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NOTES ON GEOGRAPHIC DISTRIBUTION

Occurrence of chitons (Mollusca, Polyplacophora) in estuaries: first records in Brazil

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Abstract. Chitons are molluscs with scarce world records in estuaries. In the present study, we provide the first records of two species of Polyplacophora in the Coreaú River estuary, Camocim, Ceará, Brazil: *Ischnochiton striolatus* and *Ischnoplax pectinata*. The data shows these animals thrive in estuary coastal regions. The taxonomic data together with the ecological data presented in this study, it is possible to conclude that this research represents a significant milestone in understanding the biodiversity of Brazilian estuarine areas.

Key words. Chitonida, mangrove, northeastern Brazil, semi-arid coast

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INTRODUCTION

Estuaries are coastal bodies of water that have a free connection to the open sea and dilution with freshwater draining from off the land. Variation in salinity and passage of nutrients and sediments brought by water from inland to coastal regions is common (Silva 2000; Dias et al. 2016), forming diverse habitats for benthic organisms throughout their life cycle (Menegotto et al. 2019). Knowledge of the distribution of marine species in an estuary can be useful for assessing changes in benthic habitats resulting from sea-level rise attributed to global warming (Shaw et al. 2009).

The class Polyplacophora is restricted to marine environments, where they live at depths down to 8,000 m (Kaas and Jones 1998) and shallower, coastal environments, such as rocky beaches, tide pools, and reefs (Eernisse and Clark 1994; Guimarães et al. 2008; Schwabe 2010; Veiga et al. 2016). Few studies have reported the occurrence of chitons in estuaries (Figure 1). Chalmer and Hodgkin (1976) first reported chitons in an estuary, in the Swan River estuary of Western Australia; they found *Acanthochitona* sp. (Acanthochitonidae) and a lepidopleurid of uncertain genus in this temperate estuary. In the same region, Shaw et al. (2009) found the following species: *Ischnochiton cariosus* Carpenter, 1879 (Ischnochitonidae), *Ischnochiton contractus* (Reeve, 1847) (Ischnochitonidae), *Cryptoplax striata* (Lamarck, 1819) (Cryptoplacidae), and *Acanthochitona bednalli* (Pilsbry, 1894).

Giberto et al. (2004) recorded the occurrence of *Chaetopleura isabellei* (d'Orbigny, 1841) (Chaetopleuridae) in the estuary of the Rio de la Plata, between Argentina and Uruguay. Wolff (2005) collected *Leptochiton cancellatus* (G.B. Sowerby II, 1840) (Leptochitonidae) in the Oosterschelde estuary, Holland. Arias and Anadón (2013) indicated the presence of *Tonicia atrata* (G.B. Sowerby II, 1839) (Chitonidae) in the Eo and Avilés estuaries (Spain), and in the Sado estuary (Portugal). There are no records of chitons in estuaries from other regions; however, polyplacophorans are little studied when compared to other classes of molluscs (Correia et al. 2015). In the present study, we document the first occurrence of chitons in an estuary in Brazil.

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METHODS

The sampling of chitons was carried out at low spring tide on the rocky shore of the lower estuary of the Coreaú River, which is in the municipality of Camocim, Ceará, northeastern Brazil. The estuary is on the

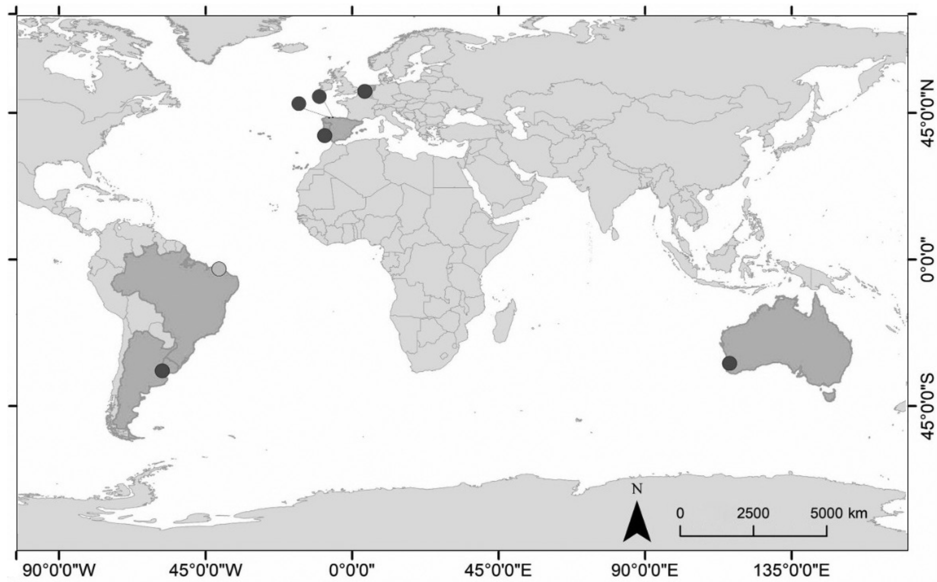

Figure 1. New record (light grey circle) and previous records (dark grey circles) of Polyplacophora in estuaries.

equatorial coast of the semi-arid region of Brazil (Morais et al. 2020), where the average annual rainfall is 1,114 mm (Climate-data.org n.d.).

The Coreaú River originates at the confluence of Jatobá and Caiçara streams, at the foot of the Serra da Ibiapaba. It flows for 167.5 km before entering the Atlantic Ocean. The estuary of this river features sediment rich in organic matter sourced from nearby mangroves along the shores, along with the presence of silico-ferruginous rocks and detritus and sandstone reefs (Morais et al. 2006).

Bimonthly, between March 2017 and March 2019, three sampling points were selected along the estuarine strip of the Coreaú River. The points were spaced 2 km apart. At each point, the distance to the low tide line was 30 m^2 in all intertidal zones, and for each point three random quadrants with an area of 5 m^2 each were delineated. In each quadrant, chitons were collected through the active search method, for 10 min with the sampling effort of four observers. The ambient air temperature was measured at each sampling point with a thermo-hygrometer, and salinity was measured with a refractometer. Rainfall data were extracted from the Fundação Cearense de Meteorologia e Recursos Hídricos, Funceme (2017–2019).

In the laboratory, animals were fixed and preserved in 70% alcohol. The taxonomic information for diagnosis and identification of the material was based on the literature (Righi 1970, 1971; Kaas and Belle 1985, 1990, 1994; Simone and Jardim 2009). Measurements of length, spanning from the cephalic to the anal valve, were acquired from diagnostic individuals utilizing digital calipers with 0.01 mm precision.

Individuals were classified into three size categories, as defined by (Iredale et al. 1924; Schwabe 2010): small individuals, where the length was ≤15 mm; medium individuals, where the length ranged from >15 mm to ≤30 mm; and large individuals, with a length >30 mm. To analyze sampling effort efficiency, an accumulation curve based on the monthly sampling effort (Jackknife) was performed. After analysis in the laboratory, a few specimens of each species were selected for vouchers and deposited in the Collection Malacological Prof. Henry Ramos Matthews (**CMPHRM**) from the Institute of Marine Sciences at the Federal University of Ceará.

Only specimens deposited in the CMPHRM collection were used in describing diagnostic characters. The other, non-vouchered specimens were only considered in our study of abiotic factors and abundance. We observed and compared variations in abiotic factors, such as temperature and salinity, and abundance during the sampling period.

RESULTS

In our study, we found 981 individuals, which belong two species: *Ischnochiton striolatus* (Gray, 1828) with 962 individuals, and *Ischnoplax pectinata* (G.B. Sowerby II, 1840) with 19 individuals. Figure 2 shows living animals of both these species on their respective substrates.

Family Ischnochitonidae

Ischnochiton striolatus **(Gray, 1828)**
Figure 2A

Material examined. BRAZIL –Ceará • Camocim, Coreaú River estuary; 02°52.125′S, 040°51.425′W; on a thick, small rock in a rocky area of a sandstone reef within tide pools; D.J. Lima & R.C. Maia leg.; 08.VII.2017; 6 spec., MPHRM 5144.

Diagnostic characters. Animal elongate-oval; small (length 9.20–3.52 mm); tegmentum slightly grayish–yellowish white, with mixed colors, spotted with beige. Dorsal valve surface striate.

Family Callistoplacidae

Ischnoplax pectinata **(G.B. Sowerby II, 1840)**
Figure 2B

Material examined. BRAZIL – Ceará • Camocim, Coreaú River estuary; 02°53.143′S, 040°50.742′W; on a thick, small rock in a rocky area of a sandstone reef within tide pools; D.J. Lima & R.C. Maia leg.; 08.VII.2017; 2 spec., CMPHRM 5143.

Diagnostic characters. Animal very elongate-oval; small to large (length 9.75–17.17 mm); tegmentum colour varying from beige (sometimes greyish) to greenish. Dorsal valve sculpture with radial ribs on the head valve has radial ribs; median valves have ribs on margins in lateral and pleural areas; central region of median valves with a smooth jugal line; terminal valve with ribs. Anteromucronal area (before the apex) concave and with a prominent apex.

Ecological aspects. The accumulation curve based on the bimonthly sampling effort indicated an estimate of the richness of five chiton species (Jackknife = 4.99 ± 0.59), with a collection efficiency coefficient of 80.16%. Throughout the sampling period, the ambient air temperature ranged from 22.5 °C on September 18 to a peak of 41 °C on March 2017 (with an average temperature of 31 °C ± 0.31 °C). Concurrently, salinity levels ranged between 8.20 ppt. on March 19 and 43 ppt. on September 2018 (with an average salinity of

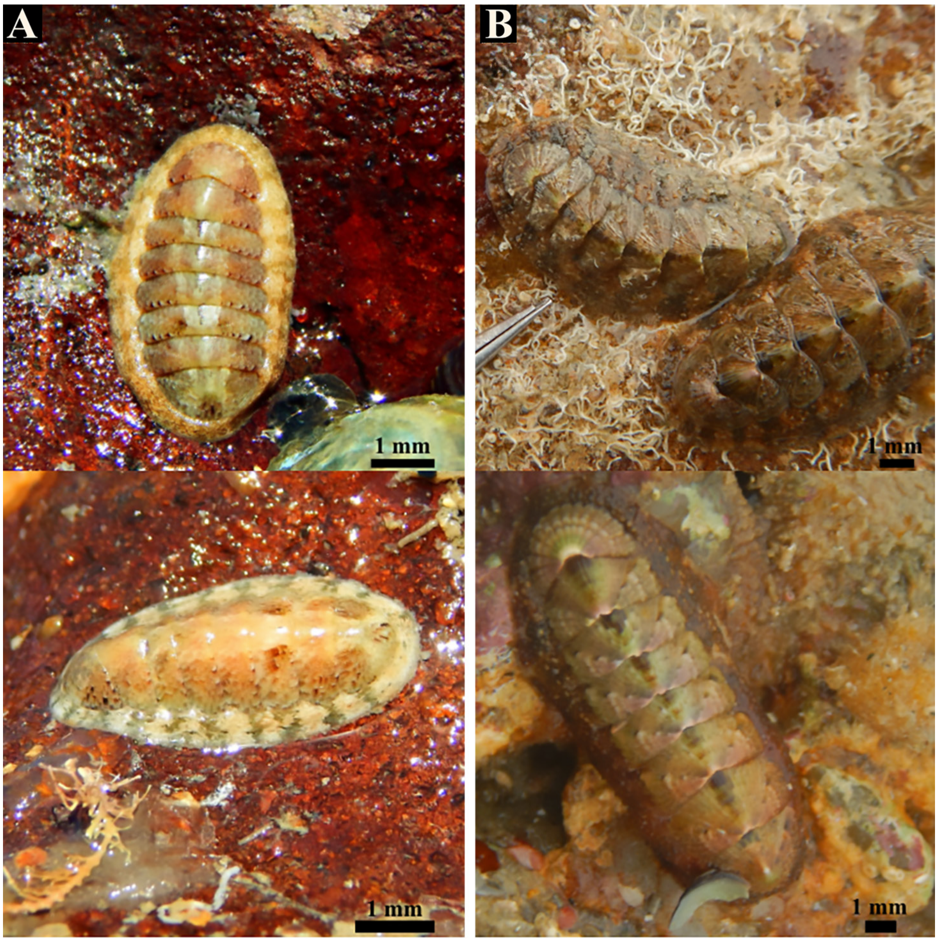

Figure 2. Species of Polyplacophora in the estuary of the Coreaú River, Ceará, Brazil. **A.** *Ichnochiton striolatus*. **B.** *Ischnoplax pectinata*.

32.5 ppt. ± 0.78 ppt.). The greatest abundance of *Ischnochiton striolatus* was observed on July 17, with 158 individuals, *Ischnoplax pectinata* was most numerous on May 2018, with seven individuals (Figure 3). The average rainfall during the study ws 106.54 mm ± 16.97, and greatest rainfall was on March 2019 collection (Figure 4).

DISCUSSION

We record for the first time the occurrence of two species of Polyplachophora in a Brazilian estuary. Until now, chitons had only been observed in estuaries in temperate regions (Giberto et al. 2004; Wolff 2005; Arias and Anadón 2013).

Ischnochiton striolatus and *Ischnoplax pectinata* both occur along the coast of the Western Atlantic Ocean, from North Carolina, USA, to Santa Catarina, Brazil (Simone and Jardim 2009; Jardim 2015; Matthews-Cascon and Menezes 2019). In the state of Ceará, Veras et al. (2013) found *Ischnochiton striolatus* and *Ischnoplax pectinata* living on sandstone reefs at Pacheco Beach. Rocha-Barreira et al. (2017) also reported the occurrence of *Ischnochiton striolatus* on rocky beaches and marine angiosperms banks, and they noted that the occurrence of *Ischnoplax pectinata* was restricted to sandstone reefs. Lopes et al. (2019) documented the occurrence of *I. striolatus* on Picos Beach in Icapuí, where this chiton settled on shells of the gastropod *Turbinella laevigata* Anton, 1838.

From our collections, we identified two species, but the accumulation curve indicates that, with greater temporal and spatial replication, there potentially could be three additional species found. This highlights the effectiveness of our analysis in terms of the methods applied and the sampling duration. However, further studies in similar estuarine areas are needed prove the curve analysis correct.

The variation in salinity at our sampling points revealed that these chitons can tolerate extreme conditions, as evidenced by the lower salinity levels observed on March 19, which was due to a prevailing, seasonal rainy period at that time (Figure 3). The stress caused by reduced salinity in estuaries is the main factor responsible for structuring faunal communities (Nebra et al. 2016). Estuaries in tropical and arid regions have higher salinity than estuaries in temperate regions due to much less freshwater reaching the sea and because of higher insolation (Eyre and Balls 1999). Thus, the Coreaú river estuary is a propitious environment for the occurrence of chitons, as seem by the abundance of specimens in the Coreaú river estuary, even amid seasonal variations.

Similar to the decrease in salinity, rainy seasons are associated with a reduction in the abundance, as evidenced by a decrease in abundance of chitons on March 17–18, May 18, and March 19. Conversely, in other months, except for September 18 and November 18, individuals were more abundant (Figure 4). Our abundance data, along with abiotic factors, do not support more complex ecological analyses; they merely serve to characterize the environment in our study. Variable characteristics present in the Coreaú estuary suggest that habitats there are favorable for the development of a chiton community. This hypothesis agrees with the results obtained by Vidy (2000), who found that estuarine environments represent natural nurseries for marine life.

Other factors, such as soil-texture composition, can also modify the distribution of organisms in an estuary (Boyle 1969; Rostal and Simpson 1988; Grayson and Chapman 2004). Chitons are associated with consolidated substrates, which are uncommon in estuaries (Eernisse and Clark 1994). In the Coreaú River, the presence of sandstone reefs strongly contributes to the establishment of these animals, as these reefs—in areas dominated by soft substrates—provide a solid substrate that allows for the movement of individuals

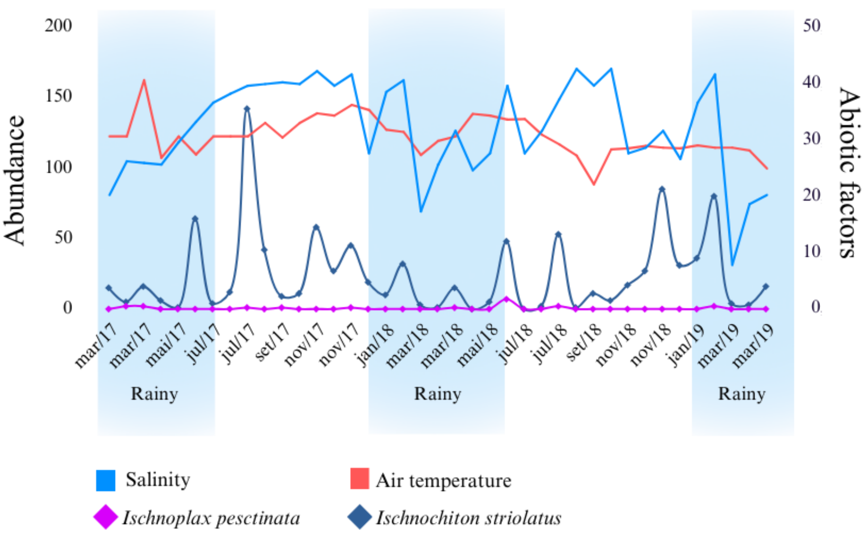

Figure 3. Sample variation graph based on the abundance results of the species *Ischnochitons striolatus* and *Ischnoplax pectinata*, and abiotic characteristics (salinity and air temperature) in relation to the sampling axis from March 17–19.

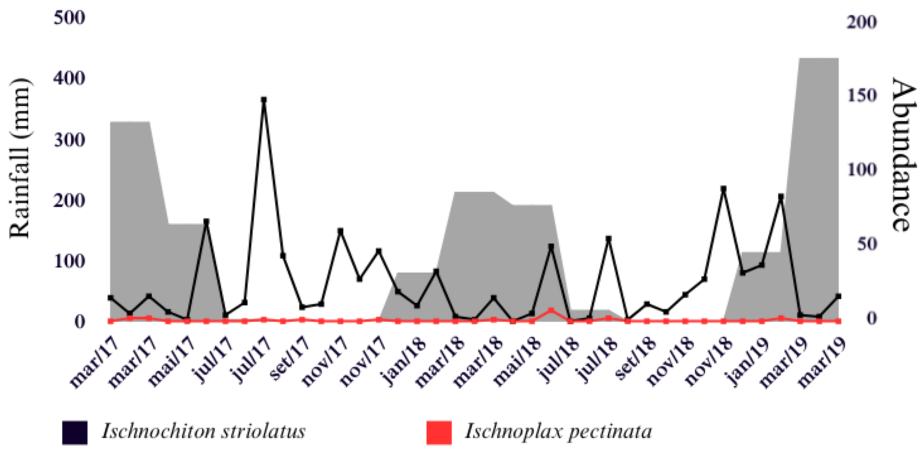

Figure 4. Sample variation graph based on the abundance results of the *species Ischnochitons striolatus* and *Ischnoplax pectinata*, and rainfall in relation to the sampling axis from March 17–19.

for feeding and serves as refuges against predators, which results in a greater survival of young and, thus, in a higher density of individuals (Ferreira et al. 2007; Mendonça et al. 2015; Lefcheck et al. 2019).

Our research is a significant in better understanding the biodiversity of Brazilian estuarine areas. The new data represent the first recorded occurrences of chitons in an estuary in the region, contributes to the knowledge of the geographic distribution of these organisms, and elucidates their environmental adaptation to the Rio Coreaú estuary. Additionally, data on seasonal variations in temperature, salinity, and precipitation provides important insights into the environmental factors that may influence the abundance and distribution of these species. Our results are may help support conservation and management measures for estuarine ecosystems and highlight the importance of scientific research for the preservation of Brazilian marine biodiversity.

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ADDITIONAL INFORMATION

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

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Author contributions

Conceptualization: DJAL, RCM. Funding acquisition: RCM. Investigation: DJAL, RCM, JAJ. Methodology: DJAL, RCM, JAJ. Project administration: RCM. Writing – original draft: DJAL. Writing – review and editing: DJAL, RCM, JAJ.

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Data availability

All data that support the findings of this study are available in the main text.

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