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Effectiveness of Two Gathering Techniques for *Ucides cordatus* in Northeast Brazil: Implications for the Sustainability of Mangrove Ecosystems

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Introduction

Mangroves are complex coastal ecosystems situated in tropical and subtropical zones, utilized by a wide range of plants, invertebrate (crustacean, molluscan and others) and some vertebrate species for all or specific stages of their life cycles (Hatcher *et al*. 1989; Robertson *et al*. 1992; Twilley *et al*. 1996). Crustaceans are important faunal components of mangrove ecosystems because of their abundance and participation in the food chain (Alves and Nishida 2004; Diele and Smith 2007). Crabs are the most conspicuous and abundant components of epibenthic macrofauna in mangrove ecosystems, and they carry out several ecological functions assimilating a large amount of carbon (Robertson 1986, 1991; Micheli *et al*. 1991). The predominance of burrowing forms enhances oxygenation of soil and drainage of sediments (Jones 1984). The land crab *Ucides cordatus* (Linnaeus 1763), known in Brazil as 'caranguejo-uçá', is particularly important in the biogeocycling of nutrients in mangrove ecosystems (Corrêa *et al*. 2000). Koch and Wolff (2002) point out that epifaunal species contribute about 75% to the faunal biomass in mangrove ecosystems (*U. cordatus* 63% and deposit-feeding crabs 12%), indicating the important role of this faunal group which directly channels the energy and nutrients fluxes in the ecosystem.

Besides their ecological importance, crabs are one of the most exploited resources in Brazilian mangrove areas, generating jobs and incomes for coastal communities near mangrove habitats, mainly in the northeastern regions (Nordi 1992, 1995; Alves and Nishida 2002, 2003; Alves *et al*. 2005; Nishida *et al*. 2006a). A review of management and economic sustainability in Brazilian mangrove areas suggested that artisanal fishing of crustaceans most notably the land crab 'caranguejo-uçá' (*U. cordatus*) is the most profitable activity of local human populations (Kjerfve and Lacerda 1993; IBAMA 1995). Based on the catch selectivity of *U. cordatus*, where neither smaller sized nor female individuals are collected but are returned to their habitat, Ivo and Gesteira (1999) concluded that this crustacean can be sustainably harvested. Nevertheless, depletions of natural stocks of *U. cordatus* have been reported in the states of Paraíba (Alves and Nishida 2002, 2003), Espírito Santo (Nunes 1992), and Pará (Gondim and Araújo 1996). *M*angrove ecosystems are seriously threatened, mainly by human activities that impact the habitat of crabs (Pons and Fiselier 1991; Fouda and Al-Muharrami 1995; Farnsworth and Ellison 1997). Thus studies on these ecosystems as well as studies of animals highly dependent on them are important for establishing measures for their effective and sustainable management (Bacon and Alleng 1992; Hudson and Lester 1994; Farnsworth and Ellison 1997).

In the case of 'caranguejo-uçá' environmental and economic factors such as their relative abundance and low seasonality, and the low capital demands of gathering the crabs with their commercial value, all contribute to the intensification of the harvest. Crab gatherers are members

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of marginal groups of extremely poor people who have minimal recognition among other artisanal fishermen. Most of the gatherers are illiterate or semi-illiterate, living in poorly built houses with poor hygienic conditions (Nordi 1992; Alves and Nishida 2003). Land crab gathering is their main activity, although in many places they generate supplementary income from subsistence agriculture (Alves and Nishida 2003). Crab gatherers are not even identified as fishers on the official register (IBAMA 1994). The crabs they collect are sold to intermediate buyers who sell them in the open markets or directly door-to-door or to restaurants and bars. A higher demand for crabs occurs throughout summer, when the number of tourists increases (IBAMA 1994; Alves and Nishida 2003).

In the mangrove ecosystems of the state of Paraíba, Northeast Brazil, among the five techniques used for catching 'caranguejo-uçá' recorded by Nordi (1992), the most utilized are 'tapamento' (to fill up the burrow opening with mud and tree twigs) and 'braceamento' (the gatherer inserts his arm in the burrow to catch the crab by its dorsal carapace). In the present study we analyze the efficiency of these two techniques by observing directly the entire process of capture and by obtaining data concerning the characteristics of this animal. The results are interpreted in the context of the gatherers' reality, avoiding generalizations that would generate incomplete or mistaken formulations.

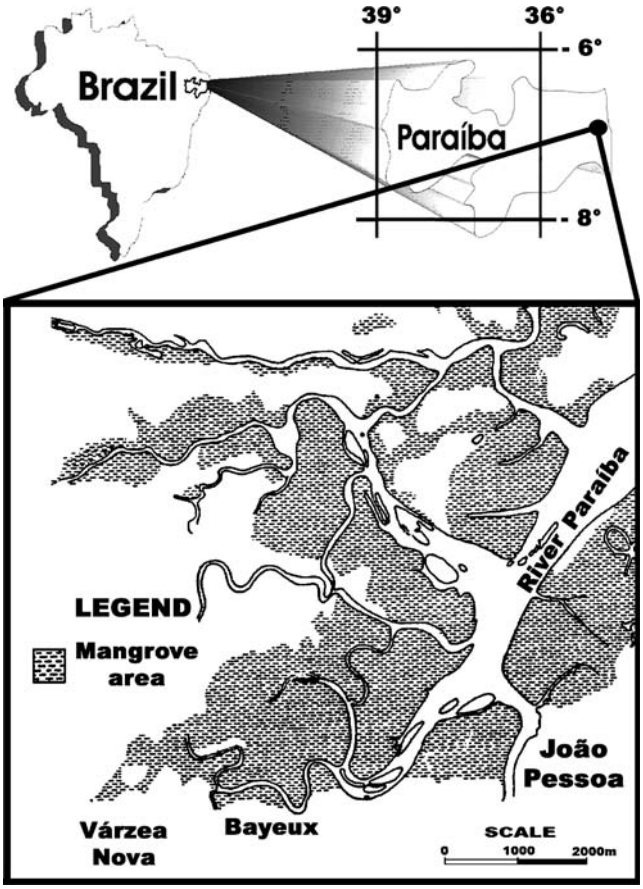

Fig. 1 Map of the areas of capture of the land crab (*Ucides cordatus*)

Study Area and Methods

We investigated crab gatherers in the region of Várzea Nova, a district in the municipality of Santa Rita, state of Paraíba (Fig. 1). The study area is close to the basin of the River Paraíba do Norte, extending for ca. 380 km, crossing 37 municipalities. The basin is divided into three sections: High, Median, and Low Paraíba (Gualberto 1977). It is located between latitude 60°57′ and 70°08′ S, and longitude 34°50′ and 34°55′ W, in the Low Paraíba, with drainage basins in the municipalities of João Pessoa, Bayeux, Santa Rita, and Cabedelo, close to river mouth (Nishida *et al*. 2006a, b).

The mangrove ecosystem in the estuary of the River Paraíba do Norte is composed mainly of the following tree species: *Rhizophora mangle*, *Avicennia schaueriana*, *Laguncularia racemosa*, and *Conocarpus erecta* (Nishida *et al*. 2006c). At the edge of the mangrove area, on dry land, in some locales there are *Dalbergia ecastophillum* and *Annona glabra*, which are associated species. Exploitation of natural resources in the estuary, mainly fish, mollusks, and crustaceans, has been intensified over the last 10 years as a consequence of the increasing human population on the periphery of João Pessoa.

For information on crab gathering techniques, we accompanied gatherers throughout the whole process of capture. We chose the first gatherer going to the study area at sunrise assuming he agreed and that he had not previously been sampled. We refer to the accompanied gatherer as 'focal man', following Altman's 'focal animal' (1974) in the study of primate behavior.

Our samples were taken from 14 gathering trips with 'tapadores' (gatherers who practise 'tapamento') and 15 with 'braceadores' (gatherers who practise 'braceamento'). Each excursion started and finished on the same day, averaging 8.4 h—a total of 250 h of observation. Data on the size and sex of gathered crabs were obtained during their sale when each gatherer displayed his 'corda de caranguejo' (literally, rope of crabs; a cluster of 12 crabs tied to a rope made from the sisal plant *Agave sisalana*). The proportion of male and female crabs was recorded, their carapaces were measured and their mean size was estimated.

Results and Discussion

Figures 2 and 3 illustrate the two crab gathering techniques of 'tapamento' and 'braceamento' used in the region of Várzea Nova (see also Alves and Nishida 2003 for gatherers in the estuary of the Mamanguape river, municipality of

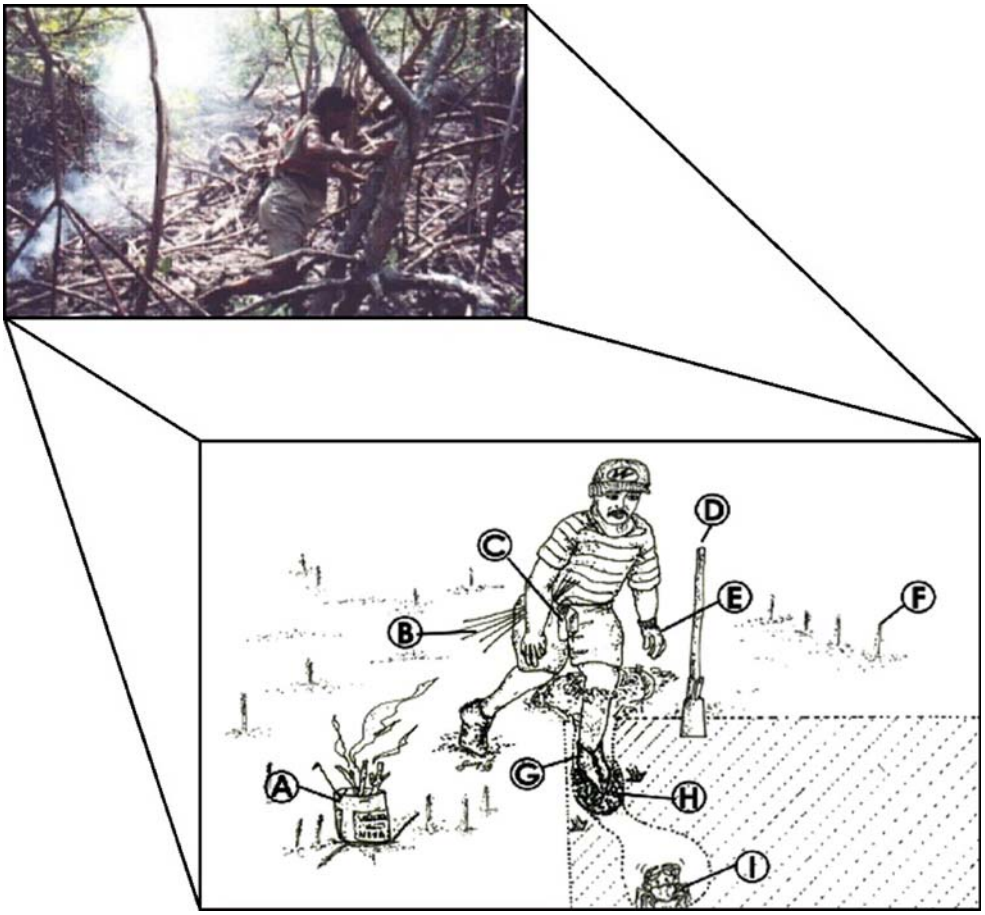

Fig. 2 Capture of the land crab (*Ucides cordatus*) by a gatherer who utilizes the technique of 'tapamento'. *A* 'boi-de-fogo,' a tin with burning twigs for producing smoke, *B* sisal fibers from *Agave sisalana*, *C* container with cooking oil, *D* 'ferro-de-cova', a straight spade for cutting roots and widening the burrow entrance, *E* cotton gloves, *F* roots of a mangrove tree, *G* 'mangrove shoes' made from inner tube of truck tire, *H* stopper, prepared with mud and tree roots and pressed for filling up the burrow opening, *I* the land crab (Photo: Rômulo R. N. Alves; Illustration: Alberto K. Nishida)

Rio Tinto, Paraíba State). Gatherers who utilize 'tapamento' are called 'true crab fishers' because this method requires greater knowledge of both the land crabs and their environment. According to Nordi (1992) this was the predominant technique among the indigenous population for centuries. On the other hand, Maneschy (1993), who studied the mangrove ecosystems of Pará State, northern Brazil, suggests that 'braceamento' is the oldest technique.

Even though 'tapamento' is the least productive form of collection, in terms of rope of crabs per hour and kilograms per hour (Nordi 1994), it is more complex, less predatory, and more selective than 'braceamento.' Those who utilize it are less likely to be unsuccessful or in danger, and this, plus the higher commercial value of crabs obtained, seem to be the main reasons for the persistence of the higher number of gatherers utilizing 'tapamento' (see Nordi 1992 for a discussion of other less used techniques).

Groups of two or three crab gatherers meet daily to go to the mangrove collection areas and later to sell the crabs. They exchange information about tide movement, rainfall and also about the potential productivity of the sites they are going to visit including 'packed sites'—overexploited areas to be avoided (see Marques 1995; Acheson 1972, 1975; Begossi 2001; Montenegro *et al.* 2001). As noted by Alves and Nishida (2002) and Alves *et al.* (2005), crab gatherers have wide knowledge of the bioecology and abiotic factors related to the crab's life cycle. They speak of crabs 'subidor' (literally, up-goer), that are easily caught, and of 'velhaco' (a sort of villain) more difficult to catch. They also talk of females that make burrows on clean sites, and of males that make their burrows under tree roots and dead tree trunks, making their capture a little difficult. These exchanges are probably important to avoid overlapping foraging areas (Winterhalder 1983) and to highlight more efficient capture procedures. Respecting each other's fisheries territories is important in regulating the transfer, use and distribution of rights to the common resources (Berkes 1985; McCay and Acheson 1987; Begossi *et al.* 1995).

We did not observe, as in other kinds of fishing, the practice of secrecy or manipulation of information that would result in the establishment of privileged gathering areas. The naming of collection sites by crab gatherers generates a complete map of foraging patches and allows an estimate of the total gathering area.

Crab gatherers prepare for fishing trips as follows. They wear few clothes and 'mangrove shoes,' which they make from inner tubes of truck tires and which will not stick in mud, besides being light and easy to get rid of. They grease

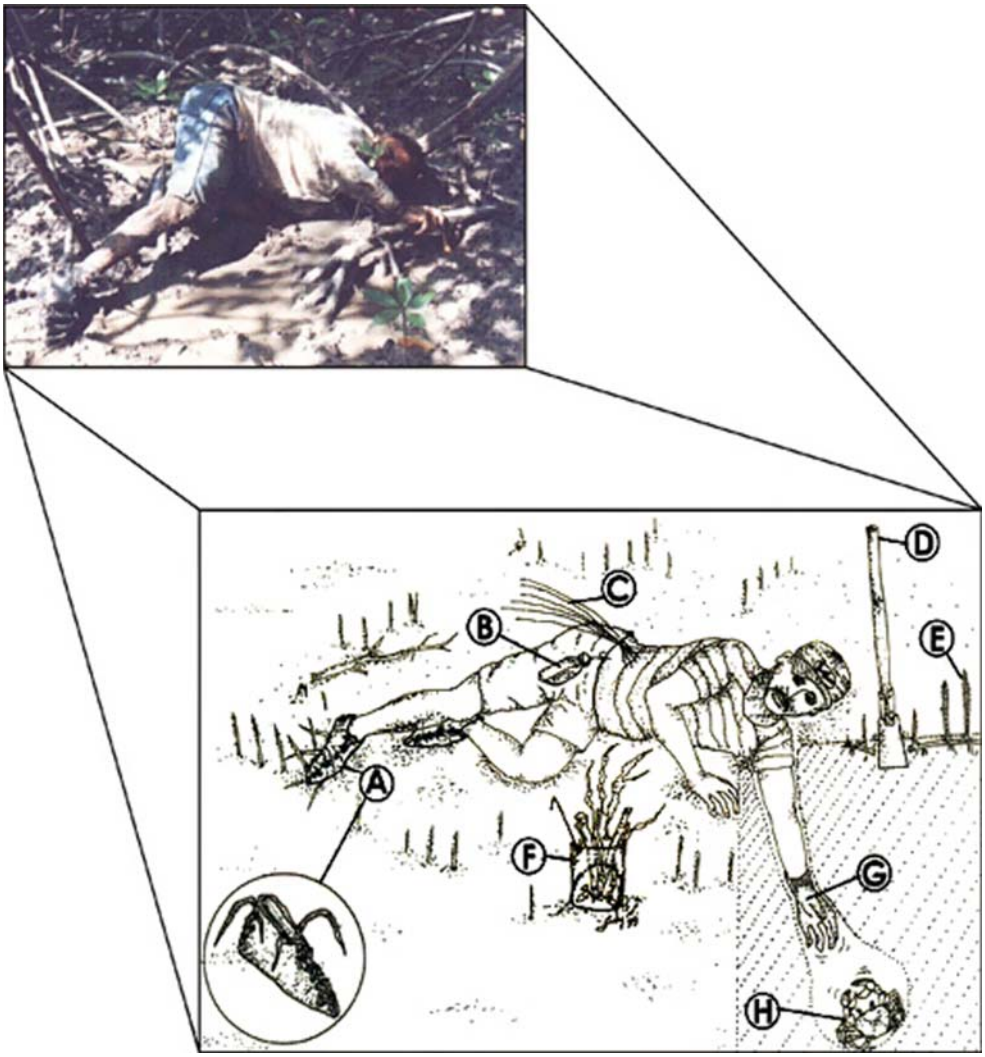

Fig. 3 Capture of the land crab (*Ucides cordatus*) by a gatherer who utilizes the technique of 'braceamento.' *A* 'mangrove shoes', made from inner tube of truck tire, *B* container with cooking oil, *C* sisal fibers from *Agave sisalana*, *D* 'ferro-de-cova', a straight spade for cutting roots and widening the burrow entrance, *E* roots of a mangrove tree, *F* 'boi-de-fogo', a tin with burning twigs for producing smoke, *G* cotton gloves, *H* the land crab (Photo and Illustration: Alberto K. Nishida)

exposed skin with cooking oil and light their 'boi-de-fogo' (literally, ox of fire), an insect repelling device made from an empty powdered milk or similar tin, open on one side with holes on the opposite side for circulation in which they burn mangrove twigs to produce smoke that repels insects like 'maruim' (Diptera: Ceratopogonidae) and 'mutuca' (Diptera: Tabanidae), the main enemies of crab gatherers.

Each trip to the mangrove area lasts an average of 7.51 h for 'braceamento' gatherers (4.25 h for going and return, and 3.26 h for collection) and an average of 8.75 h for 'tapamento' gatherers (3.93 h for going and return, and 4.82 h for collection).

'Tapamento' gatherers (Fig. 2) stop up the burrow opening with mud and tree twigs, which, they explain, forces the crab out for air making its capture quite easy. However, since the crabs have a low metabolic requirement well adapted to a usually low level of oxygen in the burrow (Mota Alves and Madeira 1980) it is more likely that the crab feels disorientated in the dark, compelling it to get out of the burrow.

'Tapamento' gatherers plot an approximately circular route so that the last burrow they stop up is close to the first one (Fig. 4), allowing easier movement in the collection area. Smaller circles are made inside the big one in order to maximally exploit the selected area. Sometimes they mark the burrow with mangrove twigs, mainly during rainy periods when water accumulates on the burrow's entrance, in order to locate the correct sequence of covered burrow, quite a difficult task since the mangrove habitat is a very phytophysiognomically homogeneous ecosystem.

Table 1 presents data on covered burrows, number of captured crabs, and number of burrows the gatherers missed when they returned to catch the crabs. The data show a low mean percentage of missed burrows, only 3% (a range from 0.7% to 7.4%), which means 97% success, an indication of the gatherers' skill.

The 'braceamento' gatherer (Fig. 3) inserts his arm into the burrow, grasps the crab by its dorsal carapace, pressing its chelae with his thumb and index finger and immobilizing them against the palm of his hand, pulling the crab out

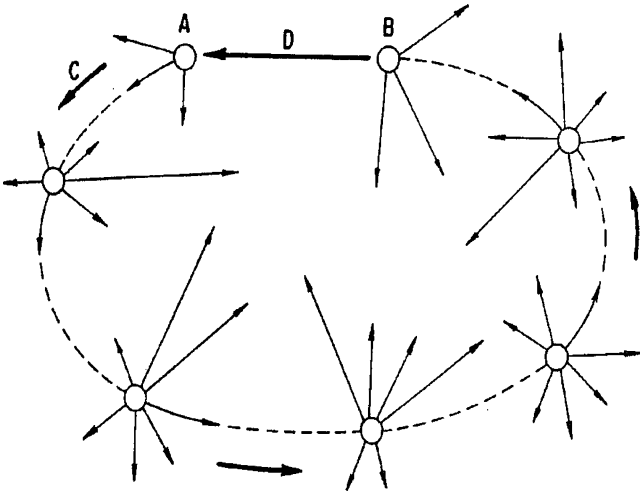

Fig. 4 The route of 'tapamento' gatherers. *A* the first burrow stoppered, *B* the last burrow stoppered, *C* anticlockwise direction of the path, *D* moving from the last burrow stoppered to the first one for capturing the crab

laterally. The main advantages of this technique are (a) gatherers do not follow a pre-defined route and are thus able to cover a larger foraging area than 'tapamento' gatherers; and (b) they do not have to revisit burrows.

Relative Efficiency of 'Tapamanto' and 'Braceamento'

Our results show that 86% of crabs captured by 'braceamento' measured from 4.2 to 5.3 cm, and 90% of crabs captured by 'tapamento' measured from 4.8 to 5.9 cm (Table 2). The average size of crabs collected by these techniques was 4.82±0.48 and 5.41±0.37 cm, respectively. The differences were significant (D_{max}=0.2850; p<0.05), showing

Table 1 Data on foraging by 'tapadores'

Collection excursions	Burrows stoppered	Crabs captured	Missed burrows	Percentage of losses (%)
01	68	63	5	7.4
02	68	64	4	5.9
03	145	144	1	0.7
04	93	88	5	5.4
05	118	114	4	3.4
06	130	127	3	2.3
07	122	120	2	1.6
08	179	177	2	1.2
09	117	114	3	2.6
10	127	123	4	3.2
11	97	94	3	3.1
12	169	167	2	1.2
13	100	95	5	5.0
14	120	115	5	4.2
Mean	118.1	114.6	3.4	3.0

Table 2 Different classes of carapace length of the land crab (*Ucides cordatus*) for 'braceamento' and 'tapamento'

Classes of carapace length (cm)	'Braceamento'		'Tapamento'	
	Number of crabs	Percent	Number of crabs	Percent
3.6–4.1	10	3.0	01	0.5
4.2–4.7	156	46.4	03	1.4
4.8–5.3	134	40.0	97	45.0
5.4–5.9	35	10.4	98	45.0
6.0–6.5	01	0.3	17	7.9
Total of crabs measured (*n*)	336		216	
Mean (cm)	4.82±0.48		5.41±0.37	

that 'tapamento' gatherers selected larger crabs. Since there is no difference in stopping up large or small burrows, gatherers choose the former because they certainly contain larger and more valuable specimens, even though they collect a smaller number of animals overall (Table 2).

Nordi (1994), investigating a mangrove ecosystem also in the district of Várzea Nova, reported a mean daily production per gatherer during summer of 11.1 and 7.4 ropes of crabs for 'braceamento' and 'tapamento' techniques, respectively. In terms of the ratio *gross weight/utilizable crab meat* the mean values obtained from 'braceamento' and 'tapamento' were 15.6:3.9 kg and 13.7:3.2 kg, respectively, leading to the conclusion that 'braceamento' is of a high efficiency to 'tapamento.' However, Nordi (1994) concluded that 'tapamento' has less risk of failure as opposed to 'braceamento,' which has a higher variation of production. Based on optimal foraging theory (Pike *et al*. 1977, Smith 1983, and Stephens and Krebs 1986), 'braceamento' could be considered an efficient technique that maximizes the capture rate in the least possible time.

The technique of 'tapamento', as we have seen, is more selective than the 'braceamento' because larger specimens

Table 3 Male and female land crab (*Ucides cordatus*) captured by 'braceamento' and 'tapamento'

Sex ratio (m/f)	'Braceamento'		'Tapamento'	
	Ropes of crabs	Percent	Ropes of crabs	Percent
12/0	37	34.3	31	48.4
11/1	20	18.5	13	20.3
10/2	18	16.7	07	10.9
9/3	05	4.6	03	4.7
8/4	08	7.4	04	6.2
7/5	02	1.8	03	4.7
6/6	07	6.5	–	–
5/7	01	0.9	03	4.7
4/8	06	5.6	–	–

m males, *f* females

go deeper in the burrow, and are thus difficult to reach by hand. About 53% of captures by 'tapamento' were of bigger crabs (from 5.4 to 6.5 cm), whereas 'braceamento' totaled only about 11% of specimens of this size class (Table 2).

Data on the collection of male and female crabs are shown in Table 3. About 48% of the ropes of crabs captured by 'tapamento' were composed solely of males, and only 5% had equal or higher number of females per rope. For 'braceamento' the values were 34% and 17%, respectively. A mean range of females per rope, from 2.3 to 2.7, was obtained from 'braceamento', whereas the range was from 1.1 to 1.3 for 'tapamento'. Despite the fact that both groups of gatherers equally prize male crabs, this difference was significant (t=3.29; p<0.05) and confirms that 'tapamento' favors the capture of males.

Implication for the Sustainability of Mangrove Ecosystems

In the mangrove ecosystems of the state of Paraíba it is quite clear that populations of *U. cordatus* are decreasing (Alves and Nishida 2003, 2004). The high unemployment rate is forcing many of the unemployed people to practice artisanal fishing, mainly crab gathering (Alves and Nishida 2003). The consequent decrease of crab populations, the utter poverty of human populations in the periphery of cities in the northeastern region along with continuing environmental degradation, and increasing numbers of unemployed, point to a predictable worsening of this situation in a very short time. A similar situation has been observed by Glaser and Diele (2004) in areas on the Pará coast, North Brazil, where the low investment costs for crab collection, high demographic growth, few alternative income sources, and the open-access management regime of crab collection areas, have continued to attract a high percentage of new participants in the crab collection, which is also absorbing "surplus labour" from elsewhere in the economy.

The regulation of crab collection is the responsibility of the Brazilian Federal Environmental Agency (IBAMA). A conservation-oriented regulatory framework based on prohibitive rules which were mostly designed without the participation of the crab collectors is currently in use. Crab collection is illegal during the annual mating days, when crabs walk on the surface rather than hide in their burrows. This is generally ignored by or unknown to crab collectors and the general public (Alves and Nishida 2003; Glaser and Oliveira 2003).

Urgent interventions are needed in this area, either aimed at the management of the mangrove ecosystems or at improving the specific regulations that will benefit the maintenance of the resource (Alves and Nishida 2003). The lives of the gatherers and their experience through the generations must be taken into consideration in government decision-making involving the interaction of these human populations with their environment (Nordi 1992; Alves and Nishida 2003). The participation of direct ecosystem users, as recently envisioned in comanagement pilot projects in the Brazilian coastal zone (Glaser and Oliveira 2003), is the most likely avenue to address of social and economic priorities for resource management.

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References

Acheson, J. M. (1972). The Territories of the Lobstermen. Natural History 81(4): 60–69.

Acheson, J. M. (1975). The Lobster Fiefs: Economic and Ecological Effects of Territoriality in the Maine Lobster Industry. Human Ecology 3: 183–207.

Altman, J. (1974). Observational Study of Behavior: Sampling Methods. Behavior 14: 227–267.

Alves, R. R. N., and Nishida, A. K. (2002). A ecdise do caranguejo-uçá, *Ucides cordatus* (Crustacea, Decapoda, Brachyura) na visão dos caranguejeiros. Interciencia 27(3): 110–117.

Alves, R. R. N., and Nishida, A. K. (2003). Aspectos socioeconômicos e formas de percepção ambiental dos catadores de caranguejo-uçá *Ucides cordatus cordatus* (L. 1763) (Decapoda, Brachyura) do estuário do rio Mamanguape. Interciencia 28(1): 36–43.

Alves, R. R. N., and Nishida, A. K. (2004). Population Structure of the Mangrove Crab *Ucides cordatus* (Crustacea: Decapoda; Brachyura) in the Estuary of the Mamanguape River, Northeast Brazil. Tropical Oceanography 32(1): 23–37.

Alves, R. R. N., Nishida, A. K., and Hernandez, M. I. M. (2005). Environmental Perception of Gatherers of the Crab Caranguejo-uçá (*Ucides cordatus*, Decapoda, Brachyura) Affecting Their Collection Attitudes. Journal of Ethnobiology and Ethnomedicine 1: 1–8.

Bacon, P. R., and Alleng, G. P. (1992). The Management of Insular Caribbean Mangroves in Relation to Site Location and Community Type. Hydrobiologia 247(1–3): 235–241.

Begossi, A. (2001). Mapping Spots: Fishing Areas and Territories in the Atlantic Forest Coast, Brazil. Regional Environmental Change 2: 1–12.

Begossi, A., Amaral, B. D., and Silvano, R. A. M. (1995). Reserva Extrativista do Alto Juruá: Aspectos de Etnoecologia. In Barbosa, S. R. C. S. (ed.), A Questão Ambiental: cenários de pesquisa. A experiência do Ciclo de Seminários do NEPAM. Textos NEPAM, Série "Divulgação Acadêmica". UNICAMP, Campinas, São Paulo, pp. 95–106.

Berkes, F. (1985). Fishermen and the Tragedy of the Commons. Environmental Conservation 12(3): 199–206.

Corrêa, J. D. Jr., Allodi, S., Amado Filho, G. M., and Farina, M. (2000). Zinc Accumulation in Phosphate Granules of *Ucides cordatus* Hepatopancreas. Brazilian Journal of Medical and Biological Research 33(2): 217–221.

Diele, K., and Simith, D. (2007). Effects of Substrata and Conspecific Odour on the Metamorphosis of Mangrove Crab Megalopae,

Ucides cordatus (Decapoda: Ocypodidae). Journal of Experimental Marine Biology and Ecology 348: 174–182.

Farnsworth, E. J., and Ellison, A. M. (1997). Global Patterns of Predispersal Propagule Predation in Mangrove Forests. Biotropica 29(3): 318–330.

Fouda, M. M., and Al-Muharrami, M. (1995). An Initial Assessment of Mangrove Resources and Human Activities at Mahout Island, Arabian Sea, Oman. Hydrobiology 295(1–3): 353–362.

Glaser, M., and Oliveira, R. (2003). Whose rights, whose duties and whose priorities? The prospects for co-management of mangrove ecosystems on the North Brazilian coast. In: Rights and Duties in the Coastal Zone. Multi-disciplinary Conference, 12–14 June 2003, Beijer Institute, Stockholm, Sweden, 15 pp.

Glaser, M., and Diele, K. (2004). Asymmetric outcomes: assessing central aspect of biological, economical and social sustainability of a mangrove crab fishery, *Ucides cordatus* (Ocypodidae), in North Brazil. Ecological Economics 49:361–373.

Gondim, M., and Araújo, F. B. (1996). Redução dos tamanhos dos caranguejos (*Ucides cordatus* L.) capturados nos manguezais de Maracanã, zona do Salgado Paraense. In: Anais do 3° Congresso de Ecologia do Brasil.

Hatcher, B. G., Johannes, R. E., and Robertson, A. I. (1989). Review of Research Relevant to Conservation of Shallow Tropical Marine Ecosystems. Oceanography and Marine Biology, Annual Review 27: 337–414.

Hudson, D. A., and Lester, R. J. G. (1994). Parasites and Symbionts of Wild Mud Crabs *Scylla serrata* (Forskal) of Potential Significance in Aquaculture. Aquaculture 120: 182–199.

IBAMA—Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis. (1994). Lagosta, caranguejo-uçá e camarões do Nordeste. Relatório da reunião do Grupo Permanente de Estudos (GPE) da lagosta. Brasília, IBAMA. Coleção Meio Ambiente. Série Estudos—Pesca 10: 9–106.

IBAMA—Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis (1995). 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. MMA, Brasília.

Ivo, C. T. C., and Gesteira, T. C. V. (1999). Sinopse das observações sobre a bioecologia e pesca do caranguejo-uçá, *Ucides cordatus cordatus* (Linnaeus, 1763), capturado em estuários de sua área de ocorrência no Brasil. Boletim Técnico Científico CEPENE 7(1): 9–51.

Jones, D. A. (1984). Crabs of the mangal ecosystem. In Por, F. D., and Dor, W. (eds.), Hidrobiology of the Mangal. Junk, The Hague, pp. 89–109.

Kjerfve, B., and Lacerda, L. D. (1993). Management and status of the mangroves of Brazil. In ISME/ ITTO, Conservation and Sustainable utilization of mangrove forests in Latin America and Africa regions. Part I Latin Ameri, pp. 245–272.

Koch, V., and Wolff, M. (2002). Energy Budget and Ecological Role of Mangrove Epibenthos in the Caeté Estuary, North Brazil. Marine Ecology. Progress Series 228: 119–130.

Maneschy, M. C. (1993). Pescadores nos manguezais: estratégias técnicas e relações sociais de produção na captura de caranguejo. In Furtado, L. G., Leitão, W., and Fiúza, A. (eds.), Povos das Águas: Realidade e Perspectivas na Amazônia. MCT/CNPq, Belém, Brasil, pp. 19–62.

Marques, J. G. W. (1995). Pescando pescadores: etnoecologia abrangente no baixo São Francisco. NUPAUB-USP, São Paulo.

McCay, B. J., and Acheson, J. M. (1987). The Question of The Commons: The Culture and Ecology of Communal Resources. The University of Arizona Press, Tucson, Arizona.

Micheli, F., Gherardi, F., and Vannini, M. (1991). Feeding and Burrowing Ecology of Two East African Mangrove Crabs. Marine Biology 111: 247–254.

Montenegro, S. C. S., Nordi, N., and Marques, J. G. W. (2001). Contexto cultural, ecológico e econômico da produção e ocupação dos espaços de pesca pelos pescadores de pitu (*Macrobrachium carcinus*) em um trecho do baixo São Francisco, Alagoas—Brasil. Interciência 11: 535–540.

Mota Alves, M. I., and Madeira, P. H. Jr. (1980). Algumas considerações sobre a respiração do caranguejo-uçá, *Ucides cordatus* (Linnaeus, 1763) (Crustacea: Decapoda). Arquivos de Ciências do mar 20(1/2): 63–69.

Nishida, A. K., Nordi, N., and Alves, R. R. N. (2006a). Molluscs Production Associated to Lunar-tide Cycle: A Case Study in Paraíba State. Journal of Ethnobiology and Ethnomedicine 2(28): 1–6.

Nishida, A. K., Nordi, N., and Alves, R. R. N. (2006b). Mollusk Gathers of Northeast Brazil: Gathering Techniques and Productivity. Human Ecology 34(1): 133–145.

Nishida, A. K., Nordi, N., and Alves, R. R. N. (2006c). The Lunar-tide Cycle Viewed by Crustacean and Mollusc Gatherers in the State of Paraiba, Northeast Brazil and their Influence in Collection Attitudes. Journal of Ethnobiology and Ethnomedicine 2(1): 1–12.

Nordi, N. (1992). Os catadores de caranguejo-uçá (*Ucides cordatus*) da região de Várzea Nova (PB): Uma abordagem ecológica e social. Ph.D. Thesis, Universidade Federal de São Carlos, São Carlos.

Nordi, N. (1994). A captura do caranguejo-uçá (*Ucides cordatus*) durante o evento reprodutivo da espécie: o ponto de vista dos caranguejeiros. Revista Nordestina de Biologia 9(1): 41–47.

Nordi, N. (1995). O processo de comercialização caranguejo-uçá (*Ucides cordatus*) e seus reflexos nas atitudes de coleta. Revista Nordestina de Biologia 10(1): 39–46.

Nunes, A. G. A. (1992). Os argonautas do mangue: uma etnografia visual dos caranguejeiros do Município de Vitória—ES. M.Sc. Dissertation, UNICAMP—Campinas University, Campinas, São Paulo State, Brazil.

Pike, G. H., Pulliam, H. R., and Charnov, E. L. (1977). Optimal Foraging: A Selective Review of Theory and Tests. Quarterly Review of Biology 52: 137–154.

Pons, L. J., and Fiselier, J. L. (1991). Sustainable Development of Mangroves. Landscape and Urban Ecology 20(1–3): 103–109.

Robertson, A. I. (1986). Leaf-burying Crabs: Their Influence on Energy Flow and Export from Mixed Mangrove Forests (*Rhizophora* spp) in Northeastern Austrália. Journal of Experimental Marine Biology and Ecology 102: 237–248.

Robertson, A. I. (1991). Plant–Animal Interactions and the Structure and Function of Mangrove Forests Ecosystems. Australian Journal of Ecology 16: 433–443.

Robertson, A. I., Alongi, D. M., and Boto, K. G. (1992). Food chains and carbon fluxes. In Robertson, A. I., and Alongi, D. M. (eds.), Tropical Mangrove Ecosystems. American Geophysical Union Press, Washington, DC, pp. 293–326.

Smith, E. A. (1983). Anthropological Applications of Optimal Foraging Theory: A Critical Review. Current Anthropology 24(5): 625–651.

Stephens, D. W., and Krebs, J. R. (1986). Foraging Theory. Princeton University Press, Princeton, NJ.

Twilley, R. R., Snedaker, R. R., Yáñez-Arancibia, S. C., and Medina, A. (1996). Biodiversity and ecosystem processes in tropical estuaries: perspectives of mangrove ecosystems. In Mooney, H. A., Cushman, J. H., Medina, E., Sala, O. E., and Schulze, E. D. (eds.), Functional Roles of Biodiversity: a Global Perspective. Wiley, New York, pp. 327–370.

Winterhalder, B. P. (1983). Opportunity–Cost Foraging Models for Stationary and Mobile Predators. American Naturalist 122: 73–84.