calculated by the ratio number of crabs collected / day x number of harvesting days x number of weeks in the month. The daily gross income for each gatherer was calculated by the ratio of CPUE x Price for the set of four crabs tied in ropes (called rope) x harvesting frequency.

The information collected was scanned in electronic spreadsheets for the description and statistical analysis of data, using Excel and Statistica 13 (2016) programs. Variance Analysis (ANOVA) was performed to compare the mangrove crab harvest data in the different months evaluated. In cases where the ANOVA results were statistically significant, the T test with $p < 0.05$ was used (Costa *et al.*, 2013).

RESULTS

According to the information collected, the harvesting of the crab is an activity organized and performed almost daily (five times a week). The gatherers are organized in groups the previous day, establishing with the owner of the boat (who is also a gatherer) the number of people, usually four to five gatherers per boat (Tab. 1), the location, the harvesting time and the payment for transportation. They prepare the paraphernalia, the food, and leave early the next day. They spend at least six hours in the mangrove, returning to the Tatus Harbor for selling the crabs to local merchants (Fig. 1). They receive the payment on time and return to their homes to restart the cycle of gather and sale of the crustacean (Tab. 1).

Table 1. General aspects of the *Ucides cordatus* harvesting in the Parnaíba River Delta, Brazil. Average followed by different letters in the columns indicates statistical difference ($p < 0.05$). N = 84. Source: drafting of the authors.

Month	Number of canoes / day	Duration of harvesting for crabs (hours)	Times / week harvesting for mangrove crab	Number of gatherers / day	Number of gatherers / canoe	CPUE (crabs / gatherers / day)
Dec/2014	12 ^a	6.69 ^{ab}	5.67 ^a	81 ^a	6.75 ^{ab}	58.84 ^a
Jan/2015	12 ^a	6.83 ^{ab}	4.08 ^b	53 ^b	4.42 ^{abc}	96.13 ^a
Feb/2015	06 ^b	6.73 ^{ab}	5.00 ^{ab}	34 ^{bc}	5.67 ^{abc}	90.14 ^a
Mar/2015	06 ^b	4.63 ^b	4.80 ^{ab}	23 ^c	3.83 ^{abc}	102.55 ^a
Apr/2015	07 ^b	2.35 ^b	5.33 ^{ab}	22 ^c	3.14 ^c	52.69 ^a
May/2015	10 ^a	6.95 ^{ab}	5.10 ^{ab}	49 ^b	4.90 ^{abc}	75.63 ^a
Jun/2015	10 ^a	6.54 ^{ab}	4.80 ^{ab}	51 ^b	5.10 ^{abc}	90.19 ^a
Jul/2015	15 ^a	7.15 ^{ab}	5.53 ^a	65 ^{ab}	4.33 ^{abc}	61.87 ^a
Aug/2015	08 ^{ab}	7.58 ^a	5.75 ^a	32 ^{bc}	4.00 ^{abc}	75.06 ^a
Sept/2015	07 ^b	7.15 ^{ab}	4.86 ^{ab}	24 ^c	3.43 ^c	80.86 ^a
Oct/2015	06 ^b	7.24 ^{ab}	4.67 ^{ab}	22 ^c	3.67 ^{bc}	66.49 ^a
Nov/2015	04 ^c	6.34 ^{ab}	5.25 ^{ab}	15 ^d	3.75 ^{bc}	73.64 ^a
Average	8.58	6.35	5.07	39.25	4.42	77.01
CV (%)	42.11	15.42	24.17	31.25	59.23	48.61



Figure 1. Details of the commercialization of *Ucides cordatus*. A) Larger vessel arriving at the Tatus harbor; B) Small vessel (more common) arriving in the harbor; C) Negotiations between traders and gatherers with exposure of collected crab; D) Payment of the product (detail of the merchants offering predetermined amounts to the gatherers). Photos: F.H.S. Fogaça.

The number of canoes and collectors per month may vary. However, it was observed that in the months of May to August and December to January there was a greater number of boats or canoes (12–15), whereas in November, only four canoes/day went to the harvest (Tab. 1). A greater number of gatherers (81) was observed in December 2014, followed by June, July and January (65, 53 and 51 gatherers), with an average of 39 gatherers per day engaged in the harvesting activity (Tab. 1).

The number of gatherers per canoe was lower ($p < 0.05$) in April (3.14) and September of 2015 (3.43). For the other months, it was statistically similar (Tab. 1). The duration of harvesting was lower ($p < 0.05$) in March and April 2015 (4.63 and 2.35 hours, respectively) and higher in August 2015 (7.85 hours), but it was similar in the other monitorized months (Tab. 1).

This homogeneity between the number of gatherers per canoe and the duration of harvesting may be observed in the catch per unit of harvesting effort (CPUE), which was statistically the same ($p < 0.05$) in all the months evaluated, with an average of 19.25

ropes/gatherer/day or 77 crabs/gatherer/day (Tab. 1). The CPUE did not correlate with the duration of harvesting (Fig. 2), demonstrating that longer staying in the mangrove did not promote a larger number of crabs/gatherer/day (Tab. 1).

The crabs are captured in different locations of the Parnaíba River Delta, however, all of them are located on the Maranhão side of the Delta. Sixteen gather areas that ranged from igarapés to mangroves around the delta islands, mostly located within the “Resex Marinha Delta do Parnaíba” extractive reserve, popularly known as Crab’s Resex (Fig. 3), were cited. Despite the diversity of localities, there is a notable preference for the Igarapé do Periquito (43%), followed by the Ilha das Canárias (15%), Igarapé do Doce (12%) and Poldros (10%) (Fig. 4).

The most cited site for harvest mangrove crab of the Parnaíba Delta, the Igarapé do Periquito, presented lower CPUE (17.1 ropes/gatherer/day) compared to the values determined for Igarapé do Doce (20.0 ropes/gatherer/day) and for Poldros (19.4 ropes/gatherer/day) (Fig. 5).

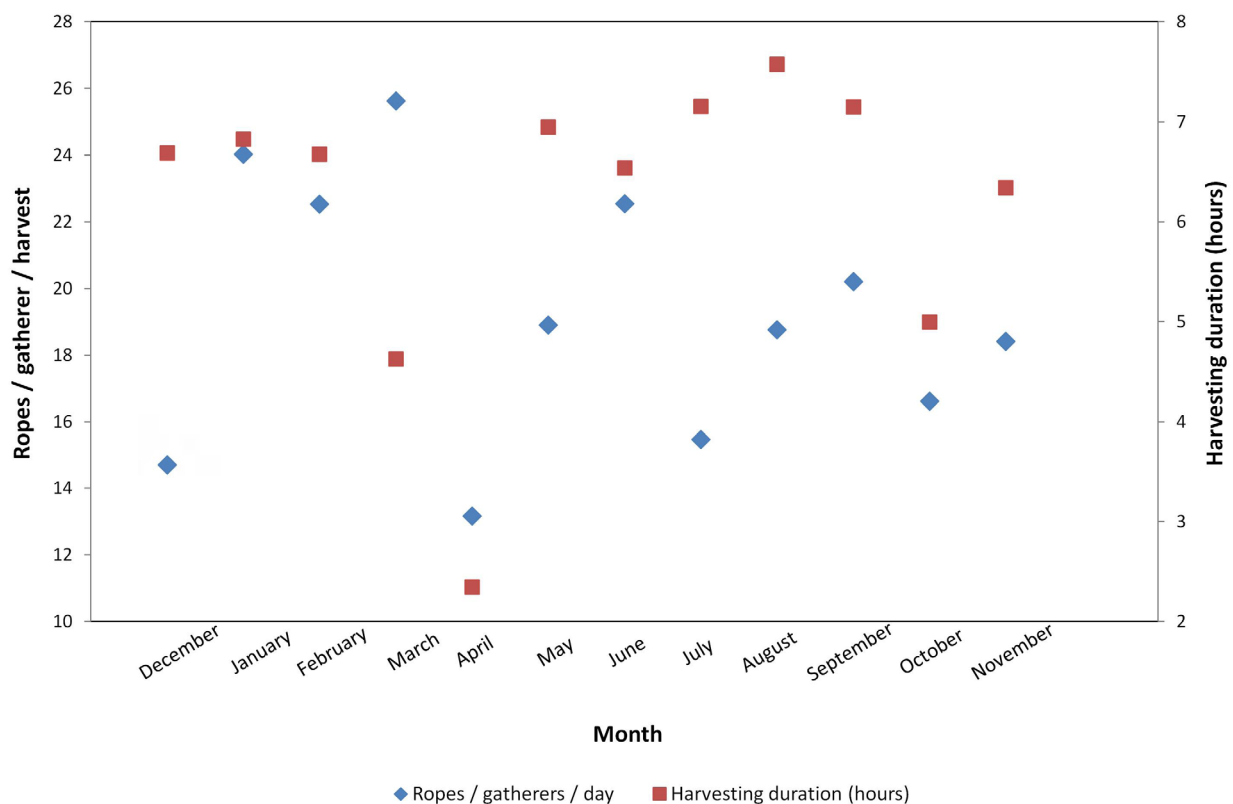


Figure 2. Monthly values for CPUE and duration of harvesting (hours) of *Ucides cordatus* in the Parnaíba River Delta, Brazil, from December 2014 to November 2015. N = 84.

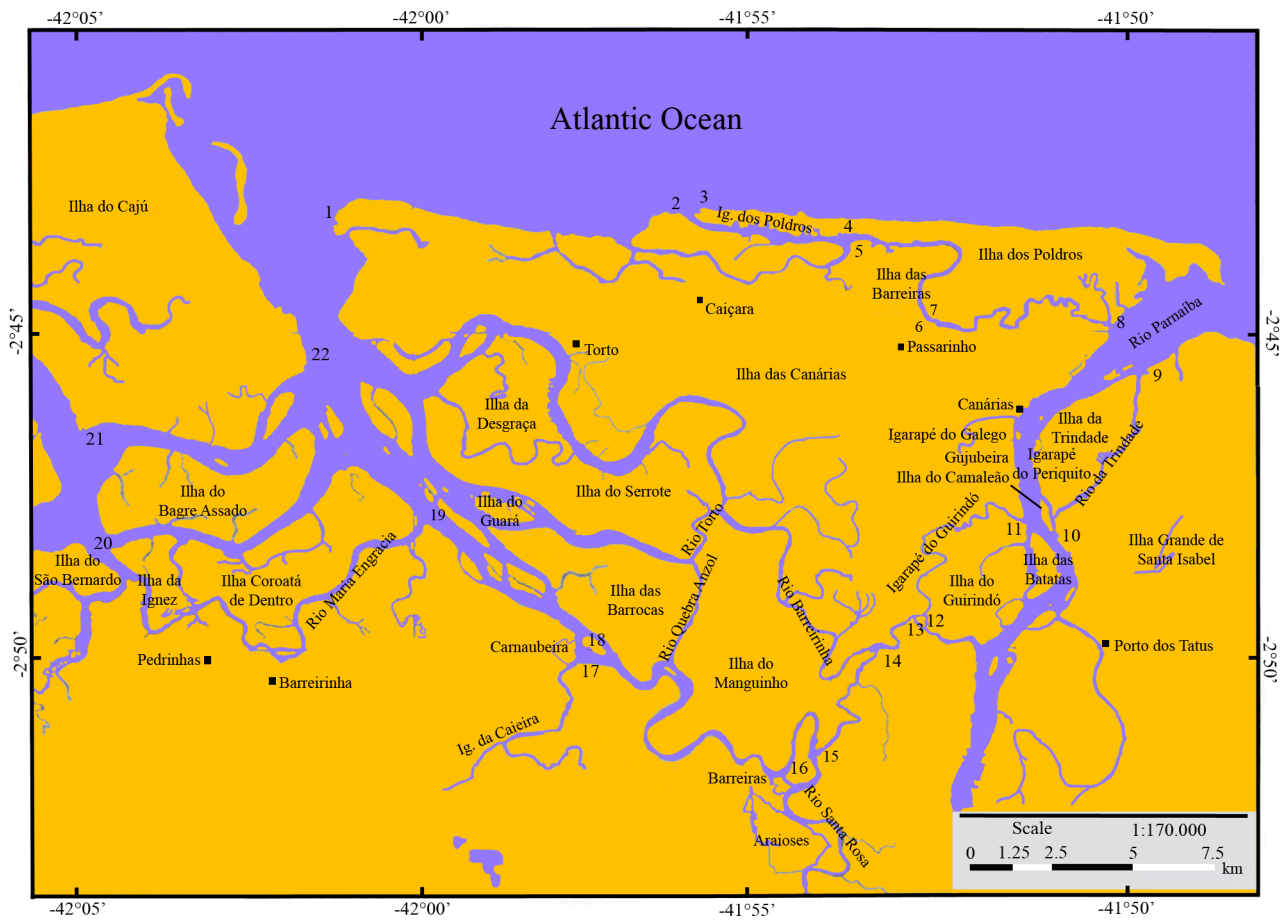


Figure 3. Location map of *Ucides cordatus* sites in the Parnaíba River Delta, Brazil. N = 84. Source: adapted from ICMBio (2016).

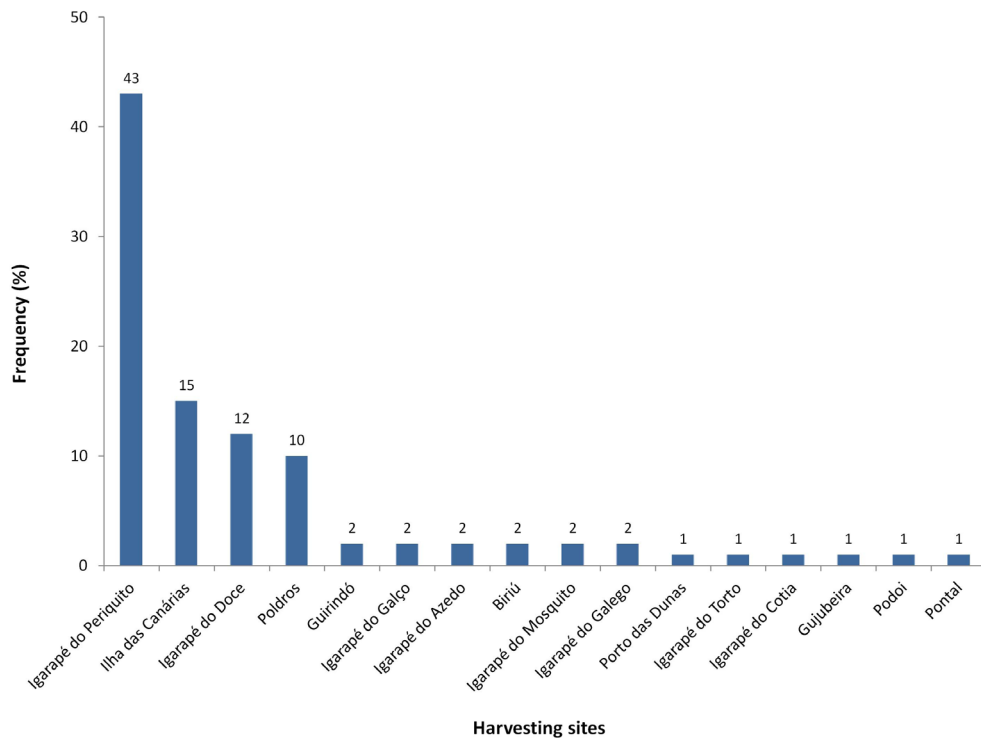


Figure 4. Frequency (%) of citation of *Ucides cordatus* sites in the Parnaíba River Delta, Brazil. N = 84.

However, there is no linear Pearson's correlation ($p > 0.05$) between the CPUE for the Parnaíba Delta and the number of gatherers at the capture sites. The CPUE for 13 gatherers/day (25 ropes/gatherer/day) was similar to that of 2 gatherers/day (23.44 ropes/gatherer/day) or 1 gatherer/day (24.2 ropes/gatherer/day), while the lowest values were determined for 12 gatherers/day (10 ropes/gatherer/day) and eight gatherers/day (11.75 ropes/gatherer/day) (Fig. 6).

Traditionally, collected crabs are tied in ropes containing four animals and arranged in groups of ropes, which may vary from 20 to 40 ropes each. After landing in the harbor, these groups of ropes are sold by the gatherers and distributed in the commerce of Ilha Grande and Parnaíba, resold to restaurants, "breakers" (places of extraction of crab meat) and consumers.

Regarding the daytime landing of the crab, in the period 2014–2015, 178,636 ropes or 714,544 crabs were landed, with a monthly average of $14,886 \pm 5,535.05$ ropes (Fig. 7). The highest volumes were observed in the months of January (18,342 ropes), February (19,440 ropes), June (21,446 ropes), July (21,602 ropes) and September (19,700 ropes). However, there was no Pearson's correlation ($p > 0.05$) between the price for rope and the quantity landed (Fig. 8).

For the Parnaíba Delta, the average price applied was USD \$ 0.77/rope or USD \$ 0.19/crab. In January and July, the price of the rope ranged from R \$ 0.93 to USD \$ 1.00, an increase of 22.80% (Fig. 8). Based on the sales values of the crab (Fig. 8) and in the CPUE of each site (Tab. 1), a daily gross income can be estimated for each gatherer, which for the Parnaíba Delta was USD \$ 14.89/day or USD \$ 301.55/month.

DISCUSSION

As observed in the Delta of the Parnaíba River, other authors describe that the exploitation of the crab in the Brazilian mangrove occurs throughout the year (Santos *et al.*, 2014), which is a concerning for the preservation of the species, mainly in relation to the renewal of natural stocks (Alves, 2001). However, it has been observed that the gather of the mangrove crab is intensified when there is greater demand for the product in the places of consumption. Therefore, in the months of greater tourist frequency (January, February

and July) in the region, there may be greater pressure on the natural stocks of the species, as observed in the total volume captured in these months, except for the months of June and September (Fig. 7).

It was found lower intensity for crab gather in November, observed by the lower frequency of boats in that month (Tab. 1). This frequency may be related to the higher difficulty of capture at this time, when the crab shuts themselves in the holes for changing of exoskeleton and then their bodies remain fragile and can break when being pulled from the holes or during transportation. According to studies, *U. cordatus* presents a seasonal pattern to make the molt or ecdysis, with preference for the hottest months of the year and with peaks in November (Pinheiro and Fiscarelli, 2001; Lima and Oshiro, 2006), coinciding with the Parnaíba Delta, where ecdysis period occurs from September to November (Terceiro *et al.*, 2013).

It is interesting to note that, regardless of the months, the average duration of 6 hours for harvesting (Tab. 1) is the same, the time is similar to other regions of Brazil, and the gatherers of the Parnaíba Delta have a higher harvesting frequency (five days per week) when compared to other extractive communities. In the community of Gargaú, Rio de Janeiro, the gatherers also spend six hours in the mangrove, but engage only three times a week (Santos *et al.*, 2014), while the gatherers from the Maracanã Extractive Reserve in Pará engage four days week (Freitas *et al.*, 2015).

The method of capture may also influence the number of crabs caught and the frequency of harvesting. The technique of "braceamento with the help of the hook or "cambito" demands more effort and time by the gatherer, resulting in a lower CPUE (Capture per Unit of Harvesting Effort). While the "redinha" method, characterized by the closure of the entrances of the burrows with a net, requires a shorter time, as the gatherer is laying the nets along the mangrove and after two hours returns to collect the crabs trapped. Therefore, the highest harvesting frequency of mangrove crab is directly related to the catch method, which for the Parnaíba Delta was 19.25 ropes/gatherer/day or 77 crabs/gatherer/day (Tab. 1). In the opposite region, in the Environmental Protection Area of the Maranhão Reentrances, the average CPUE is 125 crabs/gatherer/day (Lima *et al.*, 2010); in Resex Maracana, Pará, is 92.22 crabs/gatherer/day (Freitas *et*

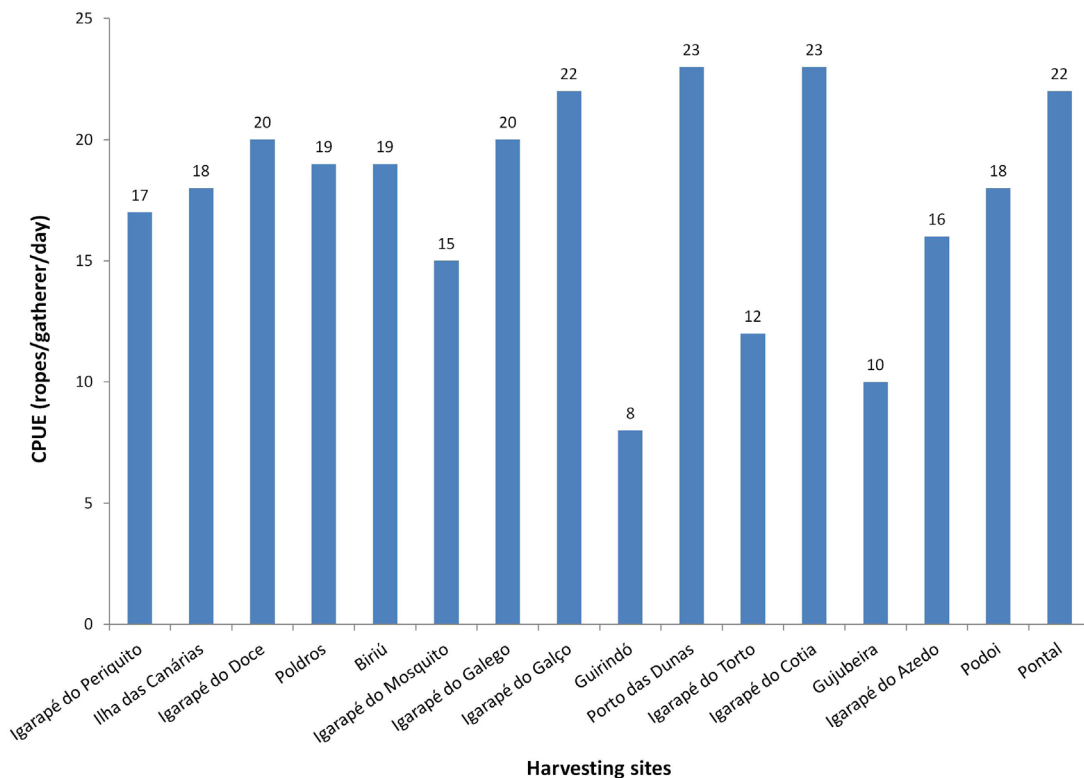


Figure 5. CPUE (ropes / gatherer / day) for the *Ucides cordatus* harvesting sites in the Parnaíba River Delta, Brazil. N = 84.

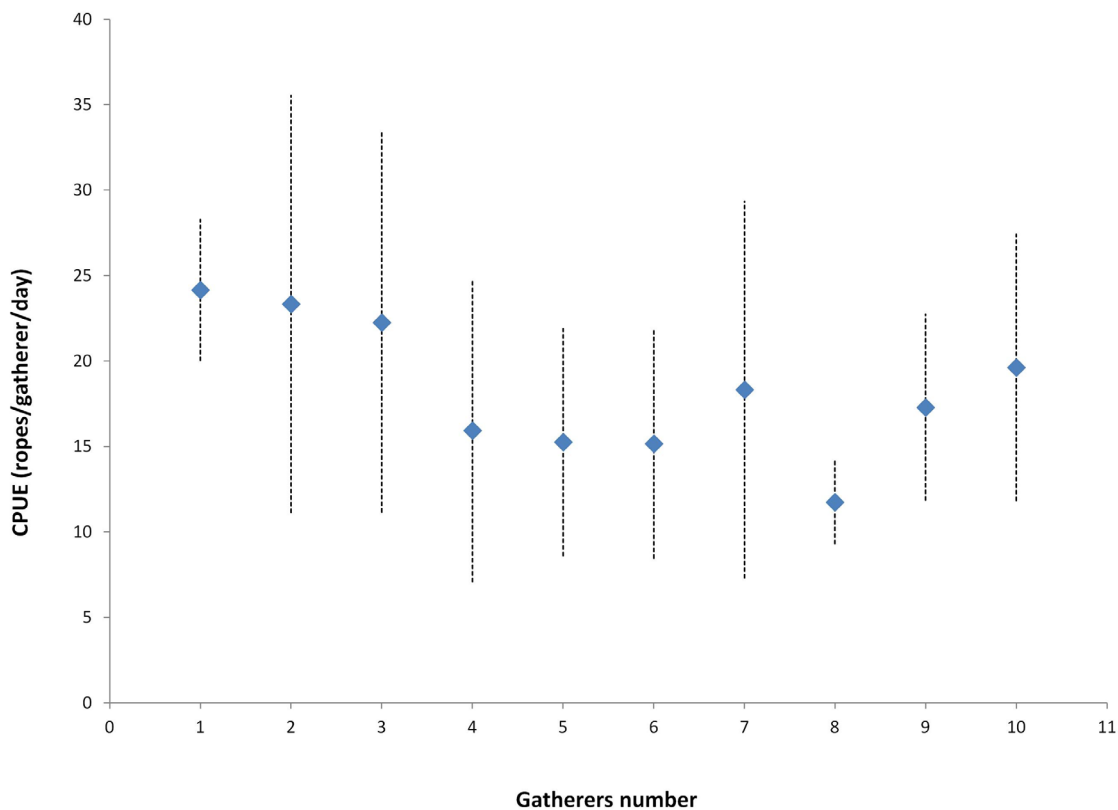


Figure 6. CPUE according to the number of *Ucides cordatus* gatherers in the Parnaíba Delta, Brazil. Dotted lines represent the standard deviation.

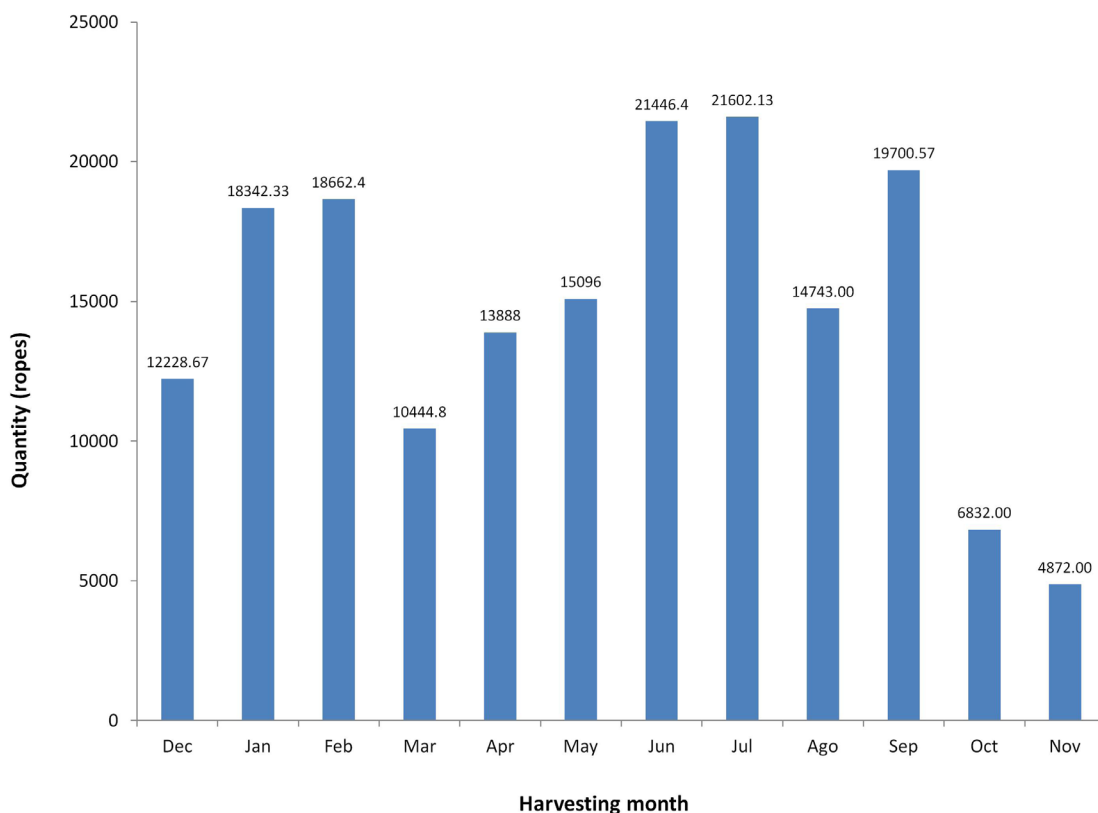


Figure 7. Quantity (ropes) of *Ucides cordatus* recorded at daytime landing at Tatus Harbor, Ilha Grande, Piauí, Brazil.

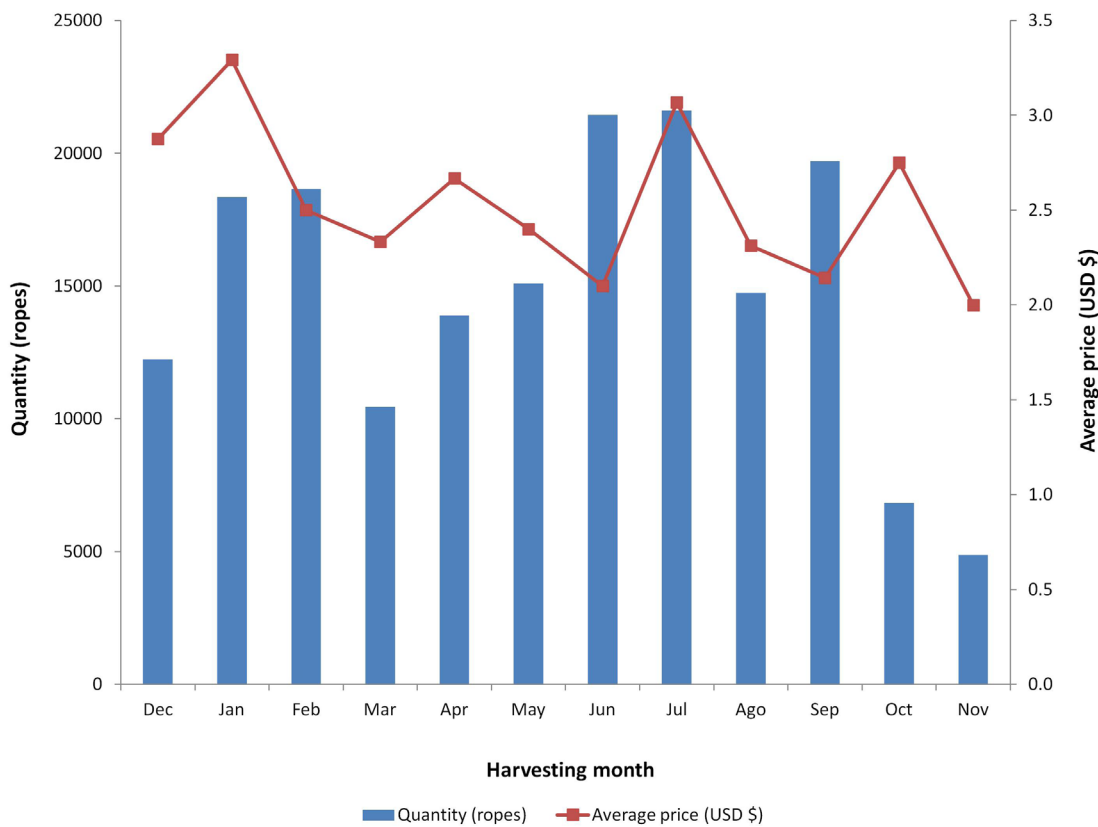


Figure 8. Price of ropes (USD \$) of *Ucides cordatus* marketed during daytime landing at Tatus Harbor, Ilha Grande, Piauí, Brazil, from December 2014 to November 2015.

al., 2015); in the community of Gargaú, Rio de Janeiro, is 125 crabs/gatherer/day (Santos *et al.*, 2014) and in the municipality of Quatipuru, Pará, can reach 167.6 crabs/gatherer/day (Silva *et al.*, 2008).

The greatest harvesting effort occurs in areas that use the “redinha” as fishing gear. Although predatory and prohibited by law (IBAMA Order No. 52 of September 30, 2003, Brazil, 2003b), this technique requires less physical effort and less experience of the gatherers, allowing a larger number of people to engage in this activity (Nascimento *et al.*, 2012). According to Nascimento (2006), in the state of Pará, the market for meat or “mass” of crabs encourages greater exploitation of stocks and predatory actions such as gather of animals with sizes below that the allowed by legislation (< 60 mm, IBAMA, 2003; Ordinance n.º 34, June 24, 2003), and of females, which is not traditionally performed by the gatherers. In the Parnaíba Delta, 100% of the gatherers use the hook or cambito and harvest only the males, requiring a higher frequency of harvesting to obtain a larger number of crabs.

Regarding the harvesting, statistics show that the CPUE of professional collectors increased around 68% from 1995 to 2007, in Pará, and since 2005, there is homogeneity among the values (Freitas *et al.*, 2015). In the Delta of Parnaíba, studies conducted from 1999 to 2002 recorded a CPUE ranging from 14.6 to 22.6 ropes/gatherer/day, according to the months of capture (Legat *et al.*, 2005), an increase of 75.84%, considering the lowest average in relation to the CPUE determined in 2014/2015 (19.25ropes/gatherer/day). Increasing CPUE may indicate a reduction in the natural stock of crabs over the past 10 years, whose perception has already been reported by gatherers (Capistrano and Lopes, 2012).

The time of year can also influence CPUE for the mangrove crab. Some authors verified seasonal differences for CPUE in Pará, whose values were 8.69% higher in the dry season (Glaser and Diele, 2004). According to the gatherers, the rainy months make the harvesting difficult due to the rise of the river level and, consequently, the water level in some mangrove areas. However, in the Parnaíba Delta, the inverse occurred, there was a CPUE 14.28% higher in the rainy months (January to June) (Tab. 1). This is because, in addition to having numerous mangrove areas with different characteristics that can be explored daily,

the first semester there are three months of tourism to the region: January, February and July, bringing the gatherers to the harvesting of mangrove crab, which will have guaranteed sale.

The intensification of exploitation in these months of the year can be observed in the volume of crabs harvested and landed in Ilha Grande (Fig. 7). Considering an average weight of 188 g for crab (Galvão *et al.*, 2010), 133.34 t of *U. cordatus*/year were obtained only with the daytime landing, bringing forth a total gross amount of USD \$ 137,892.53/year (total number of ropes x average price). Of this amount, 45% or 60.0 t were collected in January, February, June and July (Fig. 7).

There is also a high coefficient of variation (CV) for CPUE (48.61%). This means that the minimum CPUE (52.69 crabs/gatherer/day) is 50% smaller than the largest (102.55 crabs/gatherer/day) (Tab. 1). This variation was also observed in the state of Pará and the differences were attributed to the different environmental characteristics of the mangrove areas explored (Freitas *et al.*, 2015).

Among the 16 sites mentioned by the collectors, the Igarapé do Periquito (or Igarapé da Trindade) is the place that receives the largest number of gatherers per day, probably because it has an abundance of crabs and is easily accessible. The other sites do not show similarity, ranging from more distant sites such as the Igarapé dos Poldros and Torto, to the closest mangroves like Gujubeira and Guirindó (Fig. 3). The choice of areas depends on mangroves that have larger numbers of crabs and are larger in size, than areas closer to their home or apparently less polluted, as reported by gatherers from the state of Rio de Janeiro (Santos *et al.*, 2014).

The values for CPUE can also occur according to the degree of exploitation of the resource in each mangrove (Lima *et al.*, 2010), which corroborates with the results determined for the Parnaíba River Delta, where it was observed that the largest number of gatherers (43%) attend Igarapé do Periquito, which the production is 15% lower than in the Igarapé do Doce (12% frequency of gatherers) and 26% smaller than in the Igarapé do Cotia (1% frequency) (Figs. 4, 5). These data indicate that the act of harvesting in a group is a social behavior of the gatherer, not a gather strategy aimed at harvest more crabs.

In Brazil, traditionally harvested crabs are organized in tied up ropes (Legat and Puchnick-Legat, 2009) and sold alive to local commerce. With the exception of state of Pará, which produces meat or crab mass, the commercialization of *U. cordatus* is based on the sale of the product *in natura* (Santos *et al.*, 2014), whose price varies according to season year.

In the months of January and July, when the demand for the product increases due to the greater tourist movement in the Northeast, the price may increase up to 22.80%, from USD \$ 0.93 to USD \$ 1.00 (Fig. 8). This increased value of the product at some times of the year may lead to a greater exploitation of natural stocks and, indirectly, affect the population that depends on mangrove crab to survive (Cordovil *et al.*, 2014). In other words, other types of fishermen and even residents of the Parnaíba River Delta take advantage of the increased demand for crabs in the tourist months as an opportunity to earn extra income, raising the pressure on natural crab stocks and competing with traditional gatherers. This increase in the number of “usual gatherers” was cited by 29% of gatherers as the reason for reducing stocks of mangrove crab from Rio Grande do Norte (Capistrano and Lopes, 2012).

The values attributed to mangrove crab also depend on the region of exploitation. In the state of Rio de Janeiro, in 2013, each specimen was traded at USD \$ 0.15 (Santos *et al.*, 2014), while in state of Pará in 2008 the unit was traded at USD \$ 0.09 (Freitas *et al.*, 2015), prices 20.0% to 52.4%, respectively, lower than those applied in the Parnaíba River Delta. In this sense, the estimated gross income for the Delta gatherers, calculated based on the sales values of the crab and the local CPUE, is about 20% higher when compared to other locations, whose relatively low values are USD \$ 242.91/month, as observed in Pará in 2009 (Cordovil *et al.*, 2014).

The low income obtained with the crab harvesting is related to the way in which the product is sold, where each gatherer individually negotiates what he collected, weakening the figure of the gatherer and devaluing his product. This type of commercialization characterizes the crab production chain as the beneficiary of the middleman in detriment of the gatherer (Costa *et al.*, 2013). According to Nordi (1992), the crab gatherers are the fishermen who have

lower purchasing power, since they sell the product *in natura*, without possibility of value aggregation, where bars and restaurants are the final links of the productive chain and the responsible for the profitability of the business. Even so, harvesting is a source of income and food, contributes to the permanence of the gatherers to his place of origin (Passos, 2016) and, therefore, the activity is renewed every day.

The monitoring of artisanal harvesting for quantification of its production has always been criticized, partly because it is erroneously considered “inefficient” or “unproductive”, but mainly due to difficulties in data collection due to the wide diversity of this activity. Today, based on data from fisheries statistics, it is noted that, in many areas, their participation in national landings is equivalent to or greater than that of industrial fisheries (Ministério da Pesca e Aquicultura, 2012).

To contextualize the importance of fishing in Brazil, total catch has been quite stable at around 800,000 tonnes in 2010. Small-scale fisheries contribute to 50–60% of the total production from capture fisheries. In 2011, 875,700 fishermen, 64% for marine fisheries, were engaged directly in full time fishing activities (FAO, 2011). The northeastern region is the main seafood producer in Brazil. The extractivism of crustaceans is in second place, and the extractivism of *U. cordatus* represents the third most exploited resource in Brazil or 2.5% of the small-scale fishing production (Ministério da Pesca e Aquicultura, 2011). That is why the extractivism of mangrove crab, essentially traditional and artisanal, is very important for the states of the North and Northeast of Brazil.

Despite the importance of the activity for the Northeastern region, most states do not have an accurate effort surveys, although some estimates of the gatherer number. It is estimated that Maranhão has 4,000 crab gatherers, Paraíba 3,100; Piauí 2,500 and Sergipe 1,250. In the Parnaíba Delta, approximately 4,500 crab gatherers work in the region (Dias-Neto and Dias, 2015). Unfortunately, there is not an updated list of fishermen in Brazil by state or even by type of fishing, which makes impossible to compare catches between localities or species.

Currently, there is no fishery statistics program that monitors the main exploited species, quantifying

the landed volume, identifying CPUE reductions and following the personal observations of fishermen and gatherers. The mangrove crab is in an unknown situation, as there are no systematized and continuous studies for the species in the areas of bioecology that can be associated to the fishery statistics. However, isolated research can guide regulatory actions. In the state of Alagoas, mangrove crab harvesting suggests an overexploitation of the species based on the reduction of CPUE values (Araújo and Calado, 2008), but there is no annually quantification of landings. In Brazil's southeast, studies with crab bioecology and harvesting subsidized a management plan for exploration of this crustacean (Rodrigues *et al.*, 2000). Pará is the state with the largest number of monitoring papers about artisanal harvesting, and is also the main explorer of the mangrove crab in the country. In Pará, there is no evidence of overharvesting for the species, only greater difficulty of access reported by the gatherers (Santa Fé and Araújo, 2013).

Coastal ecosystems are ecologically, culturally, and economically important, and hence are under pressure from diverse human activities: urban, industrial, agricultural, land reclamation or direct exploitation of resources (Vasconcelos *et al.*, 2007). In the case of crab extractivism, the social conflicts are associated with the activity intensification, especially in Pará (Araújo, 2006). Due to the low initial investment of the extractivism, the high population growth, the lack of employment and source of income, the high crab demand in the market and the free access to the resource (Glaser, 2005). In 2012, a study carried out with the Ilha Grande extractive population, in Piauí, showed that 100% of local residents and users collected the crab as source of food and income (CIA, 2012). In Pará, 83% of the about 15.000 residents extract products from the mangroves for subsistence and 68% of rural coastal households benefits from the sale of mangrove products (Glaser and Oliveira, 2004).

Other social problems as disagreements over territorial rights and fishing methods between different types of mangrove users; target conflicts between various uses of the mangrove ecosystem (such as logging versus crab collection and honey collection; rice cultivation in mangrove areas versus extractivism) and conflicts over market access (local crab collectors and

fishers versus traders of fish and crabs) are described by local residents who use mangrove resources (Glaser and Oliveira, 2004). Although mangroves are public domain areas, the involved communities have to develop forms of appropriation that control access, in response to the growing markets for crabs, generating conflicts over the territories domination (Oliveira and Maneschy, 2014).

Despite the conflicts observed in other states, in the present study, there was no conflict regarding the use of mangrove areas in the Parnaíba Delta. According to studies, Maranhão has the largest mangrove area in Brazil, about 5,415 km², while Pará has less than half of that (2,177 km²) (Nascimento Júnior *et al.*, 2013). It is estimated that approximately 305 person-day use the Bragança mangroves in Pará (Diele *et al.*, 2010), while we estimated approximately 39 person-day using the study area in the Parnaíba Delta mangroves (Tab. 1).

In addition to the environmental and socioeconomic importance of mangrove crab extractivism, we must consider the aspects related to health (Passos, 2016) and to the empowerment of the gatherers. It is the gatherer who exposes himself to the risks inherent of gathering: sunstroke, humidity, mud, presence of insects and venomous animals (spiders and snakes), shells of oysters (which often cause cuts), mangrove roots (possibility of injury), but even though has not yet gained recognition and appreciation for its work, being the weakest link and earning the lowest remuneration for its workforce.

This low-income picture associated with the exploration of the gatherer's work must be accompanied and reversed mainly through actions managed by the public power. Specific policies for the class of gatherers, as well as socioeconomic and educational insertion programs, could be developed and instituted in traditional harvesting regions. These actions, associated with public technical advice with quality, could empower gatherers, enhancing their culture and ordering the exploitation of the natural resources of the Parnaíba River Delta, contributing to a safer, egalitarian and self-sufficient society. It is essential to valorize the gatherer, as well as formulate public policies that recognize and foster the productive chain of *U. cordatus* in Brazil, in its regional, social, economic, environmental and cultural aspects.

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ERRATUM

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