Fecundity of *Uca uruguayensis* and *Chasmagnathus granulatus* (Decapoda, Brachyura) from the "Refugio de Vida Silvestre" Bahía Samborombón, Argentina

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Received February 9, 2006 – Accepted June 7, 2006 – Distributed November 30, 2007

Abstract

The aim of the present work conducted at the Refugio de Vida Silvestre Bahía Samborombón is to analyse the most relevant aspects of the fecundity of *Chasmagnathus granulatus* and *Uca uruguayensis*. Samplings were carried out from March 2001 to February 2003. Ovigerous females of *U. uruguayensis* (N = 13) and *C. granulatus* (N = 25) were found during spring and summer, their sizes (CW) varied from 9.1 to 11.7 mm for the former species and from 22.8 to 32.4 mm for the latter. The egg diameter in *U. uruguayensis* ranged from 245 to 260 µm for embryos in the early stage of development and from 250 to 345 µm for those in mid-developmental stage, while in *C. granulatus* from 250 to 345 µm and from 260 to 365 µm respectively. Fecundity varied from 1126 to 6745 eggs/brood in *U. uruguayensis* and 15688-57418 eggs/brood in *C. granulatus*. For those females with broods in mid-developmental stage, several relationships were made. For *U. uruguayensis* the best correlation coefficients were obtained for the relationships: female weight vs. egg mass weight and carapace width vs. egg mass weight; for *C. granulatus* the best association was obtained between female size and the egg number and the egg mass weight.

Keywords: fecundity, *Uca uruguayensis*, *Chasmagnathus granulatus*, Argentina.

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Resumo

O objetivo do presente trabalho foi analisar os aspectos mais relevantes da fecundidade de *Chasmagnathus granulatus* e *Uca uruguayensis* no Refúgio da Vida Silvestre Bahia Samborombón. As amostragens foram realizadas de março de 2001 a fevereiro de 2003. As fêmeas ovígeras de *U. uruguayensis* (N = 13) e de *C. granulatus* (N = 25) foram capturadas na primavera e verão. A largura da carapaça (LC) de *U. uruguayensis* variou de 9.1 a 11.7 mm, e de 22.8 a 32.4 mm para *C. granulatus*. O diâmetro dos ovos de *U. uruguayensis* variou de 245 a 260 µm para embriões em estágio de desenvolvimento inicial e de 250 a 345 µm para aqueles em estágio intermediário; para *C. granulatus* as variações foram de 250 a 345 µm e de 260 a 365 µm, respectivamente. A fecundidade de *U. uruguayensis* variou de 1126 a 6745 ovos/desova e para *C. granulatus* de 15688 a 57418 ovos/desova. Para as fêmeas com massa de ovos em estágio de desenvolvimento intermediário foram efetuadas várias relações: para *U. uruguayensis* os melhores coeficientes de correlação foram obtidos nas relações: peso da fêmea vs. peso da massa de ovos, e largura da carapaça vs. peso da massa de ovos. Para *C. granulatus*, a melhor associação foi obtida entre o número de ovos e o peso da massa de ovos.

Palavras-chave: fecundidade, *Uca uruguayensis*, *Chasmagnathus granulatus*, Argentina.

1. Introduction

The reproductive aspects and fecundity in brachyurans from the Neotropical region has been treated for different families, among them Portunidae (Mantelatto and Fransozo, 1997), Grapsidae and Varunidae (Spivak et al., 1996; Luppi et al., 1997; Conde et al., 2000; Leme, 2002, 2004), and Ocypodidae (Spivak et al., 1991; Costa et al., 2006). These papers refer mostly to Brazil and the Mar Chiquita Lagoon (Argentina). From them it can be appreciated that reproductive aspects are adaptive processes intimately related with environmental conditions, such as latitude, temperature, larval food availability, giving a single species a continuous reproduction in tropical areas of its distribution and a seasonal one in the temperate zones (Spivak et al., 1991; César et al., 2005; Costa et al., 2006).

Chasmagnathus granulatus Dana, 1851 (Varunidae) and *Uca uruguayensis* (Nobili, 1901) (Ocypodidae) are two endemic species of crabs recorded in the template biogeographic region of the southwestern Atlantic Ocean. The former inhabit estuaries, *Spartina* sp. salt-marshes, halophyte meadows and mangroves from Río de Janeiro (Brazil) to the Río Negro River (Argentina), while the latter is found as far as Quequén River (Buenos Aires, Argentina). Both species occupy the high levels of the silty or silt-sandy intertidal ecosystem (Spivak et al., 1991; Spivak, 1997a, 1997b) and are semi-terrestrial species that build burrows and use the habitat in a rather complex way. Very dense populations of *C. granulatus* and *U. uruguayensis* inhabit the intertidal ecosystem of Samborombón Bay (César et al., 2005), giving to the landscape a special physiognomy called "cangrejales". The southernmost permanent populations of *U. uruguayensis* inhabits Samborombón Bay, however some intermittent populations are found in the Mar Chiquita coastal lagoon, 250 km further south (Spivak et al., 1991). The Samborombón Bay includes the so-called "depression of the Salado river" that extends from Punta Piedras (35° 30' S and 56° 45' W) to Cabo San Antonio (36° 22' S and 57° 23' W). This bay is a depocentre of significant magnitude, formed by clayish sediments from the sea and the Uruguay and Paraná rivers generating coastal plains with large marshes (Violante et al., 2001). The coast of the bay is bathed by salty waters of variable salinity corresponding to the estuarine area of the Río de la Plata River (Boschi, 1988).

The aim of the present work conducted at the "Refugio de Vida Silvestre" Bahía Samborombón was to analyse the most relevant aspects of the fecundity of these two crab species.

2. Material and Methods

Sampling was conducted during each season (three occasions in spring and two in the other seasons) between March 2001 and February 2003 at the mouth of Channel 1 at the Refugio de Vida Silvestre Bahía Samborombón (36° 16' S and 57° 06' W). Ovigerous females were collected by hand using a square of 5 m x 5 m, with 0.5 m x 0.5 m subunits (N = 10) following Elliott (1983). In September 2001, October and December 2002 five ovigerous females of *C. granulatus* were collected just beside the square. The crabs were kept in plastic bags and frozen. On each sampling occasion physico-chemical variables were measured (using the Checkmate Modular Testing system by Ciba Corning Analytical): temperature (°C), pH, and conductivity, then salinity was obtained after multiplying the conductivity by 0.9; due to difficulties with the equipment only the measure of conductivity and pH could be taken in winter. In the laboratory, crabs were thawed at room temperature and fixed in 10% formalin. Total carapace widths (CW), wet and dry weight (60 °C, during 48 hours) were measured. The dry weights of the brooded egg mass and number of eggs per brood (extrapolated from the dry weight of a counted sub-sample of 1000 eggs) were measured in order to determine the brood size (Hines, 1982; Mantelatto and Fransozo, 1997; Luppi et al., 1997; Leme, 2004). Although some authors (Mantelatto and Fransozo, 1997) recommend the use of embryos in developmental stages from late blastula to early gastrula for fecundity analysis, to avoid effects of embryonic diameter swelling during late stages of development, we considered here (following Hines, 1982; Luppi et al., 1997; Leme, 2004) also those embryos in the intermediate stage of development, as determined by formation of eyes.

3. Results

The registered physical and chemical variations are typical of an estuarine ecosystem and are shown on Table 1.

In both species the ovigerous females captured presented broods with embryos in early and intermedi-

Table 1. Physical and chemical variables measured at sites sampled on Channel 1, Bahía Samborombón. The salinity values were obtained after multiplying the conductivity by 0.9.

Season	T (°C) (x ± SD)	Conductivity (μS.cm^{-1}) (x ± SD)	Salinity (mg.L^{-1}) (x ± SD)	pH (x ± SD)
Summer	27.3 ± 2.68	4790 ± 2349.55	4311 ± 2114.59	8.41 ± 0.29
	min: 23.8	min: 3210	min: 2889	min: 8.09
	max: 29.6	max: 7490	max: 6741	max: 8.68
Autumn	16.53 ± 0.72	828.50 ± 190.21	745.65 ± 171.19	8.39 ± 0.51
	min: 15.7	min: 694	min: 624.6	min: 8.03
	max: 17	max: 963	max: 866.7	max: 8.76
Winter	13.5 ± 4.94	-	-	-
	min: 10	675	607.5	8.97
	max: 17	-	-	-
Spring	25.46 ± 4.18	981.87 ± 75.59	883.68 ± 68.03	8.14 ± 0.32
	min: 19.3	min: 857	min: 771.3	min: 7.82
	max: 30.7	max: 1088	max: 979.2	max: 8.77

ate stages of development. Ovigerous females of *Uca uruguayensis* (N = 13) were found in December 2001 (N = 2), December 2002 (N = 4) and February 2003 (N = 7). The sizes (CW) of the smallest and biggest individuals were 9.1 and 11.7 mm, respectively, and their brood sizes varied from 1126 to 6745 eggs /brood (X ± SD = 3338.58 ± 1758.86). The egg diameter ranged from 245 to 260 µm (X ± SD = 253.25 ± 4.66) for embryos in the early stage of development and from 250 to 300 µm (X ± SD = 285.97 ± 15.07) for embryos in mid-developmental stage. For those females with broods in mid-developmental stage, the following relationships were analysed: carapace width vs. number of eggs, carapace width vs. brood dry weight, female wet weight vs. brood dry weight, brood dry weight vs. number of eggs and finally, female wet weight vs. number of eggs (see Table 2).

Ovigerous females of *C. granulatus* (N = 25, one of them, with zoeas about to hatch, was not considered in the analysis) were found on the same date reported for the former species (N = 7 on December 2001, N = 8 on December 2002, N = 8 on February 2003) and also on September 2001 (N = 1) and October 2002 (N = 1). Sizes of these individuals ranged from 22.8 to 32.4 mm. The sizes of the broods varied from 15688 to 57418 eggs/brood (X ± SD = 31371.08 ± 10217.23). The egg diameter ranged from 250-345 µm (X ± SD = 287.10 ± 20.33) for embryos in the early stage and 260-365 µm (X ± SD = 314.05 ± 24.89) for embryos in the intermediate stage of development. The above mentioned relationships between carapace width, female wet weight, brood dry weight and number of eggs were also determined for *C. granulatus* (Table 2).

4. Discussion

The "cangrejal" studied is inhabited by large populations of *C. granulatus* and *U. uruguayensis* which coexisted in Samborombón Bay, building their burrows in close proximity to one another (César et al., 2005). They were active during the period studied, except in July 2002 when no individuals from either species were recorded in their burrows (at least up to 50 cm deep) or on the surface. This could be due to climate factors, in particular to the frequent frosts registered during that winter. Many brachyurans diminish their activities during the most rigorous seasons of the year and remain apparently inactive, dug into their burrows or hidden inside of crevices of trees. Such behaviour was also reported by Spivak et al. (1996) for *C. granulatus* in the Mar Chiquita lagoon and for *Aratus pisonii* (H. Milne Edwards, 1837) in the mangroves of São Paulo State, Brazil (Leme, 2002).

Ovigerous females of *U. uruguayensis* were found in summer, Spivak et al. (1991) also found ovigerous females of this species in Mar Chiquita lagoon in summer but in higher percentages than ours. Although the population studied in Samborombón Bay has a high density (César et al., 2005), the fact of having collected a low number of ovigerous females could be due to a differential behaviour during this incubation period. Costa et al. (2006) captured the ovigerous females very deep in their burrows and suggested that this species would not feed during this period. On the other hand, *U. uruguayensis* presented continuous reproduction throughout the year in the north limit of its distribution (Brazil), while in the south (the population here studied in Samborombón Bay and the one studied by Spivak et al., 1991 in Mar

Table 2. Regression analysis of fecundity in *Uca uruguayensis* and *Chasmagnathus granulatus* in intermediate stage of development (r: correlation coefficient; Fe: number of eggs; CW: carapace width; WBW: wet body weight of ovigerous female; DWB: dry weight of broods); (*, **: regression coefficient significantly different from zero P < 0.05, < 0.01, respectively, ns: statistically not significant P > 0.05).

Relation	Power $Y = aX^b$	Log-Log Transformation $\ln Y = \ln a + b \ln X$	r
***Uca uruguayensis* (n = 11)**			
Fe vs. CW	$Fe = 2.4303 \times 10^{-3}\ CW^{2.9982}$	ln Fe = –6.0197 + 2.9982 ln CW	0.5076 ns
DWB vs. CW	$DWB = 2.0434 \times 10^{-4}\ CW^{2.5149}$	ln DWB = –8.4957 + 2.5149 ln CW	0.9620 *,**
DWB vs. WBW	$DWB = 0.1671\ WBW^{0.8091}$	ln DWB = –1.7887 + 0.8091 ln WBW	0.8795 *, **
Fe vs. DWB	$Fe = 61.0565\ DWB^{1.1933}$	ln Fe = 4.1118 + 1.1933 ln DWB	0.5282 ns
Fe vs. WBW	$Fe = 12.8442\ WBW^{1.5019}$	ln Fe = 2.5529 + 1.5019 ln WBW	0.7226 *
***Chasmagnathus granulatus* (n = 18)**			
Relation	**Power $Y = aX^b$**	**Log-Log Transformation $\ln Y = \ln a + b \ln X$**	**r**
Fe vs. CW	$Fe = 3.1739 \times 10^{-5}\ CW^{2.4131}$	ln Fe = –4.4984 + 2.4131 ln CW	0.4984 *
DWB vs. CW	$DWB = 1.4269 \times 10^{-9}\ CW^{1.9874}$	ln DWB = –8.8456 + 1.9874 ln CW	0.4501 ns
DWB vs. WBW	$DWB = 2.1272 \times 10^{-4}\ WBW^{0.6259}$	ln DWB = –3.6722 + 0.6259 ln WBW	0.5648 *
Fe vs. DWB	$Fe = 2.8536 \times 10^{-6}\ DWB^{0.9528}$	ln Fe = –5.5446 + 0.9528 ln DWB	0.8689 *, **
Fe vs. WBW	$Fe = 86.7560\ WBW^{0.6448}$	ln Fe = 1.9383 + 0.6448 ln WBW	0.5307 *

Chiquita Lagoon, both in Argentina), its reproduction was seasonal.

In the case of *C. granulatus*, the ovigerous females were found in spring and summer, such as reported by López Greco and Rodríguez (1999) at "Faro San Antonio" beach, at the southern point of Samborombón Bay. Also Spivak et al. (1996) reported for this species in Mar Chiquita Lagoon a seasonal reproduction during spring and summer.

In brachyuran crabs fecundity is related to female size, latitudinal distribution and habitat adaptations. For the organisms that develop in similar environments, female size and the volume of the body cavity appear to limit the brood size, being these features the main factors to determine fecundity and reproductive effort (Hines, 1982; Thurman, 1985; Mantelatto and Fransozo, 1997).

The effective fecundity expressed as the number of eggs per brood would be related as mentioned above, to the different kinds of environments and to the female sizes. Thus, in the *Uca* species from intertidal brackish environments, such as *U. triangularis* (Milne-Edwards, 1873), *U. annulipes* (Milne-Edwards, 1837) and *U. rapax* (Smith, 1870), fecundity varied among 3390, 6400 and 28500 eggs/brood respectively, being their average sizes 9.6, 11.3 and 15.8 mm of carapace width (Thurman, 1985). On the other hand, the population of *U.uruguayensis* studied by Costa et al. (2006) in Ubatuba, Brazil, presented a lower fecundity (mean fecundity: 1883 ± 490 eggs) than the population here studied, which is related to the smaller size in the ovigerous females captured ($C.W = 6.6 \pm 0.8$ mm).

In *C. granulatus* the effective fecundity was similar to that recorded in the Mar Chiquita by Luppi et al. (1997), though a bit lower than that determined by Botto and Irigoyen (1979) for the population at Salado river. Other grapsoids studied showed the association mentioned between fecundity and female size, thus *Cyrtograpsus angulatus* exhibited similar values to that of *C. granulatus*, and *Aratus pisonii* lower ones (Luppi et al., 1997; Conde et al., 2000). In the case of *Sesarma rectum* Randall, 1840, *C. granulatus* presented a higher fecundity but the eggs of the former species were almost double in size (Leme, 2004).

In *U. uruguayensis* the correlation coefficients for the relationship of female weight with egg mass weight and female size and egg mass weight showed the best association between the parameters analyzed. In *C. granulatus* the female size (CW and female weight) was strongly correlated with the brood (number of eggs and dry weight) as well as reported by Luppi et al. (1997) in Mar Chiquita lagoon. According to Hines (1982), allometric limitations on space available for yolk accumulation in the body cavity appeared to be the main constraint on brood size.

Acknowledgments — We are very grateful to Dr. Maria Helena de Arruda Leme for the Portuguese translation of the abstract of this manuscript and the Ranger Corps, Daniel Mc Lean and Pablo Rojas, of the Refugio de Vida Silvestre Bahía Samborombón for their help during the samplings.

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