

**MEAT YIELD OF THE MANGROVE CRAB, *Ucides cordatus* (Linnaeus, 1763)
(CRUSTACEA, BRACHYURA, UCIDIDAE)***

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ABSTRACT

Specimens of *Ucides cordatus* were captured from September 1998 to September 2000 in mangroves from Iguape, SP, Brazil (24°41'25"S - 47°27'48"W) and analyzed by sex, biological period (reproductive, October to March; and non-reproductive, from April to September) and size. The meat yield of each corporal structure, and the residuals were quantified. Each crab was measured (carapace width) with a vernier caliper (0.05 mm) and their corporal structures weighed with an analytic scale (0.0001 g). Biometric variables were previously tested (normality and homoscedasticity) with indication of a statistical parametric procedure (ANOVA) at 5% significance level. Males had higher wet weight than females, the same occurring when their corporal structures were compared ($p < 0.05$). The meat yield in males was of 25.4%, a little above than what was registered in females (21.1%); meat yield hierarchy among corporal structures was very similar between sexes and biological periods, but differing in relation to chelipeds, which were bigger in males. During the reproductive period males had a bigger meat yield due to their size when compared to males of non-reproductive period, as well as with females independently of their biological period. The expressive meat yield in males can be explained by the positive allometric growth of the chelipeds after puberty molt when this structure grows proportionally more than the body itself, accounting for 40% of the total wet weight in this gender.

Keywords: biometry; crab; fishery resource; meat extraction; morphology; reproduction

**RENDIMENTO DE CARNE DO CARANGUEJO-UÇÁ, *Ucides cordatus* (Linnaeus, 1763)
(CRUSTACEA, BRACHYURA, UCIDIDAE)**

RESUMO

Espécimes de *Ucides cordatus* foram capturados de setembro de 1998 a setembro de 2000, nos manguezais de Iguape, SP, Brasil (24°41'25"S - 47°27'48"O) e analisados por sexo, período biológico (reprodutivo: outubro a março; e não reprodutivo: abril a setembro) e tamanho. O rendimento de carne de cada estrutura corporal e os resíduos foram quantificados. Cada caranguejo foi medido (largura da carapaça) com um paquímetro (0,05 mm) e suas estruturas corporais pesadas com uma balança analítica (0,0001 g). As variáveis biométricas foram previamente testadas (normalidade e homocedasticidade) com indicação de um procedimento estatístico paramétrico (ANOVA) ao nível de 5% de significância. Os machos apresentaram maior peso úmido do que as fêmeas, o mesmo ocorrendo quando suas estruturas corporais foram comparadas ($p < 0,05$). O rendimento de carne nos machos foi de 25,4%, pouco acima daquele registrado nas fêmeas (21,1%), sendo a hierarquia de rendimento de carne entre as estruturas corporais muito similares entre os sexos e os períodos biológicos, porém diferindo em relação ao peso dos quelípodos, que foram maiores nos machos. Durante o período reprodutivo, os machos apresentaram um maior rendimento de carne de acordo com seu tamanho em relação aos machos do período não reprodutivo, bem como com as fêmeas, independentemente do seu período biológico. O rendimento de carne, mais expressivo nos machos, pode ser explicado pelo crescimento alométrico positivo de seus quelípodos logo após a muda da puberdade, quando esta estrutura cresce proporcionalmente mais do que o próprio corpo, representando 40% do peso úmido total neste gênero.

Palavras chave: biometria; caranguejo; extração de carne; morfologia; recurso pesqueiro; reprodução

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INTRODUCTION

Ucides cordatus (Linnaeus, 1763) is a brachyuran crab species very common and endemic in Brazilian mangroves, where it is known as 'uçá'-crab. This species reaches maturity with a cephalothoracic width of 60 mm (PINHEIRO and FISCARELLI, 2001) and a maximum size of 96 mm (IBAMA, 2011), occupying the second place among edible crabs in Brazilian mangroves (OLIVEIRA, 1946), just after the *Cardisoma guanhumi* (Latreille, 1825), popularly called 'guaiamú'.

It is important to highlight that the *Ucides* gender consists of only two species, with *U. cordatus* occurrence registered in Atlantic Occidental (Florida, U.S.A. to the city of Laguna, SC, Brazil) (MELO, 1996) and *U. occidentalis* in Pacific Oriental (PEÑA *et al.*, 1994). *Ucides cordatus* has a relevant ecological role in mangrove areas due to its sediment bioturbation action (RODRIGUES *et al.*, 2000; AMOUROUX and TAVARES, 2005), litter fragmentation and nutrient recycling to mangrove sediment (WOLFF *et al.*, 2000; CANNICI *et al.*, 2008; CHRISTOFOLETTI *et al.*, 2013). According to PINHEIRO and FISCARELLI (2001) the reproduction of this species is seasonal, occurring only in some months of the year when females have mature gonads or eggs attached in to their abdominal appendages.

'Uçá'-crab is one of the main fishery mangrove products, providing income and food to the traditional coastal communities (OSTRENSKY *et al.*, 1995; HATTORI and PINHEIRO, 2003; BARBOZA *et al.*, 2008). In Brazil the capture of this species is regulated by Brazilian laws to protect wild stocks of the North-Northeastern (IBAMA, 2003a) and South-Southeastern (IBAMA, 2003b). The meat industrialization of this crustacean is still underdeveloped, making it difficult to achieve international standards of quality, mainly by the high quantity of residues of the exoskeleton, endophragmal invaginations (apodemes) or hemolymph in end products (OGAWA *et al.*, 2008). Brachyuran's meat is not usually processed, but supplied fresh (HATTORI *et al.*, 2006), being subjected to the proliferation of harmful health agents (VIEIRA *et al.*, 2004; GRISI and GORLACH-LIRA, 2005), which can bring

alterations to its flavor, texture and smell (CIFUENTES and QUIÑINAO, 2000), based on the type of storage. In spite of the 'uçá'-crab meat being traded frozen in some shops specialized in fishes (OGAWA *et al.*, 2008), it still prevails the primitivism in its commercialization and difficult meat extraction techniques (OSTRENSKY *et al.*, 1995; HATTORI *et al.*, 2006; MARTINS, 2009).

Despite the economic importance of some crustacean decapods (e.g., lobsters, shrimps, prawns, crayfishes and crabs), a wide review from 50 years (1963-2013) reveals few meat yield articles available in the literature. A predominance of these studies is centered in Brachyura (76.5%), mainly in Portunidae (CHINNAMMA *et al.*, 1986; SUMPTON, 1990; MATHAI and DEVI, 1993; HATTORI *et al.*, 2006; WU *et al.*, 2010; D'ACHIARDI-NAVAS and ALVAREZ-LEON, 2012), and significantly less in Cancridae (BARRENTO *et al.*, 2009a,b, 2010), Geryonidae (CIFUENTES and QUIÑINAO, 2000), Menippidae (OSHIRO *et al.*, 1999), Varunidae (SHAO *et al.*, 2014) and Ucididae (OGAWA *et al.*, 2008). The other 23.5% remaining articles about meat yield in crustaceans occur with Astacidae species (HARLIOĞLU, 1999; HARLIOĞLU and HOLDICH, 2001; HARLIOĞLU and GÜNER, 2006; BERBER and BALIK, 2009). Some articles about crustacean meat yield (e.g., CHERIF *et al.*, 2008; MARQUES *et al.*, 2010) featured themes addressing chemical composition. In Brazil the articles about meat yield in crustacean are so few (OSHIRO *et al.*, 1999; HATTORI *et al.*, 2006; OGAWA *et al.*, 2008). A smaller number of studies were focused in meat yield differences between sexes, size classes or capture periods (LOBÃO *et al.*, 1984, 1988; OSHIRO *et al.*, 1999; WOLL *et al.*, 2006). However, the biometric evaluation of species with economic potential has enabled the estimation of meat yield based on the animal size (or weight), an important information necessary to develop the meat production and extractive process (OSTRENSKY *et al.*, 1995; HATTORI *et al.*, 2006).

Considering that meat yield is the proportional weight of the animal to be consumed (OSHIRO *et al.*, 1999), determining size and capture period would permit a better optimization of the resource and offer a superior quality of product. Such innovations can also aid to preserve

species compromised by overfishing, assuring their sustainable use and identifying areas with higher extractive potential.

The present study aims to determine the meat yield for *U. cordatus*, considering its body parts (chelipeds, pereopods and cephalothorax), based on intersexual differences, as well as in function of reproductive and non-reproductive periods.

MATERIAL AND METHODS

Raw-material

Specimens of *U. cordatus* were captured in the 'Canaanéia-Iguape-Peruíbe' Estuarine Lagoon Complex (APA-CIP), in a mangrove island close to 'Icapara' Bar (24°41'25"S - 47°27'48"W), near Iguape municipality, south coast of the State of São Paulo, Brazil. The capture was carried out manually ('braceamento') or by traps ('lacinho') - see definitions at PINHEIRO and FISCARELLI (2001) - during two biological periods of the species' annual cycle, as it follows: 1) reproductive period (from October 2003 to March 2004), when an increase of individuals with mature gonads or ovigerous are registered; and 2) non-reproductive period (from April to September 2003), also known as 'fattening period', when the individuals stock energy as glycogen in their hepatopancreas (PINHEIRO and FISCARELLI, 2001). Whichever the period, the captured individuals were identified by inspecting the diagnostic characteristics (MELO, 1996), individualized in plastic bags to avoid loss of appendices and maintained frozen until their laboratory processing. Only intermolt specimens (see PINHEIRO and FISCARELLI, 2001) were used in meat yield analysis, discarding those with absence of pereopods or any other morphological damage. Thus, 128 individuals were used, 39.1% of them captured during the reproductive period (n = 50; 22 males and 28 females) and 60.9% from non-reproductive period (n = 78; 41 males and 37 females).

Biometry and crab processing

Each crab was sexed according to abdominal morphology and number of pleopods (PINHEIRO and FISCARELLI, 2001), grouped by biological period (R, reproductive; and NR, non-reproductive) and submitted for biometry with a

precision caliper (0.05 mm), for measuring their body size. In brachyuran crabs the carapace width (CW) is the biometric variable most used to represent the body size, and due to absence of lateral spines in *U. cordatus* this measure was established as the maximum width of cephalothorax.

Each specimen had its wet weight (WW) recorded in a digital precision scale (0.01 g), submitted to manual cephalothorax removal and extraction of viscera (digestive system, gonads, hepatopancreas and gills) by a surgical suction pump (ACME® Bio-Junior). Afterwards, the abdomen and mouthparts (maxillipeds, maxillas, maxillules and mandibles) were also removed, added to viscera and named as 'residues' (RE), in this study. The end product of each crab processing ('carcasses') was individually cooked in 500 mL of distilled water until boiling point for 20 minutes. Subsequently, each carcass was dismembered with separation of the two chelipeds and other pereopods, by cutting the coxal joint with scissors, separating these locomotion appendages from the cephalothorax. Three main body parts resulted of the crab processing: 1) chelipeds (RC, right; LC, left; and both chelipeds, TC = RC + LC); 2) pereopods (PE, eight complementary locomotion appendages constituted by 2nd to 5th pairs; and total pereopods, TP = PE + TC); and 3) cephalothorax (CE). Each one of these structures was weighed before the meat extraction. Immediately after this procedure, each structure had its meat removed using a hammer and PVC cutting board, with meat removal aided by tweezers and a sharp probe made of stainless steel.

Meat yield evaluation

Each meat portion by body structure had its weight recorded and added to calculate the overall meat yield by applying the following formula:

$$Y = (MW/WW) \times 100,$$

where: Y, meat yield in each body structure or region; MW, meat weight extracted from each body structure or region; and WW, total wet weight of the body structure or whole animal. The meat yield equation was determined for each sex based on two biometric relations: MWxWW

(MW, wet meat weight; WW, total wet weight) and MW×CW (MW, previously cited; CW, cephalothoracic width). The empirical points for each biometric relation were submitted to simple linear regression ($y = bx+a$) and their fitting evaluated with the coefficient of determination (r^2).

The statistical analyses were conducted using 'R' Version 2.5.0 (IHAKA and GENTLEMAN, 1996). These analyses began with a previous submission of each variable to a normality test (Shapiro-Wilk). Data with significant normal distribution were compared by ANOVA, otherwise Kruskal-Wallis was used to compare the medians (SOKAL and ROHLF, 2003), considering a statistical significance level of 5 %. The confirmation of the data's normal distribution indicates an application of the parametric test (ANOVA, F test) in a completely randomized design with different number of repetitions, with three factors (two sexes *vs.* two biological periods *vs.* six corporeal structures) or two factors (two sexes *vs.* two biological periods).

RESULTS

Biometry and weight proportion by parts

Ucides cordatus specimens used in the biometric analyses had cephalothoracic width (CW) varying from 60.0 to 83.4 mm (69.9 ± 5.1 mm), without a significant size difference between biological periods ($F = 3.56$; $p > 0.05$) the same occurring between the sexes, independently of these periods ($F = 1.89$; $p > 0.05$).

The wet weight of the isolated body parts was always bigger in males (Table 1), regardless of the biological period (reproductive, $F = 167.6$; and non-reproductive, $F = 212.3$; $p < 0.01$). Wet weight mean for the total of specimens was 149.1 ± 31.1 g (97.7 to 237.3 g), being greater during the reproductive period ($F = 9.16$; $p < 0.01$) and for males ($F = 19.59$; $p < 0.01$). Means of PE and CE do not differ statistically when sexes or biologic periods were compared ($p > 0.05$), but the total weight mean of all pereopods (PT) corresponding to twice of the cephalothoracic weight mean (CE).

Table 1. *Ucides cordatus* (Linnaeus, 1763) – Wet weight (in grams) for each corporal structure (RC, right cheliped; LC, left cheliped; TC = RC + LC; PE, 2nd-5th pair of pereopods; PET = TC + PE; and CE = cephalothorax), to each sex during (R) reproductive season (n = 50) and (NR) non-reproductive season (n = 78), and the results of ANOVA and contrast by Tukey test. Min, minimum value; Max, maximum value; x, mean value; and sd, standard deviation).

Corporal Structure	Males			Females					
	Min	Max	x ± sd	Min	Max	x ± sd			
R	RC	5.8	42.9	19.3 ± 10.9	Ba ⁽¹⁾	4.8	22.5	11.9 ± 5.5	Aa
	LC	7.2	48.9	23.4 ± 13.1	Ba	3.7	19.8	10.7 ± 4.6	Aa
	TC	20.6	65.5	42.4 ± 12.8	Bb	11.8	30.9	22.5 ± 4.3	Ab
	PE	28.4	58.9	40.9 ± 9.5	Bb	21.6	41.6	30.9 ± 4.8	Ac
	PET	50.8	113.9	83.3 ± 20.1	Bc	38.8	71.6	53.5 ± 8.5	Ad
	CE	20.7	51.2	35.8 ± 9.4	Bb	20.7	39.9	28.7 ± 5.2	Ac
NR	RC	5.9	44.6	17.6 ± 10.9	Ba	5.7	23.2	12.0 ± 5.2	Aa
	LC	6.6	38.1	19.9 ± 8.8	Ba	4.2	23.1	11.0 ± 5.8	Aa
	TC	20.5	58.7	37.5 ± 8.6	Bb	13.9	30.9	23.0 ± 4.4	Ab
	PE	24.2	50.5	35.6 ± 7.1	Bb	16.4	36.4	26.1 ± 5.0	Abc
	PET	48.0	109.2	73.1 ± 14.9	Bc	36.4	63.7	49.1 ± 8.1	Ad
	CE	22.3	52.3	33.7 ± 7.5	Bb	21.5	38.8	29.5 ± 4.6	Ac

⁽¹⁾ Means of a same sex and biological period followed by an equal lowercase letter were not statistically different ($p > 0.05$), the same occurring when the means in a same corporal structure and biological period followed by an equal uppercase letter.

Mean weight of the right cheliped (RC) did not differ significantly from the mean weight of the left cheliped (LC), independently of sex or

biological period ($p > 0.05$), the same occurred for the weight of both chelipeds (TC). The order of importance of wet weight for each body structure

to *U. cordatus* regarding the individual total wet weight for each sex by biological period, is as it follows:

Reproductive

Males: TP > (TC = PE) > CE > (RC = LC)
(F = 313.2; $p < 0.01$)

Females: TP > (PE = CE) > TC > (RC = LC)
(F = 270.8; $p < 0.01$)

Non-reproductive

Males: TP > (TC = PE = CE) > (RC = LC)
(F = 570.9; $p < 0.01$)

Females: TP > CE > PE > TC > (RC = LC)
(F = 573.6; $p < 0.01$)

For males the proportions of wet weight per body structure did not differ between biological periods (F = 0.19; $p > 0.05$), while for females a contrast between proportions was

observed on cephalothorax (CE) (F = 20.10; $p < 0.01$) and residues (RE), which were greater during the non-reproductive period (F = 60.44; $p < 0.01$) (Figure 1). However, when the eggs were added to the residues in the reproductive period (45%), this proportion was significantly increased when confronted to the non-reproductive one (41%) (F = 42.7; $p < 0.01$).

Meat yield

The general meat yield for *U. cordatus* varied from 15 to 30.8% ($23.2 \pm 0.14\%$). The meat yield mean in males was $25.4 \pm 2.6\%$ (20.6 to 30.8%), greater and significantly different than $21.1 \pm 2.1\%$ (15 to 25.8%) that was recorded for females (F = 88.4; $p < 0.01$). The same occurred when the meat yield was compared between the sexes in biological periods (Table 2), with the biggest mean of meat yield verified for males in the reproductive period ($26.7 \pm 2.9\%$; F = 8.8; $p < 0.01$).

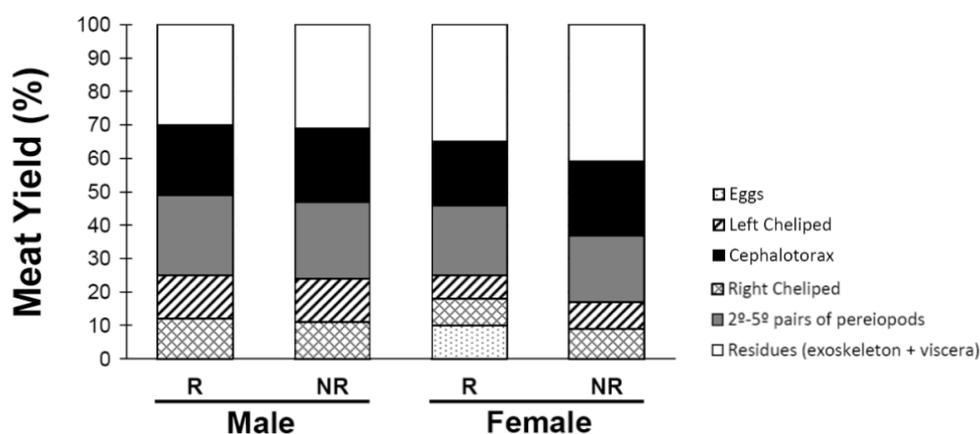


Figure 1. *Ucides cordatus* (Linnaeus, 1763) – Meat yield (%) by body structures, proportion of residues (and eggs) by sex biological period (R, reproductive; and NR, non-reproductive).

Table 2. *Ucides cordatus* (Linnaeus, 1763) – Meat yield (%) of each sex and total of specimens in relation to biological period (R, reproductive; NR, non-reproductive), and the results of mean contrast using ANOVA by Tukey test. N, number of specimens; Min, minimum value; Max, maximum value; x, mean value; and sd, standard deviation).

Biologic Season	Sex	N	Min	Max	x ± sd
R	Male	16	20.6	30.1	26.7 ± 2.9 c ⁽¹⁾
	Female	24	15.0	25.8	20.6 ± 2.1 a
	Total	40	15.0	30.1	23.1 ± 3.9
NR	Male	38	21.0	30.8	24.8 ± 2.3 b
	Female	30	17.9	25.1	21.5 ± 2.1 a
	Total	68	17.9	30.8	23.3 ± 2.8

⁽¹⁾ Means followed by the same lower case do not differ statistically ($p > 0.05$).

During the reproductive period the meat yield for males of *U. cordatus* was greater than females, independently of the analyzed body part ($F = 29.6$; $p < 0.01$), the same occurred in the non-reproductive period, except for right cheliped (RC) and cephalothorax (CE) meat yields, which did not contrast between the sexes ($F_{RC} = 1.5$; $F_{CE} = 0.03$; $p > 0.05$). Chelipeds' meat yield did not contrast with handedness, with similarity between the meat yield means of RC and LC, independent of sex or biologic period analyzed ($p > 0.05$). For males, it was also verified that the meat yield of both chelipeds (TC) was similar ($p > 0.05$) to the eight pereopods (PE) summed ($p > 0.05$), differing from females in these structures, where $PE > TC$ ($p < 0.05$). The hierarchical order of the meat yield to each body structure in *U. cordatus* in function of sex and biological period, is as it follows:

Reproductive

Males: $TP > (CE = TC = PE) > (RC = LC)$
($F = 4168.3$; $p < 0.01$)

Females: $TP > (CE = PE) > TC > (RC = LC)$
($F = 5268.4$; $p < 0.01$)

Non-reproductive

Males: $TP > CE > (PE = TC) > (RC = LC)$
($F = 8745.0$; $p < 0.01$)

Females: $TP > CE > PE > TC > (RC = LC)$
($F = 9981.9$; $p < 0.01$)

The equations expressing the weight of the meat yield of the *U. cordatus*, based on the total wet weight (WW), can be found in the relations MW / WW (Figure 2 and Table 3).

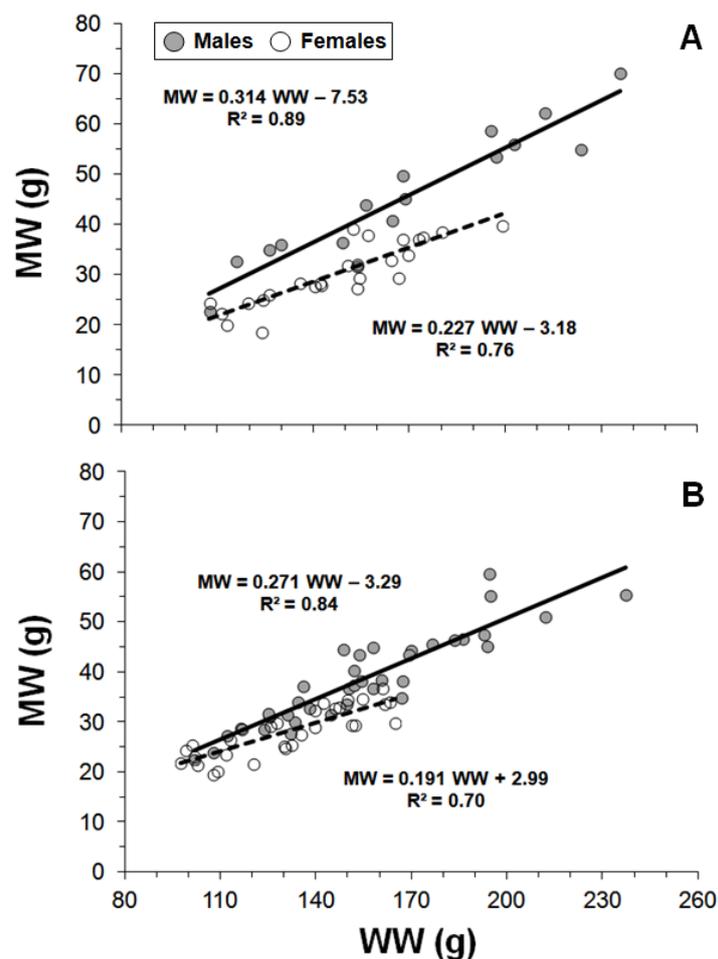


Figure 2. *Ucidés cordatus* (Linnaeus, 1763) – Wet meat weight (MW, in grams) by total wet width (WW, in grams) to each sex by biological period (A, reproductive; and B, non-reproductive).

Table 3. *Ucides cordatus* (Linnaeus, 1763) – Equations of meat yield by sex and total of specimens, based on the relation involving meat wet weight (MW, in grams) by total wet weight (TW, in grams) during biological periods (R, reproductive; NR, non-reproductive). N, total number of specimens analyzed; R², determination coefficient; F, Snedecor test. All equations were statistically significant ($p < 0.01$).

Biological period	Sex	N	Linear equation ($y = bx + a$)	R ²	F
R	Male	16	MW = - 7.53 TW + 0.314	0.89	112.21
	Female	25	MW = - 3.18 TW + 0.227	0.76	73.90
	Total	41	MW = - 14.9 TW + 0.328	0.77	130.41
NR	Male	38	MW = - 3.29 TW + 0.271	0.84	182.28
	Female	30	MW = 2.99 TW + 0.191	0.70	66.81
	Total	68	MW = - 6.53 TW + 0.280	0.81	274.74
TOTAL	Male	55	MW = - 6.42 TW + 0.296	0.85	304.41
	Female	54	MW = 1.29 TW + 0.201	0.73	146.53
	Total	109	MW = - 9.33 TW + 0.296	0.78	385.51

Regardless of the time of capture, males had higher meat yield than females ($p < 0.05$), indicating a more significant income during the reproductive season. The graphical analysis involving the biometric relation MWx CW (Figure

3 and Table 4) indicates a reduction of meat yield in function of sex (greater in males) and within it a superior value during the reproductive period, as it follows: Males R > Males NR > Females R > Females NR (Figure 4).

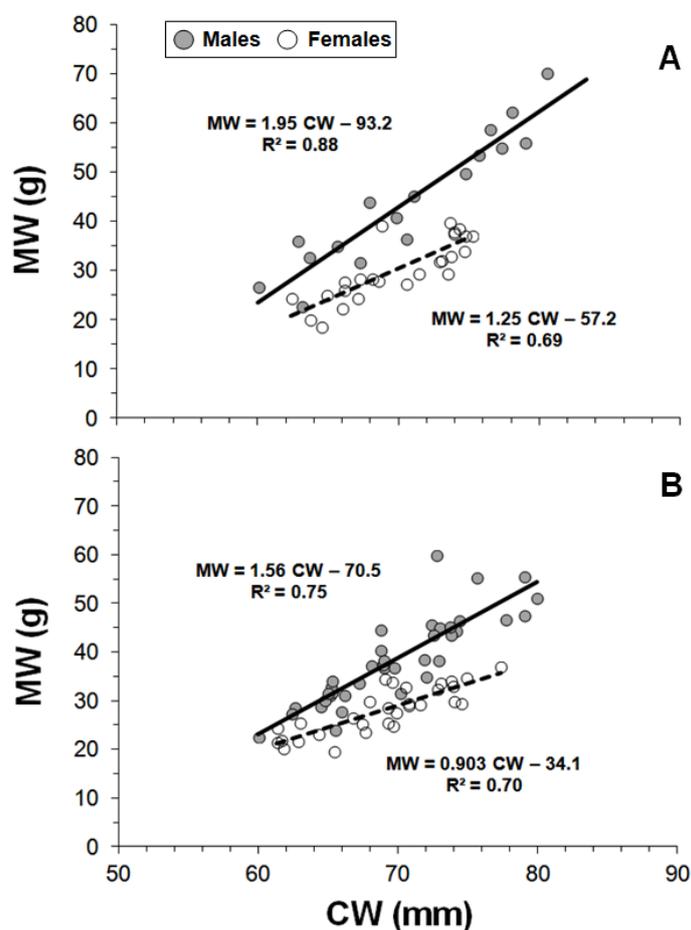


Figure 3. *Ucides cordatus* (Linnaeus, 1763) – Wet meat weight (MW, in grams) by cephalothoracic width (CW, in millimeters) to each sex by biological period (A, reproductive; and B, non-reproductive).

Table 4. *Ucides cordatus* (Linnaeus, 1763) – Equations of meat yield by sex and total of specimens, based on the relation involving meat wet weight (MW, in grams) by cephalothoracic width (CW, in mm) during biological periods (R, reproductive; NR, non-reproductive). N, total number of specimens analyzed; R², determination coefficient; F, Snedecor test. All equations were statistically significant ($p < 0.01$).

Biological period	Sex	N	Linear equation ($y = bx + a$)	R ²	F
R	Male	17	MW = - 93.2 CW + 1.95	0.88	114.37
	Female	25	MW = - 57.2 CW + 1.25	0.69	50.66
	Total	42	MW = - 89.3 CW + 1.78	0.59	58.44
NR	Male	38	MW = - 70.5 CW + 1.56	0.75	109.24
	Female	30	MW = - 34.1 CW + 0.903	0.70	66.89
	Total	68	MW = - 62.9 CW + 1.39	0.54	78.93
TOTAL	Male	55	MW = - 82.5 CW + 1.75	0.79	154.09
	Female	55	MW = - 44.5 CW + 1.061	0.68	112.48
	Total	110	MW = - 74.2 CW + 1.57	0.56	140.11

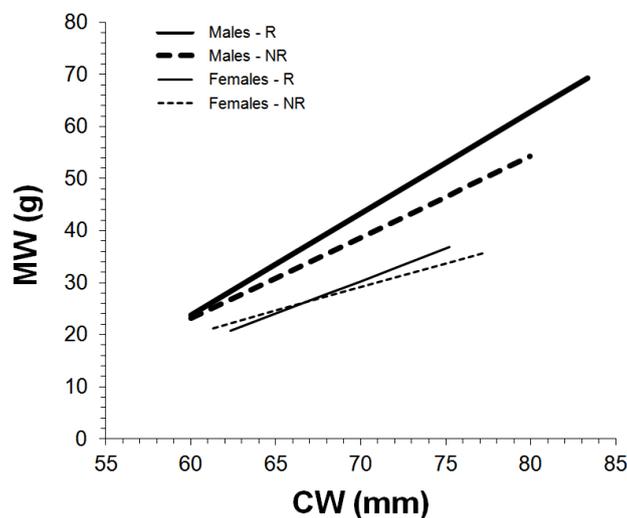


Figure 4. *Ucides cordatus* (Linnaeus, 1763) – Equations of wet meat weight (MW, in grams) in relation to cephalothoracic width (CW, in millimeters), by sex and each biological period (R, reproductive; NR, non-reproductive).

DISCUSSION

Meat yield in decapod crustaceans can be influenced by sex (BARRENTO *et al.*, 2010), size/phase of development (LALRINSANGA *et al.*, 2014) and seasonally (BARRENTO *et al.*, 2009), as a different action of reproduction and growth processes which are antagonistic in these animals (NAGARAJU, 2011; SWETHA *et al.*, 2011). The management of this processes are mainly generated by exogenous factors (*e.g.*, temperature and photoperiod – see PAYEN 1980-81) that when elevated promote an energy direction from storage organ (hepatopancreas) to

gonadal development. Therefore, during crustaceans' reproduction the growth ceases, occurring in females a more intense energetic use to vitellogenesis and a higher values of the gonadosomatic index (GSI) when compared with that from males (WU *et al.*, 2010; BARRENTO *et al.*, 2010). This fact occurs due to reduced development time of the testicles and duration of spermatogenesis process (MOTALVES, 1975). Parental care is other reproductive aspect with energetic cost in brachyuran crustaceans (FERNÁNDEZ *et al.*, 2000; HARTNOLL, 2006) intensifying the difference between sexes and generating a higher effect in

females, despite *U. cordatus* presenting a seasonal reproduction with ovigerous occurrence once a year from November to May (PINHEIRO and FISCARELLI, 2001; IBAMA, 2011). These factors contribute to an expressive alteration in the amount of meat generated in intersexual comparison, with an overall wet weight of males tending to be larger than females in a same comparative size, especially when greater than 60 mm CW (PINHEIRO and FISCARELLI, 2009), and the same occurring with isolated body parts of *U. cordatus*. PINHEIRO and FISCARELLI (2001) reported in Southeastern Brazil to *U. cordatus* a size at onset maturity greater than 51.3 mm CW (males) and 39.1 mm CW (females), with a characteristic variation from 44-61 mm CW (51.7 ± 5.3 mm) and 38.6-57.4 mm CW (46.7 ± 5.7 mm), respectively, considering the distinct Brazilian geographic locations and taken into account in Brazilian laws (IBAMA, 2003a,b).

For *U. cordatus* females the reproduction was the main explanatory factor for the variation of meat yield, while in males the growth was the process responsible for the variation. This fact can be explained by a pronounced growth of the cheliped (positive allometry) when compared with corporeal size (CW) an event registered after puberty molt (51 mm CW) contrasting with a coincident but reduced positive allometric growth in females (DALABONA *et al.*, 2005; PINHEIRO and HATTORI, 2006). Such strategy aims to amplify the size difference between sexes for this species, which could favor sexual recognition and couple formation by visual stimuli, considered priority aspects in mating of semi terrestrial brachyuran crabs by HARTNOLL (1969). Greater males of many decapod crustaceans (including crabs) take reproductive advantage when compared to smaller males due to their larger chelipeds widely used in partner selection or intraspecific confrontations (ELNER and BENINGER, 1995; PINHEIRO and FRANSOZO, 1999). This fact explains why the capture of this fishery resource is targeted to males in North and Northeast Brazilian regions (MACHADO, 2007; CAVALCANTE *et al.*, 2011), which is a crucial issue for retailers and restaurant managers, who value mainly crabs with bigger size and chelipeds. This fact differ to other crustacean groups where meat is associated to abdominal somites (e.g., shrimps, prawns, lobsters and crayfishes).

Meat yield data obtained to *U. cordatus* (total: 23.2%; males: 25.4%; females: 21.1%) are included in the variation of 18 to 32% that was indicated in a review by HATTORI *et al.* (2006) for other brachyuran crabs previously studied: 18% (*Cardisoma guanhumi*) and 21.5-22.2% (*Menippe nodifrons*) by OSHIRO *et al.* (1999); 25.1% (*Chaceon chilensis*) by CIFUENTES and QUININAO (2000); 14.6-15.1% (*Scylla serrata*) by CHIOU and HUANG (2003); 23.5-27.8% (*Carcinus maenas*) by NACZK *et al.* (2004); 22.1-28.5% (*Callinectes bocourti*) by HATTORI *et al.* (2006); and 32% (*Portunus pelagicus*) by WU *et al.* (2010). OGAWA *et al.* (1973) reported slightly lower meat yield values for *U. cordatus* when compared with present study (total: 21.2%; males: 22.6%; females: 20.9%), revealing differences between 0.2 to 2.8%. According to these authors the lowest meat yield values to this species were detected for cephalothorax (7.8% *vs.* 9.1% in present study) while for pereopods (PE + TC) the values were very similar (13.4% *vs.* 13.9%, respectively). Therefore it is relevant to clarify that meat yield values can differ among authors working with a same species, in function to endogenous sources of variation and others related to distinct procedures during the extractive method. As an example, dexterity during meat extraction is easier in the chelipeds than in the cephalothorax, this latter structure characterized by thoracomers' chambers where the musculature is separated by endophragmal exoskeleton, composed by thin and easily breakable septa, which makes the meat extraction a slow process. This fact was confirmed for *U. cordatus* when meat yield obtained by machine was compared to manual extraction (artisanal) by OGAWA *et al.* (2008), verifying an increase of 6.2-7.1% with machine use. Artisanal meat extraction is a slow and careful process (HATTORI *et al.*, 2006) implying more time spent and reduction of sanitary quality, requiring special caution during all process. Reviewing the literature it is possible to demonstrate an increase in the number of patents applied with the purpose of optimizing meat extraction in crustaceans that can reduce the extraction time, as well as the operational and final cost of this product.

During meat extraction procedures an expressive percentual (30-40%) of the wet weight of *U. cordatus* specimens were residues, represented by hepatopancreal and gonadal tissues, both of

them with high protein and lipid contents (VIJAYAVEL and BALASUBRAMANIAN, 2006) and hard tissues, composed by endophragmal exoskeleton, mouthparts and abdomen, very calcified and rich in chitin (BOßELMANN *et al.*, 2007; COSTA *et al.*, 2012). These secondary products of the meat extraction could be used as sources of mineral nutrients in supplemental rations for animals (ASSIS and BRITTO, 2008), as pesticide and fertilizer in agriculture (BENCHIMOL *et al.*, 2006) and synthesis of other pharmaceutical products (CAMPANA-FILHO *et al.*, 2007). Eggs are included among residuals of meat extraction in crustaceans and ovigerous of *U. cordatus* had the eggs' wet weight mean equivalent to the wet weight from one of their chelipeds, with values closer than 10% (HINES, 1988) and similar in the portunid *Arenaeus cribrarius* (13.2%) by PINHEIRO and TERCEIRO (2000) and in the ucidid *U. cordatus* (8.7%) according to PINHEIRO *et al.* (2003). Actually, crab eggs at initial embryonic development can be used as 'caviar' in international cuisine, with remarkable yield expressed by specific equations available in fecundity studies as previously described to *U. cordatus* by PINHEIRO *et al.* (2003).

Only with the development of industrial procedures, comprising techniques of crushing, brine flotation and meat compacting, as done with other crabs and crustaceans, it would be possible to reduce the operational costs of a handicraft work. However, in Brazil crabmeat picking is one of the most traditional activities connected to fishery with an elevated socioeconomic importance in many regions (HATTORI *et al.*, 2006; MACHADO, 2007; MONTEIRO *et al.*, 2014). The industrialization of the crab meat extraction can optimize processes but promote social problems if implemented in some Brazilian regions as North and Northeast. In fact, the fishery of *U. cordatus* has a cast of problems to be resolved (CAVALCANTE *et al.*, 2011; IBAMA, 2011) among of them a common clandestine capture (using unauthorized traps, like 'redinha'), deficient handling / lack of any sanitary procedures (MARTINS, 2009), a fifty percent mortality caused during road transport (LEGAT *et al.*, 2006) and inefficient natural stock of this product.

CONCLUSIONS

Meat yield in males of *U. cordatus* (25.4%) was higher than females (21.1%) due to differential growth of the chelipeds in the former, both corresponding to 40% of the total wet weight in this gender. A similar hierarchy among corporal structures was verified in a sexual comparison, the same when reproductive and non-reproductive periods were compared. Reproductive period was characterized by larger males and bigger meat yield in comparison to males of non-reproductive period, while this fact was not confirmed in females independently of their biological period. Somatic growth and reproductive processes are confirmed as the main sources of meat yield explanation in males and females of brachyuran crabs, respectively.

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