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ADDISONIA ENODIS, A NEW SPECIES OF ADDISONIIDAE (MOLLUSCA, ARCHAEOGASTROPODA) FROM THE SOUTHERN BRAZILIAN COAST

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ABSTRACT

Addisonia enodis, a new species of Addisoniidae from deep waters off Southeastern Brazil is described, the first record of this family in the South Atlantic. Shell, radula and anatomical characters were studied and compared with the other three known addisoniid species. The shell lacks well developed radial sculpture and the shell muscle scar shows anterior hooks. Mantle with two projections (left and right sides), rachidian radular tooth somewhat long; and whole gill at right side of the body, with elongated distal filaments.

The deep water limpets of the genus *Addisonia* Dall, 1882 are assigned to a separate family (Addisoniidae Dall, 1882) by most recent authors, mainly due to its unique radula (McLean, 1985). This status has been confirmed by investigation of the internal anatomy (Haszprunar, 1987, 1988); these studies reflect a highly enigmatic organization of *Addisonia* among the Archaeogastropoda, and a unique combination of primitive and advanced characters.

Up to now three species of Addisoniidae were known: *Addisonia paradoxa* Dall, 1882 (type species of the genus) from the western Atlantic (Nova Scotia to Jamaica, 119 to 1,170 m); *A. lateralis* (Requien, 1848) from the eastern Atlantic (Biscay to Morocco) and Mediterranean Sea; and *A. brophyi* McLean, 1985, from California, eastern Pacific.

One complete specimen and two shells of the genus *Addisonia* Dall, 1882 were collected from 184 m depth, in dredges of the integrated project "Utilização Racional dos Ecossistemas Costeiros da Região Tropical Brasileira: Estado de São Paulo" conducted by Instituto Oceanogrático da Universidade de São Paulo (IOUSP). Conchological and anatomical analysis showed a new species of this genus not as yet reported in the Southern Hemisphere.

Some brief anatomical data are included herein, but limited by the study of a single specimen avaliable with soft parts. These data are compared with studies of McLean (1985) and Haszprunar (1987 and 1988).

MATERIAL AND METHODS

The single specimen with soft parts and the two shells (one of them young) were preserved in 70% ethanol. The soft parts were easily extracted from the shell, examined, drawn, and carefuly dissected. The pericardic and ctenidial region were removed and dehydrated in ethanol series, dyed in carmine fluid, cleared and fixed in creosote. Afterwards, six gill filaments were extracted and examined on a slide. The radula was examined on a slide with Hoyer fluid; after this, a examination in SEM was possible, but the Hoyer was not altogether removed, even with exaustive ultrasonic cleaning; both, drawings and SEM photo are included herein, each one with interesting details of the radular structure. All drawings were made using a camera lucida. Anatomical terminology is based on Haszprunar (1987) and conchological and radular terminology on McLean (1985).

Addisonia enodis new species
Figures 1–43

Types.—Holotype MZUSP 27956, Paratypes: MZUSP 27957 and MZUSP 27958.

Type Locality.—Brazil, São Paulo State, off Ubatuba continental shelt, "station 5191" 24°36'04"S 44°33'04"W, 184 m depth (20/July/1987)

Diagnosis.—Shell large (max. 17 mm), almost smooth surface, rounded apex; pericardium trapezoid, turned to the anterior; pair of small projections of the mantle border (left and right); gill in right side of the body; rachidian radular tooth somewhat long and centrally depressed, outer radular teeth clearly with three plates.

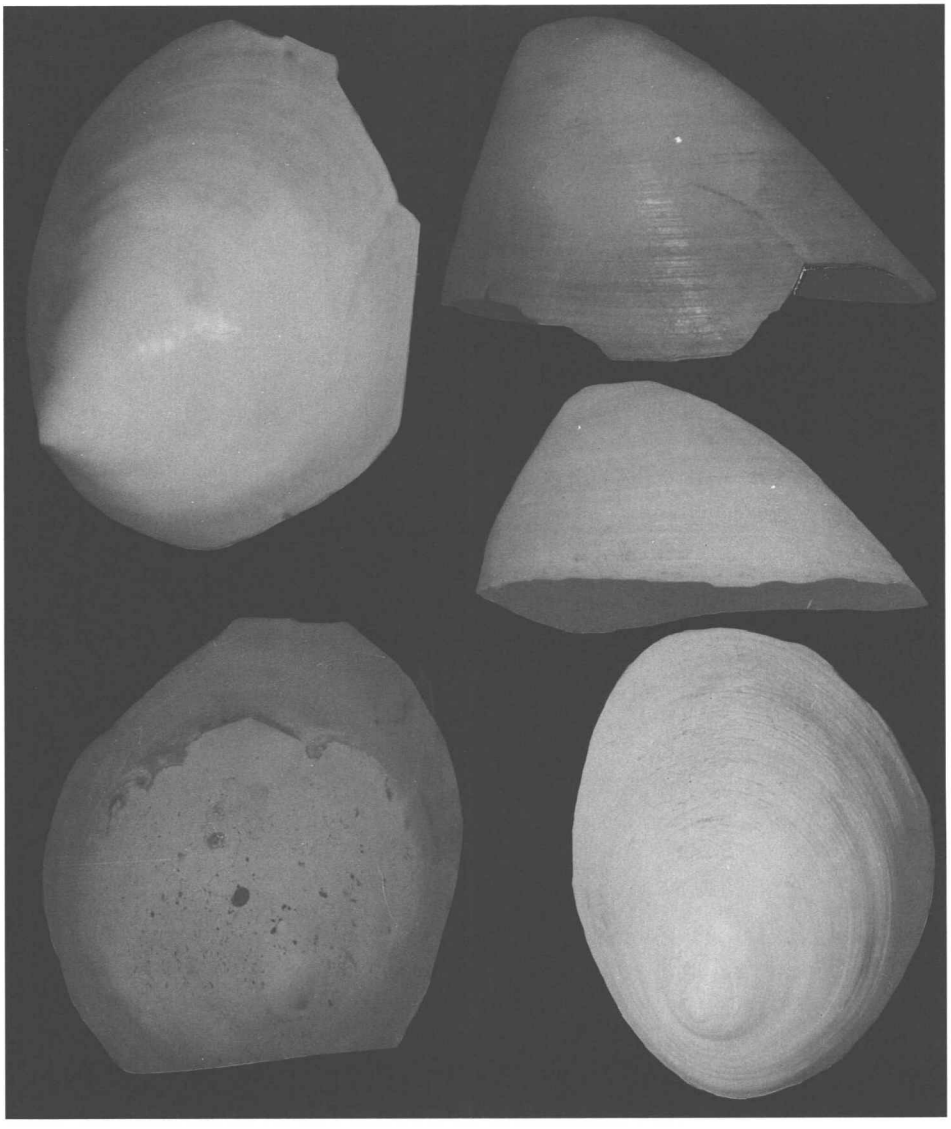
Description.—SHELL (Figs. 1–14). Medium sized (to 17 mm), cap-shaped, thin, non-nacreous, periostracum thin, smooth; homogeneous white in color. Margin sharp and fragile, ends slightly raised relative to sides, generally broken. Outline asymmetrical, anterior either broader or narrower than posterior. Apex near midline and near posterior margin in young shell (Figs. 12–14); rounded tip, with anterior region convex and posterior concave. Apex of large shells offset towards left, slightly curved backwards and downwards. Protoconch somewhat eroded, rounded apex. Radial sculpture lacking in young specimen and obsolete and difficult to be seen in inferior half of large shells. Concentric sculpture of growth lines. Inner surface glassy smooth. Muscle scar horseshoe-shaped, narrow throughout, not broken into discrete bundles, anterior terminations curved inward and directed posteriorly, symmetrical. A narrow pallial line extends in a broad arc from anterior limitation of muscle scar, towards to anterior region.

EXTERNAL MORPHOLOGY AND TOPOGRAPHY. Like the shell, the soft parts are asymmetric as an inner mould (Figs. 17–20). Ventrally a central, rather small, foot is viewed (Figs. 15, 16). Head small, with snout and pair of short lateral tentacles (Figs. 21, 22), without eyes, partially covered by skin, snout partially covered by foot (in contracted condition). Snout a short and wide tube (Figs. 21, 22), irregular and thick walled, rounded in section. Right tentacle longer than left, with deep seminal groove from base to tip (Fig. 24). All ventral structures pale brown in color. Large gill on right side of pallial cavity (Fig. 24). Dorsally a large, dark brown midgut gland occupies most of surface, and a small, clear gonad found in central region (Figs. 17–20). Anterior of midgut gland there are pericardial structures and anterior border of gill, as posterior border of this gland is the intestine.

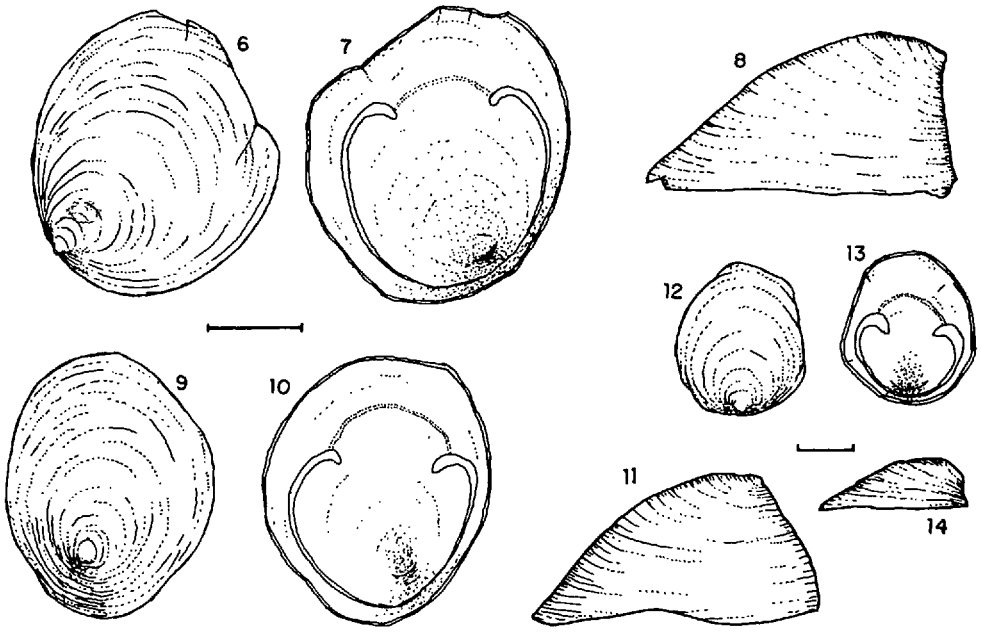
MANTLE BORDER. Rather thick (Figs. 15–20, 23, 24), without tentacles or other structures except flattened semi-eliptical projection in left side of mantle border as shown in Figures 16 and 18. No inner structures of this projection were found, except a homogeneous transparent tissue. On opposite side (right) there is another similar structure, but smaller (Fig. 16). Mantle pale brown in color.

MAIN MUSCLE SYSTEM. The paired shell muscle very weakly developed and forms continuous horseshoe-like organ, thin layer of pallial muscles also present, those of anterior region more developed. As is usual in Archaeogastropods (Haszprunar, 1988) the symmetrical head retractors are inserted at the inner edge of the anterior ends of the shell muscle.

MANTLE CAVITY. Mantle cavity moderate deep in right and anterior sides and shallow in left and posterior sides of body (Fig. 16). Large gill (Figs. 16, 24) consists of 34 free, monopectinate, triangular leaflets, each one with narrow and long tip (Figs. 24–27). Anterior leaflets wider and with shorter tip (Fig. 25), gradualy leaflets become narrower and more elongate in posterior region (Figs. 26, 27). Gill leaflets occupy anterior right part of mantle cavity and right subpallial cavity. Efferent gill sinus situated near mantle border, and afferent one near body wall (Figs. 23, 24). Rods of leaflets usually paired and resemble those of other gastropods (Figs. 25–27).



Figures 1 to 5. *Addisonia enodis*; 1—upper left) dorsal view of the holotype shell; 2—lower left) ventral partial view of the same; 3—upper right) lateral-hight view of the same; 4—center right) lateral-right view of the paratype; 5—lower right) dorsal view of the same. Abbreviations: an: anus, ap: approximator muscle of cartilages, ar: anterior radular cartilage, as: afferent gill sinus, au: auricle, bc: buccal constrictor muscle, bw: body wall, dm: duct of midgut gland, dr: direct radular tensor muscle, es: efferent gill sinus, fc: fusion of radular cartilages, ft: foot, gf: gill fold, gi: gill, go: gonad, gp: gonopore, he: heart, is: intestine sac, iw: inner wall of intestine sac loop, lk: left kidney, lp: lateral protactor muscle, mb: mantle border, mg: midgut gland, mo: mouth, nr: mervous ring, od: odontophore, oe: oesophagus, og: oesophagial gland, pc: posterior radular cartilage, pe: pericardium, pl: left projection of mantle border, pm: post median retractor muscle of the radula, pr: right projection of mantle border, ra: radula, re: rectum, rk: right kidney, sg: sperm groove, sh: shell, sm: shell muscle, sn: snout, sr: subradular membrane, te: tentacle, ve: ventricle and vh: ventral horizontal muscle.



Figures 6 to 14. *Addisonia enodis* shell: 6) dorsal; 7) ventral; 8) lateral-left view of the holotype, scale = 5.0 mm; 9); 10) and 11) the same of MZUSP 27957, scale = 5.0 mm; 12); 13); and 14) the same of MZUSP 27958 paratype, scale = 1.0 mm.

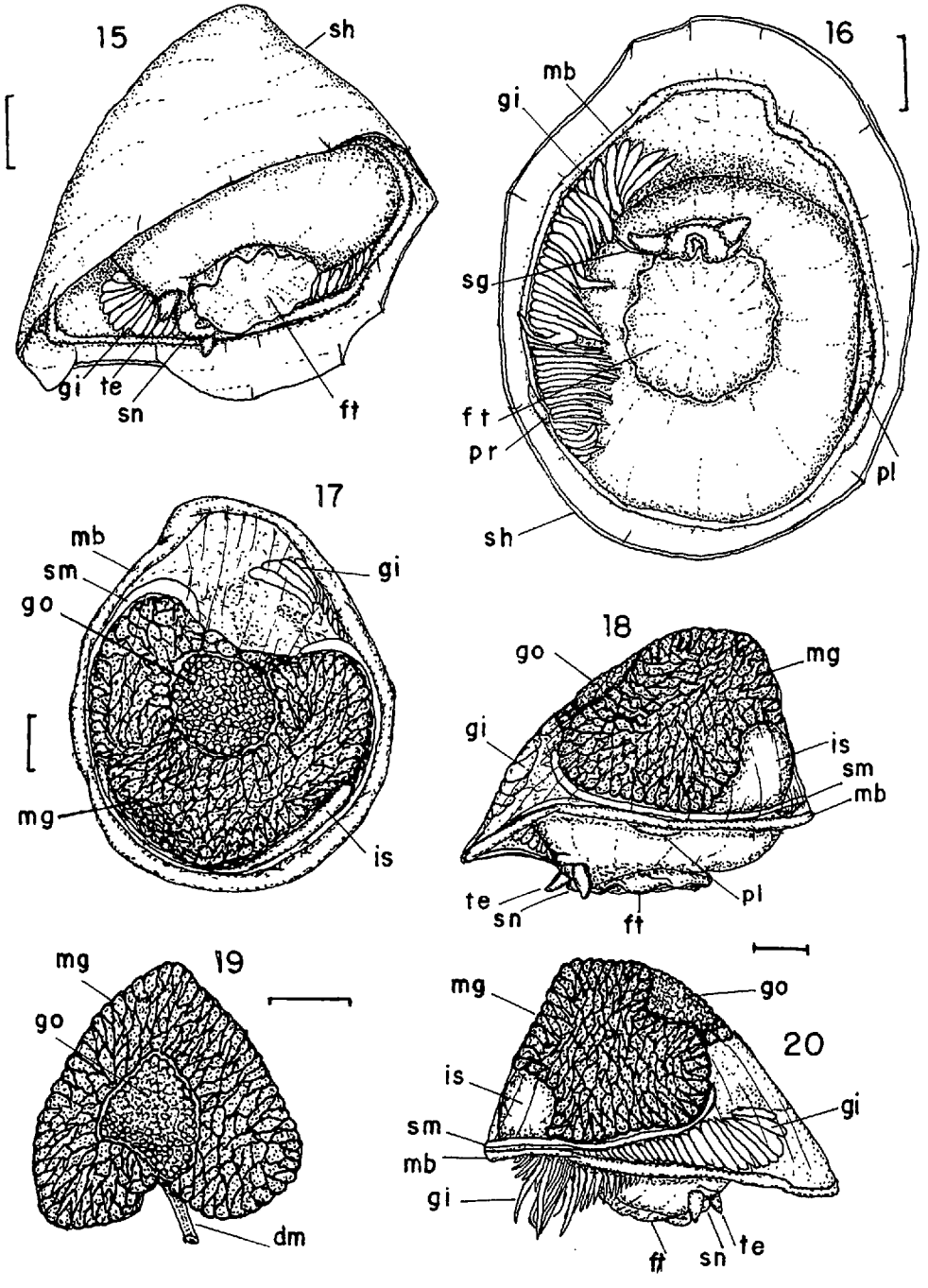
Osphradium not found. Fold of the medial region of the gill border present begining anteriorly in body wall, just posteriorly to sperm groove (see down), and inserts in afferent gill sinus in region between median and posterior third part of this, as shown by Figure 24.

Only two openings visible (Figs. 23, 24); most anterior is anus, between body wall and anterior border of afferent gill sinus. Posterior to anus is genital aperture.

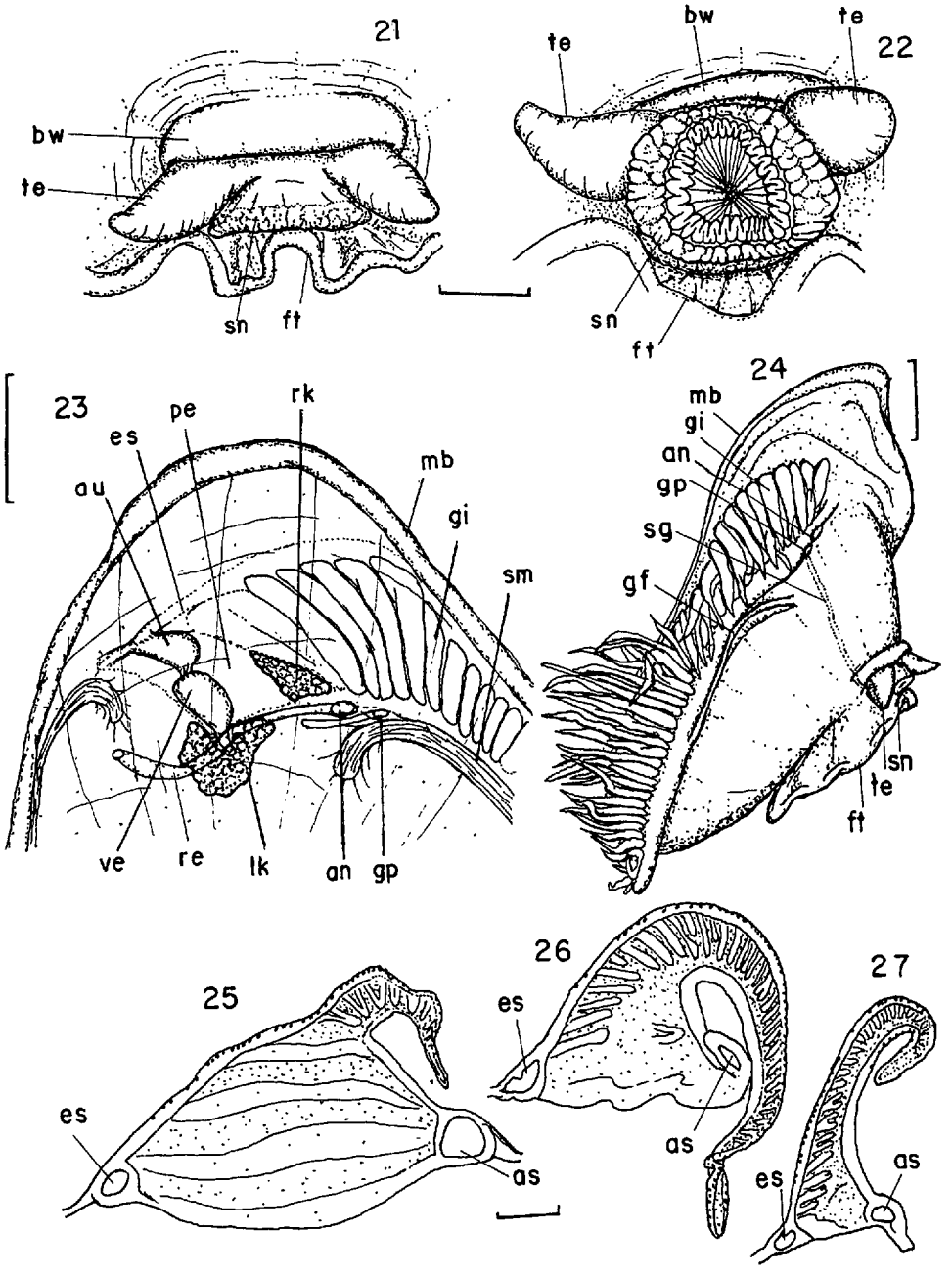
PERICARDIAN STRUCTURES (Fig. 23). Pericardium large, located in anterior mantle roof (Fig. 23), somewhat trapezoid. Head consists of single auricle (anterior-left) and rather small ventricle. Blood circulation appears to be similar to that described by Haszprunar (1987: 272) for *Addisonia* spp.

There are two small kidneys, right kidney triangular, connected within pericardium, with single reno-pericardial pore. Left kidney little larger and flattened. A detailed description of the renal pores and ducts is impossible, but the disposition of these structures is somewhat different from that shown in figure 2 by Haszprunar (1987: 171) for *A. lateralis*. The pericardian structures are medial in *A. enodis*.

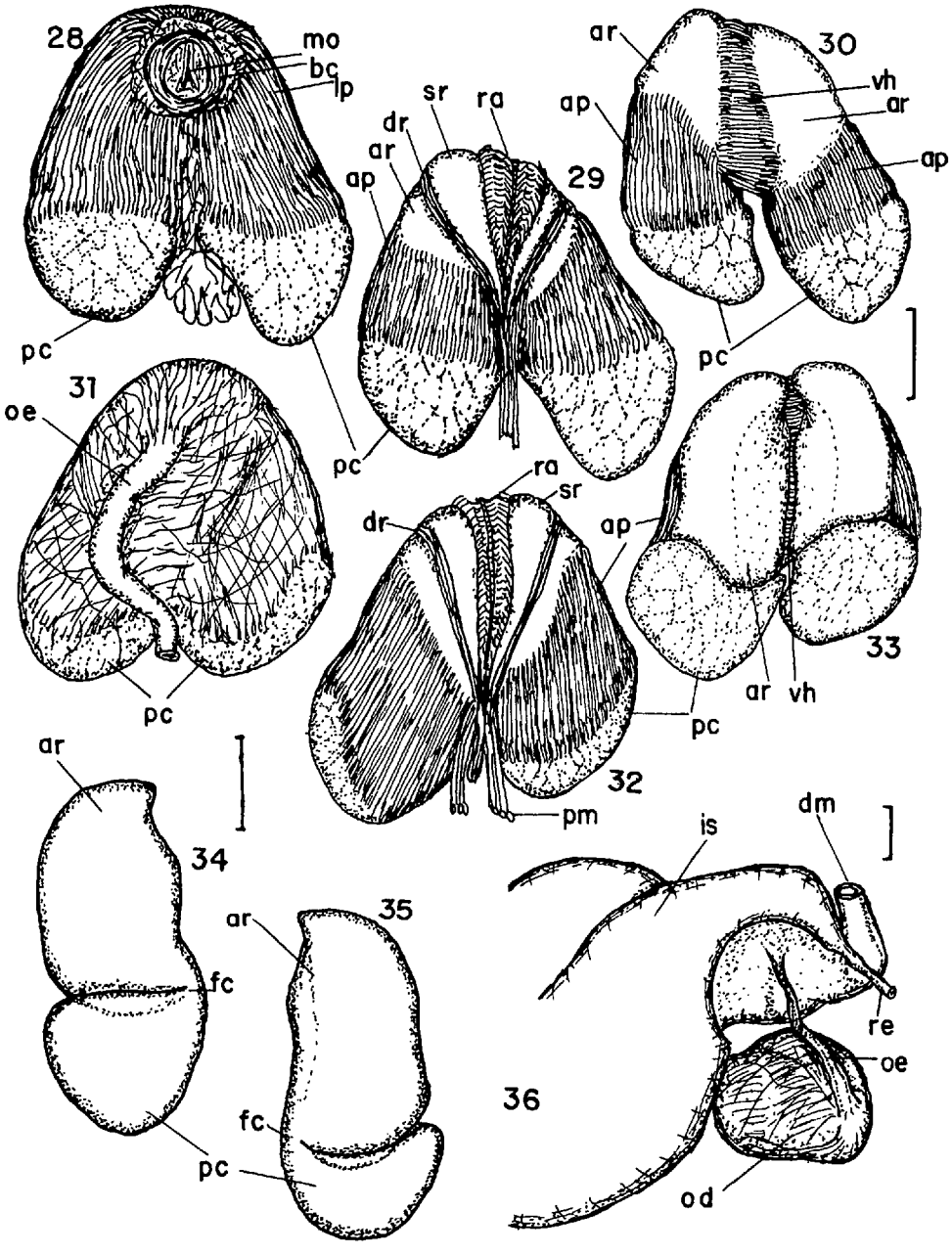
DIGESTIVE SYSTEM. Mouth opening rounded in shape, lacks oral lappets, inner surface of mouth undulating-folded (Fig. 22). Odontophore oval (Figs. 28–36), its ventral muscle being buccal constrictor muscle (oral sphincter) (Fig. 28), this muscle flanked by ventral and lateral protactor muscle, originate in floor of snout and insert in posterior cartilages; when removed inner muscular layer and radular complex exposed (Figs. 29, 32): direct radular tensor muscle inserts at ventral margin of subradular membrane; post-median retractor muscle of radula inserts at dorsal margin of subradular membrane; approximator muscle of cartilages found uniting anterior pair of cartilages with adjacent posterior cartilages. Ventral horizontal muscle exposed when radula and subradular membrane removed (Figs. 30, 33), uniting both anterior cartilages. Form of cartilages shown in Figures 33,



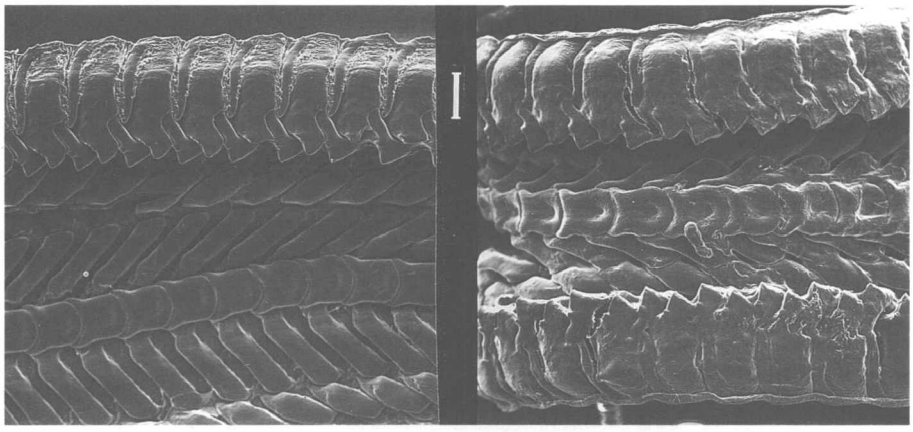
Figures 15 to 20. *Addisonia enodis*; 15) lateral left view of holotype; 16) ventral view of holotype; 17) dorsal view of holotype, shell extracted, anterior region upper; 18) lateral left view of holotype, shell extracted; 19) detail of midgut gland and gonad, dorsal-posterior view; 20) lateral right view of holotype, shell extracted; scales = 2.0 mm.



Figures 21 to 27. *Addisonia enodis*; 21) anterior view of head; 22) ventral view of head; 23) dorsal view of pericardian region; 24) lateral view of holotype with right extrutures exposed; 25) third gill filament; 26) 14th gill filament; 27) 28th gill filament; scales (21 to 24) = 2.0 mm; (25 to 27) = 0.5 mm.



Figures 28 to 36. *Addisonia enodis*; 28) ventral view of odontophore; 29) odontophore, first muscular layer extracted, ventral view; 30) odontophore, second muscular layer and radula extracted, ventral view; 31) dorsal view of odontophore; 32) odontophore, first muscular layer and tegument extracted, dorsal view; 33) odontophore, second muscular layer and radula extracted, dorsal view; 34) dorsal view of right radular cartilages; 35) ventral view of right radular cartilages; 36) anterior view of digestive system, odontophore removed down; scales = 1.0 mm.



Figures 37(left) and 38(right). *Addisonia enodis*: details of the radula, SEM, scale = 50 μm.

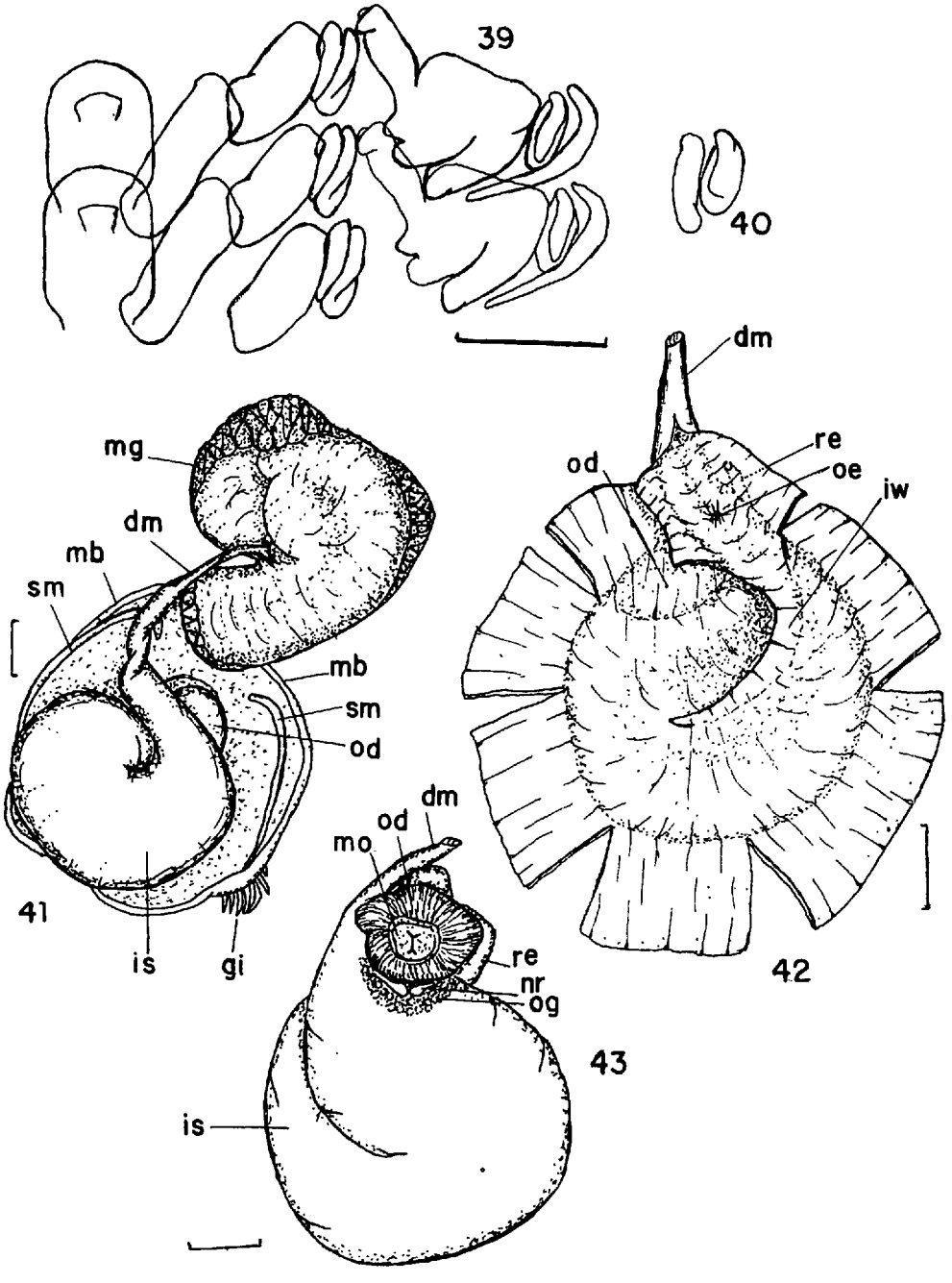
34 and 35. Anterior and posterior cartilages of each side partialy fused (Figs. 34, 35); anterior cartilages long, rather flattened, angulose anteriorly and rounded posteriorly. Posterior cartilages hemisphaerical, concave anteriorly and convex posteriorly. Four cartilages have soft consistence.

Radula of *A. enodis* resembles those of other species of family (Figs. 37–40). Rachidian subcylindrical, uncuspided, somewhat long, with median triangular depression (Figs. 37, 38), fitting with rachidian elements anterior and posterior to it to form continuous, jointed cylindrical column along central longitudinal axis. Rachidian flanked by two pairs of unicuspid, solid rhomboidal plates in V-shaped alignment, most medial rectangular and most lateral little arched. These plates flanked by two pairs of narrow sigmoid teeth, medial narrow and lateral tooth similar but with wide base (Fig. 40). Outermost three plates complexly interlocked, first of these with trapezoid large base, in median limit one tall, long projection, flattened tip, two cusps in basis of this projection; another projection inserted in outer-lateral limit, projected medialy, also with flattened tip (Fig. 39). Second plate small, has eliptical basis and sygmoid, longitudinal cusp. Third a narrow element, hook shaped, with single and very long cusp projected medialy, conturing limit with adjacent inferior tooth.

Oesophagus runs dorsally in odontophore (Fig. 36), depressed tube with no clear subdivisions into anterior and posterior portions, runs backwards for some distance, then joins with duct of midgut gland (Fig. 36). Intestine has expanded sac region (Figs. 36, 41, 42, 43) (within fibrotic compact material, brown in color); intestine wall thin and transparent (Fig. 42) having single loop, occupies about two thirds of animal's body, inner wall of intestinal loop fused (Fig. 42, iw); intestine runs downwards and narrows gradualy in anterior region (Fig. 36) until anus (Fig. 23).

Small oesophageal gland (Fig. 43) covers pedal ganglion of nerve ring. Midgut gland occupies large dorsal space of animal's body (Figs. 17–20); filled with dark-brown staining granules; it is molded dorsally by shell and ventraly by intestine sac. Duct of midgut gland single, wide and opens between oesophagus and stomach, which is completely reduced.

GENITAL SYSTEM. No histological study was made, but according to early papers on *Addisonia* spp. (McLean, 1985, Haszprunar, 1987, 1988) the gonad is hermaphroditic, and found dorsaly in viceral mass (Figs. 17–20). No duct viewed,



Figures 39 to 43 *Addisonia enodis*. 39) partial view of radula, rachidian teeth left 40) detail of fourth and fifth radular teeth; 41) dorsal view of soft parts with midgut gland removed anteriorly; 42) detail of opened intestine sac, dorsal view; 43) digestive system, ventral view; scales (Figs. 39–40) = 0.1 mm; (Figs. 41–43) = 2.0 mm.

except short portion, just posterior to anus (Fig. 23). From genital aperture shallow seminal groove leads of neck region, to back of right cephalic tentacle (Fig. 24), with has no further special structures for its addictional function as a copulatory organ, except a deep longitudinal dorsal furrow.

Measurements.—(respectively length, width and height) Holotype = 16.5 × 14.0 × 9.3 mm; MZUSP 27957 = 15.6 × 12.5 × 8.0 mm; MZUSP 27958 = 3.0 × 2.7 × 1.0 mm.

Habitat.—*Addisonia* spp. were found in deep waters associated with shark egg cases (McLean, 1985). *A. enodis* was collected in 184 m depth, but no information on shark egg cases was available in the station 5191.

Range.—Only known from type locality.

Etymology.—The specific name refers to the almost smooth surface of the shell which lacking developed nodes radialy disposed (*enodis*).

Discussion

The characters (conchological and anatomical) of *Addisonia enodis* are similar of those of the other *Addisonia* species (McLean, 1985; Haszprunar, 1987), but some few differences were observed.

All *Addisonia* species are closely similar respecting to the shell characters. However, this is a simplificed structure, and only few and variable systematic data are obtained (as size, radial sculpture and apex site), McLean observed (1985: 101): "It may well be that the differences among the three [species] are purely quantitative, but in the absence of sympatry the question is moot. A pragmatic approach is taken here in accepting three species, although it is recognized that equal justification could be offered for the recognition of three subspecies of a single, widely distributed species." If changed "three" for "four" this concept can be adopted herein.

A. enodis differs from *A. lateralis* and *A. brophyi* (sensu Haszprunar, 1987) in having larger size; shell radial sculpture poorly developed; pericardian structures more anteriorly turned; the gill leaflets with elongated distal filaments; the projection of right and left sides of mantle border; the fold of the inner gill margin; apparently different arrangement of the posterior intestine; only one duct of midgut gland; rachidian tooth of radula shorter and the three outer teeth clearly separate in three plates (compared with McLean, 1985: 104; Fig. 15).

There is no complete anatomical study on *A. paradoxa,* the most similar species to *A. enodis.* Conchologicaly the shells are very similar, but *A. enodis* differs from *A. paradoxa* in having the radial sculpture less developed, apex more rounded (not as a hook) and the shell muscle scar turned anteriorly (*A. paradoxa* has this scar slightly turned to right). On anatomy, *A. enodis* was compared with *A. paradoxa* by McLean (1985: 104; Figs. 16, 17), *A. enodis* has the gill altogether in right side of the body (the gill of *A. paradoxa* has the anterior limit in left side), the projection of mantle border (right and left) present and the rachidian radular tooth a little more elongated and with a median depression.

Acknowledgment

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