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# Chitons (Mollusca, Polyplacophora) from São Tomé and Príncipe Islands

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ABSTRACT

The chiton fauna of São Tomé and Príncipe Islands is poorly known and here we present the first comprehensive and illustrated account of living Polyplacophora from these islands. Four species have been reported to date: *Lepidochitona rolani* Kaas & Strack, 1986, *Chiton lyratus* Sowerby, 1840, *Chiton canariensis* d'Orbigny, 1839 and *Notoplax productus* (Carpenter in Pilsbry, 1892). Two of these species are actually valid, while *C. lyratus* is considered a synonym of *Rhyssoplax canariensis*. *N. productus* was incorrectly considered to be the valid name for *Craspedochiton foresti* (Leloup, 1965). The present paper increases the list of living chiton species to 12, of which two are described as new, namely *Stenoplax hernandezi* sp. n. and *Callochiton saotomensis* sp. n. Three species are assigned only at generic level but reflect new records for these islands. Type specimens of *Chiton lyratus* and *Chiton canariensis* are figured.

KEY WORDS: Atlantic Ocean, Polyplacophora, Chitons, new species, systematics, type specimens.

## INTRODUCTION

The aim of this paper is to facilitate future research on the chiton fauna of the São Tomé and Príncipe Islands by providing the first comprehensive and illustrated revision of living Polyplacophora of this archipelago. During the past few decades, numerous papers on the molluscan fauna of West Africa have been published; some of them are devoted to the molluscan fauna of the São Tomé and Príncipe Islands (Fig. 1) (e.g. Gofas & Fernandes 1988; Fernandes & Rolán 1991, 1993; Rolán & Rubio 1990, 1996; Rubio & Rolán 1990; Rolán & Fernandes 1992; Gofas 1995; Rolán & Hernández 2007; Ryall *et al*. 2009; Horro *et al*. 2010; Houart & Rolán 2012; Rolán & Gori 2012). However, the chiton fauna of the archipelago has been little studied. The main contributions were published by Lamy (1907), Tomlin and Shackleford (1915) and Leloup (1965, 1968*a*), while the only recent revisionary paper which deals exclusively with the São Tomé and Príncipe Islands, is that of Fernandes and Rolán (1993). It summarizes information concerning the known polyplacophoran species: *Lepidochitona rolani* Kaas & Strack, 1986, *Chiton lyratus* Sowerby, 1840, *Chiton canariensis* d'Orbigny, 1839, and *Notoplax productus* (Carpenter in Pilsbry, 1892). To this list, however, must be added Leloup's (1968*a*) record of *Callochiton septemvalvis* (Montagu, 1803) from northeast of Príncipe and Mosteiros Islands. Within a framework of an inventory of the archipelago, numerous chitons were collected and are reported upon herein. *Inter alia*, two new species are described and range extensions delineated for some previously known species. A comprehensive faunal list of chitons at the archipelago level allows us to compare the biogeographic patterns of chitons on a regional scale.

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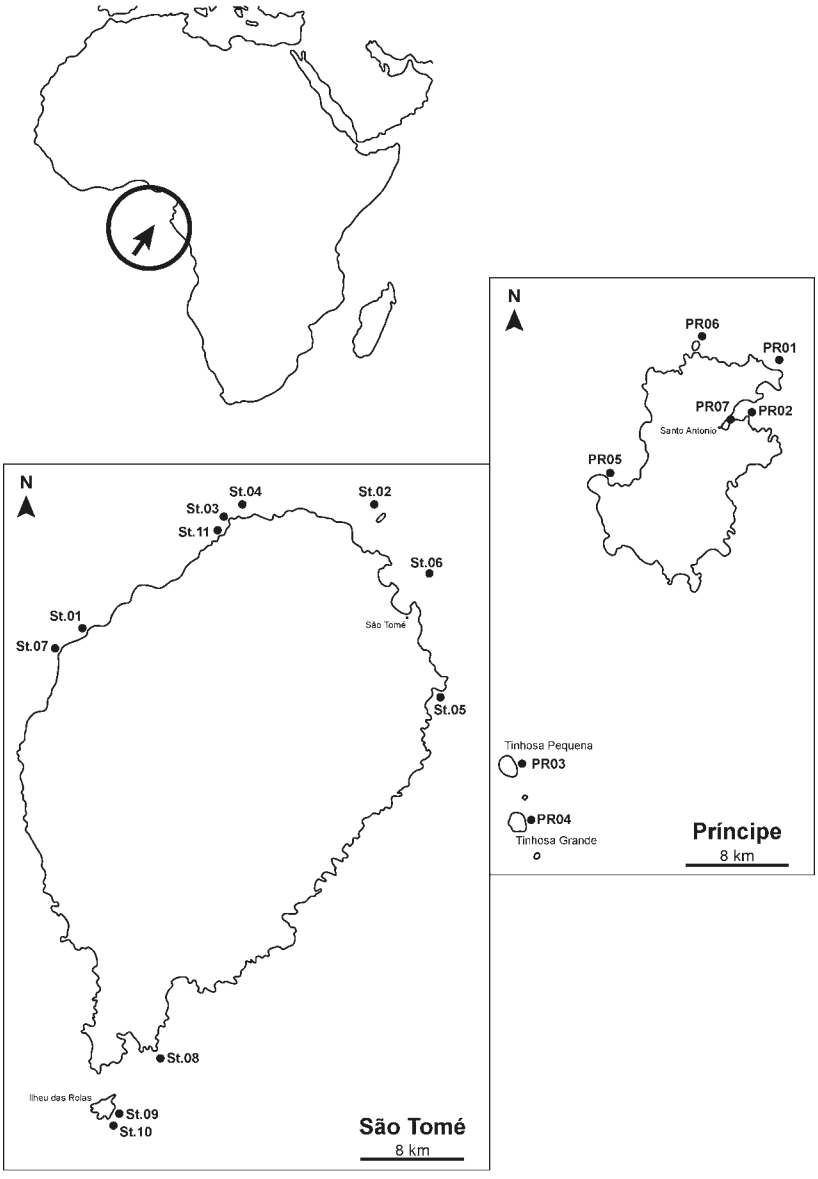


Fig. 1. Collecting localities of chitons from the São Tomé and Príncipe Islands.

## MATERIAL AND METHODS

The material originated mostly from collecting that was carried out in 2007–2012 by Sandro Gori (Livorno, Italy). The sampling was done mainly at a depth of 20–40 m, and yielded living specimens and some disarticulated valves, which were separated from large amounts of detritus. Specimens collected at the São Tomé and Príncipe Islands by Emilio Rolán (Spain) in 1989–1990 and 2006, and from amongst the material stored at the Bavarian State collection of Zoology (Munich, Germany), were also examined.

Scanning electron micrographs were taken using a Hitachi S-2400 and a JSM-5200 (at the MZB), with specimens used for SEM partly disarticulated, enabling examination of valves, perinotum, and radula. The dorsal elevation is determined by the ratio of the fourth valve height : valve width (Kaas & Van Belle 1981).
The sampling sites are listed in Table 1.
The higher classification used follows Sirenko (2006).

Abbreviations:

BD – Bruno Dell'Angelo collection, Genova, Italy (to be deposited in MZB);
ER – Emilio Rolán collection, Vigo, Spain (to be deposited in MHNS);
MHNS – Museo de Historia Natural, Santiago de Compostela, Spain;
MNCN – Museo Nacional de Ciencias Naturales, Madrid, Spain;
MNHN – Muséum National d'Histoire Naturelle, Paris, France;
MSNG – Museo Civico di Storia Naturale "Giacomo Doria", Genova, Italy;
MZB – Zoological Museum University of Bologna, Italy;
NHMUK – The Natural History Museum [formerly British Museum (Natural History)], London, United Kingdom;
NSMT – National Museum of Nature and Science, Tokyo, Japan;
RMNH – Nationaal Natuurhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie), Leiden, The Netherlands;
RSMNH – Royal Scottish Museum of Natural History, Edinburgh, United Kingdom;
SG – Sandro Gori collection, Livorno, Italy;
ZIS – Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia;
ZSM – Bavarian State collection of Zoology, Munich, Germany.

## TAXONOMY

### Class Polyplacophora Gray, 1821
### Subclass Loricata Schumacher, 1817
### Order Lepidopleurida Thiele, 1909
### Family Leptochitonidae Dall, 1889
### Genus *Leptochiton* Gray, 1847

*Leptochiton*: Gray 1847*a*: 127. Type species: *Chiton cinereus* Montagu, 1803, *non* Linnaeus, 1767 (= *Chiton asellus* Gmelin, 1791), by subsequent designation (Gray 1847*b*: 168).
For synonymy, see Kaas & Van Belle (1985*a*).

Distribution: Worldwide; Lower Carboniferous – Recent.

### *Leptochiton denhartogi* Strack, 2003

Figs 2A–D

*Leptochiton denhartogi*: Strack 2003: 409, figs 1–8; Schwabe 2005: 93; Lopez Cabrera & Olivero 2011: 973. Holotype: RMNH 94969. Paratypes: many specimens in several institutions (see Strack 2003). Type locality: Angola, Off Luanda, 50–60 m, attached to stones or dead shells.

Material examined: ST03: 1 intermediate valve, width 2.8 mm (BD 105).

Distribution: Angola and São Tomé Island.

Comparison and remarks: The characters of the single intermediate valve available are sufficient to identify the species with certainty. This is the first report of occurrence

TABLE 1
Sampling sites of chitons from São Tomé and Príncipe Islands.

| Sample code | Island | Site | Coordinates | Depth | Collector |
|---|---|---|---|---|---|
| ST01 | São Tomé | Esprainha | 00°20.09'N:06°31.14'E | | Rolán 11.04.1989 |
| ST02 | São Tomé | Kia Reef | 00°25.256'N:06°41.695'E | 15–25 m | SG 2007-2010 |
| ST03 | São Tomé | Lagoa Azul | 00°24.00'N:06°36.00'E | 10–37 m | SG 2007-2010, Rolán 1990, 2006 |
| ST04 | São Tomé | Praia Quatorze | 00°24.37'N:06°37.00'E | 72 m | SG 2007-2010 |
| ST05 | São Tomé | Ubabudu | 00°15.804'N:06°45.569'E | 20 m | SG 2007-2010 |
| ST06 | São Tomé | Minerio | 00°23.016'N:06°46.228'E | 41–47 m | SG 2007-2010 |
| ST07 | São Tomé | Ponta de Diogo Vaz | 00°19.159'N:06°29.633'E | 15–21 m | SG 2007-2012 |
| ST08 | São Tomé | Tauchstelle "Furnas" | 00°00.54'N:06°30.66'E | | Wittmann 26.11.2003 |
| ST09 | São Tomé | Ilheu das Rolas | - | 0–5 m | Wirtz 08.2002 |
| ST10 | São Tomé | Canal das Rolas | 00°00.92'N:06°31.79'E | | Wittmann 26.11.2003 |
| ST11 | São Tomé | Praia Mutamba | 00°23.50'N:00°36.17'E | 6 m | Rolán 1990, 2006 |
| PR01 | Príncipe | Mosteiros fora | 01°41.129'N:07°27.337'E | 20 m; rocks | SG 21.02.2011 |
| PR02 | Príncipe | Ponta da Mina | 01°38.438'N:07°26.258'E | 7 m; at night | SG 19.02.2011 |
| PR03 | Príncipe | Tinhosa Pequena | 01°22.521'N:07°16.535'E | 25 m; rocks | SG 23.02.2011 |
| PR04 | Príncipe | Tinhosa Grande | 01°20.413'N:07°17.698'E | 15 m | SG 11.02.2012 |
| PR05 | Príncipe | Bahia das Agulhas | 01°36.09'N:07°20.29'E | 15 m | Rolán 1990 |
| PR06 | Príncipe | Bom Bom Island | 01°41.47'N:07°24.14'E | | Wirtz 02.2004 |
| PR07 | Príncipe | Santo Antonio | 01°38.27'N:07°25.21'E | 8 m | Rolán 1990 |

of the species since it was described, and extends the geographical distribution to São Tomé Island.

*Leptochiton* sp.

Figs 2E–H

Material examined: ST11: 2 tail valves, maximum width 2.1 mm (BD 106).

Description:

Tail valve less than semicircular (Fig. 2E), mucro central, somewhat swollen although not prominent, antemucronal slope slightly convex, postmucronal slope slightly concave just behind the mucro (Fig. 2F).

Tegmentum coarsely sculptured, with rather irregular, roundish and obliquely elevated granules, arranged in longitudinal series, obliquely directed in antemucronal area, radially in postmucronal area. About 28 series of granules in antemucronal area, 31 in postmucronal area, interrupted by thin, commarginal growth lines, more evident in the postmucronal area. Granules with a central macroaesthete, and a few microaesthetes irregularly disposed along margin.

Articulamentum without insertion plates. Apophyses small, subtriangular.

Distribution: São Tomé Island.

Comparison and remarks: This species differs from other *Leptochiton* species living along the West African coast.

*Leptochiton denhartogi* Strack, 2003 has a coarser tegmental sculpture, with regularly arranged roundish granules that are completely different from those of *Leptochiton* sp. (cf. Fig. 2H with Fig. 2C).

*Leptochiton odhneri* (Bergenhayn, 1931), known from the northwestern coast of Africa, the Canary Islands, and Madeira, has a more weakly sculptured tegmentum, with granules that are arranged in quincunx on the head valve, the lateral areas of intermediate valves, and the postmucronal area of the tail valve.

The species is similar to *Leptochiton serenae* Dell'Angelo, Piccioli Resta & Bonfitto, 2007 from the Lower Pleistocene of southern Italy, which shows a more stressed sculpture pattern shaped by granules developed obliquely from the tegmentum, but a different tail valve shape (i.e. the anteriorly located mucro and the wider, trapezoidal apophyses).

The scarcity of material does not permit us to attribute it to a known species, so it is preferable to leave the identification as *Leptochiton* sp. until such time as more material becomes available, ideally complete specimens.

Order Chitonida Thiele, 1909

Suborder Chitonina Thiele, 1909

Family Ischnochitonidae Dall, 1889

Genus *Ischnochiton* Gray, 1847

*Ischnochiton*: Gray 1847*a*: 126. Type species: *Chiton textilis* Gray, 1828, by subsequent designation (Gray 1847*b*: 168).

For synonymy, see Kaas & Van Belle (1990).

Distribution: Worldwide, widespread in all seas, except for the northern Atlantic and Arctic Oceans. Eocene – Recent.

### *Ischnochiton* cf. *rissoi* (Payraudeau, 1826)

Figs 2I–K

*Chiton rissoi*: Payraudeau 1826: 87, pl. 3, figs 4–5.
*Ischnochiton* (*I.*) *rissoi*: Kaas & Van Belle 1990: 78, fig. 32; Dell'Angelo & Smriglio 1999: 100, pls 29–31, figs 40–48. Syntype: MNHN 6109 (not seen). Type locality: France, Bonifacio, Corse (41°23'10"N 09°09'31"E).

Material examined: ST06: 1 specimen, length 1.3 mm (BD 107).

Distribution: São Tomé Island.

Comparison and remarks: The single available specimen shares with *Ischnochiton rissoi* a similar tegmental sculpture and dorsal girdle scales. *I. rissoi* varies considerably in size and sculpture (Carmona Zalvide & García 1999; Dell'Angelo & Smriglio 1999). The sculpture of the specimen examined is similar to the "forma 4" described by Carmona Zalvide and García (1999), from the Gibraltar area. The minute size of the specimen and the fact that the nominal species has so far not been reported from the African Atlantic coast, led us to the tentative identification. *I. rissoi* is typically Mediterranean, and recorded from the Atlantic only in the vicinity of Gibraltar. Records from the Canary Islands (Shuttleworth 1853; Bergenhayn 1931) as well as the Selvagens and Azores Islands (Bergenhayn 1931) require confirmation.

### *Ischnochiton* sp.

Figs 2L–Q

Material examined: ST06: 1 specimen, length 2 mm (BD 108).

Distribution: São Tomé Island.

Comparison and remarks: This specimen is characterized by a tegmental sculpture consisting of rough and closely spaced nodules, irregular in outline and irregularly distributed (Figs 2O–P). The dorsal girdle is beset with rectangular overlapping scales, bearing up to 11 strong ribs (Fig. 2Q).

Only five species of *Ischnochiton* are known from the northern and central Atlantic African coasts and islands, namely *I. sererorum* (de Rochebrune, 1881) from Mauritania and Cape Verde Islands, *I. cessaci* (de Rochebrune, 1881) from Mauritania, Senegal, Angola, Canary Islands and Cape Verde Islands, *I. goreensis* Thiele, 1909 from Senegal and Cape Verde Islands, *I. paessleri* Thiele, 1909 from Cape Verde Islands, and *I. nicklesi* Kaas & Van Belle, 1990, from Senegal and Cape Verde Islands (Kaas & Van Belle 1990; Rolán 2005, 2011). However, all have a tegmental sculpture that is mainly smooth or finely granulose.

Congeners from South African Atlantic waters, namely *I. textilis* (Gray, 1828), *I. oniscus* (Krauss, 1848), *I. bergoti* (Vélain, 1877), and *I. elizabethensis* Pilsbry, 1894, could also be found along part of the southwest African coast but differ from the present specimen not only in their generally larger size, but they also have morphological peculiarities, summarized in Kaas and Van Belle (1990) and Sirenko and Schwabe (2002), that are lacking in this specimen, although their juvenile stages have not been carefully compared.

Description of a new species on the basis of the single small specimen is not justified, so it is preferable to leave the identification as *Ischnochiton* sp. until such time as more material becomes available.

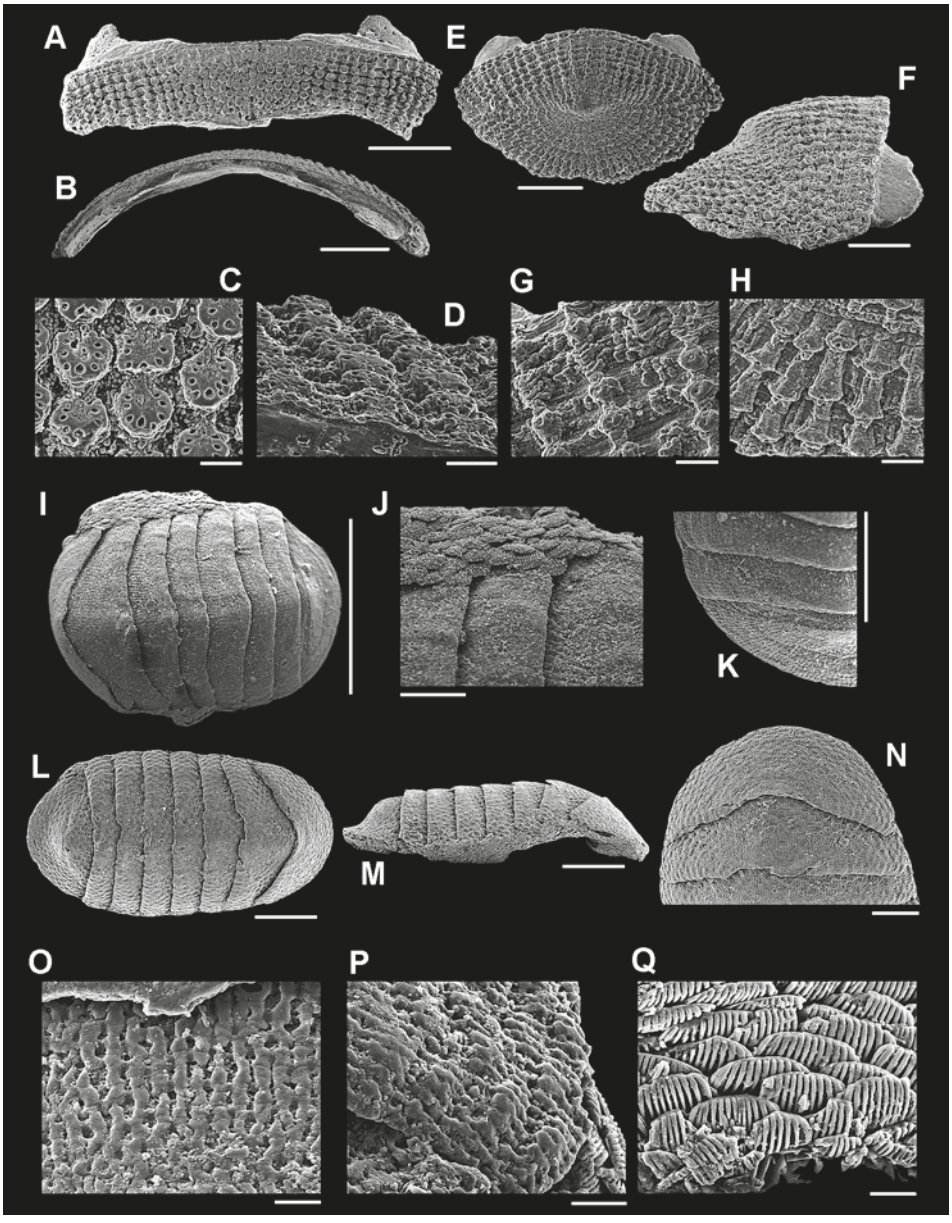


Fig. 2. (A–D) *Leptochiton denhartogi* Strack, 2003, São Tomé Island, ST03, intermediate valve: (A–B) dorsal and frontal views, (C–D) detail of the sculpture of the tegmentum, close-ups of granules with aesthetes in different views; (E–H) *Leptochiton* sp., São Tomé Island, ST11, tail valve: (E–F) dorsal and lateral views, (G–H) detail of the sculpture of antemucronal and postmucronal areas, respectively; (I–K) *Ischnochiton* cf. *rissoi* (Payraudeau, 1826), São Tomé Island, specimen from ST06: (I) dorsal view, (J) dorsal girdle scales, (K) detail of the intermediate and tail valves; (L–Q) *Ischnochiton* sp., São Tomé Island, specimen from ST06: (L–M) dorsal and lateral views, (N) detail of the head and the first intermediate valves, (O–P) detail of the sculpture of central and lateral areas, respectively, (Q) dorsal girdle scales. Scale bars = 1 mm (B); 800 μm (I); 600 μm (A); 500 μm (E); 400 μm (L, M); 300 μm (F, K); 200 μm (N); 100 μm (J); 60 μm (G, H); 50 μm (D); 40 μm (C); 30 μm (P); 20 μm (O, Q).

## Genus *Stenoplax* Dall, 1879

*Stenoplax*: Dall 1879: 296. Type species: *Chiton limaciformis* Sowerby, 1832, by original designation. For synonymy, see Kaas & Van Belle (1987).

Diagnosis: Of small to large size, elongate, the length 2 to 3 times the width, tail valve relatively large, depressed, mucro subcentral and inconspicuous, slit formula many / 1 or more / many, girdle decorated with minute to large, more or less elongate scales, or with stout, bent, striated spines (Kaas & Van Belle 1987).

Distribution: East Pacific Ocean (from Canada to Peru), Indo-Pacific Ocean (from Japan to India), Indian Ocean (Madagascar), West Atlantic Ocean (from Florida to Brazil). Eocene – Recent.

Remarks: The genus *Stenoplax* is divided in two subgenera, *Stenoplax* s.s. (having the insertion plates of intermediate valves single-slitted), and *Stenoradsia* Dall, 1879 (having the insertion plates of intermediate valves multi-slitted). This character does not reflect phylogenetic affinity amongst the scattered, non-eastern Pacific species (Eernisse pers. comm.), so we do not consider an attribution at subgeneric level.

### **Stenoplax hernandezi** sp. n.

Figs 3A–U, 9A–B

Etymology: Named in honour of José María Hernández, malacologist from Gran Canaria, who passed away recently. He had frequently been a companion of Sandro Gori on trips and dives.

Description:

General shell shape: Animal small, up to 8 mm long, holotype 7.6 × 3.3 mm (Fig. 9A), elongate oval, much longer than twice the width, moderately elevated (dorsal elevation 0.31), back evenly rounded with convex side slopes. Colour of tegmentum uniformly light orange, somewhat variegated, with sandy brown streaks or flecks. Girdle of the same colour, with lighter bands present.

Head valve semicircular (Fig. 3F), posterior margin widely V-shaped. Intermediate valves (Fig. 3I) with anterior margin slightly convex and sinuate at both sides, side margins rounded, posterior margin more or less straight, apices not evident, lateral areas little raised, poorly defined. Tail valve semicircular (Fig. 3L), length less than ⅔ of width, anterior margin straight and directed backwards laterally, mucro central, poorly evident, antemucronal slope slightly convex (Fig. 3M), postmucronal slope slightly concave just behind the mucro.

Head valve, lateral areas of intermediate valves, and postmucronal area of tail valve sculptured with many close-set, irregularly undulate concentric grooves, better defined towards periphery (Fig. 3H); central area of intermediate valves and antemucronal area of tail valve smooth, some longitudinal grooves present but hardly visible.

Articulamentum: Apophyses triangular, widely separated by a straight sinus (Fig. 3J), insertion plates short, slit formula 15 / 3 / 11, slit rays neatly indicated by distinct rays of pores, teeth sharp and not equidistant, eaves narrow.

Girdle: Densely covered with small, rectangular, slightly bent, imbricating scales dorsally (Fig. 3S), rounded at the top, up to 55 µm long and 65 µm wide, with 14–15 narrow riblets, interstices wider. Compared to congeners, the scales are smaller, more rectangular and distally straight along a narrow strip at the margin, among which arise

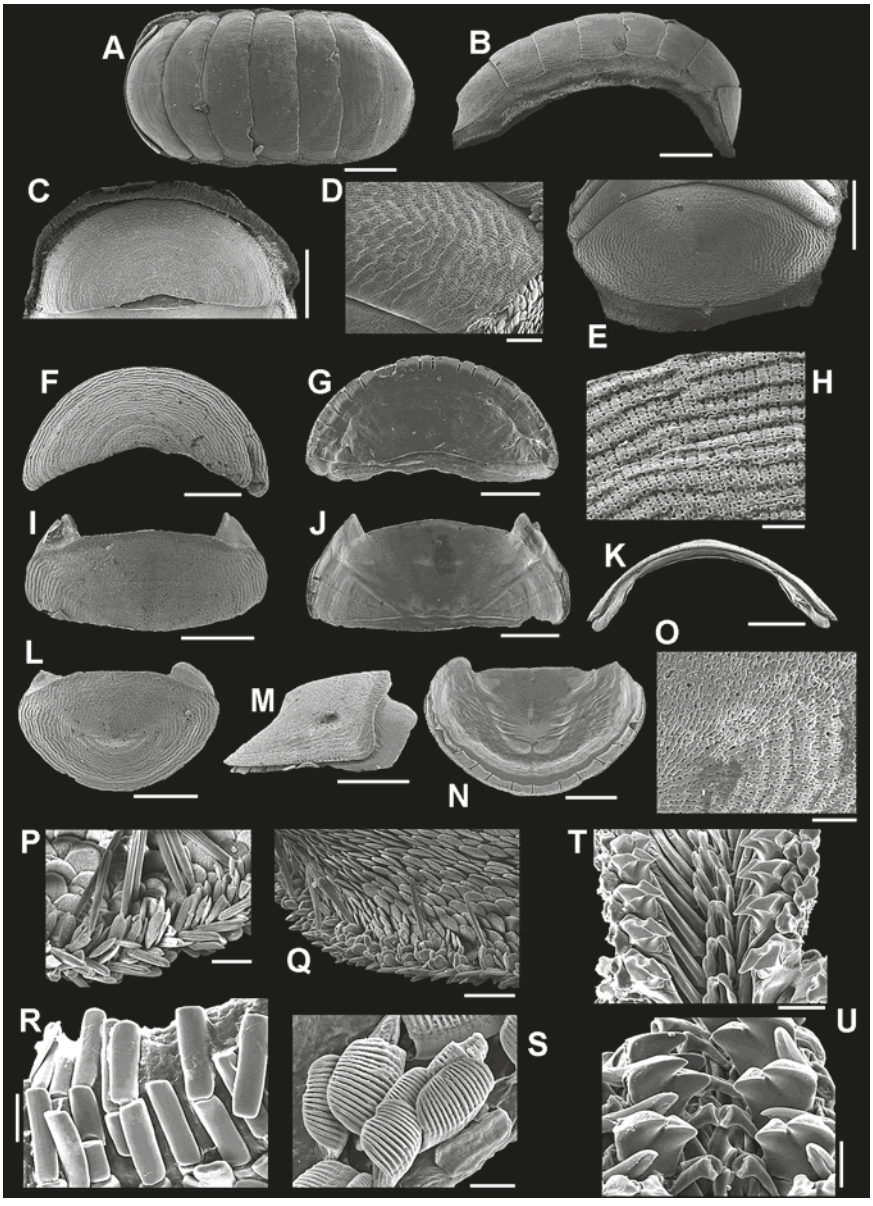


Fig. 3. (A–U) *Stenoplax hernandezi* sp. n., São Tomé Island: (A–E), (P–Q), (T–U) specimen from ST10 (ZSM Mol-20034150), length 5.7 mm, disarticulated and coated for SEM analysis, (A–B) dorsal and frontal views, (C) detail of the head valve, (D) detail of the sculpture of an intermediate valve, (E) detail of the tail valve, (P–Q) girdle formations *in situ*, (T–U) radula, (T) complete view, (U) detail of major lateral tooth; (F–O), (R–S) paratype MZB 49752, specimen from ST06, length 6.8 mm, disarticulated and coated for SEM analysis, (F–H) disarticulated head valve, (F–G) dorsal and ventral views, (H) detail of the sculpture, (I–K) disarticulated intermediate valve, dorsal, ventral and frontal views, (L–O) disarticulated tail valve, (L–N) dorsal, lateral and ventral views, (O) detail of the sculpture, (R–S) detail of girdle formations, (R) ventral spicules, (S) dorsal scales. Scale bars = 1 mm (A, B); 800 µm (C, E, I, L); 600 µm (F, G, J, K, M, N); 100 µm (D); 80 µm (O, Q); 60 µm (H, T); 40 µm (P); 30 µm (R, S, U).

some conical, weakly longitudinally striated, pointed spines, up to 100 μm long (Fig. 3Q). Marginal fringe composed of small, longitudinally striated, pointed spines, *ca* 47 × 8 μm (Fig. 3P). Ventrally, the girdle is paved with radiating rows of small, cylindrical, smooth spicules (Fig. 3R), up to 60 μm long.

Radula: Central tooth small and narrow, first lateral tooth elongate (Fig. 3T), with a narrow blade and a subapical wing, major lateral tooth (Fig. 3U) bears a bicuspid head with two equally strong denticles.

Holotype: SÃO TOMÉ AND PRÍNCIPE: São Tomé, Minerio, ST06, 7.6 × 3.3 mm, Fig. 9A (MZB 49751).

Paratypes: Same data as holotype: 1 specimen, length 5.5 mm, slightly curled (BD 109); 1 specimen, length 7 mm, slightly curled (MNHN IM-2012-2701); 1 specimen, length 6.8 mm, disarticulated and coated for SEM analysis (MZB 49752); 1 specimen, length 4.9 mm, slightly curled (SG); 1 specimen, length 5.6 mm, slightly curled (ZISP 2197). Other paratypes: ST10, 1 specimen in alcohol, length 5.7 mm (ZSM Mol-20034146); ST10, 1 specimen in alcohol, length 5 mm (ZSM Mol-20034144); ST10, 1 specimen in alcohol, length 5.7 mm (ZSM Mol-20034150), disarticulated and coated for SEM analysis (Figs 3A–B); PR03, 1 specimen in alcohol, of a darker colour, Indian red with lighter streaks, length 6.8 mm (MHNS 100601).

Other material examined: ST03: 1 specimen, length 8 mm, disarticulated for SEM analysis (Fig. 9B), and 76 valves (15 head, maximum width 3 mm, 12 intermediate, maximum width 3.4 mm, and 49 tail, maximum width 3 mm) (BD 110, ER); ST06: 2 specimens, maximum width 6.7 mm, and 11 valves (3 head, maximum width 3 mm, 5 intermediate, maximum width 3 mm, and 3 tail, maximum width 2.3 mm) (BD 111); ST08: 2 specimens, maximum length 5 mm (ZSM Mol-20034145).

Distribution: São Tomé and Príncipe Islands.

Comparison and remarks: This species was assigned to the genus *Stenoplax* mainly because of the elongate shape, with the length 2 to 3 times the width. On their own, not all characters of the new species match those of the genus *Stenoplax*. The lateral areas of *Stenoplax* species are generally rather elevated (Kaas & Van Belle 1987: 124; Vendrasco *et al*. 2012: 34), but are little raised and poorly defined in our species. However, the same characteristic is seen in other *Stenoplax* species, e.g. *S. marcusi* (Righi, 1971).

About half of the approximately 22 living species of *Stenoplax* worldwide, occur in the temperate or tropical eastern Pacific, but a few species are found in the Caribbean, and two species are known from Brazil, namely *Stenoplax kempfi* (Righi, 1971) and *S. marcusi* (Righi, 1971). The finding of *Stenoplax hernandezi* sp. n. on the Atlantic African coast greatly extends the distribution of this genus.

*Stenoplax kempfi* differs from the present species mainly in respect of the different sculpture (radial riblets on the head valve, lateral areas of intermediate valves, and postmucronal area of tail valve, longitudinal riblets on the central area of intermediate valves, and antemucronal area of tail valve, vs. concentric undulate grooves and no riblets in the new species); the greater dimensions (maximum length from 44 to 120 mm vs. 8 mm); and the dorsal girdle formations (always elongate scales/spicules, not rectangular scales as in the new species).

*Stenoplax marcusi*, originally placed in *Ischnochiton*, and later attributed to *Stenoplax* by Kaas and Van Belle (1994) following study of the type material, has a tegmental sculpture more similar to that of *S. hernandezi* sp. n., a similar colour, and it is of comparable size (maximum length 11.8 vs. 8 mm). It differs because of the higher elevation (dorsal elevation 0.47 vs. 0.31), the number of intermediate valve slits (1 vs. 3), and the different girdle formations (see Righi 1971; Kaas & Van Belle 1994).

Only a single species of *Stenoplax* is known from the Indian Ocean, namely *S. madagassica* (Thiele, 1917) from Madagascar. This species differs from the present

species in having greater dimensions (up to 65 mm long vs. 8 mm), being more highly elevated (dorsal elevation 0.42 vs. 0.31), having different dorsal girdle scales (elongate and up to 145 μm long with interspersed whitish ringshaft-needles vs. rectangular up to 55 × 65 μm), and in respect of the geographical distribution (Madagascar vs. São Tomé ).

*Stenoplax hernandezi* sp. n. is generally similar to some of the small *Ischnochiton* species reported from West African coasts (i.e. *I. goreensis*, *I. paessleri*, and *I. nicklesi*), but they all have a tegmental sculpture that is mainly smooth or finely granulose.

## Family Chaetopleuridae Pate, 1899
## Genus *Chaetopleura* Shuttleworth, 1853

*Chaetopleura*: Shuttleworth 1853: 182. Type species: *Chiton peruvianus* Lamarck, 1819, by subsequent designation (Dall 1879: 296).
For synonymy, see Kaas & Van Belle (1987).

Distribution: Worldwide, but most species occur in the tropical and subtropical regions of Africa, and South and Central America (Schwabe 2006). Oligocene – Recent.

### *Chaetopleura caboverdensis* (Kaas & Strack, 1986)

Figs 4A–L

*Lepidochitona caboverdensis*: Kaas & Strack 1986: 79, figs 1–15; Kaas & Van Belle 1987: 31, fig. 14; Kaas 1991: 91; Slieker 2000: 28, fig. 17; Ardovini & Cossignani 2004: 18. Holotype: MNHN, 5.8 × 3.2 mm, preserved dry. Paratypes: Many specimens in several institutions (see Kaas & Strack 1986). Type locality: Senegal, Dakar.
*Chaetopleura caboverdensis*: Rolán 2005: 27, fig. 2; Sirenko 2006: fig. 1I.

Material examined: ST03: 21 valves (4 head, maximum width 2.5 mm, 16 intermediate, maximum width 3 mm, and 1 tail, width 1.5 mm) (ER); ST11: 21 valves (4 head, maximum width 2.3 mm, 15 intermediate, maximum width 3 mm, and 2 tail, maximum width 2.2 mm) (BD 112A); PR05: 1 intermediate valve, width 2.3 mm (BD 112B); PR07: 2 intermediate valves, maximum width 2.2 mm (BD 112C); CAPE VERDE: Cape Verde Archipelago, São Vicente, Praia da Matiota: 1 specimen (BD 2919).

Distribution: Cape Verde Archipelago, Senegal, and São Tomé and Príncipe Islands.

Comparison and remarks: This species was originally placed in the genus *Lepidochitona*, mainly due to the morphology of the ventral girdle scales and to the characters of the articulamentum, but was later considered as belonging to *Chaetopleura* (see Rolán 2005; Sirenko 2006). The available material was only separate valves, well defined by the subcarinate and slightly beaked intermediate valves, and by the characteristic microsculpture: rounded and elevated granules with a central macroaesthete on the top (Figs 4C, 4I). The microsculpture of a specimen of *Chaetopleura caboverdensis* from the Cape Verde Archipelago (Figs 4K, 4L) is presented for comparison. This is the first report of this species for the São Tomé and Príncipe Islands.

## Family Callochitonidae Plate, 1901
## Genus *Callochiton* Gray, 1847

*Callochiton*: Gray 1847*a*: 126. Type species: *Chiton laevis* Montagu, 1803 (*non* Pennant, 1777) [= *Callochiton septemvalvis* (Montagu, 1803), *fide* Kaas 1978], by subsequent designation (Gray 1847*b*: 168).
For synonymy, see Kaas & Van Belle (1985*b*).

Distribution: Mostly tropical and subtropical regions of the Indo-Pacific (including Japan; absent from the northeastern Pacific). In the Atlantic Ocean, restricted to the eastern and southern (sub-Antarctic) parts. Oligocene – Recent.

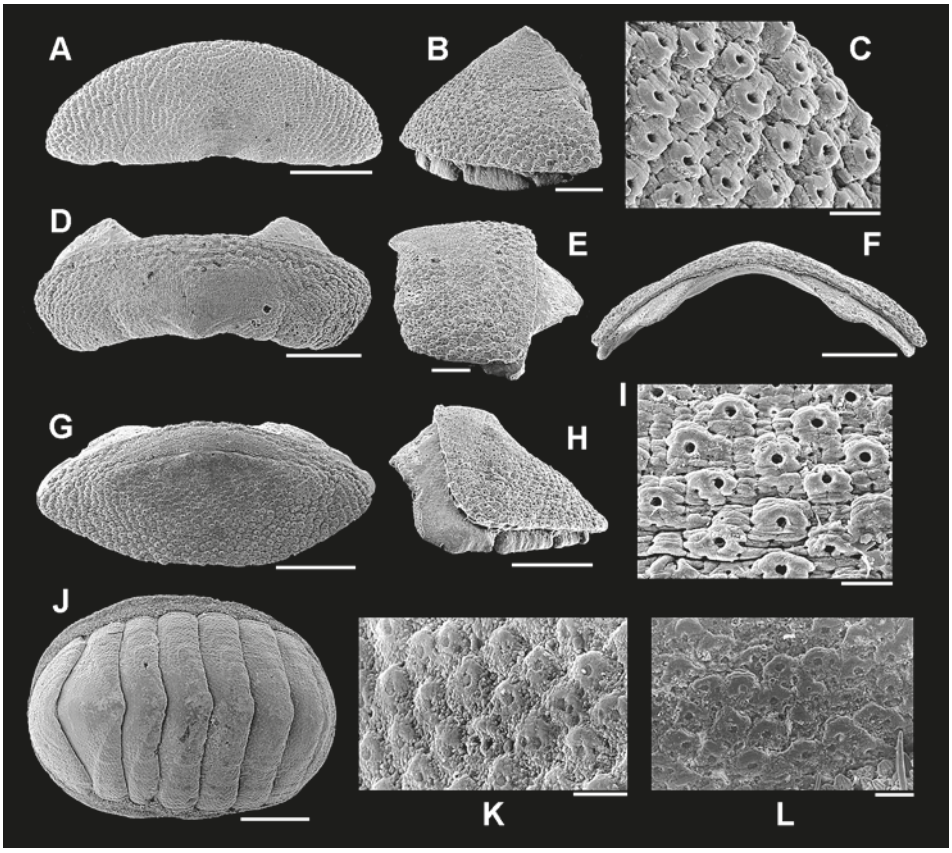


Fig. 4. (A–L) *Chaetopleura caboverdensis* (Kaas & Strack, 1986): (A–I) São Tomé Island, ST03, (A–C) head valve, (A–B) dorsal and lateral views, (C) detail of the sculpture, (D–F) intermediate valve, dorsal, lateral and frontal views, (G–I) tail valve, (G–H) dorsal and lateral views, (I) detail of the sculpture; (J–L) Cape Verde Archipelago, São Vicente, Praia da Matiota, BD 2919: (J) complete specimen, (K) detail of the sculpture of the head valve, (L) detail of the sculpture of the tail valve. Scale bars = 1 mm (J); 500 μm (A, D, F); 400 μm (G); 300 μm (H); 200 μm (B, E); 50 μm (K, L); 40 μm (C); 30 μm (I).

**Callochiton saotomensis** sp. n.

Figs 5A–S, 9C–E

Etymology: Named for the São Tomé Island, the type locality of the species.

Description:

General shell shape: Animal of small size, maximum length 6.5 mm, elongate, moderately elevated, dorsal elevation 0.36, subcarinated. Tegmentum evenly reddish, more or less dark; the surface areas of the intermediate valves sometimes lighter laterally, and the girdle evenly of a lighter tone.

Head valve semicircular (Fig. 5A), with a straight anterior slope and a wide, V-shaped posterior margin, unnotched in the middle. Intermediate valves more or less rectangular (Fig. 5D); anterior margin slightly concave in the jugal area; side margins somewhat rounded; posterior margin concave on both sides of the beaked apex; lateral areas raised.

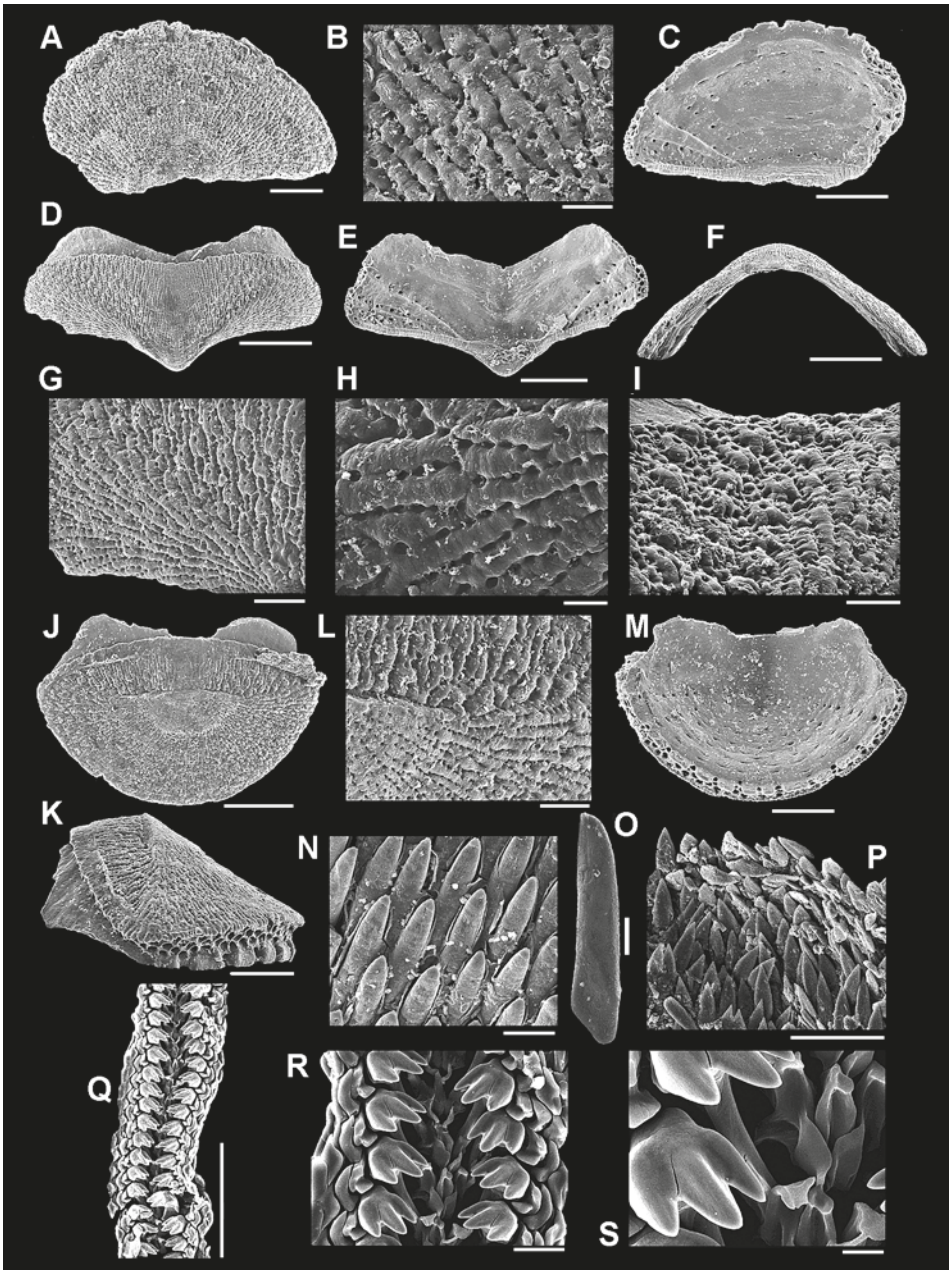


Fig. 5. (A–S) *Callochiton saotomensis* sp. n., São Tomé Island, ST06, specimen disarticulated and coated for SEM analysis, MZB 49762: (A–C) head valve, (A) dorsal view, (B) detail of the sculpture, (C) ventral view, (D–I) intermediate valve, (D–F) dorsal, ventral, and lateral views, (G–I) detail of the sculpture, (J–M) tail valve, (J–K) dorsal and lateral views, (L) detail of the sculpture, (M) ventral view, (N–P) girdle formations, (N–O) dorsal spicules, (P) ventral spicules, (Q–S) radula, (Q) complete view, (R) detail of central and first two lateral teeth, (S) detail of cusp of major lateral tooth. Scale bars = 400 μm (D–F); 300 μm (C, J, M); 200 μm (A, K, Q); 80 μm (P); 50 μm (G, L, N); 40 μm (I); 30 μm (B, R); 20 μm (H, O); 10 μm (S).

Tail valve more than semicircular (Fig. 5J); mucro elevated and situated anteriorly, antemucronal and postmucronal slopes straight (Fig. 5K).

Tegmentum roughly covered with elevated dorsal papillae (Fig. 5I), on which the apical caps are situated with no apparent association with the surrounding subsidiary caps (Fig. 5H). Dorsal papillae arranged in irregular rows, radially in the head valve, the lateral areas of intermediate valves and the postmucronal area of tail valve, longitudinally in the central area of intermediate valves and the antemucronal area of tail valve. The rows have an irregular pattern, in some cases with the dorsal papillae assembled in series not connected among them (Fig. 5L), looking like segments sometimes slanting in the central area of intermediate valves. Apical caps circular, diameter *ca* 6 μm. Black pigmented shell eyes present in the head valve, the lateral areas of intermediate valves, and the postmucronal area of tail valve.

Articulamentum: Red-brownish and thin. Apophyses short and wide with anterior edge broadly rounded, connected by a wide V-shaped sinus. Insertion plates long, slit formula: ? / 2–3 / 12–13. Teeth of insertion plates broad and solid. Slit rays indicated in all valves by radial rows of elongate holes (Fig. 5E). Eaves spongy.

Girdle: Densely covered dorsally with long, round-topped, inwardly directed and smooth rectangular spicules (Fig. 5N), measuring 110 × 25 to 200 × 40 μm (Fig. 5O). Ventrally, the girdle is paved with radiating rows of small, sharply pointed, imbricating scales (Fig. 5P), up to 50 μm long.

Radula: Asymmetric central tooth elongate (Fig. 5R), tulip-shaped. First lateral tooth with broad shaft and wing-shaped extension in front (Fig. 5S), blade sharply pointed, with a shallow depression in the middle. Major lateral tooth (Fig. 5S) bears a broad tridentate cusp with pointed denticles.

Holotype: SÃO TOMÉ AND PRÍNCIPE: São Tomé, Lagoa Azul, ST03, length 4.6 mm, Fig. 9C (MZB 49761).

Paratypes: Same data as holotype: 1 specimen, length 6.5 mm, slightly curled (BD 115); 1 specimen, length 3.4 mm (MNHN IM-2012-2702). Other paratypes: ST06: 1 specimen, length 3 mm (BD 116); ST06: 1 specimen, length 4.2 mm (MSNG 57363); ST06: 1 specimen, disarticulated and coated for SEM analysis (MZB 49761); ST06: 1 specimen, length 4.9 mm, Fig. 9D (NHMUK); ST06: 1 specimen, length 4.1 mm (SG); ST06: 1 specimen, length 4.4 mm, Fig. 9E (ZISP 2198); ST10: 1 specimen in alcohol, length 4.5 mm (ZSM Mol-20034148).

Other material examined: ST03: 1 specimen, length 4.3 mm, and 4 valves (3 intermediate, maximum width 2.8 mm, and 1 tail, width 2.5 mm) (BD 117, ER); ST06: 8 specimens, maximum length 4 mm, and 4 intermediate valves, maximum length 2.3 mm (BD 118).

Distribution: São Tomé and Príncipe islands.

Comparison and remarks: A rather uniform species. Also, the colour is prevalently as described, evenly reddish. Only a few specimens have a lighter tone, evenly evident on some valves, either on the entire valve or only some parts thereof, e.g. pleural areas (Fig. 9D, Paratype NHMUK). Some inconspicuous, oblique coloured striae in the central areas of the intermediate valves give the impression of real streaks.

Only one congener, *Callochiton septemvalvis* (Montagu, 1803), is common throughout the Mediterranean Sea and also occurs along all of the European Atlantic coast, from Norway and the Shetland Islands as far south as the Canary Islands (Kaas & Van Belle 1985*b*; Dell'Angelo & Smriglio 1999; Rolán 2011), the Azores (Avila & Albergaria 2002), the West African coast and the Gulf of Guinea (Leloup 1968*a*). Another species, *C. calcatus* Dell'Angelo & Palazzi, 1994, is known from scattered localities in the

Mediterranean Sea, and is characterized by the strongly angulated valves, with a dorsal elevation of *ca* 0.7.

*C. septemvalvis* differs by the larger size (length up to 30 mm), the greater number of slits in the insertion plate of the tail valve (14–18 vs. 12–13), the central mucro of the tail valve (vs. situated anteriorly), some differences in radular teeth (an elongate first lateral tooth), and mainly by the different tegmental sculpture, with the very regular arrangement of non-elevated dorsal papillae (cf. Baxter & Jones 1984: pl. 2, figs a–d), and the larger diameter of the apical caps (8.5 μm vs. 6 μm).

*C. septemvalvis* has a very complicated taxonomic history (Kaas 1978; Kaas & Van Belle 1985*b*; Dell'Angelo & Smriglio 1999). Many authors separated the typical Atlantic form from the Mediterranean one, which is characterized by its smaller size and the presence of longitudinal grooves on the pleural areas, at subspecific or specific level (Kaas 1978; Carmona Zalvide *et al*. 2002). Specimens from the African coast and the Canary Islands invariably have longitudinal grooves (see Kaas & Van Belle 1985*b*: 14). Occurrence records include "Cap de Naze et Cap de Somone" (1 specimen, 7.5 mm), Dakar (1 specimen) and the Gulf of Guinea ("Calypso", northeast of Príncipe and Mosteiros Islands, 37 m, 1 specimen, 3.5 mm). These last records, all reported by Leloup (1968*a*), should be checked to clarify whether the material is *C. septemvalvis* or the new species.

## Family Chitonidae Rafinesque, 1815
## Subfamily Chitoninae Rafinesque, 1815
## Genus *Rhyssoplax* Thiele, 1893

*Rhyssoplax*: Thiele 1893: 368. Type species: *Chiton affinis* Issel, 1869, by subsequent designation (Thiele 1909: 91).

For synonymy, see Kaas *et al.* (2006).

Distribution: Tropical and subtropical waters of the Indo-Pacific (except for the East Pacific), also in the eastern Atlantic. Cretaceous – Recent.

### *Rhyssoplax canariensis* (d'Orbigny, 1839)

Figs 9F–N

*Chiton canariensis*: d'Orbigny 1839: 99, pl. 7, figs 18–19; Gray 1854: 19; MacAndrew 1856: 117; Nierstrasz 1906: 515; Thiele 1909: 6; Lamy 1907: 151; Bergenhayn 1931: 18, pl. 1, figs 30–33, pl. 3, fig. 66; Nickles 1950: 14, fig. 3; Sourie 1954: 239, 299; Marche-Marchad 1958: 11; Leloup 1968*a*: 28; Sabelli & Spada 1970: 6; Fischer 1978: 43; Altimira & Ros 1979: 9; Bernard 1984: 122, pl. 63; Poppe & Goto 1991: 60, pl. 1, fig. 12; Slieker 2000: 32, pl. 4, figs 39, 39a; Ardovini & Cossignani 2004: 18, figs p. 58. Type material: NHMUK 1854.9.28.152, 3 Syntypes (Figs 9H–J). Type locality: Canary Islands.

*Chiton* (*Lophurus*) *canariensis*: Shuttleworth 1853: 205.

*Chiton* (*Gymnoplax*) *canariensis*: Dautzenberg 1910: 108; 1912: 80.

*Chiton* (*Rhyssoplax*) *canariensis*: Van Belle 1984*a*: 101, pl. 3; Strack 1987: 181; Gerber *et al*. 1989: 22; Kaas 1991: 94; Kaas *et al*. 2006: 156, fig. 57 (chresonymy and synonymy); Rolán 2011: 50, figs 4I–T.

*Chiton lyratus* Sowerby 1840*a*: fig. 126 (*nom. nud.*); 1840*b*: 293; Reeve 1847: pl. xviii, species 110; Pilsbry 1893: 184, pl. 31, figs 35–36; Nierstrasz 1906: 515; Tomlin & Shackleford 1915: 269; Fernandes & Rolán 1993: 33. Type material: NHMUK 1979176, 2 Syntypes (Figs 9F–G). Type locality: unknown (Prince Island, West Africa, *fide* Reeve 1847).

Material examined: ST01: 2 specimens in alcohol, maximum length 11 mm (ZSM Mol-20080400); ST02: 5 specimens, maximum length 20 mm (Figs 9L, 9N) (BD 119A); ST03: 38 specimens, maximum length 22 mm (Figs 9K, 9M) (BD 119B); ST03: 1 specimen in alcohol, length 21 mm (ZSM Mol-20071398), and

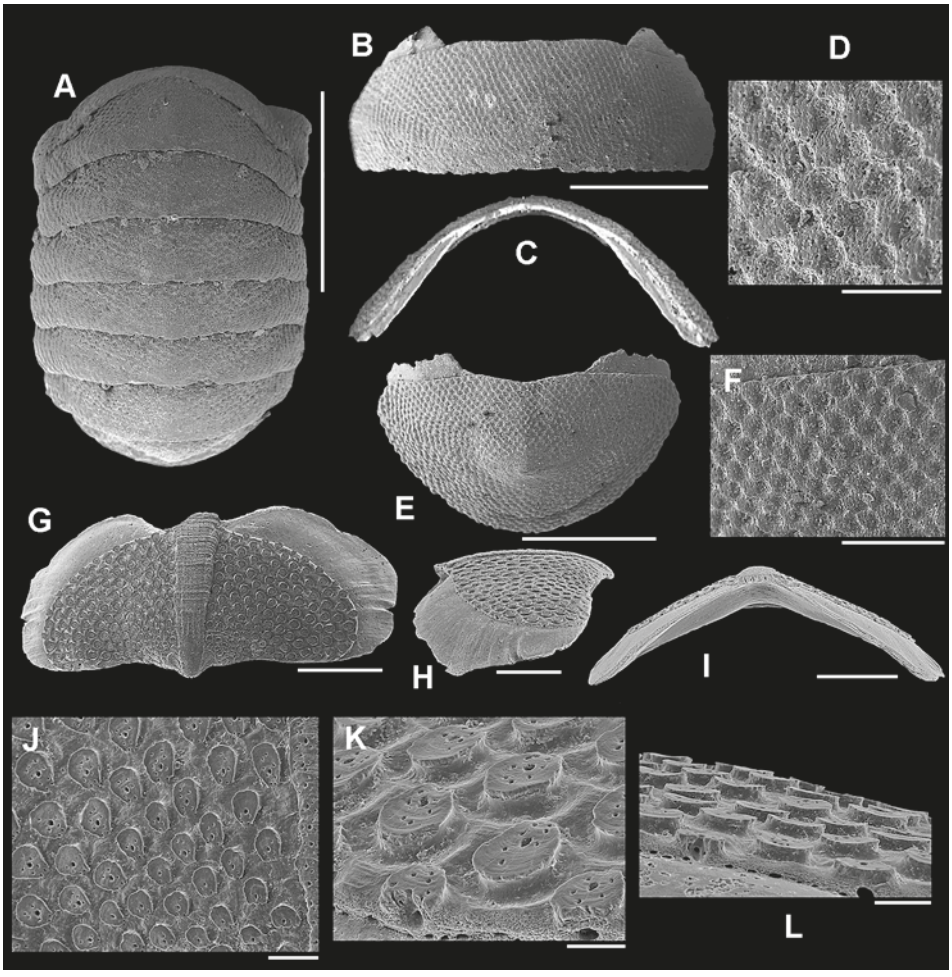


Fig. 6. (A–F) *Lepidochitona rolani* Kaas & Strack, 1986, São Tomé and Príncipe Islands: (A) complete specimen from ST06, (B–D) PR07, intermediate valve, (B–C) dorsal and frontal views, (D) detail of the sculpture, (E–F) ST11, tail valve, (E) dorsal view, (F) detail of the sculpture; (G–L) *Acanthochitona crinita* (Pennant, 1777), São Tomé Island, ST03, intermediate valve: (G–I) dorsal, lateral and frontal views, (J) detail of the sculpture, (K–L) detail of granules in different views. Scale bars = 1 mm (A, B, E); 800 μm (G, I); 600 μm (H); 200 μm (F); 100 μm (D, J); 80 μm (L); 60 μm (K).

81 valves (14 head, maximum width 5 mm, 54 intermediate, maximum width 8 mm, and 13 tail, maximum width 4.2 mm) (BD 119C, ER); ST05: 6 specimens, maximum length 13 mm (BD 119D); ST07: 3 specimens, maximum length 26 mm (BD 119E); ST09: 8 specimens in alcohol, maximum length 15 mm (ZSM Mol-20040494); ST09: 3 specimens in alcohol, maximum length 14 mm (ZSM Mol-20040503); ST10: 7 specimens in alcohol, maximum length 15 mm (ZSM Mol-20034143); ST10: 1 specimen in alcohol, length 6 mm (ZSM Mol-20034149); ST11: 10 valves (3 head, maximum width 3.5 mm, and 7 intermediate, maximum width 3.5 mm) (BD 119F); PR01: 5 specimens, maximum length 19 mm (BD 119G); PR02: 2 specimens, maximum length 18.5 mm (BD 119H); PR03: 1 specimen, maximum length 16 mm (BD 119I); PR04: 1 specimen in alcohol, length 26 mm (BD 119J); PR06: 11 specimens in alcohol, maximum length 21 mm (ZSM Mol-20040208); PR07: 9 intermediate valves, maximum width 7.2 mm (BD 119K).

Distribution: *Rhyssoplax canariensis* is a common subtidal species, reported from the Canary Islands and western Africa, from Morocco to Angola (Kaas *et al*. 2006), and

the São Tomé and Príncipe Islands. It does not occur in the Cape Verde and Madeira archipelagos except for one report from Porto Santo, Madeira, as a Pleistocene fossil (Gerber *et al*. 1989).

Comparison and remarks: *Chiton lyratus* is considered a synonym of *Rhyssoplax canariensis*, as already reported by Pilsbry (1893: 184). Syntypes of both taxa are illustrated (Figs 9F–G, 9H–J). The examination of the 100 valves found gives a slit formula of 8–9 / 1 / 10–13 vs. 8 / 1 / 7–11, reported by Kaas *et al*. (2006), which can be considered to be within the range of acceptable variation for a common and widely-distributed species. Only one intermediate valve with 2 slits on the right side was found, out of a total of 70 intermediate valves checked.

A unique head valve from ST03 has a shell scar due to injury, which caused the development of a new insertion plate under the older one in the articulamentum.

Suborder Acanthochitonina Bergenhayn, 1930
Superfamily Mopalioidea Dall, 1889
Family Tonicellidae Simroth, 1894
Genus *Lepidochitona* Gray, 1821

*Lepidochitona*: Gray 1821: 234. Type species: *Chiton marginatus* Pennant, 1777 (= *Chiton cinereus* Linnaeus, 1767), by monotypy.
For synonymy, see Kaas & Van Belle (1985*b*).

Distribution: Atlantic coast of Europe, Mediterranean Sea, West Africa, Caribbean area, western coast of North, Central and South America. Paleocene – Recent.

*Lepidochitona rolani* Kaas & Strack, 1986

Figs 6A–F

*Lepidochitona rolani* Kaas & Strack 1986: 83, figs 1, 16–28; Kaas & Van Belle 1987: 33, fig. 15; Kaas 1991: 91; Rolán 2005: 27, fig. 3. Type material: Holotype in MNCN. Paratypes: Many specimens in several institutions (see Kaas & Strack 1986). Type locality: Cape Verde Archipelago, São Vicente, Calhão, intertidal.

Material examined: ST06: 1 specimen, length 2 mm, and 7 valves (2 head, maximum width 2.2 mm, and 5 intermediate, maximum width 3 mm) (BD 120A); ST11: 3 valves (2 intermediate, maximum width 2.2 mm, and 1 tail, width 2.1 mm) (BD 120B); PR05: 5 intermediate valves, maximum width 2.5 mm (ER); PR07: 13 valves (2 head, maximum width 2.8 mm, 10 intermediate, maximum width 3.7 mm, and 1 tail, width 1.6 mm) (BD 120C).

Distribution: Cape Verde Archipelago, and São Tomé and Príncipe Islands.

Comparison and remarks: The material examined was a unique, small living specimen (Fig. 6A) and many separate valves, well defined by the rounded intermediate valves, and by the characteristic microsculpture (Figs 6D, 6F). All are characters that agree well with the original description given by Kaas and Strack (1986).

Superfamily Cryptoplacoidea H. & A. Adams, 1858
Family Acanthochitonidae Pilsbry, 1893
Genus *Acanthochitona* Gray, 1821

*Acanthochitona*: Gray 1821: 234. Type species: *Chiton fascicularis* Linnaeus, 1767, by monotypy.
For synonymy, see Gowlett-Holmes (2001).

Distribution: Worldwide. Oligocene – Recent.

### *Acanthochitona crinita* (Pennant, 1777)

Figs 6G–L, 9O

*Chiton crinitus*: Pennant 1777: 71, pl. 36, figs 1, A1. Neotype designated and figured by Kaas (1985: 591, fig. 27), RSMNH 1978.052.02601 (not seen). Type locality: Hebrides Islands, Monach Island, North Uist, U.K. (57°31.5'N: 07°38.5'W).

*Acanthochitona crinita*: Kaas 1985: 588, figs 7–50 (chresonymy and synonymy); Dell'Angelo & Smriglio 1999: 198, pls 66–68, figs 124–130; Bonfitto *et al.* 2011: 173, figs 2, 4B, 6B.

Material examined: ST03: 103 valves, 12 head (maximum width 3 mm), 82 intermediate (maximum width 5 mm), and 9 tail (maximum width 3.5 mm) (BD 113A); ST06: 3 specimens, maximum length 6.5 mm (Fig. 9O), and 11 valves, 10 intermediate (maximum width 2.5 mm), and 1 tail (width 1.8 mm) (BD 113B); ST11: 9 intermediate valves, maximum width 2.5 mm (ER); PR07: 1 intermediate valve, width 1.7 mm (BD 113C).

Distribution: Mediterranean Sea, the Atlantic coast of Europe (as far north as Norway), and the northern West African coast, plus São Tomé and Príncipe Islands.

Comparison and remarks: *Acanthochitona crinita* appears to be very variable, in its tegmental sculpture, dorsal elevation, the shape of the valves, and in the colour of the tegmentum (Leloup 1968*b*; Kaas 1985; Dell'Angelo & Smriglio 1999). Also, the shape of the granules is variable, being round to slightly oval, to a more or less elongate drop (Kaas 1985; Bonfitto *et al*. 2011), but they are always widely separated, not as densely orientated as in *A. fascicularis*. The granules have a flat or slightly concave surface, with a central macroaesthete and 8–16 microaesthetes irregularly arranged around it.

Kaas (1985) examined the type material of the five northwest African species of *Acanthochitona* described by de Rochebrune, (1881–1884) (formerly studied by Thiele 1909), i.e. *A. dakariensis*, *A. adansoni*, *A. bouvieri*, *A. joallesi*, and *A. stercorarius*. All of these were synonymized with *A. crinita* by Leloup (1968*b*: 68). Kaas concluded that only *A. joallesi* is a valid species, whereas *A. adansoni* and *A. bouvieri* are synonymous with *A. crinita* (Pennant, 1777). *A. dakariensis* and *A. stercorarius* are considered *nomina dubia*. Leloup's (1941) *Acanthochitona subrubicunda* from Cape Verde Islands may be separated by its broad, wedge-shaped jugal area.

## Genus *Craspedochiton* Shuttleworth, 1853

*Craspedochiton*: Shuttleworth 1853: 191. Type species: *Chiton laqueatus* Sowerby, 1841, by monotypy. For synonymy, see Gowlett-Holmes (2001).

Distribution: Atlantic (African coast) and temperate and tropical Indo-Pacific. Eocene – Recent.

### *Craspedochiton foresti* (Leloup, 1965)

Figs 7A–T, 9P–S

*Notoplax foresti* Leloup 1965: 155, text figs 1–3, pls 1–2; Kaas 1979: 873; Kaas 1986: 20 [as synonym of *Notoplax* (*Spongiochiton*) *productus*]; Kaas 1989: 109 [as synonym of *Notoplax* (*Spongiochiton*) *producta*]; Kaas & Van Belle 1998: 75 [as synonym of *Notoplax* (*Spongiochiton*) *producta*]. Holotype, MNHN 5922 (disarticulated). Type locality: Príncipe Island, Caroço Isl., 2–8 m, "Calypso" st. 88, 26.vi.1956.

*Craspedochiton foresti*: Strack 1996: 132 (in the discussion of *Craspedochiton productus*).

Material examined: ST03: 2 specimens, slightly curled, maximum length 16 mm (Figs 9P–S) (BD 114A); ST03: 1 specimen, disarticulated and coated for SEM analysis (MZB 49763); ST03: 1 tail valve, length 3.5 mm (BD 114B); ST04: 1 specimen, length 4.5 mm (BD 114C); ST07: 5 specimens, slightly curled, maximum length 29 mm (BD 114D); ST07: 1 specimen in alcohol, curled, length 15 mm (BD 114E); ST07: 1 specimen in alcohol, strongly curled, length 10 mm (NSMT-Mo 78636); PR04: 5 specimens, slightly curled, maximum length 18 mm (BD 114F); PR06: 1 specimen in alcohol, slightly curled, length 16 mm (ZSM Mol-20040209).

Distribution: São Tomè and Príncipe Islands.

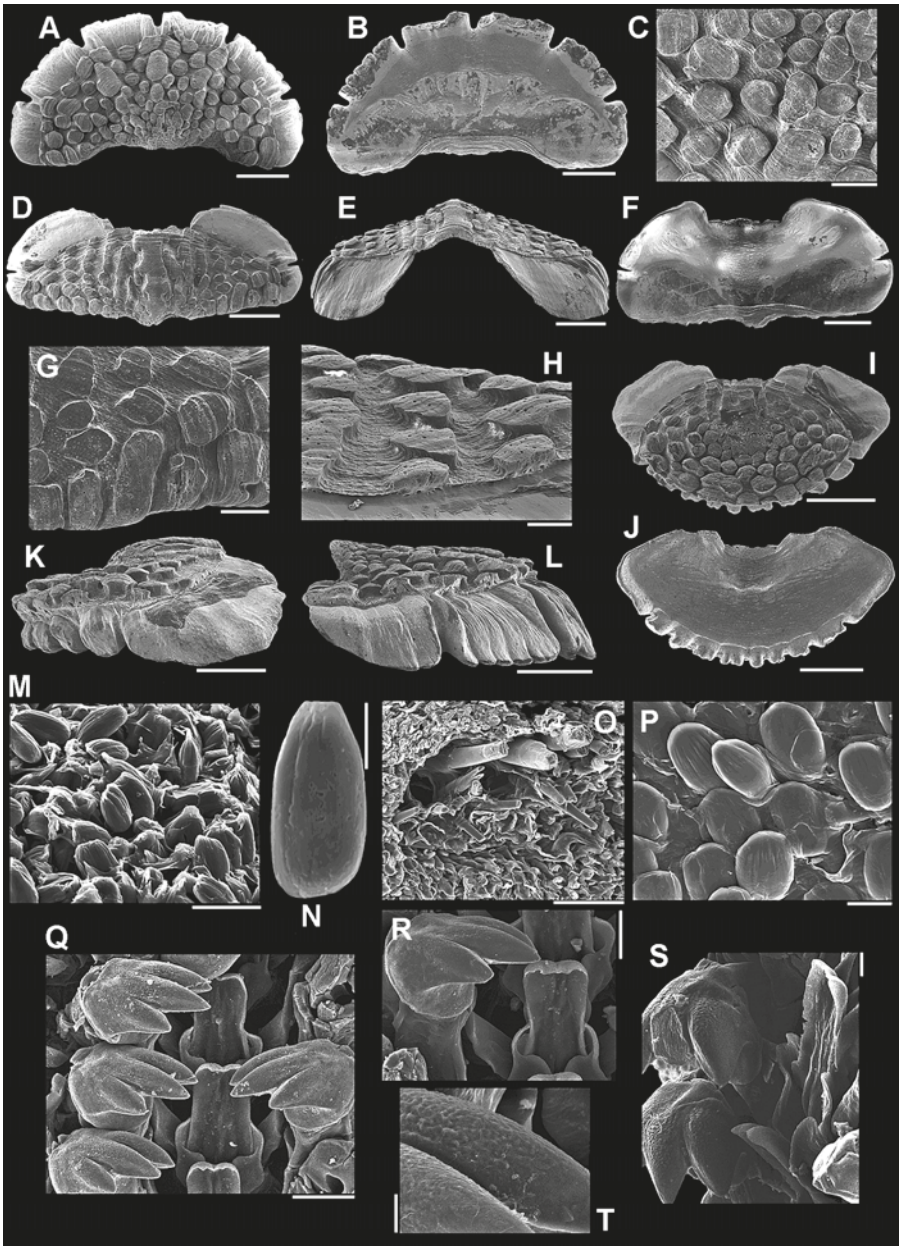


Fig. 7. (A–T) *Craspedochiton foresti* (Leloup, 1965), São Tomé Island, ST03, specimen disarticulated and coated for SEM analysis, MZB 49763: (A–C) head valve, (A–B) dorsal and ventral views, (C) detail of the sculpture, (D–H) intermediate valve, (D–F) dorsal, frontal, and ventral views, (G–H) detail of the sculpture in different views, (I–L) tail valve, dorsal, ventral, lateral, and frontal-lateral views, (M–P) girdle formations, (M) dorsal scales, *in situ*, (N) detail of a dorsal scale, (O) tuft of spines, (P) ventral scales, (Q–T) radula, (Q–R) detail of central and first two lateral teeth, (S) the same, lateral view, (T) detail of the minute granulations present on the upper surface of the cusps. Scale bars = 1 mm (A, B, D, E, F, I, J); 800 μm (K, L); 300 μm (C, G); 200 μm (H); 60 μm (O, Q); 40 μm (R, S); 20 μm (M, P); 8 μm (T); 6 μm (N).

Comparison and remarks: A detailed description of this species is given by Leloup (1965), pertaining to the genus *Notoplax* H. Adams, 1861. We confirm the assignment of the species to *Craspedochiton*, already reported by Strack (1996), based mainly on the wide expansion of the anterior girdle. The status of the relationship between the genera *Notoplax* and *Craspedochiton* was discussed by Gowlett-Holmes (1991), who redefined the genus *Notoplax*, and considered it to be restricted to Australia and New Zealand (but see under *Notoplax* sp.).

We give only some information additional to the original description, based on the SEM observations. The tegmentum is covered by well separated pustules of irregular shape, from roundish/oval to squarish/rectangular, some of them coalesced, giving the impression of orientation in a radiating pattern from the jugum in the intermediate valves (Figs 7D, 7H) and in the antemucronal area of the tail valve. The pustules are elevated and of cylindrical shape (Fig. 7H), with up to 15 or more (Fig. 7G) microaesthetes, disposed without any apparent order. The microaesthetes are also present in the interpustular space.

The radula is probably not useful for distinguishing between species of *Craspedochiton* (H. Saito pers. comm.). The radula of *C. foresti* (Fig. 7Q–T) is similar to that of *C. productus* illustrated in Saito (2004: figs 5E, F). The radula of *C. foresti* has minute granulations on the upper surface of the cusps (Fig. 7S–T), but it remains unclear whether this character has specific relevance. Some other species in different genera also show such granulation, e.g. *Craspedoplax variabilis* (H. Adams, 1864), and *Leptoplax curvisetosa* (Leloup, 1960) (Saito 2004: figs 4C, 8F).

*Craspedochiton. foresti* was considered a synonym of *C. productus* (Carpenter in Pilsbry, 1892) by Kaas (1979: 873), who stated: "I received from the M.N.H.N. the holotype of *Notoplax foresti* Leloup, 1965… The specimen originates from Ile Príncipe, Gulf of Biafra. Though it was disarticulated it appears from the shell plates and the preparations of the girdle, that it does not substantially differ from *C. productus* and must be regarded as another synonym of the latter, which extends the range of distribution considerably". Subsequent authors (e.g. Kaas 1986, 1989; Kaas & Van Belle 1998) followed this decision.

We re-examined both species and became aware that *C. productus* can easily be separated from *C. foresti*, mainly on the basis of the structure of the valves: intermediate and tail valves more oval in *C. foresti*, but trapezoidal in *C. productus*; larger and triangular jugal area in *C. productus*, narrow and rectangular in *C. foresti*; pustules more dense and more irregularly arranged in *C. productus*; wider apophyses in *C. productus*; slit formula 5 / 1 / 4 in *C. productus*, 5 / 1 / 7 in *C. foresti*, with short and irregular slits. The valves of a specimen of *C. productus* from South Africa (NSMT-Mo 72867) are illustrated for comparison (Figs 8A–F). The differences from *C. productus* have already been discussed by Leloup (1965: 159): "*N. productus* se caractérise par des valves intermediaries proportionnellement plus élevées, au sinus plus large, aux lames d'insertion plus obliques et à bords latéraux du tegmentum plus obliques".

Thiele (1909: 33) described another congener from the Atlantic coast of Africa: *Craspedochiton liberiensis* Thiele, 1909. He examined a single specimen, which was 7 mm in length. Comparison with a 4.5 mm long specimen from ST04 indicates that Thiele had another species in hand. *C. liberiensis* exhibits at this size a more or less regular pattern of nearly round granules, which are elongated in our small specimen. Thiele (1909, pl. 4, fig. 30) illustrated an intermediate valve in which the arrangement of

the granules are directed towards the indistinct jugal area. This is contrary to the pattern on our examined juvenile. The specimen's jugal area is clearly wedge-shaped, well demarcated from the pleural area, and the granules are directed outwards. Whether *C. liberiensis* is a valid species or, as concluded by Kaas and Van Belle (1998), a synonym of *C. productus*, needs to be clarified by comparing a number of valves and specimens that are of similar size. Such comparisons are beyond the scope of the present study.

### Genus *Notoplax* H. Adams, 1861

*Notoplax*: H. Adams 1861: 385. Type species: *Cryptoplax* (*Notoplax*) *speciosa* H. Adams, 1861, by monotypy. For synonymy, see Gowlett-Holmes (1991).

Distribution: Restricted to Australia and New Zealand (Gowlett-Holmes 1991). Oligocene – Recent.

### *Notoplax* sp.

Figs 8G–J

Description:

Intermediate valve beaked, tegmentum a little wider than long, very reduced in the anterior portion, with anterolateral margins sinuose in the upper part, almost straight and obliquely directed in the lower one; sutural laminae very large, separated anteriorly by a wide sinus; lateral margins oblique, with a single slit. Jugum well defined, raised, smooth, separated from the latero-pleural areas. Lateral and pleural areas with similar sculpture of irregularly rounded pustules.

Material examined: ST03: 1 intermediate valve, width 2.8 mm (BD 121).

Distribution: São Tomé Island.

Comparison and remarks: The reduced tegmentum, the very large insertion plates, the pustulose sculpture of the lateropleural areas, and the well defined and narrow jugum support our tentative assignment of this unique intermediate valve to the genus *Notoplax*, as redefined by Gowlett-Holmes (1991).

Our tentative assignment of this valve to *Notoplax* greatly extends the distribution of the genus, considered to be restricted to Australia and New Zealand by Gowlett-Holmes (1991), but already widened to Japanese waters by Saito (1995, 1997, 2005 for *Notoplax hilgendorfi* Thiele, 1909), and Saito (1998, 2004 for *Notoplax* sp.), and to South Vietnam by Sirenko (2012 for *Notoplax* sp.).

Some species with a similar wing-shaped tegmentum, to date attributed to *Acanthochitona*, are known, e.g. *A. rhodea* (Pilsbry, 1893) from the Caribbean coasts of Costa Rica, Panama and Colombia, and *A. mastalleri* Strack, 1989 from the Red Sea, Oman and Kenya. However, both have a different tegmental layout (Lyons 1988: fig. 12; Strack 1989: pl. 19, fig. 2).

This valve may belong to an undescribed species, but additional material is needed to give a complete description of the species.

## DISCUSSION

The tropical islands of the Gulf of Guinea are important for understanding biogeographic distributions of Atlantic marine animals, not only because of their intermediate position between the northern and southern Atlantic Ocean, but also considering that they

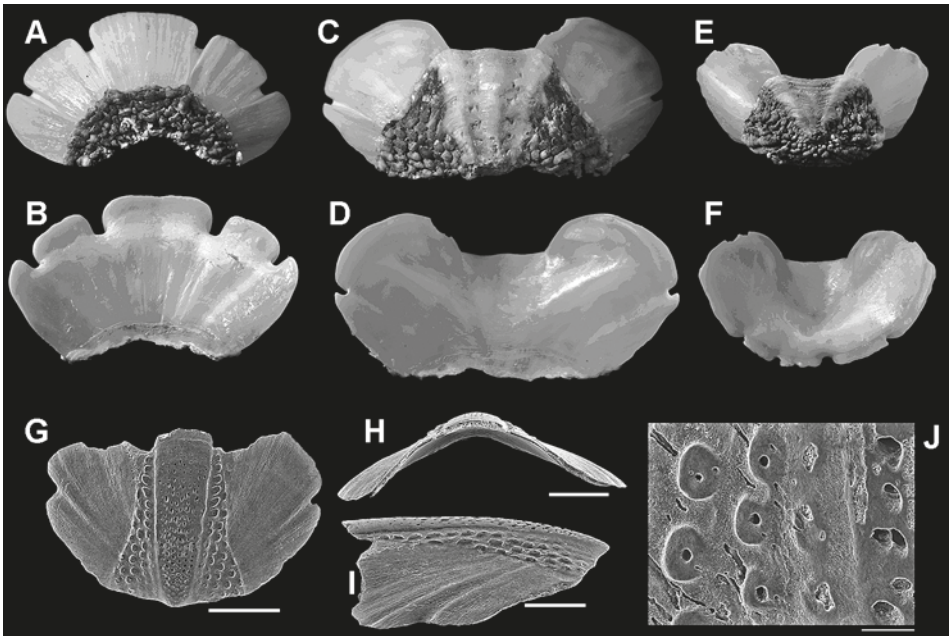


Fig. 8. (A–F) *Craspedochiton productus* (Carpenter in Pilsbry, 1892) from South Africa (NSMT-Mo 72867), specimen disarticulated: (A–B) head valve, width 11.2 mm, dorsal and ventral views, (C–D) intermediate valve, width 13.1 mm, dorsal and ventral views, (E–F) tail valve, width 9.1 mm, dorsal and ventral views; (G–J) *Notoplax* sp., São Tomé Island, ST03, intermediate valve: (G–I) dorsal, frontal, and ventral views, (J) detail of the sculpture. Scale bars = 800 μm (G); 600 μm (H); 500 μm (I); 80 μm (J).

represent the eastern margin of the eastward flowing equatorial currents. Accordingly, one would predict that the marine fauna inhabiting the islands represents a combination drawn from the eastern Atlantic regions, or the amphi-Atlantic components of tropical East Atlantic species and West Atlantic influences. Despite limited information concerning the species inventory (Gascoigne 1993, 1996), this generalized statement seems to hold true (e.g. Wirtz 2001, 2003, 2004, 2009; Wirtz & d'Udekem d'Acoz 2008; Schliewen 2011 – and references therein). Moreover, Wirtz (2001) also stated that amphi-Atlantic species occur in higher numbers towards the equator, but this hypothesis was advanced in the light of current knowledge; and the perception might be influenced by limited sampling efforts in more southern areas. Species diversity of abyssal molluscs appears to reflect latitude, decreasing from the Equatorial Guinea Basin toward the deep-sea basins of the Antarctic region (Schrödl *et al.* 2011). In contrast, more mobile and shallow-water fish exhibit an opposite trend (Schliewen 2011) . Schrödl *et al.* (2011) also summarized contrasting hypotheses for such latitudinal distribution patterns. One of these emphasizes regional Atlantic hydroclimatic conditions, as summarized in detail by Le Loeuff and von Cosel (1998), who compared species diversity patterns of various benthic invertebrate groups, including bivalve molluscs (stating that gastropods are too poorly known for comparison). They found that the equatorial West African coast has a surprisingly low diversity compared to areas at increasing latitudes. Based on our results, their conclusions can likely be extended to another molluscan group: the chitons.

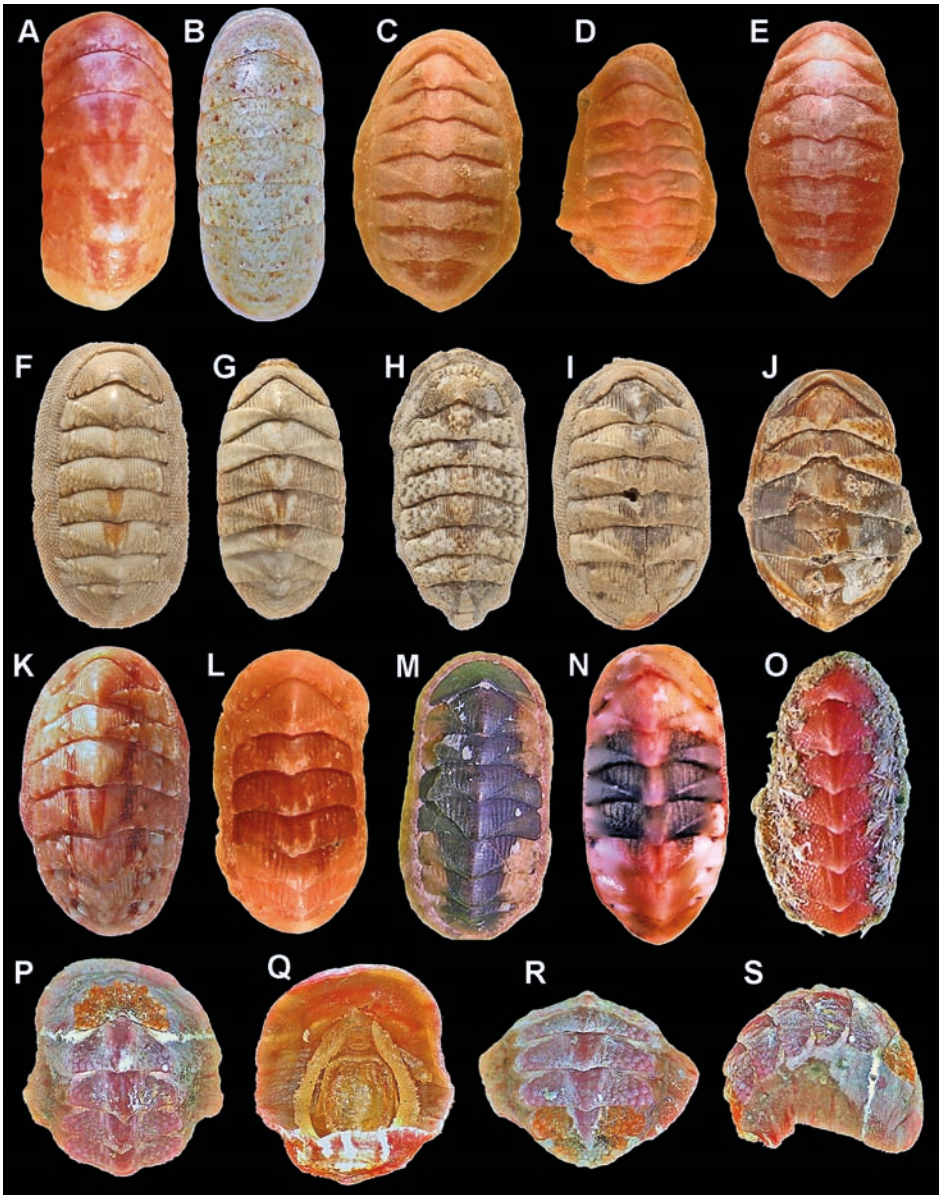


Fig. 9. (A–B) *Stenoplax hernandezi* sp. n., São Tomé Island: (A) ST06, Holotype, length 7.6 mm, MZB 49751, (B) ST03, length 8 mm, specimen disarticulated for SEM analysis; (C–E) *Callochiton saotomensis* sp. n., São Tomé Island: (C) ST03, Holotype, length 4.6 mm, MZB 49761, (D) ST06, length 4.9 mm, Paratype NHMUK, (E) ST06, length 4.4 mm, Paratype ZISP 2198; (F–G) *Chiton lyratus* Sowerby, 1840, NHMUK 1979176, two Syntypes, type locality: unknown (restricted to Príncipe Island); (H–J) *Chiton canariensis* d'Orbigny, 1839, NHMUK 1854.9.28.152, three Syntypes, type locality: Canary Islands; (K–N) *Rhyssoplax canariensis* (d'Orbigny, 1839), colour variations, (K) ST03, length 20.5 mm, (L) ST02, length 8 mm, (M) ST03, length 13.2 mm, (N) ST02, length 8.8 mm; (O) *Acanthochitona crinita* (Pennant, 1777), São Tomé Island, ST06, length 6.5 mm; (P–S) *Craspedochiton foresti* (Leloup, 1965), São Tomé Island, ST03, (P–Q) length 16 mm, dorsal and ventral views, (R–S) length 10 mm, dorsal and lateral views.

TABLE 2
Number of complete specimens and valves found from São Tomé and Príncipe Islands.

| Species | Specimens | Valves | Sampling sites |
|---|---|---|---|
| *Leptochiton denhartogi* | | 1 | ST03 |
| *Leptochiton* sp. | | 2 | ST11 |
| *Ischnochiton* cf. *rissoi* | 1 | | ST06 |
| *Ischnochiton* sp. | 1 | | ST06 |
| *Stenoplax hernandezi* sp. n. | 15 | 87 | ST03, ST06, ST08, ST10, PR03 |
| *Chaetopleura caboverdensis* | | 45 | ST03, ST11, PR05, PR07 |
| *Callochiton saotomensis* sp. n. | 19 | 8 | ST03, ST06, ST10 |
| *Rhyssoplax canariensis* | 94 | 100 | ST01, ST02, ST03, ST05, ST07, ST09, ST10, ST11, PR01, PR02, PR03, PR04, PR06, PR07 |
| *Lepidochitona rolani* | 1 | 28 | ST06, ST11, PR05, PR07 |
| *Acanthochitona crinita* | 3 | 124 | ST03, ST06, ST11, PR07 |
| *Craspedochiton foresti* | 17 | 1 | ST03, ST04, ST07, PR04, PR06 |
| *Notoplax* sp. | | 1 | ST03 |
| Total | 151 | 397 | |

Up until now, records of chitons from the São Tomè and Príncipe Islands have been restricted to four species, in four separate families: *Lepidochitona rolani* Kaas & Strack, 1986, *Rhyssoplax canariensis* (d'Orbigny, 1839), *Craspedochiton foresti* (Leloup, 1965) and, probably, *Callochiton septemvalvis* (Montagu, 1803) (Table 3).

The present study clearly shows (Table 2) that chiton diversity on these islands has been considerably underestimated to date, and has now been increased to a total of 12 polyplacophoran species (including the ones reported before). This is already threefold the number of species that were known prior to our study. Moreover, the material examined includes genera previously unrecorded from this area, as well as two undescribed species. The present study verifies for the first time the occurrence of the families Leptochitonidae, Ischnochitonidae and Chaetopleuridae; and the genera *Leptochiton*, *Ischnochiton*, *Stenoplax*, *Chaetopleura*, *Acanthochitona* and *Notoplax*. Thus, the increments on the different taxonomic levels are all large: family level – 42.9 %, genus level – 60 %, and species level – 66.7 % .

Table 2 shows the distribution of the single taxa over the 18 sampling sites, indicating that *Rhyssoplax canariensis*, which was found at 14 sites, is by far the most common species, while six species were collected at 3–5 sites, and the remaining species at a single site. Four species are represented by isolated valves only, and three of these by only one or two valves.

The new data will allow for comparisons on a regional scale, but such analysis has to be handled with care. A future, more intensive re-examination of Atlantic island groups or the West African coast might also result in an increase of recorded species

TABLE 3
Summary of the current status of chitons from São Tomè and Príncipe Islands, with valid species marked in bold.

| Species recorded | Current status | Recorded in |
|---|---|---|
| ***Leptochiton denhartogi*** | unchanged | herein |
| ***Leptochiton*** sp. | unchanged | herein |
| ***Ischnochiton*** cf. ***rissoi*** | unchanged | herein |
| ***Ischnochiton*** sp. | unchanged | herein |
| ***Stenoplax hernandezi*** sp. n. | unchanged | herein |
| ***Chaetopleura caboverdensis*** | unchanged | herein |
| ***Callochiton saotomensis*** sp. n. | unchanged | herein |
| *Callochiton septemvalvis* | probably a misinterpretation of ***Callochiton saotomensis*** sp. n. | Leloup 1968a |
| ***Chiton canariensis*** | ***Rhyssoplax canariensis*** | Lamy 1907; Fernandes & Rolán 1993; herein |
| *Chiton lyratus* | ***Rhyssoplax canariensis*** | Tomlin & Shackleford 1915; Fernandes & Rolán 1993 |
| ***Lepidochitona rolani*** | unchanged | Fernandes & Rolán 1993; herein |
| ***Acanthochitona crinita*** | unchanged | herein |
| ***Notoplax foresti*** | ***Craspedochiton foresti*** | Leloup 1965; herein |
| *Notoplax productus* | incorrectly considered the valid taxon for *Craspedochiton foresti* | Fernandes & Rolán 1993 |
| ***Notoplax*** sp. | unchanged | herein |

– as Wirtz (2001) already pointed out for amphi-Atlantic species. Extracting data for different regions, we account for 23 chiton species along the West African coast (Kaas 1991; Ardovini & Cossignani 2004), 15 species for the Canary Islands (Van Belle 1984*a*; Strack 1987; Rolán 2011), eight species for Madeira Island (Van Belle 1985; Kaas 1991), 11 species for the Azores Islands (Van Belle 1984*b*; Strack 1991; Avila & Albergaria 2002; Avila & Sigwart 2013), and a total of 14 species for the Cape Verde Archipelago (Kaas 1991; Rolán 2005).

Surprisingly, it is apparently only *Acanthochitona crinita* that occurs in all of these regions. Genera like *Notoplax* and *Stenoplax* are unknown from the regions listed above. A representative of *Stenoplax* is especially interesting to find because it could reflect phylogenetic affinities with the species known from Brazil (*S. kempfi* and *S. marcusi*), or from the southwest Indian Ocean (*S. madagassica*). Should our new species, *S. hernandezi*, be phylogenetically closer to the Brazilian species, then we could speculate that its origins involved an amphi-Atlantic pathway. In contrast, *Craspedochiton* and *Notoplax* are genera that not known from closer than the southwest Indian Ocean or possibly the South African Atlantic Ocean waters, and their near absence in the Atlantic suggests that they have only recently dispersed to there. Three other genera, *Rhyssoplax*, *Callochiton* and *Lepidochitona*, have not yet been recorded in Brazilian waters but are known from southern and northeastern Atlantic waters. The only species co-occuring

in Cape Verde and São Tomé are the abovementioned *Acanthochitona crinita* and also *Chaetopleura caboverdensis* and *Lepidochitona rolani*. According to Le Loeuff and von Cosel (1998), the Cape Verde Archipelago lies within the northern alternance region (characterized by strong seasonal contrasts of thermic fronts; cf. Le Loeuff & von Cosel 1998), and São Tomé in the southern alternance region. In both areas, periodic upwelling events occur, bringing cold water to the surface, and more typical warm tropical water without upwelling. The intermediate typical tropical regions with warm water and reduced salinity are unlikely to be a distributional barrier for the chitons, if patterns demonstrated for other benthic marine invertebrate taxa also apply to them.

At present, we can say little about endemism of chitons for the São Tomé and Príncipe Islands. *Craspedochiton foresti* could be a candidate, but its status as a potential endemic is confounded by the uncertain systematic position of *Craspedochiton liberiensis*. The apparent absence of a species in a surrounding area could be real or might instead merely reflect lack of sampling. This could for example apply to the two new species described herein as well as be an explanation for the single genus records.

This region is important for understanding broad-scale biogeographic hypotheses in marine invertebrates (Schliewen 2011). The colonization history of the São Tomé and Príncipe Islands by chitons is not yet traceable, but establishment of a robust species inventory is an important first step.

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