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Nota Científica

Meat yield of *Callinectes bocourti* A. Milne Edwards, 1879 (Crustacea, Portunidae) in Iguape, São Paulo, Brazil*

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ABSTRACT. The objective of the present study was to analyze the meat yield for both sexes of the crab *Callinectes bocourti* in the region of Iguape, Brazil. The carapace width for males was 78.1-114.0 mm (96.7 ± 9.5 mm) and for females 76.0-106.3 mm (93.0 ± 7.8 mm). In males, the total wet weight ranged from 65.53 to 224.36 g (134.04 ± 40.77 g) and for females from 56.66 to 164.74 g (105.93 ± 26.88 g). A comparison of morphological structures revealed that the greatest meat yield was in the carapace (55.1%), followed by the right chela (16.9%), the left chela (15.9%), and the legs (12.1%). The total yield from the males (28.5%) was slightly higher than that from the females (22.1%). In general, portunids yield more meat than other crab species. The results of this study will allow the optimization of meat production for this crab species. Manual meat removal makes the process more expensive. This activity could offer an alternative to the fishing communities that live exclusively from this fishery resource.

Key words: crab meat, meat yield, Brachyura, Portunidae, *Callinectes*, Brazil.

Rendimiento de la carne de *Callinectes bocourti* A. Milne Edwards, 1879 (Crustacea, Portunidae), en Iguape São Paulo, Brasil*

RESUMEN. El objetivo del presente estudio fue analizar el rendimiento de la carne del cangrejo *Callinectes bocourti* en ambos sexos en la región de Iguape, Brasil. Los machos presentaron un ancho de carapazón entre 78,1 y 114,0 mm (96,7 ± 9,5 mm) y las hembras 76,0 a 106,3 mm (93,8 ± 7,8 mm). El peso húmedo total de los machos varió de 65,53 a 224,36 g (134,04 ± 40,77 g) y entre 56,66 y 164,74 g (105,93 ± 26,88 g) en las hembras. Comparando las estructuras morfológicas, se encontró que el mayor rendimiento de carne estuvo en el carapazón (55,1%), seguido de la pinza derecha (16,9%), izquierda (15,9%) y patas (12,1%). En los machos el rendimiento total fue 28,5%, levemente superior al de las hembras (22,1%). Los portúnidos generalmente presentaron mayor rendimiento de carne al compararlo con otras especies de cangrejos. Los resultados de este estudio permiten optimizar la producción de carne en esta especie de cangrejo. La remoción de la carne es una actividad manual, lo que encarece este proceso. Esta actividad puede ser considerada una alternativa para las comunidades pesqueras que viven exclusivamente de ese recurso pesquero.

Palabras clave: carne de cangrejo, rendimiento de carne, Brachyura, Portunidae, *Callinectes*, Brasil.

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The swimming crabs of the genus *Callinectes* are distributed along the American coasts (Melo, 1996) and represent a considerable part of the benthonic estuarine fauna (Severino-Rodrigues *et al*., 2001).

Crab meat removal is an intensive activity in many countries such as Vietnam, China, the USA, Japan, and Canada (FAO-Eastfish Project, 1996). According to this report, Brazil occupies the 9th place in commercialization of crab meat; this is a good position considering that crab meat is not processed commercially and does not meet quality standards for exportation.

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Most commercially important brachyuran species belong to the Family Portunidae (genus *Callinectes* and *Portunus*); the genera *Cancer* (Family Cancridae) and *Chionoecetes* (Family Majidae) are more exploited in the USA and Canada. In Brazil, some brachyuran species have been used as seafood given the large size of the adult phase: e.g., rocky shore crabs *Menippe nodifrons* (Oshiro *et al*., 1999), mangrove crabs *Cardisoma guanhumi* (Oliveira, 1949), and *Ucides cordatus* (Ogawa *et al.,* 1973).

The blue crab *Callinectes sapidus* is an important shell fishery product (Gangar *et al*., 1996) and its meat is used as the main seafood in a lot of restaurants around the world. The commercialization of crab meat was a lucrative fishery activity, with incomes of US$ 31.6 million in the USA in 1994; this figure only considers commercial frozen crab meat (FAO-Eastfish Project, 1996).

Blue crab meat usually fetches good prices on the market due to its high nutritional value and irregular supply (Çelik *et al*., 2004). According to Skonberg & Perkins (2002), this crab meat has a large range of polyunsaturated fatty acids (PUFAs) in its tissue. These authors also affirm an association between PUFA content and the reduction of coronary artery disease. Moreover, portunids are considered to be an ideal source of protein and are used as a good supplement in animal feed rations (Haefner, 1985).

Various blue crab products, including the soft shell crab, meat, and cocktail claws are consumed on US markets. In Brazil, information about blue crab products is lacking. Some Brazilian studies mention the meat yield for the mangrove crab *Ucides cordatus* (Ogawa *et al.,* 1973) and the rocky shore crab *Menippe nodifrons* (Oshiro *et al*., 1999). Research is currently underway to determine the feasibility of developing and marketing various crab products (Skonberg & Perkins, 2002), with an emphasis on meat production. The main problem in crab meat production is the process of meat removal. However, studies about meat yield in brachyurans are rare in the literature. This information could help develop a meat removal process and improve industrial-scale crab meat production.

Although brachyurans are abundant in many regions of Brazil, this resource has not been explored commercially (Fiscarelli, 2004). Regular crab meat consumption was not common in Brazil, but began in the coastal region, associated with tourist sites.

The present study analyzed the *C. bocourti* meat yield, considering all morphological structures (body, claws, legs) commonly used for human consumption. These results may help improve the meat removal process, optimizing meat production.

All specimens were acquired from a fishery market in Iguape, São Paulo, Brazil. The swimming crab was transported live to the laboratory. The brachyurans were identified using the morphological characteristics described by Melo (1996). Each crab was individually measured for carapace width (CW) using a vernier caliper (0.05 mm). The specimens were weighed using a scale (0.01 g) and the following biometric structures were recorded: total wet weigh (WW); right chela (RC), left chela (LC); pereiopods (2^o to 5^o pair) (PE); and carapace weight (CA) (without the viscera).

The crabs were cooked in a recipient with 1 L of water at 100°C for 20 min. The claws, legs, and body meat were removed manually using hammer and nippers. After this, all the meat that was extracted was weighed for yield analyses. The yield was registered individually and calculated using the equation $Y = M/WW \cdot 100$ (where Y = yield, M = removed meat weight, WW = total wet weight). The total meat removed (TM) was recorded for each crab and calculated by adding the total meat yield from all the morphological structures. The total meat removed was related to the crab size (CW) using a regression analysis ($Y = a \cdot x^b$) verified by the determination coefficient (R^2) to verify the relationship between the meat yield and crab size.

The average meat yield by sex was submitted to a one-way ANOVA. A Student-Newman-Keuls test routine was used to compare the average values for total and morphological structure yields, with a significance of $p < 0.01$.

A total of 73 swimming crabs of *Callinectes bocourti* were used (37 males, 36 females). Male sizes ranged from 78.1 to 114.0 mm (96.7 ± 9.5 mm) and females from 76.0 to 106.3 mm (93.0 ± 7.8 mm). For males, the total weight varied from 65.53 to 224.36 g (134.04 ± 40.77 g) and for females from 56.66 to 164.74 g (105.93 ± 26.88 g).

The total meat yield for males ranged from 23.44 to 34.22% (28.49 ± 2.32%); a similar pattern was reported for the total female meat yield, which ranged from 18.68 to 27.45% (22.08 ± 2.4%). The total meat yield for all individuals varied from 16.1 to 34.2% (23.4 ± 3.9%)

The meat yield by morphological structure is presented in Figure 1 and Table 1. For both sexes, the carapace meat yield was higher than for the other structures.

For both sexes, the relationship between the total meat removed (TM) and carapace width (CW) was recorded, as was total wet weigh (WW). All biometric relationships showed the best fit when using a power function verified by the determination coefficient (R^2) (Table 2).

The meat yield by morphological structures varies among brachyuran species. Crab meat was associated with the morphology of the body structure, particularly for brachyurans that feed on bivalves, as they have strong chelae adapted to opening shells (e.g., specimens from the genus *Cancer*) (Taylor *et al.*, 2000). Besides that, the process of removing the crab meat could influence the meat yield (Ogawa *et al.*, 1973).

The high meat yield in the *C. bocourti* carapace, when compared to another brachyurans (e.g., *Ucides cordatus* by Fiscarelli, 2004), could be explained by the morphology and size of thoracomeres, small cavities covering the muscle tissue inside the carapace. Large thoracomeres facilitate the meat removal process. Another positive characteristic of the carapace meat is its high amount of polyunsaturated fatty acids (PUFAs) as compared to claw meat and hepatopancreas (Çelik *et al.*, 2004).

The claw meat yield was entirely associated with each species' food habits. Some brachyuran species, principally those living on rocky shores and feeding mainly on bivalve mollusks (e.g., *Menippe nodifrons*, reported by Oshiro *et al.*, 1999), showed a large amount of muscle tissue in the chelae. Other deeper species such as *Chaceon chilensis* (Cifuentes

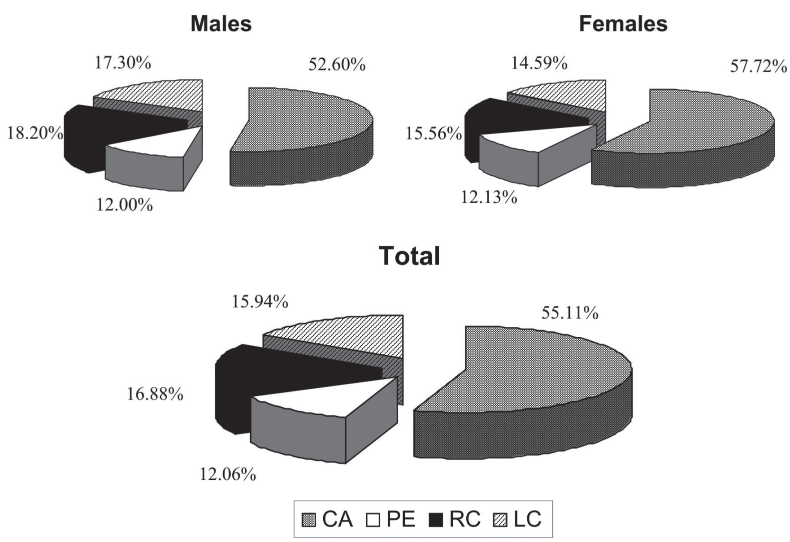

Figure 1. Total meat yield among sexes. CA: carapace, PE: pereiopods, RC: right chela, LC: left chela.

Figura 1. Rendimiento total entre los sexos. CA: carapazón, PE: patas, RC: pinza derecha, LC: pinza izquierda.

Table 1. Percentage meat yield for males and females.

Tabla 1. Porcentaje de rendimiento de la carne para machos y hembras.

Structure	Male		Female		F ($p < 0.01$)
	n		n		
Carapace	37	51.89 ± 5.67	36	45.05 ± 2.72	7.35*
Chela	37	37.91 ± 2.20	36	34.32 ± 2.86	8.52*
Pereiopods	37	28.10 ± 3.62	36	26.08 ± 2.72	3.80*
Total	37	28.49 ± 2.32	36	22.08 ± 2.91	17.70*

& Quiñinao, 2000) showed similar claw meat yield patterns due to chela morphology. For the genus *Callinectes*, the chelae were slight and not robust, as in *M. nodifrons*. This morphology could explain the low meat yield when compared to other body structures.

The pereiopod meat was not usually considered in the analyses (Oshiro *et al*., 1999). Because of its morphology, this body structure has little meat. The only exception was the spider crabs of the genus *Chionoecetes*, harvested in temperate regions; these were intensively exploited and a large part of the crab meat obtained from the chelae and pereiopods. The meat yield from *Chionoecetes* chelae and pereiopods was similar and has been sold as an individual packet on markets in the USA and Canada (FAO-Eastfish Project, 1996).

Recently, the exploitation of some portunid species, particularly highly abundant species, has been mentioned as an alternative source of income for people that live on crab harvesting. The portunid *Carcinus maenas* were considered an invasive species in Europe and have not previously been targeted by the crab-picking industry, primarily due to their small size and the difficulty of meat removal. However, the abundance of this swimming crab and their relatively easy capture make them a potential resource for a new capture fishery, especially related to meat production (Skonberg & Perkins, 2002). Portunids usually had better meat yield values than other brachyurans (Table 3). However, crab meat yields are influenced by many factors (Ulmer, 1964; Türeli *et al*., 2002).

The swimming crab *Callinectes bocourti* has

Table 2. Meat yield equations by sex and for all specimens. CW: carapace width, TM: total meat yield, WW: total wet weight.

Tabla 2. Ecuaciones del rendimiento de carne en cada sexo y en el total de ejemplares. CW: ancho del carapazón, TM: rendimiento de carne total, WW: peso húmedo total.

Categories	n	Relation	Equation Ln y = ln a+b·ln x	R^2	F ($p < 0.01$)
Males	37	CWxTM	lnTM = -12.21+3.45·lnCW	0.89	219.48
	37	WWxTM	lnTM = -1.79+1.11·lnCW	0.96	661.34
Females	36	CWxTM	lnTM = -8.52+2.63·lnCW	0.79	104.77
	36	WWxTM	lnTM = -0.97+0.88·lnWW	0.86	247.53
Total	73	CWxTM	lnTM = -12.43+3.49·lnCW	0.70	138.65
	73	WWxTM	lnTM = -2.14+1.16·lnWW	0.86	472.39

Table 3. Average values of meat yield for different crab species. TM: total meat yield, M: males, F: females.

Tabla 3. Valores medios de rendimiento de carne en diferentes especies de cangrejos. TM: rendimiento total, M: machos, F: hembras.

Family	Species	Author	TM (%)		
			M	F	Total
Portunidae	*Callinectes bocourti* A. Milne Edwards, 1879	Present study	28.5	22.1	23.4
	Portunus pelagicus (Linnaeus, 1758)	Brown (1986)	-	-	39.0
	Scylla serrata (Forskal, 1755)	Brown (1986)	-	-	29.0
	Charybdis natator (Herbst, 1794)	Sumpton (1990)	-	-	35.0
Menippidae	*Menippe nodifrons,* Stimpson, 1859	Oshiro *et al.* (1999)	22.2	21.0	-
Gecarcinidae	*Cardisoma guanhumi* Latreille, 1825	Oshiro *et al.* (1999)	18.0	21.5	-
	Cardisoma guanhumi Latreille, 1825	Taisson (1974)	22.2	21.5	-
Ocypodidae	*Ucides cordatus* (Linnaeus, 1763)	Ogawa *et al.* (1973)	22.6	20.9	21.2
	Ucides cordatus (Linnaeus, 1763)	Fiscarelli (2004)	25.4	21.1	23.2

been commercially exploited in Iguape due to its large size and abundance. According to Silva *et al.* (2005), a total of 18 tons of blue crab (*Callinectes* spp.) were fished in this Brazilian region from October to November 2004 (peak fishing period). However, there is little information about the biology of *C. bocourti*. This brachyuran species is odorous when alive, but its odor disappears after cooking and it can be consumed. Although this negative characteristic could affect the commercialization of the blue crab, people in Iguape buy the blue crab on fishery markets without restriction.

The main problem in crab meat commercialization is the process of meat removal. In Brazil, there are no established techniques for crab meat removal (Ogawa *et al*., 1973). The process is done manually and is considered to be the main cause of the high prices of crab (Fiscarelli, 2004). Ulmer (1964) verified that the swimming crab meat yield could vary by season and the meat removal process (e.g., machines or manual). Türeli *et al.* (2002) mentioned that the meat composition also varied by sex throughout the year.

A determination of the blue crab meat yield might provide meat producers with information that could improve the production. Meat should only be removed from the carapace, due to the large amount found there as compared with the other body structures (over 50% the total meat). The pereiopods and viscera should be used as sources of mineral nutrients in supplemental rations for animals (Haefner, 1985). The claws should be sold in separate packets on markets such as the USA and Canada. The claws packets could bring a high price due to improved meat quality. The shell resulting from the crab meat removal process (waste) can be used as a source of chitosan, as it contains values from 12.6 to 14.5% of chitin (Naczk *et al*., 2004).

The crab meat removal process might represent an alternative for fishermen to improve their livehood. This activity is socio-economically important, because processed crab meat has a higher value on the fishery market than a whole crab sold alive. Besides, processed (tinned and frozen) crab meat could extend the shelf-life (Henry *et al*., 1995). The production of *C. bocourti* meat could provide an alternative to improve the livehood of the people living from the harvest of swimming crabs, as is the case in Iguape, São Paulo, Brazil.

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