



Ethnoecology, gathering techniques and traditional management of the crab *Ucides cordatus* Linnaeus, 1763 in a mangrove forest in south-eastern Brazil



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ABSTRACT

This study presents the ethnoecology of the crab *Ucides cordatus* Linnaeus, 1763 through the perception of traditional gatherers in a mangrove forest of northern Rio de Janeiro, south-eastern Brazil. The study also describes gathering techniques and assesses the development of traditional management actions. A total of 66 ethnographic interviews was performed, from which the gatherers' ability to correctly identify the target species and describe aspects of its biology, ecology and behavior was determined. The gatherers who collect *U. cordatus* in this mangrove forest are primarily female, and the techniques applied include the 'redinha' or net method, the 'braceamento' or arm method, and the 'mão' or hand method. Crab gatherers have developed a traditional management system based on selective gathering according to the sex and size of the animals and the establishment of fallow areas in the mangrove forest. This system facilitates the long-term sustainability of the gathering activity. The existence of a traditional management system in this crab-gathering activity illustrates the fact that traditional knowledge can be applied in the conservation process. Integration of traditional knowledge with scientific knowledge plays a critical role in the development and execution of management plans. This study established a network of relationships between research institutions, the Fishermen's Colony and the community. The acknowledgment of this traditional management system allowed the recognition of certain key individuals who will facilitate the elaboration of educational programs. These local actors can be community members who disseminate ideas and help with decisions related to fishery management. Traditional knowledge can help researchers to understand the environmental conflicts and interests of a community. The union of this knowledge with scientific information can provide support for defining conservation strategies and elaborating laws and thus might improve management plans.

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1. Introduction

Local ecological knowledge (LEK) is defined as the knowledge and experience of traditional communities regarding the natural and supernatural worlds that are transmitted orally from one generation to another (Berkes, 1993; Castro, 2000). These

communities apply LEK in their exploitation practices and natural resource utilization to develop traditional management methods (Gelcich et al., 2006; Rasalato et al., 2010; Mirera, 2011).

Although punctual, LEK has been used to improve the management of natural resources in coastal areas. In some areas of world, successful projects related to fishery management have been executed with the involvement of stakeholders (traditional knowledge), government (law) and researchers (scientific knowledge). In north-central California, a planning process for California's Marine Life Protection Act was established and applied, using as strategic principles legislative mandate, political will, traditional knowledge and funding, which collectively permitted a transparent

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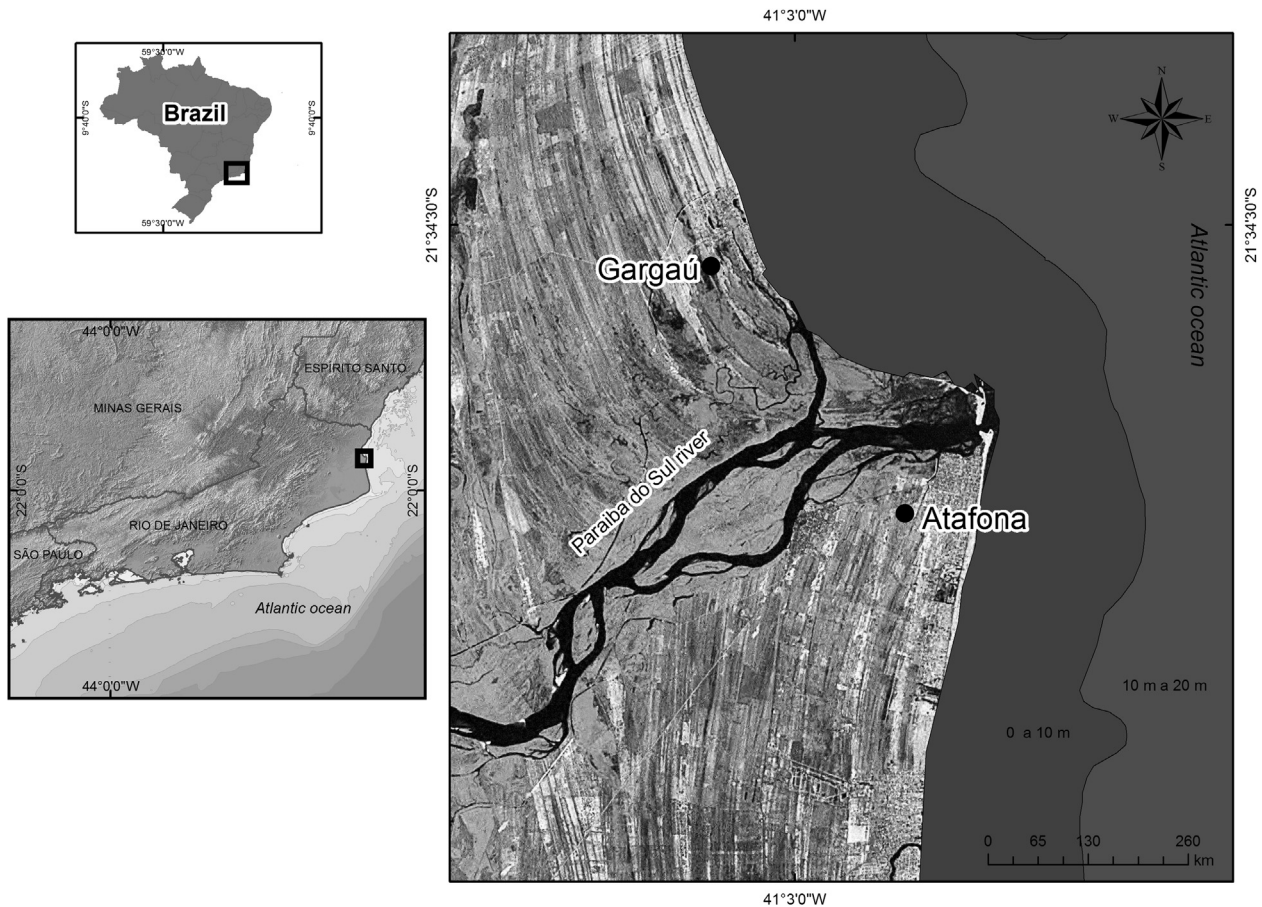


Fig. 1. Location of Atafona and Gargaú communities in northern Rio de Janeiro, south-eastern Brazil.

public planning process and achieved the support of stakeholders (Gleason et al., 2010). Another study was performed in the Huave Lagoon System of Mexico, where the integration of fishermen's perspectives and opinions with the consensus-building process allowed the construction of a holistic management policy to conservation of the lagoon and maintenance of traditional fishery activity (Espinoza-Tenorio et al., 2013). Considering the traditional communities of fishers who inhabit coastal regions, little is known about how their traditional knowledge influences their ability to exploit natural resources or how this knowledge could be applied to management practices (Mirera et al., 2013).

Brachyuran crustaceans, including *Ucides cordatus* Linnaeus, 1763 (mangrove crab), *Cardisoma guanhumii* Latreille, 1825 ('guaia-mum'), and *Goniopsis cruentata* Latreille, 1803 ('aratu'), are among the main resources exploited in Brazilian mangrove forests by surrounding communities (Alves and Nishida, 2002, 2003; Firmo et al., 2011). The gathering of these species is practiced by individuals who access the mangrove forest by canoe or by foot (Fiscarelli and Pinheiro, 2002). Among these species, *U. cordatus* has the highest economic importance to traditional communities of crab gatherers in Brazil (e.g., Alves and Nishida, 2003; Glaser and Diele, 2004; Passos and Di Benedetto, 2005). This species is also an important component of the mangrove trophic web in the western Atlantic Ocean, being widely consumed by fish, birds and mammals (Pinheiro et al., 2005; Wunderlich et al., 2008).

In northern Rio de Janeiro (21–22°S), south-eastern Brazil, artisanal fisheries (including *U. cordatus* gathering) support the local economy, and traditional communities are dependent on these activities (Vergara Filho and Pereira Filho, 1995; Di Benedetto,

2001; Passos and Di Benedetto, 2005). Thus, the non-rational use of these resources and decreases in exploited populations can lead to social problems that affect the economic well-being of those who directly depend on these activities.

The present study describes the ethnoecology of the crab *U. cordatus* in the mangrove forest of northern Rio de Janeiro, with a focus on traditional knowledge related to this resource as well as gathering techniques. The study also assesses whether communities have developed traditional management systems that will promote the sustainability of this resource and the maintenance of the gathering activity in the future.

2. Material and methods

2.1. Study area

The study was conducted in the communities of Atafona (21°37' S; 41°03' W) and Gargaú (21°36' S; 41°03' W), which are located in areas surrounding the mangrove forest of the Paraiba do Sul River estuary in northern Rio de Janeiro (Fig. 1). The estuary has two exits towards the sea: one is located in Atafona (main estuary), and the other near Gargaú (secondary estuary). This mangrove forest is characterized by the presence of black mangrove (*Avicennia germinans* [L.] Stearn, 1764), white mangrove (*Laguncularia racemosa* [L.] Gaertn f. 1807), and red mangrove (*Rhizophora mangle* L. 1753). The black mangrove is dominant, occupying 53% of the cover, followed by white mangrove (28%) and red mangrove (19%) (Bernini, 2008). Commercial crab gathering has been performed by these

traditional communities for decades (Vergara Filho and Pereira Filho, 1995; Passos and Di Benedetto, 2005).

Fishermen's Colony Z-2, with approximately 3 600 registered members, is located in Atafona, while Fishermen's Colony Z-1, with approximately 2 000 members, is located in Gargaú. Local crab gatherers are also registered in these colonies, totaling 46 professionals in Atafona and 50 in Gargaú. According to the president of Fishermen's Colony Z-2, the effective number of gatherers who perform this activity in Atafona is smaller ($N = 16$) than denoted in official records because there are gatherers who no longer perform the activity.

2.2. Data collection

Data were obtained between March and October 2012 through 66 interviews conducted with all active crab gatherers in both communities. Participant observation was applied to establish contact with the gatherers and learn about their daily routines without interfering with their activities (Malinowski, 1978). All interviews were conducted by same interviewer through dialogs (question–answer format) to maximize confidence between the interviewer/researcher (L.H.O. Côrtes) and the interviewee and increase the reliability of the data (Opdenakker, 2006).

To avoid the interference of one informant on the testimony of others, each interview was conducted individually, either in the residence of the interviewee or in the mangrove forest where the crab-gathering activity was performed. The interviewer/researcher (L.H.O. Côrtes) not only observed what was reported but also closely observed the interviewer–interviewee contact and the meaning of each report so as to prevent the collection of false reports (Clifford, 1998).

Before each interview, the objectives of the research were explained to the interviewees, who were also asked whether they would be willing to participate (Librett and Perrone, 2010). In addition, before each interview, the researchers explained to the local community members that their names would not be disclosed and that there was no need to provide their family names; only first names were requested for the purpose of polite communication.

The interviews were guided by a semi-structured questionnaire with open ($N = 47$) (respondent has a chance to add more detail beyond that anticipated in the questions) and closed ($N = 10$) questions (yes or no answers or pre-established answers) (Huntington, 2000; Quivy and Campenhout, 1992; Schensul et al., 1999). Terms used on the questionnaire were in conformity with the common vocabulary of the fishermen to avoid misinterpretation of the questions asked. These terms were based on studies carried out by authors in the same communities (Di Benedetto, 2001; Passos and Di Benedetto, 2005; Tudesco et al., 2012; Rosa et al., 2012). To test the reliability of the information provided and confirm the accuracy of the data reported, the technique of repeating information in a synchronous situation was employed; hence, the same questionnaire was applied to all local community members (Opdenakker, 2006).

The questionnaire was divided into the following categories: 1) characterization of the gatherer's community, 2) ethnoecology of the crab, 3) crab gathering and traditional management, and 4) awareness about the law (Table 1). For the last category, the information contained in the Ministerial Order No. 52 of September 30th, 2003, of the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) was taken into account. This law governs *U. cordatus* gathering in the mangrove forests of southern and south-eastern Brazil and establishes the closed season for the species, when gathering must be suspended (IBAMA, 2003).

Table 1

Questionnaire topics to assess the aspects related to crab *Ucides cordatus* gathering in northern Rio de Janeiro.

1. Characterization of gatherers' community
Gender
Age
Education
2. Ethnoecology of crab <i>U. cordatus</i>
Carapace width
Carapace color
Abundance
Reproduction and spawning
Ecdysis
Feeding
3. Crab gathering and traditional management
Methods
Amount
Sex differentiation
Sex and carapace width
Management of gathering activity
4. Local ecological knowledge (LEK) about the law
Awareness of the period
Purpose of the closed season
Gathering during the closed season

Interviewees who participated in the study met the following requirements: 1) crab gatherers registered in Fishermen's Colony Z-1 (Gargaú) or Z-2 (Atafona); 2) reported crab gathering as their main economic activity; and 3) performed the activity in northern Rio de Janeiro. For the first contact in the community of Atafona, the interviewer/researcher (L.H.O. Côrtes) had the aid of an employee of the local Fishery Department who lives in the community and served as a local guide (S.R. Gomes). In Gargaú, the local guide was the President of Fishermen's Colony Z-1 (J.G. Soares).

The selection of the first respondent in each community was carried out with the assistance of the local guides. After contacting the second respondent, we applied the snowball sampling method, in which a potential respondent was indicated by community members who had already responded to the questionnaire (Bailey, 1982; Patton, 1990). Initially, this technique was used to acquire a sampling of respondents, but in the end, all of the crab gatherers were interviewed due to the small size of this group ($N = 66$). This method works with reference chains, making use of relationships between people and acting as a "personal network" in which there is a focal individual who is in direct or indirect contact with all other people in the community through his/her relationships. The indications of new members allow the addition of varied insertion points (Goodman, 1961).

2.3. Data analysis

Only interviewees who were able to identify crabs belonging to the species *U. cordatus* were selected for the present study. The selection was based on knowing at least two of the following three characteristics that can be used to recognize adult crabs of species: 1) a carapace width between 5 and 9 cm (Glaser and Diele, 2004; Passos and Di Benedetto, 2005), 2) carapace color varying from sky-blue to dark brown (Pinheiro and Fiscarelli, 2001), and 3) feeds on leaves, seeds, roots and sediment of the mangrove forest (Branco, 1993; Nordhaus and Wolf, 2007). These characteristics are specific to the species *U. cordatus* and ensure the correct identification by the selected interviewees. Concerning the LEK about the closed season for this species, responses that included at least two of the three months established by law for gathering interruption were considered correct (October–December). The results were quantified and expressed as percentages.

The information obtained in the participant observations and interviews was grouped into thematic categories to classify the reports and facilitate their interpretation (Bogdan and Biklen, 1994). This classification made it possible to clarify the relationship between the language and the social interaction between researchers–interviewees with the crab *U. cordatus*. Data related to ‘the characterization of the gatherer’s community’, ‘the ethnoecology of the crab’, ‘crab gathering and traditional management’ and ‘awareness about the law’ were quantified and expressed as percentages.

3. Results

3.1. Characterization of the gatherers’ community

Of the 66 gatherers interviewed, 87.5% ($N = 14$) in Atafona and 100% ($N = 50$) in Gargaú were selected for this study. Among the selected gatherers, most were women aged between 23 and 76 years. Regarding education, most had not completed elementary school (Table 2).

3.2. Ethnoecology of the crab *U. cordatus*

According to the reports from both communities, the carapace width of this crab varies from 3.0 to just over 10 cm, and the carapace color ranges from shades of blue to red. The greatest abundance of adult crabs occurs in January and February due to the species’ breeding migration (locally known as ‘*andada*’). According to the gatherers, this event occurs between November and April or, more frequently, between January and February (Table 3).

Reproduction itself was described as an event that occurs between December and February (Atafona: 57.1%, $N = 8$; Gargaú: 40%, $N = 20$) (Table 3). During this period, the gatherers observed that male crabs become aggressive and ‘fight’ with other individuals for access to females. Males can hit and break the carapace of the opponent with their largest chela, causing death.

Gatherers reported that copulation occurs in the mangrove substrate, and a few noted its occurrence inside burrows (Table 4). When mating occurs, the male grasps the female with the aid of the chela in an action called the ‘hug’, and their abdominal portions fit into each other. At the end of copulation, the reproductive partners drift apart. Fertilized, or ‘egg-bearing’, females lodge the eggs on the surface of their abdomen. These females migrate to the banks of the Paraíba do Sul River channels, inside the mangrove forest, and move the abdomen to initiate spawning (Gargaú: 14%, $N = 7$). They can also release their eggs on the flooded mangrove surface or inside burrows during the high tide period (Atafona: 7.1%, $N = 1$; Gargaú: 20%, $N = 10$). In this region, this event occurs between March and May and is dependent on water (Table 3).

Table 2
Gender and education level of gatherers from the communities Atafona and Gargaú, as reported by gatherers in northern Rio de Janeiro.

	Localities	
	Atafona	Gargaú
<i>Gender of gatherers</i>		
Women	92.9% ($N = 13$)	62% ($N = 31$)
Men	7.1% ($N = 1$)	38% ($N = 19$)
<i>Education</i>		
Not completed Elementary School	78.6% ($N = 11$)	80% ($N = 40$)
Completed Elementary School	–	2% ($N = 1$)
Not completed High School	–	2% ($N = 1$)
Completed High School	–	2% ($N = 1$)
Not studied	21.4% ($N = 3$)	14% ($N = 7$)

Ecdysis or crab molt is a phenomenon known as molt or ‘hull change’ by the gatherers interviewed. Crabs prepare for molt by stocking mangrove vegetation leaves in their burrow. Burrow openings are obstructed, and the tunnel excavated in the substrate becomes deeper. According to the gatherers, crabs tend to accumulate more fat during this life cycle stage; they become heavier and travel to the surface less frequently. The interviewees fully recognized the phenomenon and species behavior of this life cycle stage.

During the molt period, ‘milk crabs’ are observed. These are individuals with a fragile and flexible carapace containing a whitish liquid (called ‘milk’) in their interior. The gatherers reported that the liquid begins to accumulate before the carapace (which will be changed) loses rigidity and that they verify its formation by removing one of the crab’s pereiopods. The gathering of crabs in this state is hampered by the fragility of their carapaces, and the ingestion of ‘milk crabs’ causes abdominal pain, nausea and diarrhea, making them unfit for human consumption and commercialization.

The crabs of this region consume black and red mangrove leaves, mud (sediment), seeds, and mangrove roots as food (Table 4). Each gatherer described more than one food item.

3.3. Crab gathering and traditional management

Gatherers use the following techniques for crab gathering: the ‘*redinha*’ or net method, the ‘*braceamento*’ or arm method and the ‘*mão*’ or hand method (see explanations below) (Table 5). Each gatherer can use more than one technique.

In Atafona, the gatherers generally obtain each between 100 and 200 crabs per day, whereas in Gargaú, daily gathering does not exceed 100 crabs per gatherer. The resource is commercialized *in natura*, alive and without any type of processing (Table 5).

‘*Redinha*’ is a monofilament net made with silk thread (2 mm thick) that is 50 m long and 40 cm high, with an 8 cm mesh measured between adjacent nodes. This gear is positioned over the openings of the burrows built in the substrate of the mangrove forest by the crabs and identified as belonging to the males of the species. In ‘*braceamento*’, the gatherer keeps her/his body extended on the substrate (or next to it) and introduces one of her/his arms into the burrow, seizing the crab with the hand by the dorsal section of the carapace (Fig. 2). ‘*Mão*’ refers to the method of gathering the crabs using the hand as an instrument when the animals are out of their burrows, which occurs primarily during breeding migration. The reports indicated that the proportional use of ‘*redinha*’ is increasing in the Gargaú community and is gradually replacing the ‘*braceamento*’ technique.

Some gatherers reported the emergence of diseases caused by contact with the mangrove ecosystem during crab gathering (Atafona: 43%, $N = 6$ and Gargaú: 14%, $N = 7$). The diseases described include mycoses, ear infection, gynecological problems, cuts on the body, especially the feet, hands and arms, and ‘back pain’.

The interviewed gatherers were able to recognize males and females of the species through abdominal morphology, the presence of bristles on the pereiopods, and/or the greater body size of males compared with the females (Table 5). Each gatherer mentioned more than one sexually dimorphic characteristic. Sexual differentiation is also made indirectly via characteristics of the crab’s burrow opening (Atafona: 42.9%, $N = 6$; Gargaú: 84%, $N = 42$). A male burrow has a wide opening with blackened fecal material and elongated deep traces on its edge (‘tracks’ or ‘footsteps’). The traces are left by the male’s bristles and pereiopods while moving. A female burrow has a narrower opening with thin brown fecal material and superficial traces on its edge. This difference between

Table 3Ethnoecological information about the crab *Ucides cordatus*, its occurrence and period of gathering, as reported by gatherers in northern Rio de Janeiro.

Ethnoecological information	Periods of occurrence											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Abundance of adult specimens	X	X										
Breeding migration	X	X	X	X							X	X
Breeding migration (greatest frequency)	X	X										
Reproduction/copulation	X	X										X
Spawning			X	X	X							
Crab gathering	X	X	X	X	X	X	X	X	X	X ^a	X ^a	X ^a

^a Closed season for crab – October through December. This period was enacted for the protection of the species during its breeding migration according to Brazilian law (IBAMA, 2003). Even with the closure of crab gathering, some gatherers reported that this activity continues to occur in this period (see Results – Section 3.4. Awareness about the law).

male and female traces is related to the absence of bristles on the pereopods and the lower body weight of the females.

Collection of both sexes of crab was reported by 78.6% ($N = 11$) of gatherers in Atafona and 86% ($N = 43$) in Gargaú. In both communities, males are preferentially gathered (Table 5). This preference is related to the higher market value of the males and resource maintenance in the local mangrove forest. Females are mainly intended for family consumption. All gatherers in Atafona and 88% ($N = 44$) in Gargaú stated that crabs with a carapace width between 8 and 9 cm are used for commercial purposes.

Concerning the management of crab gathering, the interviewees stated that there is a rotation of the mangrove areas that are exploited throughout the year. Crabs with a blue carapace (termed blue crab) are more common in areas with a predominance of black mangrove, whereas those with a reddish carapace (termed red crab) are more common in red mangrove areas. According to the reports, in red mangrove areas, the carapace becomes reddish due to the release of a 'tinting' substance present in the plants (see Results on the Ethnoecology of the crab *U. cordatus*).

During the summer (November–April, according to the gatherers), the crabs distributed in areas with a predominance of red mangrove are present at greater abundance and with larger carapace width. This makes the red crab the main target during this period. In winter (May–October), the catch-effort is greater in areas with a predominance of black mangrove, where the blue crab is more abundant. In this way, the mangrove areas that are exploited over half of the year remain fallow ('resting') during the other half. This management was characterized as 'unintentional' by the gatherers, who called it 'natural management' (Fig. 3).

3.4. Awareness about the law

The period determined by law for the closure of crab gathering in the region (October–December) was identified by gatherers of Atafona and Gargaú. The closed season as a measure for species protection was recognized in association with its reproduction, spawning, growth and ecdysis (Atafona: 85.7%, $N = 12$; Gargaú: 92%, $N = 46$). However, the gatherers' reports indicated that crab gathering continues during the closed season (Table 6).

Gatherers justified crab gathering during this period with the following arguments: 1) compensation for the low income obtained through this activity via a catch-effort during the closure period, 2) delays in the payment of financial benefit to which they are entitled during the suspension of the activity (closure insurance), and 3) surveillance deficiency. The gatherers reported that there is a discrepancy between the period established by law for the closed season in the region (October–December) and the period in which breeding migration really occurs (October–April, with greater frequency between January and February).

4. Discussion

4.1. Characterization of the gatherers' community

Crab gathering is predominantly performed by women, in northern Rio de Janeiro, which is a peculiarity of the region compared with other mangrove areas along the Brazilian coast. This fact was reported by Vergara Filho and Pereira Filho (1995). In other regions, men generally perform the crab gathering because of the unhealthy nature and danger of the activity, whereas women engage in the processing of the gathered product (Fiscarelli and Pinheiro, 2002; Alves and Nishida, 2003; Walter et al., 2012).

In recent years, the proportion of men engaged in crab gathering in Gargaú has increased. This phenomenon may be related to the diversification of fishing activities practiced by community members to increase monthly income. Gargaú is characterized by a strong economic dependence on fishing activities, whereas in Atafona, there are other ways to generate income beyond artisanal fishing. Atafona is approximately 3 km from São João da Barra (county seat). This town underwent the installation of the mega-enterprise 'Logistics and Industrial Complex of Porto of Açú' (CLIPA) approximately four years ago, which expanded income options for local residents due to the increase in commercial establishments and residences. CLIPA, which is more accessible to the community of Atafona than that of Gargaú, has attracted fishermen and gatherers with good offers of remuneration and working conditions.

Both localities (Atafona and Gargaú) are characterized by a low education level. This pattern was also observed in other regions of Brazil (Fiscarelli and Pinheiro, 2002; Alves and Nishida, 2003).

4.2. Ethnoecology of the crab *U. cordatus*

The crab carapace widths reported by gatherers are comparable to those from other regions of Brazil (e.g., Ivo et al., 1999: 2.3–

Table 4Local of copulation and food items consumed of the crab *Ucides cordatus*, as reported by gatherers in northern Rio de Janeiro.

	Localities	
	Atafona	Gargaú
<i>Place's copulation</i>		
Mangrove substrate	50% ($N = 7$)	38% ($N = 19$)
Inside the burrows	14.2% ($N = 2$)	–
Unable to respond	35.6% ($N = 5$)	62% ($N = 31$)
<i>Food items consumed^a</i>		
Black and red mangrove leaves	73.7% ($N = 14$)	83.1% ($N = 49$)
Mud (sediment)	15.8% ($N = 3$)	10.2% ($N = 6$)
Seeds	10.5% ($N = 2$)	1.7% ($N = 1$)
Mangrove roots	–	5.1% ($N = 3$)

^a Each gatherer described more than one food item.

Table 5

Techniques for *Ucides cordatus* crab gathering, crabs obtained per day and identification of males and females, as reported by gatherers in northern Rio de Janeiro.

	Localities	
	Atafona	Gargaú
<i>Techniques for crab gathering^a</i>		
'Redinha' or net method	20.8% (N = 5)	40.2% (N = 43)
'Braceamento' or arm method	45.8% (N = 11)	22.4% (N = 24)
'Mão' or hand method	33.3% (N = 8)	37.4% (N = 40)
<i>Crabs gathering per day</i>		
>100 crabs/day	28.6% (N = 4)	60% (N = 30)
Between 100 and 200	42.9% (N = 6)	30% (N = 15)
Between 201 and 300	14.3% (N = 2)	8% (N = 4)
Between 301 and 400	7.1% (N = 1)	–
<400 crabs/day	–	2% (N = 1)
Unable to respond	7.1% (N = 1)	–
<i>Identification of males and females^b</i>		
Abdominal morphology	60% (N = 12)	50% (N = 41)
Presence of bristles on the pereopods	30% (N = 6)	28.1% (N = 12)
Greater body size of males compared to the females	10% (N = 1)	22% (N = 18)
<i>Preference by sex of crab</i>		
Males	100% (N = 14)	98% (N = 49)
Females	–	–
Unable to respond	–	2% (N = 1)

^a Each gatherer uses more than one technique.

^b Each gatherer mentioned more than one sexually dimorphic characteristic.

8.9 cm in Piauí [2° S]; Goes et al., 2010: 1.7–8.5 cm in Espírito Santo [20° S]; and Fiscarelli and Pinheiro, 2002: 5.0–11 cm in Iguape [24° S]). This demonstrates the gatherers' skill in estimating the size of the crabs without measuring instruments. The reported carapace color ranged through shades of blue and red, which is in accordance with the literature (Pinheiro and Fiscarelli, 2001; IBAMA, 2003). This color variation most likely gave rise to the popular denominations of 'blue crab' and 'red crab', which to date had not been described for this species. In some Brazilian mangrove areas, the popular denomination 'blue crab' applies to the 'guaianum' (*C. guanhum*) (IBAMA, 2002). According to Falqueto et al. (2008), the leaves of the red mangrove are rich in carotenoids. The influence of food resources containing carotenoids on the carapace color of crustaceans is a topic that has been widely described in the literature (Meyers, 1994; Bjerkeng, 2008). In this way, the reddish color of the carapace, which inspired the popular denomination 'red crab', is related to the crabs' ingestion of this food, as suggested by the interviewed gatherers.

Along the Brazilian coast, the breeding migration varies within the interval stated by the gatherers; monthly peaks have also been recorded (Ivo et al., 1999; Fiscarelli and Pinheiro, 2002; Wunderlich et al., 2008). The breeding migration is characterized by a massive search for partners (Fiscarelli and Pinheiro, 2002; Castilho-

Westphal et al., 2008) and occurs during conditions of high temperature, rainfall and photoperiod (Pinheiro and Fiscarelli, 2001; IBAMA, 2011). During this event, crabs walk on the mangrove substrate or roots, even at night, and do not maintain fidelity to their burrows (Alves and Nishida, 2003; Diele and Koch, 2010; IBAMA, 2011).

The antagonistic behavior between male crabs described by the local gatherers is in accordance with the literature (Pinheiro and Fiscarelli, 2001; Diele and Koch, 2010). The copulation behavior described by the gatherers is also confirmed by the available information on the mating behavior of *U. cordatus* (Pinheiro and Fiscarelli, 2001). After copulation, *U. cordatus* females remain sheltered in burrows or under mangrove roots for three–four weeks until the larvae are released; during this period, the eggs remain attached to the pleopods (Pinheiro and Fiscarelli, 2001; Diele and Koch, 2010). Spawning may occur once or twice a year and is carried out on the banks of channels, on the mangrove substrate or inside burrows, in synchronicity with the largest tidal amplitudes (Castilho-Westphal et al., 2008; Wunderlich et al., 2008; Diele and Koch, 2010). There was a consensus among the gatherers that spawning is dependent on water, corroborating data from the literature.

The crabs' preparation for molting and the presence of 'milk crabs' or exuvial liquid were well described by gatherers. Storage of leaves and other types of food (vegetation seeds and stalks) during the period preceding molt, for post-molt consumption, has been described in the literature (Pinheiro and Fiscarelli, 2001; Alves and Nishida, 2002). During this period, the burrows are excavated to greater depths, and crabs block their openings (Pinheiro and Fiscarelli, 2001; Fiscarelli and Pinheiro, 2002; Wunderlich et al., 2008). In the pre-molt period, when the crabs lose carapace rigidity, their internal organs turn a milky-white color due to the formation of exuvial liquid (Pinheiro and Fiscarelli, 2001; Fiscarelli and Pinheiro, 2002). The presence of high levels of carbonates in the crabs' bodily constitution during the pre-molt stage makes them unfit for consumption because these compounds can affect the nervous and digestive systems (Pinheiro and Fiscarelli, 2001; Fiscarelli and Pinheiro, 2002). This reveals the gatherers' understanding of the entire molt process.

The gatherers reported more than one food item for these crabs. These reports agree with studies on the feeding habits of *U. cordatus* that noted the preferential consumption of leaves in addition to fruits, seeds, roots and sediment (Branco, 1993; Pinheiro and Fiscarelli, 2001; Nordhaus and Wolf, 2007; Castilho-Westphal et al., 2008). Nordhaus and Wolf (2007) found that the species' preference for black and red mangrove leaves in Pará (1°S), northern Brazil, is due to the greater ease of chewing and digestion, in addition to the provision of a greater quantity of dry matter per sheet consumed compared with white mangrove leaves. According



Fig. 2. Techniques utilized in the gathering of crabs in northern Rio de Janeiro, southern Brazil: a) 'Redinha' (Photo: Laura Helena de Oliveira Côrtes), b) 'braceamento' (Photo: Camila Silva) and c) 'mão' (Photo: Camila Silva).

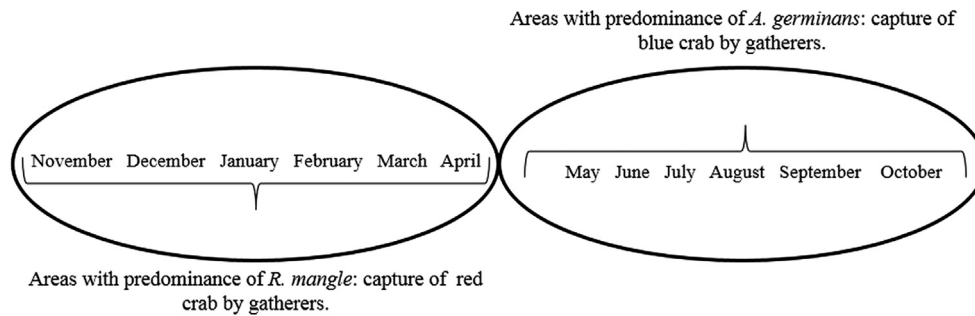


Fig. 3. Layout of the 'natural management' of crab (*Ucides cordatus*) gathering performed by gatherers in northern Rio de Janeiro.

to the interviewed gatherers, *U. cordatus* also exhibits this food preference in the study area (21°S), suggesting a specific food pattern.

4.3. Crab gathering and traditional management

Brazilian law prohibits the use of traps or fishing gear for crab gathering and forbids gathering during the crabs' breeding migration (IBAMA, 2003). This makes the use of 'redinha' and 'mão' (during the breeding migration) illegal. Non-traditional gathering methods (such as 'redinha') are used by crab-gathering communities to facilitate gathering, cause fewer physical injuries to gatherers and increase production (Nascimento et al., 2012). The use of 'redinha' does not seem to increase the number of crabs gathered, but its use is safer and preserves the physical health of the gatherers. This is important for gatherers with long-term economic dependence on this activity, such as those in Gargaú.

'Braceamento' is a traditional technique for crab gathering permitted by law (Pinheiro and Fiscarelli, 2001; IBAMA, 2003). However, it requires great physical effort by gatherers and causes injuries to their hands and arms (Fiscarelli and Pinheiro, 2002). Despite this, 'braceamento' is the most common method used by the gatherers of Atafona, and it is still widely used throughout Brazilian mangrove forests (e.g., Souto, 2007; Magalhães et al., 2011; Nascimento et al., 2012). The gatherers of the two communities share capture sites in the mangrove forest of the Paraíba do Sul River estuary. However, according to the interviews, the number of crabs gathered is lower among the gatherers of Gargaú, who preferentially use the 'redinha' method, compared with those of Atafona, who more frequently use 'braceamento'. In this sense, it is likely that the Atafona gatherers are opting for the benefit of increased harvest over the detriment of the cost that this technique poses to physical health.

Some gatherers reported the emergence of diseases due to contact with mangrove mud. This is a reality described in other areas and indicates the existence of a public health problem in communities that practice crab gathering (Walter et al., 2012). Despite the educational campaigns on mangrove and *U. cordatus* conservation executed by management offices in both communities (Atafona and Gargaú), we did not identify any disease prevention campaigns focused on diseases that can be acquired by contact of the gatherers with the mangrove ecosystem. According to Rosa and Mattos (2007), the activity of crab gathering in Brazil can be considered potentially dangerous, as it can expose the gatherer to pathological agents present in mangroves as well as accidents related to perforation of the limbs (arms and legs) by vegetative material present in the sediment (roots and trunks). In this sense, despite the potential for the 'braceamento' method to impair physical health, the gatherers prefer to use this technique over 'redinha' because of the larger number of crabs that can be

gathered. While 'braceamento' allows the capture of more crabs, it is likely not more destructive than 'redinha'. 'Redinha' is not selective, and parts of the equipment are sometimes abandoned in the mangroves, causing pollution, in addition to the loss of the root and branch fragments used to fix the 'redinha' and removed from the mangrove. The 'braceamento' method is targeted and does not pollute the environment. In this sense, the development of a traditional management system by gatherers can offer a solution to the problem of making crab gathering sustainable.

The gatherers were able to recognize males and females of the target crab species. Sexual differences are evident in this species, facilitating this recognition process. The ability to distinguish the sexes was also verified in other gatherer communities along the Brazilian coast (Fiscarelli and Pinheiro, 2002; Souto, 2008). Recognition of sexual differences allows the gathering of specimens with the greatest commercial value and contributes to resource conservation because females are spared and stock replacement is maintained.

Gathered crabs with a carapace width between 8 and 9 cm are within the limit set by law, which only allows gathering of crabs with a carapace larger than 6 cm (IBAMA, 2003). Although the 'redinha' is a prohibited technique, the ability of local gatherers to estimate the crabs' sex and size in advance by assessing burrow opening characteristics and sexually dimorphic traits means that they target the more commercially valuable crabs and return the rest to the mangrove, thus reducing the impact of this gear on the crab population.

The rotation of the exploited mangrove areas described by the gatherers can be characterized as an 'unintentional' management system. This management system allows mangrove areas of the Paraíba do Sul River estuary to remain fallow for approximately six months of the year. The fallow period allows reproduction and population growth of the *U. cordatus* crab, contributing to the continuity of the resource for gathering.

4.4. Awareness about the law

The closed season for crab, established by law for southern and south-eastern Brazil, extends from October 1 to December 31 for females and from October 1 to December 1 for males. This period was intended for the protection of the species during its breeding migration. The law also prohibits gathering and commercialization of ovigerous females and commercialization of the crab's body parts during any period (IBAMA, 2003).

The law covers an extensive area of the Brazilian coast (18–28°S) that is exposed to different light intensities and photoperiod intervals. These factors directly influence the reproductive patterns of *U. cordatus* (Pinheiro et al., 2003). However, the law also establishes that each Federation Unit (state) can set a closed season for the species that better fits its environmental reality. In southern

Table 6

Identification of the period determined by law for the closure of crab gathering and the occurrence of crab gathering, as reported by gatherers in northern Rio de Janeiro.

	Localities	
	Atafona	Gargaú
<i>Identification of closed season</i>		
Identified	50% (N = 7)	80% (N = 40)
Not identified	7.1% (N = 1)	6% (N = 3)
Unable to respond	42.9% (N = 6)	14% (N = 7)
<i>Crab gathering during the closed season</i>		
Practice	42.9% (N = 6)	28% (N = 14)
No practice	57.1% (N = 8)	58% (N = 29)
Unable to respond	–	14% (N = 7)

and south-eastern Brazil, Espírito Santo (18–21°S) is the only state to have established its own closed season for this crab, extending from January to April, with a 1-week prohibition for crab gathering each month (IBAMA, 2013).

The laws regulating crab gathering do not consider the traditional knowledge of gatherers and do not reflect the economic and social situation of these workers (Nordi, 1994). The inefficiency of these regulatory laws for crab gathering is mainly attributable to the lack of awareness of the population, alternative work for the gatherers during the reproductive period and efficient monitoring by environmental agencies (Alves and Nishida, 2002). These justifications were reported by the gatherers in this study.

It is therefore sensible to suggest a review of the period established for the closed season in Rio de Janeiro state (21–23°S). The establishment of management plans based on the knowledge of traditional communities encourages the enforcement of the law by the inhabitants (McClanahan et al., 1997; Gelcich et al., 2006). As proposals for improvements for crab-gathering activity and conservation of this species, is suggested: 1) developing cooperative proposals in partnership with educational and research institutions that could act together with the community to improve the product and marketing; 2) partnerships between the Fishermen's Colonies (Z-1 and Z-2) and public health agencies that could assist in the prevention of diseases contracted in the mangroves; 3) partnerships between environmental agencies, research institutions and Fishermen's Colonies (Z-1 and Z-2) to (i) conduct educational campaigns on species conservation, (ii) perform studies to understand the zoning in the capture region and (iii) delineate a crab-gathering projection, using as variables the reduction in the size of the *U. cordatus* population and changes in the local economy due to port activities, public policies and co-management. Such measures can make the gathering profession more sustainable and consequently promote the preservation of *U. cordatus* and the mangrove ecosystem (Linhares et al., 2008).

This study allowed us to understand the perception of gatherers with respect to the legislation and the problems that exist in the crab-gathering activity. In this sense, the results presented herein indicate the importance of conducting studies on local ecological knowledge (LEK) and how this knowledge can be incorporated into public policies.

4.5. How to ensure the quality of information obtained through local ecological knowledge (LEK)?

Studies of local ecological knowledge (LEK) are based on the beliefs and symbols of a community and, because of this, are considered subjective and complex (Begossi, 1992). The information obtained by reports of local community members is sometimes not quantifiable but allows the approach between subject and object and, in this sense, has proven to be appropriate for studies of

cultural perception. The reports enable the researcher to better understand the historical, social and cultural context. Qualitative research is concerned with meaning and not with generalized hypothesis statements, so the data is useful for understanding the subjective process of a culture (Crouch and McKenzie, 2006).

In a traditional knowledge study, some information is provided with pleasure, while other information is offered with reluctance or simply not provided (Clifford, 1998). The response of the local community member to the researcher may reveal the real reason why some questions remain unanswered. Some questions elicited closed responses followed by open justifications or explanations, thus allowing the local community members to express their reasoning (Librett and Perrone, 2010). It is therefore very important that researchers explain the objectives of their study to the interviewees before the interview (Librett and Perrone, 2010). Interviews carried out through dialog are more effective for obtaining information that reflects the local reality. Dialog grants the informants the freedom to present their knowledge and allows interlocutors to have a shared vision of local reality (Kvale, 1996).

The process of obtaining information is facilitated when the researcher breaks down the barriers between himself and the local community member in terms of language, clothing, behavior and especially the fact of not belonging to the group. In this sense, the researcher will always be an outsider to the group and must carefully evaluate and analyze what is captured in the discourse of local community members (Zaluar, 1986).

5. Conclusions

Gatherers in the Atafona and Gargaú communities are skillful at recognizing crabs belonging to the species *U. cordatus* and describing aspects of their biology, ecology and behavior. This indicates that the LEK of these communities is in accord with the available literature on the species.

The communities differ in some aspects that characterize their gathering activities in the local mangrove forest. In Atafona, the lower number of gatherers indicates that crab gathering as an economic activity is declining, most likely because of a loss of family tradition and/or the existence of other income-generating opportunities. In Gargaú, the scarcity of work in other sectors generates strong economic dependence on fishing activities, including crab gathering. This scenario led to the professionalization of crab gathering and the development of 'redinha' as a preferred technique, in spite of its legal prohibition. 'Redinha' does not seem to increase the number of crabs gathered per fishing effort undertaken but preserves the gatherers' health and contributes to their quality of life and longevity in the occupation. Although the 'braceamento' method is considered the technique more effective for crab gathering, it apparently does not affect the conservation of *U. cordatus* in the region because both communities have developed some practices. These practices, together with the recognition of sexual differences between crabs, the ability of the local gatherers to estimate crab size and the rotation of exploited mangrove areas, comprise a traditional management system. This system is based on crab-gathering practices that involve the use of fallow areas and selective gathering of large animals, which should facilitate the sustainability of this activity in the region over the long term, if there is no loss of habitat and no anthropogenic disturbance.

A management plan aiming to minimize impacts on *U. cordatus* and conflicts between communities and government should establish a partnership among research institutions, cooperatives, Fishermen's Colonies, public health agencies and environmental agencies. Establishing these partnerships is important to deepen the discussion about the practices of crab gathering, the occurrence of traditional management systems, educational programs and the

socioeconomic reality of the fishing communities. To enact educational programs, some key individuals from each community should be included in the management plan. These tasks must be carried out with the active participation of local communities.

Observing the interaction of a community with surrounding natural elements is important to understand the reasons for and reality of its coexistence with nature. Cultural perceptions may therefore aid in answering environmental questions. Local gatherers are excellent candidates to act as partners in research activities and in the development of management plans and local co-management. It is clear that such partnerships are always long processes that in some cases do not occur. The use of interviews in this study allowed us to make the important step of establishing partnerships based on trust between research institutions, Fishermen's Colonies and the community. The next challenge is to promote closer relationships between public health and environmental agencies with local communities. Rapprochement among fishery managers, regulatory agencies, researchers, and community members is important for establishing successful management plans and for the adaptation of the closed season to the environmental reality of northern Rio de Janeiro.

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