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A revision of the genus *Atelecrinus* PH Carpenter (Echinodermata: Crinoidea)

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Abstract

The unusual bathyal comatulid crinoid genus *Atelecrinus* is widespread in the Atlantic and tropical Pacific Oceans and currently includes three recognized species. A re-assessment based on examination of new and existing specimens requires establishment of two new genera and five new species, and returns three junior synonyms to species-level status. *Paratelecrinus* is erected to accommodate *Atelecrinus wyvilli* PH Carpenter, *A. conifer* AH Clark, *A. cubensis* PH Carpenter, *P. orthotriremis*, new species, *P. amenouzume* new species, *P. laticonulus* new species and *P. telo* new species. *Adelatelecrinus* is erected to accommodate *Atelecrinus sulcatus* AH Clark and *Adelatelecrinus vallatus* new species. *Atelecrinus* retains *A. balanoides* PH Carpenter and *A. helgae* AH Clark, which restricts the genus to the Atlantic. In both *Paratelecrinus* and *Adelatelecrinus*, the basals articulate with the centrodorsal via ligament bundles anchored in deep ring-like interradial pits that project into the centrodorsal cavity, whereas in *Atelecrinus* the centrodorsal rim has shallow interradial concavities and attaches to the basals via a tight junction with no obvious ligament bundles. The spoon-shaped aboral fossa in the basals of *Paratelecrinus* appears to be unique among articulate crinoids and differs from the smooth fossa found in both *Atelecrinus* and *Adelatelecrinus*. New material extends the range of the family to the Indian Ocean. A few species are now known from enough specimens to identify some ontogenetic and distributional variations. Proximal ray morphology varies substantially with size in *P. cubensis* and *P. orthotriremis*. *A. balanoides* generally occurs in deeper water in the Lesser Antilles than in the Bahamas and Strait of Florida, while *P. orthotriremis* occurs in shallower water in the Lesser Antilles and deeper in the Bahamas.

Key words: Atelecrinidae, *Atelecrinus*, *Paratelecrinus*, *Adelatelecrinus*, Crinoidea, Echinodermata, bathyal, new species

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Introduction

Atelecrinus PH Carpenter, 1881, includes unusual feather stars from bathyal depths (chiefly ~200–1500 m, with one record from >3,500 m) in the Atlantic, Indian and tropical Pacific Oceans that differ from all other living crinoids that lose the postlarval stalk in having the following unique combination of adult features: a complete ring of basal ossicles unmodified as a rosette; no proximal pinnules; proximal syzygies at 3+4 and usually 6+7, 9+10; arms terminating in a distal filament lacking pinnules, and cirrus sockets flanked by projecting fulcral tubercles that give the centrodorsal a serrated profile (AH Clark and AM Clark 1967, Hess and Messing 2011, and herein). PH Carpenter (1881) established the genus on the basis of the first two characteristics, which he considered to be persistent larval features. Messing's (2003) examination of two species using scanning electron microscopy (SEM) and macrophotography revealed additional unusual features, including the unique shoe-shaped *probolus Adidas*™ on one pair of adjacent axils (Figure 1a–b), and ambulacral lappets on the proximal arms modified as "pseudopedicellariae" (Figure 1c), as well as important differences in centrodorsals and basals between species. The genus currently includes *A. conifer* AH Clark, 1908a, previously known from one specimen from Hawai'i; *A. wyvilli* PH Carpenter, 1888, from the tropical western Pacific, and *A. balanoides* PH Carpenter, 1881, from Brazil to the Gulf of Mexico, Bahamas, and the northeastern Atlantic (AH Clark and AM Clark 1967, AM Clark 1970, Messing and Dearborn 1990).

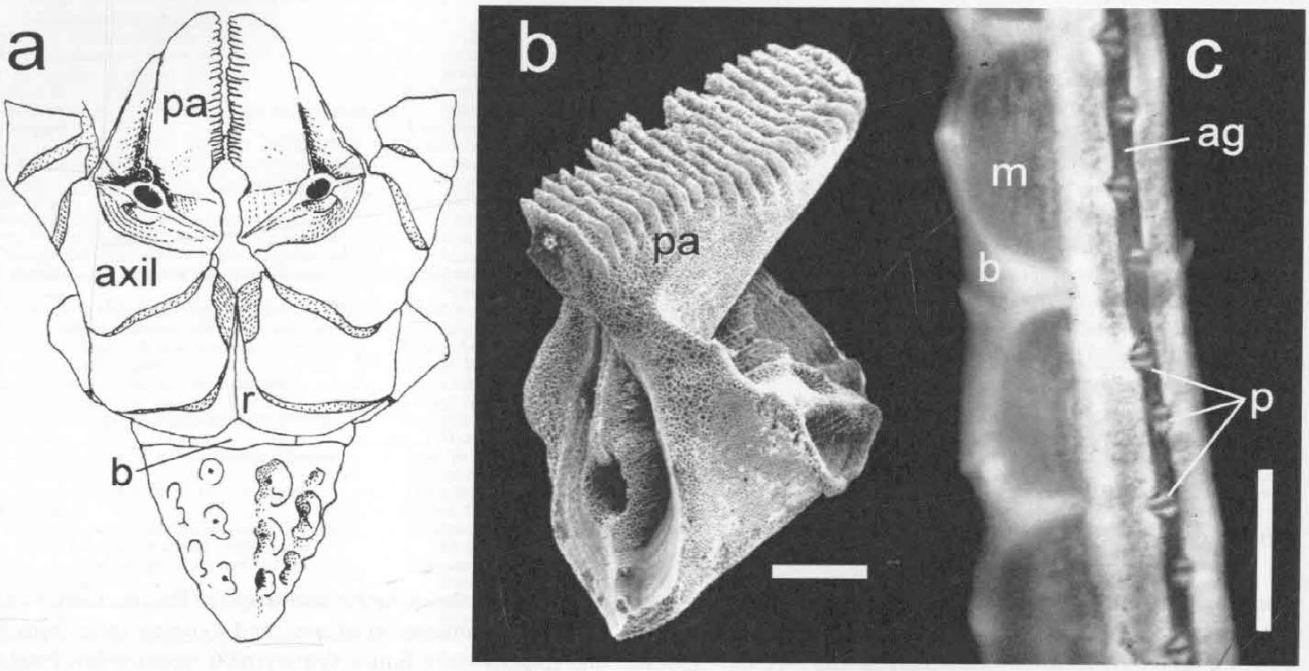

FIGURE 1. a. *Atelecrinus balanoides*: lateral interradial view of centrodorsal and bases of two rays with two adjacent arm bases removed, showing a pair of *probolus Adidas*™ (pa) abutting each other; basal ossicle (b), radial ossicle (r). b. *Paratelecrinus wyvilli*: Iax_2 with *probolus Adidas*™; oblique lateral view with proximal articulation facing left and distal articulation toward right; scale bar 0.5 mm. c. *Paratelecrinus cubensis*, proximal portion of an arm in oblique ambulacral view; scale bar 1.0 mm; ambulacral groove (ag), brachial ossicle (b), muscle bundle (m), pseudopedicellariae (p). Modified from Messing (2003).

Until recently, most specimens consisted of only the centrodorsal and ray bases; the cirri and the arms beyond ~$IIbr_{10}$ were usually lost. From 1983 to 1989, however, a series of expeditions to the Bahamas and eastern Caribbean Sea using the submersibles *Johnson Sea-Link I* and *II* (Harbor Branch Oceanographic Institute at Florida Atlantic University, Ft. Pierce, FL) retrieved multiple specimens of *A. balanoides*, *A. cubensis* PH Carpenter, 1881 (restored here from synonymy under *A. balanoides*), and a new species in much more complete condition. Additional new material has also been collected more recently from Japanese waters and by French expeditions to the southwestern Pacific (Solomon Islands and Fiji) and Indian oceans. Examination of this and earlier material supports several taxonomic changes and recognition of new taxa. *Atelecrinus wyvilli*, *A. conifer* and *A. cubensis* are

removed to *Paratelecrinus* n. gen. together with four new species. *Atelecrinus sulcatus* AH Clark, 1912 (restored from synonymy under *A. wyvilli*) is removed to *Adelatelecrinus* n. gen. together with a new species. *Atelecrinus* retains *A. balanoides*, and *A. helgae* AH Clark, 1913 (restored from synonymy under *A. balanoides*). [The genera *Atelecrinus* and *Adelatelecrinus* are abbreviated *At.* and *Ad.* below to avoid confusion.]

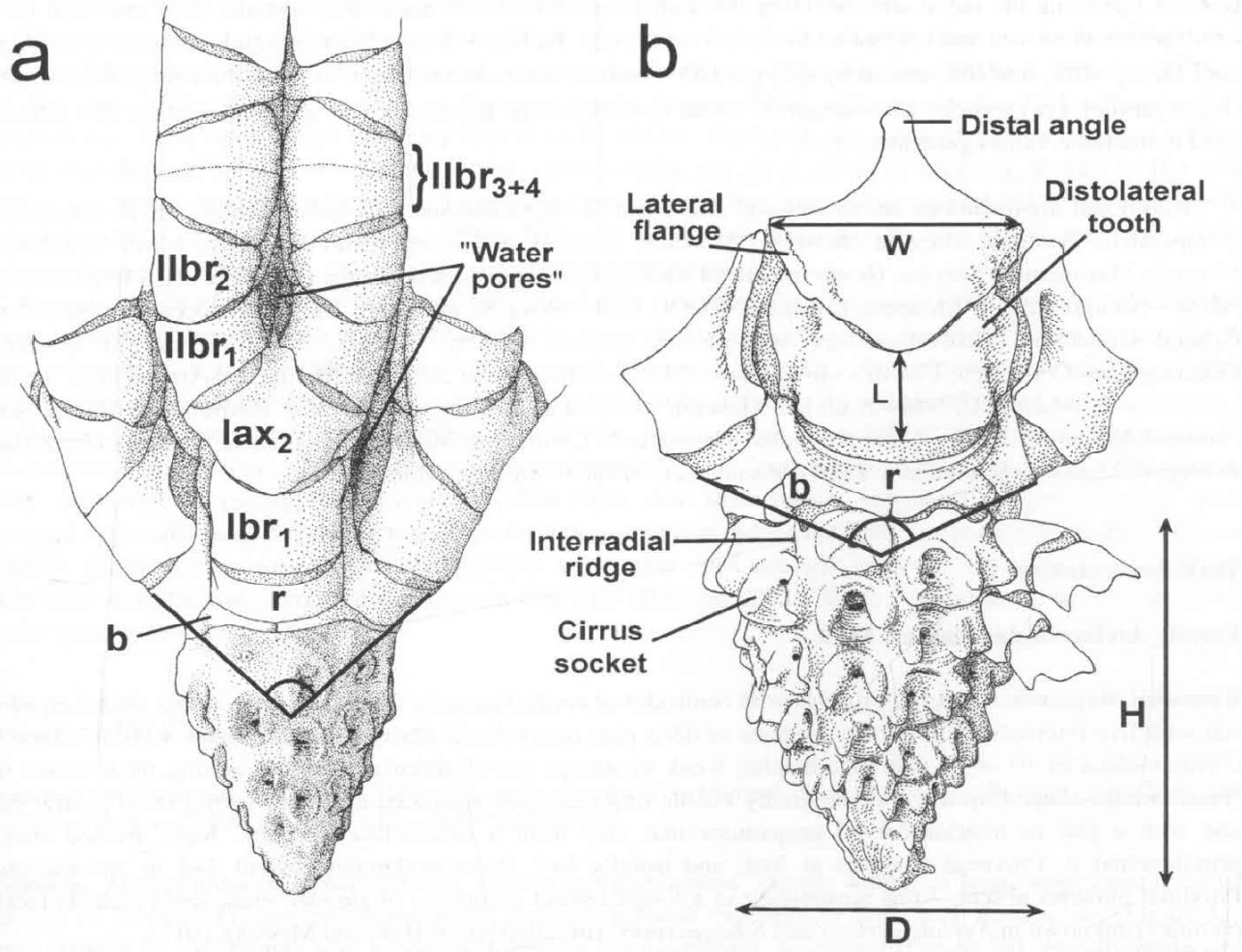

FIGURE 2. Primary morphological features of Atelecrinidae discussed herein. a. *Atelecrinus balanoides* PH Carpenter. b. *Paratelecrinus cubensis* (PH Carpenter). b = basal ossicle; r = radial ossicle; Ibr_1 and Iax_2 = primibrachials 1 and 2 (the latter an axil); $IIbr_1$ and $IIbr_2$ = secundibrachials 1 and 2; $IIbr_{3+4}$ = secundibrachials 3 and 4 united by syzygy; H = centrodorsal height; D = centrodorsal basal diameter; W = ossicle width; L = ossicle length. Angles show radial profiles: 90° (a) and >90° (b).

Figure 2 illustrates primary morphological features and some of their variations. Messing and Dearborn (1990), Messing (1997, 2001), Messing *et al.* (2000), Roux *et al.* (2002) and Hess and Messing (2011) give detailed treatments of crinoid morphology. Note that the abbreviations for the axil (the ossicle at which a ray forks) and for ossicles of the undivided arm following the axil differ from previous usage in comatulids. Standard usage since AH Clark (1915) established the modern skeletal terminology for comatulids has been 'br' followed by a sequential Arabic subscript (i.e., br_1, br_2...) for brachial ossicles of the undivided arm, i.e., following the distalmost axil or, in undivided rays, following the radial ossicle (the most proximal ray ossicle). In almost all comatulids, the second primibrachial ossicle (Ibr_2) is an axil; in ten-armed comatulids, such as Atelecrinidae, each axil gives rise to two undivided arms. To more clearly identify skeletal homologies, the brachials of the undivided arms are treated here as secundibrachial ossicles, abbreviated as $IIbr_1$, $IIbr_2$, etc. Previously, this designation was used only for the second brachitaxis that itself ended with an axil [although Bather (1900), who erected Atelecrinidae for *Atelecrinus*, referred to the undivided arms as IIBr, with the B indicating the entire series of ossicles]. In taxa with additional ray divisions, designation of the ossicles of the undivided arms will vary depending upon the brachitaxis from which

the arm arises, e.g., $IIIbr_1$ arising from a secundibrachial series. AH Clark also used no special abbreviation for axils. Axils in living stalked crinoids are often abbreviated, for example, as I Br 4 ax (the fourth primibrachial ossicle is an axil) (Améziane 1997, Bourseau and Roux 1989). For clarity and brevity, axils are here designated by 'ax', i.e., Iax_2 (the second ossicle of the primibrachial series is an axil) instead of Ibr_2. Other morphological abbreviations are: c—cirrus segment (=cirral), numbered from the base; IBr2—the primibrachial series of two ossicles following the radial and including the axil; P—pinnule (each numbered from the most proximal on the exterior side of an arm and lettered on the interior side, e.g., P_1, P_a); + designates a syzygial articulation (=syzygy), e.g., $IIbr_{3+4}$—$IIbr_3$ and $IIbr_4$ united by syzygy; HD—ratio of centrodorsal height to basal diameter; WL—width to length ratio of a ray ossicle; LW—length to width ratio of a distal brachial, cirral or pinnular (these two ratios are used to maintain values generally >1).

Additional abbreviations are as follows: *JSL I* and *II*—*Johnson Sea-Link* submersibles; MCZ—Museum of Comparative Zoology, Harvard; MNHN—Muséum national d'Histoire naturelle, Paris; MMS-NGOMCS—Minerals Management Service, Northern Gulf of Mexico Continental Slope Study, 1983–1998 (US Dept. Interior); NHM—Natural History Museum, London; NSUOC CRI—Nova Southeastern University Oceanographic Center Crinoid Collection; OMNH—Osaka Museum of Natural History; TAMU—Texas A and M University Oceanography Collection; UMML—Invertebrate Museum, Rosenstiel School of Marine and Atmospheric Science, University of Miami; USNM—National Museum of Natural History, Smithsonian Institution (=United States National Museum); NCB—NCB Naturalis, Netherlands Centre for Biodiversity, Leiden, Netherlands; ZMK—Zoologisk Museum, København; ZSM—Zoologische Staatssammlung, München.

Taxonomic section

Family Atelecrinidae Bather, 1899

Emended diagnosis. Articulate crinoids with centrodorsal conical (usually taller than wide across the base); adoral rim with five interradial depressions, sockets or deep pits; centrodorsal cavity broad and deep, with no adoral lip. Cirrus sockets in 10 or 15 columns, bearing weak to strong, lateral articular tubercles arising from socket rim. Basals wedge-shaped, forming an externally visible ring (rarely as separated triangles) with a small central canal and with a pair of interior curved projections that may form a rosette-like structure. Rays divided once at primibrachial 2. Proximal syzygies at 3+4, and usually 6+7, 9+10 (unknown beyond 3+4 in *Sibogacrinus*). Proximal pinnules absent. Arms terminating in a long filament composed of slender, elongated brachials lacking pinnules (unknown in *Adelatelecrinus* and *Sibogacrinus*) (modified from Hess and Messing 2011).

Type genus. *Atelecrinus* PH Carpenter, 1881.

Remarks. Bather (1900) erected Atelecrinidae for *Atelecrinus* after first mentioning the family name without comment (Bather 1899). Three genera have subsequently been variously added or removed. AH Clark (1912) added monotypic *Atopocrinus sibogae* based on its tall conical centrodorsal, socket fulcral ridges, and similar proximal brachials, though he also noted similarities with the comatulids *Zenometra* and *Psathyrometra* [then in Antedonidae; now in Zenometridae (Messing and White 2001)]. *Atopocrinus* also has five undivided rays similar to those of the comatulid *Pentametrocrinus* AH Clark, 1908 (Pentametrocrinidae), and a complete complement of pinnules. AH Clark (in Clark and Clark 1967) added *Sibogacrinus* for *Atelecrinus anomalus* AH Clark, 1912, which led AM Clark (in Clark and Clark 1967) to diagnose the family with few uniting features and numerous exceptions, e.g., 10 arms or (in *Atopocrinus*) 5 arms; centrodorsal with cirrus sockets flanked by "prominent elevations" [p. 811] sometimes forming a horseshoe-shaped ridge (except in *Sibogacrinus*); pinnules absent from the first 12 or more brachials (except in *Atopocrinus*).

Gislén (1924) transferred Upper Cretaceous *Atelecrinus belgica* (Jaekel 1901) to a new genus, *Jaekelometra*, and removed it to the fossil family Conometridae. Rasmussen and Sieverts-Doreck (1978) returned the genus to Atelecrinidae (see also Jagt 1999) but recognized only one feature common to the then four included genera (*Atelecrinus, Atopocrinus, Sibogacrinus, Jaekelometra*): cirrus sockets with a distinct fulcral ridge or pair of tubercles and a more or less prominent edge. Messing (2003) removed *Jaekelometra* and *Sibogacrinus* from the family, because the tall thin basals of *J. belgica* (Jaekel, 1902) and *J. columnaris* Gislén, 1924, differed completely

from the flattened wedge-shaped ossicles of *Atelecrinus*, and the tall basals of *Sibogacrinus* (only known at the time in external view) appeared similar to those of *Jaekelometra*. He also cited the basals of *J. meijeri* Rasmussen, 1961, as flattened and wedge-shaped, but small, without interior processes, and nestled within a much smaller central cavity than in *Atelecrinus*; however, these were actually broken portions of typical *Jaekelometra* basals (Jagt 1999) and possibly an extreme form of *J.* group of *concava* (Schlüter, 1878) (Hess, in Hess and Messing, 2011). Messing (2003) treated both *Sibogacrinus* and *Jaekelometra* as *incertae sedis*.

Most recently, new material of *Atopocrinus* from Japan has revealed a small rather than cavernous centrodorsal cavity, and five tongue-like basal rays instead of a complete basal ring (Messing, unpublished). Messing (in Hess and Messing, 2011) placed the genus in the new family Atopocrinidae without superfamilial assignment. In *Jaekelometra*, atelecrinid socket tubercles appear to be absent, the basals are tall and thin rather than wedge-shaped, and the oral surface of the centrodorsal varies widely, e.g., in *J.* group of *concava*, it may be flat with shallow interradial grooves or bear five large radial pits resembling those of the comatulid *Notocrinus virilis* Mortensen, 1917 (Notocrinidae) (Jagt 1999). Hess (in Hess and Messing, 2011) erected the new family Jaekelometridae for this genus, also without superfamilial assignment.

Reexamination of the unique but now deteriorated type specimen of *S. anomalus* (Messing, unpublished) has revealed thick, wedge-shaped basals more similar to those of *Atelecrinus* than *Jaekelometra*. The cirrus sockets also bear weak triangular fulcral processes. As a result, Hess and Messing (2011) retained *Sibogacrinus* within Atelecrinidae, although its centrodorsal cavity is much less spacious than in the other atelecrinid genera.

Within the Atelecrinidae, relationships among the four genera included in this paper appear to be (*Sibogacrinus* (*Atelecrinus* (*Adelatelecrinus*+*Paratelecrinus*)). The latter three share a cavernous centrodorsal cavity, distinctive projecting fulcral tubercles, thin rather than thick basals, and much longer cirri with more elongated segments. *Adelatelecrinus* and *Paratelecrinus* group together on the basis of their common possession of 5 hollow, interradial buttresses in the centrodorsal cavity that open adorally as deep, ring-shaped pits, whereas *Atelecrinus* has shallow interradial depressions (see also Messing 2003). Table 1 provides a tabular key to all named species in Atelecrinidae.

Atelecrinus PH Carpenter, 1881

Atelecrinus PH Carpenter 1881:16–18; 1882:488–489; 1888:68–70.—Hartlaub 1912:480–481.—AH Clark 1918:262, 266–267.—Clark and Clark 1967:817–819.—AM Clark 1970:49.

Diagnosis. Atelecrinidae with centrodorsal hollow and thin-walled, closely joined to basal ring; central cavity diameter >0.6 of basal diameter; adoral rim of centrodorsal with five shallow interradial depressions (Figure 3a). Cirrus sockets in 10 columns with moderately (Figure 2a) to strongly developed (Figure 2b) aborally-projecting lateral fulcral tubercles, triangular in side view; cirri tapering to a point with no opposing spine, of up to 40 segments, 65 mm long. Externally visible portion of each basal flat or slightly arched, weakly or moderately swollen interradially, with lateral portions parallel-sided or tapering, and ends contiguous midradially; sometimes reduced, triangular and separated midradially. Aboral surface of basals with featureless, central depression (Figure 3b) and with adorally curved and distally expanded pair of interior projections. Radial cavity with delicate aboral calcareous deposit. Most proximal pinnule usually on $IIbr_{17}$.

Type species. *Atelecrinus balanoides* PH Carpenter, 1881.

Other included species. *Atelecrinus helgae* AH Clark, 1913.

Remarks. Unlike *Paratelecrinus* and (most) *Adelatelecrinus*, described below, *Atelecrinus* has a tight suture between centrodorsal and basal ring, and shallow interradial depressions rather than deep, ring-shaped pits on the adoral rim of the centrodorsal (Messing 2003). Although these deep pits are usually associated with an interradial, ligament-filled, externally visible gap or slit between centrodorsal and basals, a few *Adelatelecrinus sulcatus* specimens also exhibit the tight suture of *Atelecrinus*; the presence of the deep pits therefore cannot be uniformly recognized without dissociation. A few *Ad. sulcatus* specimens also share with *Atelecrinus* comparatively weaker cirrus socket fulcral tubercles, and a dissociated specimen of *At. balanoides* and one of *Ad. sulcatus* both have a cluster of irregular calcareous needles forming a thin, delicate plug at the aboral end of the radial cavity not yet seen in other atelecrinids.

TABLE 1. Tabular key to species of Atelecrinidae. Abbreviations: character absent (-); character present (+); character unknown (?); ratio of centrodorsal height to basal diameter (HD); small specimens (sm); large specimens (lg). Colons (:) separate different characters within a cell. Semicolons (;) separate a character present in all of the preceding character states, e.g., a basal may be of uniform height whether straight or gently arched (Straight or gently arched; uniform height). NOTE: Although both *Adelatelecrinus* and *Paratelecrinus* are diagnosed as having adoral pits in the centrodorsal rim, and the ligament-filled gap between centrodorsal and basals has so far corresponded with their presence, this character is listed as ? for those species that have not been dissociated and the presence of pits verified.

	Centrodorsal						Basals		
Taxon	**HD**	**Adoral pits**	**No. socket columns**	**Sockets per column**	**Interradial margin**	**Interradial ridge strength: Length**	**External thickness: Shape**	**Centrodorsal-Basal gap**	**Interradial swelling: Shape**
At. balanoides	1.2-1.7	-	10	2-4	Flat or convex	Weak: Short	Thin: Flat or chevron or small triangle	None	Slight: Triangular
At. helgae	1.0-1.4	-	10	2-5	Variable	Strong: Short or long	Thin: Flat or chevron or small triangle	None	Moderate to strong: Triangular or knoblike
Ad. sulcatus	1.2-1.3	+	10	3-4	Variable	Weak: Short	Thin: Flat or slightly arched	None/Slit	Slight: Triangular
Ad. vallatus	1.3-1.4	?	10	2-3	Flat or slight V	Weak: Short	Thin: Wide triangular	None/Slit	Flat: Triangular
P. amenouzume	1.2	?	10	7	Concave	Narrow: Long	Thin: Chevron of uniform height	Large	None: Divided?
P. conifer	1.2-1.3	?	15	4-7 (lat) 3-5 (mid)	Projecting V	None/Slight: Short	Thin: Straight or gently arched, of uniform height	None/Large	Slight
P. cubensis	1.1-1.4	+	10	3-6	Concave or with deep V	Usually weak: Short	Thin: Chevron with expanded rounded ends	Large	Strong
P. laticonulus	<1.0	?	10	5-6	Shallow U or V	None	Thin: Straight; laterally narrow	Large	Strong: Broad, often bilobed
P. orthotriremis	1.0-1.4	+	15	5-7 (lat) 3-4 (mid)	Weakly concave	None	Thin: Almost straight or gently arched or chevron with slightly expanded ends	Large	Slight
P. telo	1.1	?	15	4-5 (lat) 3-4 (mid)	Slight V	Weak: Short	Thin: Straight or gently arched; tapered laterally	Thin	Slight: Triangular or pentagonal
P. wyvilli	1.2-1.3	+	10	4-7	Flat or weakly concave	Absent or weak: Short if present	Thin: Gently arched or chevron with slightly expanded ends	Large	Flat or slight: Triangular
S. anomalus	1.4	-	10	3	Roughly quadrate excavation	None	Thick: Heptagonal	None	None

.....continued on the next page

TABLE 1. (continued)

Taxon	Cirri	Radial	Ibr_1	Iax_2 (axil)	
	Opposing spine	**Profile angle**	**Lateral margins**	**Shape**	**Lateral margin**
At. balanoides	-	<90°	Parallel	Rhombic	Smooth
At. helgae	-	>90°	Parallel with small triangular or rounded distal projection	Hexagonal or rarely rhombic	Knobbed or diverging
Ad. sulcatus	-	≤80°	Parallel with small distal triangular tooth	Hexagonal	Diverging, sometimes with small tooth
Ad. vallatus	?	70°	Concave with distal flange	Hexagonal	Thick flange
P. amenouzume	?	<90°	Converging	Shield	Diverging, concave
P. conifer	?	90-120°	Slightly converging	Rhombic	Diverging
P. cubensis	+	80° (sm) 120° (lg)	Parallel with thin flange	Hexagonal (sm) Rhombic (lg)	Winglike flange
P. laticonulus	?	<70°	Converging	Hexagonal	Concave diverging
P. orthotriremis	+	~65-80° (sm) ~90-100° (lg)	Parallel	Hexagonal (sm) Rhombic (lg)	Straight or convex (sm) Diverging (lg)
P. telo	?	>90°	Concave	Hexagonal or rhombic	Concave diverging
P. wyvilli	?	90-110°	Parallel or slightly sinuous with distal corners cut away	Hexagonal or rhombic	Slightly sinuous or Diverging
S. anomalus	+	~50°	Slightly diverging	Hexagonal or rhombic	Diverging

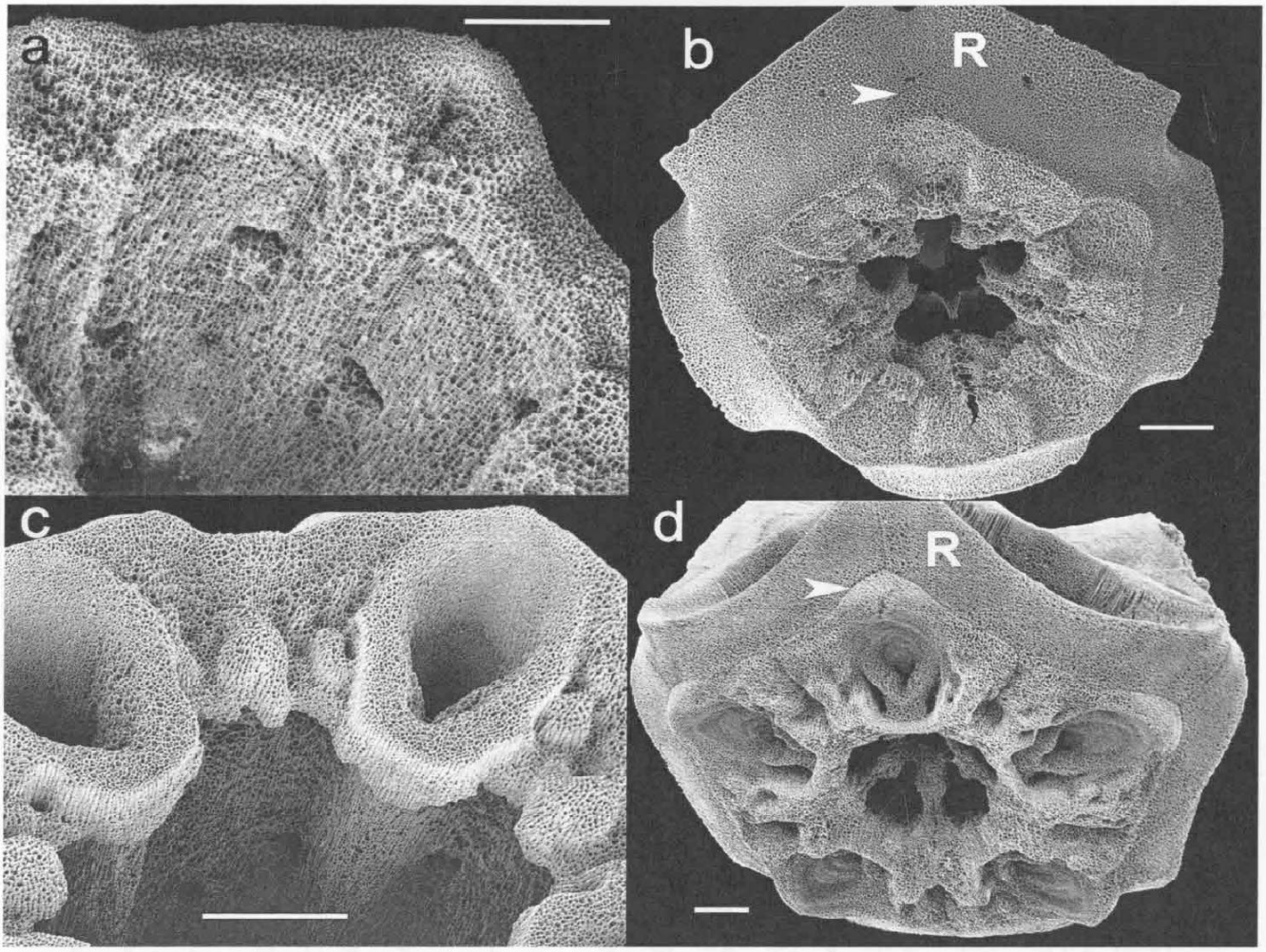

FIGURE 3. Adoral view of centrodorsal cavity of (a) *Atelecrinus balanoides* PH Carpenter showing shallow interradial depressions, and (c) *Paratelecrinus orthotriremis* **n. sp.** showing interradial buttresses and deep pits. Aboral view of basal ring of (b) *At. balanoides*, showing central, shallow, flat depression on each basal, and (d) *P. orthotriremis* showing central spoon-shaped fossa on each basal. Arrows indicate suture of basal with radial ossicle. R = radial ossicle. Scale bars (a–d) 0.5 mm.

AM Clark (1977) attributed a post-pentacrinoid juvenile (centrodorsal basal diameter 0.6 mm) collected by R/V *Atlantis II* off Argentina to *Atelecrinus* sp. based on its complete basal ring, very attenuated cirri, and lack of pinnules proximal to $IIbr_{14}$. This identification may not be correct. Remodeling of the basals into a rosette takes place after stem loss in some other comatulids, e.g., *Antedon bifida* (Pennant, 1777) (WB Carpenter 1866). Similarly attenuated cirrus segments occur in other deep-water comatulids, e.g., *Bathymetra*, *Thaumatometra* (Clark and Clark 1967), although the latter have an opposing spine not present in the *Atlantis* specimen. The initial pinnule appears at a similar distance along the arm ($IIbr_{12}$) in *Antedon serrata* AH Clark, 1908b (as *Compsometra serrata* in Mortensen 1920). In addition, the proximal syzygies lie at 3+4 and 9+10, as in Antedonidae, rather than 3+4, 6+7, 9+10, as in Atelecrinidae. AM Clark (1977) also attributed three pentacrinoid postlarvae to *Atelecrinus* sp. based on the similarity of their aboral cups to that in the juvenile (one was collected at the same station). However, the constricted base of the basal ring and the raised median belt on the more distal figured columnals (her fig. 5b) are characteristic of many Hyocrinidae, which retain the stalk (e.g., Roux & Pawson 1999, Roux 2002, Roux *et al.* 2002). Nevertheless, these pentacrinoids may be comatulids; little enough is known about postlarvae in any deep-sea crinoids.

Atelecrinus balanoides PH Carpenter, 1881

Figures 4, 5

Antedon cubensis Pourtalès, 1869: 356 (part); 1878: 214–215 (part).

Atelecrinus balanoides PH Carpenter 1881:15–19, pl. 1, figs. 1–6; 1882: 489–491 (part); 1888:70–72, pl. 6, figs. 6–7.—Hartlaub 1912:481–485, pl. 6, figs. 5–6, pl. 14, figs. 1, 2, 4, 6, 7.—AH Clark and AM Clark 1967: 819, 823–831.—AM Clark 1970: 49–51 (part).

Atelecrinus balanoides form *balanoides*: Messing and Dearborn 1990:10, 11, 23.

Holotype. St. Kitts and Nevis: MCZ 230, *Blake* 151, 17°08'21"N, 62°42'00"W, 15 Jan 1879, 668 m.

Other material examined. Gulf of Mexico: TAMU 3-0751, *Alaminos* 68A13-4, 25°38.4'N, 96°18.3'W, 512 m, 12 Nov 1968, WE Pequegnat, coll. (1 spec.); TAMU 0-0730, *Alaminos* 68A13-23, 27°35'N, 95°23'W, 732 m, 20 Nov 1968, WE Pequegnat, coll. (1); TAMU 3-0729, *Alaminos* 68A13-21, 27°38'N, 95°21.5'W, 512–641 m, 19 Nov 1968, WE Pequegnat, coll. (1); NSUOC CRI-494, MMS-NGOMCS sta. WC3, sample 5503-1, 27°35'13'N, 92°22'40"W, 768–781 m, 9 Jun 1985 (1); NSUOC CRI-551, MMS-NGOMCS sta. E2B, sample 4511, 28°18'58"N, 86°18'56"W, 600–625 m, 17 May 1985 (13); NSUOC CRI-542, MMS-NGOMCS sta. WC6, sample 5506, 27°42'44"N, 91°32'55"W, 543–783 m,10 Jun 1985 (5); NSUOC CRI-555, MMS-NGOMCS sta. E2F, sample 4507, 28°01'04"N, 85°39'38"W, 629 m, 16 May 1985 (3); NSUOC CRI-545, MMS-NGOMCS sta. E2, sample 4510, 28°16'04"N, 86°12'05"W, 613–618 m, 17 May 1985 (1); NSUOC CRI-493, MMS-NGOMCS sta. WC4, sample 5505, 27°43'10"N, 92°09'14"W, 516–527 m, 10 Jun 1985 (3); NSUOC CRI 621, MMS-NGOMCS sta. WC2, sample 5504, 27°45'08"N, 92°29'08"W, 518–585 m, 9 Jun 1985 (5); NSUOC CRI-540, MMS-NGOMCS sta. E2A, sample 4502, 25°38'01"N, 86°45'44"W, 625 m, 13 May 1985 (1). Strait of Florida: MCZ 233, *Blake* 43, 24°08'N, 82°51'W, 1877-8, 620 m (1); MCZ 1102, *Atlantis* 2999, 23°10'N, 81°29'W, 17 Mar 1938, 485–770 m (3); USNM E19281, *Gerda* 146, 24°45'N, 80°09'W, 23 Jun 1963, 659–686 m (1); USNM E19286, *Gerda* 112, 24°14'N, 82°56'W, 18 Jun 1963, 641–686 m (1); USNM E19287, *Gerda* 289, 24°11'N, 81°36'W, 3 Apr 1964, 594–604 m (11 + 1 dissociated); USNM E19289, *Gerda* 439, 24°14'N, 82°29'W, 29 Nov 1964, 566–584 m (2); USNM E19292, *Gerda* 93, 25°03'N, 79°45'W, 19 Apr 1963, 733 m (1); USNM E19293, *Gerda* 861, 24°08'N, 81°36'W, 29 Aug 1967, 514–558 m (1). Bahamas: USNM E19284, *Columbus Iselin* 27, Chub Cay, 25°24'54"N, 78°05'24"W, 7 Jul 1972, 658–666 m (2). Nicholas Channel: MCZ 1072, *Atlantis* 2990, 23°15'N, 80°08'W, 14 Mar 1938, 714 m (2). Jamaica: E17834, *Pillsbury* 1261, 17°13'00"N, 77°50'W, 15 Jul 1970, 595–824 m (3). St. Kitts and Nevis: MCZ 43, *Blake* 150, 17°11'22"N, 62°46'W, 15 Jan 1879, 686 m (1). Montserrat: USNM E17880, *Pillsbury* 946, 16°43'30"N, 61°57'W, 17 Jul 1969, 732–832 m (1). Guadeloupe: USNM E17833, *Pillsbury* 920, NW of Marie-Galante, 16°05'48"N, 61°18'42"W, 12 Jul 1969, 631–704 m (3). St. Lucia: MCZ 229, *Blake* 222, 13°58'37"N, 61°04'45"W, 16 Feb 1879, 772 m (1). St. Vincent and Grenadines: USNM E42679, *JSL II* 1746, York Bay, 13°09'23"N, 61°17'30"W, 25 Apr 1989, 739 m (1). Barbados: USNM E42690, *JSL II* 1731, Maycock's Bay, 13°16'17"N, 59°45'24"W, 17 Apr 1989, 838 m (1). Colombia: USNM E17876 (23), USNM E26227 (2), *Pillsbury* 781, W of Riohacha, 11°30'N, 73°26'30"W, 30 Jul 1968, 531–567 m. Venezuela: USNM E17872, *Pillsbury* 740, S of Orchila I., 11°13'N, 66°15'W, 23 Jul 1968, 827–924 m (3); USNM E17877, *Pillsbury* 754, N of Zamuro Point, 11°36'54"N, 68°42'W, 26 Jul 1968, 684–1574 m (1).

Diagnosis. A species of *Atelecrinus* in which the centrodorsal base is usually parallel-sided; fulcral tubercles weak to moderate; basals weakly inflated interradially, forming continuations of short weak ridges on the centrodorsal, sometimes reduced to interradial triangles not contiguous midradially; radial profile usually ≤90°; axils well-separated laterally, rhombic or hexagonal with diverging lateral margins; lateral margins of proximal brachials rounded.

Description. Centrodorsal conical with sides usually parallel near base (Figures 4a–c), rarely tapering from base to apex (Figure 4d); interradial ridges short, weak; sockets in two columns per radial area of 2–4 sockets each, with weak to moderate fulcral tubercles; HD 1.2–1.7; basal diameter 1.8–3.5 mm. Cirri XIX–XLIII (chiefly XXV–XXXIII); one complete peripheral cirrus (Figure 5a) (others incomplete), of ~40 cirrals, ~65 mm long; c1 to c3–4 short; c4 or c5 squarish or longer than broad, LW 1.3–2.8; following cirrals flattened and longer than wide; c11–12 longest, LW up to 4.4 (to 5.0 on some apical cirri); middle segments slightly shorter and narrower; distal several segments tapering to straight or slightly bent claw; penultimate cirral longer than wide; claw sometimes blunt, kinked in at least one case. Apical cirri shorter, more slender and with fewer cirrals (Figure 5b).

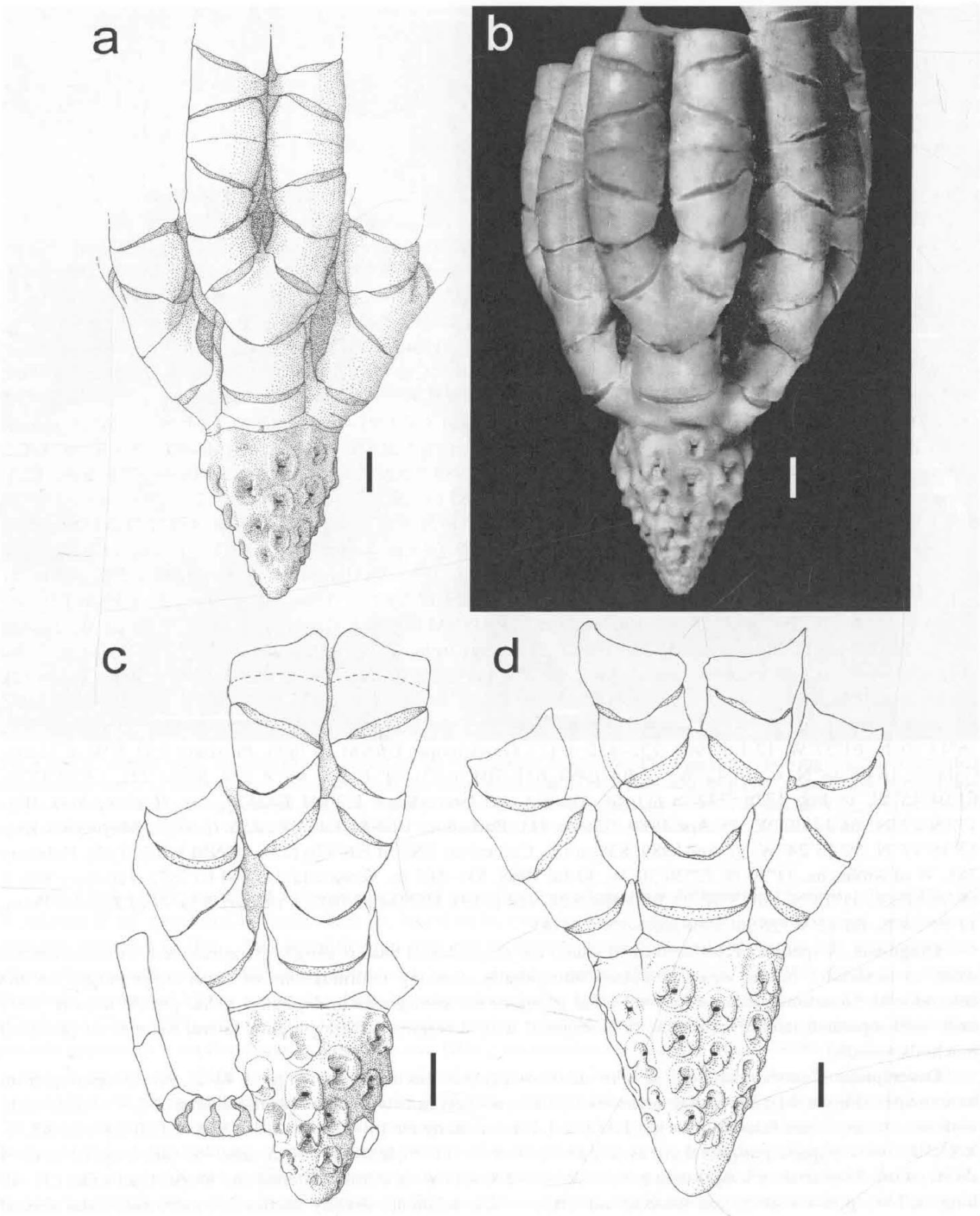

FIGURE 4. *Atelecrinus balanoides* PH Carpenter. Centrodorsal and ray bases in lateral view. a. E19287. b. MCZ 43. c. MCZ 230 (holotype). d. USNM E42690. Scale bars: 1 mm.

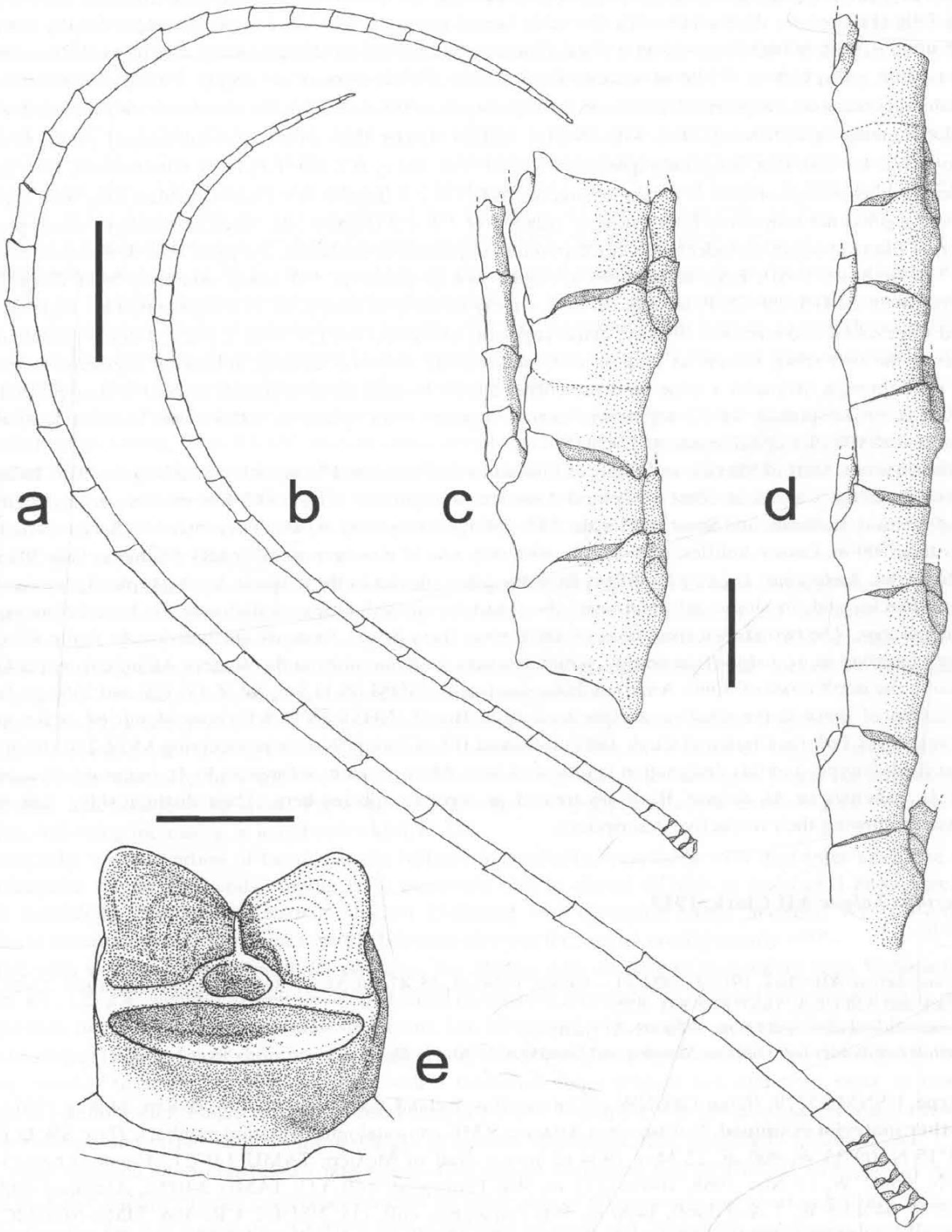

FIGURE 5. *Atelecrinus balanoides* PH Carpenter. a. Peripheral cirrus. b. Apical cirrus. c. Five middle brachials. d. Ten distal brachials. e. Articular facet of radial ossicle. Scale bars: upper left (a, b) 5 mm; upper right (c, d) 1 mm; lower left (e) 1 mm.

Externally visible portion of basals flat or slightly chevron-shaped, slightly swollen and usually triangular interradially, laterally narrower (Figures 4a, c), rarely very narrow or reduced to interradial triangles and not visible midradially (Figures 4b, d). Radials with diverging lateral margins, WL 1.7–2.8; profile angle usually ≤90°. Ray length up to ~200 mm including +65-mm distal filament. Synarthrial swellings usually absent on IBr2, sometimes weak on $IIbr_{1-2}$. Ibr_1 oblong or almost square; distal margin slightly concave to deeply V-shaped, sometimes with distolateral corners cut away; WL 1.2–1.8. Axil (Iax_2) rhombic; WL 1.0–1.25. Proximal brachials rounded, with no lateral flattening or thickening. $IIbr_1$ with interior margin shorter than exterior; distal margin gently to deeply concave; WL 1.4–2.0. $IIbr_2$ irregularly quadrate; WL 1.1–1.5. $IIbr_{3+4}$ WL 0.9–1.3; 1.1–2.0 mm across. $IIbr_5$ through middle brachials wedge-shaped to almost triangular; WL 1.0–2.0 (Figure 5c). Distal brachials long with expanded ends and a proximal transverse finely spinose ridge; LW 1.3–1.9 (Figure 5d). Sides of brachials along proximal portion of filament retaining indentation corresponding to pinnule articulation. Syzygies at 3+4, 6+7 (second rarely 5+6, 7+8 or 8+9), 9+10; interval between syzygies 2–4 proximally, 3–5 along mid-arm, 5–11 distally. One specimen with 3+4+5, 10+11. P_1 usually on $IIbr_{17}$ (rarely as early as $IIbr_{13}$), of >19 segments; first segment short, second trapezoidal and narrower distally; distal segments elongated but LW only 2.1–2.8. Middle pinnule of >17 segments, the first short, second as long as wide and slightly narrower distally; following segments longer than wide; third through fifth with a spine on distal corner closest to arm; distal segments slender with expanded ends; LW to 8.0. Distal pinnule of 32 segments; second segment with spine on distal corner nearest arm; middle segments with LW 3.0, distal segments LW 4.0.

Distribution. Gulf of Mexico and Strait of Florida to Colombia and Venezuela, including the West Indies, but unknown from the Caribbean coast of Central America. Bathymetric range: 512–838 m, but varying regionally. Gulf of Mexico, Bahamas and Strait of Florida: 512–768 (possibly 783) m, with only three of 25 records definitely deeper than 700 m. Lesser Antilles: 686–838 m, with only one of nine records definitely shallower than 700 m.

Remarks. *Atelecrinus balanoides* differs from the other species in the genus in having typically weaker cirrus socket tubercles and, in almost all specimens, the centrodorsal with sides parallel near the base before tapering toward the apex. The two known specimens of *Atelecrinus* from Brazil, formerly attributed to *At. balanoides*, have been re-identified as *At. helgae* (see below), which restricts *At. balanoides* to the western Atlantic from the Gulf of Mexico to the north coast of South America. Four specimens (NHM 88.11.9.1, MCZ 43, 229 and 230) are labeled "type." One of these is the *Challenger* specimen from Brazil (NHM 88.11.9.1), now identified as *At. helgae*. However, AM Clark (in Clark and Clark 1967) followed H.L. Clark (1941) in recognizing MCZ 230 (from *Blake* 151) as the holotype, and this designation is followed here. Most previous references to *At. balanoides* incorporate either *At. cubensis* or *At. helgae*. Both are treated as separate species here. Their distinguishing features are discussed following their respective descriptions.

Atelecrinus helgae AH Clark, 1913

Figure 6

Atelecrinus helgae AH Clark, 1913:4; 1923:44.—Gislén, 1924: 43, 45, 47, 50, 53, 81, 83, 93.—Mortensen, 1927: 22–23.—AH Clark and AM Clark, 1967: 819, 831–832.
Atelecrinus balanoides: AM Clark, 1970: 49–51 (part).
Atelecrinus balanoides form *helgae*: Messing and Dearborn, 1990: 11, 23.

Holotype. USNM 35779, *Helga* 120, NW of Galway Bay, Ireland, 53°58'N, 12°24'W, 698 m, 24 Aug 1901 (1).

Other material examined. Northeastern Atlantic: ZMK (no catalogue or station number), *Thor*, SW of Faeroe Is., 61°15'N, 09°35'W, 900 m, 22 May 1904 (2 spec.). Gulf of Mexico: TAMU 3-0727, *Alaminos* 68A13-12A, 25°31'N, 95°51'W, 17 Nov 1968, 1061–1317 m, WE Pequegnat, coll. (1); TAMU 3-0752, *Alaminos* 69A11-7, 27°01.3'N, 94°43.5'W, 7 Aug 1969, 1400 m, WE Pequegnat, coll. (1); NSUOC CRI-496, MMS-NGOMCS sta. WC12, sample 5509-1, 27°19'37"N, 91°31'21"W, 1170–1236 m, 13 Jun 1985, LGL, coll. (1); USNM E41942, *Citation* CO8, SW of Grand Island, LA, 27°31'04"N, 89°48'56"W, 15 Nov 1984, 1064 m (2). Blake Plateau: USNM 34956, *Albatross* 2415, off NE Florida, 30°44'N, 79°26'W, 1 Apr 1885, 805 m (1); USNM E19291, *Gerda* 182, N of Little Bahama Bank, 27°55'N, 78°40'W, 2 Jul 1963, 860–897 m (1); USNM E19285, *Gerda* 403, N of Little Bahama Bank, 27°49'N, 78°50'W, 20 Sep 1964, 824 m (1). Strait of Florida: USNM E17879, *Pillsbury* 636, SE of Key West, 23°54'N, 81°27'W, 25 Mar 1968, 1003–1336 m (2); USNM E19282, *Gerda* 130, W of Cay Sal

Bank, 23°59'N, 81°10'W, 21 Jun 1963, 1021 m (1); USNM E19283, *Gerda* 374, S of Key West, 23°50'N, 81°37'W, 17 Sep 1964, 1208–1241 m (2); UMML 44.180, *Gerda* 448, NE of Havana, 23°54'N, 82°21'W, 1135–1184 m, 1 Dec 1964 (2). USNM E19290, *Gerda* 963, NE of Havana, 23°41'N, 82°16'W, 1 Feb 1968, 1441–1454 m (1). Bahamas: USNM E19288, *Columbus Iselin* 60, Tongue of the Ocean, 24°26'06"N, 77°29'W, 28 Feb 1973, 2793–2825 (1); USNM E19295, *Columbus Iselin* 103, Tongue of the Ocean, 24°08'N, 77°22'W, 21 Sep 1973, 1450 m (1); USNM E19294, *Columbus Iselin* 301, no data (1). Caribbean Sea: USNM 16893, *Albatross* 2117, Aves I., 15°24'40"N, 63°31'30"W, 27 Jan 1884, 1249 m (1); USNM E42680, *JSL-II* 1729, off Speightstown, Barbados, 13°15'30"N, 59°45'47"W, 16 Apr 1989, 866 m (1); USNM E17842, *Pillsbury* 847, NW of Tobago, 11°37'18"N, 59°24'W, 2 Jul 1969, 733–1281 m (1); MCZ 231, *Albatross* 2751, St. Kitts and Nevis, 16.9°N, 63.2°W, 28 Nov 1887, 1257 m (1). Brazil: MCZ 232, *Albatross* 2756, Fortaleza, 03.367°S, 37.817°W, 14 Dec 1887, 763 m (1). NHM 88.11.9.1, *Challenger* 122, off Barra Grande, 09°05'S, 34°50'W, 10 Sep 1873, 640 m (1).

Diagnosis. A species of *Atelecrinus* in which the centrodorsal usually tapers from the base; fulcral tubercles moderately to strongly developed; basals inflated interradially, forming continuations of usually well-developed ridges on centrodorsal; angle of radial profiles usually >90°; Iax_2 hexagonal with weakly- to well-developed lateral knob- or ear-like lobes, or short diverging lateral margins; exterior margin of $IIbr_1$ and $IIbr_2$ and usually interior margin of $IIbr_{3+4}$ flattened, often with a thick ridge along the edge.

Redescription of the holotype. Centrodorsal conical, tapering from its base; basal diameter 2.3 mm; HD 1.15; interradial ridges strong. Cirri XXXV, with an immature peripheral socket apparently beginning a third column in two radial areas; tubercles prominent. Basals swollen interradially. Radial profile >90°. IBr2 almost smooth in profile with weak synarthrial swelling. Ibr_1 with distolateral corners slightly swollen. Iax_2 hexagonal with lateral margins diverging distally or with weak lateral thickening. $IIbr_1$ and $IIbr_2$ somewhat thickened and expanded exteriorly; well separated. $IIbr_{3+4}$ 1.4 mm across.

Description of other specimens. Centrodorsal conical and tapering from its base (Figures 6a, c, d) or rarely with slightly swollen sides (Figure 6b); aboral tip conical or blunt; basal diameter 2.1–3.9 mm; HD 1.0–1.4; interradial ridges usually well developed, ranging from short (Figure 6a) to half height of centrodorsal (Figures 6b, c), rarely extending almost to tip; fulcral tubercles moderately to strongly developed; sockets in 2 columns per radial area of 2–5 sockets each; small apical sockets sometimes present.

Cirri XX–XLII (chiefly XXV–XXX); one complete apical cirrus of 30 cirrals (Figure 6e), 30 mm long, laterally compressed and tapering to a straight conical terminal segment; c1–2 short; c3 slightly longer than wide; following cirrals increasing in length to c7 with LW 3.0; cirrals beyond c9 decreasing in length but remaining with LW at least 2.0; no opposing spine. Proximal 10 segments of a peripheral cirrus consisting of c1–3 short; c4 squarish; following increasing in length; c9 with LW 4.0.

Externally visible portion of basals usually inflated interradially, sometimes with the center knob-like rather than triangular (Figure 6c); ends ranging from extremely thin to almost as high as interradial knob; rarely not visible midradially (Figure 6d). Radials shallow U-shaped with diverging lateral margins, WL 2.0–3.6; thin margins of muscular fossae sometimes visible between adjacent Ibr_1; radial profile usually >90°.

IBr2 with weak to strong synarthrial swelling. Ibr_1 oblong with shallow to moderately deep V-shaped distal margin, WL 1.2–2.4; weakly- to well-developed small distolateral triangular or rounded projection usually present on more than one ossicle (absent in small specimen). Iax_2 hexagonal with weakly- to well-developed lateral knob- or ear-like lobes (Figure 6a) or short parallel or diverging lateral margins (Figure 6c); WL 1.0–1.4. Exterior margin of $IIbr_{1-2}$ weakly to strongly flattened, often with a thickened ridge (Figure 6c), and with weak to moderate synarthrial swelling. $IIbr_1$ longer exteriorly, distal margin shallow V-shaped; WL 1.5–2.3; interior margin almost as long as exterior, and distal margin almost straight in smaller specimens. $IIbr_2$ irregularly quadrate; WL 1.2–1.5. $IIbr_{3+4}$ often flattened interiorly, 1.3–2.7 mm across. $IIbr_5$ almost triangular. USNM E19295 with one ray missing; pair of *probolus Adidas*™ facing each other on axils on either side of missing ray (one short or broken), suggesting that the missing ray had a *probolus Adidas*™ facing outward on each axil. Both *Thor* specimens have the typical two processes facing each other on adjacent axils. One specimen (E17879) with one undivided ray.

USNM E42680, the smallest known but most complete specimen, differs chiefly in having less well developed diagnostic features and proportionally more elongated ray ossicles. Centrodorsal with strong interradial ridges extending almost half way to tip, and with a few remaining apical sockets; HD 1.2; basal diameter 1.9 mm. Cirri XXIII, with 1–3 per column. Radials with WL 1.9. IBr2 lacking synarthrial swellings; Ibr_1 squarish, with slightly

concave sides, weak distolateral triangles, and distal margin very shallowly V-shaped; WL 1.3. Iax_2 distinctly hexagonal with slightly diverging lateral margins, slightly projecting laterally on two as incipient lobes; WL 1.1. $IIbr_{1-2}$ slightly flattened exteriorly. $IIbr_1$ slightly longer exteriorly, with distal margin shallowly concave; WL 1.5. $IIbr_2$ irregularly quadrate; WL 1.2. $IIbr_{3+4}$ 1.1 mm across. $IIbr_5$ wedge-shaped; WL 1.4. $IIbr_8$ almost oblong; WL 1.0. Brachials following $IIbr_{9+10}$ weakly wedge-shaped and slightly longer than wide, with slightly raised distal margins. Syzygial interval 3–4. P_1 on $IIbr_{16-17}$ (on $IIbr_{15}$ on an arm with $IIbr_{10+11}$ instead of $IIbr_{9+10}$). All pinnules broken; first pinnular short; second trapezoidal, narrower distally and longer than wide (LW 1.3); following segments longer and slenderer, up to at least LW 7.0 and with somewhat expanded distal ends.

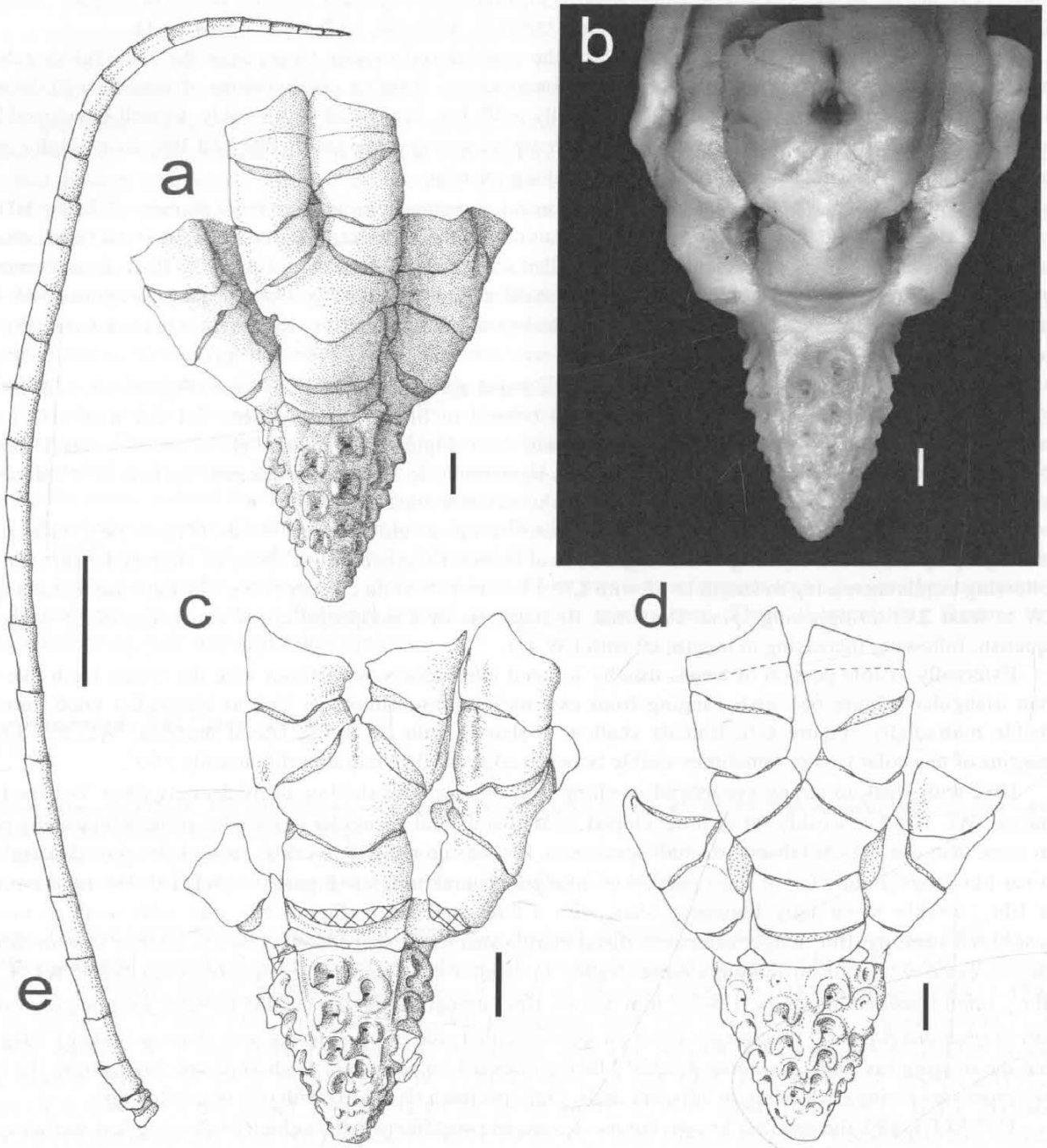

FIGURE 6. *Atelecrinus helgae* A.H. Clark. a–d. Centrodorsal and ray bases in lateral view. a. UMML 44.180. b. USNM E19294. c. ZMK *Thor* (center and right-hand ray bases above cross-hatching are a single unit detached from the radial circlet and centrodorsal). d. NHM 88.11.9.1. e. Cirrus, USNM E19291. Scale bars: (a–d) 1 mm; (e) 3 mm.

Distribution. North and west of the British Isles, Gulf of Mexico, southern Blake Plateau, Strait of Florida, Bahamas, eastern Caribbean Sea and Brazil. Bathymetric range: 640–1450 (possibly 1454) m, with one Bahamian record from 2793–2825 m. *Atelecrinus helgae* appears to occur in deeper water than *At. balanoides* wherever the two co-occur (maximum possible ranges given): 1061–1400 vs. 512–781 m in the Gulf of Mexico; 1003–1454 vs. 514–733 m in the Strait of Florida; 1450–2825 vs. 658–714 m in the Bahamas, and 866–1257 vs. 598–838 m in the Lesser Antilles. (USNM E17842 was collected somewhere between 733–1281 m off Tobago.) *At. helgae* also generally occurs at shallower depths at higher latitudes. Records from the Blake Plateau (805–897 m), NE Atlantic (698–900 m) and Brazil (640–763 m) are shallower than those for the Gulf of Mexico, Bahamas and Caribbean Sea (chiefly 1003–1454 m with one record off Barbados in 866 m), though this must also reflect varying oceanographic conditions: the Gulf of Mexico records are deeper than those from the Blake Plateau at similar latitudes.

Remarks. AH Clark (1913) distinguished the holotype of *At. helgae* from *At. balanoides* by its smaller, straight-sided (i.e., not parallel-sided at the base) and more sharply conical centrodorsal with more numerous and crowded cirrus sockets. Clark and Clark (1967) added the *Thor* specimen and diagnosed *At. helgae* only by its smaller size and sharply conical centrodorsal just slightly longer than the basal width, although they also noted that the lateral edge of the axil may bear a prominent tubercle. Both specimens were collected in the NE Atlantic, while *At. balanoides* was restricted to the tropical W Atlantic. AM Clark (1970), in comparing the *Challenger* specimen of *At. balanoides* from Brazil with the *Thor* specimen, found no significant differences between their centrodorsals and synonymized *At. helgae* under *At. balanoides*. Messing and Dearborn (1990) treated *At. helgae* as a deeper-water infrasubspecific variant of *At. balanoides* (form *helgae*) based mostly on material collected in the Strait of Florida and Caribbean Sea by the University of Miami's R/V *Gerda* and *Pillsbury* (though they gave no station data). These specimens share with NE Atlantic *At. helgae* the centrodorsal tapering from the base with more prominent interradial ridges, fulcral tubercles and basal swelling; radial profiles >90°, and thickened or flattened exterior margins of $IIbr_1$ and $IIbr_2$ and (sometimes) interior margin of $IIbr_{3+4}$. The ridge- or knob-like lateral margins of the hexagonal axils are more prominent in most of the W Atlantic specimens than in the holotype. They noted that the *helgae* form was collected chiefly below 1000 m but that most of the distinctions between it and typical *At. balanoides* were "not uniformly clear-cut relative to depth" (Messing and Dearborn 1990: 23). However, re-examination of existing specimens plus new material suggests that, although some character overlap exists, *At. helgae* constitutes a valid species distinct from *At. balanoides*. In specimens with a weakly developed lateral ridge or knob on only one or two axils (e.g., the holotype, USNM E19290 and E19285), the other axils remain hexagonal (with diverging lateral margins) and differ from the rhombic form typical of *At. balanoides*. Axils are similarly hexagonal in the few specimens that lack any lateral ridge or knob, including both the *Thor* specimens from the NE Atlantic and *Challenger* specimen from Brazil. It is thus not surprising that AM Clark (1970) considered them the same species. The *Challenger* specimen is here treated as *At. helgae*, although its identity remains uncertain. A few other specimens with some other less well developed diagnostic features still appear distinguishable from *At. balanoides*, e.g., USNM E17842 has short, weak interradial ridges but retains a radial profile angle >90°, very short radials, and $IIbr_1$ with the exterior margin thickened.

Atelecrinus helgae appears to be less abundant than *At. balanoides* on substrates amenable to trawling and dredging. Whereas more than a third of the trawl samples of *At. balanoides* recorded here included three or more specimens (up to 25), no more than two *At. helgae* specimens were ever taken in a single haul.

Although AH Clark (1913) and Clark and Clark (1967) indicated that the *Thor* collected a single specimen, the jar contains two specimens with the same station data. Both are partly dissociated. The holotype of *At. helgae* is almost completely dissociated.

Adelatelecrinus new genus

Atelecrinus: AH Clark 1912: 152.—Hartlaub 1912:480–481 (part).—AH Clark 1918:262, 266–268 (part).—Clark and Clark 1967:817–819 (part).

Diagnosis. A genus of Atelecrinidae with centrodorsal hollow and thin-walled, closely joined to basal ring or slightly separated interradially by narrow gap or slit; central cavity diameter ≥0.6 of basal diameter; adoral rim of centrodorsal with 5 hollow, interradial buttresses that open adorally as deep, ring-shaped pits (Figure 7d). Cirrus

sockets in 10 columns with moderately developed aborally-projecting lateral fulcral tubercles triangular in side view; cirri (when known) tapering to a point with no opposing spine. Externally visible portion of each basal flat or slightly arched, weakly swollen interradially if at all, with lateral portions parallel-sided or tapering, and ends contiguous midradially (Figures 7a, 8); sometimes reduced, triangular and separated midradially (Figure 7b, c). Aboral surface of basals with featureless, central depression, and with adorally curved and distally expanded pair of interior projections (Figure 7e). Radial cavity with delicate aboral calcareous deposit. Most proximal pinnule on $IIbr_{15-16}$.

Type species. *Atelecrinus sulcatus* AH Clark, 1912.

Other included species. *Adelatelecrinus vallatus* new species.

Etymology. From the Greek *adelos*, meaning obscure, unknown, unseen, and the generic name *Atelecrinus*.

Remarks. Some specimens of species in this genus are externally indistinguishable from *Atelecrinus* in having a close suture between centrodorsal and basal ring (Figures 4, 6, 7a, c, 8). However, most exhibit a narrow interradial gap or slit between the centrodorsal and basals (Figure 7b) not found in *Atelecrinus*. *Adelatelecrinus* shares with *Paratelecrinus* (described below) distinctive deep interradial pits in the centrodorsal rim (Figure 7d), which separate both from *Atelecrinus*. However, *Adelatelecrinus* lacks the complex articular facet on the aboral surface of the basal ossicles characteristic of *Paratelecrinus* (Compare figures 3d and 7e).

Adelatelecrinus sulcatus AH Clark, 1912

Figure 7

Atelecrinus sulcatus AH Clark, 1912:152.—AH Clark, 1915:192 (fig. 123).
Atelecrinus wyvilli: AH Clark and AM Clark, 1967: 819, 820–823 (part).—AM Clark, 1967:171–172.

Holotype. NCB (V.ECH.C 2098), *Siboga* 85, Makassar Strait, 00°36'30"S, 119°29'30"E, 724 m, 17 Jun 1899.

Other material examined. Indonesia: USNM 36220, *Albatross* 5619, W of Halmahera I., 0°35'00"N, 127°14'40"E, 27 Nov 1909, 795 m (1 spec.). Nicobar Islands: ZSM (no catalog number), Deutschen Tiefsee-Expedition 210, 06°53'N, 93°33'E, 753 m (2; examined from photographs). Solomon Islands: MNHN IE-2007-7710, IE-2007-7711, SALOMON 1 cruise, DW-1773, N of Malaita I., 08°11.0'S, 160°39.9'E, 331–397 m, 28 Sep 2001 (2 spec; [IE-2007-7710 dissociated for SEM]); MNHN IE-2007-7712, SALOMON 1 cruise, CP-1802, off Guadalcanal I., 09°31.1'S,160°35.0'E, 245–269 m, 2 Oct 2001 (1 partly crushed, dissociated for SEM).

Diagnosis. A species of *Adelatelecrinus* with brachitaxes and arm bases rounded and separated, with a small distolateral triangular tooth on Ibr_1 and a small lateral flange or 1–2 weak teeth on Iax_2; either or both may be rudimentary or absent on some rays.

Redescription of the holotype *(Figure 7a).* Centrodorsal conical, 2.85 mm across the base, 3.3 mm high; HD 1.17; base parallel-sided; tip broken with open hole at apex, 0.4 mm across. Cirrus sockets XXXII, 3–4 per column in 10 columns, no cirri retained. Fulcral tubercles moderately developed, triangular or very slightly hooked in profile. Interradial ridges weak but well defined, tapering toward apex, reaching level of second socket in each radial area. Centrodorsal margin very shallowly concave across radial areas, negligibly concave interradially. Centrodorsal/basal suture close; no space or ligament visible externally. Externally visible portion of basals triangular interradially, very slightly swollen; narrower and parallel-sided laterally; suture between adjacent basals barely visible, if at all. Radials oblong, slightly wider distally; radial profile ≤80°; WL 2.0; distal margin very broadly and shallowly U-shaped. IBr2 smoothly rounded aborally, with no synarthrial swelling; well separated laterally with well-developed roughly rhombic gap between adjacent rays ("water pore" in earlier terminology; Figure 2a). Ibr_1 oblong with small triangular distolateral tooth; WL 1.9; distal margin shallow V-shaped. Iax_2 hexagonal with diverging lateral margins; small rounded or triangular lateral tooth usually present; distal angle truncated; WL 1.1. $IIbr_{1-2}$ separated interiorly by gap, slightly flattened exteriorly. $IIbr_1$ slightly U-shaped; WL 1.6. $IIbr_2$ irregularly quadrate, longer exteriorly; proximal margin shallow V-shaped; WL 1.3. $IIbr_{3+4}$ rounded aborally, in contact interiorly, WL 1.2; diameter 1.8 mm. $IIbr_5$ almost triangular, WL 1.7. Brachials following $IIbr_{6+7}$ strongly wedge-shaped, WL 1.6–1.8. Syzygies at 6+7, 9+10.

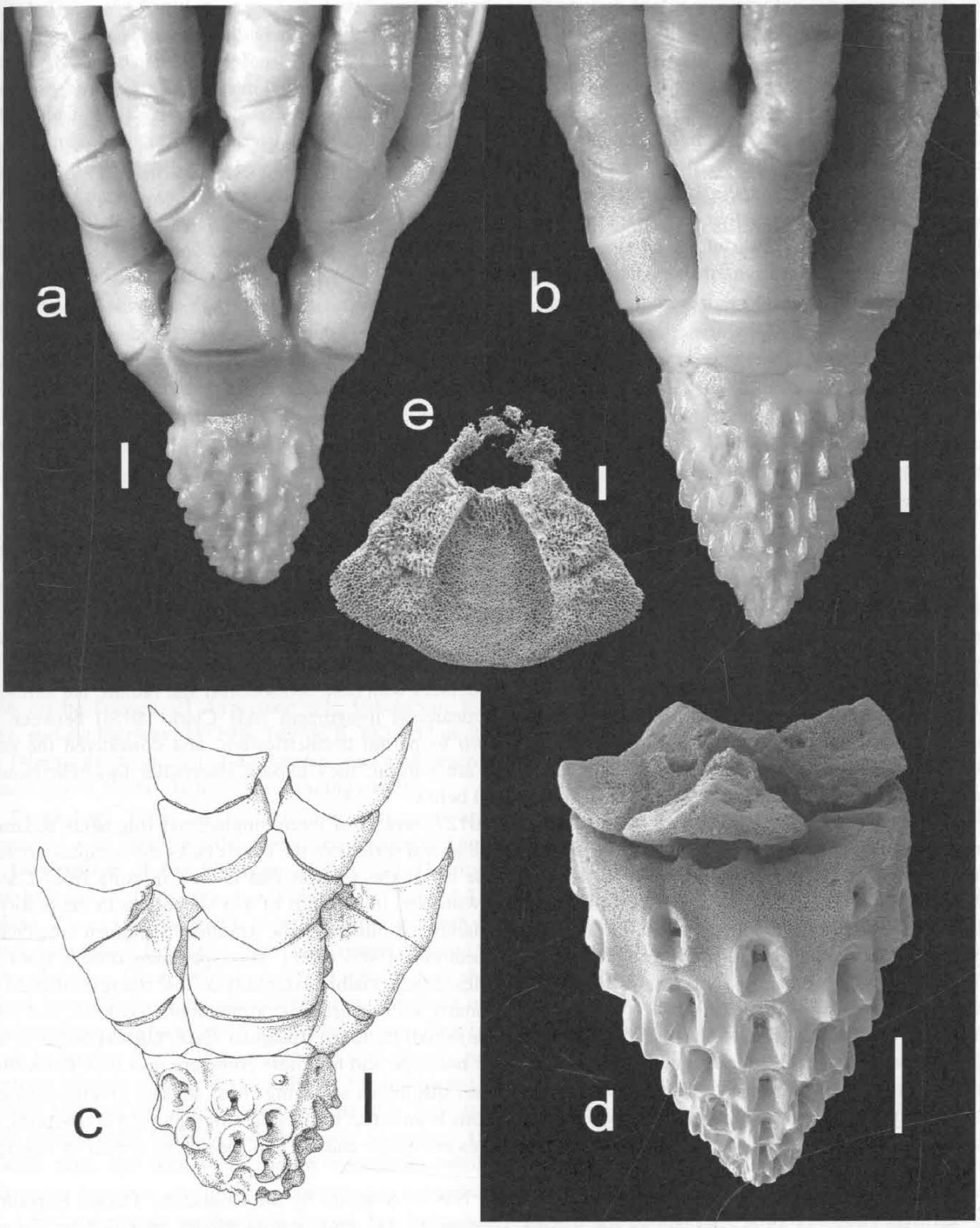

FIGURE 7. *Adelatelecrinus sulcatus* (A. H. Clark). a–c. Centrodorsal and ray bases in lateral view. a. NCB V.ECH.C. 2098 (holotype). b. MNHN IE-2007-7711. c. USNM 36220. d. MNHN IE-2007-7710, centrodorsal and four (of five) basals partially separated from centrodorsal to reveal deep interradial pit in centrodorsal margin. e. MNHN IE-2007-7710, basal ossicle, aboral view (interior processes partially crushed). Scale bars: (a–d) 1 mm; (e) 100 µm.

New material. Centrodorsal conical, 3.5–3.8 mm across the base, 4.6 mm high; HD 1.2–1.3; tapering from base; apex sometimes with narrow ridges derived from obsolete apical sockets. Cirrus sockets XLV–LIIII, 4–6 per column in 10 columns. Fulcral tubercles moderately developed. Interradial ridges almost nonexistent to slight low swellings that reach apical end of first socket. Centrodorsal margin flat (Figure 7c) or very shallowly concave across radial areas (Figure 7b), slightly projecting and flat or shallowly V-shaped interradially. Centrodorsal/basal suture distinct, with slight to low triangular interradial gap. Externally visible portion of basals flat to slightly arched, triangular interradially, slightly swollen; narrower and parallel sided laterally; suture between adjacent basals visible externally (Figure 7d) or not (Figure 7c). In IE-2007-7710, dissociated for SEM, the pair of internal curved projections meet at their tips, enclosing a circular space; those of adjacent basals are attached along their length; these projections together form a rosette-like structure roofing the centrodorsal cavity. Radials oblong; WL 2.0–2.2; radial profile 60°; distal margin almost straight to very broadly and shallowly U-shaped. IBr2 smoothly rounded aborally, with no synarthrial swelling; well separated laterally by roughly rhombic gap. Ibr_1 oblong with small triangular distolateral tooth (sometimes lost); WL 1.5–1.7; distal margin shallow V-shaped. Iax_2 hexagonal with diverging lateral margins, sometimes with small lateral tooth; distal angle short and rounded or truncated; WL 1.0–1.1. $IIbr_{1-2}$ slightly flattened exteriorly, separated interiorly by roughly rhombic gap. $IIbr_1$ almost oblong and longer exteriorly; WL 1.7–1.8. $IIbr_2$ irregularly quadrate/pentagonal, longer exteriorly; proximal margin shallow V-shaped; WL 1.3. $IIbr_{3+4}$ rounded aborally, in contact interiorly; WL 1.3; diameter 1.6–1.8 mm. $IIbr_5$ almost triangular; WL 1.8–2.0. Brachials following 6+7 wedge-shaped; WL 1.4. $IIbr_8$ and following brachials becoming less strongly wedge-shaped; $IIbr_{19}$ with WL 1.1. Syzygies at 6+7, 9+10, 12+13, followed by intervals of 2 or 3 muscular articulations.

Distribution. From NW of Sumatra and the Makassar Strait to Halmahera, Indonesia, and the Solomon Islands in (?245) 269–795 m.

Remarks. AH Clark (1912) distinguished *Atelecrinus sulcatus* (from *At. wyvilli*) by its more sharply conical centrodorsal, with a shallow interradial furrow rather than a flat space between adjacent columns of sockets. Curiously, when he synonymized *A. sulcatus* under *At. wyvilli* (in Clark and Clark 1967), he added additional distinguishing features not mentioned in the original description: centrodorsal base lacking interradial indentations; sockets with stronger fulcral tubercles, and basals in close contact with both centrodorsal and radials. He attributed the narrow interradial gap filled with perisome [=noncalcareous integument (AH Clark 1915)] between the centrodorsal and each basal in the holotype of *At. wyvilli* to partial decalcification, and considered the other distinctions of minor importance. However, these gaps are natural; they expose interradial ligament bundles characteristic of a distinct genus, *Paratelecrinus*, described below.

The centrodorsal of the holotype (as of 15 August 2012) consists of three longitudinal fragments separated from the basal ring; two fragments bear interradial pits. The aboral surface of the basals lacks the complex articular features of *Paratelecrinus*, described below. Although the tip of the centrodorsal is now missing from USNM 36220, AH Clark (1915:192, figure 123) shows it entire, with cirri in columns of 4–5 sockets as in the holotype. [Although the figure legend states "from the Philippine Islands", it illustrates the *Albatross* specimen collected in northern Indonesia during the *Albatross* Philippine Expedition, 1907–1910.] This specimen differs from the holotype in having more strongly developed socket tubercles, basals visible externally as low triangles that do not meet midradially, a wider radial profile (~90°), proportionally shorter broader primibrachial ossicles, and some axils with a weak lateral flange or 1–2 (rather than just one) small flattened triangular teeth. USNM 36220 is also slightly larger (basal centrodorsal diameter 3 mm) than the holotype and has more complete rays with P_1 on $IIbr_{16}$. AH Clark (1912) and Clark and Clark (1967) described both specimens as having cirrus sockets of adjacent radial areas separated by a shallow interradial furrow. However, this is an effect of the adjacent high fulcral tubercles, not an actual groove in the centrodorsal surface. The differences are minor and the two specimens appear to belong to the same species.

AM Clark (1977) described two specimens collected NW of Sumatra by the Deutschen Tiefsee Expedition (sta. 210, 06°53'N, 93°33'E, 753 m) as *At. wyvilli*. Comments and photographs kindly provided by Thomas Heinzeller (Ludwig-Maximilians-Universität München) and Bernhard Ruthensteiner (Zoologische Staatssammlung München) show a slight interradial slit between the centrodorsal and basal ring as in the new material described herein. The longest remaining cirri (30 mm long with 29–31 cirrals) taper near the distal end with the penultimate segment much longer than wide, no opposing spine, and slightly bent, conical terminal claw, as in *At. balanoides* and *At. helgae*, and unlike the cirrus tips of *Paratelecrinus* species for which complete cirri are

known (except for two specimens tentatively attributed to *P. wyvilli*; see below). The specimens also agree with *Adelatelecrinus sulcatus* in having HD 1.2–1.3; weak interradial ridges at the centrodorsal base; the aboral or adoral rim of the peripheral cirrus sockets often raised above surrounding stereom; up to XLIII cirri; basals only slightly swollen interradially, if at all; a small triangular distolateral projection on Ibr_1, and a weak lateral flange on the axil (AM Clark, 1977).

The holotype and USNM 36220 closely resemble the other specimens in all respects except in lacking any interradial gap or slit between centrodorsal and basal ring. In the Nicobar and Solomon Islands specimens, the suture is not tight and a small interradial gap exists. Dissociation of two of the latter reveals deep interradial pits in the centrodorsal rim. One has basals with a deep, smooth, aboral depression and a pair of curved internal projections that together form a rosette-like structure that roofs the centrodorsal cavity (not observable in the damaged specimen). The combination of features warrants separation of this species from *Atelecrinus* at the generic level.

Although the Solomon Islands specimens were collected in substantially shallower water (269–331 [possibly 245–397 m]) than the Nicobar and Indonesian material (753–795 m), no features appear to differ by depth, e.g., both the Solomon and Nicobar Islands specimens exhibit the gap between centrodorsal and basals.

Adelatelecrinus vallatus new species

Figure 8

Holotype. Solomon Islands: MNHN IE-2009-9003, SALOMON 2 cruise, CP-2246, W of Vella Lavella I., 07°43' S, 156°25' E, 664–682 m, 1 Nov 2004.

Paratypes. Solomon Islands: MNHN IE-2009-9002, SALOMON 2 cruise, CP-2211, SW of Choiseul I., 07°36'S, 157°42' E, 313–387 m, 26 Oct 2004 (1 spec.); MNHN IE-2012-843, SALOMON 2 cruise, CP-2245, W of Vella Lavella I., 07°43'S, 156°26' E, 582–609 m, 1 Nov 2004 (1).

Other material examined. Solomon Islands: MNHN IE-2007-7713, SALOMON 1 cruise, CP-1802, off Guadalcanal I., 09°31.1'S,160°35.0'E, 245–269 m, 2 Oct 2001 (1); MNHN IE-2007-5946, EXBODI cruise, CP-3808, off Ile Toupeti, 21°43'S, 166°39'E, 598-645 m, 5 Sep 2011 (1). MNHN IE-2007-5469, EBISCO cruise, CP-2651, sud-est Fairway, 21°29'S, 162°36'E, 883-957 m, 23 Oct 2005 (1).

Diagnosis. A species of *Adelatelecrinus* with brachitaxes laterally flattened and apposed with no gap between adjacent rays; lateral flattening continuing on $IIbr_1$.

Etymology. From the Latin *vallum*, a rampart or palisade. The specific epithet means surrounded with a rampart or wall, reflecting the characteristic flattened and apposed sides of the ray bases.

Description of the holotype *(Figure 8a)*. Centrodorsal conical, tapering from base (although base partly straight-sided in some views), 4.0 mm across base, 5.4 mm high; HD 1.35; apex rounded with traces of obsolete sockets. Cirrus sockets XXIX, 3 per column (one with 2) in 10 columns. Fulcral tubercles moderately developed, rounded triangular in profile. Interradial ridges reduced to slight swelling, not reaching beyond basalmost socket in each radial area. Centrodorsal margin straight or very shallowly concave across radial areas, flat or very slightly V-shaped interradially. Centrodorsal/basal suture close or with short, slit-like interradial gap. Longest remaining attached cirrus fragment of 18 segments, 36 mm long (distal portion missing); c1–3 short; c4 squarish; following cirrals becoming longer and compressed with distally projecting adoral margin; c9–10 longest, LW 4.3; following segments slightly shorter. Externally visible interradial portion of basals large, irregularly triangular, almost flat, strongly tapering and barely in contact laterally. Radials with diverging lateral margins; WL 2.3; radial profile 70°; distal margin very broadly and shallowly U-shaped. IBr2 laterally flattened and apposed with no gap between adjacent rays, and with weak narrow synarthrial swelling. Ibr_1 oblong, with lateral margins concave—initially converging but then diverging as distolateral, flat-sided flange continuous with flat-sided lateral margin of Iax_2; WL 1.6; distal margin shallowly V-shaped. Iax_2 hexagonal with diverging, thickened and flat-sided lateral margins apposed against adjacent axil; distal angle rounded; WL 1.3. $IIbr_{1-2}$ well separated interiorly with well-developed gap. $IIbr_1$ longer and flat-sided exteriorly; WL 1.6. $IIbr_2$ irregularly quadrate, longer exteriorly; proximal margin shallow V-shaped; WL 1.3. $IIbr_{3+4}$ thickened and in contact interiorly, WL 1.4; diameter 2.3 mm. $IIbr_5$ almost triangular, WL 2.8. Brachials following 6+7 strongly wedge-shaped, with small alternating articular tubercles; WL 1.6. Syzygies at 6+7, 9+10; one arm with 6+7, 10+11, and one with 6+7, 11+12, 16+17, 21+22.

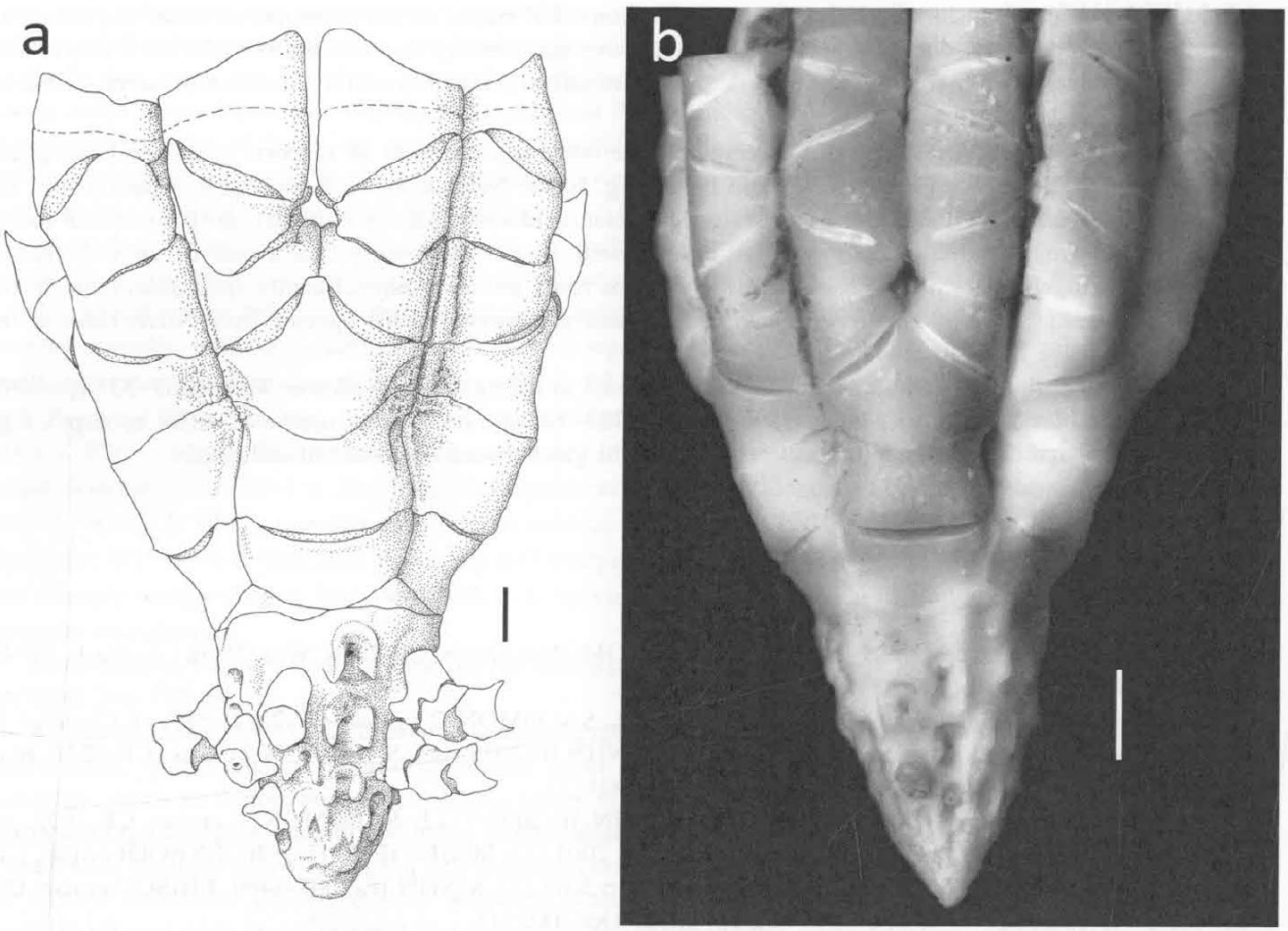

FIGURE 8. *Adelatelecrinus vallatus* new species; centrodorsal and ray bases in lateral view. a. MNHN IE-2009-9003 (holotype), b. MNHN cat no. IE-2007-5946. Scale bars: (a) 1 mm; (b) 2 mm.

Paratypes. The paratypes differ slightly as follows. Centrodorsals of both taper from the base. In MNHN IE-2009-9002, centrodorsal tip lost; basal diameter 3.9 mm; midradial basal margin concave or flat; interradial margin slightly projecting and V-shaped; no gap between basals and centrodorsal. Cirri XXV, none retained; 2–3 functional and 1–2 obsolete sockets per column; socket fulcral tubercles low to moderate. Externally visible interradial portion of basals rhombic, barely inflated. Proximal ray ossicles similar to those of holotype but proportionally slightly shorter, e.g., WL of radials, Ibr_1, Iax_2, $IIbr_1$ and middle brachials 2.5, 1.4, 1.8, 2.0, and 1.3–1.5, respectively. Syzygies at 3+4, 7+8 on 5 arms; 3+4, 6+7 on 3 arms; next syzygy at 10+11 (5 arms), 11+12 (2) or 12+13 (1); following at intervals of 2–3 articulations. In MNHN IE 2012-843, centrodorsal 5.5 mm tall, 4.2 mm across base; HD 1.3; interradial ridge a short, low swelling; interradial margin of centrodorsal straight; no gap between basals and centrodorsal. Cirri XXXI, none retained, in 3 functional sockets per column (1 column with 4). Externally visible interradial portion of basals triangular, slightly swollen, some not reaching adjacent basal. IBr2 and $IIbr_1$ not as strongly flat-sided as in other two specimens, but still apposed and without gap. Lateral flange of Iax_2 not as strong. Proximal ray ossicles proportionally shorter than both preceding specimens, e.g., WL of radials, Ibr_1, Iax_2, and $IIbr_1$ 2.8, 1.9, 1.0 and 2.3, respectively. Syzygies at 3+4, 6+7 and 9+10 or 10+11. Weak articular tubercles present on $IIbr_7$ and following ossicles.

Description of other specimens. MNHN IE-2007-5946 (Figure 8b). Large specimen. Centrodorsal conical, 4.1 mm across base, 6.3 mm tall; HD 1.5; tapering from base; apex rounded conical with traces of obsolete sockets. Cirrus sockets XXXI, 3 per column (one with 4). Fulcral tubercles low; sockets elongated along oral-aboral axis. Interradial base of centrodorsal lacking ridge; instead, a slight depression between two short, low swellings. Midradial base of centrodorsal distinctly depressed. Centrodorsal margin straight or very slightly V-shaped

interradially. Centrodorsal/basal suture close. Externally visible portion of basals are wide, low triangles; each interradial portion slightly projecting and spanning width of two low interradial swellings on centrodorsal; strongly tapering laterally and not in contact laterally. Ray bases similar to those of holotype, apposed and flattened laterally, with rhombic gap interiorly between $IIbr_1$ and $IIbr_2$. Radial WL 2.2; radial profile ~70°; Ibr_1 WL 1.6; Iax_2 with weaker lateral flanges than in holotype; WL 1.2. $IIbr_{3+4}$ WL 1.2; diameter 2.4 mm.

MNHN IE-2007-7713. Small specimen. Centrodorsal conical, 2.3 mm across base, 3.0 mm tall; HD 1.3; base straight-sided; apex rounded conical with traces of obsolete sockets; midradial margin gently concave; interradial margin flat; interradial ridges low but sharp, reaching just beyond first socket. Cirri XXIV, 2–3 per column in 10 columns; bases of several cirri retained; c1–3 short, c4 with LW 1.6; c4 and c5 of more apical cirrus with LW 2.8 and 3.8, respectively. Externally visible interradial portion of basals triangular, slightly inflated as continuation of centrodorsal ridge, becoming somewhat narrower and parallel-sided laterally. Centrodorsal/basal suture well defined but with no distinct gap. Radials with diverging lateral margins, WL 1.3; profile 70°. IBr2 flat-sided, apposed, with no synarthrial tubercles or gap between adjacent IBr2. Ibr_1 with slightly concave lateral margins and with broadened flange restricted to distolateral corner; more rounded aborally than in larger specimens; distal margin slightly concave; WL 1.4. Iax_2 hexagonal with short diverging lateral margins expanded as flat-edged flange apposed against adjacent axil; WL 1.2. $IIbr_1$ longer and flattened exteriorly, with distal margin only slightly concave; WL 1.6. $IIbr_2$ pentagonal, longer exteriorly, with small interior gap between adjacent $IIbr_2$; WL 1.2. $IIbr_{3+4}$ 1.3 mm across; WL 1.1. $IIbr_5$ wedge-shaped; WL 1.7. One arm lacking $IIbr_{3+4}$; $IIbr_3$ wedge-shaped, $IIbr_4$ parallelogram-shaped, $IIbr_5$ wedge-shaped, followed by $IIbr_{6+7}$; all other arms with syzygies at 3+4, 6+7; additional syzygies retained at 10+11, 15+16.

Distribution. Currently known only from the Solomon Islands in 387–664 (possibly 313–682) m.

Remarks. This species is placed in *Adelatelecrinus* because it shares with the type species, *Ad. sulcatus*, similar centrodorsal structure and the presence in at least some cases of a small, interradial slit between the centrodorsal and basals. It differs in having brachitaxes with distinctly broadened, flat-sided and apposed lateral margins.

Although the small specimen, MNHN IE-2007-7713, was collected with *Ad. sulcatus*, it is identified here as *Ad. vallatus* as it shares with this species closely apposed adjacent brachitaxes and the characteristically broadened and flat-sided axils. However, this assignment is tentative. Two species of atelecrinid have never previously been collected in the same sample. Also, the broadened axil might be a feature of small *Ad. sulcatus* lost with growth, similar to the ontogenetic changes in axil shape seen in *Paratelecrinus cubensis* and *P. orthotriremus* described below, even though the trait is retained in large *Ad. vallatus*.

Paratelecrinus new genus

Atelecrinus PH Carpenter 1881:16–18 (part); 1882:488–489 (part); 1888:68–70 (part).—Hartlaub 1912:480–481 (part).—AH Clark 1918:262, 266–267 (part).—Clark and Clark 1967:817–819 (part).

Diagnosis. A genus of Atelecrinidae with the centrodorsal hollow and thin-walled, separated at least interradially from basal ring by ligament-filled gap; central cavity diameter >0.6 times basal diameter; adoral rim of centrodorsal with 5 hollow, interradial buttresses that open adorally as deep, ring-shaped pits (Figure 3c). Cirrus sockets in 10 or 15 columns with fulcral tubercles similar to those of *Atelecrinus* and *Adelatelecrinus* but often more strongly developed, producing a strongly serrated centrodorsal profile (Figures 9c, 11b, 14b); cirri (when known) with weak opposing spine and curved claw (Figures 9d, 11d, 15c, d), of up to 45 cirrals, 94 mm long (possibly also tapering to point with no opposing spine). Externally visible portion of each basal a shallow chevron (=inverted V-shape) (e.g., Figures 9a–c, 11a–b, 14a) to almost straight (e.g., Figure 13a, 14b), swollen interradially or not; ends contiguous midradially, often rounded. Aboral surface of basals with spoon-shaped articulation in central depression flanked by a pair of small fossae, and with adorally curved and distally expanded pair of interior projections (Figure 3d). Radial cavity apparently lacking delicate aboral calcareous deposit. Most proximal pinnule usually on $IIbr_{17}$ (rarely $IIbr_{12-20}$).

Type species. *Atelecrinus cubensis* PH Carpenter, 1881.

Other included species. *Atelecrinus wyvilli* PH Carpenter, 1881; *Atelecrinus conifer* AH Clark, 1908a; *Paratelecrinus orthotriremis*, new species; *Paratelecrinus amenouzume* new species; *Paratelecrinus laticonulus* new species, and *Paratelecrinus telo* new species.

Remarks. In *Atelecrinus*, the adoral rim of the centrodorsal bears shallow interradial depressions rather than deep, ring-shaped pits, and the basal ring and centrodorsal are tightly joined (Figures 3a, 4). Whereas the aboral surface of the basals in *Atelecrinus* and *Adelatelecrinus* bears a shallow, flat, interradial depression (Figures 3b, 7e), in *Paratelecrinus* it is more strongly and intricately sculpted: the aboral surface bears a distinctive central spoon-shaped structure with a short, thick "handle" flanked by deep narrow recesses; the "spoon" itself is roughly teardrop-shaped with the narrow end toward the central cavity (Figure 3d). The adoral rim of the centrodorsal bears three small pegs or processes between the raised rims of adjacent deep interradial pits (Figure 3c). A socket or fossa formed by the concave margins of adjacent basals accommodates the central and largest peg, while a small, shallow, oblong fossa on each side of the "spoon handle" accommodates the two smaller flanking pegs (Figure 3d). The articulation of the centrodorsal and basals via interradial ligament bundles is almost always visible externally. The interradial pits and articular surfaces have been examined in dissociated specimens of *P. wyvilli* (Messing 2003) and *P. orthotriremis*.

The first four species described below (*P. cubensis*, *P. wyvilli*, *P. amenozoume* and *P. laticonulus)* have ten columns of cirrus sockets, two per radial area. The following three (*P. telo*, *P. conifer* and *P. orthotriremis*) have 15 columns of cirrus sockets, three in each radial area.

Paratelecrinus cubensis PH Carpenter, 1881

Figures 9, 10

Antedon cubensis Pourtalès 1869:356 (part); 1878:214–215 (part).
Atelecrinus cubensis PH Carpenter 1881:15–19, pl. 1, fig. 7; 1882:491–492; 1888:70–72.—AH Clark 1907:155.—Hartlaub 1912:281, 386, 484, pl. 14, figs. 3, 8, 9.
Atelecrinus pourtalesi AH Clark 1907:4.—H.L. Clark 1941:13.
Atelecrinus balanoides: AH Clark and A.M Clark 1967:819, 823–831 (part).

Neotype. USNM E42652, *JSL I* 2005, French Bay, San Salvador I, Bahamas, 23°55'03"N, 74°31'40"W, 800 m, 23 Apr 1987, D. Pawson and P. Kier, colls.

Other material examined. Bahama Islands: USNM E42670, *JSL I* 1501, New Providence I., 24°59'59"N, 77°34'34"W, 705 m, 20 Oct 1987, J. Miller and C. Norlund, colls. (2 spec.); USNM E42671, *JSL I* 1501, New Providence I, 24°59'59"N, 77°34'34"W, 757 m, 20 Oct 1987, J. Miller and C. Norlund, colls. (1); USNM E42683, *JSL II* 813, Eleuthera I., 25°30'51"N, 76°55'01"W, 751 m, 12 Apr 1984, D. Pawson and G. Hendler, colls. (1); USNM E42684, *JSL II* 813, Eleuthera I., 25°30'51"N, 76°55'01"W, 768 m, 12 Apr 1984, D. Pawson and G. Hendler, colls. (1); USNM E42693, *JSL I* 2268, Crooked I., 22°41'24"N, 74°21'18"W, 890 m, 15 Sep 1988, D. Pawson and D. Billett, colls. (1); USNM E42694, *JSL I* 2264, San Salvador I., 24°03'37"N, 74°33'22"W, 876 m, 13 Sep 1988, D. Billett and G. Hendler, colls. (1); USNM E42695, *JSL I* 2261, Exuma Sound, 23°50'45"N, 75°09'36"W, 832 m, 12 Sep 1988, P. Kier and Peterson, colls. (1); USNM E42696, *JSL I* 2274, Acklins I., 22°36'30"N, 73°38'36"W, 835–843 m, 18 Sep 1988, G. Hendler and E. Balser, colls. (2); USNM E43082, *JSL I* 2267, Crooked I., 22°42'N, 74°22'W, 892 m, 15 Sep 1988, J. Miller and Peterson, colls. (1); USNM 43083, *JSL II* 1497, Andros I., 25°12'12"N, 77°59'56"W, 789 m, 18 Oct 1987, G. Hendler and C. Norlund, colls. (1). Cuba: MCZ 1073, *Atlantis* 3341, Golfo Cazones, 21°59'N, 81°20'W, 567–778 m (1).

Diagnosis. A species of *Paratelecrinus* with 10 columns of cirrus sockets and Iax_2 hexagonal or rhombic with thin, often wing-like lateral flanges. Interradial margin of centrodorsal concave or with a deep V-shaped excavation (Figures 9a–c).

Description of the neotype. Centrodorsal conical, broadest across level of peripheral sockets; basal diameter 3.0 mm, HD 1.3; interradial margin with often deep triangular or U-shaped excavation; midradial margin with small triangular projection; very weak interradial ridge adjacent to centrodorsal base; apex with thin weak glassy ridges; fulcral tubercles strongly projecting and triangular. Cirri ~XLV (too crowded to count accurately); detached intact peripheral cirrus (broken during examination) 94 mm long, of 45 segments; c1–2 short; following increasing in length, becoming compressed with expanded distal ends; c8–18 longest, LW 6.7; distal few cirrals tapering; distal three cirrals preceding claw with a weak aboral spine; antepenultimate and penultimate cirrals squarish. Apical cirrus of 28 segments, 19 mm long.

Basals forming a complete ring well separated from centrodorsal, especially interradially, by a distinct ligament bundle; externally visible portion of basals swollen interradially, narrowing laterally and expanding to elongated oval ends accommodated by shallow concavities in centrodorsal margin on either side of small midradial projection. Radials short, WL 3.3; profile 100°; lateral margins visible between bases of rays, separating adjacent brachitaxes. Longest attached ray 120 mm long, complete to just beyond last pinnule; arm tip a slender filament lacking pinnules composed of slender brachials with expanded ends (similar to distal pinnulars or middle cirrals); longest intact filament 32 mm long, of 40 brachials following distalmost pinnule (now detached). Brachitaxes and proximal brachial pair with moderately developed synarthrial swellings. Ibr_1 separated laterally, roughly oblong with V-shaped distal margin; WL 2.3; lateral margins with a thin flange sheathed in transparent tissue and depressed toward center of body, sometimes with a small triangular spine just in front of flange. Iax_2 rhombic; WL 1.2; with transparent wing- or ear-like flanges; distal portion parallel-sided; proximal margin V-shaped. $IIbr_1$ longer exteriorly, slightly separated over axil; WL 3.1; exterior lateral margin with thick ridge or flange. $IIbr_2$ irregularly quadrate, longer exteriorly and wider distally; proximal margin V-shaped; WL 1.3; exterior lateral margin not thickened; well-developed gap between adjacent $IIbr_2$ on each ray. $IIbr_{3+4}$ longer interiorly; WL 1.1; 1.7 mm across. Middle brachials wedge-shaped; WL 1.1; alternating articular tubercles present on $IIbr_{7-8}$ and following brachials. Syzygies at 3+4, 6+7, 10+11 and chiefly at intervals of 2 (sometimes 3) muscular articulations.

Description of other specimens. Centrodorsal conical, often with convex sides, sometimes with weak (rarely strong) interradial ridge near base; basal diameter 1.5–3.0 mm; HD 1.1–1.4; interradial margin concave or with a deep V-shaped excavation accommodating ligament bundle; midradial margin with a pair of shallow concavities accommodating ends of adjacent basals. Apex rounded or truncated, often with thin weak ridges extending to tip from apical cirrus socket tubercles. Cirrus sockets in 2 columns per radial area, chiefly 4–5 per column (rarely 3 or 6), with strongly projecting, triangular fulcral tubercles. USNM E42681 from Barbados bears a third middle column of 1–2 sockets in 4 radial areas (similar to *P. orthotriremis* below).

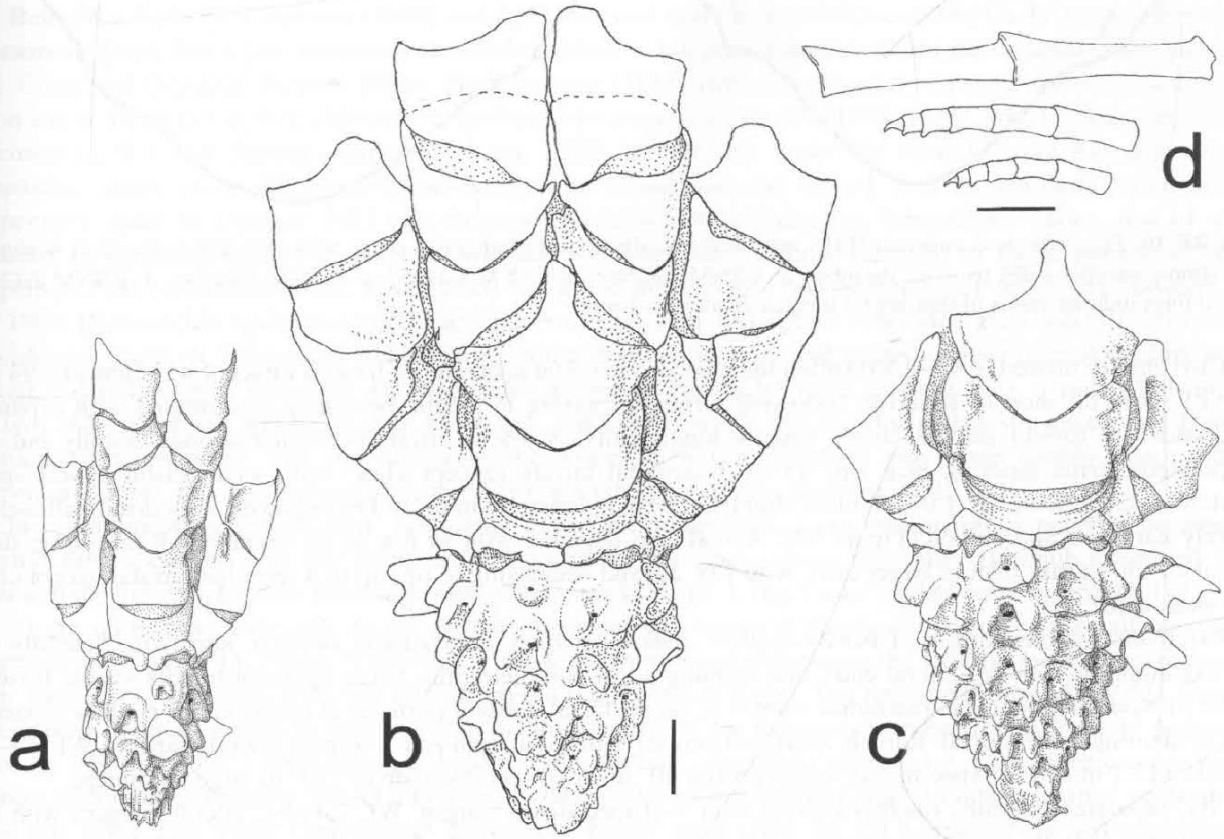

FIGURE 9. *Paratelecrinus cubensis* (PH Carpenter). a–c. Centrodorsal and ray bases in lateral view. a. USNM E42683. b. USNM E42695. c. USNM E42693. d. Two middle cirrals (upper) and tips of two cirri (middle, lower), USNM E42693. Scale bars: lower (a–c), upper (d) both 1 mm.

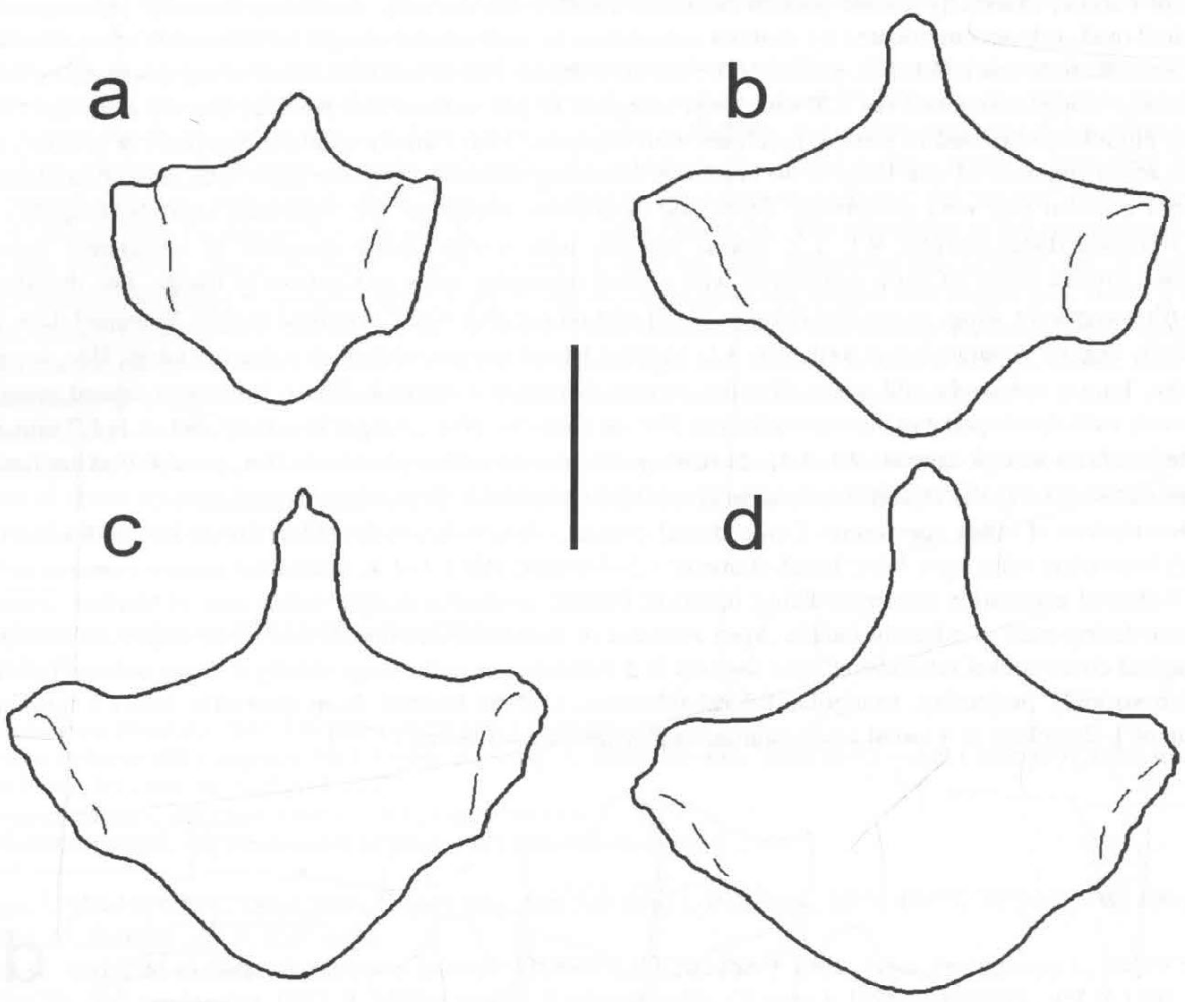

FIGURE 10. *Paratelecrinus cubensis* (PH Carpenter) Iax_2 illustrating changes in shape with increasing size from hexagonal with almost parallel sides to more rhombic. a. USNM E42683. b. USNM E42652. c. USNM E42696. d. USNM E42695. Dashed lines indicate bases of thin lateral flanges. Scale bar: 1 mm.

Cirri chiefly broken, ~XX–LVII (often too crowded to count accurately), longest intact of 45 segments, 94 mm long; c1 short; c2 short or squarish; following cirrals increasing in length, becoming compressed with expanded distal ends; up to ~11 middle cirrals equally long, with LW ~6–8; cirrals becoming shorter distally but still compressed; cirrus tapering near tip; up to 3 terminal cirrals (except claw) with weak distal aboral spine; penultimate cirral with LW 1.0–1.3; claw slightly shorter to longer than preceding segment, with distal half usually abruptly narrower and curved (Figure 9d). Apical cirri delicate, with as few as 23 segments, 8 mm long; distal several cirrals shorter than in larger cirri, with LW 2.0 and decreasing to tip; up to 4 terminal cirrals (except claw) with weak spine.

Externally visible portion of basals shallow chevron-shaped, interradially swollen, narrowing laterally and then expanding to rounded lateral ends, and forming a low complete ring. Large ligament bundle visible between middle of basal and concave interradial margin of centrodorsal. Lateral portions of basals either slightly separated from or abutting centrodorsal. Radials short, with concave distal margin and diverging lateral margins; WL 3.8–5.2 (as little as 2.1 in smaller specimens); radial profile 80° in small specimen, up to 120° in large specimens.

Ibr_1 separated laterally, roughly oblong with V-shaped distal margin; WL 2.4–3.1; lateral margins with thin flange widest distally (ossicle sometimes appearing to have converging lateral margins with flange depressed toward center of body), sometimes with small triangular spine just in front of flange (both lateral features absent in smaller specimens); smaller specimens with WL 1.4–1.7. Iax_2 hexagonal in small specimens (Figures 9a, 10a–b),

becoming more rhombic with increasing size (Figures 9b–c, 10c–d); WL 0.9–1.0, longer than wide in smaller specimens; lateral margins with thin often transparent and wing-like flanges best developed in small specimens (Figures 9a, 10a); synarthrial swelling usually present.

Ray length to ~152 mm. Slender apinnulate distal arm filament of up to ~100 slender brachials. $IIbr_1$ longer exteriorly, just in contact interiorly over axil; WL 2.4–3.1 (2.0–2.1 in smaller specimens); exterior lateral margin with short, thick adambulacral ridge or flange. $IIbr_2$ irregularly quadrate, longer exteriorly and wider distally; WL 1.3–1.4 (0.9–1.0 in most smaller specimens); exterior lateral margin thickened or not; well-developed interior gap between adjacent $IIbr_2$ on each ray. $IIbr_{3+4}$ longer interiorly; 1.1–1.8 mm across; WL 1.1–1.3 (0.9 in smaller specimens). $IIbr_5$ and following few brachials weakly to strongly wedge-shaped; WL 1.3–2.1 (chiefly 1.6–1.9, and 0.7 in smaller specimen). Middle brachials wedge-shaped to almost triangular, with one side much longer than the other; WL 0.9–1.7; alternating articular tubercles present on $IIbr_{7-8}$ and following brachials. Distal brachials wedge-shaped and longer than wide, with distal and proximal ends smooth or raised aborally as weak alternating articular tubercles; WL 0.6–0.8. Syzygies at 3+4, 6+7 and 9+10; subsequently at intervals of 2 (occasionally 3) articulations. One specimen with 8+9; another lacking 3+4.

P_1 on $IIbr_{17}$, of up to 35 segments, 20 mm long; first pinnular short; second trapezoidal; following pinnulars becoming more slender and much longer with expanded distal ends; LW up to 10.0 (14.0 in small specimen); decreasing in length near tip. Several proximal segments beginning with third or fourth bearing a distal aboral spine.

Anal papilla central; mouth marginal or submarginal; ambulacra running from arms to mouth via narrow tissue bridges. Ambulacra on proximal portion of arms (to beyond P_1) with sparse podia, apparently only 1–2 triads on each side of each brachial; triads accompanied by a pair of modified lappets with one saccule distal to lappet; lappet pairs sometimes resembling sessile pedicellaria ("pseudopedicellaria" of Messing 2003).

Distribution. Bahama Islands and north coast of Cuba in 705–892 m. A single specimen from the south coast of Cuba was taken in 567–778 m.

Remarks. Both PH Carpenter (1888) and AH Clark and AM Clark (1967) reviewed the history of *Atelecrinus cubensis* in detail, but a few comments should be added. In his preliminary work on the crinoids collected by the U.S. Coast and Geodetic Steamer *Blake*, PH Carpenter (1881) first recognized *Atelecrinus cubensis* as a distinct taxon and is the proper author, although he attributed the name to Pourtalès (1869, 1878), who included the original specimen (U.S. Coast Survey steamer *Bibb* sta. 139P, off Havana) under the very different *Antedon cubensis* (Pourtalès, 1869) (now *Trichometra cubensis*). The *Blake* material turned over to Hartlaub following PH Carpenter's death in October 1891 was in poor condition but included ten lithographic plates, one of which included re-engraved figures of *At. cubensis* and *At. balanoides* almost identical to those published by PH Carpenter (1881) (Hartlaub 1912). Though AH Clark had substantially revised comatulid taxonomy between 1907 and 1909, Hartlaub felt bound to use PH Carpenter's older system (AH Clark 1950:346). Hartlaub (1912) discussed *At. cubensis* under *At. balanoides* in his report on the *Blake* collection, and quoted a letter from AH Clark saying that *At. cubensis* was an immature *At. balanoides*. However, Hartlaub's plate captions (nos. 6 and 14) distinguish the two. AM Clark (in AH Clark and AM Clark 1967: 830) wrote that the distinction suggested that Hartlaub "remained unconvinced" that the two were the same. However, Hartlaub may have simply continued PH Carpenter's usage, having received plate number 6 with the two species distinguished.

In removing *At. cubensis* from synonymy under *At. balanoides*, I am designating a neotype because the original *Bibb* specimen was lost along with many *Blake* specimens some time after Hartlaub examined them. Although the lithograph of the *Bibb* specimen (Carpenter 1881, pl. 1, fig. 7) and its derivative (Hartlaub 1912, pl. 6, fig. 7) are quite schematic and do not reveal important species-level diagnostic features, a small photograph (Hartlaub 1912, plate 14, figure 3) appears to show the thin lateral flanges on the axil unique to this species. No other specimens have been collected since from the north coast of Cuba. The neotype (USNM E42652), from the Bahamas, is the most complete specimen and exhibits several of the features distinguishing it from *At. balanoides* noted by PH Carpenter (1881) (though these are not the only diagnostic characters), e.g., more crowded cirrus sockets with more prominent fulcral tubercles; basals produced interradially, and stronger proximal projection of axils and $IIbr_2$. The wider centrodorsal diameter-to-height ratio cited by PH Carpenter as distinguishing *At. cubensis* from *At. balanoides* overlaps widely in the two species.

Of the two other species of *Paratelecrinus* with cirri in ten columns, *P. wyvilli* from the western Pacific differs (from *P. cubensis*) in having basals forming a thin band of almost uniform height rather than narrowing laterally

and expanding again at their ends; Ibr_1 with distolateral corners cut away, and rhombic axils lacking wing-like lateral flanges. *P. amenouzume*, from much deeper water off Japan, has well-developed narrow interradial ridges on the centrodorsal, proportionately more elongated IBr2, and a very shallow V-shaped articulation between Ibr_1 and Iax_2 with weak narrow synarthrial swelling.

Paratelecrinus wyvilli (PH Carpenter, 1882)

Figure 11

Atelecrinus wyvilli PH Carpenter 1882:492.—AH Clark and AM Clark, 1967:819, 820–823 (part).
Atelecrinus wyvillii: PH Carpenter 1888:72–73, pl. 6, figs. 4–5.
Atelecrinus wyvillei: AH Clark 1912:153.

Holotype. NHM 88.11.9.2, *Challenger* 174C, near Kandavu, Fiji, ~19°06'S, 178°18'E, depth uncertain (1116 m), 3 Aug 1874.

Other material examined. Philippines: MNHN IE-2009-6746, ESTASE II cruise, CP-5, S of Mindanao, 04°59'N, 125°41'E, 1 Dec 1984, 1190 m (1 spec. dissociated for SEM). Solomon Islands: MNHN IE-2007-7714, SALOMON 1 cruise, CP-1807, E of Guadalcanal I., 09°42.2'S, 160°52.8'E, 1077–1135 m, 2 Oct 2001 (1); MNHN IE-2012-849, SALOMON 1 cruise, CP-2197, S of Santa Isabel I., 08°24'S, 159°22'E, 897–1057 m, 24 Oct 2004 (1); MNHN IE-2009-9000, SALOMON 1 cruise, CP-2231, NW of Choiseul I., 06°25'S, 156°21'E, 1083–1100 m, 29 Oct 2004 (1). Japan: *Tansei-maru* cruise KT-08-03, sta. SM-01-02, Shima Spur, off Shima, Mie Prefecture, 34°00.72'N, 136°53.28'E to 34°01.55'N, 136°52.98'E, 781–789 m, 4 Mar 2008, 3-m ORI beam trawl, T. Oji, coll. (2). LOCATION? MNHN cat. no.? probably Solomon Is. or Fiji (1).

Diagnostic features. A species of *Paratelecrinus* with centrodorsal having 10 columns of sockets, basal interradial ridges weak or absent and interradial margin flat or slightly indented. Externally visible portion of basals shallow chevron-shaped; Iax_2 rhombic.

Description of the holotype *(Figure 11a)*. Centrodorsal conical, slightly wider just above base; basal diameter 3.1 mm; HD 1.16; no basal interradial ridges; interradial margin slightly concave. Cirrus sockets in 10 well-separated columns of 4–5 sockets each, with functional sockets reaching the aboral pole. Cirri ~XLV, none retained.

Basals gently arched, of almost uniform height, not swollen interradially, forming a low complete ring widely separated interradially from centrodorsal. Radials short; WL 3.9; radial profile ~90°. IBr2 and $IIbr_{1-2}$ with no synarthrial swelling. Ibr_1 oblong, straight-sided, with distolateral corners cut away and distal margin deeply V-shaped; WL 1.9. Iax_2 rhombic, lateral margins slightly sinuous; WL 1.0. $IIbr_1$ longer exteriorly, distal margin shallowly concave, exterior margins slightly ridged; WL 2.0. $IIbr_2$ longer exteriorly, irregularly quadrate; WL 1.2. $IIbr_{3+4}$ 1.4 mm across; WL 1.0. Following few remaining brachials wedge-shaped. Disk almost naked; mouth somewhat eccentric.

Description of other specimens. Centrodorsal conical, slightly wider just above base, or base barely straight-sided; basal diameter 2.9–3.7 mm; 3.8–4.9 mm high; HD 1.3; apex almost covered with obsolete sockets or with five fine ridges derived from apical sockets; socket tubercles moderate to strong, sometimes slightly hooked; interradial ridge virtually absent or low and not reaching top of basalmost socket; midradial margin gently concave; interradial margin flat or slightly concave, projecting or not. Cirri LIV–LX in 10 columns, 5–7 sockets per column; none retained; smallest specimen XLI with 4–5 functional sockets per column plus 1–2 distinct obsolete sockets. Externally visible portion of basals gently arched or shallow chevron-shaped; interradial portion triangular, weakly inflated or flat; laterally parallel-sided and only slightly thinner with slightly enlarged ends; centrodorsal/basal suture distinct with interradial slit-like gap, longer from end to end than in *Adelatelecrinus vallatus*. Radials short, separating Ibr_1; WL 3.9–4.0, 2.4 in smallest specimen; radial profile 90–110°. IBr2 separated laterally by distinct gap, and with moderately developed synarthrial tubercle. Ibr_1 roughly oblong with thin, slightly sinuous lateral edge and V-shaped distal margin; WL 1.9. Iax_2 rhombic or hexagonal with strongly diverging lateral margins; distal angle truncated; WL 1.0.

A larger specimen (MNHN IE-2009-9001) with small, thin, convex, ear-like projection distolaterally on Ibr_1, laterally on Iax_2, and continued as thin low exterior ridge on $IIbr_{1-2}$. $IIbr_1$ much longer exteriorly; WL 1.8–1.9. $IIbr_2$

pentagonal or irregularly quadrate; interior gap present; WL1.2–1.4. $IIbr_{3+4}$ with WL 1.2–1.7; diameter 1.7–2.4 mm. One arm of MNHN IE-2009-9000 with $IIbr_3$ triangular, longer interiorly, not hypozygal; WL 2.0; followed by $IIbr_{4+5}$. Normal $IIbr_5$ almost triangular; WL 1.9. All other syzygies 6+7, 9+10.

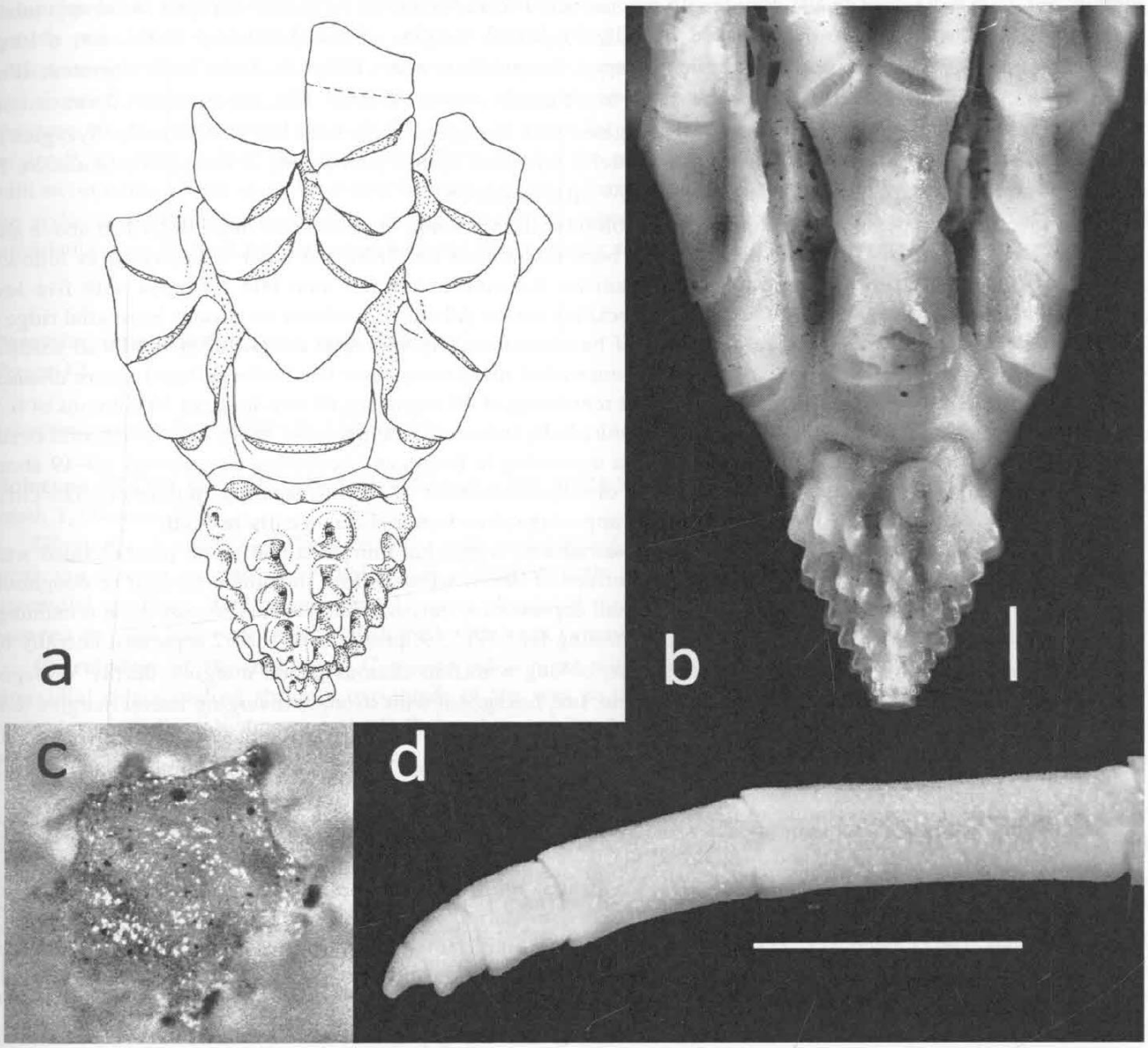

FIGURE 11. a. *Paratelecrinus wyvilli* (PH Carpenter). a. NHM 88.11.9.2 (holotype), centrodorsal and ray bases in lateral view. b–d. MNHN ? (Solomon Is. or Fiji). b. Centrodorsal and ray bases in lateral view (NOTE: Strong vertical shadows due to enhanced contrast to clarify skeletal details; the specimen is uniformly white). c. Pentagonal aboral apex of centrodorsal. d. Cirrus tip. Scale bars: (b, d) 1 mm. The holotype of *P. wyvilli* was inadvertently drawn without a scale bar; however, the diameter across the base of the centrodorsal was measured as 3.1 mm when the illustration was made. The pentagonal centrodorsal apex in c is 0.6 mm across.

A small slender specimen (MNHN cat. no. ?) (Figure 11b) attributed to this species has centrodorsal diameter 2.4 mm, height 3.1 mm and HD 1.3, and retains a small, flat, stellate apex 0.6 mm across, with trace of central lumen—the remnant of the articulation with the postlarval stalk (Figure 11c). Interradial base of centrodorsal slightly swollen and projecting. Cirri ~XXXV, in columns of 3 and 4 in each radial area, with well developed articular tubercles, almost reaching apex (difficult to determine if apicalmost sockets are functional). Cirri detached, in fragments; longest at least 45 mm, 20 segments; c1–c2 short; c3 with LW 2.8; following cirrals somewhat compressed, with expanded distal ends; longest middle cirrals with LW >6.0; cirrals shorter distally but

remaining longer than wide to near tip; antepenultimate cirral squarish with slight distal aboral expansion; penultimate cirral shorter than wide, with small blunt opposing spine; claw short, hooked (Figure 11d). Externally visible portion of basals strongly arched, chevron shaped, with lateral ends slightly enlarged, and separated from interradial margin of centrodorsal by wide gap. Radials with straight sides and broadly shallow U-shaped distal margin; WL 2.2; radial profile 50°. Ray length reconstructed from fragments >150 mm (without distal apinnulate portion). IBr2 elongated, narrow, separated laterally by lateral margins of radial articular facets. Ibr_1 oblong, concave distally; WL 1.2. Iax_2 narrow, shield shaped, longer than wide; LW 1.7. Arms well separated; $IIbr_1$ squarish; WL 1.25. $IIbr_2$ longer than wide; proximal angle gently convex; WL 0.9. $IIbr_{3+4}$ elongated, 1.2 mm across; WL 0.7. Following brachials becoming more elongated with expanded ends, with LW >6.0 distally. Syzygies at 3+4, 6+7, 9+10, 12+13; following syzygial pairs chiefly separated by one (sometimes 2) muscular articulation. P_1 on $IIbr_{17}$. Pinnulars except first longer than broad; LW up to at least 8.0.

Two much larger specimens (*Tansei-maru* KT-08-03) differ in some respects from those described above and are treated as *P. wyvilli* only tentatively. One has been dissociated for SEM; the other is described as follows: centrodorsal conical, tapering from base; basal diameter 4.2 mm; height 6.0 mm; HD 1.4; apex with five low interradial glassy ridges (remnants of apicalmost sockets); socket tubercles moderate to strong; interradial ridge a low, short swelling, not reaching level of lumen of basalmost socket; midradial margin of centrodorsal shallow concave with tiny midradial triangular projection; interradial margin concave. Centrodorsal/basal suture distinct, with an interradial slit-like gap. Cirri LXVI, longest remaining of 40 segments, 63 mm long, in 10 columns of 6–7 sockets each; two radial areas with 1 basal socket midradially between columns; c1–3 short; c4 of peripheral cirrus with LW 0.9 (1.3 on apical cirrus); following cirrals increasing in length and becoming compressed; c9–19 about equally long, with LW 3.1; cirrals gradually shorter distally; distalmost ~12 cirrals tapering; antepenultimate cirral with LW 1.7; penultimate still longer than wide; no opposing spine; terminal claw gently hooked.

Externally visible portion of basals swollen interradially, somewhat thinner laterally and parallel-sided with slightly wider ends. Large central fossa in aboral surface of basals with shallow, indistinct, circular or doughnut-shaped depression; central recess flanked by two small depressions; only one interior curved projection remaining; no trace of calcareous plug. Radials very short, separating Ibr_1; WL 3.9; profile ~100°. IBr2 separated laterally by large gaps, and with strong synarthrial tubercle. Ibr_1 oblong with thin sinuous lateral margins, deeply V-shaped distal margin and fine diagonal distolateral raised line. Iax_2 hexagonal with strongly diverging lateral margins (can also be described as rhombic with sinuous proximolateral margins); distal angle truncated; WL 1.0. $IIbr_1$ longer and thickened exteriorly; WL 1.9. $IIbr_2$ irregularly quadrate with interior gap; WL 1.3. $IIbr_{3+4}$ 2.6 mm across; WL 1.2. $IIbr_5$ almost triangular; WL 2.2. Following sygyzgies at 6+7, 9+10.

Remaining undissociated ray bases of second specimen with syzygies beyond 3+4 at 6+7, 9+10 (3 arms), 6+7, 9+10, 13+14 (1), 6+7, 12+13 (2) and 7+8, 12+13 (2).

Distribution. Fiji; Solomon Islands; S of Mindanao, Philippines; central Japan; in (781?) 789–1190 m. Although PH Carpenter (1888) gave the depth of *Challenger* station 174C as 610 fathoms (1116 m), AH Clark (in Clark and Clark 1967) listed 411, 1115 or 384 m (225, 610 and 210 fathoms) for this station. However, his first depth is likely an error for the 255 fathoms of station 174B, and the third is the depth of dredge station 174D (Murray 1895).

Remarks. As mentioned above, the uncalcified integumentary gap between the centrodorsal and basals, and the elaborate aboral basal articular facet, indicate that this species belongs in *Paratelecrinus* (see Messing 2003). Several specimens previously attributed to *P. wyvilli* are either *Adelatelecrinus sulcatus* [*Siboga* 85 (NCB), USNM 36220, and Deutschen Tiefsee-Expedition 210 (ZSM)] (Clark & Clark 1967, AM Clark 1977) or a new species (Kogo 1998) described below. MNHN IE-2009-6746, although dissociated before the Solomon Islands specimens were examined, exhibits several characters typical of *P. wyvilli* and is retained in this species: the centrodorsal tapers from the base, bears sockets to the apex and only the slightest trace of any interradial basal swelling, and has aboral basal articular facets characteristic of *Paratelecrinus*. MNHN IE-2007-7714 and IE-2009-9000 from the Solomon Islands differ from the holotype chiefly in having a narrower slit-like interradial gap between the centrodorsal and basals, and thin ridges instead of distinct obsolete sockets at the centrodorsal apex. MNHN IE-2009-9001 also has a centrodorsal/basal slit unlike the holotype, but also differs in having distinct (although still weak) interradial ridges at the centrodorsal base, and thin lateral projections on proximal ray ossicles. This specimen is larger (centrodorsal diameter 3.7 mm) than most other *P. wyvilli* (max. 3.1 mm), so the features may be size-related.

The two large specimens from Japan are only tentatively treated as *P. wyvilli*. The general appearance of the centrodorsal and the shapes of the ray base ossicles agree with *P. wyvilli*, but the interradial portion of the basals is swollen and the ray bases exhibit strong synarthrial tubercles. As in the Solomon Islands specimens, but unlike the holotype, the interradial gap between the centrodorsal and basals is only a slit. Two additional features suggest that these specimens may not belong in *Paratelecrinus*: 1) the central fossa in the aboral surface of the basal exhibits only a trace of a spoon-shaped articulation, although there are two pairs of pits on either side (as in *P. orthotriremis*), and 2) the cirri taper to a point without an opposing spine. However, the complex basal articulation and the cirri with an opposing spine have not been described in all species attributed here to *Paratelecrinus* (because too few specimens are available in most cases for dissociation, and because complete cirri are rarely retained), so either or both may prove not diagnostic for the genus when additional specimens are collected. Cirri with an opposing aboral spine have only been described so far in *P. cubensis* and *P. orthotriremis* (see below). Also, the reduced centrodorsal/basal gap, strong synarthrial tubercles and limited sculpturing of the aboral basal articulation may perhaps be associated with the much greater size (and age?) of the specimens from Japan.

Paratelecrinus amenouzume, new species

Figure 12

Atelecrinus wyvilli: Kogo 1998:139–140, fig. 116.

Holotype. OMNH K499 [IV 2209], R/V *Soyo* sta. B4, 32°21.5'N, 141°05.0'E, 3580–3960 m, 24 Nov 1974, beam trawl, T. Okutani, coll.

Diagnosis. A species of *Paratelecrinus* with centrodorsal having cirrus sockets in 10 columns (two per radial area) and distinct narrow interradial ridges ending abruptly two-thirds of the way to the apex; basals with no interradial swelling; IBr2 proportionately more elongated than in other *Paratelecrinus* species, with articulation between Ibr_1 and Iax_2 very shallow V-shaped with weak synarthrial swelling.

Description of the holotype. Centrodorsal conical with a small flattened, excavated apex, and narrow interradial ridges ending abruptly two-thirds of the way to the apex; basal diameter 4.5 mm; HD 1.2. Base of centrodorsal shallow V-shaped midradially, with a smaller V-shaped indentation interradially. Proximal sockets projecting so that centrodorsal base appears wider than basal ring. Cirri LXX, none retained, in 10 distinct columns (2 per radial area); 7 functional sockets per column, almost reaching apex; no obsolete sockets.

Externally visible portion of basals narrow, shallow chevron-shaped, of almost uniform height, with slightly raised margins and no interradial swelling; distinct rhombic, ligament-filled space present between small interradial indentation of centrodorsal base and center of basal ossicle. Four basals appear to be divided in two, with the suture just to the right (3 cases) or left (1 case) of the ossicle mid-line; one basal appears to be divided in three with the sutures separating a small central piece from two longer lateral pieces. Radials short, shallow V-shaped; WL 3.3; radial profile 80°. IBr2 constricted in the middle with weak narrow synarthrial swelling. Ibr_1 trapezoidal with converging lateral margins and shallow V-shaped distal margin; WL 1.5. Iax_2 longer than maximum width, shield-shaped with diverging concave lateral margins; LW 1.3. One ray lost distal to Ibr_1; axils on rays flanking missing ray both bearing a *probolus Adidas*™. Four remaining rays broken distal to $IIbr_3$; longest remaining arm (reconstructed from fragments) ~63 mm long; $IIbr_1$ squarish but with slightly converging lateral margins and very shallow V-shaped distal margin; WL 1.4. $IIbr_2$ larger, with diverging lateral margins, weak proximal synarthrial swelling, and a low flat exterior thickening on some rays; WL 1.2. $IIbr_{3+4}$ longer interiorly, 2.3 mm across; WL 1.0; interior lateral margin of $IIbr_3$ flattened. Proximal brachials weakly wedge-shaped, with distinct lateral articular swellings; WL 1.3–1.4; brachials becoming shorter and more strongly wedge-shaped distally. Syzygies at 3+4, 6+7, 9+10 and subsequently at intervals of 1–3 muscular articulations; sequences of at least several syzygial pairs separated by single muscular articulations on at least two arms; one arm with 3+4, 6+7, 8+9, 11+12; another with 3+4, 6+7, 10+11. First pinnule on $IIbr_{11}$, $IIbr_{12}$ or $IIbr_{14}$.

Etymology. This species is named after Ame-no-uzume-no-kami (or Ame-no-uzume-no-mikoto), Japanese Shinto goddess of revelry and dawn, who lured the frightened sun goddess Amaterasu Omikami from her cave by dancing comically and naked on a tub. The Kojiki, the eighth century "Record of Ancient Matters" chronicle, refers

to her as the Heavenly Alarming Female. The proportions of the brachitaxes of this species closely approach those of the "classic ideal" woman's torso, as exemplified by the Aphrodite of Milos (Venus de Milo).

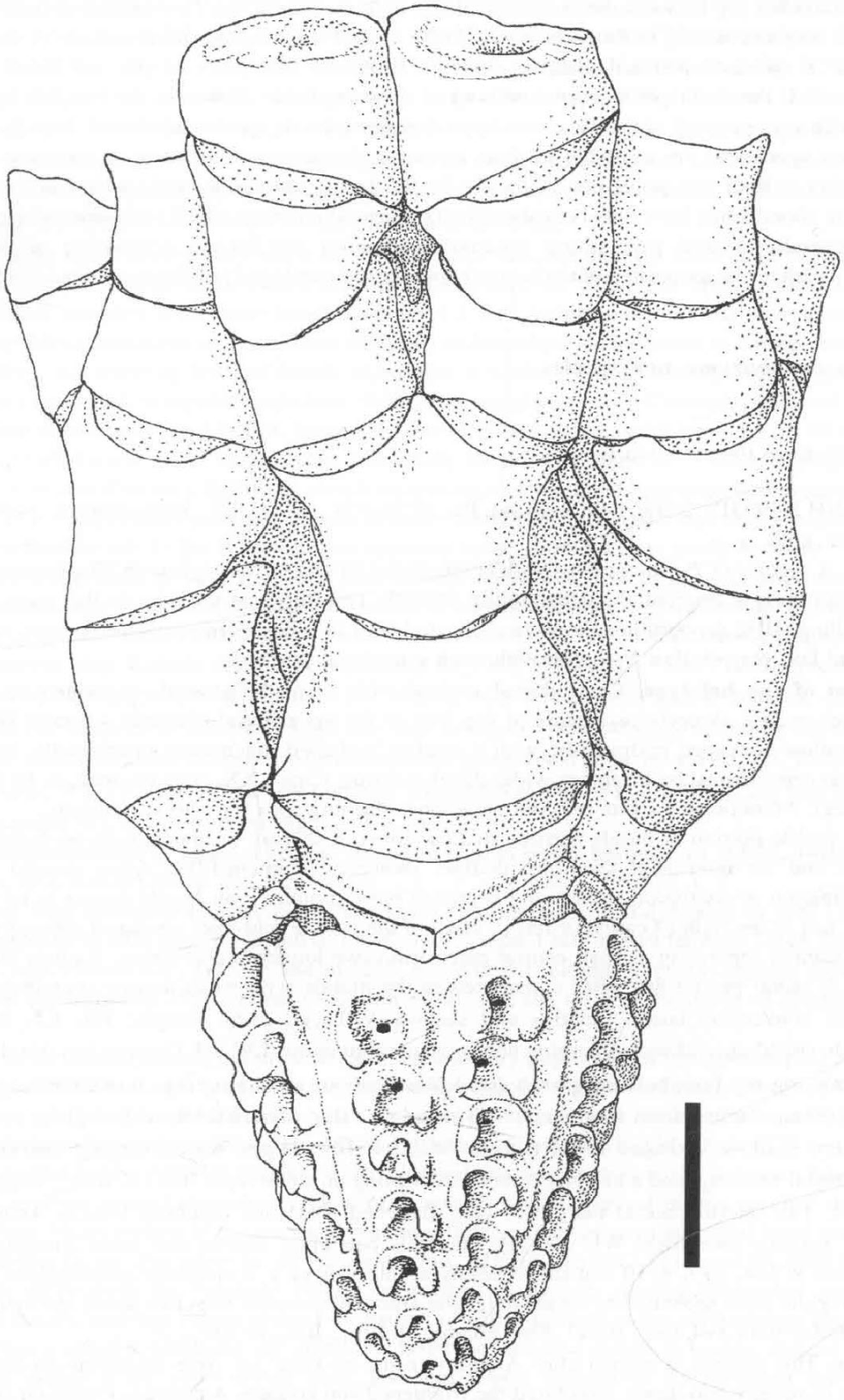

FIGURE 12. *Paratelecrinus amenouzume* new species, holotype, OMNH K499 [IV 2209]. Centrodorsal and ray bases in lateral view. Scale bar: 2 mm.

Remarks. This specimen was originally described as *Atelecrinus wyvilli* (Kogo 1998). It differs from other species of *Paratelecrinus* in having distinctively shaped and proportionally more elongated proximal ray ossicles (except for the short radials) despite its large size, and distinct narrow, almost sharp, interradial ridges on the centrodorsal.

Paratelecrinus laticonulus new species

Figure 13a

Holotype. MNHN IE-2012-845, BORDAU 2 cruise, CP-1529, SW of Fiji, 21°13'S, 174°58'E, 688–710 m, 3 June 2000.

Diagnosis. A species of *Paratelecrinus* with centrodorsal about as wide as tall, no interradial projections or ridges; interradial swellings of basal broad and sometimes bilobed; Ibr_1 with distinctly converging lateral margins.

Description. Centrodorsal conical, short; basal diameter 4.5 mm; HD slightly <1.0; interradial margin not projecting but with very shallow U- or V-shaped notch; radial margin barely concave; apex rounded, with fine possible remnants of obsolete sockets. Cirrus sockets in 10 columns, two per radial area; adjacent columns crowded midradially, separated interradially by narrow gently convex space; no distinct interradial ridge; largest peripheral sockets 0.9 mm tall; fulcral tubercles moderately developed.

Cirri LIV, 5–6 per column; none retained.

Externally visible portion of basals almost straight rather than chevron-shaped, well separated from centrodorsal at least interradially; interradial swelling distinctly wider than high and often bilobed; lateral portions much narrower. Radials crescentic, very short; WL 6.8; profile acute, <70°.

IBr2 and proximal brachial pair with moderately developed synarthrial tubercles. Ibr_1 with proximolateral corners inflated, lateral margins strongly converging, and distal angle shallow V-shaped; WL 2.3. Iax_2 hexagonal with concave diverging lateral margins; distal angle almost parallel-sided and truncated; WL 1.1. Rays lost beyond at most $IIbr_9$. $IIbr_1$ longer exteriorly, weakly wedge-shaped, very slightly concave distally, just meeting interiorly over axil; WL 1.9. $IIbr_2$ longer exteriorly, irregularly quadrate; WL 1.6. $IIbr_{3+4}$ laterally rounded; WL 1.0–1.6; diameter 2.0–2.3 mm. $IIbr_5$ strongly wedge-shaped; WL 2.4. $IIbr_{6+7}$ with WL 1.5. $IIbr_8$ less strongly wedge-shaped than $IIbr_5$; WL 2.6. Syzygies at 3+4, 6+7, 9+10.

Distribution. Known only from the type locality, SW of Fiji, in 688–710 m.

Etymology. From *latus*, meaning broad or wide, and *conulus*, a small cone (both Latin). The conical centrodorsal is the broadest relative to its height of any *Paratelecrinus* species.

Remarks. *Paratelecrinus laticonulus* differs from all other Atelecrinidae in having the centrodorsal as wide across the base as tall and in having the interradial portions of at least some basal ossicles bilobed. The converging lateral margins of Ibr_1 and extremely short externally visible portion of the radials closely resemble those of *P. telo*, described below. However, *P. laticonulus* differs as noted above, and in having sockets in only ten columns, centrodorsal with no interradial ridges, and proportionately narrower arm bases; $IIbr_{3+4}$ is two-thirds as wide as the centrodorsal base in *P. telo* but only half as wide in *P. laticonulus*. The species resembles *P. wyvilli*, which was also collected off Fiji, in lacking an interradial centrodorsal ridge, but differs in multiple respects. In addition to the short wide centrodorsal, the basals are almost straight rather than arched, and swollen and often bilobed interradially; the IBr2 ossicles are proportionally much shorter and broader with a well-developed synarthrial tubercle; the lateral margins of Ibr_1 are strongly converging instead of parallel, and the greatest width of the axil crosses the middle of the ossicle rather than its distal half.

Paratelecrinus telo new species

Figure 13b

Holotype. NW Madagascar: MNHN IE-2012-846, MIRIKI cruise, CP-3284, off Baie de Mahajamba, 14°51'S, 46°59'E, 236–297 m, 13 July 2009.

Diagnosis. A species of *Paratelecrinus* with extremely shallow V-shaped interradial notch in centrodorsal base and cirri in 15 columns (3 per radial area); centrodorsal base barely projecting interradially, if at all; peripheral

sockets large (to 1.1 mm tall); IBr2 and $IIbr_{1-2}$ with moderate synarthrial swelling; lateral margins of Ibr_1 distinctly concave; Iax_2 with short triangular distal angle.

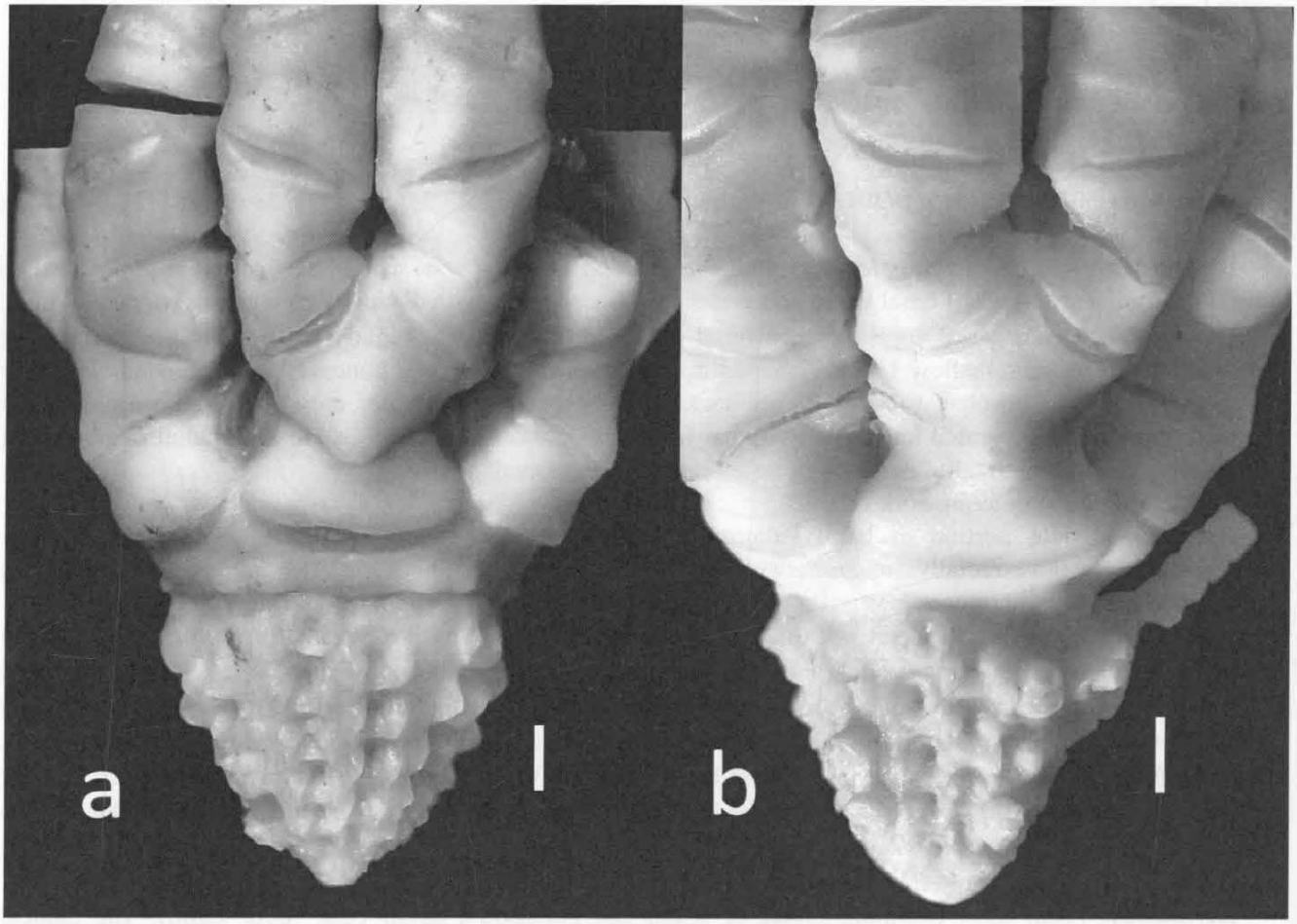

FIGURE 13. Centrodorsal and ray bases in lateral view. a. *Paratelecrinus laticonulus* new species, holotype, MNHN IE-2012-845. b. *Paratelecrinus telo* new species, holotype, MNHN IE-2012-846. Scale bars: 1 mm.

Description. Centrodorsal conical, tapering from base; basal diameter 4.7 mm; HD 1.1; interradial margin barely projecting, with extremely shallow V-shaped excavation; interradial swellings barely present; radial margin almost straight. Apex rounded, smooth. Sockets in 15 crowded columns, 4–5 lateral and 3–4 midradial, three per radial area, not separated interradially; largest peripheral sockets to 1.1 mm tall; socket tubercles moderately developed.

Cirri LXIII, few remaining all broken; 3–4 proximal cirrals short; following segments increasing in length and becoming flattened, with LW 2.9 by c7.

Externally visible portion of basals straight or gently arched, separated from centrodorsal by thin but distinct suture, slightly swollen interradially and filling slight V-shaped excavation in centrodorsal margin, much narrower and tapered laterally. Radials short, crescentic; distal margin very shallow; WL 4.4; profile >90°.

Remaining ray length ~80 mm. IBr2 and $IIbr_{1-2}$ with moderately developed, narrow synarthrial tubercles. Ibr_1 wider than long, with distinctly concave lateral margins; distal margin shallowly V-shaped; WL 2.4. Iax_2 hexagonal (almost rhombic) with short, concave and diverging lateral margins; distal angle acutely triangular; WL 1.3. $IIbr_1$ with exterior margin longer and slightly concave; WL 2.3; interior margins of adjacent pair attached with ligament. $IIbr_2$ quadrate or triangular, wider exteriorly, with weak exterior ridge; WL 1.5. $IIbr_{3+4}$ longer and slightly flattened interiorly; WL 1.4; diameter 3.1 mm. $IIbr_5$ almost triangular, flattened exteriorly; WL 2.4. WL of $IIbr_{6+7}$ 1.5. Following brachials strongly wedge-shaped, with moderately developed alternating articular tubercles; distal edge

smooth, slightly raised; WL 2.3; brachials becoming proportionately longer distally. Distal brachials triangular; WL 1.5–1.7. Syzygies at 3+4, 6+7, 9+10, 12+13 (10+11 on one arm; 14+15 following 12+13 on another); following syzygies separated chiefly by 3–4 muscular articulations (less often 2, 5 or 6; at least 7 at the distal end of one remaining broken arm).

P_1 on $IIbr_{13}$ through $IIbr_{19}$ on different arms. P_4 almost complete, of 18 segments, 5.4 mm long; first pinnular short; second about as long as broad and narrower distally; third and following pinnulars longer than wide, LW 1.3, becoming 2.0 in mid-pinnule and 3.0 distally; middle segments slightly flattened and slightly wider distally; distal segments with expanded ends.

Distribution. Known only from the type locality: off Baie de Mahajamba, NW Madagascar, in 236–297 m.

Etymology. The specific epithet, *telo*, means "three" in Malagasy, the national Austronesian language of Madagascar, and refers to the three columns of sockets in each radial area.

Remarks. *Paratelecrinus telo* resembles *P. conifer* in having 15 crowded columns of cirrus sockets and a V-shaped interradial notch in the centrodorsal base. However, it differs in several respects. The cirrus sockets are larger and fewer, although the centrodorsal is larger than in either specimen of *P. conifer*. The Ibr_1 ossicle has distinctly concave lateral margins, giving it an hourglass shape; the distal angle of the axil is short and triangular instead of parallel-sided with a truncated tip, and the synarthrial tubercles are weaker and broader than in *P. conifer*. *P. telo* was also collected at a much shallower depth than *P. conifer* (236–297 m versus a possible range of 708–1479 m).

Paratelecrinus conifer (AH Clark, 1908a)

Figure 14

Atelecrinus conifer AH Clark 1908a: 213, 214. AH Clark and AM Clark 1967: 818–820, 832.

Holotype. *Atelecrinus conifer*, AH Clark, 1908a, USNM 22685, *Albatross* 3887, NE of Molokai, Hawai'i, 21.275°N, 156.665°W, 1009–1479 m, 17 Apr 1902.

Other material examined. MNHN IE-2009-9004, SALOMON 2, CP-2180, NE of Tulaghi I., Solomon Islands, 08°48' S, 159°41' E, 708–828 m, 22 Oct 2004 (1 spec.).

Diagnosis. A species of *Paratelecrinus* in which the centrodorsal base bears short interradial adoral projections that terminate in a V-shaped notch and cirri in 15 columns (3 per radial area); peripheral sockets relatively small (to 0.8–0.9 mm tall); brachitaxes and proximal brachial pairs with strong, narrow synarthrial swelling; lateral margins of Ibr_1 straight or converging; Iax_2 rhombic, with narrow proximal angle and rectangular distal angle.

Redescription of the holotype (*Figure 14a*). Centrodorsal slightly convex conical; basal diameter 4.1 mm; HD 1.3; interradial margin projecting and with a V-shaped excavation; interradial ridges barely present. Apex with traces of obsolete cirrus sockets. Sockets in 15 crowded columns, three per radial area, not separated interradially, 0.8–0.9 mm tall; 4–5 sockets in lateral columns, 3 in midradial column.

Cirri ~LX, all broken. AH Clark (in AH Clark and AM Clark 1967) described the longest remaining piece as 19 segments, 35 mm long; c1–2 short; c3 LW ~1.5 and the following segments compressed without prominent distal ends, LW ~3.0.

Externally visible portion of basals gently arched and slightly swollen interradially, of roughly uniform height but with the aboral margin gently sinuous, forming a low complete ring separated interradially from centrodorsal by ligament bundle. Radials short, distal margin slightly concave, lateral margins slightly diverging; WL ~4.0–5.0; radial profile ~90°.

IBr2 and $IIbr_{1-2}$ with moderately developed synarthrial tubercles and separated by well developed gaps. Ibr_1 with slightly converging lateral margins and deeply V-shaped distal margin; WL 2.4. Iax_2 rhombic with sharp proximal angle and rectangular (truncated and parallel-sided) distal angle; WL 1.0.

$IIbr_1$ with exterior margin longer and slightly ridged; distal margin shallowly V-shaped; WL 2.0. $IIbr_2$ almost triangular, longer exteriorly and wider distally; WL 1.1. $IIbr_{3+4}$ longer interiorly, 2.2 mm across; WL 1.1; exterior lateral margin concave. $IIbr_5$ and following few remaining brachials short and wedge-shaped; WL of br_5 2.1. Syzygies at 3+4, 6+7, 9+10 and 12+13.

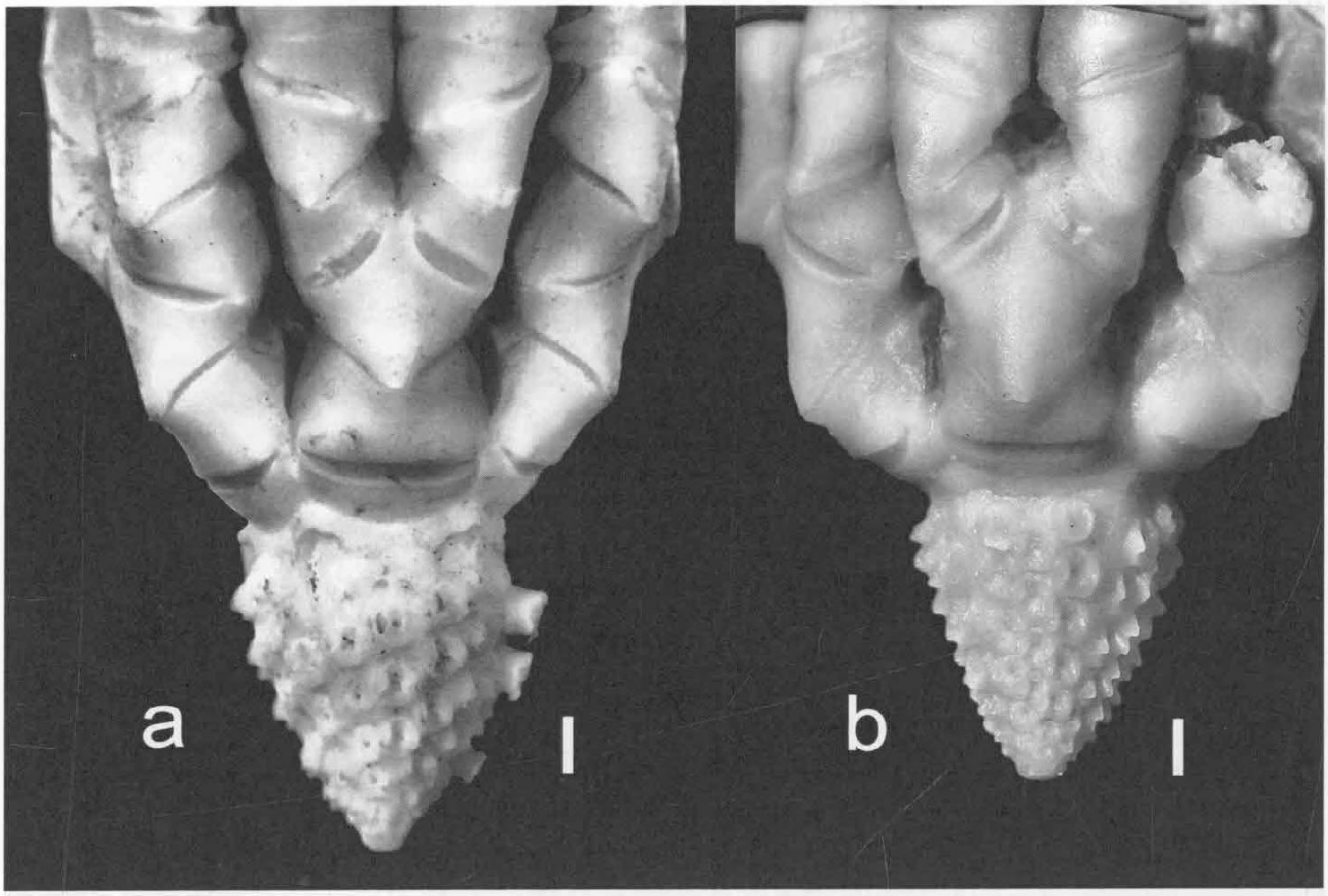

FIGURE 14. *Paratelecrinus conifer* (A.H. Clark). Centrodorsal and ray bases in lateral view. a. USNM 22685 (holotype). b. MNHN IE-2009-9004. Scale bars: 1 mm.

Distribution. Known from the Hawaiian Islands and Solomon Islands. Depth range: (possible) 708–1479 m; (constrained) 828–1009 m.

Remarks. The second specimen attributed to *P. conifer*, MNHN IE-2009-9004, is smaller than the holotype, with centrodorsal diameter 4.1 mm and HD 1.2. It is generally similar but differs as follows. Sides of centrodorsal straight rather than slightly convex (although projecting basal sockets make the centrodorsal base appear narrowed). Interradial projections much weaker; V-shaped excavations very shallow. Midradial margin straight, irregular or with small triangular projection. Cirri LXXXIII (none remaining), with lateral columns of sockets in each radial area separated from those of adjacent radial areas by narrow flat strip; two lateral columns with 6–7 sockets and central column with 4–5 sockets. Apex with weak ridges (remnants of apical sockets). Basals almost straight with no arch and without the distinct interradial gap between basals and centrodorsal. Radials shorter; WL 5.3–5.6; radial profile ~120°; sides of radials visible between bases of adjacent rays. IBr2 and $IIbr_{1-2}$ with stronger, narrow synarthrial tubercles. Ibr_1 well separated laterally, with distal margin more deeply V-shaped; WL 2.8. Iax_2 rhombic, longer than wide; WL 0.8; distal angle rectangular. Adjacent $IIbr_1$ separated interiorly above axil. $IIbr_2$ as long as or slightly longer than wide; WL 0.95–1.0. $IIbr_{3+4}$ with WL 1.0–1.3, 2.5 mm across. $IIbr_5$ almost triangular; WL 1.9. $IIbr_{6+7}$ present. All arms lost at br_3 or br_6. Long *probolus Adidas*™ visible between two adjacent rays.

Because *P. conifer* is known from only two specimens, the features that distinguish it from *P. orthotriremis* and *P. telo*, the only other species with cirri in 15 columns, might not remain useful when additional specimens are found. The shape of the axil in particular clearly varies with growth in atelecrinids, e.g., from hexagonal to rhombic in both *P. cubensis* and *P. orthotriremis* (Figures 10, 16). However, the proximal angle of the axil (and that of $IIbr_2$) is sharper in *P. conifer* than in other species when similarly-sized specimens are compared.

***Paratelecrinus orthotriremis*, new species**
Figures 15, 16

Holotype. USNM E42705, *JSL II* 1744, York Bay, St. Vincent, St. Vincent and Grenadines, 13°09'45"N, 61°16'59"W, 490 m, 24 Apr 1989.

Paratypes. Bahama Islands: USNM 1133481, *JSL II* 3691, NW Providence Channel, 26°25.361'N, 77°51.672'W, 704 m, 26 July 2009 (1 spec.); USNM E42650, *JSL II* 808, off Great Abaco I., 25°52'12"N, 77°15'30"W, 696 m, 9 Apr 1984 (1). Caribbean Sea: USNM E42673, *JSL II* 1733, Bridgetown, Barbados, 13°00'42"N, 59°39'32"W, 477 m, 18 Apr 1989 (1); USNM E42685, *JSL II* 1740, York Bay, St. Vincent, 13°07'12"N, 61°17'02"W, 393 m, 22 Apr 1989 (2).

Other material examined. Strait of Florida: USNM 34820, *Fish Hawk* 7285, S of Key West, 24°15'00"N, 81°47'30"W, 560 m, 19 Feb 1902 (1 spec.). Bahama Islands: USNM E19280, *Gerda* 242, SW of Bimini, 25°36'N, 79°21'W, 458–531 m, 30 Jan 1964 (1). USNM E17878, *Pillsbury* 1441, N of Acklins I., 22°25'06"N, 73°52'00"W, 855 m, 23 Jul 1971 (1); USNM E17959, *Pillsbury* 1478, NW of Mayaguana I., 22°27'18"N, 73°10'06"W, 770 m, 23 Jul 1971 (1); USNM E42651, *JSL I* 1500, off San Salvador I., 24°02'25"N, 74°32'32"W, 521 m, 22 Oct 1983 (1); USNM E43084, *JSL II* 811, off Eleuthera I., 26°35'00"N, 76°49'04"W, 608 m, 11 Apr 1984 (1); USNM E43085, *JSL II* 817, off Whale Cay, 25°23'03"N, 77°47'15"W, 522 m, 15 Apr 1984 (1); USNM E43086, *JSL II* 1497, off Andros I., 25°12'12"N, 77°59'56"W, 635 m, 18 Oct 1987 (1). Yucatán Channel: USNM E17832, *Gerda* 889, 20°55'N, 86°28'W, 177–220 m, 10 Sep 1967 (2). St. Vincent and Grenadines (all York Bay, St. Vincent): USNM E42672, *JSL II* 1744, 13°09'45"N, 61°16'59"W, 483 m, 24 Apr 1989 (1); USNM E42674, *JSL II* 1740, 13°07'12"N, 61°17'02"W, 407 m, 22 Apr 1989 (1); USNM E42675, *JSL II* 1745, 13°07'13"N, 61°16'46"W, 392 m, 24 Apr 1989 (1); USNM E42676, *JSL II* 1745, 13°07'13"N, 61°16'46"W, 392 m, 24 Apr 1989 (1); USNM E42685, *JSL II* 1740, 13°07'12"N, 61°17'02"W, 393 m, 22 Apr 1989 (2); USNM E42686, *JSL II* 1747, 13°07'13"N, 61°16'46"W, 414 m, 25 Apr 1989 (1); USNM E42687, *JSL II* 1740, 13°07'12"N, 61°17'02"W, 407 m, 22 Apr 1989 (1); USNM E42706, *JSL II* 1740, 13°07'12"N, 61°17'02"W, 395 m, 22 Apr 1989 (1). Barbados: E42681, *JSL II* 1727, 13°14'36" N, 59°44'90"W; 554 m, 15 Apr 1989 (1 dissociated for SEM); USNM E42682, *JSL II* 1728, 13°14'56"N, 59°43'30"W, no depth, 15 Apr 1989 (1); USNM E42689, *JSL II* 1733, 13°00'42"N, 59°39'32"W, 496 m, 18 Apr 1989 (1).

Diagnosis. A species of *Paratelecrinus* with 15 columns of cirrus sockets (3 per radial area); peripheral sockets small (0.4–0.8 mm tall) (Figures 15a–b); brachitaxes and proximal brachial pairs with moderately developed synarthrial swellings; Iax_2 hexagonal with parallel sides in smaller specimens (e.g., Figure 16, top row), rhombic with narrower distal angle in large specimens (e.g., Figure 16, bottom row); no thin, wing-like, lateral flanges. Lateral margins of Ibr_1 straight or slightly diverging.

Description of the holotype (*Figure 15a*). Centrodorsal conical, tapering from base; basal diameter ~3.6 mm (obscured by bases of cirri); height 5.0 mm; HD ~1.4; interradial margin weakly concave; radial margin weakly concave midradially, with or without weak midradial projection, convex over peripheral cirrus sockets. Apex blunt conical with weak ridges derived from obsolete sockets. Sockets in 15 crowded columns, three per radial area, with 5 sockets in midradial column, 5–6 sockets in lateral columns; narrow flat interradial strip separating columns in adjacent radial areas in proximal two-thirds of centrodorsal; no interradial ridge. Cirri compressed, too crowded to count precisely, ~LXXX; longest intact of 37 segments, 70 mm long (longest possibly ~41 segments, ~80 mm); c1–2 short; c3 squarish; longest cirrals with LW 5.0; distal adoral corner of distal cirrals spine-like in side view, producing serrate adoral profile; weak rounded aboral spine on penultimate cirral; weaker rudiment on antepenultimate cirral; terminal claw with slightly hooked tip; cirrus tapering toward tip.

Externally visible portion of basals almost straight, swollen interradially, thin laterally and with slightly expanded ends just touching midradially. Radials very short, concave distally; WL 6.4–6.6; lateral margins of radials visible between rays, separating adjacent brachitaxes; proximal corners slightly swollen over basals. Ray length 207 mm, including 25-mm incomplete distal filament. IBr2 and $IIbr_{1-2}$ with moderately developed synarthrial swelling. Ibr_1 with lateral margins parallel and distal margin moderately V-shaped; WL 2.6. Iax_2 rhombic, wider than Ibr_1; WL 1.0; distal portion parallel-sided. $IIbr_1$ curved wedge-shaped, deeply concave distally; exterior margin long, straight, thickened and apposed against $IIbr_1$ of adjacent ray; interior margin short, receding into distinct gap; WL 3.5. $IIbr_2$ almost triangular, longer exteriorly and wider distally; WL 1.5. $IIbr_{3+4}$ longer interiorly; 2.6 mm across; WL 1.4–1.6. Proximal brachials wedge-shaped, with weak alternating articular

tubercles on $IIbr_8$ and following ossicles; WL 1.8. Middle brachials almost triangular; WL 1.8. Distal brachials weakly wedge-shaped with the pinnule articulation on the longer lateral margin slightly projecting as a small shelf in aboral view; brachials beyond mid-arm with proximal aboral margin weakly everted and shelf-like, bearing a row of spines; distal aboral margin smooth; WL 0.8; becoming longer than broad (LW 1.5) with slightly expanded distal margin as arm tapers toward apinnulate tip. Elongated brachials of distal apinnulate filament with pair of weak distolateral spines; WL up to 2.7. Syzygies at 3+4, 6+7, 9+10 [3+4, 5+6, 8+9 on both arms of one ray (one followed by 11+12, 13+14, 15+16); 3+4, 7+8, 11+12 on another] and subsequently chiefly at intervals of 2 muscular articulations, many 3 distally (some 2, 4).

P_1 on $IIbr_{13}$ to $IIbr_{17}$; all broken but with first segment short, wider distally; second squarish and slightly narrower distally; third squarish; fourth slightly longer than wide; following pinnulars of about equal length but becoming narrower distally; proximal pinnulars flattened, with blunt tooth at distal corners of proximal segments beyond basal two; pinnulars becoming cylindrical with expanded overlapping distal ends as pinnule tapers distally. Following pinnules to 13.7 mm long, of 27 segments; first pinnular short, widest distally; second short, widest proximally; third slightly longer than wide, flattened; pinnulars in proximal half (beyond basal two) flattened with blunt spine at distal corners; middle and most distal pinnulars of similar length but becoming narrower and more slender with expanded ends; distal pinnulars reaching LW >7.0. Pinnule and arm ambulacra (including apinnulate distal filament) with numerous saccules.

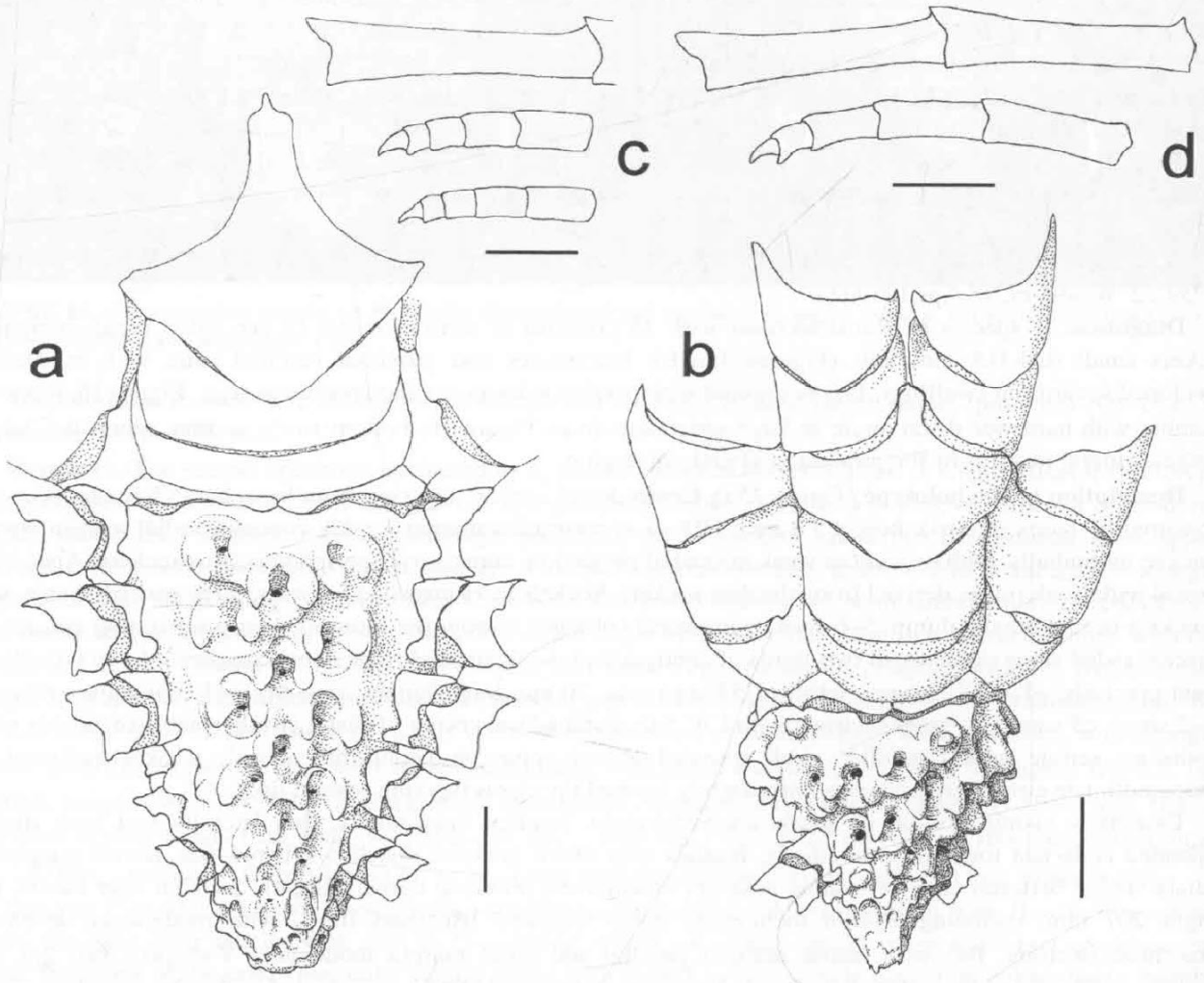

FIGURE 15. *Paratelecrinus orthotriremis* **n. sp.** a. Centrodorsal with cirrus bases and one brachitaxis in lateral view, USNM E42705 (holotype). b. Centrodorsal and ray bases in lateral view, USNM E43085. c. One middle cirral (upper) and tips of two cirri (middle, lower), USNM 42705 (holotype). d. Two middle cirrals (upper) and tip of one cirrus (lower), USNM E43085. Scale bars: 1 mm.

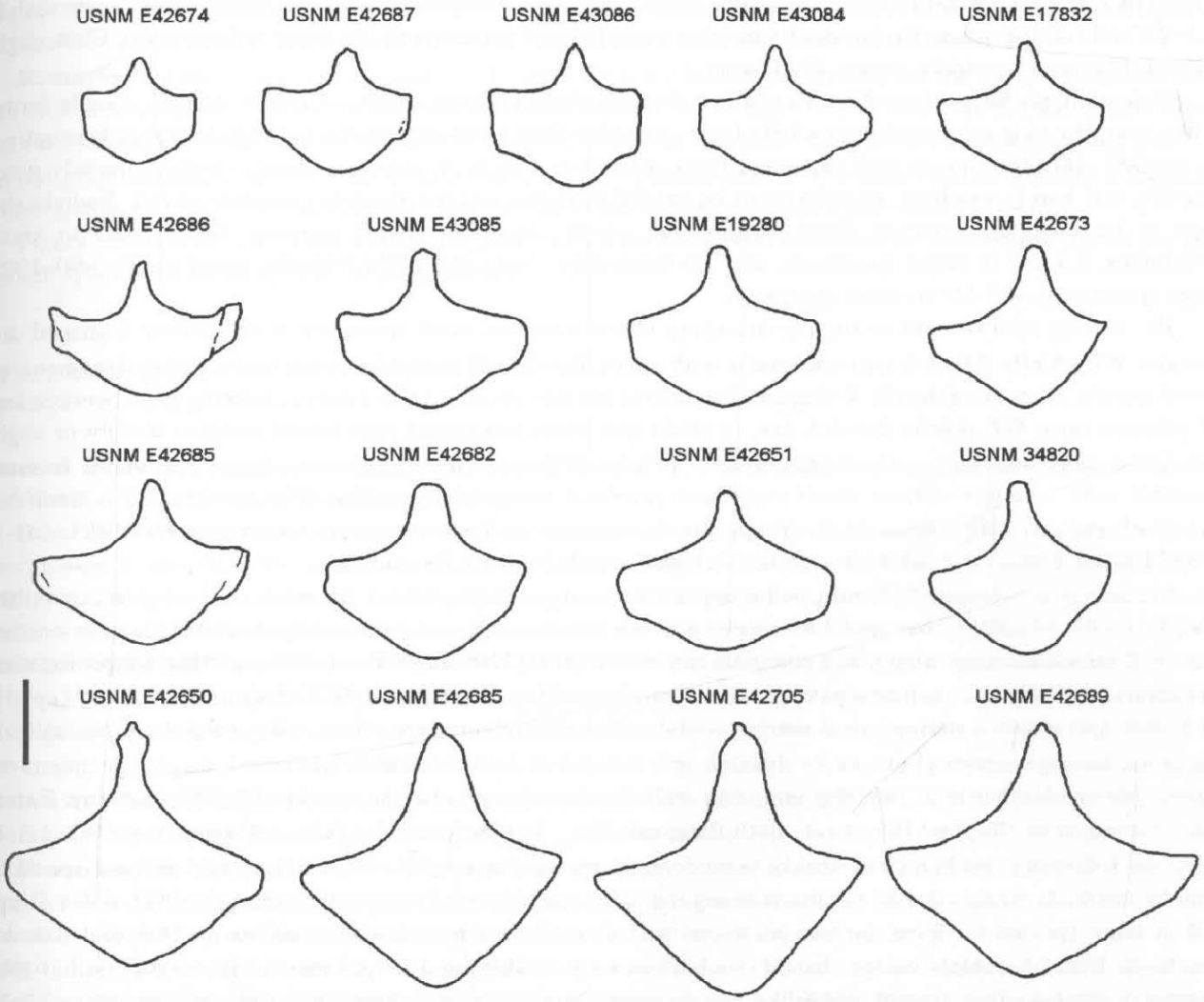

FIGURE 16. *Paratelecrinus orthotriremis* **n. sp.** Iax_2 of 17 specimens showing the gradual change from hexagonal to rhombic with increasing size. Scale bar: 1 mm.

Description of other specimens. Centrodorsal conical, with convex sides or in larger specimens tapering from the base; basal diameter 1.8–4.2 mm (chiefly ≥2.3 mm); HD 1.0–1.4, chiefly ~1.1 in smaller specimens (diam. ≤2.5 mm) and 1.2–1.3 in larger specimens (diam. ≥2.8 mm); interradial margin often weakly projecting and swollen, sometimes flat or concave, never with a deep V-shaped excavation; radial margin usually with a pair of shallow concavities accommodating ends of adjacent basals, with a weak midradial triangular projection between them; centrodorsal base of smallest specimen (diam. 1.5 mm) with thin convex interradial ridges. Apex conical or blunt conical, often with weak ridges derived from obsolete cirrus sockets. Sockets in 15 crowded columns, three per radial area; larger specimens with 3–4 sockets in midradial column, 5–7 sockets in lateral columns, and with columns in adjacent radial areas sometimes separated by narrow interradial strip; smaller specimens with 1–4 midradial sockets, 3–5 sockets in outer columns, and no interradial separation; peripheral sockets 0.4–0.8 mm tall. One small specimen (USNM E42674) with 2 columns of cirri per radial area but with an immature midradial peripheral socket forming an incipient third column. USNM E19280 with a fourth immature peripheral socket across a radial area.

Cirri ~XL–LXXXV, with at most 41 segments, ~85 mm long, compressed and distally tapering; delicate and thread-like in small specimens. Smaller apical cirri often retained, of 18–25 segments, 5.0–17.0 mm long. Up to first three cirrals short (fewer in smaller specimens); following segments increasing in length; c7–18 longest, with LW 3.5–5.4 (up to 8.1 in small specimens); middle cirrals with expanded distal ends; adoral distal corner

sometimes projecting distally and spine-like (Figures 15c–d, top). Cirrals in distal half shorter, but remaining longer than wide; terminal few cirrals lacking distal expansion. Antepenultimate and penultimate cirrals with LW 1.3–2.0 and 1.2–0.8, respectively, usually bearing curved aboral spine (rarely absent or rudimentary). Claw slightly curved (Figures 15c middle, lower; 15d lower).

Externally visible portion of basals shallow chevron-shaped, gently arched or almost straight, usually forming a low complete ring separated interradially from centrodorsal by ligament bundle, but with lateral ends usually not as swollen and often not as well separated from centrodorsal as in *P. cubensis*. Basals rarely extremely narrow laterally and barely touching, or reduced to interradial triangles and not forming complete circlet. Radials short, with at least slightly concave distal margin and usually diverging lateral margins; WL 1.7–2.3 in smaller specimens, 2.3–3.6 in larger specimens, and 7.0 (extremely short) in USNM E42689; radial profile ~90–100° in large specimens, ~65–80° in small specimens.

Ibr_1 oblong with straight or slightly diverging lateral margins; small specimens with shallow V-shaped distal margin; WL chiefly 2.0–2.4; two specimens with small distolateral triangular projections; larger specimens with distal margin often more deeply V-shaped; distolateral margins receding into interior, forming gaps between bases of adjacent rays; WL chiefly 2.4–3.3. Iax_2 in small specimens hexagonal with lateral margins straight or slightly convex, usually apposed against adjacent axil; no gaps (Figures 15b, 16 top row); larger specimens becoming rhombic with a longer narrow distal angle and proximal synarthrial swelling (Figures 15a, 16 bottom row); proximal angle broadly obtuse in small specimens, narrower in large specimens, but never <90°; WL 1.0–1.3. USNM E42673 bears one ray with an extra V-shaped ossicle between Ibr_1 and Iax_2.

Maximum ray length 207 mm, including a 25-mm regenerating distal filament without pinnules (USNM E42705). USNM E42673 has rays 140 mm long to the distalmost pinnule plus a 60-mm distal filament similar to that of *P. cubensis*, suggesting that a complete ray in USNM E42705 might reach 260 mm. $IIbr_1$ longer exteriorly, in contact interiorly over axil or separated; distal margin gently concave to deeply V-shaped; WL 1.9–2.7 (up to 3.5 in a large specimen); exterior lateral margin slightly thickened in some specimens. $IIbr_2$ irregularly pentagonal or quadrate, longer exteriorly and wider distally; WL 1.3–1.5 (1.1 in one small specimen); larger specimens with strong proximal synarthrial swelling and with well-developed gap between adjacent $IIbr_2$ on each ray. Exterior lateral margins of $IIbr_1$ and $IIbr_2$ rarely both flattened. $IIbr_{3+4}$ longer interiorly; 0.75–1.9 mm across; WL 1.0–1.5. $IIbr_5$ and following few brachials weakly to moderately wedge-shaped; WL 1.1–1.5 (up to 2.1 in large specimen). Middle brachials wedge-shaped to almost triangular, with one side much longer than the other; WL 0.9–1.5 (up to 2.0 in large specimen). Some larger specimens with low alternating articular tubercles on $IIbr_8$ and following brachials. Distal brachials wedge-shaped (sometimes only weakly) and longer than wide, with proximal aboral margin at least weakly everted, shelf-like and bearing a row of spines; distal aboral margin smooth or slightly raised; WL chiefly 0.6–0.8; slender distalmost brachials of filament up to six times longer than wide. Syzygies at 3+4, 6+7 and 9+10; subsequently at intervals of 2 (occasionally 3, rarely 4 or 5) articulations. Two large specimens with distal intervals chiefly 3–4. Rarely 8+9; 7+8 and 10+11; 7+8 and 11+12, or 6+7 and 10+11.

P_1 usually on $IIbr_{17}$ (rarely $IIbr_{12}$ to $IIbr_{20}$), mostly broken; longest with 30 segments, 14.3 mm; first pinnular short and triangular; second trapezoidal; following pinnulars becoming more slender and much longer, initially flattened but becoming cylindrical with expanded overlapping distal ends as pinnule tapers distally; distal segments extremely slender. Several proximal segments beyond second often bearing a blunt or triangular distal aboral tooth. Longest distal pinnules up to 19.2 mm long, of 33 segments; proximal pinnulars flattened; those beyond basal two with strong aboral distal tooth or blunt spine; pinnulars becoming more slender distally with expanded distal ends; middle and distal segments of about equal length but shorter near tip; distal pinnulars with LW up to 9.0.

Distribution. South of Key West, FL, Bahama Islands, Yucatán Channel, Barbados and St. Vincent. The records from the Strait of Florida and Bahamas are from generally deeper water (seven records in 521–855 m; one trawl record in 458–531 m) than those from the Caribbean Sea (nine records in 392–496 m; one in 554 m). The much shallower record from off Arrowsmith Bank (177–200 m) reflects shoaling isotherms across the Yucatán Channel from the Cuban to Mexican sides associated with northward geostrophic flow of the Yucatán Current. Meyer *et al.* (1978) recorded similarly shallower records for other crinoid species here relative to their depth distributions along the Bahama margin of the Strait of Florida, where geostrophic flow of the Florida Current depresses isotherms (Leaman *et al.* 1987).

Etymology. The name *orthotriremis* derives from Latin *triremis*, the ancient Mediterranean warship with three tiers of oars, after the three columns of cirrus sockets in each radial area, and Greek *orthos*, straight, in reference to the parallel sides of the Ibr_1 ossicles and relatively straight interradial margin of the centrodorsal.

Remarks. *Paratelecrinus conifer* and *P. telo*, both from the Indo-West Pacific, are the only other atelecrinids with cirri in 15 columns, but *P. orthotriremis* differs as follows: no V-shaped notch in the interradial margin of the centrodorsal; lateral margins of Ibr_1 straight or slightly diverging, and axil with a more rounded proximal angle. *P. telo* has proportionately larger cirrus sockets than either *P. orthotriremis* or *P. conifer*, and its axil has a distinctly different, triangular distal angle. *P. conifer* also occurs in substantially deeper water (1009–1479 m).

Figure 16 illustrates the gradual change in axil shape from hexagonal with more or less straight lateral margins in small specimens, to rhombic in larger specimens.

Atelecrinidae species A

Figure 17

Material examined. Solomon Islands: MNHN IE-2007-7715, SALOMON 1 cruise, CP-1764, 08°36.6'S, 160°07.4'E, 1327–1598 m, 27 Sep 2001 (1 spec.).

Description. Centrodorsal tapering from base; height 4.3 mm; basal diameter 3.6; HD 1.2; apex rounded conical, almost smooth, without obsolete sockets; interradial ridge a low broad swelling reaching at least to top of basalmost cirrus socket; midradial margin shallow concave; interradial margin slightly projecting and convex; centrodorsal/basal suture distinct with trace of interradial slit-like gap. Cirri XXX, in 10 columns, 3 per column; none retained. Externally visible portion of basals gently swollen interradially, forming a complete circlet of almost uniform height. Radials short, with diverging lateral margins, just separating adjacent Ibr_1; WL 3.9; radial profile 90°. IBr2 with no lateral flanges or teeth, and separated laterally by rhombic gap. Ibr_1 oblong, sides slightly converging; distal margin V-shaped; WL 1.8. Iax_2 hexagonal with strongly diverging lateral margins; distal angle rounded-truncated; WL 1.0. $IIbr_1$ slightly longer and weakly flattened exteriorly; WL 1.9. $IIbr_2$ almost triangular, separated intereriorly by rhombic gap; WL 1.25. $IIbr_{3+4}$ 2.1 mm across. All rays broken at $IIbr_1$ or $IIbr_3$.

Remarks. The externally visible appearance of the basal circlet and centrodorsal/basal articulation make identification of this specimen to genus problematic. Unlike *Paratelecrinus*, this specimen lacks a distinct centrodorsal/basal gap, and the basals are not strongly arched, although the uniform height of the externally visible portion of the basal ossicles, unlike those of *Atelecrinus* and *Adelatelecrinus* species, approaches that in several *Paratelecrinus* species. The brachitaxes most closely resemble those of *Paratelecrinus wyvilli*, but this specimen differs in having better developed interradial ridges on the centrodorsal (even if only low swellings), a smooth centrodorsal apex without obsolete sockets, and fewer, obviously larger, cirrus sockets; a fully developed basalmost cirrus socket is 0.25 of midradial centrodorsal height in this specimen, but only 0.20 in *P. wyvilli*. Because only one specimen is available, it has not been dissociated.

Conclusions

The specimens described in this paper substantially broaden the known morphological disparity, geographic range, and ontogenetic variations in Atelecrinidae. The well-developed articulation between the basal ring and centrodorsal, and the complex aboral articular facet of the basal ossicles in *Paratelecrinus* are unknown in any other living crinoid. The distal filamentous and apinnulate portion of the arm is so far unknown in other comatulids, but is found in some stalked crinoids (*Porphyrocrinus* Gislén, 1925; Messing, unpublished observations). However, too few species are known from enough complete specimens to draw firm conclusions in many cases about either generic or specific boundaries. Cirri terminate in a tapered point without opposing spine in both species of *Atelecrinus*, in *Adelatelecrinus sulcatus* (the only species in this genus for which complete cirri are known), and in the two Japanese specimens tentatively treated as *P. wyvilli*, whereas both *P. cubensis* and *P. orthotriremis*, the two best understood species in that genus, bear cirri with an opposing spine. It thus remains unclear whether the cirrus tip is a useful generic feature or not.

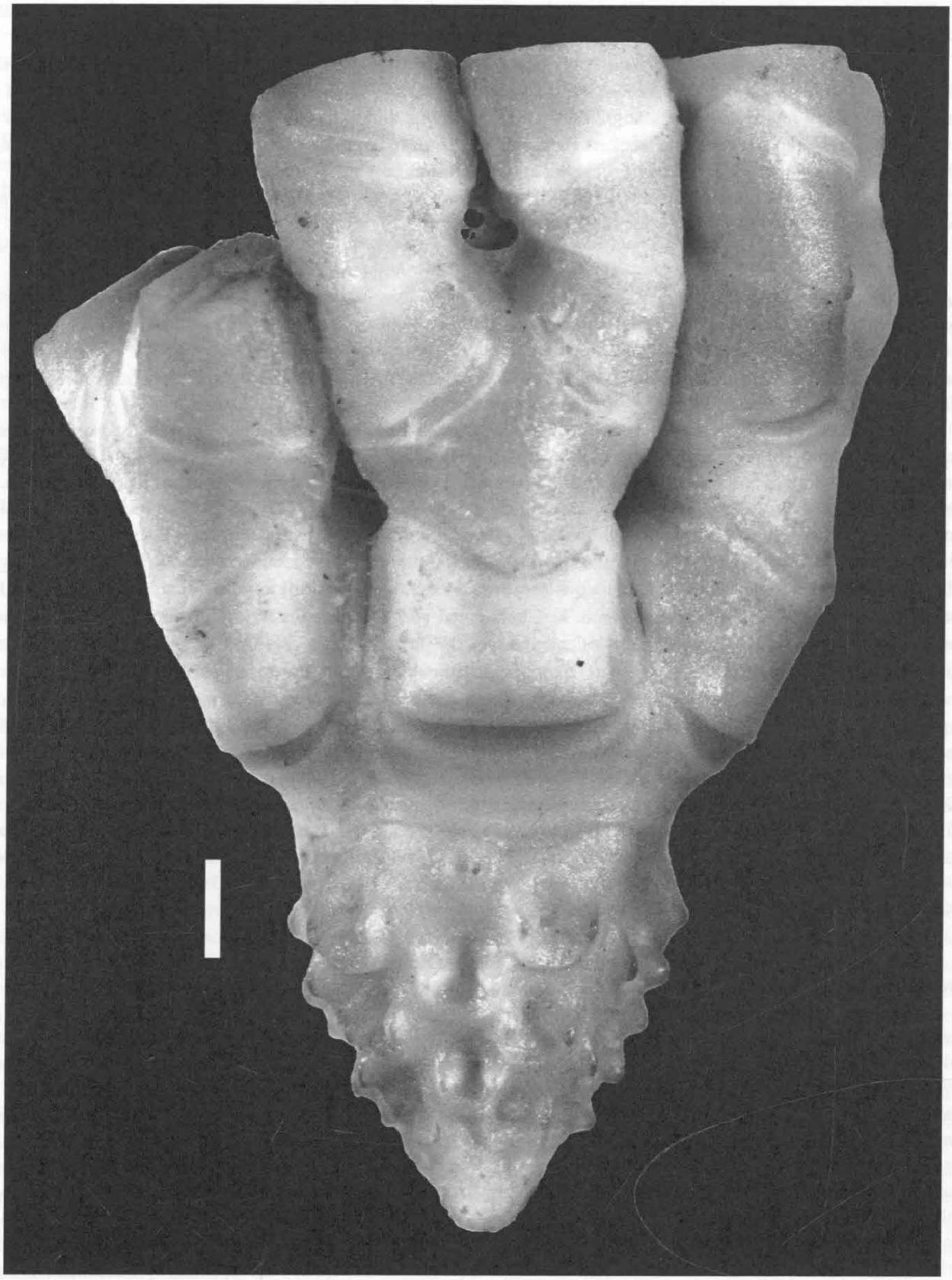

FIGURE 17. Atelecrinidae species A. Centrodorsal and bases of three rays in lateral view, MNHN cat. no. IE-2007-7715. Scale bar: 1 mm.

The deep interradial pits in the centrodorsal margin of *Adelatelecrinus* and *Paratelecrinus* appear to represent an important distinction between these two genera and *Atelecrinus*, whereas the complex aboral facet of the basal ossicles appears to distinguish *Paratelecrinus* from the other two. However, the two large Japanese specimens treated as *P. wyvilli* share much simpler aboral basal facets than found in another specimen of *P. wyvilli* or in *P. orthotriremis*, although the Japanese specimens bear what may be vestiges of the complex facet, perhaps reduced in association with their greater size (and age?). It remains unclear whether these two specimens are properly identified as *P. wyvilli*, or correctly placed in *Paratelecrinus*. More specimens are needed before generic boundaries can be unequivocally characterized.

In all dissociated specimens in all three genera, a pair of adjacent axils bear the ridged, shoe-like process, the *probolus Adidas*™ (Messing 2003) (Figures 1a–b), making this feature a potentially useful familial-level diagnostic character (although it is not known if it is present in *Sibogacrinus anomalus*). However, one specimen each of *Atelecrinus helgae* and *Paratelecrinus amenouzume* may have had two adjacent pairs of processes; in both cases, the axils on both sides of a lost ray have a *probolus Adidas*™, suggesting that the missing axil had the process on both sides. It is thus not clear how much this character varies among atelecrinids.

Finally, the curved pair of projections that arise from the interior margin of the basals in several species appear to form a central rosette-like structure that separates the centrodorsal cavity from the radial cavity. Such a feature has not been previously recognized in Atelecrinidae and deserves further examination.

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