Reproductive period of the swimming crab *Callinectes danae* at the Santa Cruz Channel, a highly productive tropical estuary in Brazil

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Abstract

The aim of this study was to analyze reproductive aspects of *Callinectes danae* in one of the most productive estuarine systems in the Northeast Brazil, Santa Cruz Channel. A total of 1.573 individuals, being 756 females (23 ovigerous) and 817 males were examined from January to December 2009. Mature males and females, as well as couples of *C. danae,* occurred in all months of the year. Ovigerous females occurred in nearly all months. The reproductive activity, based on the macroscopic observation of the gonads, occurs continuously, with distinguishable peaks in February, March and September. Ovigerous females were only recorded nearest to the sea, while couples were only in the inner estuary. Thus, a migration pattern is proposed, with couples mating inside the estuary, followed by a migration of females to the area of greater marine influence for egg laying and, probably, larval release. After this, probably the females of do not return to the estuary, characterizing habitat partitioning. The present study is the first contribution on the reproductive period of *C. danae* in an estuarine ecosystem of the Brazilian northeast coast, and elucidates some aspects of its reproductive behavior.

Key words: Brachyura, breeding season, reproductive migration

Introduction

Reproduction is the most important biological phenomenon to ensure the continuity of a species (Cobo and Fransozo, 2000). The determination of the reproductive pattern is of great importance especially for commercially exploited species. It allows the elaboration of conservation mechanisms that allow the maintenance and management of natural stocks. For many species of Brachyura, the determination of this period is mainly based on the observation of the months when ovigerous females are found along the year, and the observation of copula and gonads are used for confirmation (Giese, 1959; Pillay and Ono, 1978; Choy, 1988; Sumpton, 1990).

Among the crabs found on the

Brazilian coast, the genus *Callinectes* Stimpson 1860 is represented by species confined to shallow waters (Melo, 1996). Besides being a bycatch in many fisheries, especially shrimp trawls, these swimming crabs are also targeted by poor coastal communities that use them for their subsistence and informal commerce of the pre-treated meat (Santos, 1990; Branco and Fracasso, 2004). In southern Brazil, *C. sapidus* Rathbun, 1896 is the most abundant species of the genus, followed by *C. danae* Smith, 1869 (Weber and Levy, 2000). However, from Santa Catarina State to the North, *C. danae* becomes more abundant (Sawaya and Pereira, 1946; Farias, 1980; Medeiros, 1982; Pita *et al.*, 1985a, b). In northeastern Brazil, the species of preference for regional cuisine is *C. danae* (Calado and Souza, 2003).

The reproduction of *C. danae* has been studied in some coastal environments of southern and southeastern Brazil (Pita *et al.*, 1985a; Costa and Negreiros-Fransozo, 1998; Chacur *et al.*, 2000; Baptista-Metri *et al.*, 2005). Meanwhile, no study has determined the reproductive period of this species on the largest segment of the Brazilian coast, North/Northeast. The aim of this study was to analyze some reproductive aspects of *Callinectes danae,* including the determination of the reproductive period, in one estuarine system of Northeast Brazil.

Materials and Methods

Specimens of *Callinectes danae* were monthly collected with a dipnet from January to December 2009, at the Santa Cruz Channel (SCC) (Fig. 1), Pernambuco State, one of the most productive estuaries in the Northeast coast of Brazil (Macedo *et al.*, 2000). The sampling effort was of 50 crabs in all months and stations. Four sampling stations were determined: 01 – Congo river mouth (7°46'26" S - 34°53'27"W); 02 - Presidente Vargas bridge (7°46'28"S - 34°53'13"W); 03 – Paripe river mouth (7°48'38"S - 34°51'27"W); and 04 - Coroa do avião sand bank (7°48'59"S - 34°50'28"W) (Fig. 1). For the purpose of this

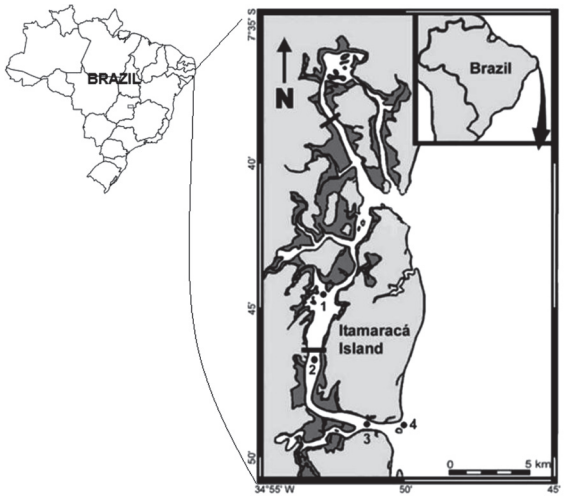

Figure 1. Santa Cruz Channel (SCC), with sampling stations indicated by numbers: 1 = Congo River mouth; 2 = President Vargas bridge; 3 = Paripe River mouth; and 4 = Coroa do Avião sand bank

paper, the first two stations were considered the upper estuary, while the last two ones, the lower estuary.

At the laboratory, the specimens were dissected for the observation of the gonads. Three stages of testes maturation (immature - IM, developing - DG and developed - DD) and four stages of ovarian maturation (immature - IM, developing - DG, ripe - RP, spent - SP) were considered (adapted from Costa and Negreiros-Fransozo, 1998 and Keunecke *et al.*, 2009a).

The percentage of each gonad stage in the total sample was determined. The monthly frequencies of mature individuals (♂ - DG and DD; ♀ - DG, RP, SP) were obtained. The determination of the reproductive period was based on the declining frequency of females with gonads at the RP stage and the increasing frequency of females with gonads at the SP stage (Vazzoler, 1996).

Based on the months in which ovigerous females (DP stage) were found, reproduction was characterized as: seasonal (presence of ovigerous females in only certain months or seasons), continuous (when ovigerous females occur during all months of the year with similar intensity) or seasonal-continuous (with the presence of these females in all months of the year, but with distinguishable peak of high reproductive activity in some months or

seasons) (Pinheiro and Fransozo, 2002). The spatial distribution of ovigerous females and couples was analyzed to investigate a possible reproductive migration.

Results

A total of 1.573 individuals of *Callinectes danae*, being 756 females and 817 males, were examined. The four stages of ovarian maturation of *C. danae* were observed. The majority of females had IM gonads (72.2%), followed by the DG (23.7%). Females with RP and SP gonads had little representation in the samples (1.9% each one).

Only the RP and SP stages did not occur in all months. Females with SP gonads occurred in February, March, from June to September, November and December, while the presence of females with RP gonads was restricted to January and from June to October (Fig. 2). In February and March, there was a peak of females with SP gonads and no females with RP gonads, indicating the posture of the ovigerous mass. There was a peak of females with RP gonads in July, which decreased in August. In September, there was the second peak of females with SP gonads (Fig. 2), indicating the posture of the ovigerous mass again. However, mature females (DG, RP and SP) occurred in all months of the year. Considering each season, it can be observed that the higher frequency of mature females occurs in the second half of the summer and winter.

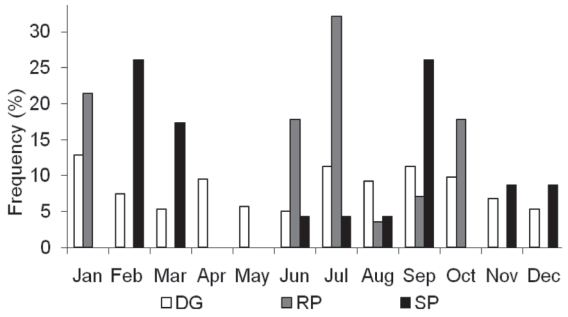

Figure 2. *Callinectes danae.* Frequency of females with gonads in the stages of development: DG = developing; INT = intermediary; AD = advanced; DP = depleted, at the Santa Cruz Channel.

The three stages of testes maturation of *C. danae* were observed in all months of the year. The majority of males had IM gonads (83%), followed by the DD (11.4%) and DG (5.6%) gonads. Males with DD gonads were in greater numbers from August to December (Fig. 3).

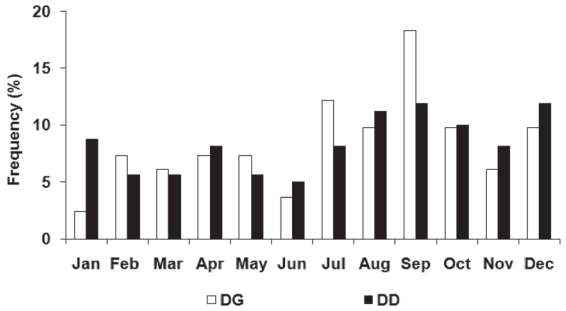

Figure 3. *Callinectes danae.* Frequency of males with gonads in the stages of development: DG = developing; DD = developed, at the Santa Cruz Channel.

In all sampling months, *C. danae* couples were observed, with most being captured in guarding position. The male was always visibly larger than the female, which had triangular sealed abdomen and IM gonads. Few couples were caught copulating, when the male gonopods were introduced into the female gonopores. On these occasions, the female had a very soft carapace, semicircular unsealed abdomen, decalcified gonopore and IM gonads. While couples were registered in the upper estuary, the ovigerous females (SP gonads) were collected in lower estuary (Tab. 1).

Table 1. *Callinectes danae.* Number of couples and ovigerous females by sampling area, at the Santa Cruz Channel.

Callinectes danae	*Upper estuary*	*Lower estuary*
Couples	13	0
Ovigerous females	0	21

Discussion

The presence of mature males and females in all months of the year, and of ovigerous females in almost all of them, indicates that the reproductive activity occurs continuously. However, the higher frequency of mature and

ovigerous females in the summer and winter indicate seasonal peaks in the reproduction. Therefore, the breeding season of *C. danae* at SCC can be characterized as seasonal-continuous, according to the classification proposed by Pinheiro and Fransozo (2002). Such a seasonal-continuous pattern corroborates the studies on the same species by Pita *et al*. (1985a), Costa and Negreiros-Fransozo (1998), Branco and Masunari (2000), Chacur *et al*. (2000), Baptista-Metri *et al*. (2005) and Keunecke *et al.* (2011). According to Giese (1959), the temperature is the most important factor to determine the beginning of the reproductive period in many species of temperate marine invertebrates. Changes in temperature may possibly function as a trigger for the reproduction of *C. danae*, stimulating the onset of sexual maturation, although *C. danae* is a tropical species.

Other tropical and subtropical species of Portunidae, as *Portunus pelagicus* (Linnaeus, 1758) at Philippines (Batoy *et al*., 1987) and *Ovalipes punctatus* (De Haan, 1833) at South Africa (Du Preez and McLachlan, 1984) also follow the seasonal-continuous pattern. Continuous or seasonal-continuous reproduction is typically found in species of tropical and subtropical environments (Pinheiro and Fransozo, 2002), as the northeastern coast of Brazil and the SCC, where the temperature remains more or less constant throughout the year. It also ensures a year-round larvae supply, and thus, a continuous recruitment of juveniles to the population (Díaz and Conde, 1989; Negreiros-Fransozo, 2002).

At the Santa Cruz Channel, the recruitment of juveniles into the population occurs year-round, but it is enhanced from March to June and from October to December (Araújo *et al.,* 2012). These pulses of recruitment are probably a result of the reproduction seasonality observed herein. The larvae coming from the ovigerous females of February contribute to the juvenile population from March to June, and the larvae coming from ovigerous females of September to the juveniles from October to December, considering a mean period of 12-15 months from hatching to attaining the mean size of juveniles (Branco and Masunari, 2000). Besides, since the majority of portunids accomplish multiple spawning (Pinheiro and Fransozo, 1999; 2002), and like in *C. ornatus* Ordway, 1863, the recruitment can exhibit several pulses throughout the year (Baptista *et al*., 2003).

All couples of *C. danae* were found in the upper estuary and it is probable that mating occurs in this area. While males remain copulating with other females inside the estuary, it is possible that the fertilized females migrate to the sea for spawning. Such pattern indicates a reproductive migration, phenomenon observed by Keunecke *et al.* (2009b) and Keunecke *et al.* (2011). Literature has showed that *C. danae* stores energy in habitats of low salinity, but the female incubate the eggs and releases them in environments with higher salinity (Norse, 1978). These saltier waters facilitate the flotation and dispersal of the larvae. Besides, the osmotic pressure is important for the development of the embryos in *C. danae* and *C. ornatus* (Pita *et al*., 1985b; Mantelatto, 2000; Fernandes *et al*., 2006), since the larval stages are much less tolerant to salinity variations (Paul, 1982; De Vries *et al*., 1983). Keunecke *et al.* (2011) suggested that the females of *C. danae* return to the estuary after spawning. However, Araújo *et al.* (2012) observed that males outnumbered females in the upper estuary, while females outnumbered males in the lower estuary at the Santa Cruz Channel. Thus, probably the females of this population do not return to the estuary, characterizing habitat partitioning.

According to Gleeson (1991), the female of *C. sapidus* Rathbun, 1896 normally copulates only once during their lifetime. This mating occurs immediately after its puberty molt (Hartnoll, 1969; Barreto *et al*., 2006), which is also its final molt (Van Engel, 1958). The male of *C. sapidus* is observed guarding a female that is about to molt, holding the female beneath him in a position called "cradle-carry" (Carr, 1988), also observed in the couples of *C. danae* at SCC. Copulation is usually initiated by the female, when the carapace is soft, the

abdomen is semicircular and unsealed, and the gonopore is decalcified, as observed in *C. danae* in the present study. The female stands beneath the male, with the abdomen extended upward, allowing the insertion of gonopods. After the spermatophores are deposited in the spermathecae, the "cradle-carry" position is restored and maintained until the carapace is hardened. Females store the spermatophores until the full development of the gonads (Subramonian, 1991), since they may copulate while their gonads are still immature, as observed in the present study and by Barreto *et al.* (2006) in a nearby population. The sperm remains viable for at least a year and is used to fertilize two or more egg laying that the female performs during her lifetime in *C. sapidus* (Hard, 1942; Van Engel, 1958).

Males from couples were visibly larger than females. The larger size of males is an adaptation that gives greater protection to females in post molt and after copulation, as has been reported for other portunids as *Arenaeus cribrarius* (Lamarck, 1818) (Pinheiro and Fransozo, 1998), *C. ornatus* (Branco and Lunardon-Branco, 1993; Mantelatto and Fransozo, 1996; Baptista *et al.*, 2003; Branco and Fracasso, 2004) and *C. danae* (Costa and Negreiros-Fransozo, 1998; Baptista-Metri *et al.*, 2005).

The present study is the first contribution on the reproductive period of *C. danae* in an estuarine ecosystem of the Brazilian northeast coast, and elucidates some aspects of its reproductive behavior. However, a study on its larval dynamics is needed for a better understanding of the biological cycle of this crab in the region.

Acknowledgements

This paper is part of a master degree dissertation on Oceanography improved by the first author. We are sincerely thankful to all laboratory members who helped us during the sampling and the laboratory activities. We also wish to thank Dr. Monica Ferreira da Costa for the important revision of the text, and to the members of the examining board, Dr. Tereza Cristina dos Santos Calado, Dr. Daniela da Silva Castiglioni, Dr. Luis Ernesto Arruda Bezerra and Dr. Petrônio Alves Coelho for important suggestions performed during the dissertation analysis, that were very useful for the elaboration of this paper.

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Submitted 14 September 2011
Accepted 01 December 2011