A new species of *Chlamydoconcha* Dall, 1884, from southeastern Brazil (Bivalvia: Chlamydoconchidae)

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ABSTRACT

The second species in the genus *Chlamydoconcha* is described. *Chlamydoconcha avalvis* new species, occurs off the coast of Rio de Janeiro coast, in southeastern Brazil. The new species has very reduced valves and a mantle surrounding the entire body, two features of the genus. The outer surface of the mantle lacks papillae except for a single one located close to the excurrent siphon. These are distinctive characters of *Chlamydoconcha orcutti* Dall, 1884, from the eastern Pacific coast of North America, the single other known species of the genus. Some of the more interesting anatomical characters of the new species are: posterior pair of retractor muscles of foot free from valves, absence of adductor muscles, gastric style sac totally separated from intestine, and the presence of a single (excurrent) siphon.

Additional keywords: Anatomy, western Atlantic, Rio de Janeiro

INTRODUCTION

The genus Chlamydoconcha Dall, 1884 (type species by original designation: *C. orcutti* Dall, 1884) has been known to be monotypic. *Chlamydoconcha orcutti* occurs from California to western Mexico (Carlton, 1979; Morton, 1981). The species is characterized by reduction of the shell, which is restricted to the anterior region of a spherical mantle cover; the mantle outer surface has many, somewhat equidistantly distributed papillae. After the original description, further anatomical studies of *C. orcutti* were done by Bernard (1897) and Morton (1981).

A sample collected by biologist Vinicius Padula on the coast of Rio de Janeiro was sent to the author for study. The analysis of the material revealed a new species of *Chlamydoconcha*, formally described herein. This paper is also the first discovery of the genus in the Atlantic Ocean, representing the second known species in the genus. The present description also includes a detailed anatomy, which is discussed in comparison to *C. orcutti* (Bernard, 1897; Morton, 1981).

The taxonomic allocation of the genus *Chlamydoconcha* has been problematic. It has been included in the Galeommatidae (Morton, 1981), but full family status has been assigned (Chlamydoconchidae, Bernard, 1983), as part of the Galeommatoidea. Full superfamily status was also considered (Chlamydoconchacea, Keen, 1969). The Galeommatoidea, are mostly mollusks with usual bivalve shells, but may also include highly modified, slug-like animals, with internal and reduced shells.

MATERIALS AND METHODS

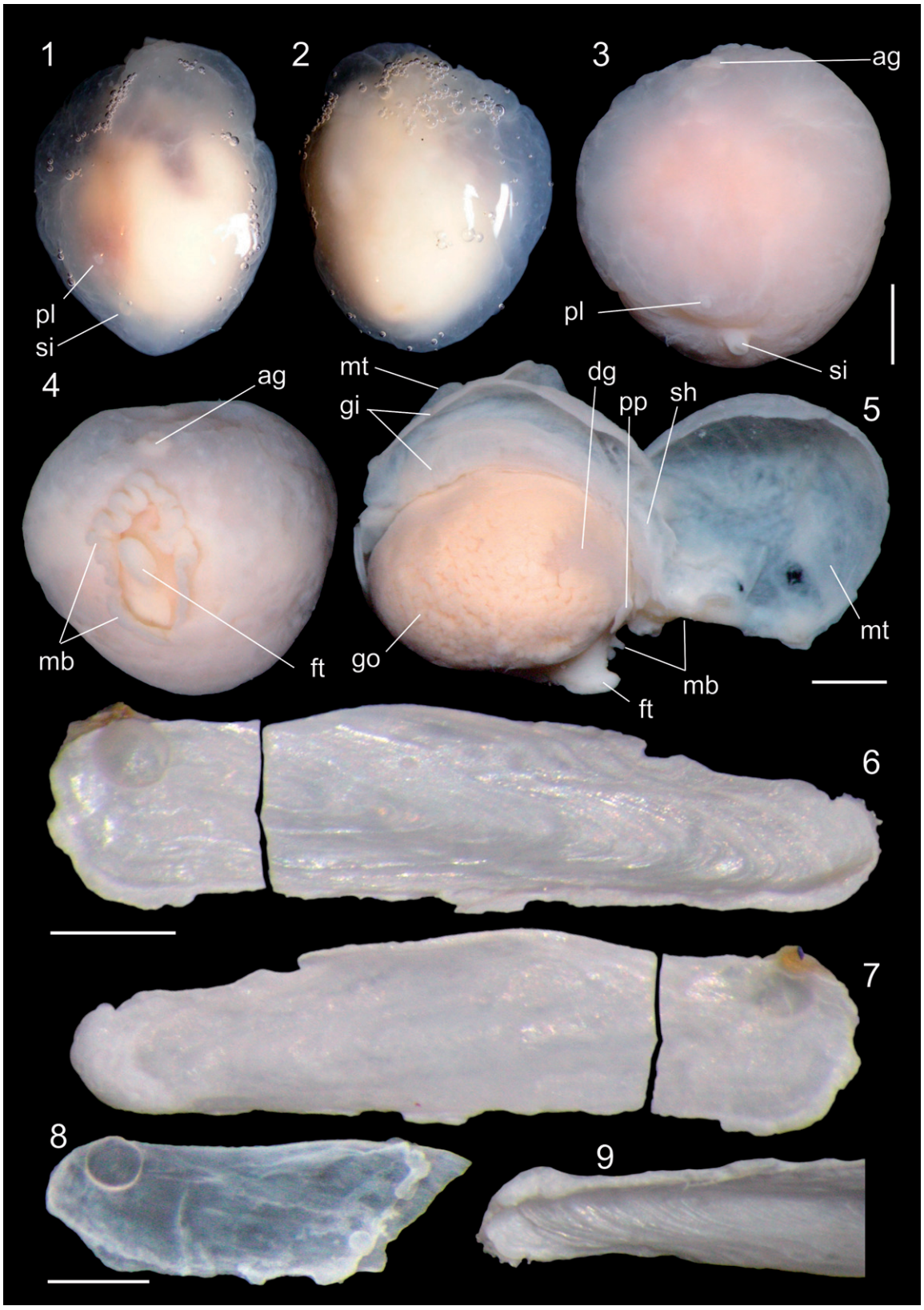
The specimen was delivered preserved in 70% EtOH. A photo of the living specimen was taken before preservation. The dissection of the preserved animal was performed by standard techniques, under a stereo microscope, with the specimen immersed in the alcohol. All dissection steps were also photographed (e.g., Figures 3–5). Drawings were made with aid of a *camera lucida*.

Abbreviations used in figures are: **an**, anus; **au**, auricle; **by**, byssal gland; **cc**, gill ciliary connection; **ce**, cerebral ganglion; **co**, cerebro-visceral connective; **dd**, ducts to digestive diverticulae; **dh**, dorsal hood; **di**, inner demibranch; **do**, outer demibranch; **es**, esophagus; **fg**, gill food groove; **fm**, posterior foot retractor muscle; **fr**, anterior foot retractor muscle; **ft**, foot; **ga**, genital aperture; **gi**, gill; **go**, gonad; **gs**, gastric shield; **in**, intestine; **ip**, inner hemipalp; **ki**, kidney; **mb**, mantle border; **mo**, mouth; **mt**, mantle; **ne**, nephropore; **op**, outer hemipalp; **pa**, pedal aperture of mantle; **pc**, pericardium; **pg**, pedal ganglia; **pl**, pallial papilla; **pm**, pallial muscles; **pp**, palp; **rt**, rectum; **sh**, shell; **si**, excurrent siphon; **ss**, style sac; **st**, stomach; **ty**, typhlosolis; **ve**, ventricle; **vg**, visceral ganglia; **vm**, visceral mass.

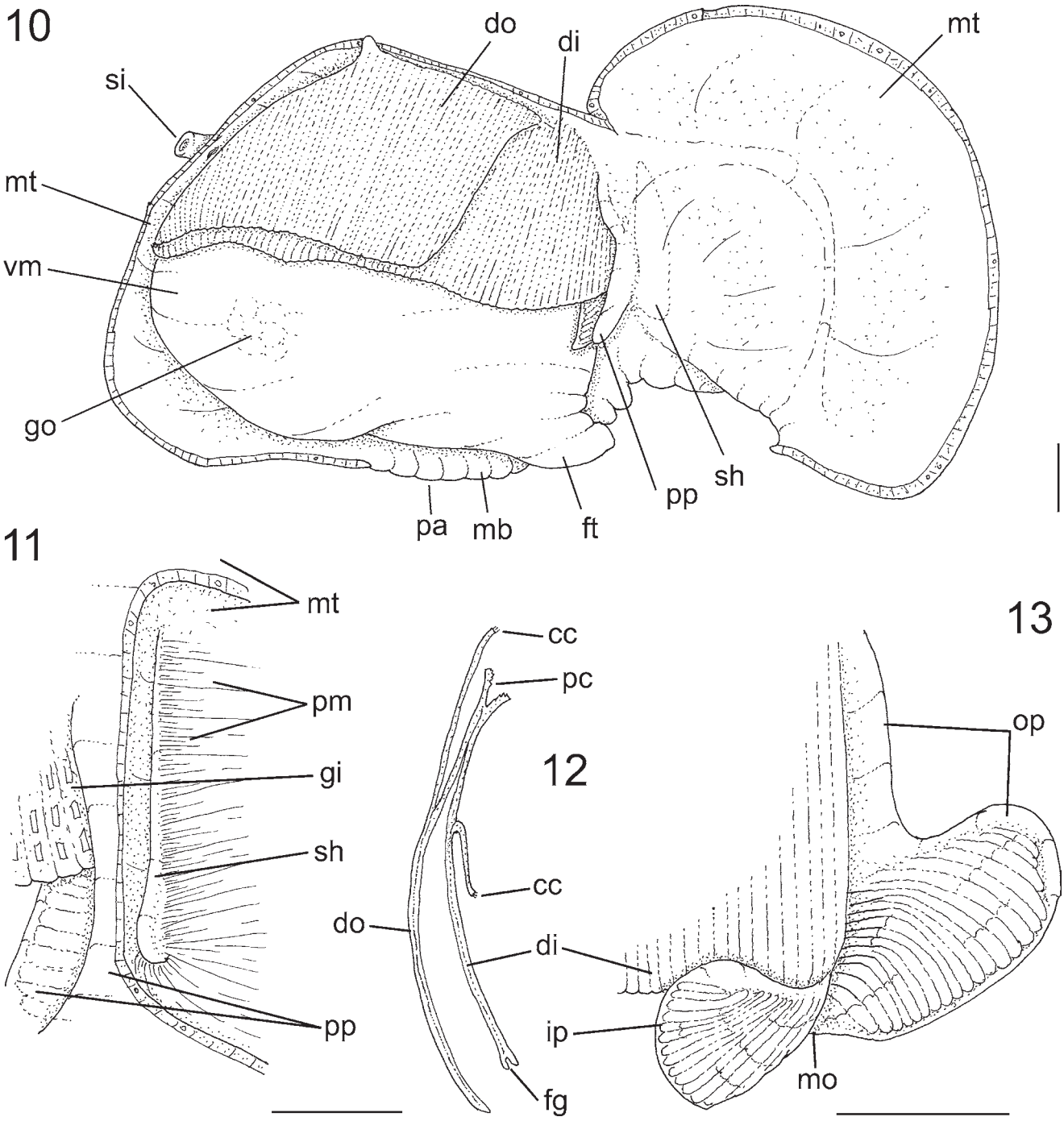
Institutional abbreviation: **MZSP**; Museu de Zoologia da Universidade de São Paulo, Brazil.

SYSTEMATICS

Chlamydoconcha avalvis new species
(Figures 1–20)



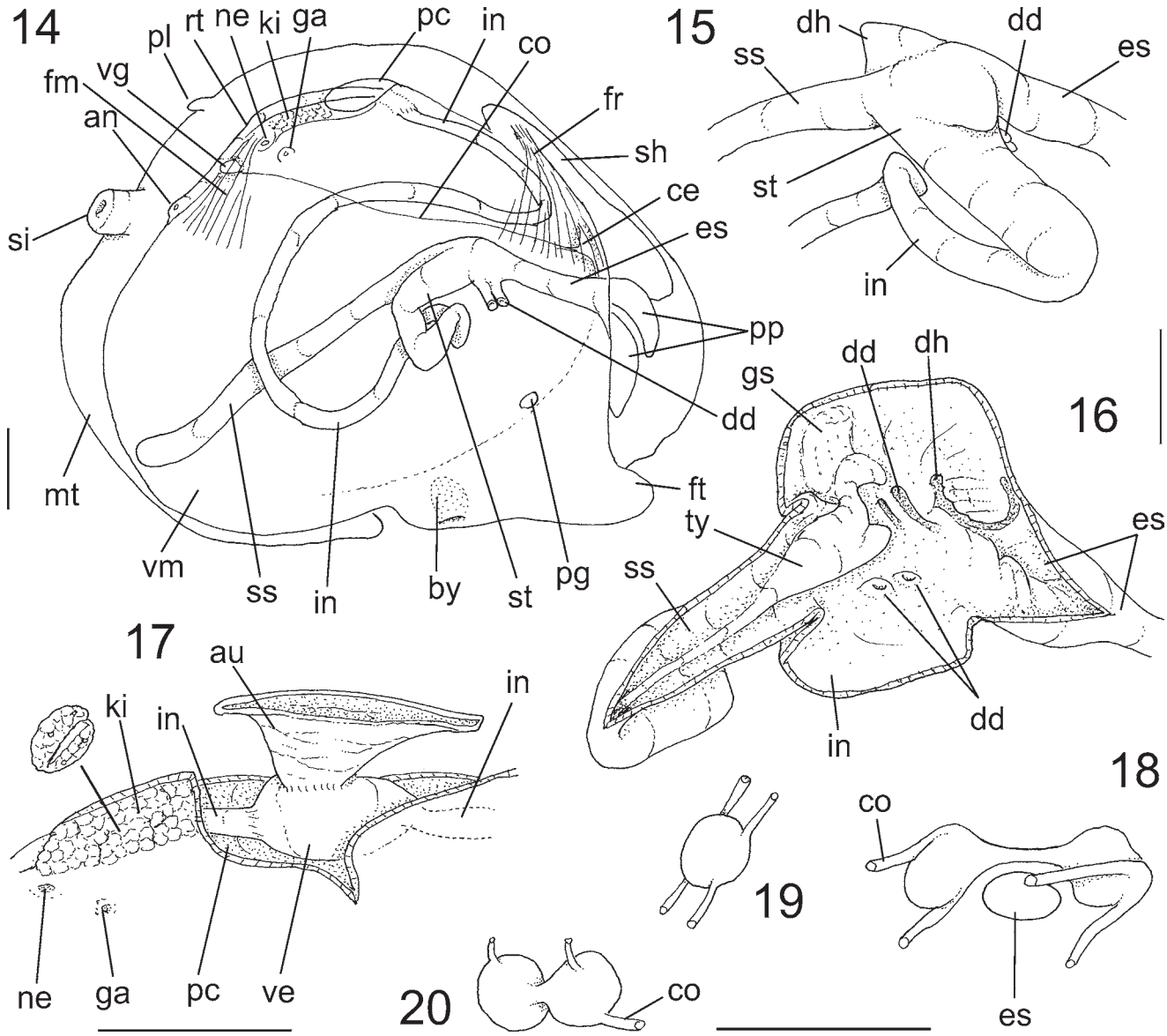
Figures 1–9. *Chlamydoconcha avalvis* Holotype photos. **1–2.** Living specimen, dorsal and lateral views, photo Vinicius Padula. **3–5.** Preserved specimen. **3.** Dorsal view. **4.** Ventral view. **5.** Left view, right mantle lobe partially removed and deflected anteriorly, right gill deflected upwards. **6.** Right valve, outer view (transversal section artificially done). **7.** Same, inner view. **8.** Left valve, inner view. **9.** Right valve, ventral view of its posterior, concave region. Scale bars = 1–5 = 2 mm; 6–9 = 0.5 mm.



Figures 10–13. *Chlamydoconcha avalvis* anatomy. **10.** Left view of entire animal, right mantle lobe partially removed and deflected anteriorly (right in Figure). **11.** Region of right valve, internal surface of mantle removed, showing pallial muscles (pm) originating in valve, some adjacent structures also shown. **12.** Gill, transversal section in its middle region. **13.** Right palp, outer hemipalp deflected anteriorly, a short portion if inner demibranch also shown. Scale bars = 1 mm.

Diagnosis: Species with a single papilla close to excurrent siphon. Anterior pallial gland shallow. Internal shell size about 10% of mantle surface; with rounded, almost squared posterior end. Anterior pair of pedal retractor muscles with a branch originated from shell. Gastric main chamber and style sac narrow and long.

Description: Shell (Figures 6–9): Reduced, inequivalve, occupying about 1/10 of mantle, embedded into mantle anterior region (Figure 10, **sh**). Length approximately 4 times width. Color white, opaque. Outline softly irregular. Both valves asymmetrical; left valve about ¼ shorter than right valve (Figure 8) (this may be



Figures 14–20. *Chlamydoconcha avalvis* anatomy. **14.** Left view of entire animal emphasizing location of digestive tract and topology of main muscles, ganglia and glands, animal artificially represented as transparent. **15.** Midgut as *in situ*, right view. **16.** Same, slit longitudinally to expose inner surface. **17.** Renopericardial structures and region, right auricle artificially disconnected from gill and deflected upwards, a transversal section of indicated level of right kidney also shown. **18.** Cerebral ganglia, posterior-slightly right view, topology of esophagus also indicated. **19.** Pedal ganglia, right and slightly posterior view. **20.** Visceral ganglia, right and slightly posterior view. Scale bars = 1 mm.

abnormal). Shape somewhat deformed and irregular; flattened, planar. Prodissoconch rounded, sub-terminal; located in middle of anterior fifth of valve length; shape semispherical, with small dorsal bulging portion; 0.26 mm long, 0.31 mm height. Outer surface somewhat irregular with strong commarginal undulations and with rounded, concave impressions; with ventral edge elevated (Figure 9). Calcareous concretions close to periphery on right valve (Figure 8). Periostracum extending about 1/3 beyond calcareous portion of each valve, wider dorsally; color yellowish, transparent. Hinge edentulous. Ligament small, restricted to umbonal region, relatively wide (Figures 6–7), pale brown; resilifer absent. Inner surface glossy. Scar of anterior retractor muscle of foot occupying about 1/5 of inner surface, 3 times longer than wide, located just posterior to umbonal concavity.

Mantle (Figures 1–5, 10): Surrounding body almost completely, spherical in contracted condition (Figures 1–4). Color pale cream, translucent (living and preserved). Outer surface smooth and simple, lacking papillae.

Pedal aperture ventral, longer anteroposteriorly (Figures 4, 10); aperture length about half total mantle length. Edges of pedal aperture thick, simple, with undulations, thicker anteriorly. Anterior gland as a blind-sac, located in anterior, median region, about 1/3 of animal height from anterior end of pedal aperture (Figure 4, **ag**); size equivalent to 1/30 of mantle outer surface; its aperture central, with about ¼ of gland size. Excurrent siphon cylindrical, small, papilla-like, located about half of animal height from posterior end of pedal aperture (Figures 3, 10, **si**); length about 1/20 of animal length; internal surface smooth, simple. Single papilla located about 1/5 of animal length dorsal to excurrent siphon (Figures 1, 3, **pl**), on median line, solid, size about half of that of siphon. Pair of small, low, bulging projections slightly dorsal to anterior gland, corresponding with shell umbos. Mantle relatively thick, mostly hollow, sponge-like. Mantle inner surface smooth, simple (Figure 5).

Main Muscle System (Figures 11, 14): Adductor muscle not seen, possibly immersed in thin layer of visceral dorsal muscles. Pair of anterior pedal retractor muscles originate about 1/3 from inner surface of valves (scar described above), and about 2/3 splayed by anterodorsal region of visceral sac; gradually becoming thicker towards ventral, up to anterior half of pedal dorsal region. Pair of posterior pedal retractor muscles somewhat similar to anterior pair; originating in dorsal visceral sac side about ¼ posterior from that of anterior pair. Thin layer of pallial muscles splayed by mantle like a net; mainly concentrated anteriorly, inserting in anterior pair of pedal retractor muscles, in level just anterior to palps.

Foot and Byssus (Figures 4, 5, 10, 14): Foot narrow, longer antero-posteriorly; length about half of animal length; width about 1/5 of animal width; projected anteriorly at about ¼ of animal length. Anterior region somewhat pointed. Byssal gland a narrow furrow located subterminally, in posterior region of foot ventral medial line; about 1/7 of foot length. Byssal gland thin, hollow, chamber depth of about 1/5 of foot length (Figure 14, **by**). No byssus found.

Pallial Cavity (Figures 5, 10–13): Surrounding almost entire space between mantle and visceral sac, except for a dorsal portion correspondent to 1/10 of visceral sac surface connected to mantle. Gill eulamellibranch, heterorhabdic, occupying about half of pallial cavity, mainly in dorsal region (Figure 10), about two times longer than wide. Outer demibranch slightly triangular, about 2/3 of inner demibranch; anterior region becoming abruptly narrow, ending about 1/8 of total gill length-posterior to inner demibranch anterior end. Inner demibranch anterior end slightly rectangular, ending between hemipalps. Gills gradually narrowing towards posterior, up to somewhat pointed posterior end. About 1/4 of each gill (their posterior region) free from visceral mass, connected with each other by cilia. Cilia connect outer lamellae of outer demibranch with mantle and inner lamellae of inner demibranch with visceral sac (Figure 12, **cc**), same ciliary connection between both inner demibranchs in their region posterior to visceral mass. Connection among gill filaments by aligned longitudinal tissue rods equivalent in width to filaments; each longitudinal rod separated from neighbor rods by distance equivalent to 5 filaments. Ventral edge of outer demibranch simple; filaments very thin (about 1/50 of gill width), outer connection mostly dorsal.

Inner demibranch filaments a little shorter than inner demibranch itself; ventral edge with food groove. Inner gill connection to visceral mass dislocated ventrally, separated from remaining dorsal gill connection by distance equivalent to half gill width (Figures 5, 12). Palps (Figure 13) with size equivalent to 1/10 of that of gill; category II (Stasek, 1963). Hemipalps similar to each other; ventral half tall, slightly triangular; dorsal half narrow (about ¼ of ventral half), smooth, surrounding anterior insertion of inner demibranch. Inner surface of palp (ventral half) with uniform, transversal folds, about 20 folds in each hemipalp; more distal folds shorter, weakly arched, folds gradually becoming longer towards medial, dorsal region of folds becoming narrower and strongly arched, forming a folded dorsal furrow in direction to mouth; ventral end of each folds rounded; dorsal end weaker; a smooth, narrow area surrounding entire edges of hemipalps (Figure 13). Both palps separated from each other by a distance equivalent to half of longer portion of palp length. Mouth surrounded by anterior and posterior relatively tall lips, inner surface smooth.

Visceral Mass (Figures 5, 14): Bulging, spherical; separation with foot somewhat distinct. Gonad color cream, surrounding most of visceral structures, occupying about 80% of outer region. Genital aperture a small slit located about 1/20 of visceral height from dorsal edge and from nephropore (Figures 14, 17, **ga**); genital duct not discernible. Digestive diverticula restricted to central area of anterior region; color pale greenish beige. Renopericardial structures occupying about 1/10 of visceral volume, located in posterior region of dorsal surface.

Circulatory and Excretory Systems (Figures 14, 17): Heart of about 1/20 of visceral volume; located anterior to kidney; length about 1/8 of total length. Auricles triangular, insertion with ctenidial veins about ¼ of their length, located in posterior quarter of gill. Connection to ventricle longitudinal, lateral, with about half of ventricle length. Ventricle occupying about entire pericardial length. Kidneys white, extending from pericardium posterior end to area equivalent to pericardial length toward posterior region. Each kidney about three times longer than tall, mostly solid except for inner flattened lumen running longitudinally long central region. Each nephropore a minute slit located just anterior to origin of pair of posterior pedal retractor muscles; inside excurrent chamber of outer demibranch.

Digestive System (Figures 14–16): Palps described above (pallial cavity). Esophagus with about 2/3 of distance between palps in width; length about 1/5 of that of

visceral mass; inner surface smooth. Stomach positioned transversal, somewhat perpendicular to esophagus, running towards right; narrowing gradually (Figure 15); estimated volume about 1/20 of that of visceral mass; Type IV (Purchon, 1958). Stomach inner surface with pair of low, narrow folds located transversally in esophageal insertion (Figure 16). Dorsal U-shaped furrow located just posterior to esophageal insertion (concavity posterior). Dorsal hood triangular, located at left side of stomach, with about ¼ of stomach height; its aperture as left end of U-shaped furrow. Ducts of digestive diverticula in two pairs; each pair located in middle region of lateral gastric side; left pair slightly longer than right pair. Typhlosole very wide on origin of style sac, narrowing relatively abruptly, running longitudinally in style sac left side as narrow, low fold. Gastric shield with about 1/8 of internal gastric surface; located inside U-shaped furrow. Style sac totally separated from intestine; long and narrow; width about 70% of that of esophagus; running somewhat straight backwards, ending in posterior wall of visceral mass. Digestive diverticula described above (visceral mass) Intestine originating in right side of style sac origin; inner surface smooth, simple; initially as wide as stomach, gradually becoming narrow up to 1/3 of its original width after a distance equivalent to that of esophagus. Intestine performing tight loops as shown in Figure 14; after this, performing wide, sigmoid loop, in such superior branch edges superior surface of visceral mass, along median line; running towards posterior. Anus sessile, simple; located at base of excurrent siphon.

Genital System: Gonad described above (visceral mass). Genital pores represented by small slits equivalent in size to nephropore (Figures 14, 17, **ga**), located about 1/20 of total animal length from nephropore, slightly posterior and ventral. No indication on brooding in gills was observed.

Central Nervous System (Figures 14, 18–20): Cerebral ganglia (Figure 18) located a short distance dorsal to mouth; each one with size equivalent to 1.5× esophagus diameter. Cerebral commissure narrow, length equivalent to each ganglion. Pedal ganglia (Figure 19) located in middle between cerebral ganglia and posterior end of foot; both ganglia completely connected with each other along median line, forming a single, spherical mass of equivalent size of each cerebral ganglion. Visceral ganglia (Figure 20) located just ventral to origins of posterior pair of pedal retractors; size equivalent to about 80% of that of cerebral ganglia, visceral commissure very short, ganglia almost touching each other. Cerebrovisceral connective very narrow, running through gonad (Figure 14, **co**).

Measurements: Animal length = 15 mm; valve = 3.7 by 1.2 mm.

Holotype: MZSP 86318, Vinicius Padula col., 05 March 2006.

Type Locality: Brazil, Rio de Janeiro, Cabo Frio, Ilha Comprida, 22°51′47″ S, 41°56′35″ W, about 6 m depth, under rocks.

Distribution: Only known from the type locality.

Etymology: The specific epithet refers to the apparent absence of the shell valves, which are virtually invisible in the living animal; a combination of the Latin negative prefix *a* and the noun *valvis*.

Comparative Remarks: *Chlamydoconcha avalvis* has the external surface of the highly developed mantle practically lacking papillae (Figures 1–4). This is the main character differentiating the species from the Pacific congener *C. orcutti*, which has a richness of papillae in the outer mantle surface, somewhat equidistantly disposed (Dall, 1884; Bernard, 1897; Williams, 1949; Morton, 1981: fig. 8). However, a single papilla is present in *C. avalvis*, close to the excurrent siphon; *C. orcutti* also possesses a differentiated papilla in the same position (Bernard, 1897: fig. 3), which was named "defensive papilla" by Morton (1981).

Anatomically, both *Chlamydoconcha* show similar organization. Mantle enlargement, foot features, position of the valves and main muscles, and internal features of glands and digestive tubes, are similar in the two species. The main anatomical differences, beyond the above mentioned papillae, are: The shell is proportionally smaller in *C. avalvis* (about 1/10 of mantle, Figure 14) than that of *C. orcutti* (about 1/6 of mantle). Although the prodissoconch (Figures 6–8) is very similar in both species, the posterior end of the shell of *C. avalvis* is more squarish than that of *C. orcutti*; in which the posterior end of the shell is pointed (Bernard, 1897: fig. 13; Morton, 1981, figs. 4–5). The anterior gland of *C. avalvis* is a blind sac, its internal chamber is small and short, practically with the same thickness of the surrounding mantle (Figure 4, **ag**); on the other hand, that of *C. orcutti* (Bernard, l894: "cheminée dorsale") has a deeper empty chamber directed posteriorly (Bernard, 1894: fig. 19, X), more recently, this gland was designated "pheromone organ" (Morton, 1981, fig. 10), and described with similar characters of *C. avalvis*. The anterior pair of pedal retractor muscles has a branch originated from the inner surface of the valves in *C. avalvis* (Figure 14, **fr**); this is not described for *C. orcutti* (Bernard, 1894: fig. 20, mp), although mentioned by Morton (1981). The midgut organization of *C. avalvis* (Figures 14–16) is quite different from that of *C. orcutti* (Bernard, 1894: figs 9, 19; Morton, 1981, fig. 24) in several details, the main characters are: the narrower and longer gastric style sac of *C. avalvis*, while that of *C. orcutti* is wider and shorter (about 1/3 of visceral sac length); the stomach is also narrower and smaller in *C. avalvis* than that of *C. orcutti*; the intestinal loops are differently performed in both species, and in *C. avalvis* it is apparently narrower.

Although the living animal of *C. avalvis* (Figures 1–2) was not observed crawling, it is possible that it also has an anterior projection of the mantle like that of *C. orcutti* (Bernard, 1894: figs.10, 11; Williams, 1949; Morton, 1981), as the mantle arrangement of that region is taller and wavy. The presence of a single siphon close to the anus shows that the siphon is excurrent; as no incurrent siphon is present, the conclusion that water intake takes place through the pedal aperture (Morton, 1981). This feature is also found in other galeommatids, such as *Kellia porculus* Pilsbry, 1904; *Scintilla nitidella* Habe, 1962 (Morton and Scott, 1989, figs. 3, 18).

DISCUSSION

Discovery of the second species in the genus *Chlamydodoncha* fits the description of the genus by Dall (1884). The anatomical characters of the *Chlamydoconcha* species are quite modified, even if considered under the light of the extraordinary suite of modifications exhibited by the Galeommatoidea (Woodward, 1893; Morton, 1981; Bieler and Mikkelsen, 1992). The reduction of the shell of *Chlamydoconcha* is apparently the most extreme in all Bivalvia; its interiorization inside the mantle is also found in other genera, e.g., *Galeomma* Turton, 1825, *Ephippodonta* Tate, 1889 (Woodward, 1893; Lützen and Nielsen, 2005), and *Divariscintilla yoyo* Mikkelsen and Bieler, 1989. All these genera and species, however, have proportionally larger valves. The foot is an important comparative character in Galeommatoidea. The "hanging" foot and the flower-like organ are some of the main characters (Bieler and Mikkelsen, 1992; Jespersen and Lützen, 2006); *Chlamydoconcha* possesses at least the first of these two characters. A molecular study (Ó Foighil et al., 2001) places *Chlamydoconcha* as terminal taxa inside the Galeommatidae, a similar result of the morphological approach (Bieler and Mikkelsen, 1992). A dwarf male has been described for *Chlamydoconcha orcutti* (Morton, 1981), however, one has not been found so far in *C. avalvis*.

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