

The Systematic Position of *Royella sinon* (Bayle) (Prosobranchia: Cerithiidae)

by

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Abstract. *Royella sinon* (Bayle), a marine prosobranch representing a monotypic genus, is herein assigned to the family Cerithiidae Fleming on the basis of characters derived from the shell, soft anatomy, operculum, and radula. A white shell sculptured with two nodular spiral cords per whorl, a short shallow anterior siphon, and the concave base of the body whorl are distinctive. The corneous operculum is circular-ovate, having few spirals and a central nucleus. The taenioglossate radula is typically cerithioid. Digitate papillae fringe the mantle edge, and within the mantle cavity a long monopectinate osphradium, a ctenidium comprised of long triangular filaments, and a thick, wide, open pallial oviduct with a large albumen gland are notable features. A pair of salivary glands that pass through the nerve ring, a midesophageal gland, and a large stomach with a short style sac, large cuticularized gastric shield, and complex sorting area indicate herbivory. The habitat is subtidal rubble bottoms. Development is inferred to be planktotrophic on the basis of the sculptured protoconch and distinct sinusigera notch.

INTRODUCTION

Royella sinon (Bayle) is an uncommon marine cerithiacean prosobranch of uncertain familial assignment that has a white shell about 20 mm long with rugose cancellate sculpture. It has an extremely wide geographic distribution throughout the Indo-Pacific region. Its exact affinity to other cerithiacean groups has long been unknown due to lack of information about the soft parts and radula.

Royella is a monotypic genus that has been assigned to the Potamididae H. and A. Adams, 1854, due to shell characters shared in common with some potamidid species such as *Pirenella conica* (Blainville), but this allocation is unsatisfactory. To resolve this problem I examined virtually all specimens of *Royella* in major national and international institutions and museums, but not a single preserved animal or shell with a dried animal was found. In addition, requests in *The Hawaiian Shell News* (HOUBRICK, 1984:12) for live-collected, preserved specimens were not successful, although some new locality records were obtained. Recently, Mr. Gustav Paulay collected *Royella sinon* alive in the Cook Islands and, through the kindness of Dr. Anders Warén, I was able to obtain the preserved specimen and study the soft anatomy and radula. The results are presented below and include a historical account, synonymy, description of the shell, animal, and radula, and the new family allocation for this taxon.

MATERIALS AND METHODS

Specimens of this uncommon snail were examined from major museums and from private collections throughout the world for shell measurements. Variables included total shell length and width, aperture length and width, and length of the penultimate whorl. The single available preserved specimen, a female, was dissected using methylene blue solution under a Wild M-5 dissecting microscope. The radula was removed, measured, and prepared for scanning electron microscope (SEM) study. Superficial and internal anatomy were studied, but swelling of the albumen gland due to the aqueous dissecting solution unfortunately obscured and partially destroyed details of the pallial oviduct. Scanning electron micrographs of the radula and operculum were made on a Cambridge 250 Mark II Stereoscan microscope.

The following abbreviations have been used in this paper: AMNH—American Museum of Natural History; AMS—Australian Museum, Sydney; ANSP—Academy of Natural Sciences, Philadelphia; BMNH—British Museum (Natural History); CAS—California Academy of Sciences; DMNH—Delaware Museum of Natural History; HUJ—Hebrew University of Jerusalem; LACM—Los Angeles County Museum of Natural History; MNHN—Museum National d'Histoire Naturelle, Paris; NMNZ—National Museum of New Zealand;

NMV—National Museum, Victoria; USNM—National Museum of Natural History; WAM—Western Australian Museum.

Material examined and literature records

RED SEA: Aqaba, Jordan (HUI 21.311/9); Elat, Israel (HUI 21.312/8). INDIAN OCEAN ISLANDS: Anse Boileau, Mahe, Seychelles (BMNH); Mauritius (BMNH). AUSTRALIA: North Australia (BMNH); outer reef, West Gun Id., Abrolhos Islands, Western Australia (WAM); Lodestone Reef, N of Townsville, Queensland (AMS); S Side Beach, York Id., Torres Strait, Queensland (AMS); Four Mile Beach, Port Douglas, Queensland (AMS); Saxon Reef, off Cairns, Queensland (Thora Whitehead coll.); Norfolk Id. (AMS); 44 m off Lord Howe Id., 31°38'25"S, 159°03'W (AMS); Lord Howe Id. (AMS, NMV). KERMADEC ISLANDS: Raoul (Sunday Id.) (AMS, NMNZ MF 141616, USNM 214757); 29°17.2'S, 177°57.2'W, 27–29 m, E end of Denham Bay, Raoul Id. (NMNZ MF26957); 29°15'S, 177°50.9'W, 31–45 m between Dayrell and Chanter Is., Herald Islets (NMNZ MF27068). JAPAN: Nada, Kii, Honshu (ANSP 224908); Shionomizaki, Kii, Honshu (ANSP 224769); Hachiojima Izu (ANSP 86166). RYUKYU ISLANDS: Ryukyus (ANSP 243288, DMNH 80887, USNM 666629); Kikai, Osumi (MNHNP, USNM 273329, 175588, CAS, AMS); Osuma, Osumi (USNM 343916, MNHNP). PHILIPPINES: Baclayon Id., Bohol (A. Adams, 1855); Cebu (LACM 25166, MNHNP). TAIWAN: (Kuroda, 1941). PALAU: SW tip, Ngatpaet Passage, E Babelthuap (ANSP 202742). MARSHALL ISLANDS: Taka Atoll (USNM 615494); Bock Id., Rongerik Atoll (USNM 594667); Majuro Id., Majuro Atoll (Bob Purtymun coll.); lagoon side, Edgigen Id., Kwajalein (DMNH 93854); Enewetak Atoll (LACM 70-72, USNM 821778). NEW CALEDONIA: (MNHNP). LOYALTY ISLANDS: (BMNH); Lifu (ANSP 132658, 196063, ANS, AMNH, MNHNP). SAMOA ISLANDS: Poloa Bay, Tutuila (Bob Purtymun coll.). COOK ISLANDS: (MNHNP); off Kimiangatau, Mauke Id. (USNM 842296); RAPA: mouth of Ahurei Bay (USNM 725617); E side of Tematapu Point (USNM 725691). SOCIETY ISLANDS: Papeete, Tahiti (Trondle Coll.); Papara, Tahiti (Trondle coll.). PITCAIRN ISLAND: off NW corner, Pitcairn (USNM 789325). HENDERSON ISLAND: (BMNH 1913.7.28.85.6).

DESCRIPTION

Family CERITHIIDAE Fleming, 1822

Royella Iredale, 1912

Royella IREDALE, 1912:219. Type-species, by monotypy: *Cerithium clathratum* Sowerby, 1855; WENZ, 1940:739, fig. 2140; THIELE, 1931:205.

Diagnosis: Shell elongate, turreted, multi-whorled, having angulate whorls sculptured with two nodulose spiral cords and weaker axial riblets. Sculptured protoconch with sinusigera notch; early whorls cancellate; suture deeply impressed. Aperture circular, with short shallow anterior canal. Operculum corneous, circular, moderately spiral, with central nucleus. Radula taenioglossate (2+1+1+1+2). Mantle edge fringed, osphradium monopectinate. Pallial gonoduct open. Paired salivary glands, esophageal gland, and large stomach with style sac, sorting area, and gastric shield present.

Remarks: This monotypic genus is not well known in the literature. It was allocated to the Potamididae H. and A. Adams, 1854, by THIELE (1929:205) and WENZ (1940:739) on the basis of shell sculpture, but as this family comprises an intertidal estuarine group, it seems unlikely that *Royella* belongs here. The type-species was first assigned to *Cerithium* Bruguière, 1789, by SOWERBY (1855:883) and later allocated to *Pirenella* Gray, 1847, by KOBELT (1895:173) and TRYON (1887:165) and to *Cerithiopsis* Forbes & Hanley, 1850, by MELVILL & STANDEN (1895:116). IREDALE (1911:320) pointed out its distinctness from these genera and proposed *Royella* to accommodate it. IREDALE (1912:219) suggested that he had seen "... other forms which appear to be congeneric ..." and figured an undescribed species (pl. 9, fig. 3), but his illustration is poor and does not allow critical comparison with *Royella sinon*. The figured shell does not appear congeneric.

Royella is herein assigned to the Cerithiidae on the basis of the radular and anatomical characters described in more detail below and in the discussion.

Royella sinon (Bayle, 1880)

Figures 1a–i, 2a, b

Cerithium clathratum A. Adams (*Cerithiopsis*) in SOWERBY, 1855:883, pl. 185, fig. 258 (Holotype: BMNH; Type-locality: Baclayon Id., Bohol, Philippines; not Deshayes, 1833 nor Menke, 1828, nor Grateloup, 1832, nor Roemer, 1841.) SOWERBY, 1865:pl. 20, fig. 147.

Cerithium (Pirenella) clathratum A. Adams: Kobelt in MARTINI-CHEMNITZ, 1895:173–174, pl. 32, fig. 13.

Cerithium sinon BAYLE, 1880:245 (new name for *clathratum* A. Adams, 1880); IREDALE, 1911:320.

Cerithiopsis sinon (Bayle): MELVILL & STANDEN, 1895:116, pl. 1, fig. 3.

Royella sinon (Bayle): IREDALE, 1912:219; HIRASE, 1936:54, pl. 84, fig. 18; KIRA, 1962:26, pl. 13, fig. 13.

Description: Shell (Figure 1a–h; Table 1). Shell elongate, turreted, reaching 29 mm in length and consisting of angulate whorls sculptured with two strong spiral, nodulose cords crossed by weak axial riblets. Numerous microscopic incised spiral lines give silky appearance to shell. Wide anterior and posterior sutural ramps present on each whorl due to deeply impressed suture. Nodules formed where axial riblets cross spiral cords and tend to be pointed; 23 axial riblets on penultimate whorl. Axial ribs more defined on early whorls, which have cancellate, pitted appearance where axial and spiral elements cross. Protoconch pink, with sinusigeral notch (Figure 1b). Body whorl sculptured with two major nodulose, spiral cords in middle and with two, closely spaced, smooth, spiral cords above siphonal constriction. Base of body whorl concave. Anterior siphonal canal short, shallow, and slightly reflected upwards and to the left. Outer lip thin, nearly straight, but wavy where spiral cords end. Shell color white, but light tan maculations may be present on spiral cords between nodules. Operculum corneous, thin, circular-ovate, with few spirals and central nucleus.

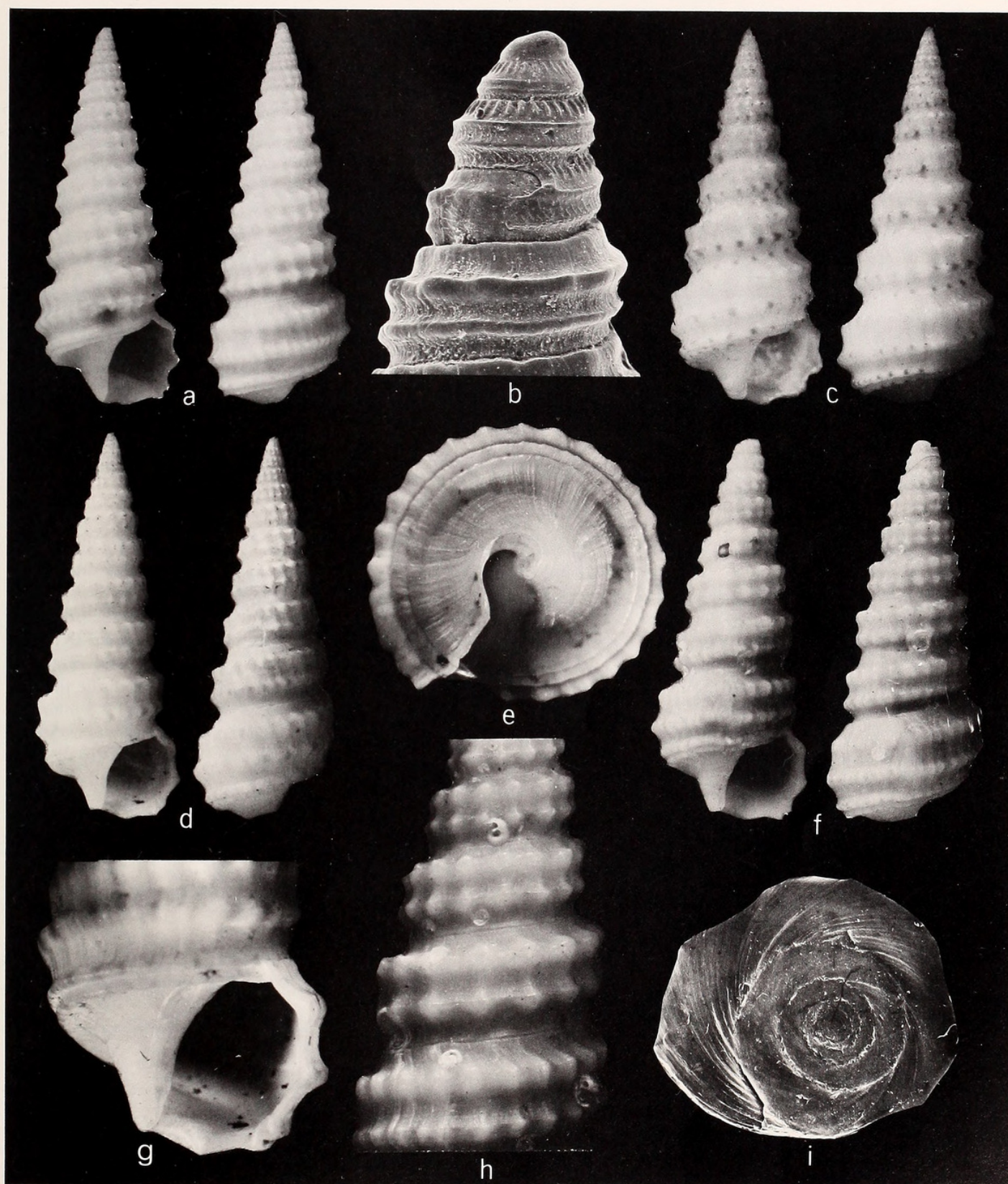


Figure 1

Shell and operculum of *Royella sinon*. a, Kikai, Osumi, Japan, 19.4 mm long (USNM 175588). b, protoconch showing larval sculpture and sinusigeral notch; 29°15'S, 177°50.9'N between Dayrell and Chanter Ids., Herald Islets, Kermadecs, New Zealand (NMNZ MF27068). c, Enewetak Atoll, Marshall Islands, 14.3 mm long (USNM 821778). d, Kikai, Osumi, Japan, 16.9 mm long. e, enlarged view of base of shell. f, Kikai, Osumi, Japan, 17 mm long (USNM 273329). g, enlargement of aperture. h, detail of sculpture on middle whorls. i, operculum, Mauke Id., Cook Ids., 1.8 mm diameter (USNM 842296).

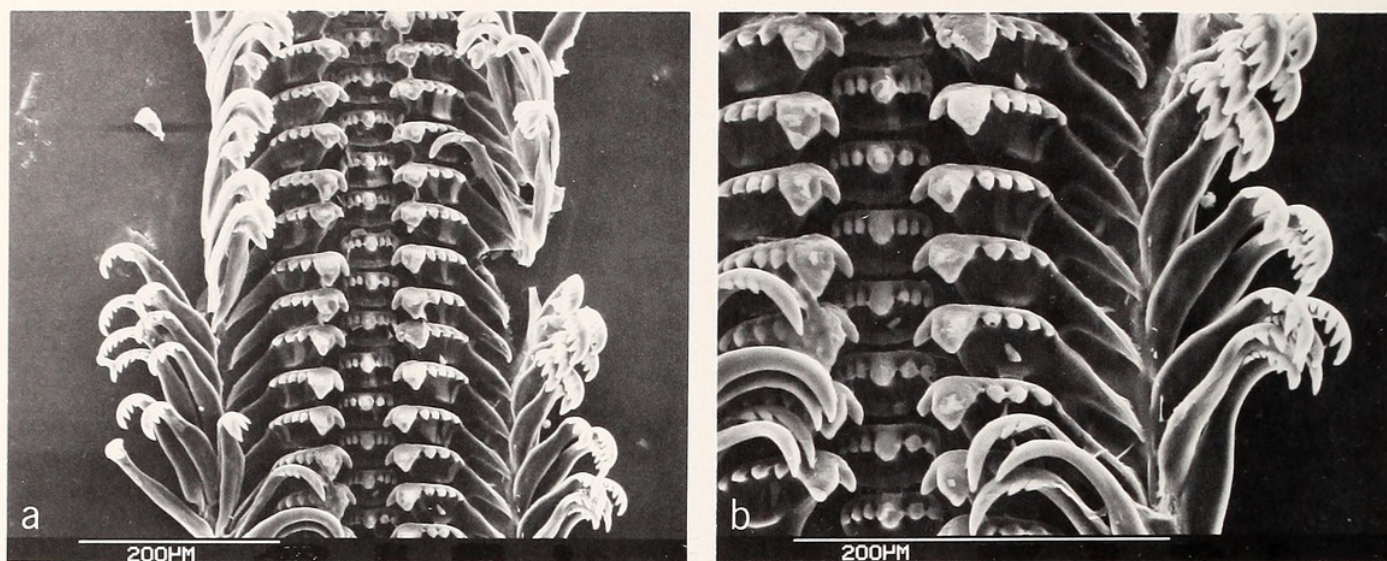


Figure 2

Radula from *Royella sinon*, Mauke Id., Cook Ids. (USNM 842296). a, general view of radula. b, half row showing details of central, lateral, and marginal teeth.

Radula (Figure 2a-b). Radula typically cerithioid. Central tooth ovate, wider than tall, having a short, pointed central cusp flanked on each side by 3, sometimes 2, small denticles. Lateral tooth trapezoid with long lateral extension and buttressed central plate with short ventral extension. Marginals long, moderately curved at tips. Central pointed cusp of inner marginal flanked with 5 short, pointed inner denticles and 2 or 3 outer denticles. Outer marginal same, only smooth on outer surface.

Animal. (This description is based on a single preserved animal from Mauke Id., Cook Ids., collected under a rock on a rubble bottom in 20–24 m depth. Removed from the shell, the body comprised about 5.5 whorls.) The animal is cream colored with darker gray lines on the head-snout. The head is broad and has a short wide snout with a bilobed tip. The cephalic tentacles are thick, each with a small dark eye at the outer base of the peduncular stalk. The left tentacle is shorter than the right. The foot is long and narrow and has a deep crescent-shaped propodial groove (gland). Behind the anterior pedal gland the sole of the foot stains heavily with methylene blue indicating a mucus-secreting area. The end of the foot is pointed. The dorsal edge of the mantle is fringed with many digitate papillae, but is smooth ventrally. There is no obvious siphonal fold or indentation. The mantle cavity is deep, extending about 2.5 whorls. Within the mantle cavity, a long, dark brown, monopectinate osphradium extends the length of the ctenidium. Individual osphradial

filaments are rectangular. The ctenidium is white, about 1.5 mm wide and extends the length of the mantle cavity. It is composed of long triangular filaments. The pallial oviduct is open, but was largely destroyed in the preserved specimen due to swelling of the albumen gland by water absorption. The buccal mass is elongate and relatively large and there is a pair of small jaws just inside the oral cavity. A short, wide, robust radular ribbon, 2.5 mm long and 0.5 mm wide, had 63 rows of teeth and was over one-seventh of the shell length (18.7 mm). A pair of large white, loosely coiled, salivary glands is present behind the nerve ring, and partially extends through it. The mid-esophagus is wide and has a large brown glandular area on its dorsal surface, which is the esophageal gland. The stomach is very large, about 2.5 whorls in length and comprises an extensive complex sorting area, a large cu-

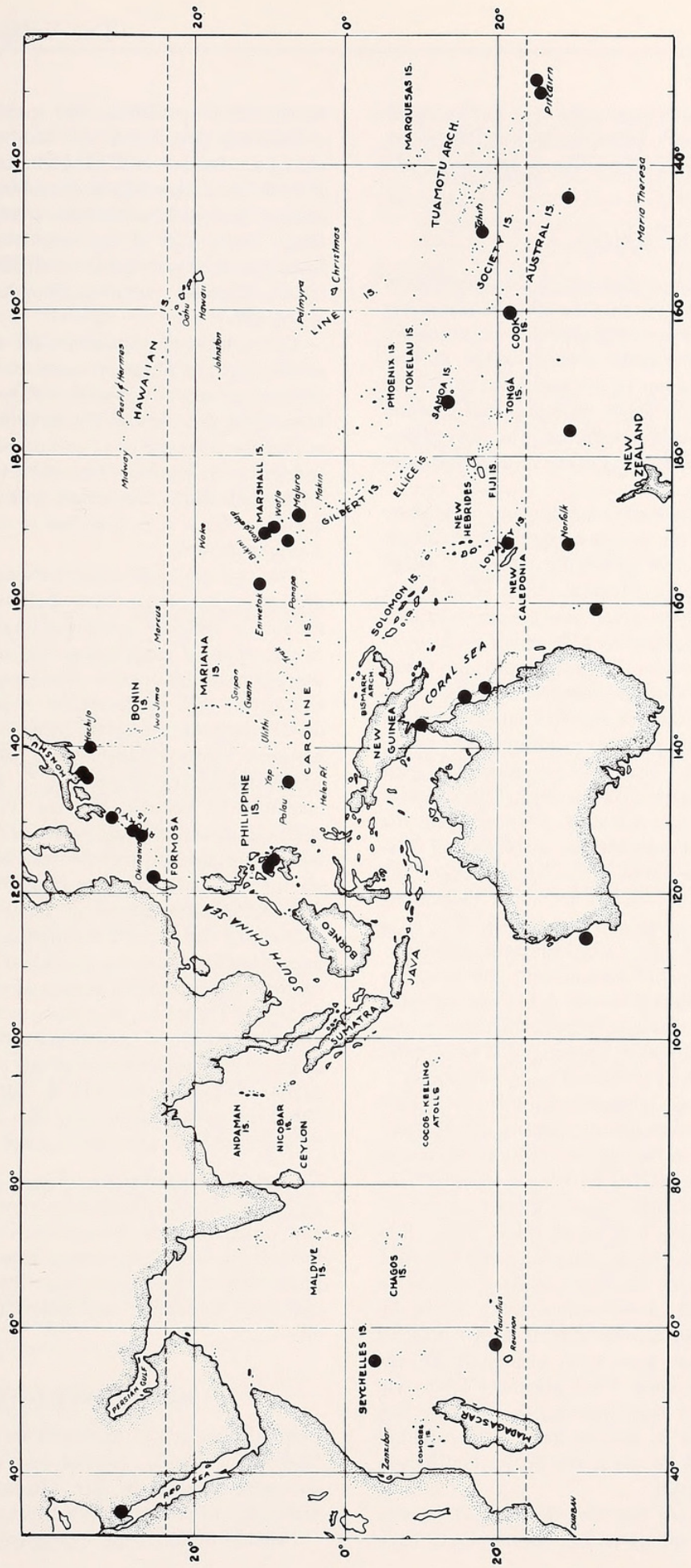
Table 1

Summary of shell measurements of *Royella sinon* (in mm).

Statistic	n	Range	$\bar{X}$	SD
Length	45	11.1–28.6	17.91	4.44
Width	45	3.2–9.7	6.59	1.50
Aperture length	36	1.3–6.2	3.59	0.97
Aperture width	36	1.1–4.8	2.46	0.78
Body whorl length	25	3.5–10.4	6.86	1.50

Figure 3

Geographic distribution of *Royella sinon* (Bayle).



ticular gastric shield and a short style sac. The intestine and rectum are large and contain transversely oriented, ovate fecal pellets. The nervous system is epiathroid and typically cerithioid in layout.

DISCUSSION

Although *Royella sinon* has a wide geographic distribution it is not a common species in museum collections and has not been well known to malacologists or conchologists. Most specimens are empty shells when collected, but living animals may be common in the proper habitat. The few records that cite details about collecting sites mention offshore, subtidal, coral-rubble habitats. The live-collected specimen described herein was taken in a similar habitat by SCUBA.

On the basis of the new data supplied by characters derived from analysis of the preserved specimen, I consider *Royella* to be a distinctive monotypic genus and assign it to the family Cerithiidae Fleming, 1822. The protoconch and shell sculpture resemble those of some members of the genus *Cerithium* Bruguière, 1798, but most *Cerithium* species are sculptured with three spiral cords per whorl and have an operculum with an eccentric nucleus; moreover, the short, shallow, anterior siphonal canal is atypical of cerithiids. The circular, spiral, corneous operculum with a central nucleus is much like those of some cerithiid genera such as *Argyropeza* Melvill & Standen, 1901, *Bittium* Gray, 1847, and *Varicopeza* Grunzel, 1976, whereas the wide short snout, fringed mantle edge, and radula of *Royella* most closely resemble those of *Cerithium* species. The monopectinate osphradium differs from the bipectinate condition in *Cerithium* species and is a unique, distinctive anatomical character of *Royella*. The radular morphology, stomach contents, fecal pellet composition, and the elaborate stomach all indicate herbivory. A few sponge spicules were found in the stomach, but these are to be expected in any algal-detritus feeding cerithiid. The subtidal habitat on rubble is similar to that of many cerithiids.

Royella has been placed in the Potamididae, but there are no compelling reasons for this assignment. The fringed, digitate mantle edge is unlike that of potamidids, which is smooth, and most potamidids have long tapering tentacles and relatively extensible snouts; moreover, the osphradium in all potamidids is a simple ridge. The radula of *Royella* is very unlike that of any potamidid species I have seen: members of the Batillariinae have distinctive cusps on the basal plate of the central tooth while the Potamidinae usually have narrow central teeth with long ventral extensions and marginal teeth with spatulate serrated tips and lateral flanges. They also have long style sacs and well developed crystalline styles. Nothing like these features are found in *Royella sinon*. The subtidal, purely marine habitat of *Royella* is also distinctly different from that of any potamidid.

I had initially suspected that *Royella* might be a very large cerithiopsid and a sponge feeder, but it does not have

an acrembolic proboscis, and is clearly a herbivore. The radula and protoconch are totally unlike those of cerithiopsid species (see MARSHALL, 1978). The shell of *Royella sinon* superficially resembles some triphorid shells such as *Metaxia* Monterosato, 1884, especially in the concavity of the base of the body whorl. *Royella*, however, has a much larger, bulkier shell than any cerithiopsid or triphorid species, attaining a length of 26 mm and a width of 9.4 mm.

The uniquely sculptured shell does not resemble that of any other cerithiacean snail with the exception of *Cerithium excavatum* Sowerby, 1865, a species known only from SOWERBY's figures (1865, 1866). I have not been able to find the holotype of *C. excavatum*, nor have I seen any specimens so labeled. The pictures in SOWERBY (1865, 1866) show that *C. excavatum* does not have the two spiral nodulose cords. It is thus best to regard *C. excavatum* as a *nomen dubium*.

The two nodulose spiral cords per whorl, deeply impressed sutural area, short shallow anterior siphon, and the strong, keel-like spiral cord on the body whorl anterior to the siphonal constriction are the main distinguishing characters of this species. The range of variation in shell characters, such as the extent of pigmentation and node development on the spiral cords, as seen in Figure 1, is not great. Some specimens have distinct spots (Figure 1c) which others lack (Figure 1a, f). A specimen in the collection of J. Trondle, Papeete, Tahiti, had thin, brown spiral lines between the nodes. The largest specimens I have examined are from Norfolk Id. and Lord Howe Id., off the east coast of New South Wales, Australia, and from the Ryukyu Islands of Japan.

IREDALE (1911:320) mentioned juveniles from dredgings as having a minute sinusigeral protoconch, and I have confirmed this by SEM studies of the protoconch. As may be seen in Figure 1b, the protoconch comprises 3.5 whorls and has a distinct, deep sinusigera notch. Thus, on the basis of protoconch morphology and the extensive geographic range (JABLONSKI & LUTZ, 1980; JABLONSKI, 1982) it is reasonable to infer that *Royella* has a moderate to long planktotrophic larval stage.

Geographic distribution (Figure 3). *Royella sinon* has a wide Indo-Pacific distribution ranging from the Red Sea and western Indian Ocean eastward to Pitcairn Island. Within the Pacific, it occurs from Japan south to Lord Howe Id., the Kermadecs, and Rapa. It probably occurs elsewhere throughout the Indo-Pacific in suitable habitats.

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