

**On the Systematic Position of Three Large
Chiton Species (Mollusca: Polyplacophora:
Chitonidae) from the Arabian Sea Region**

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ABSTRACT. Three large species of *Chiton* reported from the Arabian Sea region, *C. peregrinus* Thiele 1910, *C. salihafui* Bullock 1972, and *C. fosteri* Bullock 1972, were examined to determine their taxonomic position within the subfamily Chitoninae. Radular morphology of these species, especially the centrolateral tooth with a distal end parallel to the longitudinal axis of the animal and the major lateral tooth with a short denticle cap oriented 90° with respect to the tooth shaft, indicates that these species belong in the genus *Rhyssoplax*, not in *Chiton*.

Three large species that have been referred to the genus *Chiton* Linnaeus 1758 occur in shallow waters of the Arabian Sea region: *Chiton peregrinus* Thiele 1910, *C. salihafui* Bullock 1972, and *C. fosteri* Bullock 1972 (Bullock 1972, Kaas and Van Belle 1988). Other species of the subfamily Chitoninae are reported from the area, but these smaller species are considered by recent authors to belong to *Rhyssoplax* Thiele 1893 and *Tegulaplax* Thiele 1893.

Use of the name *Rhyssoplax* has been inconsistent. Large *Chiton* species during the last few decades have been placed in the subgenus (or genus) *Chiton* s.s., and most smaller species have been considered to belong to the subgenus (or genus) *Rhyssoplax*. As a result, no *Rhyssoplax* occur in the New World and, with the exception of the western Indian Ocean, *Chiton* s.s. is restricted primarily to the New World. In this paper I examine in detail the three large species of *Chiton* from the Arabian Sea region, and document the fact that they should be assigned not to *Chiton*, but to *Rhyssoplax*.

Materials and Methods

Specimens from major collections in Europe and the United States were examined (see below). Radula, shell, and girdle scale preparations for light and scanning electron microscopy (SEM) were prepared according to Bullock (1985). The shell-valves of selected specimens were isolated and cleaned thoroughly in a heated 2 N KOH solution followed by numerous rinses in distilled water using an ultrasonic cleaner. The samples were then mounted on aluminum stubs using wedges of aluminum foil and Duco cement, coated with carbon and 60% gold: 40% palladium in a Denton DV-502 evaporator, and studied using an ISI MSM-3 scanning electron microscope housed in the Department of Zoology at the University of Rhode Island. The girdle scales were cleaned thoroughly, individually placed on double-coated tape, positioned using fine pins, and studied using the SEM. Some shell-valves were coated with magnesium oxide to enhance sculptural detail before being photographed.

The following abbreviations are used in the text: AMNH, American Museum of Natural History, New York; AMS, Australian Museum, Sydney; ANSP, Academy of Natural Sciences of Philadelphia; BMNH, British Museum (Natural History), London; CAS, California Academy of Sciences, San Francisco; ICZN, International Commission on Zoological Nomenclature; IRSN, Institut royal des Sciences naturelles de Belgique, Brussels; MCZ, Museum of Comparative Zoology, Harvard University, Cambridge; MNHNP, Muséum national d'Histoire naturelle, Paris; RNHL, Rijksmuseum van Natuurlijke Historie, Leiden; USNM, National Museum of Natural History, Washington, D.C.; ZMA, Zoölogisch Museum, Amsterdam; ZMHU, Zoologisches Museum, Humboldt-Universität, Berlin; ZMK, Universitetets Zoologiske Museum, Copenhagen.

Systematic Section

Class POLYPLACOPIORA GRAY 1821

Family Chitonidae Rafinesque 1815

Subfamily Chitoninae Rafinesque 1815

Remarks. Much confusion exists in the taxonomic literature because many polyplacophoran species originally described in the 19th and 20th centuries as members of the genus *Chiton* are now placed in other genera and families. Based on external shell and girdle scale morphology, many of the approximately 75 Recent species that remain in *Chiton* have been placed in the subgenera (or genera) *Radsia* Gray 1847, *Rhyssoplax* Thiele 1893, *Sypharochiton* Thiele 1893, *Amaurochiton* Thiele 1893, *Delicatoplax* Iredale and Hull 1926, *Tegulaplax*

Iredale and Hull 1926, and *Mucrosquama* Iredale and Hull 1926. Van Belle (1978, 1983), Kaas (1979) and Kaas and Van Belle (1980) have utilized many of these names as subgenera, while Australian and New Zealand malacologists have used many at the generic level. Bullock (1988a) presented evidence that *Radsia* and *Sypharochiton* are not congeneric with *Chiton*, and suggested (Bullock 1988b) that *Delicatoplax* and *Mucrosquama* may be subgenera of *Rhyssoplax* and that *Tegulaplax* is a separate genus.

The shells of *Chiton* and *Rhyssoplax* exhibit sculptural features that range from smooth to nodular or boldly ribbed. Van Belle (1983) and others have presented diagnostic comments, but based on shell morphology alone it is difficult to separate the two genera. Radular morphology, on the other hand, provides a sound basis for the separation of *Rhyssoplax* from *Chiton* (Bullock 1988b). The distal edge of the centrolateral tooth in all species of the genus *Chiton* is perpendicular to the longitudinal axis of the animal (Figs. 4, 22). The conspicuous black denticle cap of the major lateral tooth is oriented at an angle greater than 90° from the axis of the tooth itself (Fig. 1); the denticle cap may be blunt to nearly claw-like. Also, the central tooth of *Chiton* is moderately broad (Figs. 4, 22). The many *Rhyssoplax* species examined have the distal edge of the centrolateral tooth parallel to the longitudinal axis of the animal (Fig. 5), the blunt denticle cap of the major lateral tooth oriented at an angle of 90° from the axis of the tooth (Figs. 2, 3, 5), and the central tooth usually very narrow (Fig. 5).

Genus *Rhyssoplax* Thiele 1893

Rhyssoplax Thiele 1893: 368. Type species, by declaration of the ICZN, Opinion 951, *Chiton affinis* Issel 1869 (*non* A. Costa 1840).

Description. Animal small to medium in size, attaining a length of 65 mm. Valves quite flat to carinate or nearly rounded. Central areas appearing smooth or with longitudinal ribs. Terminal areas and lateral triangle smooth or with radiating, usually nodular, ribs. Subtegmentum usually not well developed. Girdle scales striate, rarely smooth; apical pustules typical. Radula with narrow central tooth; centrolateral tooth with distal end parallel to longitudinal axis of animal; denticle cap of major lateral tooth blunt, oriented at 90° angle to axis of tooth.

Remarks. The radular morphology noted above is sufficiently different from that in *Chiton* and consistent within *Rhyssoplax* to justify the separation of these two genera. The shells of *Rhyssoplax* are generally characterized by the radial sculpture of the lateral triangle and the form of the longitudinal ribbing of

the central areas, which when present tends to be regular and often step-like because of the elevated lateral edge of each rib.

Rhyssoplax is worldwide in distribution in tropical seas except in the New World, where it is absent. The distribution of *Rhyssoplax* was probably greater during the Cretaceous due to Tethyan pathways, with various regions having their own endemic species. *Rhyssoplax berryi* (Smith *et al.* 1968) from the Ripley Formation (Upper Cretaceous) of Georgia, U.S.A., indicates that the genus previously occurred in the New World.

***Rhyssoplax (Rhyssoplax) peregrina* (Thiele 1910)**

Figs. 6-13, 15, 19, 23, 28

Chiton (Clathropleura) peregrinus Thiele 1910: 90, pl. 9, figs. 32-37 (Algoa-Bai, corrected to Aden by Bullock 1972; type in ZMHU).

Chiton lamyi Dupuis 1917: 538 (Obock, Aden; type material present in BMNH and MNHNP); Dupuis 1918: 531.

Chiton lamyi, var. *peregrinus* Thiele. Dupuis 1918: 532.

Chiton lamyi, var. *reticulatus* Dupuis 1918: 532 (Mer Rouge; location of type unknown); *non* Reeve 1847, *nec* Nierstrasz 1905.

Chiton wallacei Winckworth 1927: 206, pl. 29, figs. 5-8 (Aden; type in BMNH).

Chiton iatricus Winckworth 1930: pl. 8b (East Pier at Karachi, Pakistan; type BMNH 1952.11.11.255).

Chiton iatricus, var. *winckworthi* Kaas 1954: 2 (beach 2.5 miles [4 km] N of Bhuleji abb., 20 miles [32.2 km] W of Karachi [Pakistan]; type in collection of P. Kaas and A.N. Ch. ten Broek, No. 3416).

Chiton peregrinus Thiele. Leoup 1955: 4, fig. 3; Bullock 1972: 238, pl. 44, figs. 1, 2, 10; Kaas and Van Belle 1980: 98.

Chiton (Chiton) peregrinus Thiele. Kaas and Van Belle 1988: 121, figs. 28-30 [Arabian references].

Description. Animal of moderate size, attaining a length of 56 mm. Valves moderately flattened, angle about 115° . Anterior valve convex; postmucronal slope straight in immature specimens, convex in older ones. Mucro moderately blunt, slightly posteriorly acentric on end valve. Jugal region rather smooth. Central areas with small, close-packed granules. Lateral triangles not raised, granulated, bordered anteriorly and posteriorly by radiating, somewhat nodular ridges, the anterior ridge often stronger; occasional slightly nodular radial ribs between ridges. Terminal areas with numerous faint nodules. Shell color cream-white with flecks of green and reddish brown, sometimes with dark brown band on jugum. Girdle alternately banded light and dark. Interior of valves white with very light reddish brown in muscle scar regions.

Tegmentum: Suprategmentum relatively thick with scattered canals of moderate size; subtegumentum not well developed, with widely spaced, flattened canals (Fig. 13).

Esthetes: Megalopores round, situated in center of mound with associated, somewhat smaller, round micropores about 0.5 to 0.75 size of megalopores (Fig. 15).

Articulamentum: Central depression of intermediate valves lacking slits. Primary slit-ray with longitudinal slits on callus, round ones in posterior depression. Secondary slit-ray present laterally. Insertion teeth pectinate dorsally. Slit formula 10/1/15.

Girdle elements: Scales moderate in size, roundly triangular. Ventrolateral areas finely reticulate. Lower dorsolateral area with irregular nodular ribs. Much of dorsolateral area covered by conspicuous pustules irregularly arranged in longitudinal rows curved toward center (Fig. 19).

Radula: Central tooth narrow, deeply cupped distally. Distal edge of central tooth oriented anteroposteriorly; evidence of pad lacking, although slight knob present (Fig. 23). Major lateral tooth with irregular, somewhat rectangular wing which appears concave medially; denticle cap shovel-like, bluntly pointed, with circular black tab surrounded by brownish black material (Fig. 28).

Remarks. Malacologists did not agree on the name for this species for many years. The erroneous type locality cited by Thiele (1910) and the sporadic collections from northern areas of the western Indian Ocean both contributed to some of this confusion. However, Thiele's name is accepted as the correct name for this species (Bullock 1972, Kaas and Van Belle 1988). The additional names

introduced by Dupuis (1917, 1918), Winckworth (1927, 1931), and Kaas (1954) all refer to *R. peregrina*.

Rhyssoplax peregrina and *R. salihafui* are often found in eroded condition and in such condition the species could be confused. An analysis of younger and better specimens allows easy differentiation of the two species (see remarks under *R. salihafui*). The granulation of the tegmentum of *R. peregrina* (Fig. 7) immediately distinguishes this species from all other *Rhyssoplax*, including *R. salihafui*. This granulation and the esthete pore pattern (Fig. 13) are reminiscent of *Sypharochiton* (Bullock 1988a) and some species of the Ischnochitonidae.

The morphological features of the shell and radula of both *R. peregrina* and *R. salihafui* place these species in *Rhyssoplax*, not *Chiton*. The radula especially differs from that of New World *Chiton* in the orientation of the distal edge of the centrolateral tooth (Fig. 23) and the angle of the denticle cap with respect to the shaft of the major lateral tooth.

Distribution. *Rhyssoplax peregrina* is widely distributed along the northern margin of the western Indian Ocean from the northern coast of western India to the Arabian Gulf and westward to the entrance of the Red Sea. According to Kaas and Van Belle (1988: 121), *R. peregrina* is "by far the most common chiton on the Indo-Arabian coasts." *Rhyssoplax peregrina* is found in rocky intertidal areas. The species was taken from rock pools at Aden (Winckworth 1927) and from rocks forming the East Pier at Karachi, Pakistan (Winckworth 1930). *Rhyssoplax peregrina* is replaced along the eastern coast of Africa by *R. salihafui*.

Locality records. INDIA: Port Okha, Kathiwar, Gujarat (USNM). PAKISTAN: Manora Id., Karachi (BMNH, MCZ); W of Mandir, Manora Id., Karachi (RNHL); East Pier, Karachi (AMS, BMNH, IRSN, MNHNP, ZMA); NW end of Astola Id. (MCZ); IRAN: Chah Bahar (AMNH, *vide* W. Old); Tavila (ZMK); 6 km S of Bushehr (ZMK); Bushehr (BMNH). KUWAIT: (*vide* Kaas and Van Belle 1988). OMAN: (numerous localities *vide* Kaas and Van Belle 1988); Muscat (BMNH, ZMA). SOUTH YEMEN: Aden (BMNH: MNHNP); Modern Bandar Sheikh, Little Aden (DMNH); Perim Id. (MNHNP). DJIBOUTI: Obock (IRSN).

***Rhyssoplax (Rhyssoplax) salihafui* (Bullock 1972)**

Figs. 14, 16, 20, 24, 27, 29-33

Chiton (Clathropleura) tenuistriatus 'Sowerby' Thiele 1910: 90, pl. 9, figs. 38-40. *Non C. tenuistriatus* Sowerby 1840.

Chiton salihafui Bullock 1972: 240, pl. 44, figs. 3-5 (Kendwa Island, about 4 miles [6.4 km] ESE of Dar-es-Salaam, Eastern Providence, Tanzania; holotype MCZ 279163); Kaas and Van Belle 1980: 115; Ferreira 1983: 267, fig. 21.

Chiton (Chiton) salihafui Bullock. Kaas 1979: 863, pl. 2, figs. 38-40; Kaas and Van Belle 1988: 129.

Description. Animal of moderate size, attaining a length of 50 mm. Valves rather flat to moderately arched, angle 90-120°. Anterior valve slightly convex; postmucronal slope straight to slightly concave. Mucro rather blunt, anteriorly acentric on posterior valve. Jugal region smooth. Central areas with regular, low, longitudinal ribs. Lateral triangle slightly elevated, with 4-5 broad, radiating ribs; terminal areas with 18-21 similar radial ribs; numerous small concentric ribs between radial ribs. Shell generally greenish gray, occasionally greenish brown. Some specimens cream-white in central areas, with small splotches of greenish brown and 3 prominent longitudinal brown streaks across jugum. Girdle alternately banded light and dark. Interior of valves whitish; anterior slope of callus light blue-green; muscle scars very light brown; light brown streaks extending from mucronal region toward lateral portions of callus.

Tegmentum: Suprategmentum relatively thick, with medium-sized, widely spaced canals in upper portion and slightly smaller canals below; subtegumentum not well developed, with single layer of compressed, widely separated canals (Fig. 16).

Esthetes: Megalopores large, round, about 3 times as large as irregularly round micropores (Fig. 14).

Articulamentum: Jugal tract of young specimens with very few scattered transverse slits; slits absent in older examples. Primary slit-ray with oblong slits. Secondary slit-ray present. Insertion teeth pectinate. Slit formula 10/1/12.

Girdle elements: Scales moderate in size, squarish, with slightly rounded dorsal surface. Ventrolateral region finely reticulate, becoming more granular midway. Entire dorsolateral area covered with conspicuous pustules arranged, especially along margins, in more or less longitudinal rows which curve toward apex (Fig. 20).

Radula: Central tooth reduced, narrow, cupped distally. Centrolateral tooth oriented anteroposteriorly (Fig. 24); pad evident laterally. Wing of major lateral paddle-like, very bluntly pointed distally. Denticle cap shovel-like,

somewhat pointed, with circular black tab surrounded by brownish black material (Fig. 27).

Remarks. *Rhysoplax salihafui* superficially resembles the northern Arabian Sea species *R. peregrina*, but is differentiated by possession of longitudinal ribs on the central areas and radial ribs on the terminal areas and lateral triangle (see remarks under *R. peregrina*). Kaas (1979: 863, figs. 5-10) reported exceptionally fine examples from Mozambique. The shell morphology of *R. salihafui* is similar to that of *R. calliozona* (Pilsbry 1894) from South Australia. The latter species has smoother ribbing, broader ribs on the central areas, and slightly smaller, more convex scales; the morphological features of the scales differ considerably because *R. calliozona* has coarser reticular sculpture ventrolaterally, and it is quite smooth dorsolaterally except for a few pustules at the apex. In addition, the shell of *R. calliozona* is usually glossy, light greenish yellow, rarely speckled, never longitudinally banded, and characteristically free of boring and fouling organisms.

Distribution. *Rhysoplax salihafui* occurs along the east African coast from Somalia (Bullock 1972, Ferreira 1983) south to Zululand, South Africa (Kaas 1979) and Madagascar (Bullock 1972). Ferreira (1983: 290) reported that *R. salihafui* also occurs in the Seychelle Islands and Mauritius, but this statement appears to be in error; statements elsewhere in his paper (p. 268) do not support this range extension.

Locality records. SOMALIA: Mogadishu (MCZ); Sar Uanle (*vide* Ferreira 1983). KENYA: Wassini Id. (*vide* Ferreira 1983); Whale Id.; Ras Ngomeni; Turtle Bay (all BMNH). TANZANIA: Mboa Maji, Eastern Province; Kendwa Island, about 4 mi [6.4 km] ESE of Dar-es-Salaam, Eastern Province, (both MCZ). MADAGASCAR: Tamatave (ZMHU); Pointe Ibanona, Fort Dauphin (MCZ); Flacourt, Fort Dauphin (ANSP, MCZ); Fort Dauphin, (ANSP); island, 0.75 mi [1.2 km] NE of Manafiafy girls schools, Ste. Lucie; two islands, 0.25 mi [0.4 km] E of Manafiafy girls schools, Ste. Lucie (both MCZ). SOUTH AFRICA: Zululand (*vide* Kaas 1979).

Subgenus *Anthochiton* Thiele 1893

Anthochiton Thiele 1893: 377. Type species by monotypy, *Anthochiton tulipa* (Quoy and Gaimard 1835).

Remarks. The systematic status of *Anthochiton* is uncertain. Some authors (*e.g.* Van Belle 1978, 1983; Kaas and Van Belle 1980) consider this name synonymous with *Rhysoplax* Thiele 1893. Until further studies are available, it

seems best to maintain the use of *Anthochiton* at the subgeneric level for those *Rhyssoplax* characterized by a smooth lateral triangle and end valves.

Rhyssoplax (Anthochiton) fosteri (Bullock 1972)

Figs. 17, 18, 21, 25, 26, 34-41

Chiton fosteri Bullock 1972: 245, pl. 45, figs. 6-9 (Ankoalamare, 3 miles (4.8 km) SE of Ambodifototra, E coast, Ile Ste. Marie, Madagascar; holotype MCZ 279166); Kaas and Van Belle 1980: 49.

Chiton (Chiton) fosteri Bullock. Kaas 1979: 862; Kaas and Van Belle 1988: 121, figs. 31-33.

Description. Animal small to medium in size, attaining a length of 43.5 mm. Valves flattened to slightly rounded, angle 120-140°. Anterior valve slightly convex; postmucronal slope straight. Jugal and central areas smooth. Lateral triangle smooth, depressed, bordered anteriorly and posteriorly by weak ridge. End valves smooth. Shell color usually light greenish yellow with thin longitudinal green stripes and light brownish flecks in jugal and pleural regions; lateral triangles and terminal areas conspicuously banded with concentric brown bands; some specimens dark brown, with concentric brown bands obscured (Fig. 41). Girdle white, irregularly flecked with light brown, reddish brown, and orange. Dark specimens with dark girdle.

Tegmentum: Suprategmentum relatively thick, with scattered canals of moderate size; subtegumentum relatively thin, with single layer of rather large, moderately close-packed canals (Fig. 18).

Esthetes: Esthete pores situated linearly along shallow longitudinal depressions, sometimes connected by obscure crevices. Megalopores rather large, round, about twice as large as round to ovate micropores (Fig. 17).

Articulamentum: Jugal region with close-packed, elongate, transverse slits on anterior slope of callus. Primary slit-ray with large, elongate slits on callus, smaller and more rounded slits in posterior depression. Insertion teeth pectinate. Slit formula 8-9/1/15-16.

Girdle elements: Scales of moderate size, subtriangular. Ventrolateral areas with reticulate sculpture. Apical region with conspicuous, often somewhat elongate nodules irregularly arranged in rows which curve toward apex. Lateral keel evident on some scales (Fig. 21).

Radula: Central tooth quite narrow. Distal end of centrolateral tooth oriented anteroposteriorly (Fig. 25); pad evident laterally. Denticle cap fairly short, roundly pointed, with circular tab situated in yellowish substance; black band exists below yellow area (Fig. 26).

Remarks. The radular features described above clearly place this species in *Rhysoplax*, not in *Chiton*. *Rhysoplax fosteri* is easily distinguished from all other chitons of the western Indian Ocean. The species differs from the allopatric South African *R. (A.) tulipa* (Quoy and Gaimard) by having more triangular girdle scales with a smoother centrolateral surface and by having larger, more widely spaced pustules in the apical area; additionally, *R. fosteri* lacks a sharply raised lateral triangle, and the valves are much less angulate. Compared with *R. salihafui*, with which it occurs sympatrically, *R. fosteri* lacks longitudinal ribs on the central area and radial ribs of the lateral triangle, as well as the numerous large, rather round pustules on the dorsolateral and apical surfaces of the girdle scales. The valves of *Rhysoplax mauritiana* (Quoy and Gaimard 1835) from the Seychelle Islands and the Mascarene Island group are occasionally flattened, as in *R. fosteri*, but *R. mauritiana* has longitudinal grooves on the central areas near the lateral triangle. In addition to structural differences such as the presence of numerous small pustules, the girdle scales of *R. mauritiana* are translucent blue-green, whereas those of *R. fosteri* are white, light brown, or orange.

Some interesting color variation was observed. A few specimens from Zanzibar are chocolate brown and the banding pattern is obscured (Fig. 41). The late Allyn G. Smith provided me with a photograph of a specimen (California Academy of Science collection) from the Comoro Islands which exhibits a much interrupted color pattern, more properly described as a pattern of flecks (Fig. 40). Kaas and Van Belle (1988: 121) reported that their specimen from Oman was "bluish green with zebra-pattern of brownish concentric lines."

Distribution. *Rhysoplax (Anthochiton) fosteri* occurs from Masirah Island, Oman (Kaas and Van Belle 1988), south to Kenya and Zanzibar (Bullock 1972), Mozambique (Kaas 1979), and Madagascar (Bullock 1972).

Locality records. OMAN: Masirah Id. (*vide* Kaas and Van Belle 1988). KENYA: Kilifi (BMNH). ZANZIBAR: near lighthouse, Mkunduchi, SE Zanzibar; offshore reef, Pwani Mchangani (both ANSP); Kiwengwa (ANSP, MCZ); Ras Nungwe (ANSP). MOZAMBIQUE: Porto Amelia (AMNH, *vide* W. Old, pers. comm.); Conducia Bay; Mozambique Id. (both *vide* Kaas 1979). COMORO ISLANDS: Grand Comoro Id. (CAS, *vide* A.G. Smith, pers. comm.). MADAGASCAR: Ankoalamare, 3 mi [4.8 km] SE of Ambodifotra, E coast, Ile Ste. Marie; 2.5 mi [4 km] NE of Pointe d'Antsiraikiraiky, NW Ile

Ste. Marie; reef near cliffs at S end of Sarodrano Point, 12.5 mi [20.1 km] SSW of Tulear (all MCZ).

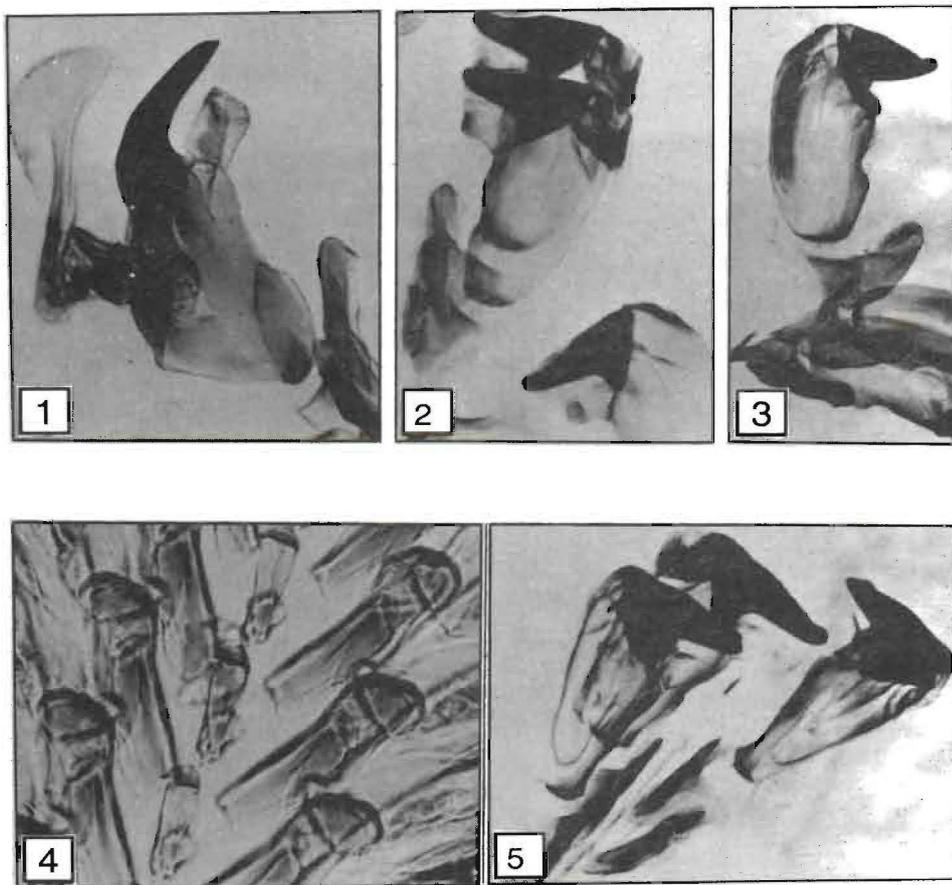
Discussion

Differences in radular morphology, including the orientation of the distal end of the centrolateral tooth and the angle of the denticle cap of the major lateral tooth with respect to the shaft, clearly differentiate *Rhysoplax* from *Chiton*. Many species of these genera have been examined to date, but none shows intermediate radular characteristics. Based on these highly consistent radular characters, the three large "*Chiton*" species from the Arabian Sea region examined in the present report must be considered to belong to *Rhysoplax*. All three species have a centrolateral tooth with the distal end oriented parallel to the longitudinal axis of the animal, and the denticle cap of the major lateral tooth is at a 90° angle from the main axis of the tooth; these features are common to all *Rhysoplax*. The smaller species of the Chitoninae that have been reported from the Arabian Sea region, including *Rhysoplax barnardi* (Ashby 1931), *R. affinis* (Issel 1869), and *Tegulaplax hululensis* (E.A. Smith 1903), all have the *Rhysoplax*-type radula.

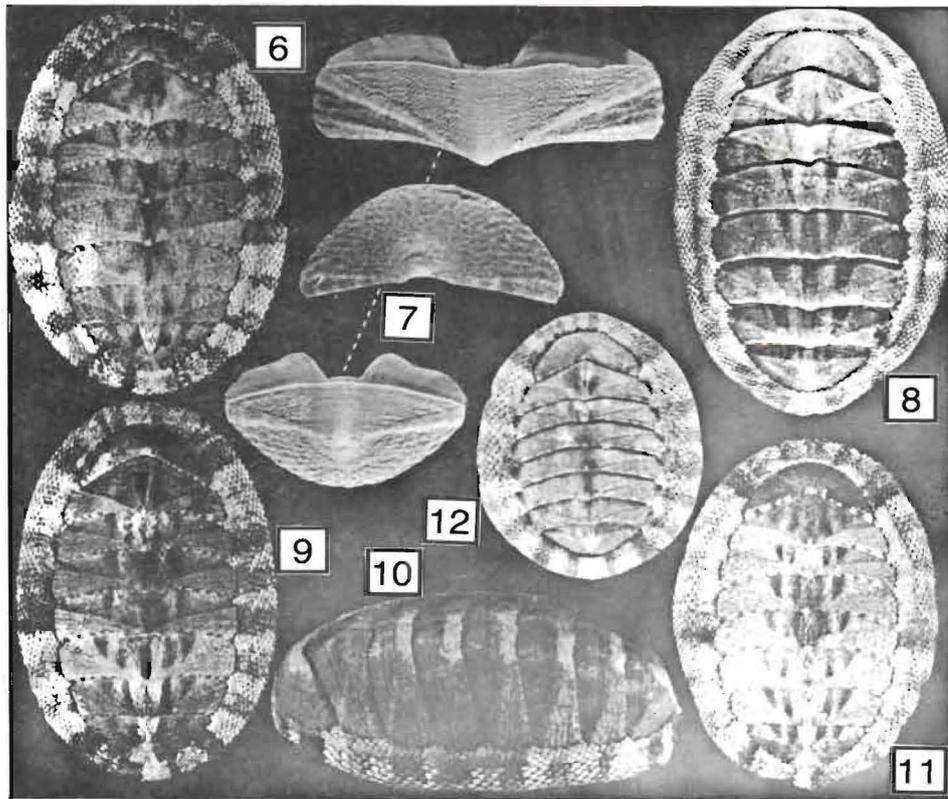
Placement of *C. peregrinus*, *C. salihafui*, and *C. fosteri* in the genus *Rhysoplax* restricts the genus *Chiton* primarily to the New World. The only members of *Chiton* that occur outside of New World waters are *Chiton (Diochiton) marquesanus* Pilsbry, 1893, known only from the Marquesas Islands, and *Chiton (Amaurochiton) glaucus* Gray, 1828, from New Zealand and Tasmania (Bullock 1988b). All other reports of *Chiton* species from non-New World localities refer to species that belong to other genera, usually *Rhysoplax*.

Acknowledgements

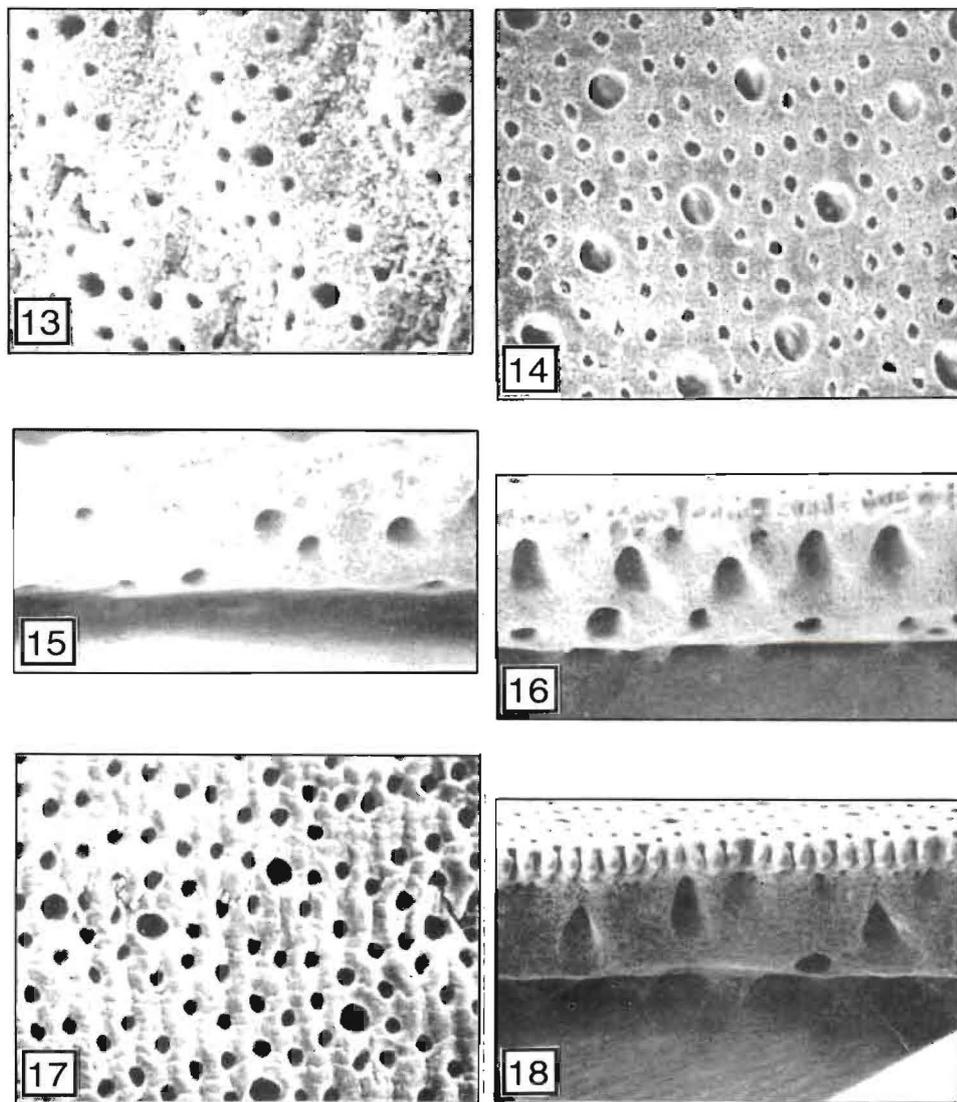
For the loan of specimens and assistance during my visits to their institutions, I thank R.T. Abbott and R. Jensen (DMNH), K. Boss and R. Turner (MCZ), H. Coomans (ZMA), E. Gittenberger and C.O. Regteren-Altena (RNHL), T. Karling and C. Holmquist (NRS), R. Kiliass (ZMHU), J. Knudsen (ZMK), E. Leloup (IRSN), B. Métivier and A.-M. Testud (MNHN), R. Robertson and G. Davis (ANSP), J. Rosewater, C. Roper, and H. Rehder (USNM), J. Taylor, K. Way, and J. Peake (BMNH). Mr. A.G. Smith (CAS) provided photographs and information about *C. fosteri* from the Comoro Islands and W. Old (AMNH) provided additional locality records. I thank Z. Amr, C. Franz, R. Turner, and an anonymous reviewer for their constructive comments on the manuscript and Z. Amr for kindly providing the Arabic summary.



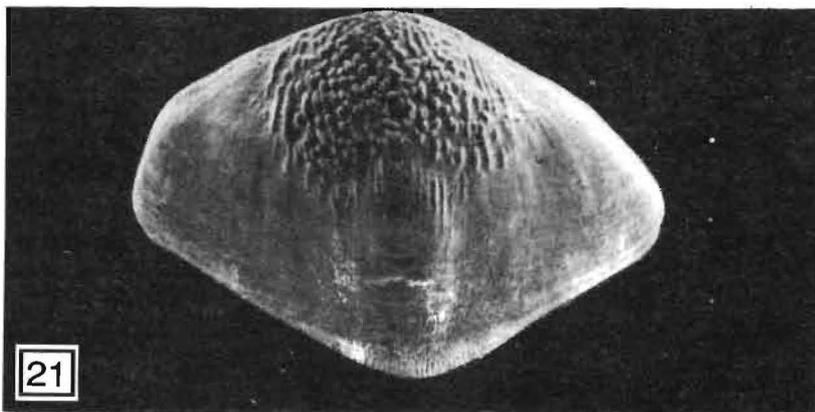
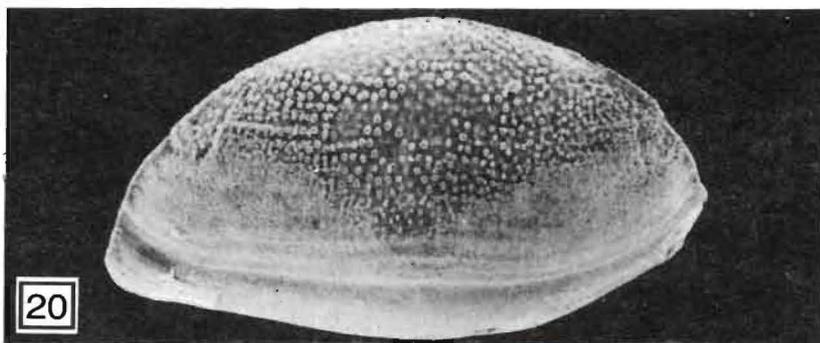
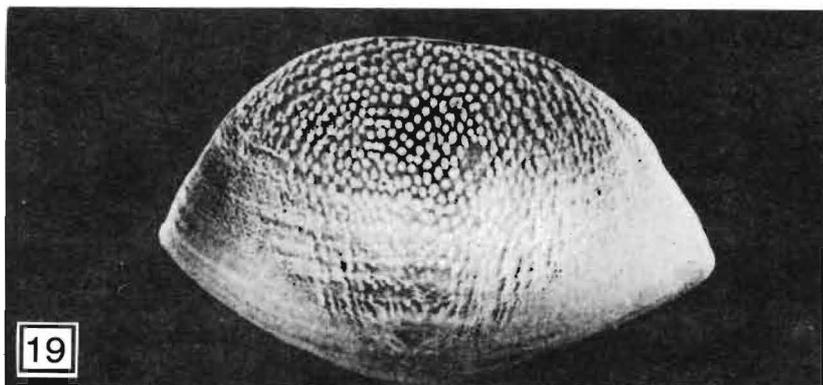
Figs. 1-5. Light micrographs of *Chiton* and *Rhyssoplax* radulae. Fig. 1. *C. tuberculatus* Linnaeus 1758, Cabo Rojo Lighthouse, Puerto Rico (RCB), major lateral tooth, with centrolateral tooth and major uncinus, side view (X65); Fig. 2. *R. canariensis* (Orbigny 1839), Puerto de la Cruz, Canary Islands (ZMK), ventrolateral teeth with major lateral teeth, side view (X65); Fig. 3. *R. crawfordi* (Sykes 1898), Summerstrand, Port Elizabeth, South Africa (ANSP 276805a), centrolateral teeth and major lateral teeth, side view (X65); Fig. 4. *C. marmoratus* Gmelin 1791, Cabo Rojo Lighthouse, Puerto Rico (RCB), centrolateral teeth with central teeth, dorsal view (X89) [Note: distal end of centrolateral teeth perpendicular to longitudinal axis of animal]; Fig. 5. *R. calliozona* (Pilsbry 1894), Sultana Bay, Yorke Peninsula, South Australia (BMNH), central teeth, centrolateral teeth, and major lateral teeth, dorsal view (X44) [Note: distal end of centrolateral teeth parallel to longitudinal axis of animal].



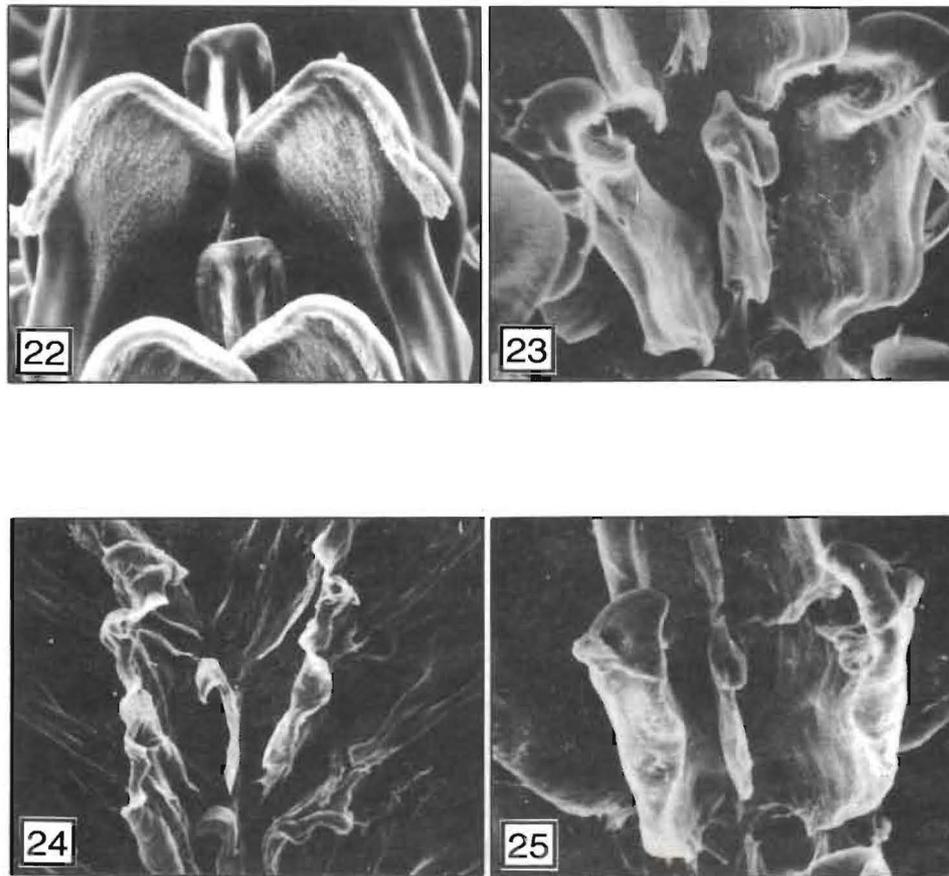
Figs. 6-12. Shells of *R. peregrina* (Thiele). Figs. 6, 9, 11. Muscat (BMNH 1952.11.10.159-161) (Fig. 6, 29 mm; fig. 9, 28 mm; fig. 11, 26 mm); Fig. 7. Disarticulated valves (coated), Manora Creek, Karachi, Pakistan (MCZ 200542) (width valve IV, 9.5 mm); Fig. 8. Holotype of *C. iatricus* Winckworth [= *R. peregrina*], East Pier, Karachi, Pakistan (BMNH 1952.11.11.25) (53.5 mm); Fig. 10. Syntype of *C. lamyi* Dupuis [= *R. peregrina*], Aden (MNHNP) (27.5 mm); Fig. 12. Another syntype of *C. lamyi* Dupuis, Perim, Aden (MNHNP) (18.6 mm).



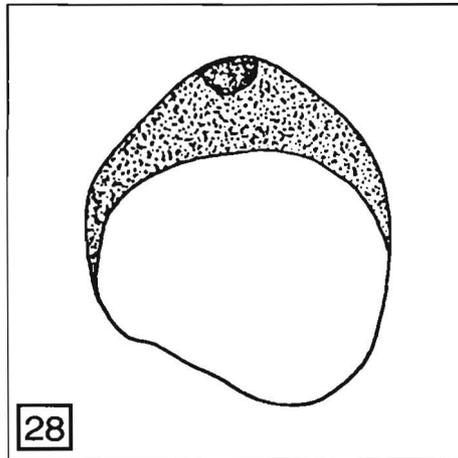
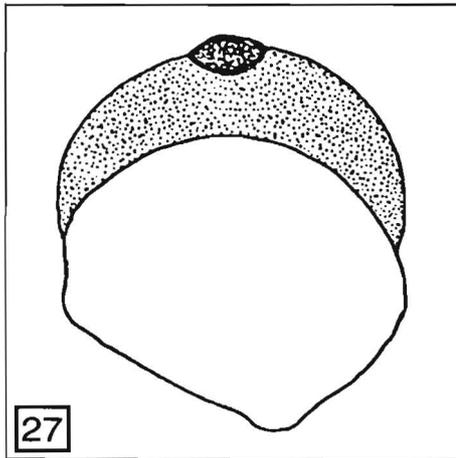
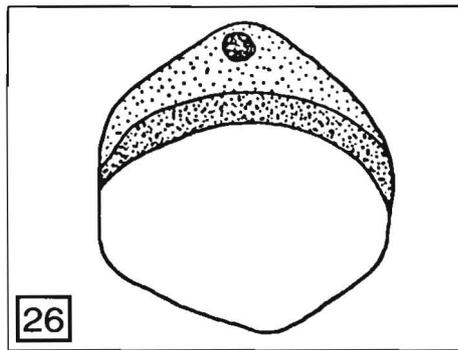
Figs. 13-18. Scanning electron micrographs of esthete pores and anterior tegmental innervation in *R. peregrina* (Thiele), *R. salihafui* (Bullock), and *R. fosteri* (Bullock). Figs. 13, 15. *R. peregrina*, Manora Creek, Karachi, Pakistan (MCZ 200542); Figs. 14, 16. *R. salihafui*, Flacourt, Fort Dauphin, Madagascar (RCB); Figs. 17, 18. *R. fosteri*, offshore reef, 0-6 ft [0-1.8 m], Kiwengwa, NE Zanzibar (MCZ) (Figs. 13, 14, 17: X296; figs. 15, 16, 18: X146).



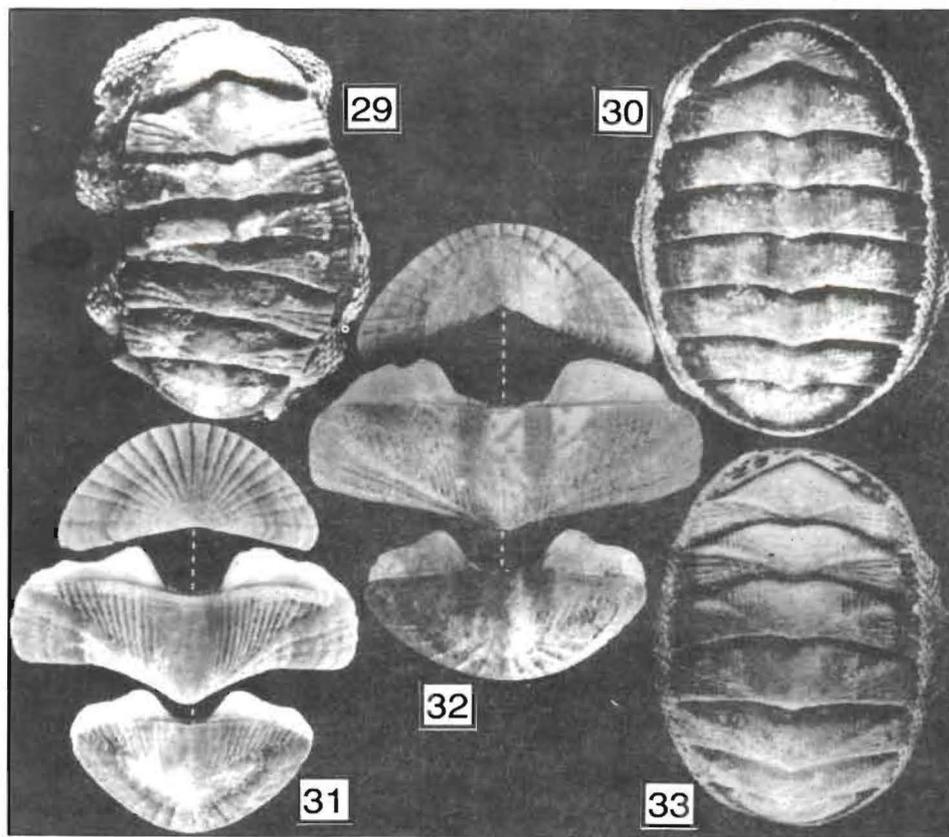
Figs. 19-21. Scanning electron micrographs of girdle scales. Fig. 19. *R. peregrina* (Thiele), Modern Bandar Sheikh, Little Aden, Aden (DMNH 30306) (X77); Fig. 20. *R. salihafui* (Bullock), Flacourt, Fort Dauphin, Madagascar (RCB) (X58); Fig. 21. *R. fosteri* (Bullock), Ankoalamare, 3 mi [4.8 km] SE of Ambodifototra, Ile Ste. Marie, Madagascar (MCZ 279166 [holotype]) (X58).



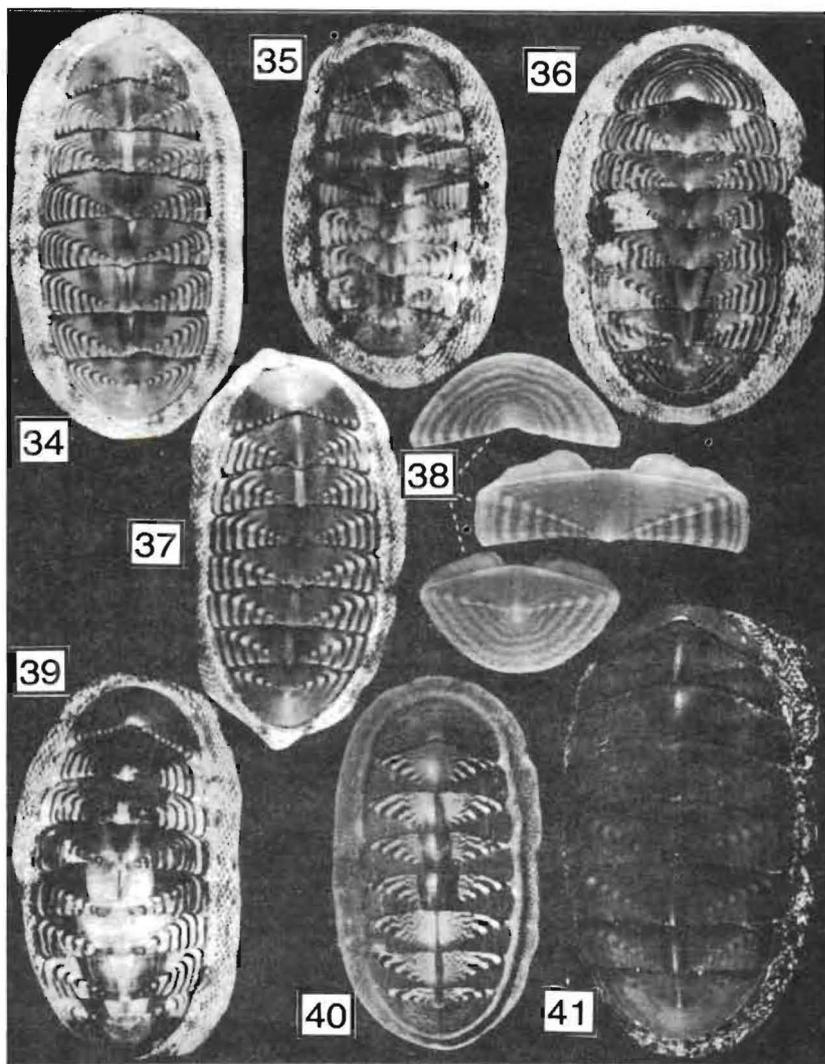
Figs. 22-25. Scanning electron micrographs of central and centrolateral radular teeth of *Chiton* and *Rhyssoplax*. Fig. 22. *C. tuberculatus* Linnaeus, Cabo Rojo Lighthouse, Puerto Rico (RCB) (X238); Fig. 23. *R. peregrina*, Modern Bandar Sheikh, Little Aden, Aden (DMNH 30306) (X280); Fig. 24. *R. salihafui*, Flacourt, Fort Dauphin, Madagascar (RCB) (X140); Fig. 25. *R. fosteri*, Ankoalamare, 3 mi (4.8 km) SE of Ambodifototra, E coast, Ile Ste. Marie, Madagascar (MCZ 279166 [holotype]) (X280).



Figs. 26-28. Denticle caps of *Rhyssoplax*. Fig. 26. *R. fosteri*, Pwani Mchangani, Zanzibar (ANSP 212570); Fig. 27. *R. salihafui*, Flacourt, Fort Dauphin, Madagascar (RCB); Fig. 28. *R. peregrina*, NW end of Astola Id., Pakistan (MCZ).



Figs. 29-33. Shells of *R. salihafui* (Bullock). Figs. 29, 32. Holotype, Kendwa Island, about 4 mi [6.4 km] ESE of Dar-es-Salaam, Eastern Province, Tanzania (MCZ 279163) (Fig. 29, about 35 mm; fig. 32, width valve IV, 16 mm); Fig. 30. Tamatave, Madagascar (ZMHU) (33 mm); Fig. 31. Disarticulated valves, Pointe Ibanona, Fort Dauphin, SE Madagascar (MCZ 247136) (width valve IV, 9.5 mm); Fig. 33. 2-3 mi [3.2-4.8 km] N of Mogadishu, Somalia (MCZ 237779) (29.5 mm, curled).



Figs. 34-41. Shells of *R. fosteri* (Bullock). Fig. 34. Paratype, near lighthouse, Mkunduchi, SE Zanzibar, (ANSP 213022) (33 mm); Figs. 35, 39, 41. Paratypes, outer reef, Kiwengwa, Zanzibar (ANSP 212257) (Fig. 35, 19 mm; fig. 39, 23 mm; fig. 41, dark variety, 31.5 mm); Fig. 36. Paratype, 2.5 mi (4 km) NE of Pointe d'Antsiraikiraiky, NW Ile Ste. Marie, NE Madagascar (MCZ 279168) (26 mm); Fig. 37. Paratype, offshore, reef, Pwani Mchangani, NE Zanzibar (ANSP 212570) (31 mm); Fig. 38. Disarticulated valves of holotype (coated), Ankoalamare, 3 mi [4.8 km] SE of Ambodifototra, Ile Ste. Marie, Madagascar (MCZ 279166) (width valve V, 11 mm); Fig. 40. Grand Comoro Id., Comoro Islands (CAS; photograph from a transparency, courtesy of A.G. Smith).

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حول الوضع التصنيفي لثلاثة أنواع كبيرة من الخيتونات (الرخويات عديدة الدروع، الخيتونات) من بحر العرب

روبرت سي . بوليك

قسم علم الحيوان - جامعة رود آيلاند، كنجستون - رود آيلاند ٢٨٨١
الولايات المتحدة الأمريكية

تم تسجيل ثلاثة أنواع كبيرة من الخيتونات (المدرعة) التابعة للجنس *Chiton* Linnaeus 1758 من منطقة بحر العرب، وهي: *C. peregrinus* Thiele 1910 المنتشر في غجارات في الهند وغرب الخليج العربي (عمان) وجيبوتي، والنوع *C. salihafui* Bullock 1972 حيث سجل من الصومال وإلى الجنوب نحو زولولاند (جنوب أفريقيا) ومدغشقر، والنوع *C. fosteri* Bullock 1972 الموجود حول عمان وإلى الجنوب نحو موزامبيق ومدغشقر. قام الباحث بفحص عينات محفوظة في متاحف رئيسية في أوروبا والولايات المتحدة من أجل معرفة الوضع التصنيفي لهذه الأنواع. تم إستعمال عينات مختارة لدراسة الأصداف والأحزمة والحراشف والمثقبات وذلك باستخدام المجهر الضوئي والمجهر الالكتروني الماسح. تتطلب خطوات تحضير العينات لدراستها بواسطة المجهر الالكتروني الماسح مايلي: تنظيف تام بمحلول هيدرواكسيد البوتاسيوم وغسل وشطف العينات عدة مرات بالماء المقطر واستخدام جهاز التنظيف الفوق صوتي. ألصقت قطع الصدفة الوسطية على حوامل من الألمنيوم وذلك بوضعها على قطع صغيرة من رقائق الألمنيوم وتثبيتها بإسمنت دكو. ومن ثم طليت العينات بطبقة من الكربون

وطبقة أخرى من الذهب ٦٠٪ وباليديوم ٤٠٪. نقلت كل من حراشف الحزام إلى شريط لاصق مزدوج ووضعت بشكل مناسب بواسطة دبوس دقيق. نظفت المثقبات وحضرت منها شرائح مستديمة لدراستها بالمجهر الضوئي. كذلك ألصقت المثقبات على حوامل بإستعمال شريط لاصق مزدوج لفحصها بواسطة المجهر الإلكتروني الماسح.

إن أصداف الجنس *Chiton* والجنس *Rhyssofax* قريبة الشبه لبعضها، ولقد استخدم بعض الدارسين الاسم *Rhyssofax* كتحت جنس. وبشكل عام، فيبدو أن الأنواع الكبيرة تعتبر تابعة للجنس *Chiton* بينما تتبع الأنواع الصغيرة الجنس *Rhyssofax* وعلاوة على ذلك، فإن مثقبات المجموعتين تختلفان بشكل واضح (Bullock 1988 b) يتميز السن المركزي للجنس *Chiton* بكونه عريض إلى معتدل ضيق، وبالحافة القصوى للأسنان المركزية الجانبية بكونها متعامدة مع المحور الطولي للحيوان. أما الغطاء السني الأسود للسن الجانبية فهو موجه بزاوية أكبر من ٩٠ درجة من محور السن. بينما يتميز الجنس *Rhyssofax* بسن مركزي ضيق، أما الحافة القصوى للأسنان المركزية الجانبية فهي متوازية مع المحور الطولي للحيوان، وبالغطاء السني الموجه بزاوية قائمة من محور السن.

وصف الباحث الثلاثة أنواع المذكورة من جنس *Chiton*، وأرفق رسومات وصور للأصداف والمعالم الغشائية وحراشف الحزام والمثقبات. بينت المقارنة المورفولوجية للمثقبات لأمثلة نموذجية من الجنس *Chiton*، والجنس *Rhyssofax* بوضوح على أن هذه الأنواع تتبع الجنس *Rhyssofax* وليس الجنس *Chiton* ونتيجة لذلك، فإن توزيع الجنس *Chiton* ينحصر في منطقة العالم الجديد وغير ممثل في مياه بحر العرب.

يتميز النوع *R. peregrina* (Thiele) بصدفه قشدية بيضاء اللون مرقطة بنقط خضراء وبنية محمرة، وفي بعض الأحيان بشريط بني غامق على النحر. وبغشاء حُبِّيبي وبوجود الفتحات الكبيرة للمجسات على مُرتَفَع صغير وبنهاية الصمام المزود بعدد كبير من خطوط حُبِّيبيّة متشعبة باهتة، يشبه النوع *R. salihafui*.

(Bullock) في حالة متآكلة النوع *R. peregrina*، إلا أن غشاءه أنعم وبوجود أضلاع طولية حول المنطقة الوسطى من الحيوان، وبأضلاع متشعبة للمثلث الجانبي ونهاية الصمام وبلون رمادي مخضر. وأحياناً يكون النحر بني مخضر أو قشدي أبيض مع وجود تنقيطات بنية مخضرة وبثلاثة خطوط طولية بنية اللون فوق النحر. يختص النوع (*R. fosteri* (Bullock) بصدفه ملساء وغالباً ماتكون صفراء مخضرة باهتة مع خطوط دائرية واضحة بنية على المثلثات الجانبية والمنطقة الطرفية للحيوان، إلا أن هناك بعض العينات بنية غامقة وبخطوط غير واضحة.