

First record of the heart urchin *Plagiobrissus grandis* (Gmelin, 1791) (Echinodermata: Echinoidea) in the coastal region of Paraná, southern Brazil

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Abstract. This study presents the first record of the cordiform echinoid *Plagiobrissus grandis* (Gmelin, 1791) (Echinoidea: Spatangoida: Brissidae) in Paraná's shallow inner shelf, in addition to a brief description of its location, body measurements, sex determination, and reproductive status. Two specimens were recorded between 2015 (bycatch by artisanal fishing) and 2016 (observed by scuba diving). The only specimen – with severe signs of weakness – captured was donated to *Associação MarBrasil* and kept in an aquarium for rehabilitation (8 days), where it was possible to observe digging movements, burying skills (partially), and camouflage or covering behavior. The organism was sent to the UNESPAR *campus* of Paranaguá and was photographed, measured (length: 155.65 mm, width: 118.93 mm, and maximum test height: 41.31 mm), fixed, and properly preserved. Digitized images of the histological preparation showed that it was a female in the recovery stage (or nutritional reserve) of the reproductive cycle. Regardless of their limitations, the current records for the Brissidae family in South Atlantic are still concentrated on the Brazilian coast, contributing to the understanding of zoogeographic, ecological, morphophysiological, and behavioral aspects of the spatangoid echinoids.

Keywords. Geographic distribution; Reproductive aspects; Echinoidea; Irregular echinoid; Spatangoida.

INTRODUCTION

The family Brissidae Gray, 1855 had, until the 1990's, 13 genera and about 69 species (Mcnamara & Henderson, 1984; Ghiold, 1989; Baker & Rowe, 1990). The World Register of Marine Species (WoRMS; <https://www.marinespecies.org>) has been validating the family, which currently has 11 genera and one the subfamily Brissopsinae Lambert, 1905, with 3 genera, totaling 39 accepted species.

Plagiobrissus grandis (Gmelin, 1791) has an oval and flat carapace rounded anteriorly and truncated posteriorly, covered by long spines (Gondim *et al.*, 2018, Martins *et al.*, 2018). The species is geographically distributed from Florida

(USA) to Brazil, including the Caribbean and the entire Central American coast (Hendler *et al.*, 1995). In Brazil, records about the species are sporadic, including the states of Alagoas (Gondim *et al.*, 2018), Bahia, the Trindade and Martins Vaz Archipelago (Martins *et al.*, 2018), and São Paulo (Netto *et al.*, 2005, Tommasi, 1958). In addition to Sealifebase data (Palomares & Pauly, 2022) from the Brazilian states Pará, Ceará, Rio Grande do Norte, and Rio de Janeiro. Its bathymetric distribution ranges from the coastal zone (1 m) to depths of 200 m (Serafy, 1979), more commonly up to the isobath of 50 m.

In southern Brazil, the latitudinal limit of *P. grandis* is speculated to be on the coast of the Santa Catarina state (Slivak *et al.*, 2022). According to

unpublished information by Oliveira (1989) and Oliveira et al. (1987), the limit would be along rocky outcrops and sandy bottoms on Campeche Island, Florianópolis (27°41'S; 48°28'W). Unfortunately, in these studies there is no indication of voucher material in museums or collections, making it impossible to confirm the biological material, or its record, quantity, and/or specimen location in this region.

This rare species lacks ecological and biological information. Its geographic distribution limits are the subject of academic discussion. Therefore, this study aims to formally present the first record of *P. grandis* occurrence on the Paraná coast, in Brazil, expanding the geographic distribution data and offering a record of its behavior and reproduction, in addition to images that help visualize their characteristics.

MATERIAL AND METHODS

The Paraná state coast is characterized by oceanic environments, estuaries, and inlets (Angulo & Araújo, 1996; Santos et al., 2015). There is a continental shelf with a width between 175 and 190 km and a slope break at approximately 150 m depth (Mahiques et al., 2004). Sediments composed of quartz sand and a smooth topographic gradient predominate in the shelf's inner region, up to 50 m depth of the platform (Veiga et al., 2006; Nagai et al., 2014). The *Parque Nacional Marinho* (PARNA) das *Ilhas dos Currais*, a set of small islands that harbor great biodiversity (Noernberg et al., 2008), resides on Paraná's internal platform.

The material analyzed in the present study comes from two observations. Whenever possible, the organisms were photographed, measured length, width, and height, fixed in 10% formalin, and preserved in 70% ethanol solution. Ten spines of each type were measured (length and width) through digital images, using the ImageJ software. The mean and standard deviation are presented in the diagnosis. Additionally, the sex of the organisms was determined, and the characterization of the gonadal development was performed. A gonadal tissue fragment (1 cm²) was removed through a small incision made under one of the interambulacral plates (1 cm²) for routine histotechnique procedures for hematoxylin and eosin (H&E). In the gametogenesis events description (Nunes & Jangoux, 2004; Tavares & Borzone, 2006, 2015), diagnoses were used for both regular echinoids: *Lytechinus variegatus* (Lamarck, 1816) (Toxopneustidae: Camarodonta) and irregular: *Echinocardium cordatum* (Pennant, 1777) (Loveniidae: Spatangoida) and *Mellita quinquesperforata* (Leske, 1778) (Mellitidae: Clypeasteroidea).

The images were obtained through an Olympus CX43 microscope with an attached Olympus EP50 camera and processed in the EP50 V2019 software to obtain morphometric measurements. The distribution map was produced with the aid of the *ggmap* (Kahle & Wickham, 2013) package for R (R Core Team, 2022).

RESULTS

One specimen (Fig. 1A and B) was captured accidentally by artisanal fishermen with a trawl net, at approximately 10 m deep, near the *Parque Nacional das Ilhas dos Currais* (Fig. 2) on August 2, 2015 (25,70°S; 48,37°W). The second specimen was observed in 2016, during scuba dive, by the researcher MSc. Robin Hilbert Loose (NGO *Associação MarBrasil*) near the Djanka ferry wreck, at 26 m deep (25,89839°S; 48,14536°W).

The first specimen was donated to *Associação MarBrasil*, already showing signs of weakness; after eight days, its aquarium rehabilitation was not successful. Although visibly weakened, the specimen under observation (in an aquarium) developed covering behavior with bottom material (shells) and excavation movements to partially bury itself (Fig. 1C). The specimen was redirected to the Marine Biology Laboratory of UNESPAR, to be deposited in the institution's scientific collection (no. ECH 033). The second specimen was only observed and not collected, due to the lack of permission of the environmental agency. However, its large size, digging behavior and morphological characteristics, could guarantee its identification.

Taxonomic review

Plagiobrissus grandis (Gmelin, 1791)

Figs 1, 2, 3 and 4

- Echinus grandis* Gmelin, 1791 – Gmelin, 1791: 3200.
Spatangus pectoralis (Lamarck, 1816) – Lamarck, 1816: 29.
Eupatagus pectoralis (Lamarck, 1816) – D'Archiac & Haime, 1853: 217-218.
Mellita pectoralis (Lamarck, 1816) – Agassiz, 1872: 144-145.
Plagiobrissus pectoralis (Lamarck, 1816) – Pomel, 1883: 29-30.
Eupatagus (Plagiobrissus) grandis (Gmelin, 1791) – Cooke, 1942: 54.
Plagiobrissus grandis (Gmelin, 1791) – Clark, 1917: 207-208, pl. 146; figs. 21, 22. Mortensen, 1951: 496-498, pl. 40-41, 63; figs. 13, 16. Tommasi, 1958: 7, pl. 11; fig. 4. Tommasi, 1966: 20, pl. 5b. Kier, 1975, fig. 2-5; pl. 1-3; pl. 4; figs. 1, 2. Martins et al., 2018: 16-18, figs. 14-15. Gondim et al., 2018: 47-49, fig. 17.

Material examined: *Parque Nacional Marinho das Ilhas dos Currais* (Paraná State) – 10 m, 02-VIII-2015, // Maristela Bueno det. 2018. 1 ♀ (UNESPAR – ECH 033); Djanka ferry wreck (Paraná State) – 26 m, 2016 // Robin Hilbert Loose, personal observation.

Diagnosis: The specimen (ECH 033) dimensions were 155.65 mm in length, 118.93 mm in width, and 41.31 mm in maximum height (Fig. 3), test oval and flattened, rounded anteriorly and truncate posteriorly (Fig. 1). The carapace is extremely thin and fragile, brittle. At the top of the test, the apical disc plating is ethmolytic, with 4 symmetrically sized gonopores. The ambulacral zones draw 4 petals radiating on the upper face from the apical system,

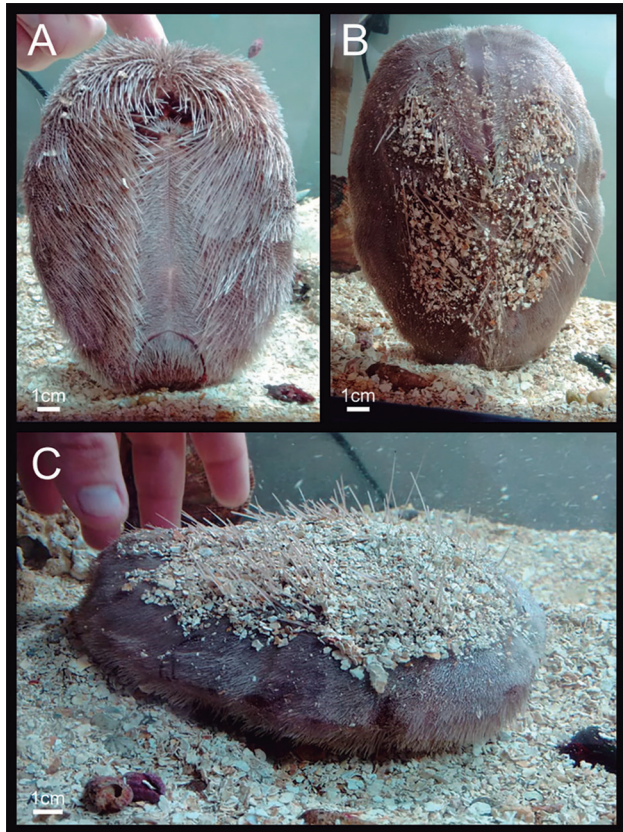


Figure 1. Live specimen *Plagiobrissus grandis* (ECH 033) in an aquarium. (A) oral view and (B) aboral view. (C) Image of the covering behavior. Photos: Robin Hilbert Loose.

these petals are slightly inserted into the test, without forming a gutter or deep furrow. At the front of the test, a shallow notch, without perforations, connects the apical system to the front concavity, under which opens the mouth or peristome (Fig. 4A), which is in an anterior and ventral position, and relatively small (18.48 mm) representing 15% of the total width of the organism. Labrum short, in contact with both sternal plates (Fig. 4A). Between these petals extend the inter-ambulacral zones covered with large tubercles in relief: these are the supports for the long spines (length = 25.35 ± 7.19 mm; width = 0.75 ± 0.19 mm; n = 10), with short, backward-curving spines between them (Figs. 1 and 2). The peripetal fasciole is covered with very small spines (length = 4.12 ± 1.11 mm; width = 0.29 ± 0.05 mm; n = 10). In the middle of the ventral face is the plastron (Fig. 3A), particularly narrow, with rectilinear and parallel edges. Outside the plastron, there are longer spines (Fig. 3B) with a fan-shaped base (length = 20.07 ± 5.04 mm; width = 0.60 ± 0.11 mm; base width = 1.38 ± 0.17 mm; n = 10). The spatulate spines in the plastron (Fig. 3C) are thinner and shorter than on the rest of the oral surface (length = 9.11 ± 1.83 mm; width = 0.51 ± 0.06 mm; tip width = 0.68 ± 0.08 mm; n = 10). The suture between the sternal and episternal plates is very marked and concave. The terminal (posterior) anus, surrounded by a subanal fasciole shield-shaped (Fig. 4B) with large plates. Periproct large (10.63 mm), tear-shaped (Figs. 4B and C), truncate, surrounded by anal fasciole (Fig. 4C).



Figure 2. Fixed specimen *Plagiobrissus grandis* (ECH 033) – captured at approximately 10 m depth near *Parque Nacional Marinho das Ilhas dos Currais* (Paraná State). Aboral view (left) and oral view (right). Photo: Maristela Bueno.

Colour: Living specimens are light brown (Fig. 1), naked test light beige.

Distribution: North America and Caribbean Sea (Palomares & Pauly, 2022). In Brazil from Alagoas, Bahia, São Paulo (Tommasi, 1958, Netto *et al.*, 2005, Gondim *et al.*, 2018), and Paraná (present study), including Trindade Island (Martins *et al.*, 2018). This is the first record of this species in Paraná State (Fig. 5). From depths of 1 to 210 m, but most common in less than 50 m (Serafy, 1979).

Biological observations

The digitized images of the histological preparations showed a high density of somatic lineage cells with

phagocytic function and storage of substances (known as nutritive phagocytes), occupying nearly the entire follicular lumen. The main highlight of these cellular elements is their globular appearance and the presence of cytoplasmic inclusions of varying sizes and colors (Fig. 6).

Yet scarce, the presence of tiny female gametes (primary oocytes) adhered to the acinus wall indicated the sex of the specimen. The gonads of this individual captured in August/2015 were categorized in the nutrient reserve accumulation stage (or reproductive cycle recovery period).

DISCUSSION

The characteristics commonly described for identification of this species were easily observed (Gondim

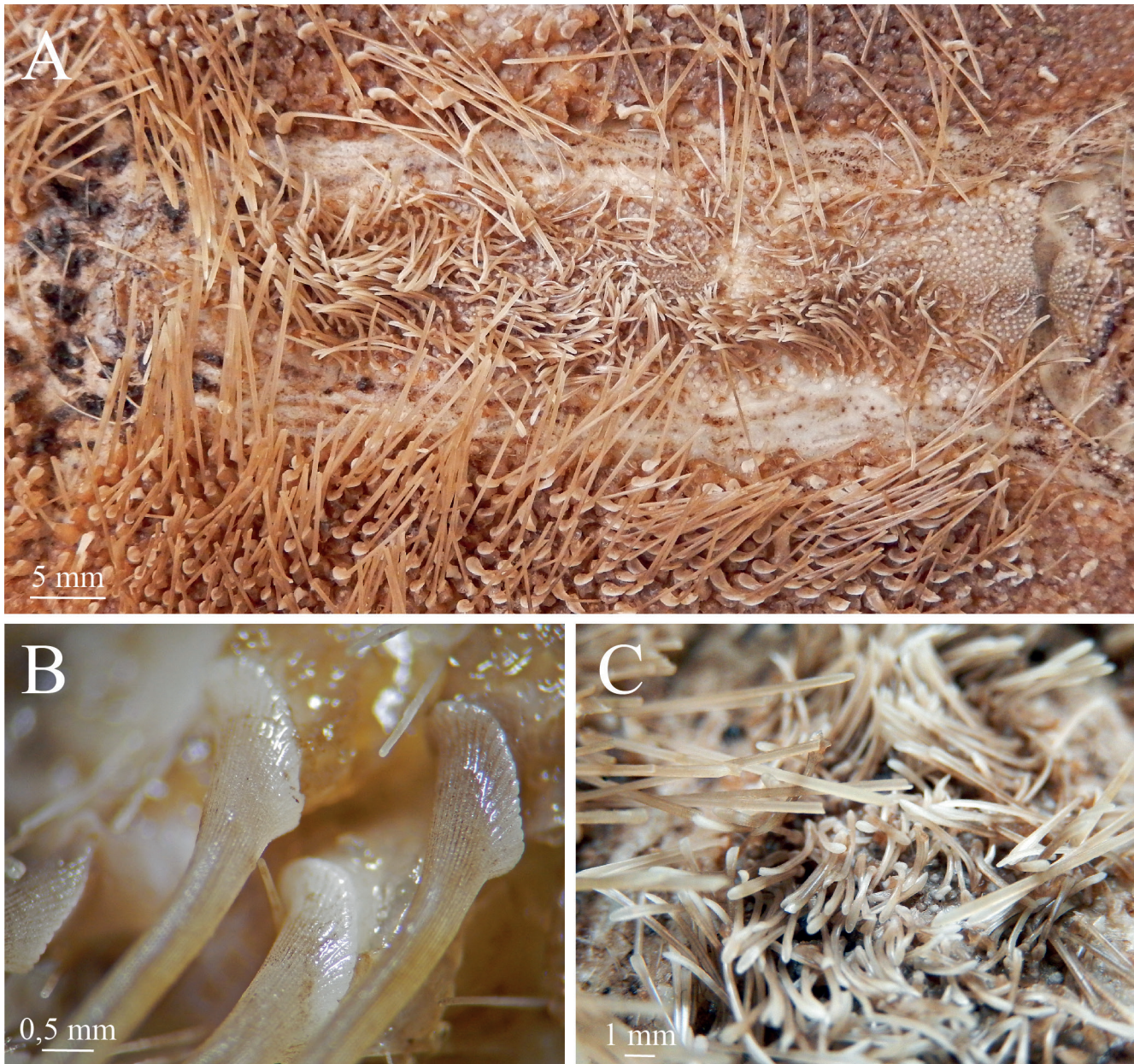


Figure 3. Oral view specimen *Plagiobrissus grandis* (ECH 033) – captured at approximately 10 m depth near *Parque Nacional Marinho das Ilhas dos Currais* (Paraná State). Oral view and plastron (A), long spines fan-shaped base, localized outside the plastron (B) and spatulate spines in the plastron (C). Photo: Maristela Bueno.

et al., 2018; Martin *et al.*, 2018; Sour-Tovar *et al.*, 2018). Comparing specimen ECH 033 with the other descriptions, it was not possible to confirm specific differences because the descriptions are more generic.

Gondim *et al.* (2018) and Martins *et al.* (2018) describe the species with long, thin spines anchored in large primary tubercles between the petals. The ethmolytic apical system, in which genital plate 2 (madreporite) is elongated, separates the genital plates 4 and 1 (posterior) and ocular plates V, and I (also posterior). It has a large petaloid, with long petals, well-developed peripetalic fasciole. Ambulacrum III (anterior) is shallow and slightly depressed (Sour-Tovar *et al.*, 2018).

Furthermore, the peristome is kidney-shaped, and covered by large plates, with small spines and trifilar pedicellariae. The subanal fasciculus is well developed, with anal fascicles extending aborally on each side of the

periproct. The oral surface of the test is flat, the periproct region is small and the plastron amphisternum is narrow. The spines on the oral surface are expanded at its base while those on the plastron are numerous and thinner than on the rest of the body (Tommasi, 1958; Gondim *et al.*, 2018).

For the South Atlantic, the rare records of *P. grandis* (photographic material and items from collections or underwater observation) are all described for the Brazilian coast (Fig. 5), including the oceanic islands. The records presented herein greatly confirm and expand the distribution of *P. grandis* 340 km to the South. There are still wide gaps in its range, and investigating nearby localities that harbor the same habitats may reveal novel and important records. New collections are necessary to actively search for the species on the coast of Santa Catarina. Yet limited, the records for the Brissidae family in both



Figure 4. Fixed specimen *Plagiobrissus grandis* (ECH 033) – captured at approximately 10 m depth near *Parque Nacional Marinho das Ilhas dos Currais* (Paraná State). Oral view, detail of peristome (A), subanal fasciole (B) and anal fasciole and periproct (C). Photo: Maristela Bueno.

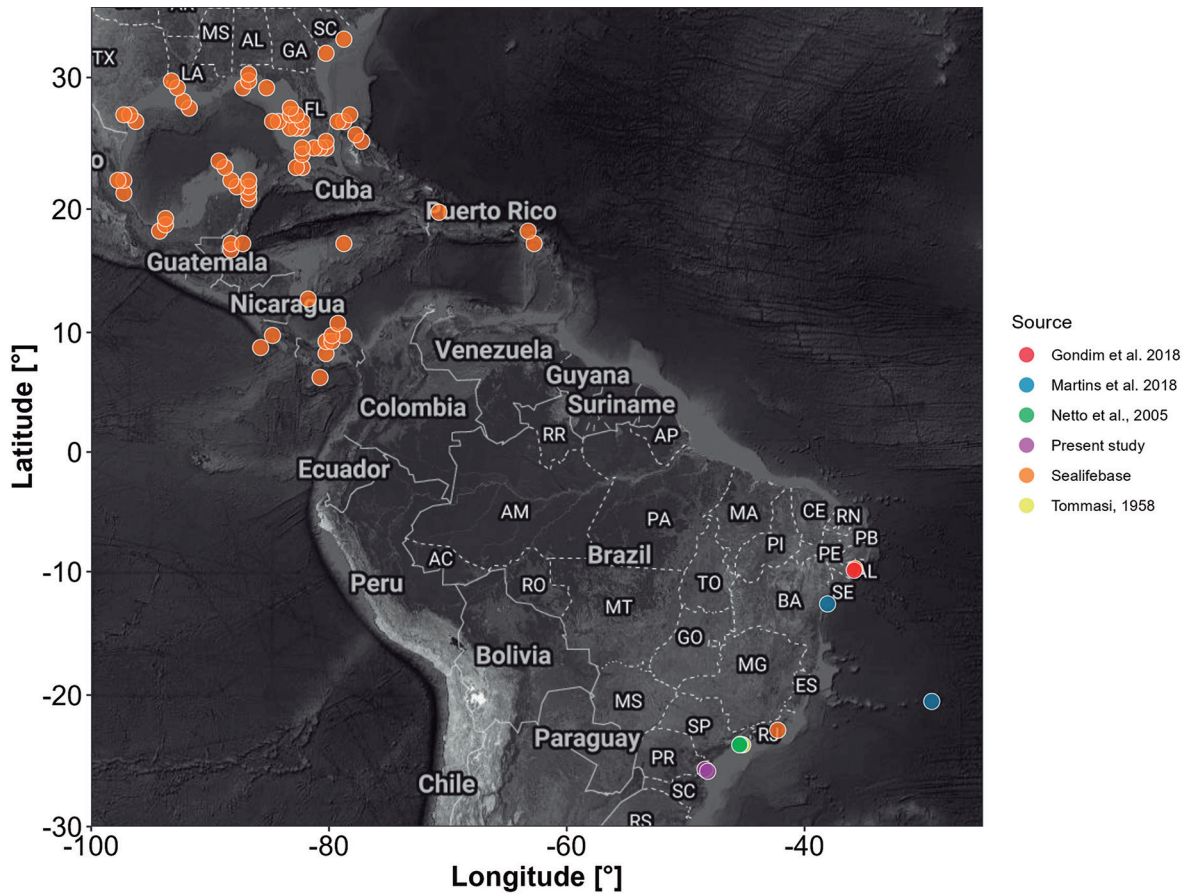


Figure 5. Geographical distribution of *Plagiobrissus grandis* in America. The dots represent the previous and new records of the species. Map background generated with package “ggmap” using Google Maps API.

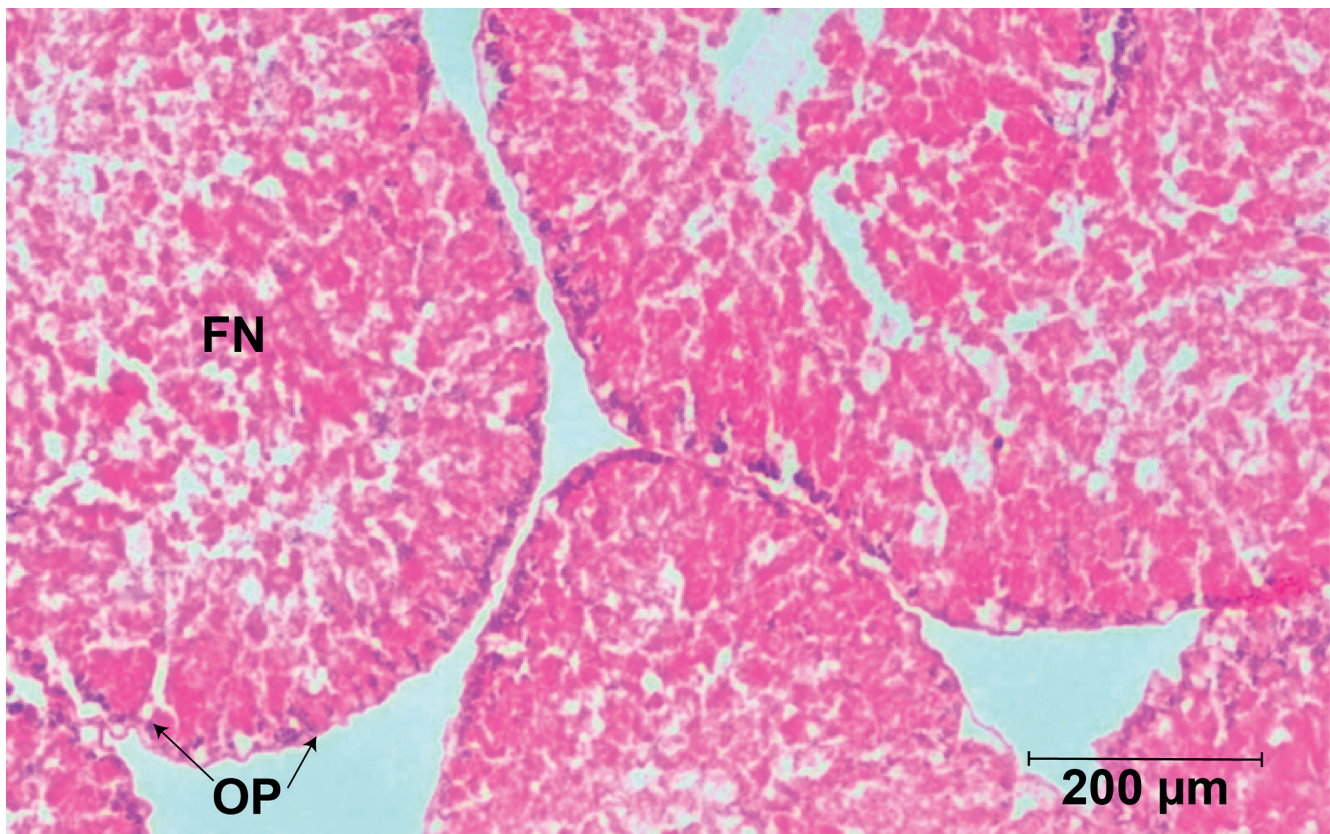


Figure 6. Photomicrograph of a female gonad follicle of *Plagiobrissus grandis* (ECH 033) found near Parque Nacional de Ilha dos Currais (Paraná State). FN: nutritive phagocyte; OP: primary oocyte. HE×10 (original magnification). Photo: Yara A. Garcia Tavares.

hemispheres and different oceans constitute important ecological contributions to understanding the latitudinal and in-depth distribution, in addition to descriptions of morphological variability and behavioral information for Spatangoida echinoids (Budicin, 2019; Nigam & Raghunathan, 2017).

Generally, observations found adult specimen solitary or in very small numbers. Most likely the populations of *P. grandis* have low densities with a high indication of non-gregarious habits of individuals, as for the occurrences of *Brissus gigas* (Cameron, 2010) in New Zealand; *Brissus latecarinatus* (Nigam & Raghunathan, 2017) for the Bay of Benguela; *Rhynobrissus cuneus* (Martínez-Melo et al., 2014; Weaver et al., 2018) in the Gulf of Mexico; and *Metalia persica* (Kanagaraj et al., 2019; Fatemi, 2020) in the Gulf of Oman and on the Arabian Sea.

The protection and camouflage strategies described here for *P. grandis* are peculiar habits among the Echinoidea (Hendler et al., 1995; Verling et al., 2004). They are also commonly described for Spatangoida representatives such as those of the Brissidae family (Kier & Grant, 1965; Serafy, 1979; del Valle García et al., 2005) and regulars such as *Lytechinus variegatus* (Toxopleuridae) (Carvalho-Souza et al., 2011).

The analyzed individual gonads were categorized in the accumulation of nutritive reserves stage (or recovery period of the reproductive cycle), frequently observed in the winter and early spring months, also in the echinoids populations inhabitants of the Paraná coast (Tavares, 2004; Tavares & Borzone, 2006, 2015).

Finally, the importance of publishing technical notes, checklists, or faunal inventories is evident, as they legitimately support proposals for coastal and marine biodiversity conservation and management (Mikkelsen & Cracraft, 2001). In Brazil, this premise is particularly important for marine benthic communities with less representation or groups that are yet poorly investigated (despite their ecological importance), such as the echinoderm fauna. Furthermore, such records can provide evidence on new occurrences of species, provide information on the conservation status or threat of taxa or even list potential environmental bioindicators.

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