



## Echinodermata associated to rhodoliths from Seixas Beach, State of Paraíba, Northeast Brazil

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**Abstract:** This study presents the species of echinoderms found inside rhodolith branches from Seixas Beach, State of Paraíba, Brazil, during one year of rhodolith sampling. A total of 64 specimens were analyzed and identified into 12 species, belonging to 11 genera, eight families and three classes. Brief taxonomic descriptions, figures and ecological notes for recorded species are provided. Ophiuroidea and Holothuroidea were the most representative taxa. Biogenic structures are an important habitat for young specimens and some small species of Echinodermata. Some species complete their life cycle in these structures, while others spend part of their life in these substrates and may also migrate to other habitats. The work complements the knowledge of echinoderm biodiversity from Northeastern of Brazil and aims to support future projects of protection and sustainable management of this area.

**Keywords:** Echinoderms, inventory, Brazilian coast.

## Echinodermata associados a rodolitos da Praia do Seixas, Estado da Paraíba, Nordeste do Brasil

**Resumo:** O presente estudo apresenta as espécies de equinodermos encontradas dentro de ramos de rodolitos provenientes da Praia do Seixas, Estado da Paraíba, Brasil. Um total de 64 espécimes foi analisado, sendo identificadas 12 espécies, pertencentes a 11 gêneros, oito famílias, e três classes. As amostras foram coletadas ao longo de um ano a partir de rodolitos. O artigo fornece uma breve descrição taxonômica, figuras e notas ecológicas para cada espécie. Ophiuroidea e Holothuroidea foram os grupos mais representativos. Os resultados mostram que essas estruturas biogênicas formam um habitat importante para espécies jovens e espécies pequenas de Echinodermata. Algumas espécies completam seu ciclo de vida dentro dos rodolitos, enquanto outras passam uma parte da vida nesses substratos para depois explorar em outros ambientes. O estudo complementa o conhecimento da biodiversidade de equinodermos para o nordeste do Brasil e fornece suporte para futuros projetos de proteção e uso sustentável da área.

**Palavras-chave:** Equinodermos, inventário, costa brasileira.

### Introduction

Rhodoliths are aggregates of nodules of unarticulated encrusting coralline algae (Amado-Filho et al. 2012). These structures occur in shallow waters up to depths of 150 m, forming extensive rhodolith beds and hard bottom habitats. In Brazil, rhodolith beds are among the largest deposits of CaCO<sub>3</sub> in the world (Amado-Filho et al. 2012). These rhodoliths provide refuge, food and other resources, protecting organisms from competitive exclusion, predation, and physical disturbance

(Riul et al. 2009, Horta et al. 2016). The Seixas Beach has a large bank of rhodoliths susceptible to degradation by anthropogenic impact, in the form of tourism and commercial exploitation.

Echinoderms can be found in various substrata. Small species and young specimens usually live associated with coral reefs, rhodolith beds, and algae. These animals are exclusively marine and belong to the benthic fauna, with many species inhabiting rocky shores, beaches, bays and subtidal zones, including the deep-sea (Pawson 2007). The phylum

consists of approximately 7,000 living species and 13,000 extinct species, comprising the classes Crinoidea, Asteroidea, Ophiuroidea, Echinoidea and Holothuroidea (Pawson 2007). According to Ventura et al. (2012), very few studies on the biogeography of echinoderms have been done in Brazil. In part, this is due to the lack of reliable information on taxonomy and distribution ranges. About 340 species of Echinodermata are recorded along the Brazilian coast (Ventura et al. 2012). Here, we list the species of echinoderms found associated with rhodoliths from the Seixas Beach, followed by brief descriptions, ecological notes for species, and a discussion on the importance of this habitat for young and small species of echinoderms.

## Material and Methods

### 1. Study site

The Seixas Beach is located about 700 m to the south of the municipality of João Pessoa, capital of the State of Paraíba, Brazil (Melo et al. 2008). The beach is located within the Tropical Northwestern Marine Ecoregion (Spalding et al. 2007). The climate is tropical and humid, with a conspicuous seasonal pattern of rainfall. The rainy season goes from March to August, and the dry season extends from September to February. Temperature ranges are small, with annual averages varying from 20 to 37°C. Mean yearly humidity is 80%, and yearly precipitation varies from 900 to 1800 mm (Lima & Heckendorff 1985).

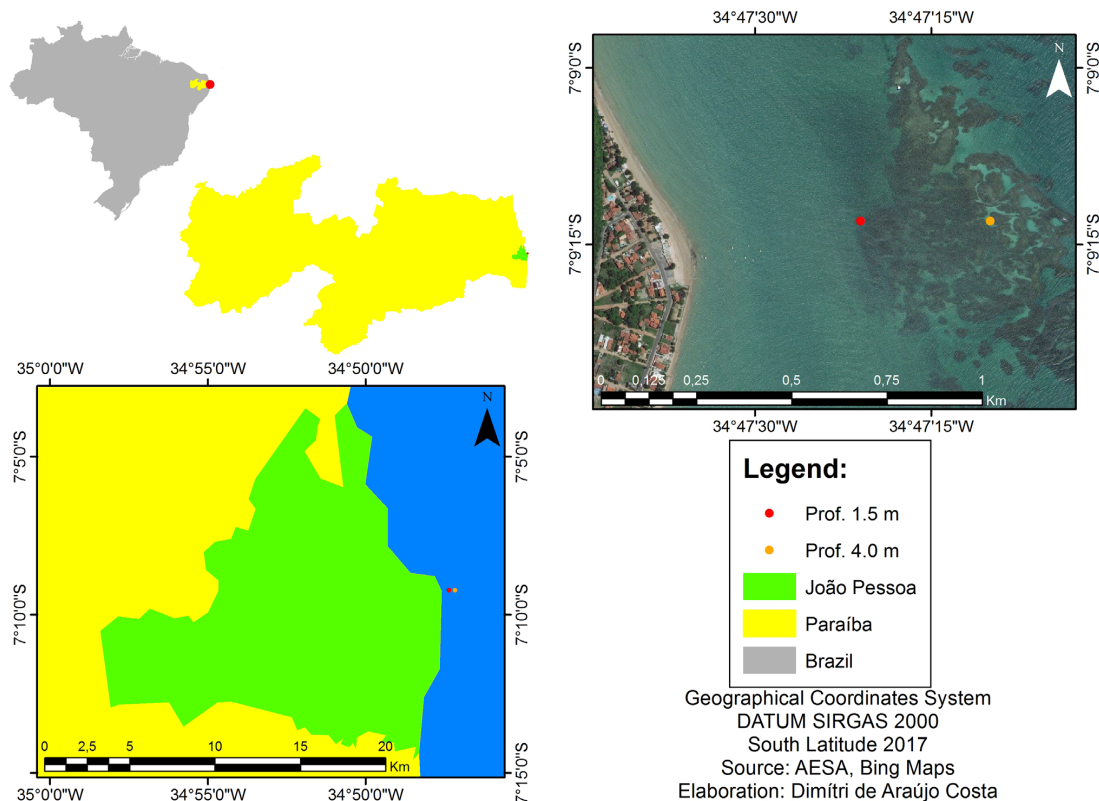
Around this rhodolith formation, water depths vary from 0.50 m to 1.50 m at low tides, except for some areas that become exposed during the lowest tides. The deeper portions vary from 3.0 to 6.0 m (Melo et al. 2014). The region is located between the coordinates of 07°08'45"S to 07°09'20"S and 34°47'45"W to 34°47'35"W. Figure 1 indicates collecting locations at the Seixas Beach (PB).

### 2. Sampling

Expeditions were conducted in the infralittoral of the Seixas Beach. Small boats were used to access to the reef environment. Collecting location were positioned at depths of 1.5 and 4.0 m. Geographical coordinates of each collecting site were recorded with a GPS. The depth of 1.5 m has coordinates 07°09'13"S and 34°47'21"W, while the depth of 4.0 m has the coordinates 07°09'13"S and 34°47'10"W. Collections were made in January, March, May, July, September and November, during the lowest tides along the year of 2015. Samples were replicated each month, totaling 12 samples in the year. Specimens were collected manually, with the help of a square of 15 X 15 cm, within which 4-5 rhodoliths were collected. The samples was conditioned in labelled plastic bags and sorted in the Laboratory of Aquatic Ecology (LABEA), Federal University of Paraíba (UFPB).

In the lab, samples were maintained separate in trays with sea water, with salinity at 35 ppm and continuously aerated, up to the time of processing of the material with a hammer and stylets. Echinoderms were separated and subsequently anesthetized with menthol, fixed in formalin at 4%, diluted with sea water, and finally preserved in alcohol at 70%. Additional material present in the Collection of Invertebrates Paulo Young (CIPY) was also considered.

Taxonomic identifications were based on Tommasi (1970), Hendler et al. (1995), Borges et al. (2002), Borges & Amaral (2005), Manso (2008), Benavides-Serrato et al. (2011), Borrero-Pérez et al. (2012), Tommasi (1969), Pawson et al. (2010), and Martins et al. (2012). Specimens were photographed with a Canon Powershot A2000IS digital camera, and a Leica MZ12.5 stereomicroscope. Measurements were obtained from fixed specimens. All specimens were deposited at CIPY, Department of Systematics and Ecology (DSE), Federal University of Paraíba (UFPB).



**Figure 1.** Study area with location of collecting points at Seixas Beach, João Pessoa, Paraíba, Brazil.

## Results

A total of 62 individuals were recorded from inside rhodoliths, belonging to three classes, four orders, eight families, 11 genera and 12 species of echinoderms, as listed below.

Class Ophiuroidea Gray, 1840

Order Ophiurida Müller & Troschel, 1840

Family Amphipruridae Ljungman, 1867

Genus *Amphipholis* Ljungman, 1866

*Amphipholis squamata* (Delle Chiaje, 1828)

(Figure 2)

*Axiognathus squamatus*—Lima-Verde, 1969: 11.

*Amphipholis squamata*—Albuquerque, 1986: 103, fig. 18a–c, est. V, fig. 1a–c; Tommasi, 1999; Borges, 2006: 34; Magalhães et al., 2005: 63; Gondim et al. 2008; Manso et al. 2008: 191, fig. 18 e–g; Oliveira et al., 2010: 6; Barboza & Borges, 2012: 11; Paim et al., 2015: 5; Alitto et al. 2016: 4.

Material examined: 5 specimens (UFPB.ECH–2260), Seixas Beach, Paraíba State, Brazil, depth 1.5 m; 1 specimen (UFPB.ECH–2275), Seixas Beach, Paraíba State, Brazil, depth 4.0 m.

Description: Disk rounded, covered by medium size scales, with circular to semicircular imbricated scales (Figure 2a, 2b). Primary scales large, easily observed (Figure 2c). Radial shields slightly long than wider, separated

by a thin scale up to the distal region of the shields. Ventral surface of the disk covered by scales similar to dorsal scales (Figure 2d). Bursal slits narrow, near the first plate of the arms. Diamond-shaped oral shield, adoral shields longer than wide, touching the proximal edge. Two oral papillae in each side of jaw, the more distal bigger and trapezoidal, other rounded and smaller. A pair of elongated infradental papillae (Figure 2e). Five arms, about five times the disk diameter. Dorsal arm plate slightly pentagonal, with distal edge rounded (Figure 2f). Ventral arm plate pentagonal, two tentacular scales (Figure 2g). Lateral arm plates meeting in the longitudinal mid-line, with four arm spines (Figure 2h). Color white.

Distribution: In the Western Atlantic, the species is found from Canada to Argentina (Hendler et al. 1995, Benavides-Serrato et al. 2011). In Brazilian coast, it was reported in Pará, Maranhão, Ceará, Paraíba (Gondim et al. 2013), Alagoas (Lima et al. 2011), Bahia (Magalhães et al. 2005), Rio de Janeiro (H.L. Clark 1915) and, São Paulo (Borges et al. 2002). The species occurs from shallow waters to 1962 m depth (Pawson et al. 2009).

Ecological notes: The specimens were found inside rhodoliths but can be buried in crevices, sand and coral rocks. The species presents bioluminescence (Bernasconi & Agostino 1975) and incubates the juveniles (Borges & Amaral, 2005).

*Amphipholis januarii* Ljungman, 1866

(Figure 3)

*Amphipholis januarii*—Tommasi, 1967: 1, fig. 1; Lima-Verde, 1969: 11; Alves & Cerqueira, 2000: 545; Magalhães et al. 2005: 63; Gondim et al., 2008: 154; Manso et al., 2008: 190, fig. 18a–d; Oliveira et al., 2010: 6; Barboza & Borges, 2012: 11; Paim et al., 2015: 3–4; Alitto et al. 2016: 4.

Material examined: 16 specimens (UFPB.ECH–2248, 2249, 2252, 2265, 2276), Seixas Beach, Paraíba State, Brazil, depth 1.5 m; 19 specimens (UFPB.ECH–2253, 2256, 2257, 2258), Seixas Beach, Paraíba State, Brazil, depth 4 m.

Description: Disk circular to pentagonal, with reentrances in inter-radial areas (Figure 3a). Disk covered by small and imbricated scales. Radial shields narrow, longer than wide, usually separated by one or two scales, the internal more elongated (Figure 3c). Ventral side of the disk covered by smaller scales, imbricated (Figure 3d). Bursal slit long, near the first arm plate. Oral shield diamond-shaped, adoral shield triangular. Two oral papillae in each side of jaw, the distal triangular and robust, a pair of elongated and robust infradental papillae (Figure 3e). Five elongated arms, about seven to ten times the diameter of the disk (Figure 3b). Arms tapering distally. Dorsal arm plate wider than long (Figure 3f), ventral arm plate pentagonal (Figure 3g), with rounded edges. Two tentacle scales, small and flattened. Lateral arm plate with three to four elongated spines, similar in size (Figure 3h). The arm spine of middle with one or two teeth at the apex. Color white to yellow.

Distribution: South Carolina, Florida, Texas, Mexico, Antilles, Belize, Panama and Brazil (Hendler et al. 1995, Alvarado et al. 2008). In Brazilian coast, the species was reported in Pará (Albuquerque 1986), Ceará (Lima-Verde 1969), Paraíba (Gondim et al. 2008), Alagoas (Lima et al. 2011), Bahia (Magalhães et al. 2005), Rio de Janeiro (Ljungman 1867), and São Paulo (Tommasi 1970, Alitto et al. 2016). From 1 to 311 m depth (Laguada-Figueras et al. 2009).

Ecological notes: This species usually is found in sand bottom and gravel (Tommasi 1970), algae, under rocks (Hendler et al. 1995).

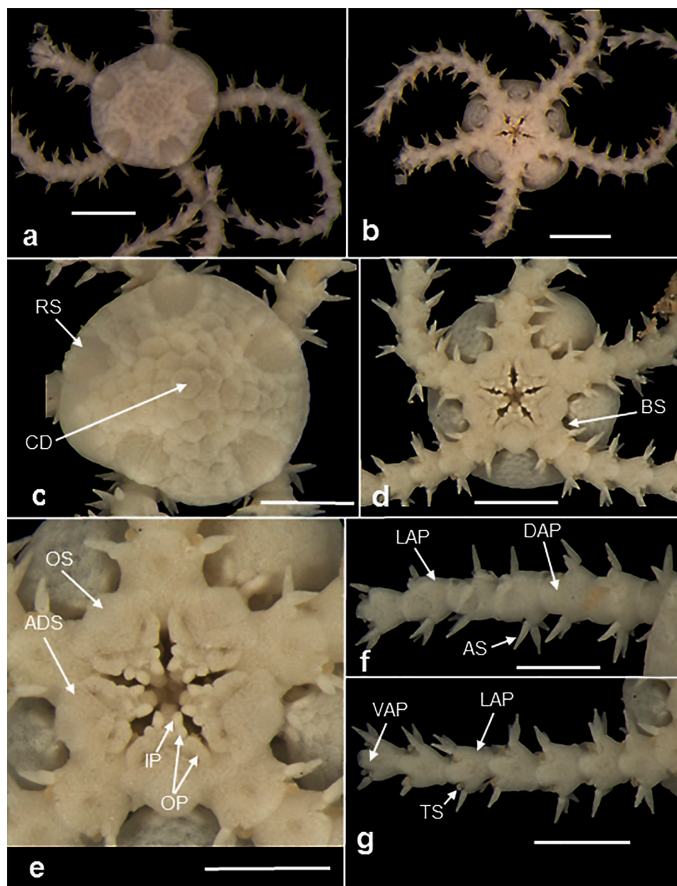
Genus *Microphiopholis* Turner, 1985

*Microphiopholis gracillima* (Stimpson, 1854)

(Figure 4)

*Microphiopholis gracillima*—Tommasi, 1970: 39, figs. 39–40; Alves & Cerqueira, 2000: 545.

*Amphipholis gracillima*—Guille & Albuquerque, 1987: 147; Albuquerque & Guille, 1991: 6; Oliveira et al., 2010: 6.



**Figure 2.** *Amphipholis squamata*. a, dorsal view of the animal; b, ventral view of the animal; c, dorsal view of the disk; d, ventral view of the disk; e, detail of the jaws; f, dorsal view of the arm; g, ventral view of the arm. ADS, adoral shield; AS, arm spine; BS, bursal slit; CD, central dorsal scale; DAP, dorsal arm plate; IP, infradental papillae; LAP, lateral arm plate; OP, oral papillae; OS, oral shield; RS, radial shield; TS, tentacle scale; VAP, ventral arm plate. Scales: a–d, f, 1 mm; e, 0.5 mm. The arms are oriented from the distal to proximal region.

*Microphiopholis gracillima*—Tommasi, 1999; Magalhães et al., 2005: 63; Barboza & Borges, 2012: 13.

Material examined: 3 specimens (UFPB.ECH-2259), Seixas Beach, Paraíba State, Brazil, depth 4 m.

Description: Disk rounded with indentations in the radial region (Figure 4a). Disk covered by numerous small and imbricated scales. Radial shields narrow and elongated, joined at half of length, and then separated by three scales on the proximal edge (Figure 4c). Ventral surface of disk covered by small and imbricated scales. Bursal slit large, near the first to fourth ventral arm plate (Figure 4d). Oral shield diamond-shaped. Adoral shield elongated and slightly wide distally. Jaws with three oral papillae, the more distal rectangular, bigger than proximal papilla. Arms long, about six to eight times the diameter of the disk (Figure 4b). Dorsal arm plate trapezoidal (Figure 4f). Ventral arm plate square-shaped, with distal edge rounded (Figure 4g). Two tentacle scales, the most internal robust. Lateral arm plate with four arm spines (Figure 4h). Second arm spine near the ventral arm plate, with small teeth. Color light brown to yellowish.

Remarks: Young specimens with only three arm spines, the first smaller than others.

Distribution: South Carolina, Florida, Antilles, Puerto Rico, Tobago, Curaçao, Belize and Brazil. In Brazilian coast, the species was reported in Paraíba (Gondim et al. 2008), Bahia (Alves & Cerqueira 2000), and

Rio de Janeiro (Tommasi 1970). From intertidal zone to 26 m depth (Hendler et al. 1995).

Ecological notes: This species is usually found in soft bottom (Tommasi 1970), with intermediate granulometry and high organic content (Zimmerman 1988).

Family Ophiactidae Matsumoto, 1915

Genus *Ophiactis* Lütken, 1856

*Ophiactis savignyi* (Müller & Troschel, 1842)

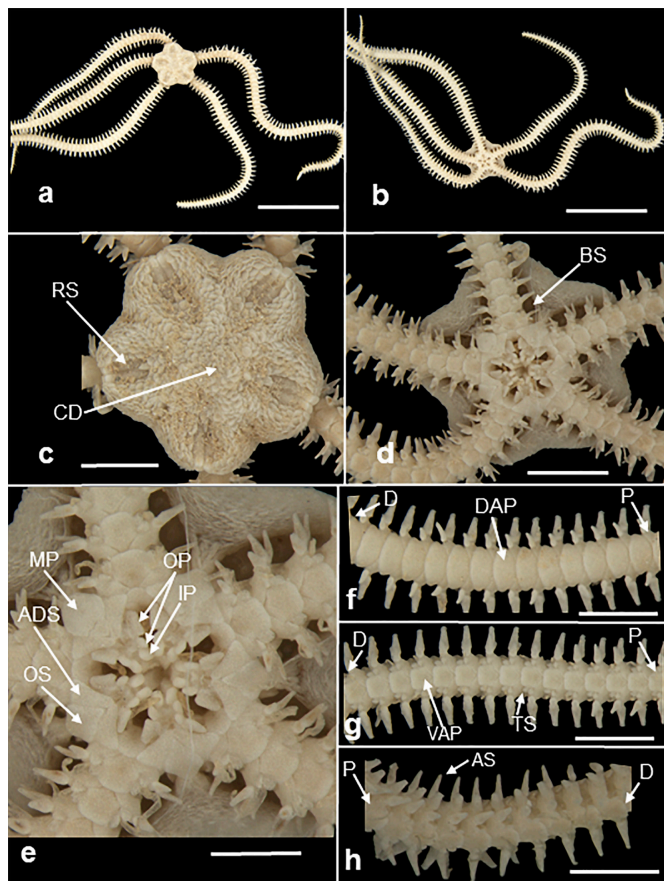
(Figure 5)

*Ophiactis krebsii*—Verrill, 1868: 366.

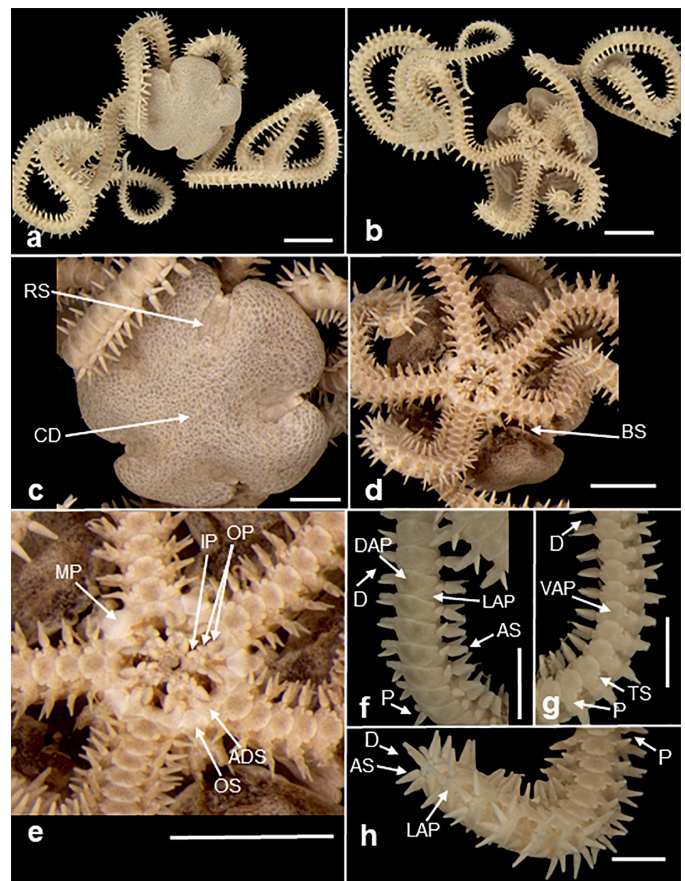
*Ophiactis savignyi*—Brito, 1960a: 4, fig.3; 1962: 2; Lima-Verde, 1969: 12; Tommasi, 1970: 24, figs.16–17; 1999; Nunes, 1975: 181; Alves & Cerqueira, 2000: 545; Magalhães et al., 2005: 63; Gondim et al., 2008: 154; Manso et al., 2008: 188, fig. 14f–h; Lima & Fernandes, 2009: 61; Oliveira et al., 2010: 6; Barboza & Borges, 2012: 9; Paim et al., 2015: 10–11; Alitto et al., 2016: 7.

Material examined: 1 specimen (UFPB.ECH-2277), Seixas Beach, Paraíba State, Brazil, depth 1.5 m; 9 specimens (UFPB.ECH-2250, 2251), Seixas Beach, Paraíba State, Brazil, depth 4 m.

Description: Disk rounded to pentagonal, covered by medium size scales, imbricated, more numerous in the center and in the interradian surface (Figure 5a). Small rough-tipped spines scattered over the disk, more



**Figure 3.** *Amphipholis januarii*. a, dorsal view of the animal; b, ventral view of the animal; c, dorsal view of the disk; d, ventral view of the disk; e, detail of the jaws; f, dorsal view of the arm; g, ventral view of the arm; h, lateral view of the arm. ADS, adoral shield; AS, arm spine; BS, bursal slit; CD, central dorsal scale; D, distal region; DAP, dorsal arm plate; IP, infradental papillae; MP, madreporite; OP, oral papillae; OS, oral shield; P, proximal region; RS, radial shield; TS, tentacle scale; VAP, ventral arm plate. Scales: a-b, 10 mm; c-d, f-h, 2 mm; e, 1 mm.



**Figure 4.** *Microphiopholis gracillima*. a, dorsal view of the animal; b, ventral view of the animal; c, dorsal view of the disk; d, ventral view of the disk; e, detail of the jaws; f, dorsal view of the arm; g, ventral view of the arm; h, lateral view of the arm. ADS, adoral shield; AS, arm spine; BS, bursal slit; CD, central dorsal scale; D, distal region; DAP, dorsal arm plate; IP, infradental papillae; LAP, lateral arm plate; MP, madreporite; OP, oral papillae; OS, oral shield; P, proximal region; RS, radial shield; TS, tentacle scale; VAP, ventral arm plate. Scales: a-b, 5 mm; c, 1 mm; d-h, 2 mm.

numerous at the edges. Radial shield large and triangular, occupying more than half the disk. They are united distally and separated by two scales proximally, the most internal more elongated (Figure 5c). Ventral surface of the disk covered by small and imbricated scales (Figure 5d). Bursal slits large. Oral shield sub-diamond shaped. Adoral shield longer than wide, more wide distally, separated proximally. Two oral papillae flattened and robust, similar in size. An apical papillae large and triangular (Figure 5e). Six arms, about five times the diameter of the disk, tapering distally (Figure 5b). Dorsal arm plate trapezoidal (Figure 5f). Ventral arm plate octagonal (Figure 5g). A flattened and large tentacle scale. Lateral arm plate with five arm spines, short and flattened. They are more robust and elongated near the dorsal arm plate. The arm spines with marginal teeth. Color olive green in the disk, with some white spots. Arms with olive green plates interspersed with white plates. Radial shields with a white spot on the distal edge.

**Distribution:** This species occurs in the Indo-West-Pacific, eastern Pacific, and Atlantic Ocean. In the western Atlantic it can be found in South Carolina, Bermuda, Puerto Rico, Gulf of Mexico, Colombia and Brazil (Hendler et al. 1995, Benavides-Serratto et al. 2011). In Brazilian coast, it was reported in Amapá, Pará, Maranhão (Albuquerque 1986), Ceará (Lima-Verde 1969), Paraíba (Gondim et al. 2008), Pernambuco (Tommasi 1970), Alagoas (Lima et al. 2011), Bahia, Rio de Janeiro (Rathbun 1879), and São Paulo (Tommasi 1970). From intertidal zone to 550 m depth (Pawson et al. 2009).

**Ecological notes:** This species occurs in hard bottoms, coral reefs, algae, and mangroves. Young specimens are found in sponges or algae (Tommasi 1970, Pawson et al. 2009).

Family Ophiocomidae Ljungman, 1867

Genus *Ophiocomella* A.H. Clark, 1939

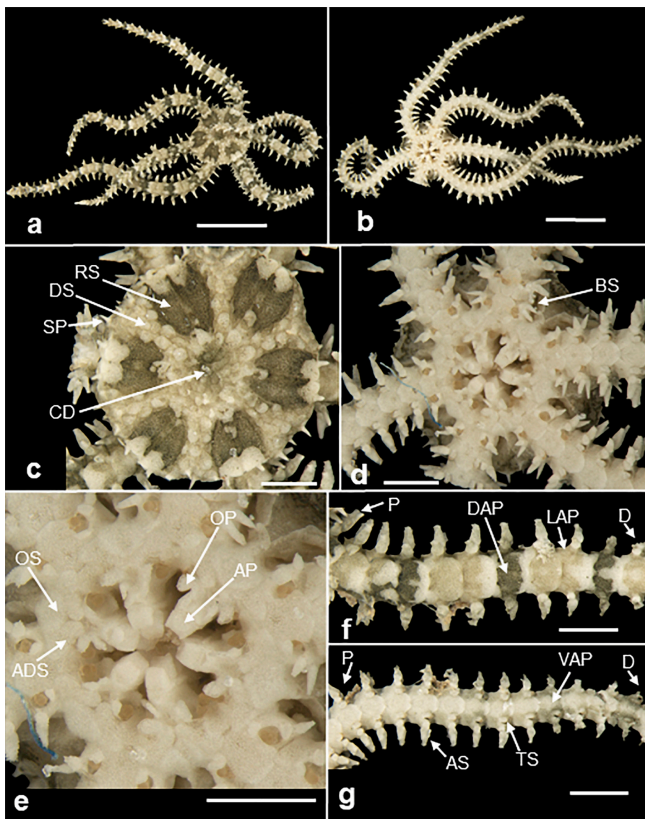
*Ophiocomella ophiactoides* (H.L. Clark, 1900)

(Figure 6)

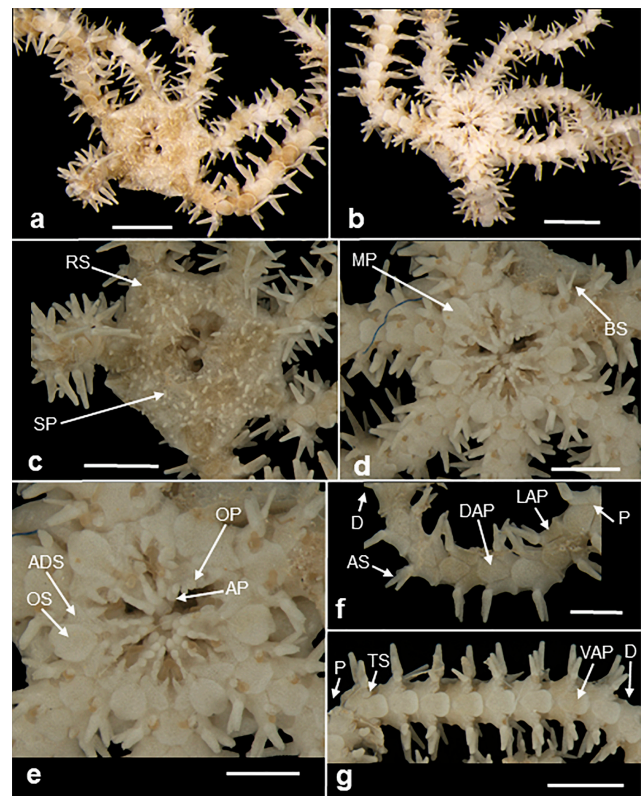
*Ophiocomella ophiactoides*—Magalhães et al. 2005: 63; Oliveira et al. 2010: 7.

**Material examined:** 2 specimens (UFPB.ECH-2255), Seixas Beach, Paraíba State, Brazil, depth 1.5 m; 1 specimen (UFPB.ECH-2254), Seixas Beach, Paraíba State, Brazil, depth 4 m.

**Description:** Disk pentagonal, covered by imbricated scales with spine-like granules (Figure 6a). Radial shields small, a little wider than long, separated by some scales and spine-like granules (Figure 6c). Ventral surface of disk covered by imbricated scales (Figure 6d). Bursal slits slender, long, from first to second or third ventral arm plate. Oral shield sub-elliptical. Adoral shield longer than wide, sub-triangular. Four flattened oral papillae and a pair of apical papillae (Figure 6e). Six arms, about three times the diameter of the disk, tapering distally (Figure 6b). Dorsal arm plate sub-pentagonal, proximal edge rounded (Figure 6f). Ventral arm plate slightly as wide as long (Figure 6g). Tentacle scale diamond-shaped. Lateral arm plate with four arm spines. That near the ventral plate longer and robust. Arm spines with small teeth. Color orange or whitish to white.



**Figure 5.** *Ophiactis savignyi*. a, dorsal view of the animal; b, ventral view of the animal; c, dorsal view of the disk; d, ventral view of the disk; e, detail of the jaws; f, dorsal view of the arm; g, ventral view of the arm. ADS, adoral shield; AP, apical papillae; AS, arm spine; BS, bursal slit; CD, central dorsal scale; D, dorsal region; DAP, dorsal arm plate; DS, dorsal scales; LAP, lateral arm plate; OP, oral papillae; OS, oral shield; P, proximal region; RS, radial shield; SP, spines of the disk; TS, tentacle scale; VAP, ventral arm plate. Scales: a-b, 5 mm; c-g, 1 mm.



**Figure 6.** *Ophiocomella ophiactoides*. a, dorsal view of the animal; b, ventral view of the animal; c, dorsal view of the disk; d, ventral view of the disk; e, detail of the jaws; f, dorsal view of the arm, oriented from the distal to proximal region; g, ventral view of the arm, oriented from the proximal to the distal region. ADS, adoral shield; AP, apical papillae; AS, arm spine; BS, bursal slit; D, distal region; DAP, dorsal arm plate; LAP, lateral arm plate; MP, madreporite; OP, oral papillae; OS, oral shield; P, proximal region; RS, radial shield; SP, spines of the disk; TS, tentacle scale; VAP, ventral arm plate. Scales: a-b, d-f, 1 mm; c, g, 2 mm.

Distribution: From Florida, Mexico, Bermuda, Puerto Rico, Jamaica, Virgin islands, Curaçao, Trinidad and Tobago, Belize, Panama, Colombia and Brazil (Hendler et al. 1995, Pawson et al. 2009). In Brazilian coast, the species was reported in Paraíba (Oliveira et al. 2010), Alagoas (Lima et al. 2011) and Bahia (Albuquerque & Guille 1991). From one to 18 m depth (Hendler et al. 1995).

Ecological notes: This species is found in reef systems (Hendler et al. 1995), usually associated with algae, inside rhodoliths.

Family Ophiodermatidae Ljungman, 1867

Genus *Ophioderma* Müller & Troschel, 1840

*Ophioderma appressa* (Say, 1825)

(Figure 7)

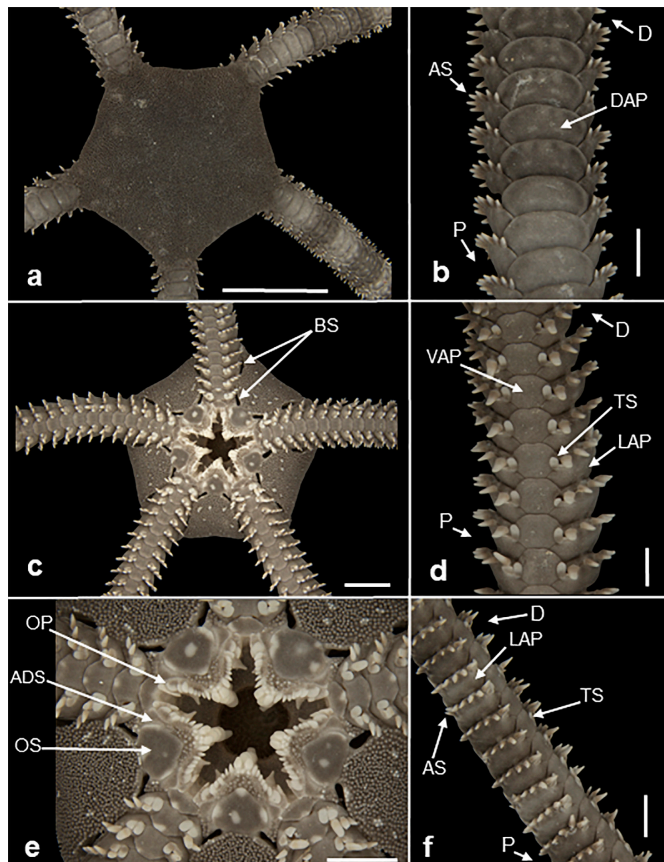
*Ophioderma appressum*—Lima-Verde, 1969: 12; Tommasi, 1999; Gondim et al., 2008: 154; Lima & Fernandes, 2009: 60.

*Ophioderma apressum*—Brito, 1962: 1, fig. 8; Alves & Cerqueira, 2000: 546; Magalhães et al., 2005: 63; Oliveira et al., 2010: 7.

*Ophioderma appressa*—Tommasi, 1970: 65, figs. 62–63. Barboza & Borges, 2012: 7; Paim et al., 2015: 12–13.

Material examined: 1 specimen (UFPB.ECH–2261), Seixas Beach, Paraíba State, Brazil, depth 1.5 m.

Description: Disk pentagonal, covered by small granules (Figure 7a). Radial shields small, covered by granules. Ventral surface of the disk covered by a thin granulation. Bursal slits short and slender, with two openings (Figure 7c). That the most proximal appear before the first



**Figure 7.** *Ophioderma appressa*. a, dorsal view of the disk; b, dorsal view of the arm; c, ventral view of the disk; d, ventral view of the arm; e, detail of the jaws; f, lateral view of the arm. ADS, adoral shield; AS, arm spine; BS, bursal slit; D, dorsal region; DAP, dorsal arm plate; LAP, lateral arm plate; OP, oral papillae; OS, oral shield; P, proximal region; TS, tentacle scale; VAP, ventral arm plate. Scales: a, 10 mm; b, d, f, 2 mm; c, 5 mm; e, 1 mm.

ventral arm plate and the more distal occur from third to fourth ventral arm plates. Oral shield diamond-shaped, rounded on the edge. Adoral shield flattened, triangular, not touching the proximal edge. Eight oral papillae, the most proximal slender, the second more proximal robust and elongated. Others gradually decrease along the length. The most distal papillae larger and flattened. Small apical papillae (Figure 7e). Five arms, about five times the diameter of the disk. Dorsal arm plate trapezoidal, proximal edge rounded (Figure 7b). Ventral arm plate squared to trapezoidal (Figure 7d). Two tentacle scales, the most internal elongated, and the external scale flattened with a slight projection at the apex. Lateral arm plate with eight arm spines, the most internal more robust (Figure 7f). Color gray to dark brown, arms with light and dark brown bands.

Distribution: From South Carolina, Florida, Mexico, Bermuda, Bahama Islands, Tortugas, Gulf of Mexico, Antilles, Belize, Panama, Colombia, Venezuela, and Brazil (Hendler et al. 1995, Laguarda-Figueras et al. 2009, Pawson et al. 2009). In Brazilian coast, the species was reported in Paraíba to Bahia (Rathbun 1879), Rio de Janeiro, São Paulo (Tommasi 1970). From intertidal zone to 364 m depth (Tommasi 1970).

Ecological notes: *Ophioderma appressa* usually occurs under rocks or in association with algae in reef ecosystems (Hendler et al. 1995).

Class Echinozoidea Leske, 1778

Order Echinozoidea Claus, 1876

Family Echinometridae Gray, 1825

Genus *Echinometra* Gray, 1825

*Echinometra lucunter* (Linnaeus, 1758)

(Figure 8a-b)

*Echinus lucunter*—Linnaeus, 1758: 665.

*Echinometra subangularis*—Rathbun, 1879: 143.

*Echinometra lucunter*—Bernasconi, 1955: 62–63; Tommasi, 1957: 29, pr. 1, fig. 1–2; Brito, 1960b: 4; 1968: 21–22; 1971: 263; Lima-Verde, 1969: 10; Alves & Cerqueira, 2000: 547; Fernandes et al., 2002: 422; Magalhães et al., 2005: 63.

Material examined: 1 specimen (UFPB.ECH–2262), Seixas Beach, Paraíba State, Brazil, depth 1.5 m.

Diagnosis: Elongate oval test with two rows of large tubercles along the ambulacra and interambulacra, pairs of pores arranged in arcs of six, and a large peristome. Spines long and slender, thickened at the base, and sharply pointed at the tips. On aboral side, primary and secondary spines dark olive green, with greenish violet to purple tips. In general, the color is blackish (Hendler et al. 1995).

Remarks. Specimen young, 3 cm in diameter (Figure 8a, b).

Distribution: Western Atlantic, from North Carolina to South Brazil (Pawson et al. 2009). In Brazilian coast, the species was reported in Ceará (Martins & Martins de Queiroz 2006), Paraíba (Gondim et al. 2008), Pernambuco to Santa Catarina (Rathbun, 1879). It is found until 45 m depth (Hendler et al. 1995).

Ecological notes: The species is usually found in hard bottoms (Tommasi 1966). It prefers exposed areas, where there are large quantities of macroalgae and food available.

Class Holothuroidea

Order Dendrochiroidea Grube, 1840

Family Phylloporidae Oestergren, 1907

Genus *Euthyonidiella* Heding & Panning, 1954

*Euthyonidiella occidentalis* (Ludwig, 1875)

(Figure 8c-i)

*Thyonidium occidentale*—Ludwig, 1875: 119.

*Phylloporus occidentalis*—Deichmann, 1930: 148.

*Euthyonidium occidentale*—Deichmann, 1938: 380; 1941:124.

*Thyonidium constituta*—Sluiter, 1910: 340; Deichmann, 1926: 124.

*Trachythyonidium occidentale*—Deichmann, 1954: 402.

*Phylloporus (Urodemella) occidentalis*—Heding & Panning, 1954: 164; Domantay, 1959: 191; Tommasi, 1969: 10.

*Euthyonidiella occidentalis*—Martins & Souto, 2015: 362–374.

Material examined: 1 specimen (UFPB.ECH-2264), Seixas Beach, Paraíba State, Brazil, depth 1.5 m.

Description: Rounded body, slightly narrow in the ends (Figure 8c). Tegument thin, smooth. Mouth and anus terminal. Tube feet numerous, small, arranged in the radii and some in interradii. Calcareous ring complex, with high radial pieces and posterior processes divided in two small pieces. Color brown. Body wall with tables of dentate margins, four large central holes and some lateral, about three in each side or two more proximal bigger than other distal tables (Figure 8g). Spire of two pillars ending in three teeth at the apex. Disk of tables from ventral region with eight or more holes and three or more spines in each side of the margin. Tube feet with supporting plates, large endplate (Figure 8h) and supporting rods (Figure 8i). Introvert with rosettes, rods and tables. Tentacles with rosettes (Figure 8d), rods (Figure 8f) and tables (Figure 8e).

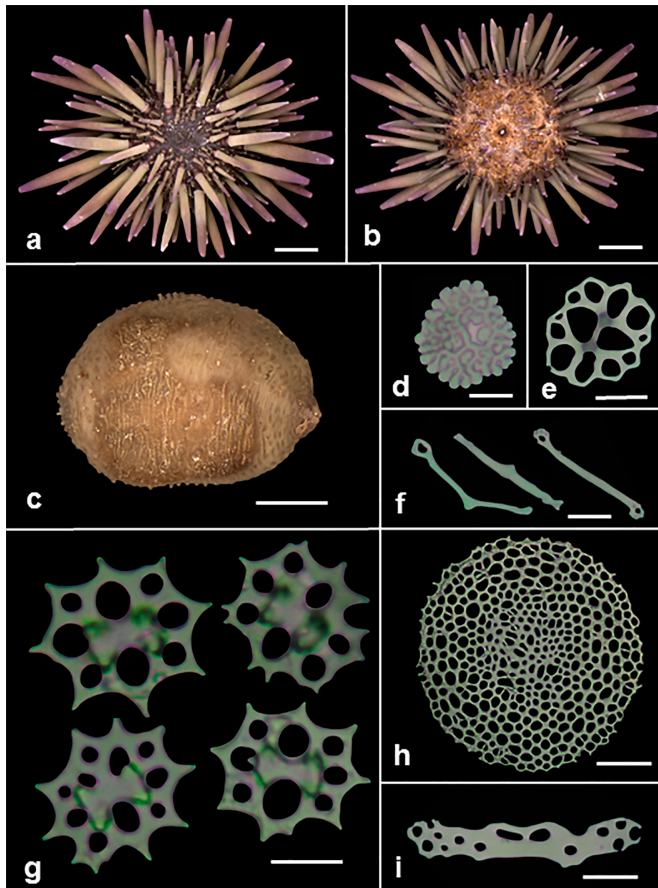
Geographical distribution: Florida, Puerto Rico, Antilles, Aruba, Trinidad, Suriname and Brazil (Hendler et al. 1995). In Brazilian coast, the species was reported in (Gondim et al. 2008), Alagoas (Miranda et al. 2012), Bahia (Deichmann 1930), Espírito Santo, Rio de Janeiro (Mondin 1973), São Paulo (Ancona Lopez 1962). It found until 45 m deep (Hendler et al. 1995). The species can be found until 99 m depth (Miller & Pawson 1984).

Ecological notes: The specimen was found in rhodoliths, but can also be found in rocks, gravel, sand and coral stones.

Genus *Stolus* Selenka, 1867

*Stolus cognatus* (Lampert, 1885)

(Figure 9a-f)



**Figure 8.** *Echinometra lucunter*. a, dorsal view of the animal; b, ventral view of the animal; *Euthyonidiella occidentalis*. c, dorsal view of the animal; d, rosette from tentacle; e, table from tentacles; f, rods from tentacle; g, tables from body wall; h, endplate from tube feet; i, rod from tube feet. Scales: a-b, 5 mm; c, 2 mm; d, f, 10 µm; e, g, i, 20 µm; h, 50 µm.

*Thyone cognita*—Deichmann, 1930: 169; Tommasi, 1969: 14.

*Thyone cognate*—Clark, 1933: 115; Mondin, 1973: 9.

*Stolus cognatus*—Caycedo, 1978: 165; Hendler et al., 1995: 275; Laguarda-Figueras et al., 2001: 33–34.

Material examined: 1 specimen (UFPB.ECH-1954) Seixas Beach, Paraíba State, Brazil.

Description: Young specimen. Body curved, with tapered ends, posterior end narrower (Figure 9a). Tegument slightly thick, rough. Mouth and anus terminal. Ten small dendritic tentacles, similar size. Tube feet arranged in double rows in the radii, larger ventrally. Calcareous ring complex, formed by small distinct pieces, posterior processes long. Color white, tentacles light brown. Body wall with numerous elongated plates, with two rows of holes (Figure 9d), sometimes perforations alternate; small buttons plate-shape with four subequal holes. Tube feet with small endplate, and supporting rods (Figure 9e), some with a third arm, and supporting plates (Figure 9f). Introvert with irregular rosettes, and large thick plates. Tentacles with rods (Figure 9c), some with holes in the ends, and rosettes (Figure 9b).

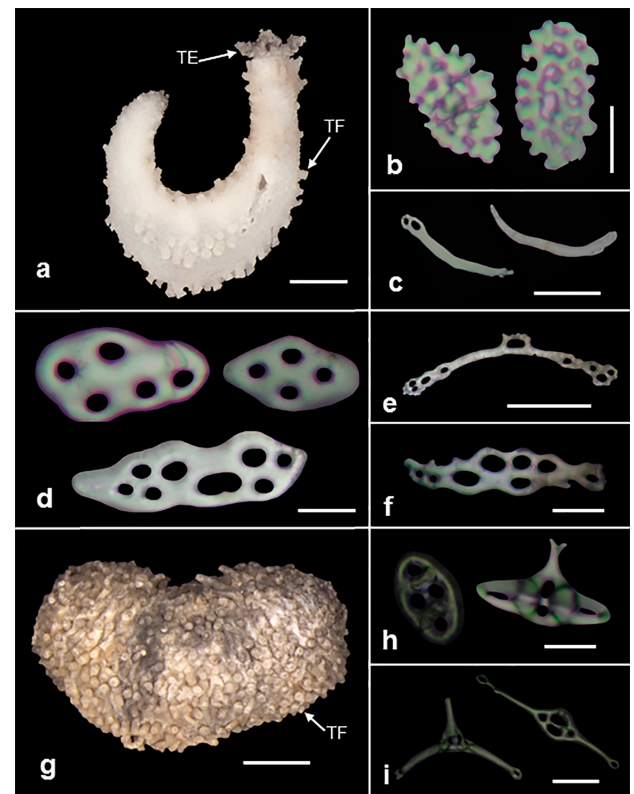
Distribution: Florida, Antilles, Venezuela and Brazil (Hendler et al. 1995). In Brazilian coast, the species was reported in Paraíba (Gondim et al. 2008), Alagoas (Miranda et al. 2012), Bahia (Deichmann 1930), Espírito Santo, Rio de Janeiro (Mondin 1973), São Paulo (Tommasi 1969). The species is found until 5 m depth (Laguarda-Figueras et al. 2001).

Ecological notes: The specimen was found inside rhodoliths. This species can be found also in coral reefs, and under rocks.

Genus *Thyone* Oken, 1815

*Thyone pawsoni* Tommasi, 1972

(Figure 9g-i)



**Figure 9.** *Stolus cognatus*. a, dorsal view of the animal; b, rosettes from tentacle; c, rods from tentacles; d, plates from body wall; e, supporting rod from tube feet; f, supporting plate from tube feet. *Thyone pawsoni*. g, dorsal view of the animal; h, tables from body wall; i, tables from tube feet. TE, tentacles; TF, tube feet. Scales: a, 2mm; b-e, 10 µm; d-e, 50 µm; f, h-i, 20 µm; g, 1 mm.

*Thyone pawsoni*—Tommasi, 1972: 19; Pawson & Miller, 1981: 397-398; Miller & Pawson, 1984: 42; Pawson et al., 2010: 30; Martins et al., 2012: 3-5.

Material examined: 1 specimen (UFPB.ECH-2266), Seixas Beach, Paraíba State, Brazil, depth 1.5 m.

Description: Short body, slightly curved (Figure 9g). Mouth and anus terminal. Tube feet elongated, numerous, scattered over the body, arranged in double rows in each end on the radii, and several tube feet in interradii, arranged into two to three rows, more abundant and bigger ventrally. Calcareous ring complex, with long posterior processes. Color light brown, with brown and white spots. Body wall with tables of disk oval, four holes and high spire of two pillars, ending in two to four teeth (Figure 9h). Tube feet with elongated supporting tables (Figure 9i), with four large central holes and one or more small holes in the ends, endplate and supporting plates with irregular holes. Introvert with tables, rosettes and plates. Tentacles with rosettes and small rods, with some perforations and sometimes prolongations.

Distribution: From North Carolina, Gulf of Mexico, Venezuela, and Brazil (Bahia) (Pawson et al. 2010, Martins et al. 2012). The species is found until 5 m deep (Laguarda-Figueras et al. 2001). It is found from 6 to 51 m depth (Pawson et al. 2010, Martins et al. 2012).

Ecological notes: The specimen was found in rhodoliths. The species also can be found buried in crevices and sand (Martins et al. 2012).

Family Psolidae Burmeister, 1837

Genus *Lissothuria* Verrill, 1867

*Lissothuria braziliensis* (Théel, 1886)

(Figure 10)

*Psolus braziliensis*—Théel, 1886: 15.

*Thyonepsolus braziliensis*—Deichmann, 1930: 192; Clark, 1933: 117; Deichmann, 1954: 401.

*Lissothuria braziliensis*—Pawson, 1967: 8-10; Tommasi, 1969: 8-9.

Material examined: 1 specimen (UFPB.ECH-2274), Seixas Beach, Paraíba State, Brazil, depth 1.5 m.

Description. Body elongate, ventrally flattened, forming a sole (Figure 10a, b, c). Tegument covered by imbricate scales, thick. Ten dendritic tentacles, with two ventral ones smaller. Mouth antero-dorsal, surrounded by numerous pointed scales. Anus postero-dorsal, surrounded by scales, small plates alternating with large plates. Five anal teeth present. Introvert short, well delimited. Tube feet from dorsal side small, covering the whole surface uniformly. Tube feet from ventral side arranged into set of four to five rows in each radius. Color light pink to white. Body wall from dorsal side with large scales (Figure 10g), with small holes and more than one network. Numerous high tables hourglass-shaped (Figure 10d, e), small tables of four pillars of reticulate structure and small perforated plates. Sole with plane plates, with irregular margins (Figure 10i). Ventral tube feet with endplate (Figure 10f), several elongated and curved supporting rods (Figure 10h, j), and irregular smooth buttons with five central holes. Tentacles with rosettes, large, flattened, perforated plates, and small plates with irregular holes and rods.

Distribution. From Antilles to Brazil (Tommasi 1969). In Brazilian coast, the species was reported in Paraíba, Alagoas (Miranda et al. 2012), Bahia (Théel, 1886), Espírito Santo (Mondin 1973). The species can be found until 5 m depth (Laguarda-Figueras et al. 2001).

Ecological notes. The species usually is found in rhodoliths and other algae.

Order Apodida Brandt, 1835

Family Chiridotidae Östergren, 1898

Genus *Chiridota* Eschscholtz, 1829

*Chiridota rotifera* (Pourtalès, 1851)

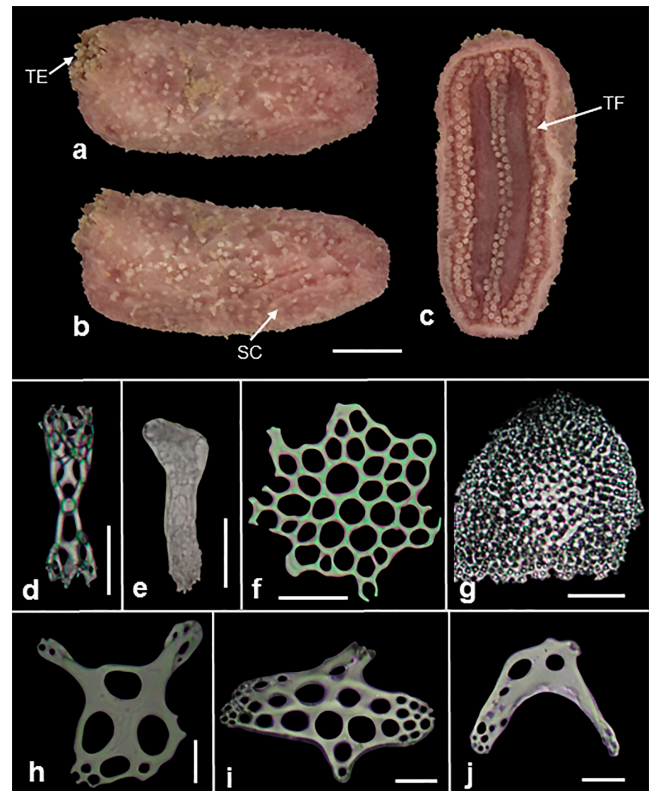
(Figure 11)

*Synapta rotifera*—Pourtalès, 1851: 15.

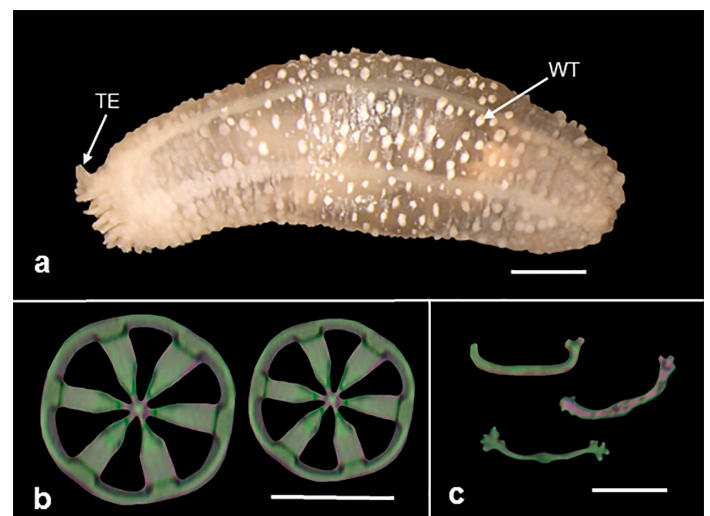
*Chiridota rotifera*—Ludwig, 1881: 41; Clark, 1907: 115; Sluiter, 1910: 341; Hedding, 1928: 293; Deichmann, 1930: 212; 1963: 112; Pawson, 1976: 381; Hendler et al., 1995: 313; Laguarda-Figueras et al., 2001: 36.

Material examined: 1 specimen (UFPB.ECH-2263), Seixas Beach, Paraíba State, Brazil, depth 1.5 m.

Description: Body cylindrical, elongated. Tegument thin, with some papillae or warts formed by agglomeration of ossicles (Figure 11a). Mouth and anus terminal. Color light pink to translucent. Body wall with



**Figure 10.** *Lissothuria braziliensis*. a, dorsal view of the animal; b, lateral view of the animal; c, ventral view of the animal; d-e tables hourglass-shaped; f, endplate; g, scales from body wall; h, j, curved supporting rods from tube feet; i, with plane plates from tube feet. SC, large scales from dorsal side; TE, tentacles; TF, tube feet. Scales: a-c, 6 mm; d-e, h-j, 20  $\mu$ m; f, 40  $\mu$ m; g, 100  $\mu$ m.



**Figure 11.** *Chiridota rotifera*. a, dorsal view of the animal; b, wheel ossicles from body wall; c, rods from body wall. TE, tentacles; WT, warts or papillae formed by agglomeration of ossicles. Scales: 2 mm; b, 50  $\mu$ m; c, 20  $\mu$ m.



wheels with six holes (Figure 11b). Small, straight to curved (C-shaped) rods in radial zones (Figure 11c). Tentacles with rods similar to those of body.

Distribution: From Florida, Mexico, Belize, Antilles, Puerto Rico, Bonaire and Brazil (Hendler et al. 1995). In Brazilian coast, the species was reported in Ceará (Martins & Martins de Queiroz 2006), Paraíba (Gondim et al. 2008), Pernambuco (Fernandes et al. 2002), Alagoas (Miranda et al. 2012), Bahia (Rathbun 1879), Rio de Janeiro (Brito 1960), São Paulo (Ancona Lopez 1957). The species occurs up to about 15 m depth (Hendler et al. 1995).

Ecological notes: The species can be found buried in the sand, under rocks, in coral reefs, rhodoliths and sponges (Hendler et al. 1995).

## Discussion

The Seixas Beach has a diverse echinoderm fauna, with species of Ophiuroidea and Holothuroidea being most abundant. The species recorded here were similar to those recorded from the Cabo Branco beach (Gondim et al. 2008), an area adjacent to the Seixas Beach. We found eight of the species previously recorded from Cabo Branco Beach. Another area from the State of Paraíba, Areia Vermelha, has also been inventoried for its echinoderm fauna (Gondim et al. 2011), but only four species were recorded additionally at Seixas. The species *Ophiocomella ophiactoides* was found only at the Seixas Beach. *Amphipholis januarii* Ljungman was the most abundant species, with 34 specimens.

The species inventoried from rhodoliths of the Seixas Beach were recorded in other areas of Northeastern coast: in Ceará, by Martins & Martins de Queiroz (2006); in Pernambuco, by Lima & Fernandes (2009); in Alagoas, by Lima et al. 2011 and Miranda et al. (2012); and in Bahia, by Alves & Cerqueira (2000), Magalhães et al. (2005), Manso et al. (2008) and Paim et al. (2015). These species also occur in the Caribbean Sea. Thus, the echinoderm fauna of the Seixas Beach presents tropical species, usually found in shallow waters and with a large distribution in the Tropical Atlantic Marine Province.

Rhodolith beds provide refuge for very small species of marine invertebrates (Schermer et al. 2010). The results show that these biogenic structures are an important habitat for young specimens and some small species of Echinodermata. *Lissothuria braziliensis* has been found only rarely in other substrata. The small species *Pentamera paraibanensis* Prata & Christoffersen, 2016 was also found inside rhodoliths (Prata & Christoffersen 2016). The fauna associated with rhodoliths needs more research in order to know what species live there, and if these species complete their life cycle in these structures or if the species spend only part of their life in rhodoliths and then explore other environments.

According to the analyzed material, *Amphipholis januarii* and *Microphiopholis gracillima* are represented by young and mature species. This suggests that these species have part of their life cycle in rhodoliths in this environment. Usually, both species are found buried in mud or sand (Hendler et al. 1995). *Ophioderma appressa* usually lives under rocks, and the specimen found is a young form. The small species *Amphipholis squamata*, *Ophiactis savignyi* and *Ophiocomella ophiactoides* seem to spend their life cycle in the rhodoliths. Usually these species are common in association with algae, among its leaves (Hendler et al. 1995, Benavides-Serrato et al. 2011). The found specimen of Echinoidea represents a young individual; these animals usually build holes in hard substrata.

Small dendrochiroitids holothurians *Lissothuria braziliensis* and *Thyone pawsoni* seem to prefer to live in rhodoliths and can pass the whole life cycle in these structures. The specimens of *Euthyonidiella occidentalis* and *Stolus cognatus* are young; this can suggest that these species have a part of their life cycle inside rhodoliths. This substrate can provide protection and easy access to food, ensuring species survival in the initial

ages. The species *Chiridota rotifera* presents viviparity and inhabit several kinds of substrates (Hendler et al. 1995, Laguarda-Figueras et al. 2001). Probably this species also passes the whole life cycle inside these rhodoliths and may reproduce there.

Most species were found at depths of 1.5 m. The species *Amphipholis squamata*, *Amphipholis januarii*, *Ophiactis savignyi* and *Ophiocomella ophiactoides* were observed at both depths, 1.5 m and 4m. *Microphiopholis gracillima* (Stimpson, 1854) was found only while sampling at 4 m. In general, these species have a wide bathymetric distribution; however, the species recorded at 1.5 m seems to prefer shallower waters.

Shallow reef ecosystems are threatened environments due to various interferences resulting from human activities (Leão et al. 2003). The area of Cabo Branco and Seixas beaches is utilized for fisheries and tourism. Tourists walk over the fauna and collect souvenirs. Residents modify the natural scenery by buildings on the waterfront, mainly for commercial activities and in an attempt to control coastal erosion (Costa et al. 2007). Sustainable exploitation and management of resources in marine and coastal areas depend heavily on adequate scientific knowledge of the physical, chemical and biological processes in the oceans and their interactions with coastal areas (Awozika & Marone 2000). Studies should thus be encouraged towards inventorying the entire fauna of echinoderms and other marine invertebrates of the Seixas Beach. Surveys of species should be conducted in other substrata as well as the rhodoliths. This study shows the need for further research in the area and the importance of rhodoliths for the survival of some species of Echinodermata.

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## Author Contributions

J.P. contributed substantially in the conception and organization of the work, in the acquisition, analysis, and interpretation of the data and in the writing of the manuscript. D.A.C. contributed in data acquisition, collection of specimens and drafting of the work. C.L.C.M. contributed to the analysis, and interpretation of data and in critical reviewing the paper, adding intellectual content. M.L.C. contributed in critically reviewing and adding intellectual content, being responsible for the English text; finally, M.C.C. contributed to critical review and the adding of intellectual content.

## Conflicts of interest

The authors declares that they have no conflict of interest related to the publication of this manuscript.

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