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First record of bilateral hypertrophy in chelas of *Uca rapax* male specimen (Crustacea, Decapoda, Ocypodidae) on the Brazilian coastline

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An adult male specimen of Uca rapax *(Crustacea, Decapoda, Ocypodidae), containing bilaterally hypertrophied chelipeds, was found in the mangrove area of the Rio Grande do Norte state, north-eastern Brazil. The chelipeds are subequal in size and similar to the major cheliped of normal male specimens of* Uca rapax. *This paper is the first record of the aforementioned anomaly for the species from the Brazilian coastline.*

Keywords: fiddler crabs, anomaly, symmetry, super-males

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INTRODUCTION

Fiddler crabs *Uca rapax* Smith, 1870 are distributed along the Western Atlantic (Florida, Gulf of Mexico, Antilles, Venezuela and Brazil – from the state of Pará (north) to the state of Santa Catarina (south)). This species dwells in galleries excavated in mud, or muddy sand, near mangroves. It also inhabits these same substrates along rivers, streams and ponds. It is usually the most abundant species of the *Uca* along the Brazilian coast (Melo, 1996).

Species of *Uca* feature a marked sexual dimorphism, with males holding one of their chelipeds hypertrophied, which can reach one third of their body mass (Rosenberg, 2001). The large cheliped is modified for intrasexual fights, defence and courtship, while the smaller one is used for eating (Crane, 1975). Also, according to the same author, females have a pair of small chelipeds, similar to the male's small pincer.

Certain bodily changes, such as prepubertal or pubertal molt, can be abrupt and may reflect a critical stage during ontogeny in Brachyura (Hartnoll, 1974). In such an ontogenetic shift, the proportions of body structures are changed while size increases (Hartnoll, 1978, 1982). Brachyura males, for instance, showed changes in the cheliped proportions before and after the puberal molt (Hartnoll, 1974). Male fiddler crabs do not exhibit distinct sexual dimorphism in the early development stages (first three stages of crab after megalopa), i.e. chelipeds are still symmetrical, similarly to females (Hyman, 1920).

Morgan (1920, 1923) was one of the first to report anomalous cases in the chelipeds of fiddler crabs. Morgan (1920) observed two variations: (1) both the male's chelipeds remain small, similarly to the one that normal males use for feeding; and (2) both the chelipeds become hypertrophied in a similar way to the major one of normal males, naming these two cases as 'intersexual' and 'super-males', respectively.

Several cases of cheliped abnormalities in fiddler crabs have been reported for the Americas: in New York (USA) with *Uca pugnax* Smith, 1870 (Mulstay, 1987); in Florida (USA) with *Uca pugilator* Bosc, 1802 (Zou & Fingerman, 2000); and in Margarita Island (Venezuela) with *Uca cumulanta* Crane, 1943 (Lira *et al.*, 2006). For the *Uca rapax*, cases were reported in: Coronie (Suriname) (Holthuis, 1959); Massachusetts (USA) (Vernberg & Costlow, 1966); and in Cumaná (Venezuela) (Ahmed, 1976). In Brazil, *Uca burgersi* Holthuis, 1967 has been reported in the south-east of Brazil (Paraty, Rio de Janeiro, Ubatuba, São Paulo) (Benetti & Negreiros-Fransozo, 2003) and *Uca uruguayensis,* in the south of Brazil (Monserrat & Rodríguez, 1995) (Table 1). For other localities, there are cases where *Uca vocans* (Takeda & Yamaguchi, 1973), *Uca lactea* (Yamaguchi, 1977) and *Uca arcuata* (Yamaguchi, 2001; Yamaguchi & Henmi, 2001) has been reported in Kyushu (Japan). Therefore, this work aims to report the first case of bilateral hypertrophy in the fiddler crab species *Uca rapax* from the Brazilian coastline.

MATERIALS AND METHODS

Fiddler crabs were manually collected at low tide every three months between March 2010 and August 2013, in a mangrove

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Table 1. Species records with abnormal chelipeds for the Americas, according to classification proposed by Morgan (1920), SC, super-male chelipeds and IC, intersexual chelipeds. Bold records for the species *Uca rapax*.

Author (year)	Sampling location	Species	SC	IC
Morgan (1920)	Northampton County, Virginia (USA)	*Uca pugilator*	X	X
Morgan (1923)	Falmouth, Massachusetts (USA)	*Uca spp.*	X	
Holthuis (1959)	Coronie (Suriname)	*Uca rapax*	X	
Vernberg & Costlow (1966)	Woods Hole, Massachusetts (USA)	*Uca rapax*	X	
Ahmed (1976)	Turpialito, Cumaná (Venezuela)	*Uca cumulanta* and *Uca rapax*		X
Mulstay (1987)	Long Island, New York (USA)	*Uca pugnax*	X	
Monserrat & Rodríguez (1995)	Florianópolis, Santa Catarina (Brazil)	*Uca uruguayensis*	X	
Zou & Fingerman (2000)	Panacea, Florida (USA)	*Uca pugilator*		X
Benetti & Negreiros-Fransozo (2003)	Paraty, Rio de Janeiro and Ubatuba, São Paulo (Brazil)	*Uca burgersi*	X	X
Lira *et al.* (2006)	La Restinga, Margarita Island (Venezuela)	*Uca cumulanta*	X	
Present study (2013)	Extremoz, Rio Grande do Norte (Brazil)	*Uca rapax*	X	

area of the Rio Grande do Norte, north-east Brazil (05°42′21″S 35°18′10″W), on the right bank of the Ceará-Mirim River (Figure 1A, B). The abnormal specimen was collected in a deactivated reservoir used for shrimp farming, which is directly connected to the lower reaches of Ceará-Mirim River's estuary. The abnormal specimen was stored in a plastic bag inside a cooler box and taken to the laboratory where it was identified according to Melo (1996) and sexed (by observing the number of pleopods; four for females and two for males). The specimen is kept in the carcinological collection of the Grupo de Estudos em Ecologia e Fisiologia de Animais Aquáticos of the Federal University of Rio Grande do Norte (voucher number GEEFAA/UFRN-071). The crab was measured using a digital calliper (Western®) with an accuracy of 0.1 mm. Measurements included: carapace length (CL), carapace width (CW), right cheliped length (RCL), right cheliped height (RCH), left cheliped length (LCL) and left cheliped height (LCH).

RESULTS

During the sampling period, only one abnormal male (CW 16.8 mm; CL 11.3 mm) was collected in August 2013. Chelipeds were similar in shape and size (LCL 15.8 mm; LCH 7.2 mm; RCL 15.4 mm; RCH 6.9 mm) (Figure 2).

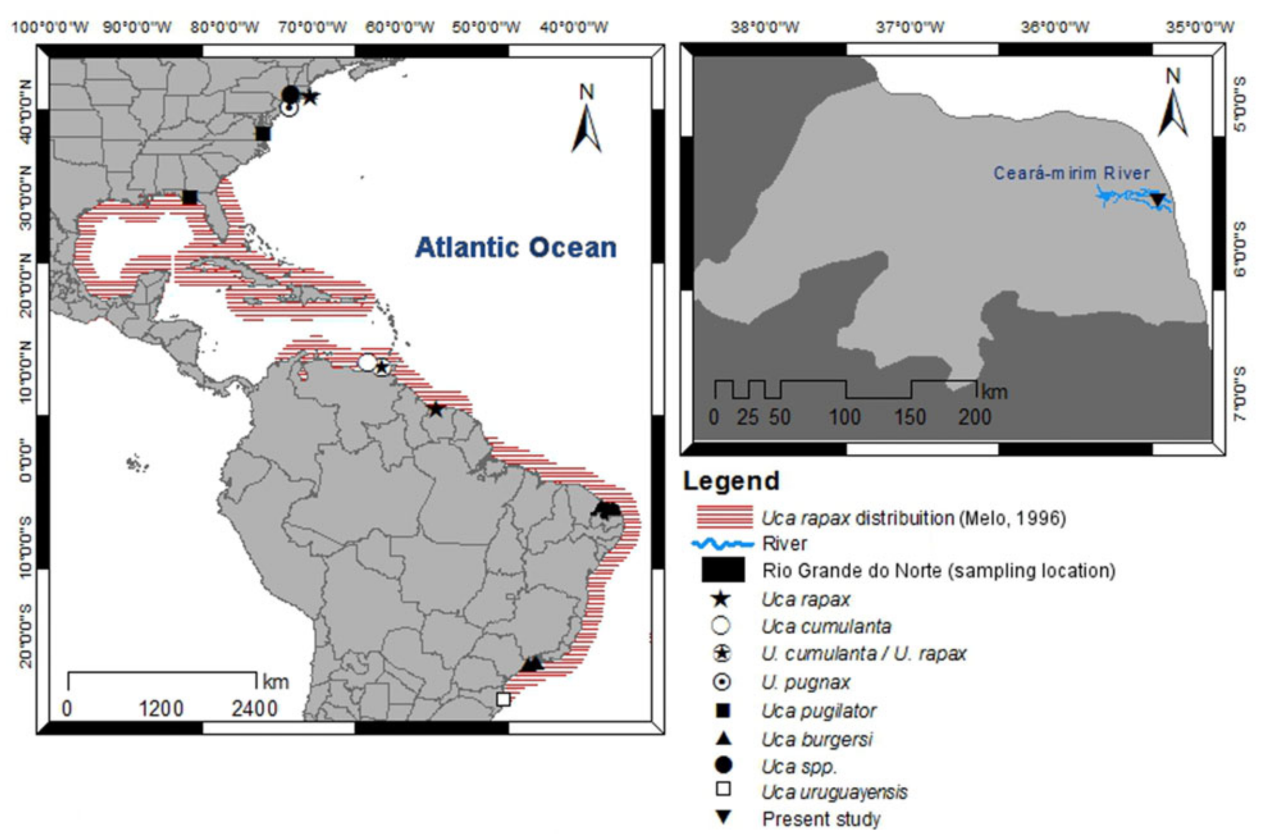

Fig. 1. Geographic distribution of *Uca rapax* (Melo, 1996) and record of abnormal chelipeds to genus *Uca* for the Americas. Primary data – present study. Secondary data – literature records. All registries, except *Uca burgersi*, had their localities estimated due to the lack of geographic coordinates in the literature records.

Fig. 2. *Uca rapax* Smith, 1870. Super-male specimen (voucher number GEEFAA/UFRN-071) collected in the Rio Grande do Norte, north-east Brazil. (A) Dorsal view, (B) frontal view and (C) ventral view.

Thus, the specimen was a representative of the super-male anomaly according to Morgan (1920).

DISCUSSION

Ahmed (1976) suggested that *Uca* males are polymorphic, with four distinct forms: larger right cheliped, larger left cheliped, both chelipeds reduced and both hypertrophied. Moreover, the author states that 'super-males' can be an abnormal case related to the embryonic or chromosomal level. In a later study, the same author affirms that an influence of hormonal and genetic alterations exists (Ahmed, 1978). Morgan (1920) mentions that abnormal forms in *Uca pugilator* may be the result of genetic and ontogenetic changes. Zou & Fingerman (2000), studying an *U. pugilator* 'intersex' male suggested that this change might be related to endocrine factors. Temperature, lack of resources, pollution, directional selection (selection by an extreme phenotype) and inbreeding are some external factors that could influence gene expression, by causing those extreme variations (Chippindale & Palmer, 1993).

The origin of handedness in the chelipeds' hypertrophy of fiddler crabs was analysed by Yamaguchi (1977) and Ahmed (1978). The authors observed the following in their experiments on magalopae and young males: when a cheliped is removed, the other (intact) is hipertrofied. However, in natural conditions, the loss of chelipeds in young males between 2.3 and 5.2 mm causes hypertrophy to the other (Yamaguchi, 1977). After the establishment of laterality (asymmetry of chelipeds), no possibility of reversal or 'compensatory regulation' (alternation in laterality after loss of hypertrophied cheliped) exists. The aforementioned fact is evidence for the genetic basis of the genus *Uca* (Von Hagen, 1962; Yamaguchi, 1977, 2001; Mariappan *et al.*, 2000). This pattern is not reported in other taxa of decapods characterized by heterochely (Wilson, 1902–1903; Cheung, 1976; Hamilton *et al.*, 1976; Simonson, 1985; Govind *et al.*, 1988; Haefner, 1990; Yamaguchi, 1995). Based in Yamaguchi (1977), the specimen collected in the present study has probably not gone through this stage and both chelipeds have undergone hypertrophy, or changes possibly occurred in the expression of genes such as the *Hox* genes, responsible for the expression of body architecture, including the development of thoracic appendices (Averof & Patel, 1997; Kaufman & Abzhanov, 2000) or *Sp-IAG* genes, responsible for the androgenic gland hormone expression that operates in the development of sexual characteristics (Zhang *et al.*, 2014).

However, Scholtz *et al.* (2014) affirm that abnormalities described in crustaceans are, apparently, majorly caused by mechanical or chemical perturbations during development or regeneration and non-mutant defects in the genetic level. Thus, consideration has been taken on the role of the androgenic gland in decapod crustaceans in sex differentiation (development of male sexual characteristics), such as colouring, morphotypes and modifications to the size and shape of chelipeds, and the control of sex reversal (King, 1964; Khalaila *et al.*, 2001; Okumura & Hara, 2004). Based on this, the specimen collected may have suffered a dysfunction of this gland, which has exacerbated this characteristic. Within the framework of endocrine factors, we should also mention the effect of the Methyl Farnesoate hormone, the main terpenoid hormone of crustaceans (LeBlanc, 2007), regulating male reproductive morphology and copulatory behavior (Laufer *et al.*, 1994, 2005; Laufer & Biggers, 2001; Ventura *et al.*, 2011). This hormone is sensitive to changes in signalling pathways by environmental factors, and doses for glandular dysfunction can result in abnormalities in ontogeny, sexual maturation and sex determination (Rotllant *et al.*, 2000; Laufer *et al.*, 2002; Olmstead & LeBlanc, 2002; LeBlanc, 2007). Therefore, changes in signal pathways and hormone dosage could generate different allometric patterns and morphological abnormality, such as the one reported in this study.

Adult males with both chelipeds hypertrophied are uncommon (Morgan, 1923; Vernberg & Costlow, 1966; Yamaguchi, 1977). Normal males in the same study area (Ceará-Mirim River estuary, north-east Brazil) exhibited mean values of 16.23 ± 3.10 mm (CW), 10.63 ± 1.97 mm (CL) and 17.99 ± 10.30 mm (MCL – major cheliped length) (*data not published*). In light of these figures, the abnormal male captured exhibited body dimensions close to the population mean body size.

One of the main relevant aspects of the occurrence of bilateral hypertrophy is related to daily activities such as feeding. Usually, the non-hypertrophied cheliped in normal males is adapted to that function (Crane, 1975; Yamaguchi, 2001). Furthermore, another key point about the reproduction for that species deserves reflection: could the super-male specimen have the advantage in courtship behaviour with females and/or agonistic encounters with normal males? Considering the aforementioned issues, it becomes clear that more physiological, genetic and behavioural studies are necessary for a better understanding of such abnormality.

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