

REVIEW OF *CALLISTOCHITON RIGHII* FROM BRAZILNATÁLIA G. DO NASCIMENTO¹, RAFAELA C. MAIA¹, SERGIO M. ALMEIDA² & JAIME A. JARDIM³¹Instituto Federal do Ceará, Laboratório Ecologia de Manguezais (Ecomangue), Av. Desembargador Armando de Sales Louzada, s/n, Monsenhor Edson Magalhães, Acaraú – CE, 62580–000.²Museu de Arqueologia e Ciências Naturais, Programa de Pós-Graduação em Desenvolvimento de Processos Ambientais, Escola de Saúde e Ciências da Vida, Universidade Católica de Pernambuco, R. do Príncipe, 526 – Boa Vista, Recife – PE, 50050–900.³Museu de Zoologia da Universidade de São Paulo, Universidade de São Paulo, Av. Nazaré, 481 – Ipiranga, São Paulo – SP, 04263–000.

Abstract *Callistochiton righii* is reviewed based on preserved specimens collected in northeastern Brazil. A complementary description based on detailed anatomical data is presented and comparisons with other local species are provided. Its distribution is extended about 2,200km northward and about 1,000km southward compared to the previously known range.

Key words Callistoplacidae, morphology, distribution, Brazil

INTRODUCTION

The family Callistoplacidae Pilsbry, 1893 comprises four genera (*sensu* Sirenko, 2006) and about 47 valid species (Kaas & Van Belle, 1994). Callistoplacids generally have a medium to large-sized elongate-oval body, living at depths of 0–340m. They can be characterised by a tegmentum that is strongly sculptured by radial ribs on all valves, especially valve i, the lateral areas of valves ii–vii, and postmucronal area of valve viii; and the presence of slits between the insertion plates that agree in number and position with the radial ribs (Kaas & Van Belle, 1994).

Currently, there are nine callistoplacids species in the Western Atlantic, seven of which occur in Brazil. Within the genus *Callistochiton* three species are reported from the Brazilian coast: *C. porosus* Nierstrasz, 1905 recorded from Rio de Janeiro State in the Southwest, *C. laticostatus* Kaas & Van Belle, 1994 and *C. righii* Kaas & Van Belle, 1994 reported from Pernambuco State, northeastern Brazil (Kaas & Van Belle, 1994).

Except for new records from Brazil, no additional information on *Callistochiton righii* has been published since the original description (Simone & Jardim in Rios, 2009). In this study, we present a detailed review of *C. righii*, with novel data on the external and internal morphology of the species and an updated distribution.

MATERIALS & METHODS

A specimen of *Callistochiton righii* was collected at Praia da Pedra Rachada (03°23.95'S 039°00.76'W), in Paracuru Municipality on the northeastern Brazilian coast. This locality harbors an intertidal zone formed by sandstone reef (Sousa *et al.*, 2008), with tide pools, pebbles, small rocks covered by different species of algae, and a horizontal tidal retreat of ca. 80m (Mathews-Cascon *et al.*, 2006). The specimen was found in the intertidal zone in January 2017. It was measured and preserved in 70% ethanol. SEM analysis, photographs, and map drawing follow Jardim *et al.* (2017). The additional material (see material examined) were based on deposited specimens in malacological collection of the Museum of Zoology, Sao Paulo (MZSP) and samples with sequential identification based on Kaas & Van Belle (1994). Specimens were photographed using Zeiss Stereo microscopy with Autofocus AxioVision and using SEM.

The taxonomy and nomenclature of the morphological structures follow Sirenko (2006) and Schwabe (2010), respectively. Additional anatomical nomenclature follows Jardim & Simone (2010).

SYSTEMATICS

Callistochiton righii Kaas & Van Belle, 1994
(Figs 2–25)

Type material Not examined.

Material examined MZSP 25847, 1 spm (4.8mm×2.7mm), Off Uaçá, Amapá State, Brazil,

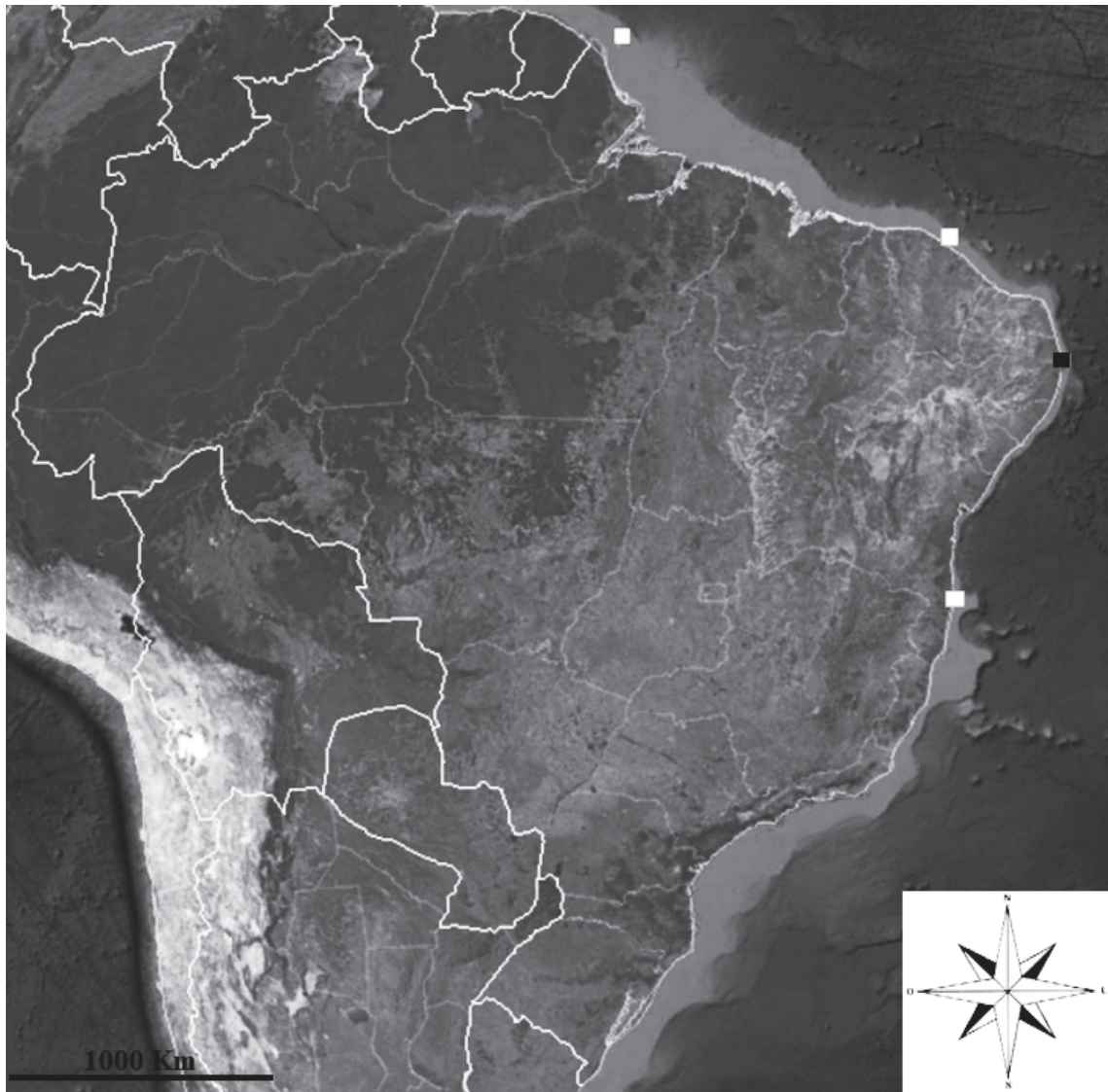


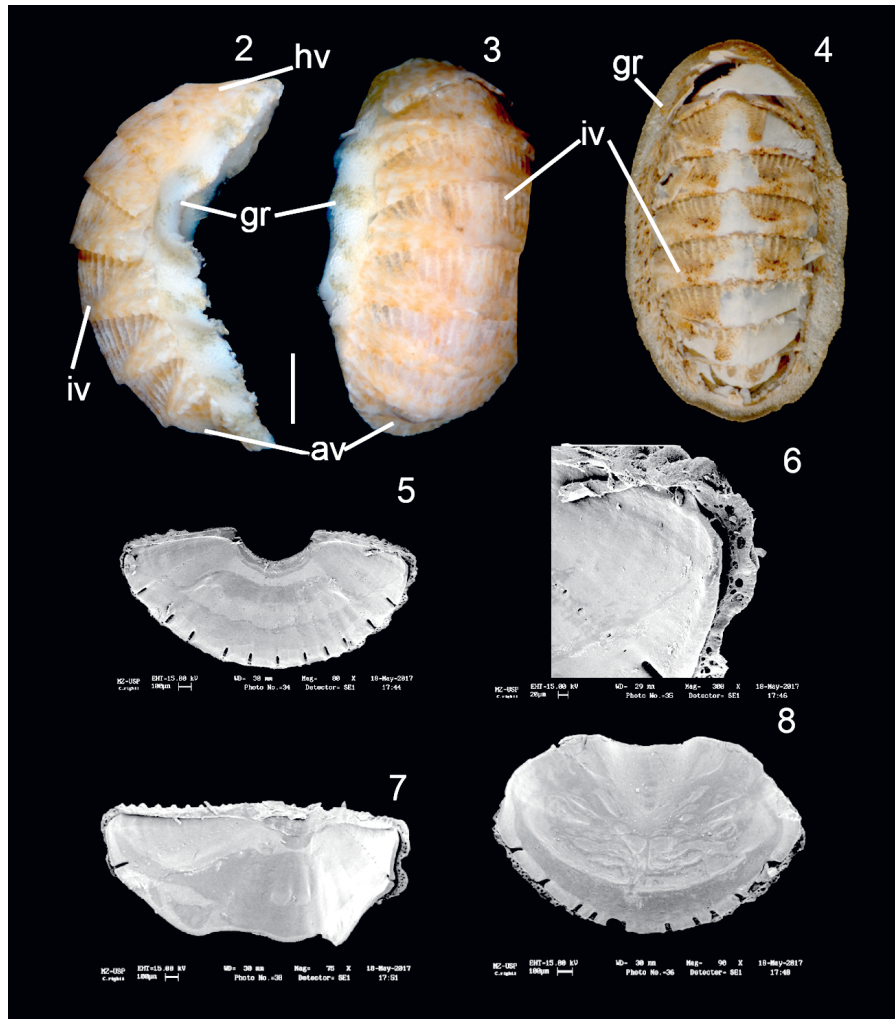
Figure 1 *Callistochiton righii* collection localities

Akaroa N-I "Almirante Saldanha", 04°08'N 50°35'W, depth 52m, 70% EtOH, articulated (damaged); MZSP 47366, 1 spm (4.7mm×2.7mm), Praia da Coroa vermelha, Parcel de Coroa vermelha, Santa Cruz de Cabralha, Bahia State, Brazil, 16°19'S 39°00'W, 70% EtOH, dissected; MZSP 87373, 1 spm (4.5mm×2.6mm), Brazil, ethanol 70%, damaged; MZSP 87395, 1 spm (4.5mm×2.7mm), Itamaracá, Pernambuco State, Brazil, ITA-17, 07°44'96"S 34°49'88"W, 70% EtOH, articulated; MZSP 122667, 1 spm (4.3mm×2.7mm), Praia da Coroa vermelha, Parcel de Coroa vermelha, Santa Cruz de Cabralha, Bahia State, Brazil, 16°19'S 39°00'W, 70% EtOH, dissected; IFCE-Acaraú, 1 spm, Paracuru, Ceará State, Brazil, Ponto 02, 03°24'S 39°01'W, 70% EtOH, articulated.

Type locality Brazil, Pernambuco State, Cabo de Santo Agostinho municipality, Suape beach, intertidal, coll. S. L. Pinto and R. L. Silva MMUP (not examined).

Diagnosis See Kaas & Van Belle, 1994: 134.

Complementary diagnosis Length 4.3–4.7mm, width 2.6–2.7mm; body highly elevated (height 1.6–1.7mm); colour varying from light yellowish to uniformly cream and green. Sculpture on valves prominent; edge spongy; periostracum fold convex on median area of the valves; lateral area with two ribs covered by numerous randomly distributed pustules, margin of valves crenulated; Perinotum covered by dorsally arched scales (length 40 µm to 80 µm; width



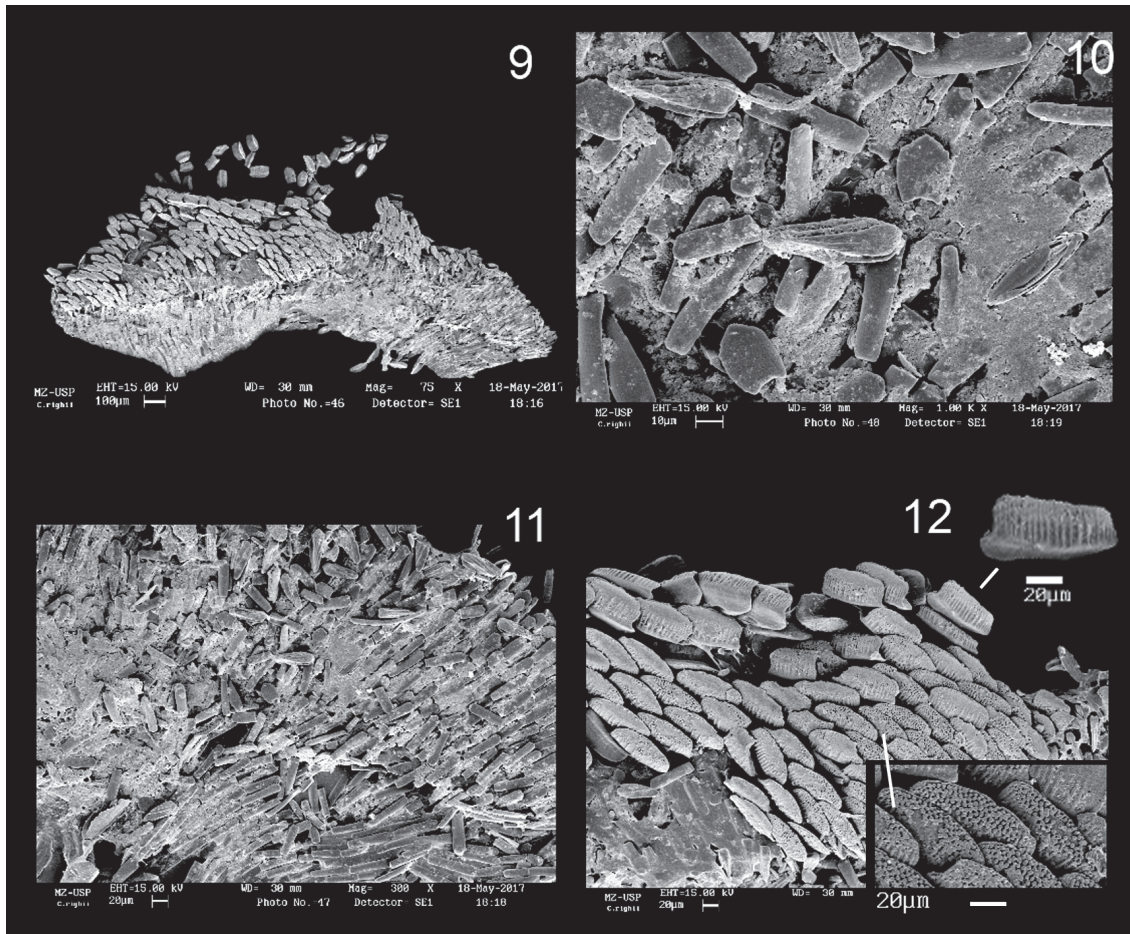
Figures 2–8 *C. righii*, 2–3 (MZSP 47366) – (length – 4.7mm×width – 2.7mm), 4 (MZSP 25847) (length – 4.8mm×width – 2.7mm), dorsal and lateral views, scale 1mm; 5 valve i, ventral view, scale 100 μ m; 6–7 valve v ventral views, scale scales 20 μ m end 100 μ m, respectively; 8 viii, ventral view, scale 100 μ m.

80 μ m to 120 μ m) bearing two distinct sculpture elements, dorsally covered by parallel ribs, and presenting randomly-distributed pustules on distal margin; fringe with triangular scales (length 30-40 μ m, width 10-15 μ m) sculptured by commarginal growth lines; hyponotum covered by scales (length 35-45 μ m, width 90–120 μ m). Radula with major lateral teeth presenting shaft on middle portion of stem, head tricuspid; minor lateral teeth slightly beaked; central tooth three times larger than lateral teeth, rounded; major uncinial tooth fused on dorsal surface of major lateral teeth (Fig. 26).

Complementary description Shell yellowish to green; sculpture strongly marked by radial grooves, mainly on valve i, lateral area of valves ii-vii and postmucronal area of valve viii; margins

spongy (Figs 2–4). Valve i entirely sculptured by randomly distributed pustules, not beaked; valves ii-vii with lateral area presenting crenulated hind margin and conspicuous diagonal ridge (Figs 3–4).

Girdle Perinotum scales sculptured by 11 to 25 longitudinal parallel ribs on dorsal surface, distal margin sculptured by randomly arranged nodules, smooth ventrally, insertion smooth. Fringe covered by triangular scales that have a convex base and the apex is a rhomboid shape, medially sculptured by commarginal growth lines; insertion margin and distal margin of scales of Hyponotum straight, generally equivalent on whole extension, but some may show base slightly wider than long (Figs 2–3, gr).

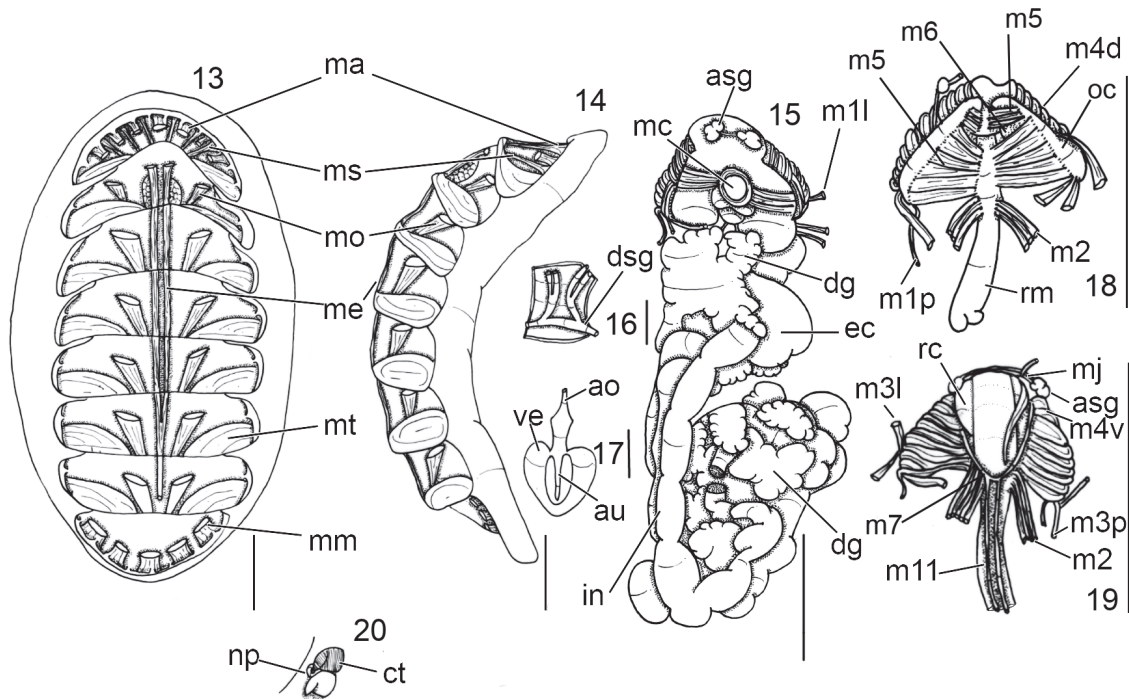


Figures 9–12 *C. righii* girdle with scales of the perinotum (MZSP 87373); 9, scale 100µm; 10, scale 10µm; 11–12 scale 20µm.

Main muscle systems Pre-oral muscle bundle square-shaped; origin in **m11**, insertion at lower portion of valve **i**; located between the **ma**; formula 3+1+3 (straight muscle used as reference); (Fig. 13–14, **ma**). Straight oral muscle bundle four to five times longer than wide, homogeneous in shape (origin and insertion with similar size); origin from **m11** and inserting on lower side of **mt**; located between muscle bundles of **ma**; formula 3+3 (number of muscle bundles) (Fig. 13–14, **ma**). Transverse muscle thrice as wide as long, elliptic; origin at **m11**, insertion at opposite side of **m11**; formula 1; (Fig. 13, **mt**). Oblique muscle three times as long as wide; origin at **mt**, insertion at ventral surface of valves **ii**–**vii**; located between **mt** and **ms**; formula 1+1 (Fig. 13–14, **mo**). Straight muscle rectangular; origin at valve **ii**, insertion at valve **vii**; located at median portion of dorsal animal surface; formula 1+1, fused in a single bundle in valves **vi**–**vii** (Fig. 13, **ms**). Tail muscle squared; origin at **m11**, insertion

at distal edge of valve **viii**; formula 2+1+2 (Fig. 13, **mi**).

Digestive system Odontophore trapezoid; located inside buccal sac. Buccal dilator muscle rectangular; origin at haemocoel wall, insertion at odontophore; located at valve **i**; formula 2+2 (radular ribbon used as reference) (Fig. 18, **rm**;21). Radular muscle elliptic, origin at ventral surface of radular ribbon, insertion at middle portion of valve **ii**; formula 1+1 (Fig. 18–19, **m2**). Protractor muscle of buccal mass rectangular; origin at haemocoel wall, insertion at lateral surface of odontophore; located between valves **i**–**ii**; formula 2+2 (Fig. 18–19, **m3l**, **m3p**). Dorsal tensor of radula muscle bundle located at anterior region of odontophore three times smaller than posterior portion; rectangular; uniform; solid and opaque; covering ca. 30–35% of odontophore inner volume; located transversely to radular ribbon; slotted on dorsal-marginal



Figures 13–20 *C. righii* anatomy 13–14 main muscular systems, scale 1mm; 15 digestive system, scale 1mm; 16 dorsal salivary gland, scale 0.5mm, 17 heart, scale 0.5mm; 18–19 odontophore and buccal mass, scale 1mm; 20 kidney pore, scale 0.5mm.

portion of odontophore cartilage; covering the lateral side of odontophore cartilage; origin at dorsal region of odontophore cartilage and insertion at lateral region of same structure (Fig. 18, m4d). Auxiliary tensor of radula muscle bundle located at anterior region of odontophore a third smaller than bundle located at posterior portion; uniform; solid and opaque; covering ventral side of odontophore cartilage occupying ca. 10–15% of odontophore volume; located immediately above m4d; spreading along third quarter of ventral surface of odontophore cartilage, from inner to intermediate surface; connecting to radular ribbon on ventral side of odontophore cartilage (Fig. 18–19, m5). Horizontal muscle square-shaped single muscle bundle, uniform, solid, and opaque; covering ca. 6% of ventral surface of odontophore cartilage, horizontally oriented, connecting both cartilages, narrower anteriorly (Fig. 18, m6). Narrower long muscle presenting a simple pair of bundles, rectangular, uniform, solid and opaque; covering ca. 1% of odontophore cartilage, longitudinally oriented; located at ventral surface of odontophore cartilage; origin at anterior region of odontophore, extending toward final portion of radular sac, insertion at inner surface of membrane (Fig. 19,

m7). Odontophore cartilage three times as long as wide, elliptic, translucent, light cream; covering ca. 30–35% of odontophore volume; simple pair; smooth (Fig. 18, oc).

Radula Rachidian tooth elongated, with upper side presenting a narrow region close to distal margin. Major lateral tooth presenting an elongated shaft, head convex dorsally. Major uncinial tooth fused on dorsal wall of major lateral tooth, with base three to four times wider than apex, apex rounded. First, second and marginal uncinial teeth with sigmoid outer side (Figs 22–26).

Esophagus Triangular, translucent, light cream colour, occupying ca. 40–45% of digestive system volume; simple sac connected anteriorly to buccal mass and posteriorly to intestine (Fig. 15, ec). Intestine circular and not uniform throughout its extension; translucent, light cream coloured; occupying ca. 60–65% of digestive system volume, with distinctly oriented loops (Fig. 15, in).

Rectum width homogeneous along its extension, fecal pellets not observed. Origin at descendent portion of intestine, from right side to middle portion of visceral mass.

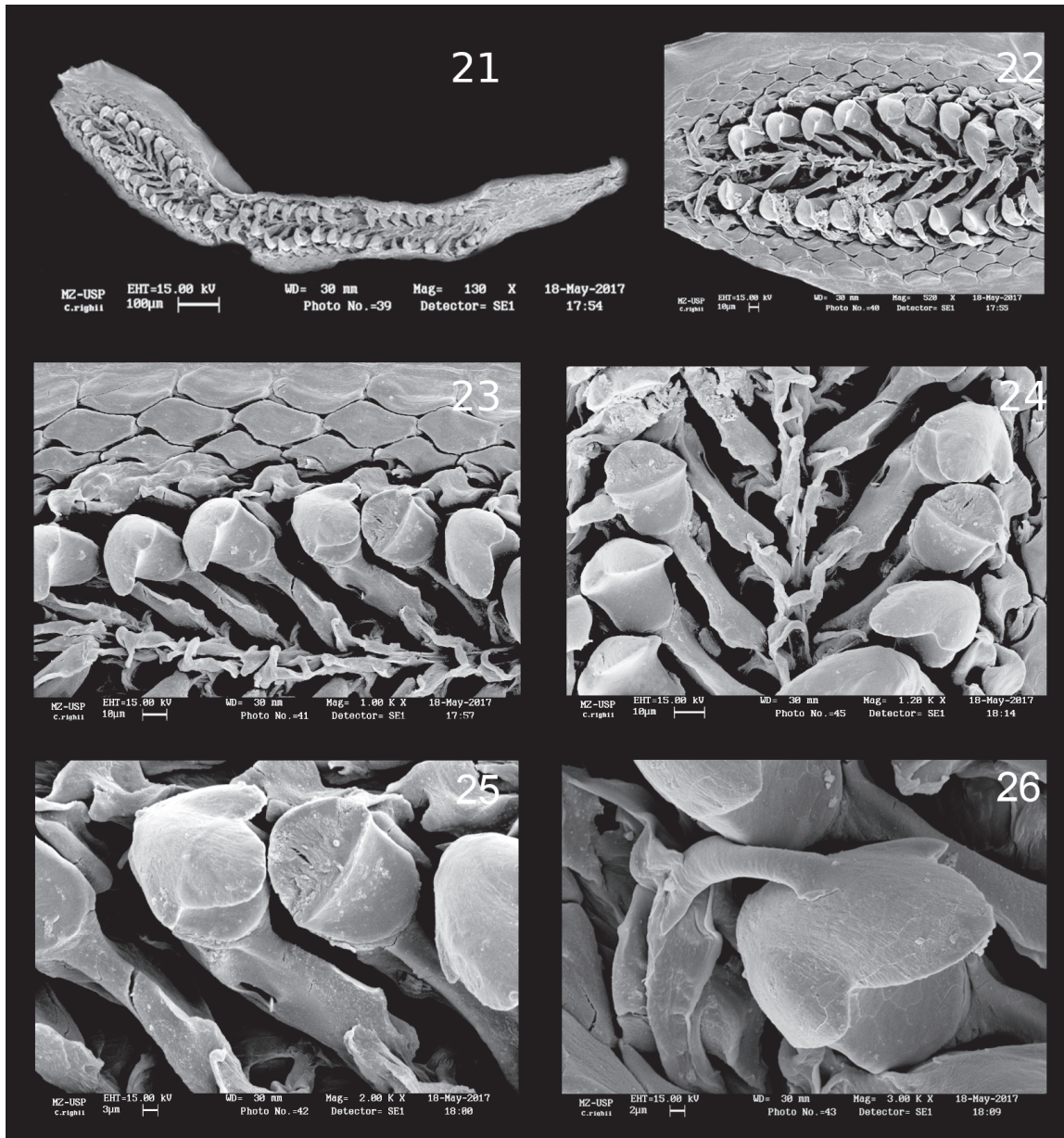


Fig. 21–26 *C. rightii* radula in SEM, (MZSP 87373), 21 panoramic view, scale 100µm; 22–24 central tooth, first lateral teeth, major lateral teeth, scale 10µm; 25 major lateral teeth, scale 3µm; 26 major uncinial teeth fused to major lateral teeth, scale 3µm.

Excretory system Kidney twice as wide as long, elliptic, solid and opaque, cream-coloured, longitudinally oriented, located on subcentral surface of dorsal wall of body. On pericardium membrane, anterior to auricles, present as a simple pair on each side, smooth. Kidney anteriorly connected to collector duct of kidney, uniform along its extension, transparent, cream-coloured, longitudinally oriented; extending from kidney to valve iii; presenting a simple pair for each kidney, smooth. Kidney pore not elevated (Fig. 20, np).

Genital system Gonad three to four times longer than wide, uniform, solid and opaque; cream-coloured; covering about 25–30% of total visceral mass; smooth; connected to dorsal wall of hemocoel and extending to dorsal surface of visceral mass, posterior portion touching pericardium on anterior portion, about third part of membrane.

Circulatory system Heart with ventricle three times longer than wide, elliptic, elongated longitudinally, translucent, covering about 20–25% of heart surface, longitudinally oriented and located

at median line of the body; presenting two main triangular expansions on anterior portion, connected anteriorly to aorta. Auricles anterior area, close to connection with ventricle, more dilated than posterior portion, translucent, occupying ca. 20–25% of total heart volume, surrounding the ventricle homogeneously; as a simple pair, connected to ventricle at middle portion of ventricle (Fig. 17, ve, au, ao).

Distribution Brazilian coast, Off Uaçá, Amapá State, 04°08'N 50°35'W to Parcel de Coroa Vermelha, Santa Cruz de Cabralha, Bahia State, 16°19'S 39°00'W, varying from intertidal zone to depth of 52m (Fig. 1).

DISCUSSION

Unfortunately, it was not possible to compare the material analysed here with the types deposited at MMUP, since the institution's team did not respond to our attempts at contact. Thus, the material was compared with the original description, as well as published figures of the types. The size of the specimens studied herein compares well with the original description, but the elevation is slightly different, varying from 1.6–1.7mm.

Comparison with other species

The colour reported for *C. righii* in the original description can be verified in our specimens, but a new green-coloured variant is reported herein. The periostracum sculpture was originally described as evenly quincuncially granulated, or nodulosus, Kaas & Van Belle (1994), in the unique holotype specimen that was only 4.7mm length, but this specific pattern was not observed in our specimens. In this case, whether the valve sculpture comprising nodules might be interpreted as reminiscent of juvenile stages, the holotype was probably described based on a juvenile specimen.

The perinotum in *C. righii* is covered by scales, which present two different sculpture patterns themselves. They are dorsally covered by 11–25 parallel longitudinal ribs, and randomly organised nodules of similar size cover the anterior portion. Some species in the same genus present similarly distributed nodules, and their presence could be taxonomically important if confirmed in future analyses on *Callistochiton*.

Differing from the original description published by Kaas & Van Belle (1994), the crenulated hind margin in valves ii-vii was verified herein, as well as a diagonal ridge between the lateral and pleural areas. However, commarginal growth lines, when present, are shallow. On the ventral side of the valves, the slit ray in valve i does not cover the marginal region of the periostracum fold, as detected in species of the same genus and non-congeners in the same family. On valves ii-vii, a simple slit ray immediately under the diagonal ridge region is present, differing from other congeners, which present slit rays covering the periostracum fold as well as the jugal area. Finally, valve viii presents a slit ray convergent from the slit of the insertion plate to the mucro.

Comparing with congener species from Western Atlantic *Callistochiton righii* is smaller and highly elevated while *C. shuttleworthianus* Pilsbry, 1893 is larger and rather depressed. About the shell the head valve in *C. righii* is sculptured by radial grooves; intermediate valves with lateral area sculptured by two weakly radial ribs; tail valve with mucro submedian, not prominent while *C. shuttleworthianus* presents head valve sculptured by radial nodulous ribs; intermediate valves with two strong and nodulous radial ribs; tail valve with mucro roughly central and prominent. Girdle in *C. righii* presents perinotum covered by scales sculptured on distal margin by randomly arranged nodules, hyponotum might have some scales that are slightly wider than they are long. In contrast, *C. shuttleworthianus* presents perinotum with scales carved on the distal margin with smooth to obsolete pustules and hyponotum covered by rectangular scales. The radula in *C. righii* presents elongate rachidian tooth; major lateral tooth tricuspid while *C. shuttleworthianus* has oblong rachidian tooth and major lateral tooth unicuspid.

In relation to Brazilian species *C. righii* is smaller than *C. porosus* Nierstrasz, 1905. In relation to head valve *C. righii* presents radial grooves in sculpture; intermediate valves with lateral area raised and sculptured by two weakly radial ribs; tail valve with mucro submedian and not prominent, postmucronal area sculptured by radial grooves while *C. porosus* presents head valve sculptured by highly elevated radial ribs; intermediate valves with lateral areas strongly raised and sculptured by two elevated, nodulose

radial ribs; tail valve with mucro about central and pointed, postmucronal area sculptured by highly elevated ribs. Girdle in *C. righii* presenting the scales of perinotum sculptured by 11 to 25 longitudinal ribs; hyponotum covered by rectangular scales while *C. porosus* presents perinotum covered by scales sculptured by longitudinal grooves; hyponotum presenting scales with distal edge rounded. The radula of *C. righii* is composed of major lateral teeth tricuspid while *C. porosus* presents bicuspid major lateral teeth.

Callistochiton righii is smaller than *C. portobelensis* Ferreira, 1976. Head valve with convex front slope, sculpture formed by radial grooves; intermediate valves not beaked, lateral area raised; tail valve semicircular, postmucronal area concave while *C. portobelensis* presents valve i with front slope straight, sculpture formed by ribs; intermediate valves with beak inconspicuous, lateral area moderately raised; tail valve triangular, postmucronal area from depressed to straight. Girdle, perinotum in *C. righii* presents strongly curled scales while the perinotum of *C. portobelensis* presents weakly imbricating, somewhat cylindrical scales. Radula in *C. righii* with rhachidian rectangular; minor lateral tooth narrower with blade on distal edge curved to posterior portion of radular ribbon; major lateral tooth tricuspid while *C. portobelensis* presents wider rhachidian tooth, minor lateral tooth more or less rectangular; major lateral tooth unicuspid.

Comparing with *C. laticostatus* Kaas & Van Belle, 1994, *C. righii* presents in valve i with front slope sculptured by radial grooves; intermediate valves not beaked, lateral area presenting low radial ribs; tail valve semicircular, mucro submedian, antemucronal area convex, postmucronal area sculptured by radial grooves while *C. laticostatus* presents in valve i sculpture formed by radial ribs; intermediate valve with apex inconspicuous, lateral area sculptured by radial ribs; tail valve semi-oval, mucro postmedian, antemucronal area weakly concave, postmucronal area sculptured by radial ribs.

Regarding the muscle systems, our observations compare well with Wingstrand's (1985) general description, showing a similar composition. The straight muscle observed here corroborates Wingstrand's notes, about *Acanthopleura brevispinosa* and *Leptochiton asellus*. However, in our specimens, it differs in the origin, which starts in valve ii. Our specimens also present

fused muscle bundles in the region of valve vi, extending toward valve vii as a single structure. The transverse muscle in our specimens differs in structure, presenting itself as independent (not fused) large bundles connected by smaller bundles. The oblique muscle origin in our specimens is located under the **me** muscle, with the insertion located at the elliptic region. The lateral longitudinal muscle is identical to Wingstrand's report. According to Wingstrand (1985), the palial muscle should be found on the anterior edge of **mt** inserting under the distal edge of apophyses, but it could not be found in our specimens, much like the pedal retractor muscles.

About the reproductive system of *Callistochiton righii*, we could not detect different sexes in the analyzed specimens, as observed in Barbosa *et al.* (2009). That author analysed species of *Acanthopleura gemmata* (Blainville, 1825), which belong to the same suborder (Sirenko, 2006), and indicated gonads of different colours for males and females.

The original description based on only the holotype reported *C. righii* as restricted to Suape, in Brazil's Pernambuco State. Based on the specimens deposited in the Museu de Zoologia da USP and IFCE – Campus Acaraú, the distribution is extended herein ca. 2,208km northward to Amapá State, and ca. 1,009km southward to Bahia State. The vertical distribution is updated from the intertidal zone to a maximum depth of 52m.

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