

CHITONS (MOLLUSCA: POLYPLACOPHORA) FROM THE COASTS OF OMAN AND THE ARABIAN GULF

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ABSTRACT

Twelve species of chitons are reported from the coasts of Oman and the Arabian Gulf. Misidentifications are corrected for five of the seven species previously reported from that area. New records for the region include *Lepidozona luzonica* (Sowerby, 1842), *Callistochiton adenensis* Smith, 1891, *Chiton fosteri* Bullock, 1972, *Tonicia* (*Lucilina*) *sueziensis* (Reeve, 1847), and *Onithochiton erythraeus* Thiele, 1910. Two new species, *Acanthochitona woodwardi* sp. nov., and *Notoplax arabica* sp. nov., are described.

The chiton fauna of the Arabian Gulf, the Gulf of Oman and the Oman coast of the Arabian Sea has not been investigated thoroughly. Melvill and Standen (1901, 1906), reporting upon the mollusks of the Persian Gulf, Gulf of Oman and Arabian Sea, did not mention any species of Polyplacophora. Biggs (1958) reported *Chiton lamyi* Dupuis, 1917 (= *C. peregrinus* Thiele, 1910) and *C. (Acanthopleura) haddoni* from the Arabian Gulf, the latter from Hormuz Island, Iran, at the entrance of the Gulf. Bosch and Bosch (1982: 145), reported a single species, *Acanthopleura haddoni* Winckworth, 1927 (= *A. vaillantii* de Rochebrune, 1882), a common rock-dweller in the Red Sea and on the coasts of the northern Indian Ocean (except in the Arabian Gulf, where it is uncommon). Those authors admitted that "there are several species of chitons to be found in Oman, but most are small and present problems in identification." Their specimens, collected principally at the island of Masirah in the Arabian Sea, were identified provisionally by Kathleen R. Smythe. Smythe (1982) enumerated eight species of chitons but, in glaring contrast to the fine color photographs of gastropod and bivalve shells, she illustrated the chitons with primitive line-drawings, by which none are recognizable. Apart from several misidentifications, Smythe should be credited for establishing the occurrence of several well known and easily recognizable species from the Arabian Gulf. Glayzer *et al.* (1984) listed five species of chitons from Kuwait, including four listed previously by Smythe. In the present study we establish the occurrence of twelve species of chitons in littoral waters of the western

Arabian Gulf, the western Gulf of Oman, and the Oman coast of the Arabian Sea.

HABITAT

A. J. Woodward provided the following descriptions of the Qatar stations where he collected chitons, mostly by snorkelling or scuba-diving. Ras Abruk (Fig. 1: no. 9) is a sheltered bay on the end of a peninsula. The predominantly limestone cliffs are ca. 10 m high, with raised fossil beds and sandy beaches. Large boulders of limestone and aggregates occur in the extreme shallows due to rock falls from the cliffs. Fasht (= limestone and aggregate slabs with shells, pieces of coral, etc.) occurs close to the shoreline and out to 30-40 m in a broad broken band that is frequently exposed at low tide and rarely covered by more than 30 cm of water. Beyond the fasht band there is a small drop-off of mostly weed-covered rocks, to a depth of about 2 m. Further offshore the substratum is composed of fine sand for about 300 m, beyond which coral and rock occur at a depth of 3-5 m. Chitons were always found in the fasht band, where summer temperatures are extremely high (50+°C). Therefore, the water temperature is often 40+°C in the shallows. Salinity is similarly high (40+ ppt by estimate).

Fuwairat (also spelled Fuwairat) (Fig. 1: no. 10) is a coastal location with 30 m high limestone cliffs and small bays at Jebel Fuwairat, about 1 km north of the village. Pebbly, loose rocks, that occur at the extreme edge of the white sand

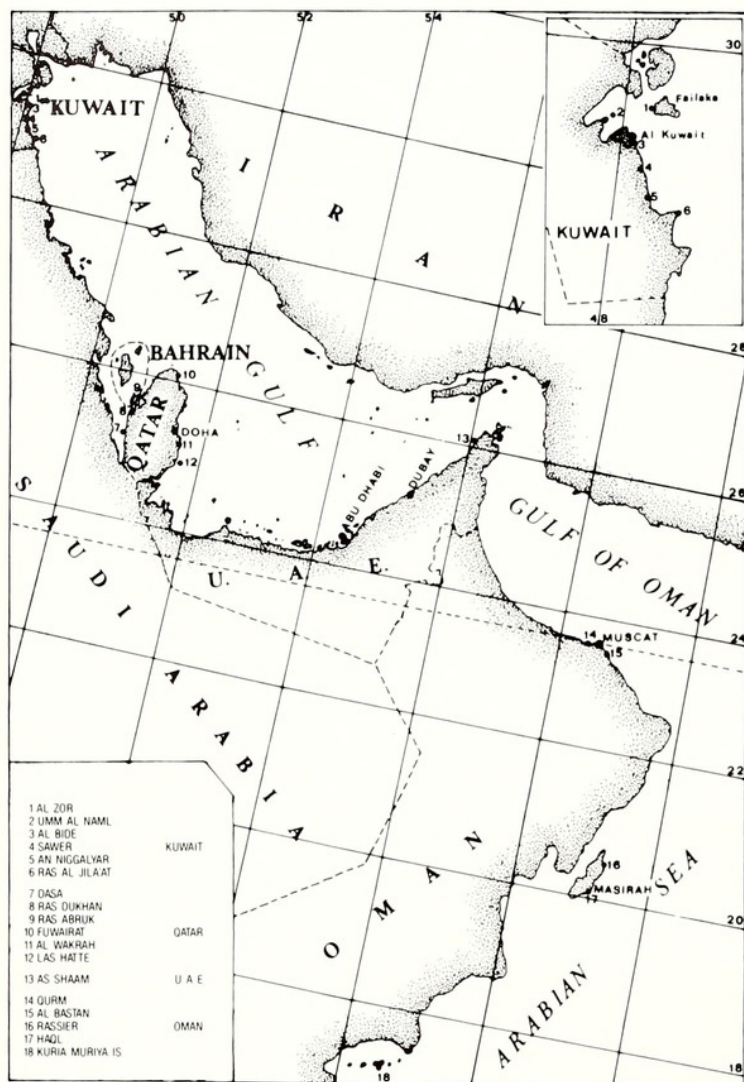


Fig. 1. Map of Oman and the Arabian Gulf.

beach, are frequently exposed at low tide (maximum tidal range ca. ± 1.5 m). A narrow band of clean sand about 20 m from shore can also be exposed during extreme low tides. Further offshore the substratum is composed of loose rock with some weed and algae cover, coral debris, small pieces of live coral and fine sand. Seaward, small patches of live coral occur on soft sand that becomes gravelly sand near coral heads. An extensive coral reef is located ca. 200 m from shore at a depth of 5 m. Chitons are found in the loose rock zone about 30-75 m from shore, usually on undersides of rocks or dead coral where the water depth rarely exceeds 1 m. Temperature is very high in the shallows, though in winter it drops below 11°C. This gives an annual temperature differential of ca. 30°C.

Wakrah is a small town south of Doha (Fig. 1: no. 11) with very wide sandy beaches backed by limestone ridges. In the extreme shallows near the beach broken fasht lies on top of shelly gravel and sand. Hard packed, fine, white, exposed sand bars are located about 50 m from the beach and extend to ca. 200-300 m from the shoreline. These are exposed at low tide. Following a slight drop-off into 1-1.5 m depths, there first occurs a band of fine white sand, then loose rock and dead coral covered by algae and weed. A second

fine white sand area occurs beyond the first and is followed by another band of shell and coral debris and loose algae and weed covered rocks that rise to ca. 30 cm in height. Here chitons were occasionally found on the undersides of rocks. Chitons were also found on shells of *Pinna muricata* L. The chitons live on the parts of the shells which are deeply buried in the sand. Chitons were never found on the broken fasht. The temperature is high, ca. 2°C less than that at Ras Abruk; the salinity is possibly higher.

Las Hatte (= Al Ashat), situated offshore from Umm Said (Fig. 1: no. 12), consists of a group of four small limestone islands with sandy beaches fringed by live coral about 75 m from shore where a fairly steep drop-off occurs. Chitons [= *Lepidozona luzonica* (Sowerby, 1842)] are found on dead valves of arkshells (Arcidae) from about 10 m down to the seabed at about 25-28 m. The substratum comprises a mixture of silty black mud and sponges. Salinity is ca. 40-50 ppt at the surface and increases with depth. The water temperature in summer is lower than at other locations, rarely exceeding 36°C; temperature in winter is ca. 12-15°C due to greater water depth.

The following abbreviations are used throughout the text: BG, Private collection of B. Glayzer; BMNH, British Museum (Natural History), London; FH, Private collection of F. Hinkle; KS, Private collection of K. Smythe; MCZ, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; MNHN, Muséum National d'Histoire Naturelle, Paris; RMNH K, Private collection of P. Kaas, now in Rijksmuseum van Natuurlijke Historie, Leiden; VB, Private collection of R. Van Belle; ZMHU, Zoologisches Museum an der Humboldt Universität, Berlin.

SYSTEMATIC ACCOUNTS

Class Polyplacophora

Order Neoloricata

Suborder Ischnochitonina

Family Ischnochitonidae Dall, 1889

Subfamily Ischnochitoninae

Genus *Ischochiton* Gray, 1847

Type Species: *Chiton textilis* Gray, 1828 (by subsequent designation, Gray, 1847).

Subgenus *Ischnochiton* s.s.

Ischnochiton (*I.*) *yerburyi* (E. A. Smith, 1891)

Figs. 2-7

Chiton (*Ischnochiton*) *yerburyi* E. A. Smith, 1891: 420, pl. 33: fig. 6.

Ischnochiton yerburyi, Pilsbry, 1892: 101, pl. 20: fig. 11. Nierstrasz, 1905: 30. Thiele, 1910: 111, 113. Kaas, 1954: 5. Leloup, 1960: 35, fig. 5. Biggs, 1973: 374. Leloup, 1980: 10. Smythe, 1982: 83, fig. 17. Ferreira, 1983: 251, figs. 1, 2. Glayzer *et al.*, 1984: 324. Kaas, 1986: 11, figs. 8, 8a, b (synonymy).

(?) *Ischnochiton rufopunctatus* Odhner, 1919: 21, pl. 3: figs. 40, 41.

(?) *Ischnochiton* (*Radsilla*) *delagoensis* Ashby, 1931: 40, pl. 6: figs. 63-66.

Ischnochiton haersoltei Kaas, 1954: 5, figs. 7-9.

Table 1. Distributional records of Polyplacophora in the Arabian Gulf and Oman. Species marked with an asterisk (*) also occur on the African coast of the Indian Ocean.

Species	Kuwait	Arabian Gulf			U. A. E.	Oman	
		Bahrain	Qatar			Gulf of Oman	Arabian Sea
* <i>Ischnochiton yerburyi</i> Smith, 1891	+	+	+	—		+	+
<i>I. winckworthi</i> Leloup, 1936	+	—	+	+		—	—
<i>Lepidozona luzonica</i> (Sowerby, 1842)	—	+	+	+		—	—
<i>Callistochiton adenensis</i> Smith, 1891	—	—	—	—		—	+
<i>Chiton peregrinus</i> Thiele, 1910	+	—	+	+		+	+
* <i>C. fosteri</i> Bullock, 1972	—	—	—	—		—	+
* <i>C. (Rhyssoplax) affinis</i> Issel, 1869	+	—	+	—		+	—
* <i>Acanthopleura vaillantii</i> de Rochebrune, 1882	—	(+) ¹	—	(+) ¹		(+) ¹	+
* <i>Tonicia (Lucilina) sueziensis</i> (Reeve, 1847)	+	+	+	—		—	+
* <i>Onithochiton erythraeus</i> Thiele, 1910	—	—	—	—		—	+
<i>Acanthochitona woodwardi</i> sp. nov.	+	—	+	—		—	—
<i>Notoplax (Notoplax) arabica</i> sp. nov.	+	—	+	—		—	—

¹Reported by Biggs (1958: 271) from Hormuz Id., Iran, at entrance of Arabian Gulf. Collected by Smythe (in litt. 3 June 1987) on the Trucial coast of the Emirates, just inside the Gulf, at Khor Khaymal and Sharjah, and also at a point in Bahrain (!). Collected by Woodward at Dubai.

SYNTYPES: BMNH 1888.4.9.345.

MATERIAL EXAMINED. KUWAIT: 1 spec., 11.5 x 5.5 mm, Bide Circle, under stones in tidepool, F. Hinkle leg., 12 June 1978, FH; —1 spec., ca. 7 mm long, id., 20 Sept 1979, FH; —3 spec., max. 15 x 8 mm, id., 1 Aug 1981, FH; —2 spec., Kuwait Bay, on *Pinna muricata*, intertidal, 19 Sept 1975, B. Glayzer leg., BG 1427; —Numerous valves, Bahrain, in shell grit on beach, Nov 1971, F. van Nieulande don., VB 2667a. QATAR: 1 spec., 9 x 5 mm, Ras Abru, under broken slabs of fasht, intertidal, May 1982, A. Woodward leg., KS; —6 spec., max. 10.5 x 5.5 mm, Fuwairat, on rocks and dead coral, 0-1 m, June 1985, A. Woodward leg., 4/KS, 2/RMNH K5105 (one disarticulated). OMAN: 3 spec., Gulf of Oman, Qurm, K. Smythe leg., 1979, KS; —2 spec., Arabian Sea, Masirah Id., Rassier, KS; —3 spec., Haql, K. Smythe leg., KS.

TYPE LOCALITY: Aden.

DISTRIBUTION: Indo-Arabian coasts from Karachi, Pakistan, to Aden in Yemen, and in the Red Sea to the Gulf of Aqaba, Israël; African coast from Somalia to Zanzibar (many of these records are unconfirmed).

DESCRIPTION: This taxon was adequately described and illustrated by E. A. Smith (1891: 420, pl. 33 fig. 6) except for details of girdle armature and radula which follow (see also Figs. 2-5). Dorsal girdle scales (Fig. 6) broadly rounded, moderately curved, ca. 100 x 80 μ m, with 12-15 elevated, slightly converging riblets separated by somewhat narrower, rather deep grooves.

Central tooth of radula (Fig. 7) narrow, abruptly widening distally to umbrella-like blade; first lateral teeth as long as central tooth, narrow, with inwardly curved, roundish blade; major lateral teeth with bidentate head, inner cusp much stronger than outer one, shaft with a short, trunk-like appendix just under and before head; spatulate uncinial with bluntly pointed, outwardly incised cusp.

DISCUSSION: Ferreira (1983: 251) combined all Indian Ocean species of *Ischnochiton* with "reticulate, thimble-like sculpture." Whether he was correct in synonymizing *Ischnochiton sansibarensis* Thiele, 1910, *I. delagoaensis* Ashby, 1931,

I. kilburni Kaas, 1979, from Mozambique, and *I. rufopunctatus* Odhner, 1919, from Madagascar, with *I. yerburyi* cannot be decided here. Close reexamination of the types could reveal a complex of sibling species, rather than one variable species. As far as we can ascertain, *I. haersoltei* Kaas, 1954, from Manora Island, Karachi, does not differ from Gulf specimens of *I. yerburyi*.

Ischnochiton (I.) winckworthi Leloup, 1936

Figs. 8-15

Ischnochiton winckworthi Leloup, 1936: 51, figs. 1-9, 1949: 1, figs. 1, 2, 3A, 4-7, pl. 1; 1952: 15. Rajagopal and Subba Rao, 1974: 404, 409. Smythe, 1982: 83, fig. 16.

Ischnochiton ranjhai Kaas, 1954: 8, figs. 10-14.

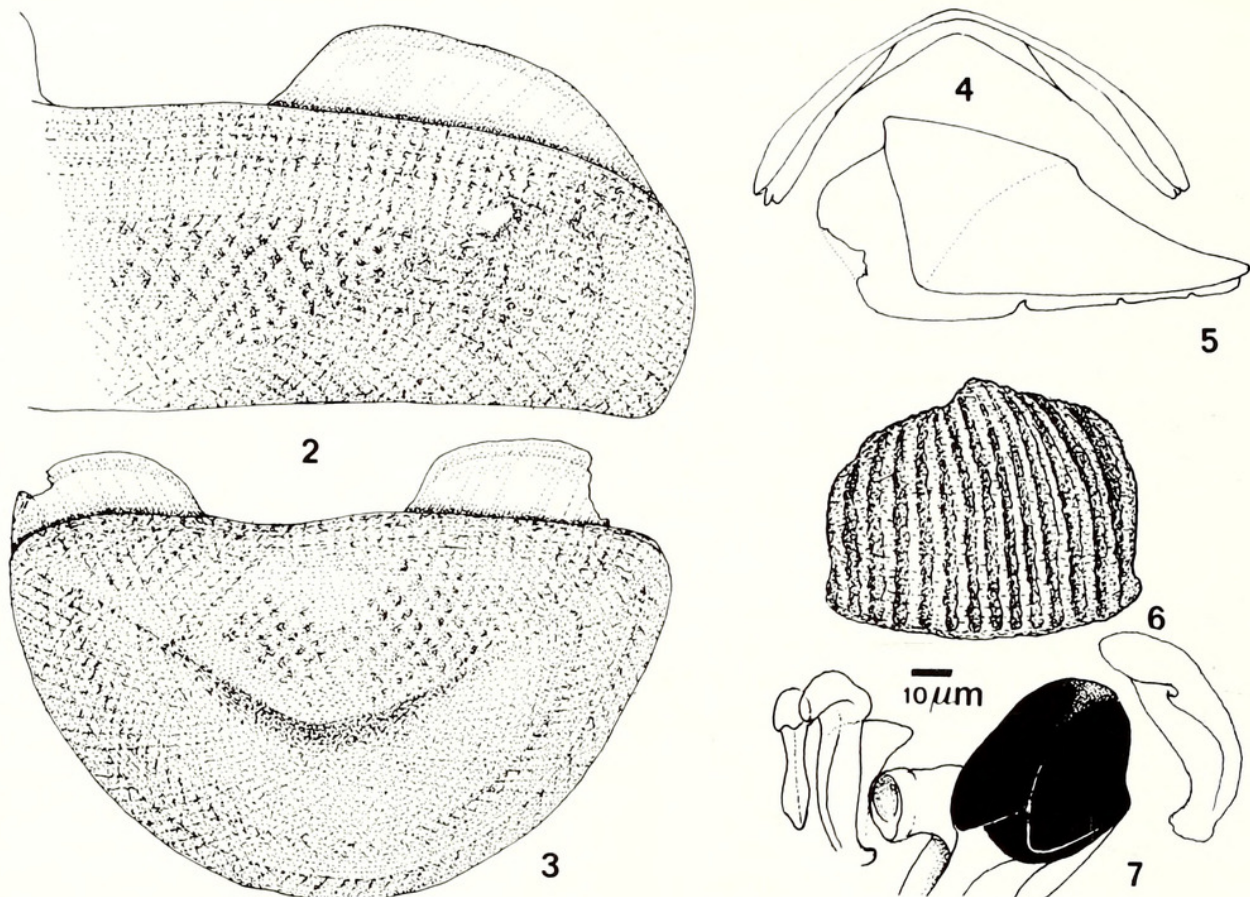
SYNTYPES: BMNH.

MATERIAL EXAMINED: KUWAIT: 1 spec., 7.5 x 4 mm, Bide Circle, under stones in tidepool, F. Hinkle leg., 20 Sept 1979, FH; —2 spec., max. 5 x 3.5 mm, id., 1 Aug 1981, FH; —2 spec., max. 7 x 4 mm, id., 10 Sept 1983, FH; —1 valve + girdle, Sawyer, 1974, K. Smythe leg., KS; —1 spec., Kuwait Bay, 14 Feb 1975, B. Glayzer leg., KS. QATAR: 2 spec., Ras Dukhan, 15 Apr 1978, K. Smythe leg., KS. —9 spec., max. 10 x 5.5 mm, Ras Abru, under broken slabs of fasht, intertidal, May 1982, A. Woodward leg., 7/KS, 2/RMNH K5097. —2 spec., Ras Abru, 2-3 Nov 1978, A. Partridge leg., KS. —3 spec., max. 10 x 5.5 mm, Fuwairat, on rocks and dead coral, 0-1 m, June 1985, A. Woodward leg., KS. U. A. E.: 2 spec., 3.2 and 2.6 mm long, Abu Dhabi, K. Smythe leg., KS.

TYPE LOCALITY: Sri Lanka, near Trincomali, Dutch Bay.

DISTRIBUTION: Locally common along the shores of Malaysia, Andaman Islands, Burma, Sri Lanka, Pakistan, Kuwait, Qatar, U. A. E.; intertidal.

DESCRIPTION: Animals small, ca. 10 mm long, width ca. 2/3 length, largest specimen recorded 15 x 9.5 mm (Leloup, 1936: 51), oval, moderately raised (dorsal elevation 0.35-0.41), carinated, side slopes straight to slightly convex, valves not beaked. Color of tegmentum variable, beige, olivaceous, dark



Figs. 2-7. *Ischnochiton yerburyi* Smith (specimens from Fuwairat, Qatar, Apr 1985, A. Woodward leg. in coll. Smythe, RMNH K5105). **Fig. 2.** Valve IV, dorsal view, 3.7 mm wide. **Fig. 3.** Valve VIII, dorsal view, 3.7 mm wide. **Fig. 4.** Camera lucida sketch of valve IV, rostral view, 5.5 mm wide. **Fig. 5.** Lateral view of valve VIII, 2.4 mm wide. **Fig. 6.** Dorsal girdle scale. **Fig. 7.** Central, first lateral, major lateral and spatulate uncinal radula teeth.

greyish green, with roughly symmetrical blotches of dirty white on central part of valves. Many specimens with 2-3 dark spots at posterior margin of valves, some specimens uniformly roseate, more exceptionally, white or brownish.

Head valve (Fig. 8) semicircular, front slope straight, posterior margin widely V-shaped, weakly notched medially. Intermediate valves (Figs. 9, 10, 13) broadly rectangular, front and hind margins nearly straight, parallel-sided, apices hardly or not indicated, side margins rounded, lateral areas little raised but neatly marked. Tail valve (Figs. 11, 12) somewhat less than semicircular, mucro not prominent, slightly anterior, posterior slope concave.

Tegmentum granulate, sculpture often obsolete in younger specimens, variable in older ones. In most commonly occurring form, head valve of adult specimen sculptured with 36-40 radiating, somewhat irregular, granulate riblets, becoming obsolete toward apex, growth lines hardly or not indicated, lateral areas of intermediate valves with 4-5 similar radiating riblets, some bifurcating near outer margin, central areas, and antemucronal area of tail valve, with weak, fine, longitudinal riblets, 10-15 per side, becoming obsolete toward the finely quincuncially granulate jugal area, postmucronal area of tail valve sculptured like head valve.

Articulamentum whitish to light roseate, tegmental color visible, apophyses thin, sharp, moderately wide, evenly arched, jugal sinus straight, ca. 1/5 width of valve, insertion

plates short, slit formula 8-11/ 1/ 9-10, slit rays finely indicated, teeth sharp, smooth, eaves solid.

Girdle moderately wide with alternating bands of yellowish and greyish green, dorsally covered with strongly bent, imbricating scales, ca. 150 x 120 µm; top rounded, ornamented with ca. 10 strong ribs wider than interstices (Fig. 14). Margin with fringe of short, white, torpedo-shaped spicules. Ventral side of girdle paved with radiating rows of elongate rectangular, smooth scales, 67 x 20 µm. Radula (Fig. 15) with narrow central tooth bearing a roundish, upwardly curled blade; first laterals equally narrow, ending in inwardly curved, hook-shaped blade; major laterals with strong, sharply pointed main cusp and short minor denticle on outside. Gills holobranchial, abanal, 18 ctenidia per side in 7.4 mm specimen.

Genus *Lepidozona* Pilsbry, 1892

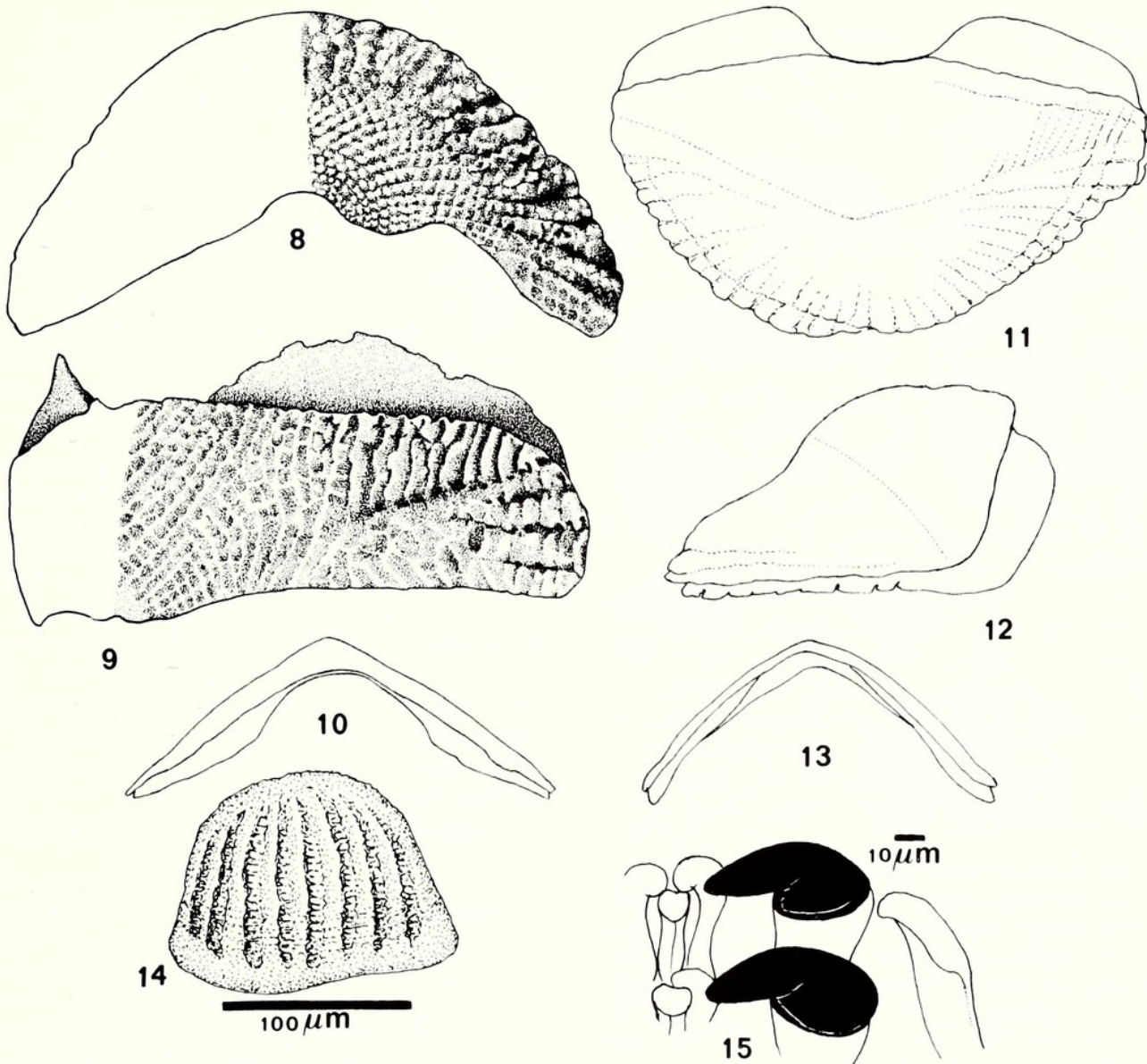
Type Species: *Chiton mertensii* von Middendorff, 1847 (by original designation).

Subgenus *Lepidozona* s.s.

Lepidozona (L.) *luzonica* (Sowerby, 1842)

Figs. 16-23

Chiton luzonicus Sowerby, 1842: 104. Reeve, 1847: pl. 25: sp. and fig. 167. Van Belle, 1982: 473.



Figs. 8-15. *Ischnochiton winckworthi* Leloup [Figs. 8-10: paratype of *Ischnochiton ranjhai* Kaas, 1954 (H. Heyn, del.), RMNH K3422; Figs. 11-15, specimen from Ras Abruq, Qatar, May 1982, A. Woodward leg. in coll. Smythe, RMNH K5097]. **Fig. 8.** Valve I, dorsal view, 3.7 mm wide. **Fig. 9.** Valve III, dorsal view, 3.5 mm wide. **Fig. 10.** Camera lucida sketch of valve VIII, rostral view, 3.8 mm wide. **Fig. 11.** Dorsal view of valve VIII, 4.7 mm wide. **Fig. 12.** Lateral view of valve VIII, 2.7 mm wide. **Fig. 13.** Rostral view of valve IV, 5.3 mm wide. **Fig. 14.** Dorsal girdle scale. **Fig. 15.** Central, first lateral, major lateral and spatulate uncinal girdle teeth.

Ischnochiton (Lepidozona) luzonicus Pilsbry, 1893: pl. 38, figs. 31-32; 1894: 85.

Ischnochiton luzonicus Nierstrasz, 1905: 34. Hidalgo, 1905: 271; Faustino, 1928: 123.

Callistochiton finschi Thiele, 1910: 86, pl. 8: figs. 57-60; 1911: 402. Ashby, 1923: 236. Iredale and Hull, 1925: 354. Ferreira, 1974: 163; 1978: 39.

Solivaga finschi Iredale and Hull, 1925: 355, pl. 40: figs. 14-16. Cotton, 1964: 55.

Lorica (Solivaga) finschi Thiele, 1929: 18.

Lepidozona luzonica Kaas and Van Belle, 1987: 245, fig. 111, map 52.

non *Ischnochiton (Lepidozona) luzonicus* Ang, 1967: 401, pl. 5: figs. 1-5 (= *Chiton* sp.).

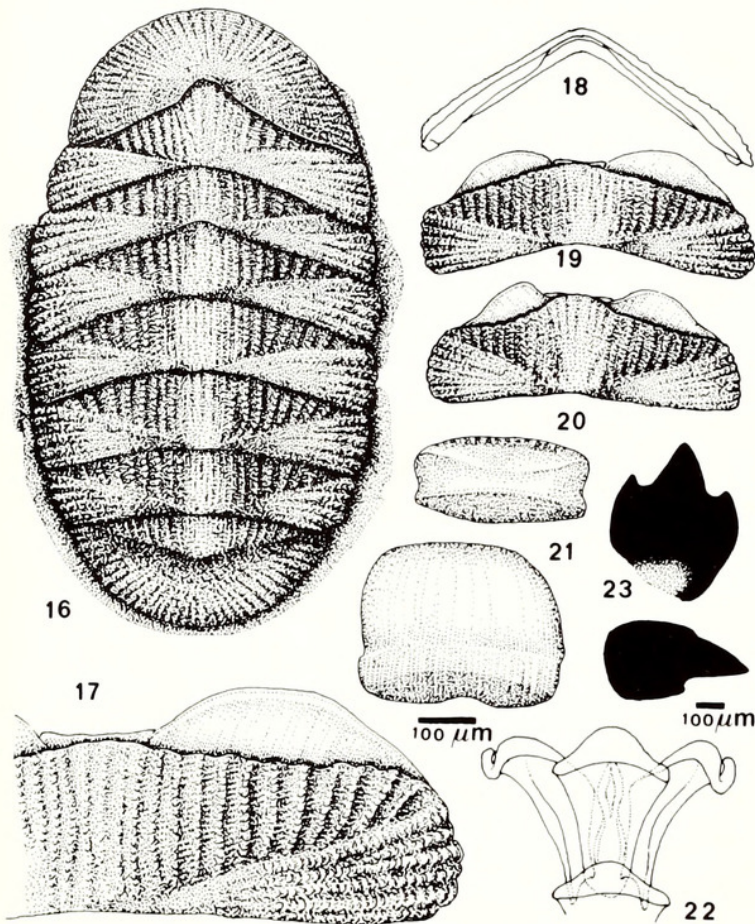
LECTOTYPE: BMNH 1979. 175/1 (by subsequent designation, Kaas and Van Belle, 1987).

MATERIAL EXAMINED: BAHRAIN: 1 valve, in shell grit on beach, Nov. 1971, F. van Nieulande don., VB 2975a. QATAR: 2 spec., Fuwairat, June 1985, A. Woodward leg., 1/KS 1/RMNH K5100. —4 spec., Las Harte, on dead shells, 10-20 m, 26 July 1985, A. Woodward leg., 2/KS, 1/RMNH K5099, 1/VB 2975b (disarticulated); —7 valves (mounted on slide) Fuwairat or Las Harte, June/July 1985, A. Woodward leg., KS. U. A. E.: 1 spec. (in alcohol), Abu Dhabi, K. Smythe leg., 4.2 mm long, KS.

TYPE LOCALITY: Philippines, province Albay, Isle of Luzon, Sorsogon, 27 m.

DISTRIBUTION: Eastern coast of Sumatra (Java Sea), Singapore (as *Callistochiton finschi*), Bahrain, Qatar and U. A. E.

DESCRIPTION: Animal small, lectotype (Fig. 16) 9.2 x 5.8 mm, largest specimen 12 x 7 mm (Iredale and Hull, 1925: 355, as *Solivaga finschi*), oval, moderately elevated (dorsal elevation



Figs. 16-23. *Lepidozonia luzonica* (Sowerby) [Fig. 16, lectotype: Figs. 17-23, paralectotypes (BMNH 1979.175)]. **Fig. 16.** Whole specimen, dorsal view, 5.8 mm wide. **Fig. 17.** Right half of valve III, dorsal view, 4.6 mm wide. **Fig. 18.** Camera lucida sketch of valve III, rostral view, 7.3 mm wide. **Fig. 19.** Valve III, dorsal view, 7.3 mm wide. **Fig. 20.** Valve II, dorsal view, 6.9 mm wide. **Fig. 21.** Dorsal girdle scales. **Fig. 22.** Central and first lateral radula teeth. **Fig. 23.** Heads of major lateral teeth.

0.36-0.39) carinated, side slopes straight, valves not beaked. Color of tegmentum yellowish to greenish with, on central areas, few longitudinal streaks of darker tone, or buff, sparsely spotted with bluish green.

Head valve semicircular, front slope somewhat concave, hind margin widely V-shaped, deeply notched in middle, tegmentum sculptured with low, radial, often bifurcating, granule riblets, 40-50 in number along outer margin, becoming obsolete toward apex. Intermediate valves (Figs. 17-20) broadly rectangular, front and hind margins straight, parallel-sided, side margins rounded, apices inconspicuous, lateral areas little raised, 5-6 riblets, up to 7-9 by splitting, central areas with 12-16 longitudinal, granule ridges per side, ridges close-set and little pronounced on jugal areas, gradually more widely spaced and elevated toward side margins, interspaces finely, densely, but irregularly, transversely grooved. Tail valve subsemicircular, almost as wide as head valve, mucro at anterior third of valve, not prominent, postmucronal area rather flat, sculptured like head valve, ca. 32 riblets along outer margin, antemucronal area sculptured like central areas.

Articulamentum glossy white, apophyses very wide, short, rounded, connected across shallow sinus by short,

slightly concave, laminated jugal plate, weakly notched at sides, slit formula 11-14/ 1/ 10-13, slits inequidistant, slit rays indicated, teeth short, weakly grooved on outside, eaves narrow, solid.

Girdle buff-colored, sometimes banded with bluish green, dorsally covered with obliquely implanted, slightly bent, more or less rectangular scales, with 12-16 obsolete ribs, up to 125 μm long, 188 μm wide in mid-girdle, smaller toward the outer margin (Fig. 21).

Central tooth of radula (Fig. 22) narrow at base, gradually widening to strong, rounded blade, first lateral tooth about as long as central one, slender, with somewhat distorted blade, major lateral (Fig. 23) with a tricuspid head, denticles sharply pointed, central one longer than others.

DISCUSSION: The present specimens undoubtedly are conspecific with *Lepidozonia luzonica*, differing only in a less pronounced sculpture; radula and girdle armature are exactly like specimens of *L. luzonica* from elsewhere. Specimens from the Arabian Gulf extend the known range of *L. luzonica* considerably to the west and establish the presence of *Lepidozonia* in the northwestern Indian Ocean.

Subfamily Callistoplacinae Pilsbry, 1893

Genus *Callistochiton* Carpenter in MS; Dall, 1879

Type Species: *Callistochiton palmulatus* Carpenter in MS (by monotypy, Dall, 1879).

Callistochiton adenensis (E. A. Smith, 1891)

Figs. 24-27

Chiton (*Callistochiton*) *adenensis* E. A. Smith, 1891: 421, pl. 33: fig. 7.

Callistochiton adenensis Pilsbry, 1893: 276, pl. 59: fig. 45. Nierstrasz, 1905: 41. Sykes, 1907: 31. Thiele, 1910: 84, pl. 8: figs. 49-51. Ashby, 1923: 233. Leloup, 1952: 30; 1953: 1, fig. 1. Kaas, 1979: 861. Ferreira, 1979: 463. Zeidler and Gowlett, 1986: 114.

Lepidopleurus rochebruni Jousseume, 1893: 102. Nierstrasz, 1905: 10; 1906: 145, 157.

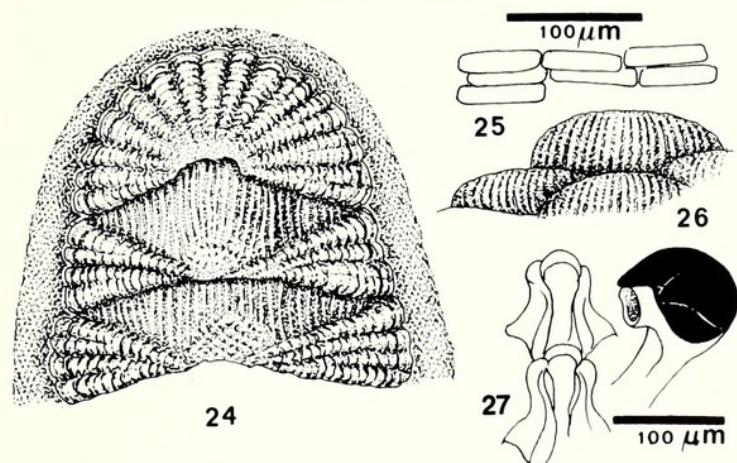
HOLOTYPE: BMNH.

MATERIAL EXAMINED: OMAN: 2 spec., max. 24 x 12 mm, Al Bastan or Masirah Id., Mar 1984, D. Bosch leg., 1/KS, 1/RMNH K5101. —1 spec., 16 mm (curled), Arabian Sea, Masirah Id., I. 1984, D. Bosch leg., KS; —1 spec., id., between Haql and Rassier, K. Smythe leg., KS. —1 spec., 18 mm, Rassier, K. Smythe leg., KS. —2 spec., 18.5 mm long, (disarticulated), Rassier, 9 Feb 1982, K. Smythe leg., 1/KS, 1/VB 2976a.

TYPE LOCALITY: Aden.

DISTRIBUTION: Gulf of Aden; Arabian coast of Oman; possibly Gulf of Oman.

DESCRIPTION: Girdle densely covered with strongly imbricating, wide, short, oval, curved scales, with more than twenty elevated riblets, narrow, latticed interstices, ca. 140 x 50 μm ; marginal scales small and narrow, bluntly conical, 25 x 50 μm , with ca. 6 ribs; ventral side of girdle covered with transverse rows of rectangular scales, ca. 60 x 15 μm (Figs. 24-26).



Figs. 24-27. *Callistochiton adenensis* (Smith) (specimen from Oman, Masirah Id. or Al Bastan, Mar 1984, D. Bosch leg. in coll. Smythe, RMNH K5101). **Fig. 24.** Valves 1-3 in situ, 12 mm wide. **Fig. 25.** Ventral girdle scales. **Fig. 26.** Dorsal girdle scales. **Fig. 27.** Central, first lateral and major lateral radula teeth.

Central tooth of radula (Fig. 27) somewhat pinched in middle, with semi-oval, rather narrow blade; first laterals somewhat S-shaped, embracing central tooth, with broad exterior wing in basal part and small rounded blade; major laterals with bicuspid head, denticles stout, sharply pointed, interior one slightly longer, shaft with short, curved appendix at inside of head; spatulate uncinals with narrow, rounded cutting edge.

Short, poorly illustrated original description of this species was amplified by Thiele (1910) who produced good figures of the valves, and by Leloup (1953), who also figured the girdle elements.

Family Chitonidae Rafinesque, 1815

Subfamily Chitoninae

Genus *Chiton* Linnaeus, 1758

Type Species: *Chiton tuberculatus* Linnaeus, 1758 (by subsequent designation, Dall, 1879).

Subgenus *Chiton* s.s.

Chiton (*C.*) *peregrinus* Thiele, 1910

Figs. 28-30

Chiton (*Clathropleura*) *peregrinus* Thiele, 1910: 90, pl. 9: figs. 23-27.

Chiton lamyi Dupuis, 1917: 538. Biggs, 1958: 271. Smythe, 1982: 82, fig. 15. Glayzer *et al.*, 1984: 324.

Chiton lamyi var. *reticulatus* Dupuis, 1918: 532.

Chiton wallacei Winckworth, 1927: 206, pl. 29: figs. 5-8.

Chiton iatricus Winckworth, 1930: 78, pl. 8b. Smythe, 1982: 82.

Chiton iatricus var. *winckworthi* Kaas, 1954: 2.

Chiton peregrinus Bullock, 1972: 238, pl. 44: figs. 1, 2, 10 (bibliography and synonymy). Ferreira, 1983: 268. Zeidler and Gowlett, 1986: 113.

SYNTYPES: ZMHU.

MATERIAL EXAMINED: KUWAIT: 4 juv. spec., Falaika Id., Al Zor, on rocks, intertidal zone, 10 Nov 1975, B. Glayzer leg., BG 1428 (as

Chiton lamyi). QATAR: 3 spec., Dasa, K. Smythe leg., KS. U. A. E.: —1 partly disarticulated spec., As Shaam, K. Smythe leg., KS. OMAN: 6 spec., max. 37 x 22 mm, Al Bastan or Masirah Id., Mar 1984, D. Bosch leg., KS. —3 spec., Gulf of Oman: Qurm, 1979, K. Smythe leg., KS. —2 spec., max. 30 x 17 mm, Muscat, Mar 1969, D. Bosch leg., VB 2651a. —2 spec. + partly disarticulated + 1 disarticulated red spec. + 6 valves, Arabian Sea, Masirah Id., 12 Jan 1984, D. Bosch leg., KS. —3 spec. + 8 valves, id., Rassier, K. Smythe leg., KS. —23 spec., max. 28 x 20 mm (slightly curled), between Rassier and Haql, K. Smythe leg., KS. —3 spec., Haql, K. Smythe leg., KS.

TYPE LOCALITY: S Africa, ? Algoa Bay (in error = Aden, *vide* Bullock, 1972).

DISTRIBUTION: Widely distributed in the northwestern Indian Ocean from the north coast of western India to the Arabian Gulf and westward to the entrance of the Red Sea; intertidal in rocky areas.

DESCRIPTION: Specimens large, up to 7 cm long, greater than 4 cm wide. Shells, older animals, typically strongly eroded; young specimens with two thread-like radial riblets on lateral areas, one accompanying diagonal mark, another at short distance from posterior margin (Fig. 28). Tegmentum always granulate, granules on central areas arranged in somewhat wavy series perpendicular to diagonal lines, converging toward jugum. Color mostly greyish green, sometimes with black markings, valves of disarticulated specimen (Masirah Id., Oman) reddish all over along with articulation.

Girdle paved with strong, large, imbricating scales, with lozenge-shaped base, strongly bent, smooth on outside if not eroded (Fig. 29); scales ca. 0.75 mm wide, slightly less high, bluntly pointed at top. Central tooth of radula very narrow, sagittate, first laterals broad at base, narrowing distally, without blade; major laterals with simple, oval head without cusp (Fig. 30).

DISCUSSION: This species was well described by several authors who, owing to intraspecific variation and state of preservation, created different names for it. The complicated synonymy was clearly established by Bullock (1972). It is by far the most common chiton on the Indo-Arabian coasts.

Chiton (*C.*) *fosteri* Bullock, 1972

Figs. 31-33

Chiton fosteri Bullock, 1972: 245, pl. 44: figs. 6-9. Kaas, 1979: 862.

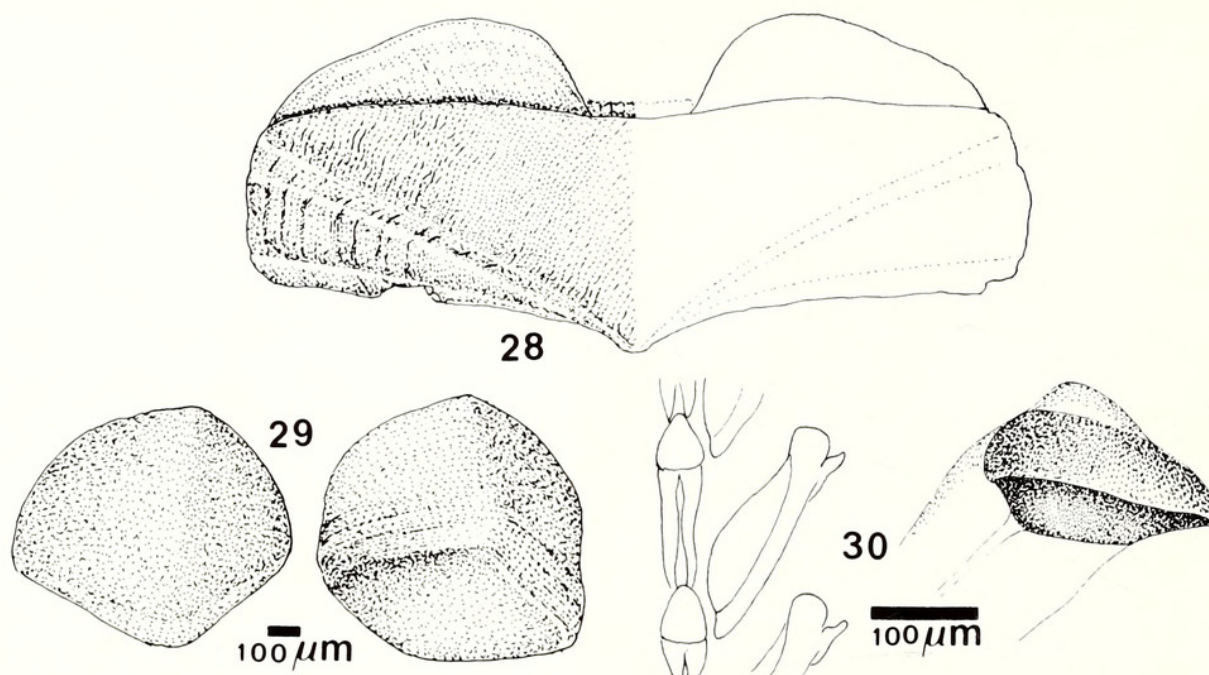
HOLOTYPE: MCZ 279166.

MATERIAL EXAMINED: OMAN: 1 spec., 40.5 x 21 mm, Arabian Sea, Masirah Id., Haql, K. Smythe leg., KS.

TYPE LOCALITY: Madagascar, Ile Ste Marie, Ankoalamare.

DISTRIBUTION: Madagascar, Mozambique, the Comoro Archipelago, Zanzibar and Kenya; locally common.

DESCRIPTION: Single specimen bluish green with faint zebra-pattern of brownish concentric lines (Fig. 31). Slit formula 9/1/16.



Figs. 28-30. *Chiton peregrinus* Thiele (Fig. 28: specimen from Manora Id., Karachi, Pakistan, 15 Feb 1953, S. M. H. Bilgrani leg., RMNH K4705; Figs. 29-30: specimen from Oman, Masirah Id., between Haql and Rassier, K. Smythe coll.). **Fig. 28.** Valve V, dorsal view, 8.9 mm wide. **Fig. 29.** Dorsal girdle scales, left dorsal, right ventral view. **Fig. 30.** Central, first lateral and major lateral radula teeth.

Dorsal girdle scales (Fig. 32) spindle-shaped, base elongate, lozenge-shaped, dorsal surface strongly convex, apparently smooth. Under high magnification scales appear finely punctate-lineate toward base, minutely bubbled around top. Scales on mid-girdle measure ca. $680 \times 300 \mu\text{m}$. Radula (Fig. 33) central tooth almost linear, with narrow, sagittal blade; major laterals closely packed, with oval head, edge of free margin sharp.

DISCUSSION: This species was well described by Bullock (1972). Additional observations were added by Kaas (1979).

Subgenus *Rhyssoplax* Thiele, 1893

Type Species: *Chiton janeirensis* Gray, 1828, *sensu* Thiele, 1893 (= *Chiton affinis* Issel, 1869) (by subsequent designation, I.C.Z.N., 1971).

Chiton (Rhyssoplax) affinis Issel, 1869

Figs. 34-40

Chiton affinis Issel, 1869: 234. Beu *et al.*, 1969: 184. Yaron, 1973: 15. Sabelli, 1974: 75. Fischer, 1978: 43.

Lepidopleurus bottae de Rochebrune, 1882: 192. Ferreira, 1983: 270, fig. 24.

Callistochiton heterodon savignyi Pilsbry, 1893: 277, pl. 60: fig. 16. Ferreira, 1983: 270.

Chiton olivaceus var. *affinis*, Leloup, 1952: 27, fig. 11, pl. 4: fig. 4. (bibliography and synonymy); 1960: 36. Sabelli and Spada, 1970: 6.

Callistochiton barnardi, Smythe, 1982: 81, fig. 14 (*non* Ashby, 1931). Glayzer *et al.*, 1984: 324.

Rhyssoplax affinis, Ferreira, 1983: 268, fig. 22.

LECTOTYPE: MNHN (by subsequent designation, Ferreira, 1983).

MATERIAL EXAMINED: KUWAIT: 2 spec., max. $12 \times 6 \text{ mm}$, Bide Circle, under stones in tidepool, F. Hinkle leg., 20 Sept 1979, FH; —3 spec., max. $11.5 \times 5 \text{ mm}$, id., 1 Aug 1981, FH; —2 spec., max. $10 \times 5.5 \text{ mm}$, id., 10 Apr 1983, FH; —6 spec. (as *Callistochiton barnardi*), Kuwait Bay, on underside of rocks, intertidal zone, 19 Sept 1975, B. Glayzer leg., 5/BG 1426, 1/KS (disarticulated). QATAR: 10 spec., max. $15 \times 8 \text{ mm}$, Ras Abruq, under broken slabs of fasht, intertidal, May 1982, A. Woodward leg., 6/KS, 2/RMNH K5104, 2/VB 2768b; —4 spec. (one heavily damaged), Ras Abruq, 3 Nov 1978, A. Partridge leg., KS. —13 spec., max. $14 \times 6.5 \text{ mm}$, Fuwairat, on rocks and dead coral, 0-1 m, June 1985, A. Woodward leg., 12/KS, 1/RMNH K5103; .2 spec., Al Wakrah, K. Smythe leg., KS. OMAN: 2 spec., Gulf of Oman, Qurum, 1979, K. Smythe leg., KS.

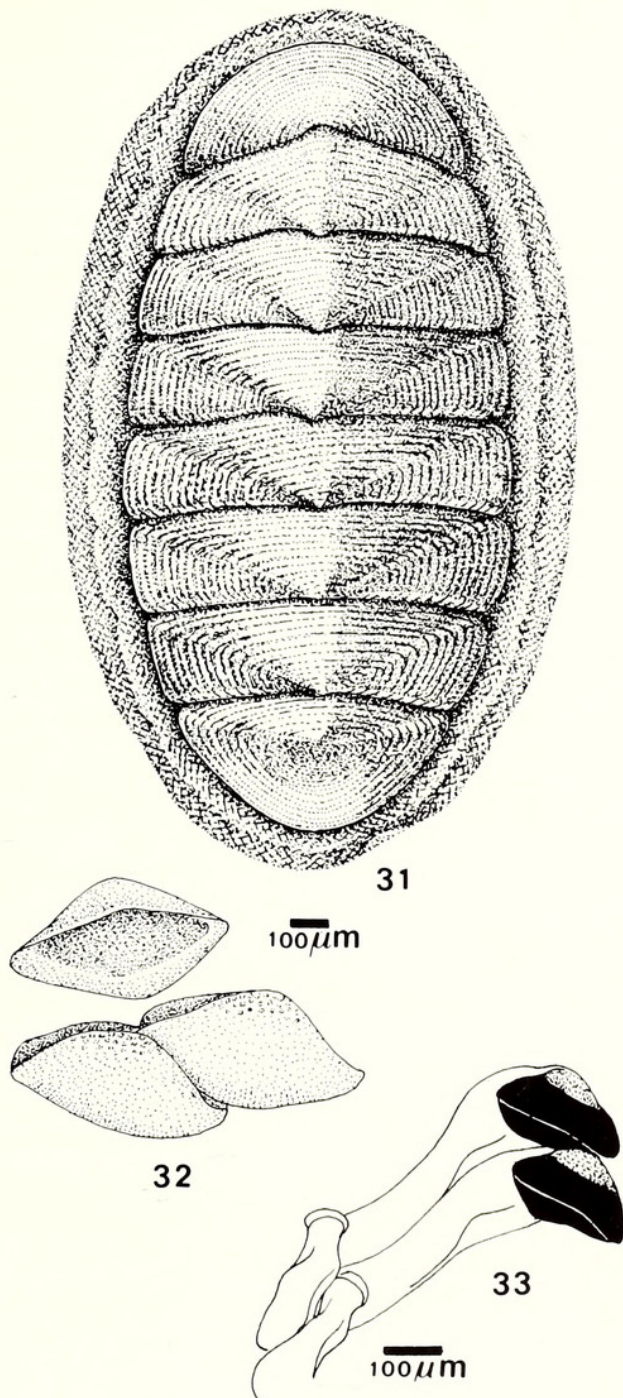
TYPE LOCALITY: Gulf of Suez.

DISTRIBUTION: Gulf of Suez, Red Sea and Somalia (southernmost record Sar Uanle), Arabian Gulf, the Gulf of Oman; intertidal to shallow subtidal.

DESCRIPTION: Dorsal girdle scales regularly imbricating, implanted in cuticula of girdle by diamond-shaped base, strongly curved dorsally, round-topped, ornamented with ca. 8 broad flat, weakly convergent ribs separated by narrow grooves, ca. $285 \times 140 \mu\text{m}$ (Figs. 34-39).

Radula (Fig. 40) with narrow central tooth, blade narrowly U-shaped; first laterals broad at base, in middle with wing-like procession on inner sides, abruptly narrowing distally, ending bluntly rounded without blade; major laterals with broad, oval head, free margin sharply edged; on the inside of it the shaft bears a slender, trunk-like appendix.

DISCUSSION: The quite extensive original description (Issel, 1869) has been supplemented by several authors. Leloup (1952) produced detailed figures of the girdle elements. Yaron (1973) demonstrated the consistent morphological differences



Figs. 31-33. *Chiton fosteri* Bullock (specimen from Oman, Masirah Id., Haql, K. Smythe leg. and coll.). **Fig. 31.** Whole specimen, dorsal view, 27.6 mm wide. **Fig. 32.** Dorsal girdle scales, above ventral view, below dorsal view. **Fig. 33.** First and major radula teeth.

between *Chiton affinis* and the related Mediterranean Sea species *C. (R.) olivaceus* Spengler, 1797. Ferreira (1983) described the radula.

Subfamily Acanthopleurinae Dall, 1889

Genus *Acanthopleura* Guilding, 1829

Type Species: *Chiton spinosus* Bruguière, 1792 (by subsequent designation, Gray, 1847).

Acanthopleura vaillantii de Rochebrune, 1882

Chiton testudo Spengler, 1797: 78 (*nom. nud.*).

Acanthopleura (sic !) *vaillantii* de Rochebrune, 1882: 192. Pilsbry, 1894: 97. Nierstrasz, 1906: 514. Winckworth, 1927: 206. Ferreira, 1983: 278; 1986: 226, 231, fig. 17.

Acanthopleura sp. (?) Haddon, 1886: 24.

Acanthopleura haddoni Winckworth, 1927: 206, pl. 28: figs. 1-4. Leloup, 1937: 172, figs. 17-19; 1960: 38. Pearse, 1978: 95, fig. 2. Leloup, 1980: 6. Bosch and Bosch, 1982: 145, fig. Smythe, 1982: 82. Ferreira, 1983: 278; 1986: 226, 227.

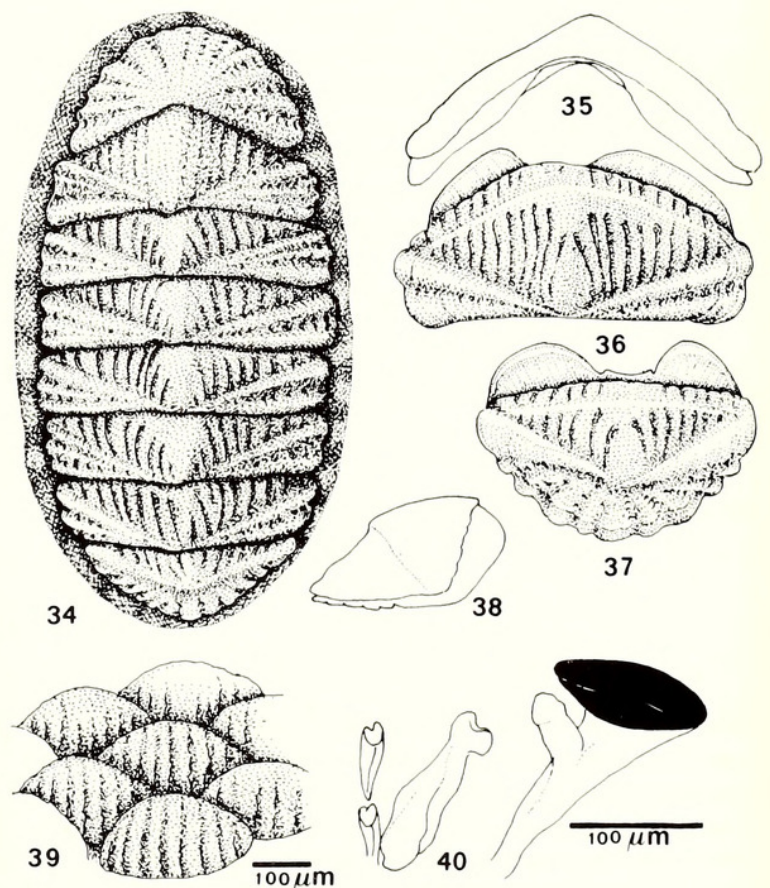
Chiton (Acanthopleura) haddoni, Biggs, 1958: 271; 1969: 201.

LECTOTYPE: MNHN (by subsequent designation, Ferreira, 1986).

TYPE LOCALITY: Suez Canal.

DISTRIBUTION: Red Sea, Yemen, Oman, Arabian Gulf at Jumeira (near Dubai), U. A. E., Khor Khaymah (S of As Shaam), U. A. E., Sharjah (N of Dubai), U. A. E., near Hormuz Id. and the opposite coast of Iran, also "at a point in Bahrain" (K. Smythe, in litt. 3 June 1987), on rocky shores and in rock pools.

DESCRIPTION: Animal large, to 75 mm long, width about 2/3



Figs. 34-40. *Chiton (Rhyssoplax) affinis* Issel. (specimens from Fuwairat, Qatar, June 1985. A. Woodward leg. in coll. Smythe, RMNH K5102). **Fig. 34.** Whole specimen, dorsal view, 6.7 mm wide. **Fig. 35.** Camera lucida sketch of valve IV, rostral view, 3.5 mm wide. **Fig. 36.** Valve IV, dorsal view, 3.5 mm wide. **Fig. 37.** Valve VIII, dorsal view, 2.75 mm wide. **Fig. 38.** Camera lucida sketch of valve VIII, lateral view, 1.94 mm wide. **Fig. 39.** Dorsal girdle scales. **Fig. 40.** Central, first lateral and major lateral radula teeth.

the length, broadly oval, moderately raised, back almost rounded, side slopes slightly convex, valves more or less beaked, generally strongly eroded. Tegmentum dark reddish to blackish brown, some specimens with traces of longitudinal bands of lighter color on jugum.

Head valve nearly semicircular, front slope convex, posterior margin concave in central part, convex toward sides. Intermediate valves broadly rectangular to widely V-shaped, side margins decidedly rounded, apices indicated, blunt, lateral areas little or not raised, hardly marked. Tail valve less than semicircular, crescentic in some specimens, as wide as head valve, mucro somewhat raised, postmedian.

Tegmental sculpture, often indistinguishable on account of erosion and incrustation, consists of small, roundish tubercles arranged in irregular, more or less concentric rows. Extra-pigmentary eyes very small, abundantly distributed on end valves and more than half of lateral areas of intermediate valves.

Articulamentum glossy, dark brown in central part of valves, light greyish brown toward sides, apophyses large, rounded, somewhat obliquely directed, connected across sinus by short, concave jugal plate, insertion plates short, slit formula 10/1/9-10, slits narrow, inequidistant, slit rays not indicated, teeth finely but deeply grooved on dorsal side, pectinate, those of tail valve slightly directed anteriorly.

Girdle wide, dark brownish, or whitish with irregular dark brown bands, densely clothed dorsally with large, coarse, blunt-pointed, calcareous spines of different forms and sizes, interspersed with small, slender spicules. Marginal spicules more or less cylindrical, almost as long as dorsal spines, blunt-topped, with some wide, longitudinal ribs. Girdle paved ventrally with radiating rows very small, thick scales, slightly longer than wide, squarish at base, distally tapering to blunt top, ornamented with 4-5 strong, longitudinal ribs.

Central tooth of radula slenderly elongate, with broad, strongly convex blade, first lateral tooth irregularly rectangular, major lateral with large unicuspid head, denticle abruptly pointed. Gills holobranchial, abanal.

DISCUSSION: This large, easily recognizable species, was well described by several authors including Haddon (1886), Winckworth (1927) and Leloup (1937). Winckworth produced good figures of the complete animal and the loose valves, and Leloup gave detailed figures of the girdle elements. "*Chiton punctatus* L." of Spengler (1797:76) is probably a synonym. It was based on animals from the Red Sea, mostly desiccated and disarticulated specimens that have lost their girdle armature, leaving deep pits in the cuticula (hence: *punctatus*!). At the end of his description Spengler wrote (p. 78): "The Arabian Society sent it from the Red Sea together with other products of this sea. Due to the similarity of the valves it might be called *Chiton testudo*" (translated from Danish). Although *A. vaillantii* is the only representative of *Acanthopleura* in the Red Sea and Spengler's specimens undoubtedly belong to this genus, there is no certainty about their true identity, so the name *C. testudo* is to be regarded a nomen dubium, leaving *A. vaillantii* the oldest available valid name.

In the opinion of Ferreira (1986), *Acanthopleura vaillantii*

should be regarded as another of the many synonyms of *A. gemmata* (Blainville, 1825). Winckworth (1927), however, clearly showed his *A. haddoni* (= *vaillantii*) to be different from *A. spiniger* (Sowerby, 1840) [= *A. gemmata* (Blainville)] in several respects; "in *haddoni* the valves are broader, the diagonal ribs almost obsolete in adult and young specimens, the sculpture is finer and closer and is uniform over the central and lateral areas, the tail valve is more rounded; the insertion plates and sutural laminae are differently proportioned..."

Leloup (1937: 174) wrote: "The characteristics of the girdle and of the tegmentum as far as the aesthetes are concerned allow us to differentiate *A. haddoni* from *A. spiniger*" (Sowerby, 1840). On the one side the girdle of *spiniger* dorsally bears an underground of uniform, small, brown spicules, which *haddoni* does not show; the thick spines are fairly regularly equal in *spiniger*, whereas they are very irregular in shape and of unequal dimensions in *haddoni*; the scales of the ventral side are relatively longer in *spiniger*. On the other side the aesthetes show the same general aspect, but they are more globulous in *haddoni*, especially in the lateral areas" (translated from French). We agree with the arguments of Winckworth and Leloup and retain *A. vaillantii* as a valid species.

Subfamily Toniciinae Pilsbry, 1893

Genus *Tonicia* Gray, 1847

Type Species: *Chiton elegans* Frembly, 1827 (non de Blainville, 1825) (= *Chiton chilensis* Frembly (1827) (by subsequent designation, Gray, 1847).

Subgenus *Lucilina* Dall, 1882

Type Species: *Chiton confossus* Gould, 1846 (= *Chiton lamellosus* Quoy and Gaimard, 1835) (by subsequent designation, Pilsbry, 1893).

Tonicia (*Lucilina*) *sueziensis* (Reeve, 1847)

Figs. 41-44

Chiton sueziensis Reeve, 1847: pl. 20, sp. and fig. 134.

Tonicia pygmata de Rochebrune, 1883: 33. Ferreira, 1983: 274, fig. 28.

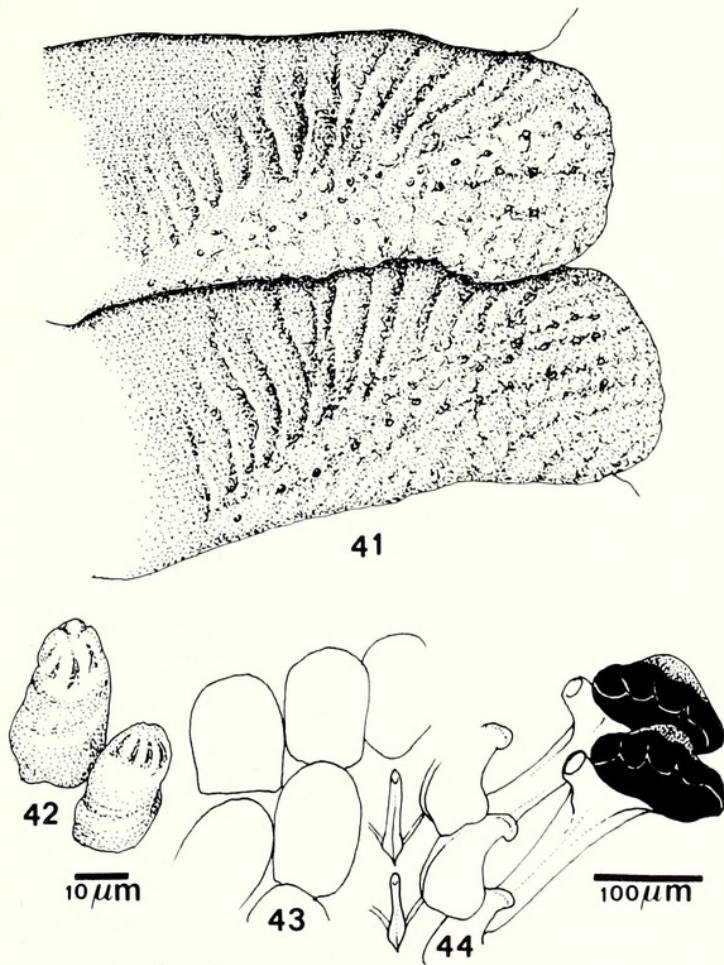
Tonicia sueziensis (sic!), Leloup, 1960: 40, figs. 6, 8, pl. 1, fig. 1 (bibliography and synonymy); 1973: 9, 18; 1980: 12.

Tonicia sueziensis, Kaas, 1979: 871. Ferreira, 1983: 271, figs. 25-27; Kaas, 1986: 18.

LECTOTYPE: BMNH 1951.2.7.7 (by subsequent designation, Ferreira, 1983).

MATERIAL EXAMINED: KUWAIT: 2 spec., max. 12 x 7 mm, Bide Circle, under stones in tidepool, F. Hinkle leg., 12 June 1978, FH. —3 spec., max. 9.5 x 6.5 mm, id., 1 Aug 1981, FH; —5 spec., max. 13 x 7.5 mm, id., 10 Apr 1983, FH. BAHRAIN: 1 valve, in shell grit on beach, Nov 1971, F. van Nieulande don., VB 2610a. QATAR: 2 spec., max 9 x 6 mm (slightly curled), Fuwairat, on rocks and dead coral, 0-1 m, June 1985, A. Woodward leg., 1/KS, 1/RMNH K 5102. —1 spec., 22.5 x 8.5 mm, AL Wakrah, on loose rocks covered with algae and weed, 0-1.5 m, June 1984, A. Woodward leg., KS.

DISTRIBUTION: Gulf of Suez, Red Sea, coasts of Somalia, Seychelles Is and Coetivy Id.; Kuwait, Bahrain and Qatar; intertidal to shallow subtidal.



Figs. 41-44. *Tonicia (Lucilina) sueziensis* (Reeve) (specimen from Fuwairat, Qatar, June 1985, A. Woodward leg. in coll. Smythe, RMNH K5098). **Fig. 41.** Right half of valves IV and V in situ, 4.25 mm wide. **Fig. 42.** Dorsal girdle spicules. **Fig. 43.** Ventral girdle scales. **Fig. 44.** Central, first and major lateral radula teeth.

TYPE LOCALITY: Egypt, Suez.

DESCRIPTION: *Tonicia (Lucilina) sueziensis* was adequately described by several authors, particularly Leloup (1960), who produced detailed figures of the girdle elements, and Ferreira (1983), who gave good figures of the lectotype and an accurate description of the radula.

Girdle covered dorsally with extremely minute, bullet-shaped spicules, $36 \times 20 \mu\text{m}$, top with 4-5 short riblets on visible half; ventral scales (Fig. 43) arranged in lateral rows, rectangular, base slightly concave, top rounded, $25 \times 19 \mu\text{m}$ (Figs. 41-43).

Central tooth of radula (Fig. 44) small, very narrow, $68 \times 7 \mu\text{m}$, with sharply pointed blade; first laterals broad, base bluntly pointed, pinched in middle, gradually widening distad, with outwardly directed extension; major laterals with tetracuspoid head, denticles short, bluntly rounded, shaft with trunk-like appendix just under and beneath head, directed inward.

DISCUSSION: Ferreira (1983: 274) wrongly synonymized *Tonicia (Lucilina) carnosus* Kaas, 1979, from Mozambique, the

Comoro Archipelago, and Madagascar, with the present species. *T. (L.) carnosus* differs considerably in color and in having much weaker sculpture with far fewer longitudinal grooves on central areas of intermediate valves.

Genus *Onithochiton* Gray, 1847

Type Species: *Chiton undulatus* Quoy and Gaimard, 1835. *non* Olfers, 1818; Wood, 1828 (= *Onithochiton neglectus* de Rochebrune, 1881 (by subsequent designation, Gray, 1847).

Onithochiton erythraeus Thiele, 1910

Figs. 45-50

Onithochiton erythraeus Thiele, 1910: 98, pl. 10, figs. 53-55.

Leloup, 1941: 13; 1960: 42, 45, 47. Glynn, 1970: 17.

Kaas, 1979: 872. Ferreira, 1983: 276-277.

Onithochiton lyelli forma *erythraeus*, Pearse, 1978: 93, 95, fig. 3.

HOLOTYPE: ZMHU.

MATERIAL EXAMINED: OMAN: 1 spec., 16 mm, Arabian Sea, Masirah Id., 12 Jan 1984, D. Bosch leg., KS. —1 spec., length 21 mm, (slightly curled), id., Rassier, 9 Feb 1982, K. Smythe leg., KS. —2 spec., max. width 12.5 mm (both curled), between Rassier and Haql, K. Smythe leg., 1/KS 1/RMNH K5098. —1 spec., length 13 mm (curled), Haql, K. Smythe leg., KS.

TYPE LOCALITY: Erythraea, El Tor.

DISTRIBUTION: Gulf of Suez, Red Sea, and Arabian Sea coast of Oman; intertidal.

DESCRIPTION: Girdle densely clothed dorsally with tiny, bluntly pointed scales, ca. $23 \times 10 \mu\text{m}$, top with 5-7 riblets (Figs. 45-49). Marginal spicules (Fig. 50) smooth, cylindrical, bluntly pointed, ca. $90 \times 22 \mu\text{m}$; ventral scales very small, shorter than wide, ca. $20 \times 15 \mu\text{m}$.

Central tooth of radula (Figs. 46, 47) about twice as long as wide, widest in anterior part, with extremely narrow, abruptly pointed blade and median, raised riblet in anterior half, base equally pointed; first laterals twice length of central teeth, truncate at base, with central, short, sharp thorn, gradually narrowing anteriorly, ending in narrow, rounded blade; major laterals with tetracuspoid head, denticles short, blunt, shaft with short, funnel-shaped appendix just under and anteriorly of head; spatulate uncinal teeth with elongate triangular blade.

DISCUSSION: Though it has not been studied thoroughly before, *Onithochiton erythraeus* has been compared with several related *Onithochiton* species. Leloup (1941) concluded it was synonymous with *O. maillardi* (Deshayes, 1863) from Mauritius. Later, he (Leloup, 1960) considered both of these species, as well as *O. quercinus* (Gould, 1846) from New South Wales, *O. literatus* (Krauss, 1848) from South Africa, *O. wahlbergi* (Krauss, 1848) from the Cape of Good Hope, *O. rugulosus* Angas, 1867 from New South Wales, and *O. scholvi* Thiele, 1910 from New South Wales, to be junior synonyms of *O. lyelli* (Sowerby, 1832). Ferreira (1983) synonymized *O. wahlbergi*, *O. maillardi* and *O. erythraeus* with *O. literatus*. Kaas (1979) expressed some doubts as to the con-

Suborder Acanthochitonina
Family Acanthochitonidae Pilsbry, 1893
Subfamily Acanthochitoninae
Genus *Acanthochitona* Gray, 1821

Type Species: *Chiton fascicularis* Linnaeus, 1767 (by monotypy).

***Acanthochitona woodwardi* Kaas and Van Belle, sp. nov.**

Figs. 51-60

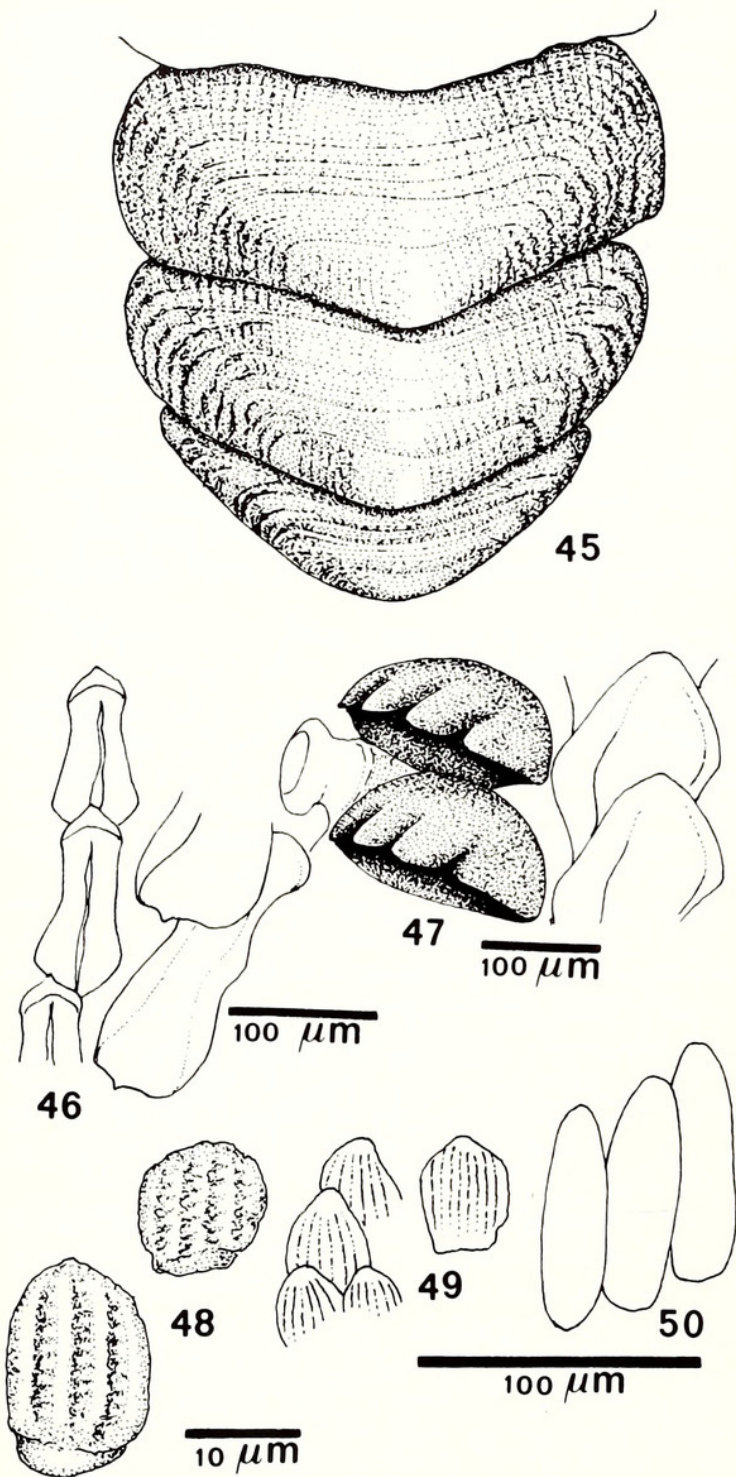
TYPE MATERIAL: HOLOTYPE: 6.7 x 4.0 mm, Qatar, Dasa, 15 Nov 1978, K. Smythe leg., BM(NH) 1987032. PARATYPES: QATAR: 17 spec., max. 9.0 x 4.7 mm, collected with holotype, 13/KS, 2/RMNH K5095 (one disarticulated, figured here), 2/VB 2968b. —2 spec. (curled, one on matchstick) Ras Abruks, 3 Nov 1978, A. Partridge leg., KS. —1 spec. (disarticulated), Ras Abruks, under broken slabs of fasht, intertidal, May 1982, A. Woodward leg., KS. —3 spec., Fuwairat, on rocks and dead coral, 0-1 m, June 1985, A. Woodward leg., 2/KS 1/RMNH K5096. —2 spec. (one juvenile), Al Wakrah, K. Smythe leg., KS. KUWAIT: 2 spec., Al Bide, on rocks in intertidal zone, 29 Jan 1975, B. Glayzer leg., 1/BG 1425 (as *Chiton* sp.), 1/KS (disarticulated, on slide). —2 spec., 5.5 x 3.0 mm (damaged) and 5.0 x 2.5 mm (disarticulated), Bide Circle, under stones in tidepool, MTL, F. Hinkle leg., 12 June 1978, former, FH, latter, VB 2968a. —1 spec., 8.5 x 4.0 mm, id., 1 Aug 1981, FH.

DISTRIBUTION: Kuwait and Qatar; intertidal.

DIAGNOSIS: Animal small, holotype 6.7 x 4 mm, length of largest specimen 9 mm, width about half length, elongate oval, rather flat (dorsal elevation 0.20-0.24), back subcarinate, side slopes straight to slightly convex, head and intermediate valves decidedly beaked. Tegmentum mostly whitish to light beige, speckled or flecked with dark greyish green, some specimens with light brownish or reddish brown, more or less triangular blotch on jugum of valve II, another specimen reddish, shading into roseate to whitish on apical areas, holotype blackish brown, with jugum and girdle whitish. Tegmental sculpture of flat, roundish to oval, neatly separated granules, jugal areas not raised, weakly ribbed longitudinally. Girdle finely spiculate, little encroaching at sutures. Major lateral radula tooth tricuspid.

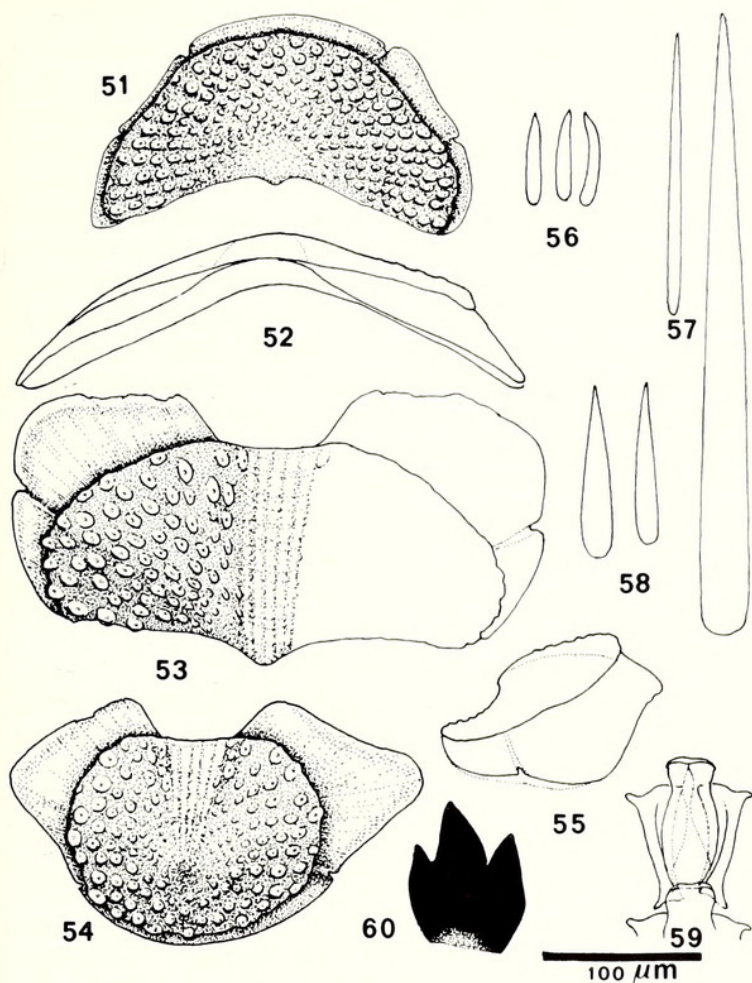
DESCRIPTION: Head valve (Fig. 51) semicircular, front slope somewhat convex, anterior margin vaguely waved, posterior margin beaked, tegmentum sculptured with neatly separated, flat, roundish to oval, quincuncially arranged granules, larger toward outer margin, smaller, becoming obsolete toward apex, no growth lines. Intermediate valves (Figs. 52-53) twice as wide as long, front margin straight to slightly convex at both sides of concave jugal part, hind margin concave at both sides of strongly protruding apex, jugal area narrowly wedge-shaped, not raised, sculptured with ca. 5 weak, flat, longitudinal ribs separated by very fine grooves, lateral areas not marked but slightly raised with regard to pleural areas, sculpture of latero-pleural areas similar to that of head valve but granules larger, more widely spaced, less regularly arranged. Tail valve (Figs. 54, 55) slightly oval transversely, mucro prominent, pointed, somewhat behind centre, posterior slope strongly concave, tegmentum sculptured like latero-pleural areas of intermediate valves.

Articulamentum whitish, tegmental color slightly visible through, intermediate valves with transverse callus in cen-



Figs. 45-50. *Onithochiton erythraeus* Thiele. Fig. 45. Valves VI-VIII in situ, dorsal view, 10.3 mm wide. **Fig. 46.** Central and first lateral radula teeth. **Fig. 47.** Major lateral and spatulate uncinal teeth. **Fig. 48.** Dorsal girdle scales from mid-girdle. **Fig. 49.** Same, near outer margin. **Fig. 50.** Marginal spicules.

clusions of Leloup (1960). Pending a thorough study of the type material and good specimens from the different localities, we prefer to treat the matter conservatively and consider *O. erythraeus* a valid species, especially after we were able to compare the Oman specimens with several lots of *O. literatus* from Isipingo, Natal, and Inhaca Id., Lourenço Marques, Mozambique, which proved to be quite differently sculptured.



Figs. 51-60. *Acanthochitona woodwardi* sp. nov. **Fig. 51.** Valve I, dorsal view, 3.33 mm wide. **Fig. 52.** Camera lucida sketch of valve IV, rostral view, 4.44 mm wide. **Fig. 53.** Valve IV, dorsal view, 4.44 mm wide. **Fig. 54.** Valve VIII, dorsal view, 3.38 mm wide. **Fig. 55.** Camera lucida sketch of valve VIII, lateral view, 1.95 mm. **Fig. 56.** Dorsal girdle spicules. **Fig. 57.** Small and large spicule from sutural tuft. **Fig. 58.** Ventral spicules. **Fig. 59.** Central and first lateral radula teeth. **Fig. 60.** Blade of major lateral tooth. (Figs. 56-60, scale bar = 100 μ m.)

tral part, apophyses rounded, sharp, smooth, jugal sinus about 1/5 valve width, weakly concave, insertion plates rather short, slit formula 5/ 1/ 2 (figured specimen with only 4 slits in valve I), slits shallow, slit rays hardly or not indicated, teeth sharp, smooth to very finely striate, eaves solid.

Girdle densely covered dorsally with small, straight to slightly bent, abruptly pointed, smooth spicules, ca. 60 x 10 μ m (Fig. 56), sutural tufts relatively short, composed of straight, slender, sharply pointed, smooth spicules of different sizes, varying from 180 x 8 μ m to 400 x 30 μ m (Fig. 57). Ventral side of girdle paved with close set, radiating rows of sharply pointed, smooth spicules, up to 100 x 20 μ m (Fig. 58). Marginal spicules similar to ventral ones.

Central tooth of radula (Fig. 59) elongate tulip-shaped, with thin blade, first lateral tooth somewhat shorter, slender, slightly widening distally, anterolateral corner with sharply pointed outward lobe, no blade, major lateral with tricuspid head, denticles pointed, central one longer than others (Fig. 60).

Gills merobranchial, abanal, 11 ctenidia per side.

DISCUSSION: This species cannot be attributed to any known species in the Indian Ocean. *Acanthochitona mahensis* Winckworth, 1927, from Mahé, India, and *A. ashbyi* Leloup, 1937, from the Indian Ocean (?), possibly a synonym of the former, differ in their greater size, more close packed, coarser granules, finely ribbed jugal areas, relatively wider tail valves with convex postmucronal slope, and longer, coarser, longitudinally striate marginal girdle spicules. In *A. curvisetosus* Leloup, 1960, from the Red Sea, the granules are smaller and more rounded, the jugal areas relatively wider and ornamented with ca. 15 longitudinal striations, and, contrary to those of *A. woodwardi*, the ventral girdle spicules are smaller than the dorsal ones. *A. limbata* Kaas, 1986, from Madagascar, differs in the form of the valves, the drop-shaped granules, the much broader jugal areas, and the form of the major lateral radula tooth.

ETYMOLOGY: This species is named after Mr. A. J. Woodward.

Genus *Notoplax* H. Adams, 1861

Type Species: *Cryptoplax (Notoplax) speciosa* H. Adams, 1861 (by monotypy).

Subgenus *Notoplax* s.s.

Notoplax (N.) arabica Kaas and Van Belle, sp. nov.

Figs. 61-72

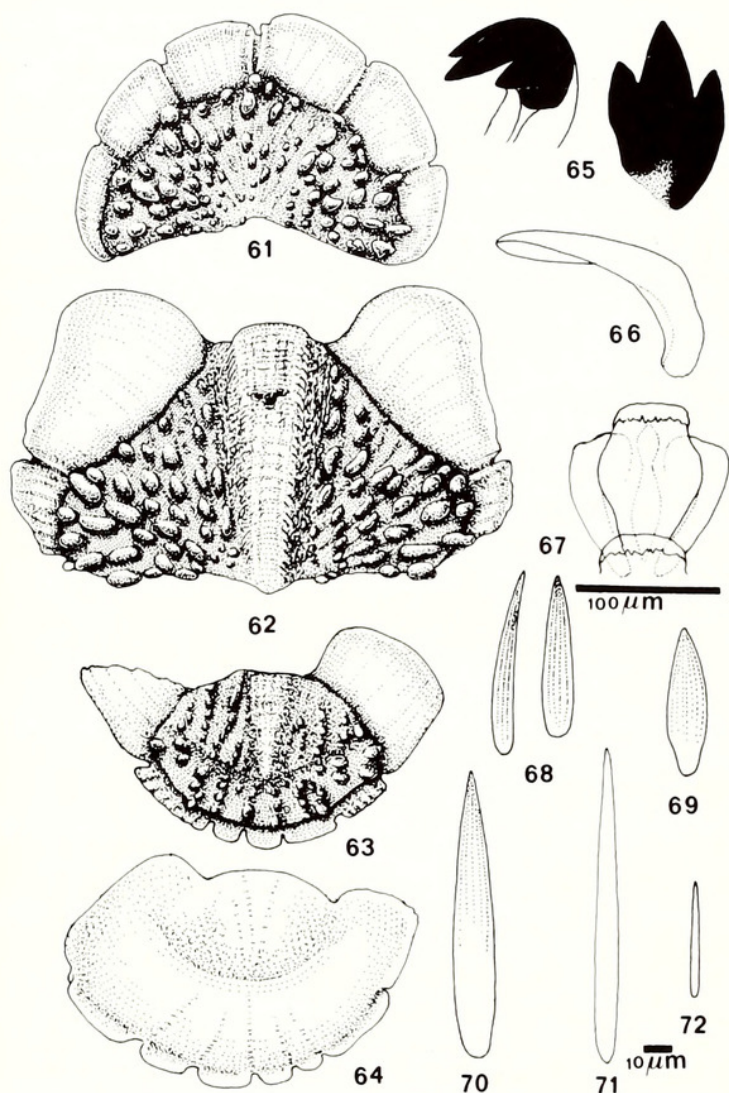
Schizochiton jousseumei, Smythe, 1982: 84, fig. 18 (non Dupuis, 1917). Glayzer et al., 1984: 324.

TYPE MATERIAL: HOLOTYPE, 11.4 x 5.9 mm, Kuwait Bay, Kuwait, on rocks and dead shells, intertidal, 14 Feb 1975, B. Glayzer leg., BMNH 1987031. PARATYPES: 2 spec., 9.9 x 5 mm and 8.3 x 3.9 mm, collected with holotype, BG 1195. —7 valves (disarticulated), collected with holotype, RMNH K5106. —1 spec., 11.0 x 6.0 mm (disarticulated), Fuwairat, Qatar, on rocks and dead coral, 0-1 m, June 1985, A. Woodward leg., KS.

DISTRIBUTION: Kuwait, Qatar; intertidal.

DIAGNOSIS: Animal small, 10-11 mm long, width about half length, rather flat, side slopes slightly convex, valves little beaked. Tegmentum uniformly light ochraceous, greyish or light orange, coarsely sculptured with large, strongly elevated, radially directed, elongate pustules, jugal areas wedge-shaped, raised, back rounded, neatly separated from the adjacent lateropleural areas by deep, wide grooves. Girdle finely spiculose, deeply encroaching between valves. Major lateral radula tooth tricuspid.

DESCRIPTION: Head valve (Fig. 61) nearly semicircular, front slope weakly convex, anterior margin with five more or less distinct waves, posterior margin widely V-shaped, minutely notched in middle, no trace of radial ribs. Intermediate valves (Fig. 62) broadly triangular, front margin slightly concave at both sides of strong, forwardly produced, convex jugal part, hind margin weakly beaked, somewhat sinuose at sides, apices sharply pointed, lateral areas indiscernible. Tail valve (Figs. 63, 64) very small, transversely oval, mucro prominent, not elevated, slightly postmedian, posterior slope deeply concave.



Figs. 61-72. *Notoplax arabica* sp. nov. **Figs. 61-63.** Valves I (4.0 mm wide) V (5.4 mm wide) and VIII (4.0 mm wide) respectively, dorsal view. **Fig. 64.** Valve VIII, ventral view (4.0 mm wide). **Fig. 65.** Heads of major lateral teeth. **Fig. 66.** Spatulate uncinal tooth. **Fig. 67.** Central and first lateral radula teeth. **Fig. 68.** Dorsal girdle spicules. **Fig. 69.** Marginal spicule. **Fig. 70.** Spicule from sutural tuft. **Fig. 71.** Spicule from girdle bridge. **Fig. 72.** Ventral spicules (Figs. 65-67, scale bar = 100 μ m; Figs. 68-72, scale bar = 10 μ m).

Tegmentum microscopically granulose, end valves and lateropleural areas of intermediate valves sculptured with large, strongly raised, convex, widely spaced, irregularly oval to decidedly elongate, radially oriented pustules, those near valve margins overhanging or projecting past valve, on some valves pustules vaguely arranged in irregular, longitudinal rows, jugal areas raised, smooth to naked eye, ornamented with extremely fine, longitudinal, beaded riblets, accompanied by shallow, longitudinal excavation on both sides.

Articulamentum slightly translucent, tegmental color shining through, apophyses strongly forwardly produced, rounded, jugal sinus moderately to strongly convex, insertion plates long, slit formula 5/ 1/ 6, slits shallow, those of tail valve inequidistant, slit rays hardly or not indicated, teeth of head and intermediate valves long, sharp, weakly striate dorsally, those of tail valve short, blunt, strongly striate.

Girdle dorsally covered with small, straight to slightly bent, sharply pointed, faintly longitudinally striate spicules, 56-62 μ m long, 8-10 μ m thick (Fig. 68), on girdle bridges interspersed with long, slender, straight, smooth spicules, 110 \times 8 μ m (Fig. 71), sutural tufts composed of stout, straight, sharply pointed spicules, 100 \times 14 μ m, weakly longitudinally striate on distal half (Fig. 70). Marginal spicules (Fig. 69) small, decidedly obese, blunt-pointed, finely longitudinally striate, 52 \times 14 μ m. Girdle paved ventrally with very small, slender, straight spicules, 40 \times 3 μ m (Fig. 72).

Central tooth of radula (Fig. 67) tulip-shaped, with straight blade, first lateral tooth somewhat shorter, narrowly aliform, without blade, major lateral with tricuspid head, denticles pointed, central one longer than others (Fig. 65), spatulate uncinal tooth bent, smooth, distal end rounded.

DISCUSSION: By its peculiar sculpture of large, elongate, convex, widely spaced pustules, *N. arabica* differs markedly from all known *Notoplax* spp. in the Indian Ocean, its closest relatives being *N. elegans* Leloup, 1981, from Madagascar, which has a greater number of close set, subcircular, concave granules, *N. alisonae* (Winckworth, MS; Kaas, 1976), from Sri Lanka, which has a much greater number of tear-shaped, flat to slightly concave granules, and *N. coarctata* (Sowerby, 1841), from the Philippines, in which the tegmentum of intermediate valves is flask-shaped.

ETYMOLOGY: The name of this species reflects its presence in the Arabian Gulf.

DISCUSSION

The most striking phenomenon among the present material is the discontinuous distribution of *Lepidozона luzonica*, hitherto known only from Luzon, Philippines, the Java Sea and Singapore. Its occurrence in the Arabian Gulf remains inexplicable except for transport resulting from human intervention via navigation. This is the case with *Chaetopleura angulata* (Spengler, 1797) and *Acanthochitona fascicularis* (Linnaeus, 1767). Another striking fact is the absence of *Chiton huluensis* (Smith, 1903), also discontinuously distributed, covering a vast area from the Tasman Sea through the Torres Straits, the Moluccas, the Timor Sea, the Maldiv Islands, Sri Lanka, the western coast of Madagascar, the coast of Mozambique, the Red Sea and through the Suez Canal to the Mediterranean coast of Israel. It should be remembered, however, that the bulk of material we studied was collected in intertidal or shallow subtidal areas, except for some specimens collected in 15-20 m depths by SCUBA.

Ferreira (1983) concluded that "at least as far as chiton faunas are concerned, the tropical western Indian Ocean constitutes a definite zoogeographic province, which includes the Red Sea, the East African coast southward to Natal, and the adjacent islands eastward to Mauritius (60°E)." Undoubtedly the chiton fauna of the western Indian Ocean is far richer in species than is that of the Indo-Arabian side. However, 50% of the species found in the Gulf and on the Oman coast also are found on the African coast, and all but one also occur in the Red Sea. On the other hand, *Callistochiton adenensis*

occurs on the Oman coast as well as in the Red Sea but has not been found in Somalia nor south of there. So we can conclude that the Red Sea chiton fauna is composed both of African and Indo-Arabian species. Nevertheless, a comparison of the faunas of both sides of the Indian Ocean leads to some preliminary conclusions. The genus *Chiton* s.s. is represented by two species on both sides: *C. peregrinus* in the east, *C. salihafui* Bullock, 1972, in the west, and *C. fosteri* on both sides. Two other Indo-Arabian chiton species reach their northern limit in the Gulf, *Ischnochiton winckworthi* and *Lepidozона luzonica*. *Acanthopleura vaillantii* appears to be the only representative of that genus in the east, whereas it is accompanied by *A. brevispinosa* (Sowerby, 1840) on the African coast. Two species of *Cryptoplax* have been reported from the African coast, of which *C. sykesi* Thiele, 1909, also is found in the Red Sea; none are found on the Indo-Arabian side.

Because of the limited number of chiton species occurring in the northern tropical Indian Ocean, the distribution data reviewed here do not allow zoogeographic provinces to be established.

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