

**TWO NEW SPECIES OF *THAIS*
(MOLLUSCA: NEOGASTROPODA: MURICIDAE)
FROM PENINSULAR MALAYSIA AND SINGAPORE,
WITH NOTES ON *T. TISSOTI* (PETIT, 1852) AND
T. BLANFORDI (MELVILL, 1893) FROM BOMBAY, INDIA**

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ABSTRACT.— Two new species of muricid gastropods, *Thais pinangensis*, new species, and *T. rufotincta*, new species, are described from Pulau Pinang and Singapore Island, respectively. They may have previously been overlooked or mistaken for *T. tissoti* or *T. blanfordi*. The latter two species are not found in the Malayan region but are probably restricted to the Indian subcontinent and east coast of Africa.

INTRODUCTION

The intertidal rocky shores of the Malayan region support a diverse molluscan fauna (e.g., Tantanasiriwong, 1978; Way & Purchon, 1981; Angot, 1984). Species in the genera *Thais* (s.l.) and *Morula* (s.l.) are some of the more conspicuous members of the gastropod assemblage present on granite boulders, breakwaters, walls of monsoon drains leading into the sea, as well as on rocks and boulders on the shore. They are often found in moderate to large numbers and generally prey on barnacles, polychaetes, bivalves and other gastropods (e.g. Taylor, 1976, 1980). Recently there has been a renewed interest in this group of animals as they can be useful indicators of tributyltin pollution in coastal waters (Gibbs & Bryan, 1986; Gibbs, Bryan, Pascoe & Burt, 1987). Despite their ubiquitousness, the taxonomy of *Thais* and *Morula* in the Indo-Pacific at the species level is in many ways inadequate and confused (Tan, 1995; Tan, in prep.). The reason may be that shell form is highly variable within some species whereas in other cases different species have very similar shells. This paper describes two species that have probably been overlooked or mistaken as variants of *Thais tissoti* (Petit, 1852) or *T. blanfordi* (Melvill, 1893). The four species are compared and defined based on their shells, anatomy, radulae, opercula and morphology of their egg capsules.

MATERIALS AND METHODS

Snails were collected during low tide at various localities along the coastline of Singapore and Peninsular Malaysia. Additional specimens were obtained from the vicinity of Bombay and Alibag, India. The pigmentation patterns of the foot and sole were noted, and the animals were then relaxed in 7.5% magnesium chloride solution mixed with an equal volume of seawater. Spermatozoa were obtained from the testes and seminal vesicles of at least two live mature males. A small amount of sperm was mounted a glass slide, and those which were quiescent and in focus at 400x magnification for most of their length were drawn with a camera lucida attached to a compound microscope. Sperm length measurements were obtained from the drawings, or read off directly using an eyepiece micrometer. About ten animals of each species were also partially dissected to record the colour and size of various organs. After they were fixed in buffered 4% seawater formaldehyde, further observations on the internal morphology were made. Aceto-carmine and methylene blue were often useful in elucidating gross organ structure. Radulae from about twenty animals of each species were extracted by dissolving the proboscis in 1M potassium hydroxide. They were rinsed in distilled water, their lengths recorded, and mounted on brass stubs using double-sided tape. The radulae were gold-coated and observed under a JEOL JSM T220-A scanning electron microscope (SEM) at 15 or 20kV accelerating voltage. Widths of the rachidians were measured off the screen to the nearest millimetre, after calibration with a standard SEM grid. Terminology used for the description of radulae generally follows that of Fujioka (1985) and Kool (1987). Shell microstructure was determined using the acetate peel technique (e.g. Kennish, Lutz & Rhoads, 1980). Egg capsules were obtained from the field, and if they were being laid, the identity of the adult was noted. Descriptive terminology is adapted from D'Asaro (1970, 1991) and Kool (1993). Larvae obtained from egg capsules hatched in the laboratory were examined whenever possible. Rearing conditions are detailed in Tan (1995). All relevant material in the following institutions was examined: American Museum of Natural History (AMNH), Australian Museum, Sydney (AMS), Academy of Natural Sciences of Philadelphia (ANSP), The Natural History Museum, London (BMNH), Center for Marine and Coastal Studies, Universiti Sains Malaysia, Pulau Pinang, Malaysia (CEMACS), Institut Royal des Sciences Naturelles de Belgique, Brussels (IRSN), Jabatan Zoologi, Universiti Malaya, Kuala Lumpur (JZUM), Museum and Art Gallery of Northern Territory, Darwin (MAGNT), Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ), Muséum d'Histoire Naturelle, Geneva (MHNG), Muséum Nationale d'Histoire Naturelle, Paris (MNHN), Museum Zoologicum Bogoriense, Bogor, Java (MZB), National Museum of Wales, Cardiff (NMW), Nationaal Natuurhistorisch Museum, Leiden (NNML), National Science Museum, Tokyo (NSMT), Phuket Marine Biological Center, Ko Phuket, Thailand (PMBC), Sarawak Museum, Kuching, Malaysia (SMK), National Museum of Natural History, Smithsonian Institution, Washington D.C. (USNM), Instituut voor Taxonomische Zoölogie, Amsterdam (ZMA), Zoologisk Museum, University of Copenhagen (ZMUC) and Zoological Reference Collection, Department of Zoology, National University of Singapore (ZRC). Selected material from Natal Museum (NM) was also examined. Much of the material available in museums consisted of dry shells and sometimes opercula. Alcohol specimens and egg capsules were examined whenever possible. Collections made by the author(s) are indicated by the initials 'TKS'. It should be noted that a taxon that is accompanied by an author's name without a long dash between them indicate that the species was originally described by the author. Species followed by a dash indicate that the taxon was cited by the author. Synonyms encountered in the literature are given but no attempts are made to provide complete synonymies. However all references containing figures of shells, radulae or egg capsules are listed. In general species lists are not included unless found useful or relevant,

as it is often impossible to verify the identity of the species cited.

Abbreviations used in the text: ABO—accessory boring organ; asg—accessory salivary gland; msg—main (acinous) salivary gland.

TAXONOMY

Thais pinangensis, new species (Figs. 1a–d, 2a–f, 3a–f, 4; Pl. 1a–h)

Material examined. — Holotype (ZRC 1996.49) (Pl. 1e, f): SH= 16.2 mm, male. Type locality: Tanjung Huma, Pulau Pinang, Malaysia. On granite, amongst serpulids, collected by K.S.Tan, 19 Mar. 1992.

Paratypes: 20 specimens deposited in ZRC (ZRC 1996. 50).

Others: **India:** Andhra Pradesh: Visakhapatnam (ANSP 294298); Waltair (MCZ); **Malaysia:** Perak: Teluk Batik (TKS); Tanjung Hantu (TKS); Pulau Pinang: Tanjung Huma (TKS); Batu Ferringhi (JZUM, MCZ); **Sri Lanka:** Chilaw (ANSP 210718).

Diagnosis. — Shell — small, up to 21 mm, high-spired, solid. Last whorl with five spiral bands, each composed of 3–4 nodose, primary cords. Each band bears 14–18 dark brown to black knobs that are more or less axially aligned. In each band, the region between the knobs are light brown, while the rest of the shell is more or less dark brown. The inside edge of the outer lip has a thin dark brown margin, while the 4–5 lirate apertural teeth are bluish-white, and there are also 4–5 thin spiral brown lines confluent with the lirae. Animal—Sole of foot yellow without subcutaneous pigment; penis simple, base gradually tapering towards flagellum; anterior oesophagus pigmented brown in fresh specimens.

Etymology. — This species was first found on the rocky shores of Pulau Pinang in the Straits of Malacca. It should be noted, however, that its distribution is not confined to this island.

Description. — Shell (Table 1; Pl. 1a–h): Height 15–21 mm, fusiform, spindle-shaped, distinctly shouldered. Entire shell surface lined with spiral cords crossed obliqually with axial threads. The last whorl bears 12–18 (mode=15, n=26) small, blunt tubercles on each spiral row, of which there are five rows. The first row is present just below the suture between the penultimate and body whorls. The second row forms the shoulder and bears the largest tubercles. Each tubercle is crossed by 3–4 spiral cords. The third, fourth and fifth rows of tubercles are less prominent. Spiral cords are also present between the spiral rows of tubercles.

Table 1. Shell characteristics of *Thais pinangensis*.

| Shell character | Mean±SD (n=26) | Range |
|-----------------|----------------|-----------|
| SH (mm) | 17.2±1.9 | 13.9–20.5 |
| AH (mm) | 10.9±1.2 | 7.6–13.3 |
| SW (mm) | 10.1±1.6 | 8.1–11.8 |
| SH/AH | 1.59±0.08 | 1.46–1.82 |
| SH/SW | 1.66±0.06 | 1.58–1.71 |

SH—Shell height; AH—Apertural height; SW—Shell width

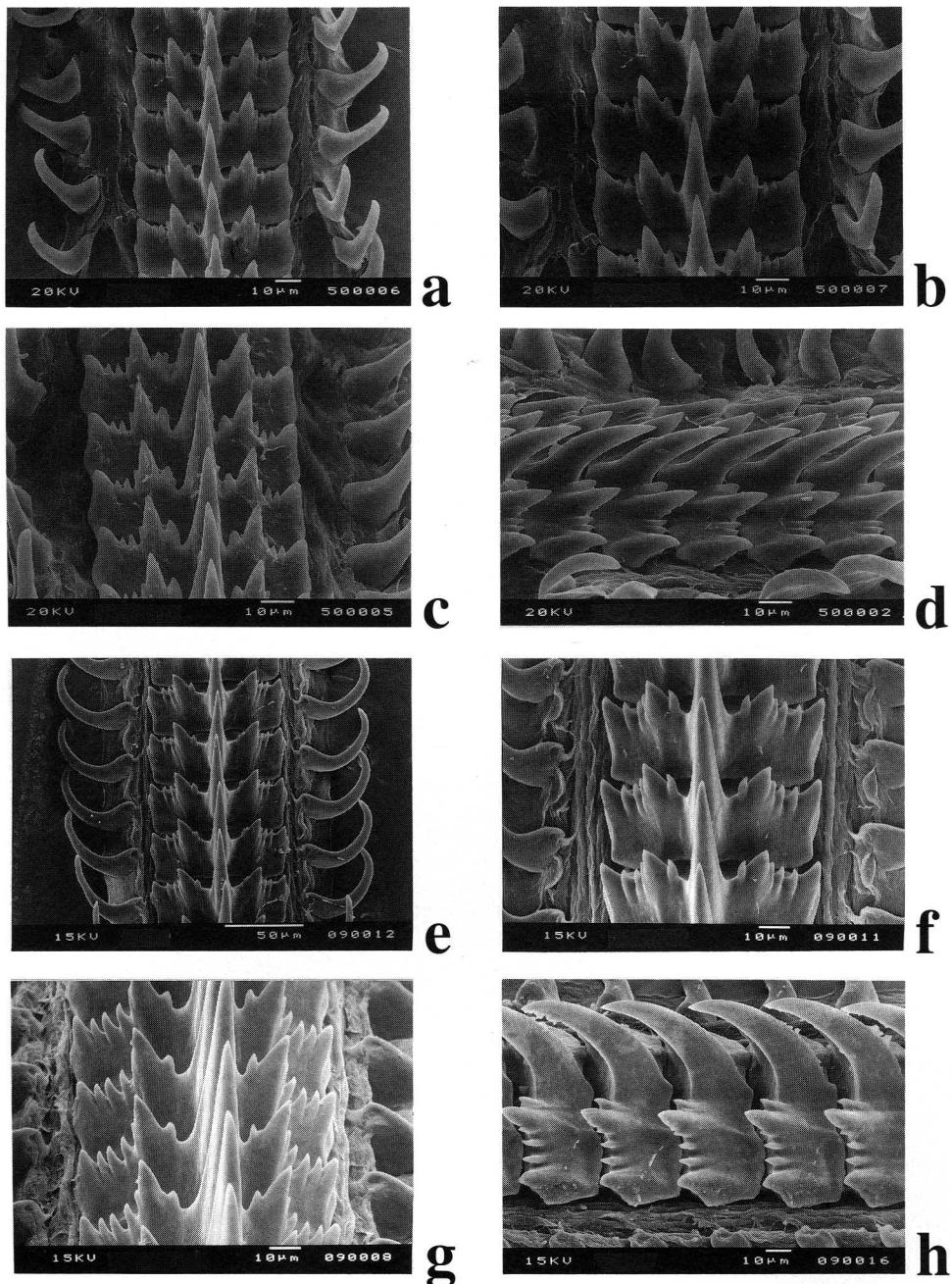


Fig. 1. Radulae of *Thais pinangensis*, new species. (a-d) and *T. rufotincta*, new species. (e-h); (a-d) Tanjung Huma, Pulau Pinang, Malaysia, SH= 16.1 mm, male; (e-h) Tanah Merah, Singapore; (e, h) SH= 24.5 mm, male; (f) SH= 24.3 mm, female; (g) SH= 23.2 mm, male; (a, b, e, f) 90° view; (c, g) 45° view; (d, h) side 45° view.

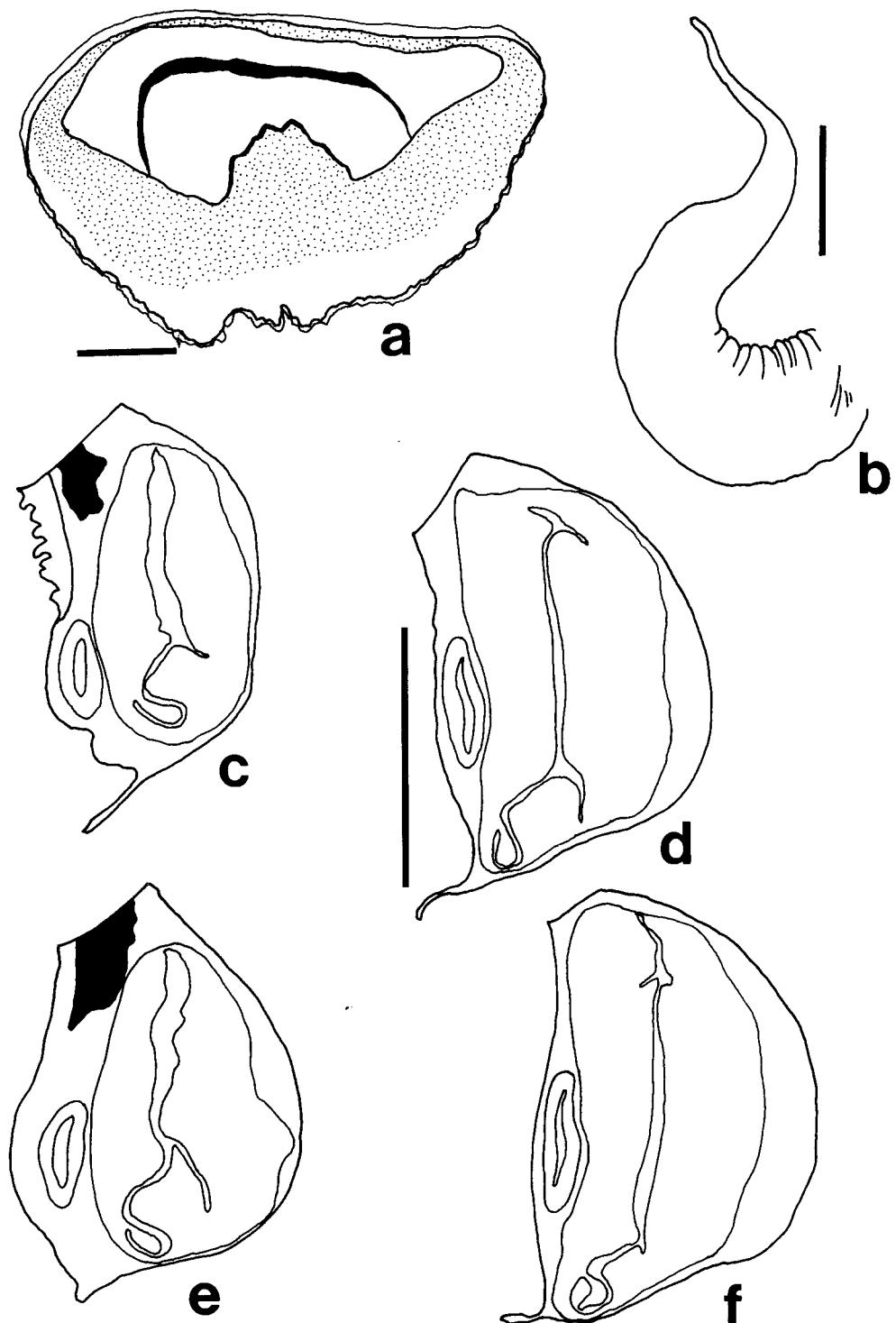


Fig. 2. *Thais pinangensis*, new species. Tanjung Huma, Pulau Pinang, Malaysia: (a) operculum, attached surface; (b) penis; (c-f) serial transverse sections of capsule gland viewed from the posterior; (c) is anteriomost. Scale bar = 1 mm.

On the sutural ramp, 3–4 spiral cords are present, while anterior to the carina, 2–3 spiral cords separate the rows of tubercles. The shell is generally dark brown with lighter coloured thin axial stripes between the darker, broader axial stripes. The tubercles are also light coloured. Aperture: The edge of the outer lip is crenulate; there are 4–5 pleat-like, narrow denticles on the inner edge of the outer lip, which are adjacent to regions between the spiral rows of tubercles. The inside edge of the outer lip has a dark brown margin, while the denticles and inside of the aperture are pale bluish-white. The denticles themselves may be tinged brown so that there are 4–5 spiral lines within the aperture. The columella is moderately wide and has no columella folds. It is generally of the same colour as that of the aperture, although the underlying brown coloration usually shows through at the parietal region. The anal canal is well developed, but there are no obvious parietal folds. Shell microstructure: Three aragonitic cross-lamellar layers.

Operculum (Fig. 2a): Reddish-brown; attachment surface with single adventitious layer; the external (free) surface bears a lateral nucleus.

Animal (Fig. 2b): Sole of foot yellow, no other pigments observed; ABO present atop ventral pedal gland in females, diameter 1 mm (SH= 19.2 mm); edge of sole with white and yellow subcutaneous pigment spots. Large concentrations of white subcutaneous pigment spots were found at the edge of the propodium. Sides of foot yellow with greyish-black surface pigment, appearing mottled. Tentacles: Eyes situated about one-third way towards tip; between base and eye, little surface pigmentation but yellow subcutaneous spots are present; between eye and tip, a greyish-black band extends incompletely around the tentacle up to halfway towards tip. Between band and tip, there is no surface pigment so that the underlying yellow pigment can be seen. Head with little or no surface pigmentation. Penis base gradually tapers towards flagellum. Mantle edge not crenulated, ventral surface pigmented light brown, dorsal surface not pigmented; ctenidial leaflets with straight efferent edge, with fine brown spots.

Anatomy (Figs. 2c–f, 3a–f): Proboscis length 4.5 mm, diameter 0.8 mm (SH= 15.9 mm, male), not pigmented; buccal mass pink; anterior oesophagus pigmented brown (i.e., from buccal mass to valve of Leiblein); msg white, asg translucent white, tubular; left asg slightly longer than right asg, separated from msg; right asg attached to msg; left asg length 0.9–1 mm, diameter 0.2–0.25 mm; right asg length 0.7–0.8 mm, diameter 0.2–0.35 mm (SH range 17–18 mm). Glande framboisée inconspicuous or absent; gland of Leiblein light brown to brownish-black. Ventral flange forming the ventral channel in the capsule gland of females is a small slightly bulbous flap with no folds. The ventral channel of the capsule gland in females is formed by a single slightly bulbous left flange. The sperm ingesting gland consists of multiple chambers. The posterior seminal receptacles are attached to the dorsal region of the anterior fold of the albumen gland. Sperm length 115–118 μ m.

Radula (Table 2; Figs. 1a–d): Central cusp narrow, long; lateral cusps broader but shorter than central cusp, with a single broad inner denticle. Marginal cusps broad, blunt, prominent. There are three small denticles between the lateral and marginal cusps.

Egg capsules: Unknown.

Larvae: Unknown.

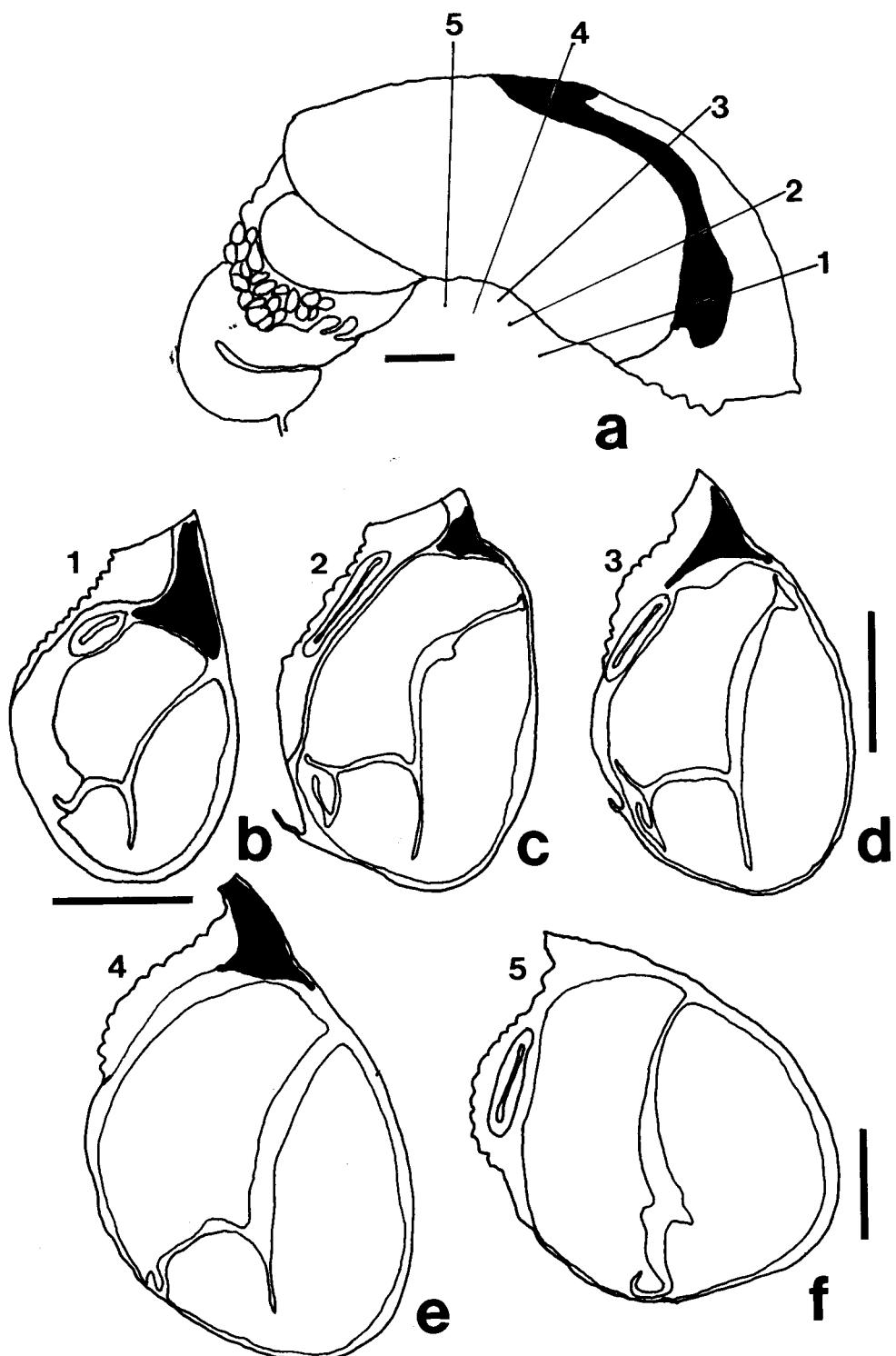


Fig. 3. *Thais pinangensis*, new species. Ujung Batu, Pulau Pinang, Malaysia: (a) part of female reproductive tract; (b-f) serial transverse sections of capsule gland viewed from the posterior; (b) is anteriormost. Scale bar = 1 mm.

Table 2. Radula characteristics of *Thais pinangensis*.

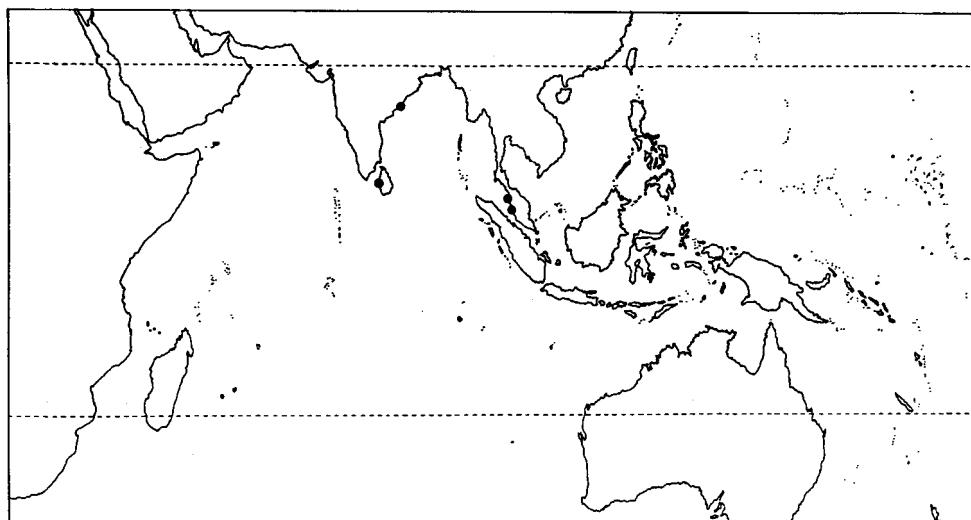
| Sex | Mean SH \pm SD (mm) (mm) | SH range (mm) | Mean RL \pm SD (mm) (mm) | RL range (mm) | Mean RW \pm SD (μ m) (μ m) | RW range (μ m) | Mean RL/ \bar{S} H RL/ \bar{S} H range |
|------------------|-------------------------------------|------------------|-------------------------------------|------------------|---|------------------------|---|
| Male (n=6) | 15.8 \pm 1.0 | 14.3–16.8 | 3.7 \pm 0.7 | 2.9–4.8 | 60.3 \pm 9.5 | 52–74 | 0.23 \pm 0.04 0.19–0.29 |
| Female (n=16) | 17.8 \pm 1.6 | 14.8–20.5 | 4.0 \pm 0.8 | 2.5–5.6 | 65.9 \pm 11.0 | 49–83 | 0.22 \pm 0.03 0.17–0.28 |

SH— Shell height; RL— Radula length; RW— Rachidian width

Habitat. — They are found in small numbers in the serpulid (*Pomatoleios*) belt, i.e., between the mid- and low littoral zone on rocky shores.

Distribution. (Fig. 4) — This species is rare in museum collections. It is only found in collections from the Straits of Malacca, the east coast of India and Sri Lanka.

Similar species. — This species may have been overlooked due to its similarity with *Thais tissoti*. However *T. pinangensis* differs from *T. tissoti* by its smaller average size, dark shell pigmentation and the lack of protuberant nodose cords on the last whorl. *T. pinangensis* may also be confounded with *T. rufotincta* which can occur in the same habitat. The two species can be distinguished by the smaller size of the shell and the larger number of knobs (14–18 on *pinangensis*, 8–15 on *rufotincta*) on the last whorl of *T. pinangensis*. The distinct, narrow dark brown to black margin on the inside edge of the outer lip of *T. pinangensis* is absent or only present as a diffuse light brown tinge in *T. rufotincta*. Their sperm lengths are also different.

Fig. 4. Distribution of *Thais pinangensis*.

Thais rufotincta, new species

(Figs. 1e–h, 5a–h, 6a–e, 7a–g, 8; Pls. 2a–p, 3a–f)

Cuma javanica—Oostingh, 1923: p. 113, fig. 13 (not *Purpura javanica* Philippi, 1848)

Thais (Cymia) javanica—Oostingh, 1935: p. 68–69, pl. 5, figs. 63–66 (not *javanica* Philippi)

Thais javanica—Springsteen & Leobrera, 1986: p. 146, sp. 10; pl. 40, fig. 10 (not *javanica* Philippi)

Thais javanica—Dharma, 1988: p. 84–85, pl. 28, fig. 8 (not *javanica* Philippi)

Material examined.—Holotype (ZRC 1996. 51) (Pl. 2a, b).—SH= 26.7 mm, male. Type locality: Tanjung Berlayar, Labrador Park, Singapore. On rocks; collected by K.S.Tan, 31 May.1990.

Paratypes: 4 paratypes deposited in ZRC (ZRC 1996. 52).

Others: **Brunei:** Anduki (NNML); Pulau Chermin, Brunei Bay (BMNH); **Burma:** Victoria Point (MCZ 267047); **Hong Kong:** Wu Kwai Sha, Tolo Channel, Hong Kong (BMNH); **India:** Kerala: Nerakkal, Ernakulam (MCZ 301832); Tamil Nadu: Krusadai (ZMUC); Mandapam (ANSP 302532; USNM 701967, ZMUC); Pondicherry (?) (BMNH); **Indonesia:** Jawa: Anjol (NNML); Balung Gabus, Sidoarjo District, E. Java (MZB); Ceribon (NNML); Cilincin (ZMA); Kaliangget Timur, Madura (MZB); Djakarta Bay (MZB); Jakarta (MNHN); Pekalongan (ZMA); Pulau Bawean (ZMA); Tanjung Priok (NNML); Kalimantan: Balik Papan (MCZ-, NNML, ZMA); Pulau Siantan, Kep. Anambas (USNM 611755); Maluku: Pulau Dagasuli, Kep. Loloda Utara (MCZ-); Riau: Tanjung Buton, Pulau Lingga (TKS); Sulawesi Selatan: Ujung Pandang (NNML); Sumatera: Sungai Liat, Pulau Bangka (NNML); Tanjung Tiram (ZMA); **Malaysia:** Johor: Tanjung Laboh (TKS); Tanjung Penawar (TKS); Teluk Makhota (Jason's Bay) (TKS); Mersing (AMS C.134283, TKS); Tanjung Kempit (TKS); Kedah: Tanjung Jaga (TKS); Pantai Merdeka (TKS); Kampong Pulau Sayak (TKS); Kuala Triang, Pulau Langkawi (TKS); Pulau Langkawi (AMS C.138831); Labuan: Sungai Membedai (NNML); Melaka: Tanjung Bidara (TKS); Negeri Sembilan: Port Dickson (TKS); Pahang: Kuantan (AMS, BMNH, CEMACS, TKS); Tanjung Cherating (TKS); Perak: Teluk Batik (TKS); Pasir Bogak, Pulau Pangkor (TKS); Teluk Nipah, Pulau Pangkor (TKS); Tanjung Hantu (TKS); Pulau Pinang: Gertak Sanggul (TKS); Bagan Pulau Betong (TKS); Batu Ferringhi (AMS C.124540, JZUM, MCZ 266931); Tanjung Bungah (BMNH); Tanjung Huma (TKS); Sabah: Tawau (USNM 309676); Teluk Marudu (USNM 632098); Tanjung Aru, Kota Kinabalu (AMNH 150665, USNM 658607); Sarawak: Bako (ZRC); Selangor: Pulau Tengah, Port Swettenham (JZUM); Terengganu: Bukit Keluang (TKS); **Philippines:** Philippines (NNML); Luzon: Bauan, Batangas (AMS); Cabcaben, Bataan (ANSP 229736); Cavite, Manila Bay (ANSP 84860); Masinloc Bay (MNHN); Negros: Miranda Beach, Pontevedra (ANSP 156596); Panay: Iloilo (USNM 383971); Visayas: Iloilo (NM J3027); **Singapore:** Singapore (AMS C.34457, BMNH); Labrador Park (ZRC); East Coast Park (TKS); Siglap (NMW; ZRC); Sarimbun (TKS); Tanah Merah Kechil (NMW); Tuas (TKS); Lim Chu Kang Road end (TKS); Sungai China (TKS); Pasir Ris Park (TKS); West Coast Park (TKS); Marina South (TKS); **Solomon Ids:** Vanikoro Id., Santa Cruz Ids. (NMW); **Tanzania:** Dar-es-Salaam (?) (BMNH); **Thailand:** Ang Hin (MCZ 262027); Bang Saen (MCZ 262040); Hua Hin (MCZ 266929); Ko Muan (ZMUC); Ko Mutapone, Chumphon (MCZ 266418); Ko Tapau Noi, off Ko Phuket (MCZ 266928); Laem Ngop (ZMUC); USNM 608654); Laem Son, Ko Phuket (ANSP 285868); Pak Meng beach, Trang (PMBC 8603); Panangtuk Bay, Chumphon (MCZ 262032); Pak Nam (USNM 361290); Prachuab (MCZ-); Rayong (USNM 363636); Sakom, Songkhla (PMBC 9008); Sattahip (MCZ 262029); Songkhla (MCZ-; USNM 405786); Sriracha (USNM 405806); **Vietnam:** Baie d'Along (IRSN); Long Hai (AMNH 171912); Ha-bin, Tonkin (NMW).

Diagnosis.—Shell—medium-sized, up to 32 mm, solid. Last whorl with 8–10 primary spiral cords which are separated from each other by 1–3 secondary spiral cords. The spiral striae separating the spiral cords are fimbriate, wide, but shallow. There are 8–13 low, compressed knobs on the last whorl. These are pronounced at the shoulder but flatten out towards the siphonal canal. As the knobs are more or less axially aligned, they form low varices, which are stained brown, while the spaces between the varices are cream-coloured. Each primary spiral cord that traverses the varices bears white and brown dashes, with the brown regions often (but not always) corresponding to the varices and the white regions between the varices. The inside of the outer lip is bluish-white to cream in shells with a

thickened edge, but stained brown in those that are still actively growing. There are 4–6 whitish-yellow lirae that spiral into the aperture, marked by faint brown spiral lines. The columella is stained brown at the parietal region but the rest is cream to light brown. Animal—Sides of foot shaded black on the surface, with diffuse yellow subcutaneous pigment grains as well as small white grains in a dark yellow background. Penis flagellate, muscular base 3–4 times as long as flagellum. Anterior oesophagus not pigmented.

Etymology. — The primary cords as well as the tubercles present on the last whorl are tinged reddish-brown, a prominent feature of the shell.

Description. — Shell (Table 3; Pls. 2a–p, 3a–f): Height 21–32 mm, solid, spindle-shaped; entire shell covered with spiral cords and fine collabral threads. Spiral cords can be grouped into wide and narrow cords. In general there are 8–10 wide spiral cords on the last whorl (excluding the nodose cord just below the suture separating the penultimate and last whorls); two of these form the shoulder, and there may be a narrow cord present between them. In the abapical direction, another pair of wide cords are present, separated from the shoulder by 2–3 narrow cords. This second set of two wide cords are usually present side by side, with either one or no narrow cord between them, as at the shoulder. The rest of the wide spiral cords present on the last whorl are separated from each other by 1–3 spiral rows of narrow cords. The sutural ramp is narrow, somewhat concave, consisting of 3–5 narrow cords, which forms a platform inclined abapically at 60 degrees. The striae separating these cords are as wide as the cords themselves. Immediately below the suture, a nodose irregular cord is present. The surface of first four spiral cords is undulating, forming low knobs that are axially aligned, so that there are between 8 and 13 low varices (mode=10, n=66) present on the last whorl. The varices are pronounced at the shoulder but gradually flatten out towards the siphonal canal. On wetted shells, brown dashes separated by shorter white to cream dashes can be seen. Brown dashes more or less correspond to the raised regions of the cords, and these may be axially aligned so that the shell appears striped in the antero-posterior direction. Aperture: Edge of outer lip crenate, inner edge of outer lip bears 4–8 ridge-like, thin, low lirae. The interior of the last whorl is greyish-white in colour with faint brown spiral lines that extend into the interior. In the case of shells with little inductra deposited, the region between the edge of the outer lip and the denticles may be stained dark brown while those with thickened outer lips have this region coloured more or less cream or yellowish-white. The columella is narrow, smooth with no columella folds, but one or two low plicae may be present at the base of the siphonal canal. The parietal region is stained dark brown while the rest of the columella is cream to light brown. Shell microstructure: Three aragonitic cross-lamellar layers.

Table 3. Shell characteristics of *Thais rufotincta*.

| Shell character | Mean±SD (n=66) | Range |
|-----------------|----------------|-----------|
| SH (mm) | 23.5±3.7 | 12.3–31.9 |
| AH (mm) | 15.7±2.2 | 11.1–21.4 |
| SW (mm) | 14.8±2.1 | 10.5–19.8 |
| SH/AH | 1.50±0.13 | 0.81–1.73 |
| SH/SW | 1.60±0.14 | 0.86±1.80 |

SH— Shell height; AH— Apertural height; SW— Shell width

Opercum (Figs. 6a, b): Light brown, with a single adventitious layer on the attachment surface; the external (free) surface bears a lateral nucleus.

Animal (Figs. 6c–e): Sole of foot dark yellow in colour, no pigment spots (however, in specimens from Pulau Langkawi, sole of foot may be grey-white with subcutaneous white pigment spots; grey surface pigment may be present around the propodium); ABO dorsal to ventral pedal gland in females. Edge of foot with subcutaneous white pigment spots; sides of foot dark yellow background with black surface pigmentation; very small white subcutaneous pigment spots and diffuse yellow subcutaneous pigment spots can be seen; tentacles tapering, eyes about 2/3 from base; between base and eye, surface uniformly shaded with black with yellow background; between eye and tip, solid black to greyish-black from eyes to halfway towards tip; tip of tentacles colourless, usually with subcutaneous yellow pigmented spots. Penis flagellate, muscular base 3–4 times as long as flagellum; flagellum muscular; penis base with subcutaneous orange-yellow pigment spots. Mantle edge slightly crenulated, thick, yellow; ventral surface of mantle skirt shaded brownish-black, more so directly above siphon. Siphon moderately long, tip flared, external surface shaded brownish black with tiny yellow subcutaneous spots, internal surface with little pigmentation except near the tip, where it is shaded black.

Anatomy (Figs. 7a–e): Proboscis of fresh specimens pinkish-white, moderately long, length 10.0 mm, diameter 2.0 mm (SH= 26.7 mm, male); msg white; asg white and translucent; glande framboisée present, small; gland of Leiblein pale orange. Right asg straight, not convoluted, separated from msg, same size or slightly larger than left asg, length 0.7–1.5 mm, diameter 0.2–0.5 mm (SH range 20–23 mm). Left asg embedded in main salivary gland and lies latero-ventrally to the oesophagus. The ventral channel is formed by a single left flange in the capsule gland of females. The sperm ingesting gland consists of multiple chambers. The posterior seminal receptacles are attached to the dorsal region of the anterior fold of the albumen gland. Sperm length 106–110 μ m.

Radula (Table 4; Figs. 1e–h, 5a, b): Central cusp narrow, lateral cusps broad, pointing outwards; inner denticle small, sharp. Marginal cusps sharp, broad, prominent, pointing outwards. There are 3–4 marginal denticles between the marginal and lateral denticles. Significant differences at the 5% confidence level were found in the radula lengths and rachidian widths between males and females. RL/SW and RW/SW were also significantly different at the 5% confidence level between males and females.

Table 4. Radula characteristics of *Thais rufotincta*.

| Sex | Mean SH \pm SD (mm) | SH range (mm) | Mean RL \pm SD (mm) | RL range (mm) | Mean RW \pm SD (μ m) | RW range (μ m) | Mean RL/SW | RL/SW range |
|-----------------|-----------------------------|------------------|-----------------------------|------------------|-----------------------------------|------------------------|-----------------|----------------|
| Male (n=12) | 23.2 \pm 1.6 | 20.9–26.4 | 6.8 \pm 0.7 | 6.0–7.8 | 97.8 \pm 9.8 | 81.0–112.5 | 0.29 \pm 0.02 | 0.23–0.32 |
| Female (n=8) | 23.2 \pm 1.2 | 21.6–24.3 | 5.9 \pm 0.8 | 4.2–6.8 | 82.2 \pm 5.8 | 74–90 | 0.26 \pm 0.04 | 0.17–0.31 |

SH– Shell height; RL– Radula length; RW– Rachidian width

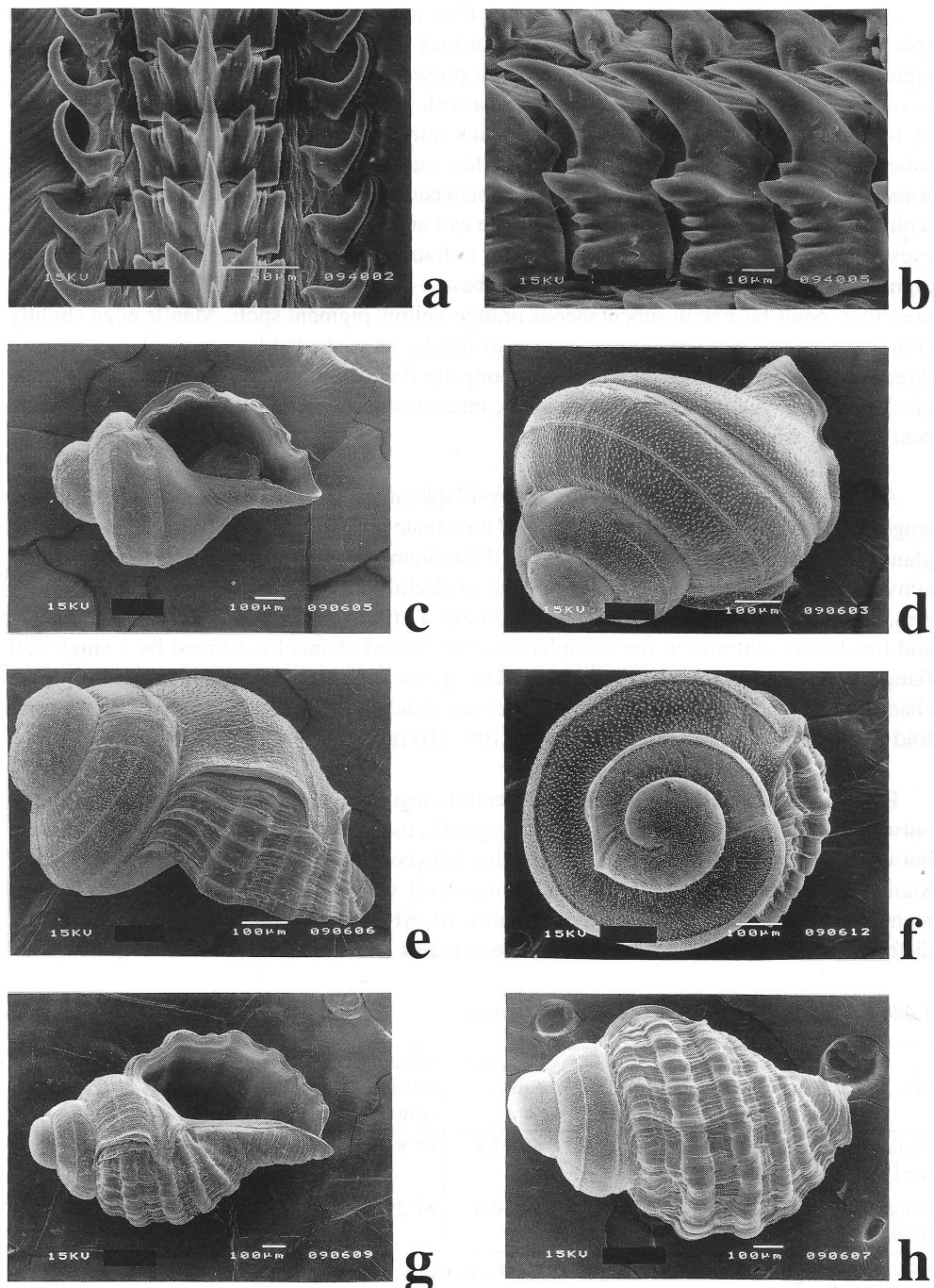


Fig. 5. *Thais rufotincta*, new species: (a, b) Wu Kwai Sha, Hong Kong (BMNH); (a) radula, 90° view; (b) rachidian, side 45° view; (c-h) post-metamorphic shells; larvae were raised in the laboratory from egg capsules obtained from East Coast Park, Singapore.

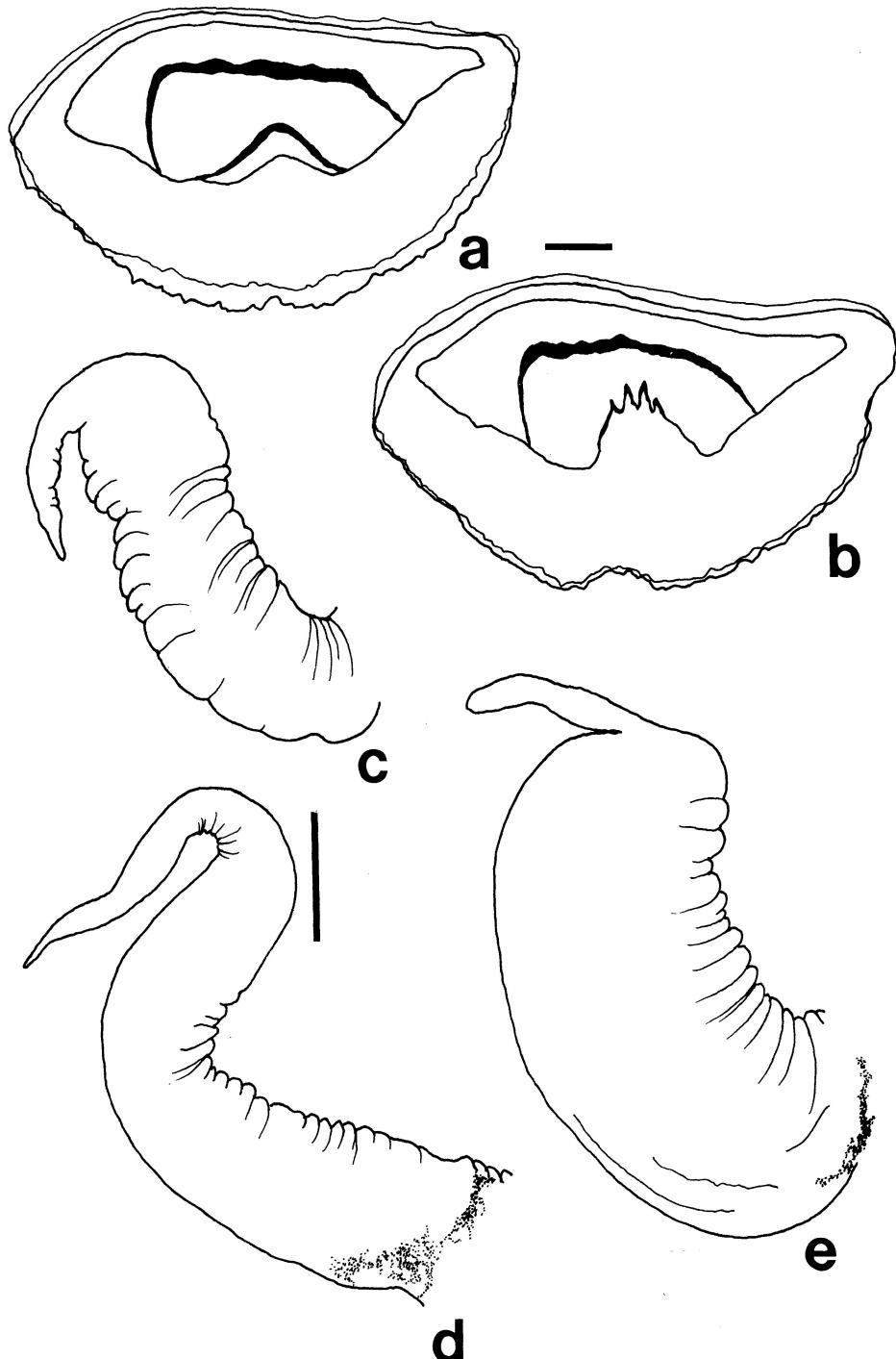


Fig. 6. *Thais rufotincta*, new species: (a, b) opercula, attached surface; (a) Tukun Ferringhi, Pulau Pinang, Malaysia; (b) East Coast Park, Singapore; (c-e) penes; (c) contracted; East Coast Park, Singapore; (d) relaxed; Tanah Merah, Singapore; (e) contracted, Tukun Ferringhi, Pulau Pinang, Singapore. Scale bar = 1 mm.

Egg capsules (Figs. 7f, g): The egg capsules are upright translucent cylinders of height 3–4 mm, with a diameter of 1.1–1.2 mm at their widest point, having slightly curved walls, so that the capsule is slightly bulbous, with a distinct groove round the uppermost part of the capsule. This separates the exit orifice from the capsule wall. The exit orifice, which is hemispherical and transparent, occupies the entire apical region of the capsule. Each capsule contains 36–45 embryos. Similar egg capsules were described by Natarajan (1957) and Barkati and Ahmed (1983) as those of *Thais tissoti*, whose capsules are indistinguishable from that of *T. rufotincta* (compare Figs. 7f, g with Fig. 12b). Van der Meer Mohr (1933) also described and illustrated (photograph of a clump of capsules) a similar kind of capsule but attributed it to *Cuma javanica*. The general appearance and shape agree with that of *tissoti*, but he gave their height as between 6–12 mm and diameter of 1–2 mm, and did not state the number of embryos in each capsule. *Cuma* (here as *Thais*) *javanica* is assigned to another species that lays a different capsule (see Tan, 1995) which may agree with van der Meer Mohr's size description but still somewhat doubtful when his illustration is taken into account. It cannot be overemphasized that any description of egg capsules or radula should be accompanied by an illustration of the shell of the species.

Larvae (Figs. 5c–h): The planktotrophic veligers hatch with a 4-lobed velum of width 500 µm. The pre- and post-oral bands are pigmented light brown. The well-developed foot is slightly pigmented black around the edges of the operculum. Only the right tentacle is present. The protoconch I is about 300 µm in width, just over one whorl with a pustulate surface. The mature larval shell (protoconch I+II) has 2.5 whorls, of width 750 µm and shell height 950 µm, beaked with a prominent sinusigera ridge. There are no tubercles present on protoconch II, which is somewhat more sparsely pustulate than protoconch I, and bears a prominent spiral groove that connects to the beak present on the outer lip. Between the groove and the suture, a narrow spiral ridge is present. During the early stages of protoconch II, there is a prominent spiral cord that is replaced later by the groove mentioned above.

After metamorphosis, a radical change in the sculpture of the shell occurs. Six spiral cords (largest and broadest cord nearest the suture) separated by spiral striae (equal in width to the cords) are present on the teloconch immediately after the sinusigera ridge. No obvious tubercles are present, although axial sculpture is present. A rapid extension of the siphonal canal after metamorphosis seems to be characteristic of this species.

Habitat. — The above species is one of the commonest thaids on the shores of Singapore. They are found on granite boulders and embankments along the east coast of Singapore amongst *Morula margariticola* and serpulids. *T. rufotincta* are usually found attached to hard substrates rather close to the bottom sediment, and appear to be highly tolerant of silty conditions. They are also present along the northern coast of Singapore, which experiences fluctuating salinity conditions. The egg capsules can be seen at most times of the year in large communal masses of more than a thousand capsules under stones and boulders.

Distribution. (Fig. 8) — This species is distributed throughout the Malayan archipelago. Records from the Indian subcontinent and Africa require confirmation.

Similar species. — Oostingh (1923, 1935) was perhaps the first to illustrate *Thais rufotincta*, but he identified the species as *T. javanica* (Philippi, 1848). The two species are different (Tan, 1995). They can be consistently distinguished by their shells, soft parts and egg capsule morphology. The shell of *T. javanica* differs from *T. rufotincta* in having 10–12 low, ridge-like tubercles on the carina, and a relatively drawn-out, dorsally upturned

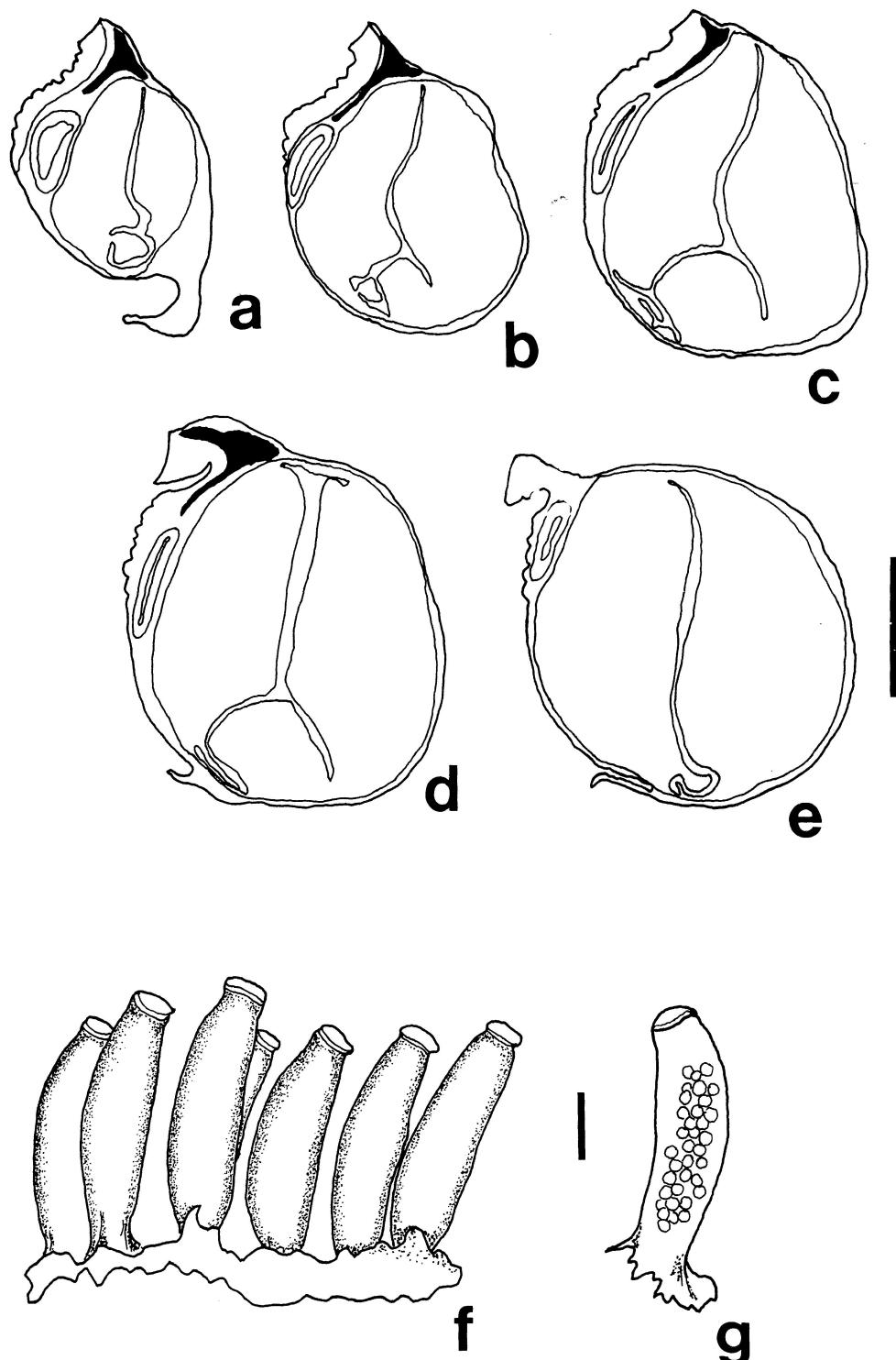


Fig. 7. *Thais rufotincta*, new species: (a–e) serial transverse sections of capsule gland viewed from the posterior; (a) is anteriomost; (f, g) egg capsules, Tuas, Singapore. Scale bar = 1 mm.

siphonal canal. The penis of *T. javanica* has a long, distinct flagellum, which can be as long as the penial base (see Tan, 1995, figs. 117b, c); in *T. rufotincta* the flagellum is only about one-third the length of the base. In cross-sections of the capsule gland from mature females, there are two ventral flanges delineating the ventral channel in *T. javanica*. The left flange is folded, larger than the right flange, and grooved extensively. This is in contrast to *T. rufotincta*, where there is only one simple flange. The egg capsules laid by *T. javanica* are cylindrical as in *T. rufotincta*, but differ in their overall shape. Those of *T. javanica* are slightly curved away from the vertical axis near the upper quarter, resembling a ship's ventilator with a cowling (see Tan, 1995, fig. 117d). They are also narrow at the base, gradually increasing in diameter until they are broadest at the curve, and are again constricted at the apex. This is quite unlike those of *T. rufotincta*, which are more or less symmetrical about their vertical axis.

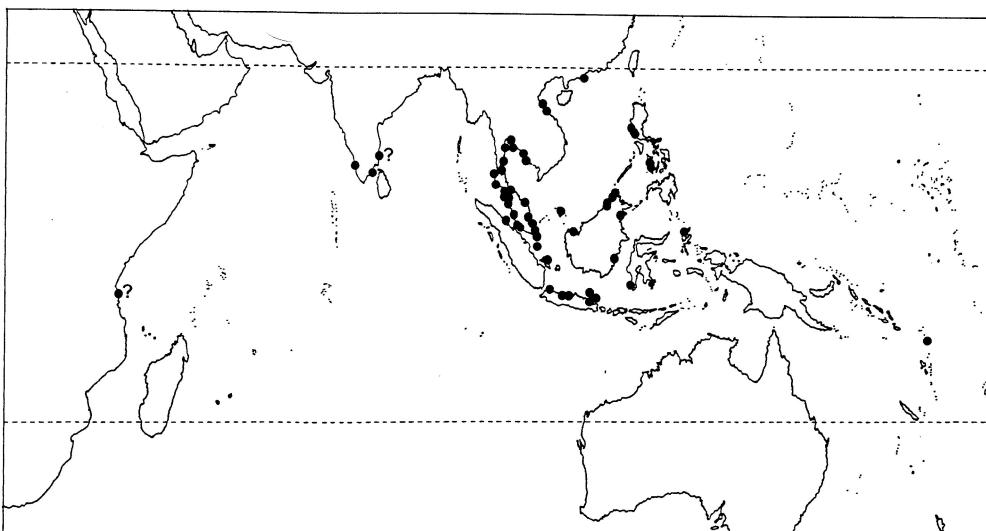


Fig. 8. Distribution of *Thais rufotincta*.

The shells of this species and that of *T. pinangensis* are rather similar, but they can be separated by the smaller average size and the closely set, more numerous knobs of the latter. The penes of the two species differ, in that those of *rufotincta* have a distinct base and flagellum, while that of *pinangensis* is gradually tapering. Another species that may have been confused with the new species is *T. tissoti* (Petit, 1852). The reason for this may lie in Petit's illustrations, where he provided two figures, which are actually two species. One is *T. tissoti*, while the other species was subsequently described by Melvill (1893) as *Purpura blanfordi*, although Melvill did not refer to Petit's figures. Subsequent workers have probably misinterpreted the extent of variation possible in *tissoti* from the figures in Petit and judged that *rufotincta* fell somewhere between the two shells illustrated. In this study, it is suggested that the three species (*T. rufotincta*, *T. tissoti* and *T. blanfordi*) are distinct. *T. tissoti* differs from *T. rufotincta* in having four prominent composite nodose cords on the last whorl with only a single narrow spiral cord between the adjacent cords; *T. blanfordi* also has four prominent composite cords (each composite cord consisting of 1–3 cords closely set) but there are three secondary spiral cords between the adjacent composite cords. Two of the composite cords bear low compressed knobs. The penial morphology of the three species also differ. *T. rufotincta* has a long base and short flagellum; *T. tissoti* has a long base and a papilla-like distal end; *T. blanfordi* has a gradually tapering penis. The opercula, radula

and egg capsules of *T. tissoti*, *T. blanfordi* and *T. rufotincta* are more or less similar. Their geographical distributions are also of some taxonomic interest. Whilst *T. blanfordi* and *T. tissoti* only occur on the west coast of the Indian subcontinent and westwards into South Africa (see below) *T. rufotincta*, seems to be confined to areas east of the Bay of Bengal.

***Thais blanfordi* (Melvill, 1893)**
(Figs. 9e–h, 10a–e, 12a, 13; Pl. 1i–n)

Purpura tissoti Petit, 1852: p. 163–164 (in part), pl. 7, fig. 4a only (types in MNHN) (not *tissoti* Petit [1852] fig. 4b)

Purpura blanfordi Melvill, 1893: p. 235, pl. 1, fig. 3 (Holotype BMNH 1893.2.16.2, SH= 27.9 mm. Type locality: Bombay)

Thais blanfordi—Cooke, 1919: p. 93 (radula description without figures)

Thais blanfordi—Subrahmanyam et. al., 1951: p. 46, 69, fig. 108

Thais (Thaisella) blanfordi—Kilburn, 1972: p. 410–411, figs. 7b (shell), 8b (radula)

Thais blanfordi—Kilburn & Rippey, 1982: p. 90

Thais blanfordi—Subba Rao & Surya Rao, 1993: sp. 70, p. 109–110; p. 105, fig. 25 (operculum); pl. 13, figs. 2, 3 (shell)

Material examined. — **India:** Goa: Don Paula (USNM 443151); Karnataka: Karwar (USNM 443652); Kerala: Nerakkal (MCZ 301832); North Bay, Cannanore (BMNH); Tellicherry (BMNH); Maharashtra: Alibag (TKS); Bombay (AMNH 140229, ANSP 231894, BMNH, MCZ-, MNHN); Chowpatti Beach, Bombay (AMNH 162834, USNM 701757); Mahim, Bombay (TKS); Vengurla (USNM 443202); **Kenya:** Mombasa (BMNH); **Madagascar:** Befotaka, Nossi Bé (ANSP 257831); **Mozambique:** Maputo (ANSP 277023, BMNH, MCZ-); **Pakistan:** Karachi (BMNH); **South Africa:** Delagoa Bay (BMNH); Durban Bay (AMNH 206037, ANSP 390743, NM A3688).

Diagnosis. — Shell—medium-sized, high spired, brownish-orange, with two spiral rows of compressed tubercles and two other rows bearing ridges. Aperture flesh-coloured, with lirate teeth inside the outer lip. Radula—Rachidian with narrow central cusp, broad lateral cusps, and there are 4–5 prominent marginal denticles.

Nomenclature. — *Thais blanfordi* (Melvill) was first described and illustrated as *Purpura tissoti* Petit (Petit, 1852, pl. 7, fig. 4a). Another species was inadvertently figured as a variety (pl. 7, fig. 4b var.), which is the present *tissoti* of authors. The use of *tissoti* is now so established in the literature that in the interest of stability the best course of action is to conserve *tissoti* as represented by fig. 4b and retain Melvill's taxon.

Description. — Shell (Table 5; Pl. 1i–n): Last whorl with four rows of tubercles which consists of spiral cords of various widths. Two rows bear 6–11 (mode=9, n=49) sharp compressed tubercles, the shoulder row being the more prominent, while the second row bears smaller tubercles. The remaining two spiral rows of protuberant cords are anterior to the second row of tubercles but these bear obsolete tubercles. The first spiral row of tubercles is separated from the second row by four cords. Spiral striae between these cords are narrow and shallow. The suture is found at or just above the second row of tubercles on the penultimate whorl. The sutural shelf is well-defined and consists of four to six spiral cords of various widths. The shell is uniformly light brown to dark orange. **Aperture:** The edge of the outer lip is crenate; the region between the apertural teeth and the edge is off-white to flesh-coloured, as is the interior of the aperture. There are six spirally elongate apertural teeth within the aperture. The columella is straight, narrow with no folds or plicae, but there may be two low elongate oblique denticles near the base of the siphonal canal. On the opposite end of the columella, it is stained brown at the parietal region up to halfway anterior to the siphonal

canal. The anal canal is well-developed. *Shell microstructure*: Two aragonitic cross-lamellar layers.

Table 5. Shell characteristics of *Thais blanfordi*.

| Shell character | Mean \pm SD (n=49) | Range |
|-----------------|----------------------|-----------|
| SH (mm) | 24.1 \pm 2.8 | 15.8–30.7 |
| AH (mm) | 15.2 \pm 1.7 | 9.8–18.6 |
| SW (mm) | 15.4 \pm 1.8 | 9.9–20.5 |
| SH/AH | 1.59 \pm 0.08 | 1.44–1.79 |
| SH/SW | 1.57 \pm 0.07 | 1.43–1.79 |

SH– Shell height; AH– Apertural height; SW– Shell width

Opercum (Fig. 10a): Yellowish-brown, translucent; attachment surface with two adventitious layers. The external (free) surface bears a lateral nucleus.

Animal (Fig. 10b): Sole of foot greyish-white, with no subcutaneous pigment spots. ABO dorsal to ventral pedal gland in females. Edge of sole with sparse white and yellow pigment grains. Sides of foot shaded greyish-black of varying density, with subcutaneous yellow pigment grains which are especially prominent at the head region. Tentacles with greyish-black surface pigment between base and eye; between eye and tip, grey-black eye band present; tip with subcutaneous yellow spots. Penis simple, gradually tapering, with a slightly bulbous flagellum.

Anatomy (Figs. 10c–e): Proboscis not pigmented; msg yellow, asg translucent, yellowish; gland of Leiblein light brown; right asg separated from msg, left asg attached to msg; right and left asg of about the same size, oval, not convoluted, length 1.5–2.0 mm, width 0.3–0.5 mm (SH range 23–26 mm). The left flange forming the ventral channel of the capsule gland in females is small and simple (see Figs. 10c–e). The sperm ingesting gland is multiple-chambered, and 3–4 posterior seminal receptacles are attached to the dorsal surface of the anterior fold of the albumen gland. Sperm length 110–113 μ m.

Radula (Table 6; Figs. 9e–h): Rachidian central cusp narrow, long, mid-region about half the width of lateral cusps; lateral cusps pointing outwards with a single inner denticle; marginal cusps sharp, prominent. There are 4–5 strong marginal denticles. Marginal groove obsolete. No sexual dimorphism was observed.

Table 6. Radula characteristics of *Thais blanfordi*.

| Sex | Mean SH \pm SD (mm) | SH range (mm) | Mean RL \pm SD (mm) | RL range (mm) | Mean RW \pm SD (μ m) | RW range (μ m) | Mean RL/SW | RL/SW range |
|---------------|-----------------------|---------------|-----------------------|---------------|-----------------------------|---------------------|-----------------|-------------|
| Male (n=8) | 24.2 \pm 1.0 | 22.7–25.6 | 7.0 \pm 0.8 | 5.9–8.0 | 107.8 \pm 12.8 | 85–123 | 0.29 \pm 0.04 | 0.25–0.35 |
| Female (n=13) | 25.7 \pm 1.9 | 22.8–28.9 | 7.7 \pm 1.0 | 5.2–9.1 | 115.5 \pm 13.2 | 92–142 | 0.30 \pm 0.04 | 0.20–0.37 |

SH– Shell height; RL– Radula length; RW– Rachidian width

Egg capsules (Fig. 12a): Upright cylindrical receptacles 3.5–4.5 mm height, with a diameter of 1.3–1.4 mm at their widest point. The cylinders are slightly bulbous at about half height, while constricted somewhat at the base (diameter about 0.6 mm), and at the tip (diameter 0.7–0.9 mm). The exit orifice is transparent and occupies the entire tip of each capsule.

Larvae: Not known.

Habitat. — *Thais blanfordi* was found in the same habitat as *T. tissoti* and *Morula subnudulosa* on the mid-littoral zone on rocky shores of west coast India.

Distribution. (Fig. 13) — This species appears to have a limited distribution, being confined to the western half of the Indian Ocean.

Similar species. — *Thais javanica* can be difficult to distinguish from *T. blanfordi*. However, *T. blanfordi* has a uniform brownish-orange shell and the aperture is flesh-coloured, while the shell of *T. javanica* is generally grey or white with brown markings, and the interior of the aperture is usually banded. Anatomically they differ in their penial morphology, with *blanfordi* having a gradually tapering base and a slightly bulbous flagellum (Fig. 10b), in contrast to *javanica* which has a distinct base and a long thin whip-like flagellum (see Tan, 1995, figs. 117b, c).

Thais tissoti (Petit, 1852)

(Figs. 9a–d, 11a–f, 12b, 14; Pl. 3g–p)

Purpura tissoti Petit, 1852: p. 163–164 (in part), pl. 7, fig. 4b only (lectotype figure here designated) (1 syntype in MNHN; lectotype here designated, SH= 18.5 mm. Type locality: Bombay, India)

Thais tissoti—Subrahmanyam et. al., 1951: p. 46, 69, fig. 106

Thais tissoti—Satyamurti, 1952: p. 166–167, pl. 16, fig. 4

Thais tissoti—Natarajan, 1957: p. 197, figs. 82–85 (larval shells, veligers); pl. 15, figs. 23, 24 (egg capsules)

Thais (Thaisella) tissoti—Kilburn, 1972: p. 409–410, fig. 7a

Thais tissoti—Starmühlner, 1974: p. 60; p. 79, no. 7 (zonation); pl. 3C (shell)

Thais tissoti—Kilburn & Rippey, 1982: p. 90, pl. 20, fig. 12

Thais tissoti—Barkati & Ahmed, 1983: p. 34, figs. 3A, B (egg capsules), figs. C–F (larval shells)

Thais tissoti—Abbott & Dance, 1986: p. 147, fig. (shell)

Thais tissoti—D’Asaro, 1991: p. 80–82, figs. 57A–E (egg capsules)

Thais tissoti—Subba Rao & Surya Rao, 1993: p. 116–117, pl. 14, fig. 5 (shell); p. 117, fig. 27 (operculum)

Material examined. — **India:** Goa: Goa (USNM 443006); Karnataka: Karwar (USNM 443671); Kerala: North Bay, Cannanore (BMNH); Nerakkal (MCZ 301832); North Bay, Cannanore (BMNH); Vypin (ANSP 303827); Maharashtra: Bombay (AMNH 140247, ANSP 231930, BMNH, MCZ, MNHN, NMW, TKS, USNM 90565); Chowpatti Beach, Bombay (USNM 701776); Vengurla (USNM 443231); Tamil Nadu: Mandapam (ANSP 302532); **Mozambique:** Beira (ANSP 283084, NMW); Ponte Maone, Maputo (ANSP 277023); **Oman:** near Salalah (BMNH); **Pakistan:** Karachi (BMNH, NNML, USNM 215671); Manora Id., Karachi (MCZ 255671); **South Africa:** Durban (NM B2638, NMW); Charles Pool, Thompson’s Bay, Natal (NM D1692); **Sri Lanka:** Chilaw (ANSP 210718); Galle (NNML); Merissa (ANSP 210864); **Thailand:** Hua Hin (MCZ 262664) (?).

Diagnosis. — Shell—up to 31 mm, light to dark brown, last whorl with four rounded prominent cords carrying brown tubercles, with an additional cord at the suture. The adjacent spiral rows of tubercles are separated from each other by a single cord sandwiched by two

deep striae of equal width as the cord itself. The inside of the outer lip has 4–5 white elongate teeth. The interior of the aperture is white, while the columella is white and brown.

Nomenclature.— This species was first described by Petit (1852). He illustrated two varieties which are actually two separate species, the other being the present *Thais blanfordi* (Melvill, 1893) (see under *T. blanfordi*, above).

Description.— Shell (Table 7; Pl. 3g–p): Shell small to medium sized (up to 31 mm), last whorl with four spiral rows (not including the sutural row) of rounded brown papillate tubercles or compressed tubercles which may be confluent so as to form a broad protuberant composite cord. These rows consist of compressed prominent cords, and the tubercles themselves are separated from adjacent rows by a single cord sandwiched by two deep striae of about equal width as the cord itself. The surface of this cord is undulating, as if secondary tubercles are present. Within the striae, growth checks give the shell surface between the tubercles a finely spotted appearance. There are 11–15 (mode= 12, n=57) brown tubercles on each spiral row, or they may be fused so that they appear as one single protuberant cord. The suture is formed at the second row of tubercles on the penultimate whorl. Immediately below the suture there is a sutural row of thickened cords but not quite amounting to the formation of tubercles. The sutural ramp itself is made up of two cords and two striae, the cords and striae being of about the same width. The tubercles are brown, as well as the striae, but the rest of the shell is light brown. *Aperture*: Edge of outer lip crenulate; on the inside of the outer lip, the region between the apertural denticles and edge is white. Apertural denticles white, somewhat elongate in the direction of spiral growth. Inside of aperture white, with faint brown spiral lines continuous with the apertural teeth. Columella straight, with no columella folds nor denticles. Anterior half of columella white, while the posterior half is brown with a white spiral streak at the parietal region. *Shell microstructure*: Two aragonitic cross-lamellar layers.

Table 7. Shell characteristics of *Thais tissoti*.

| Shell character | Mean±SD (n=57) | Range |
|-----------------|----------------|-----------|
| SH (mm) | 19.9±3.8 | 10.1–27 |
| AH (mm) | 13.1±2.5 | 6.5–18.7 |
| SW (mm) | 12.6±2.5 | 6.9–18.4 |
| SH/AH | 1.53±0.14 | 0.68–1.74 |
| SH/SW | 1.58±0.14 | 0.70–1.74 |

SH– Shell height; AH– Apertural height; SW– Shell width

Operculum (Fig. 11a): Light yellowish-brown throughout, translucent; attachment surface has a single adventitious layer, while the external surface bears a lateral nucleus.

Animal (Fig. 11b): Sole of foot greyish-white, with no subcutaneous pigment spots; ABO dorsal to ventral pedal gland in females. Edge of sole with mainly white and some yellow pigment grains. Sides of foot with greyish-black surface pigment; subcutaneous yellow (more prominent) and white pigment grains are present beneath the surface pigment. Tentacles: between base and eye, lightly pigmented grey-black; between eye and tip, grey-black pigment band present. The tip has no surface pigment but subcutaneous yellow pigment grains are present. The penis has a long elongate base with a very short flagellum.

Anatomy (Figs. 11c–f): (Based on alcohol specimens) Proboscis not pigmented. Asg yellowish-white, translucent; msg yellow. Right asg separated from msg, left asg embedded in msg. Both asg about the same size, not convoluted, length 0.7–0.9 mm, width 0.2 mm (SH range 19–21 mm). Glande framboisée present. Gland of Leiblein light brown, enmeshed in fibrous covering. The ventral channel in the capsule gland of females is defined by a single left flange. The sperm ingesting gland consists of multiple chambers. Several posterior seminal receptacles are attached to the dorsal region of the anterior fold of the albumen gland. Sperm length 110–113 μ m.

Radula (Table 8; Figs 9a–d): Rachidian central cusp long, narrow, slightly curved; base of lateral cusps about twice as broad as those of central cusp, about half as high; marginal cusps prominent, broad-based; there are 4–5 marginal denticles between the marginal and lateral cusps. Marginal groove is absent. Sample size was insufficient for determination of sexual dimorphism.

Table 8. Radula characteristics of *Thais tissoti*.

| Sex | Mean SH \pm SD (mm) | AH range (mm) | Mean RL \pm SD (mm) | RL range (mm) | Mean RW \pm SD (μ m) | RW range (μ m) | Mean RL/SH | RL/SH range |
|------------------|-----------------------|---------------|-----------------------|---------------|-----------------------------|---------------------|-----------------|-------------|
| Male | | | | | | | | |
| Female (n=20) | 20.2 \pm 1.8 | 17.4–23.1 | 6.4 \pm 23.1 | 4.1–7.8 | 104.1 \pm 14.1 | 83.0–135.0 | 0.32 \pm 0.05 | 0.19–0.41 |

SH—Shell height; RL—Radula length; RW—Rachidian width

Egg capsules (Fig. 12b): The capsules are cylindrical, slightly bulbous at mid-height, 2.3–3.0 mm in height and 0.9–1.1 mm in diameter at the widest region. The apical end has a circular transparent exit orifice 0.5–0.6 mm in diameter. A detailed description is provided by D'Asaro (1991). However, as the egg capsules of *T. blanfordi* are somewhat similar to those of *T. tissoti*, references to egg capsules without accompanying illustrations of the adult shell should be interpreted with caution. For instance, it is uncertain whether the capsules illustrated by Barkati & Ahmed (1983, figs. 3A, B) are those of *T. tissoti* or *T. blanfordi*. Also, the capsules laid by *T. rufotincta* are indistinguishable from those of *T. tissoti*.

Larvae: Natarajan (1957) has provided a short description of the planktotrophic larvae obtained from egg capsules.

Habitat.— Common on rocky shores at the mid-littoral (pers. obs.).

Distribution. (Fig. 14)— This species appears to be restricted to the west coast of India and Sri Lanka, and the east coast of Africa. There is one record from the Gulf of Thailand, but this is probably erroneous.

Similar species.— See under *Thais rufotincta*.

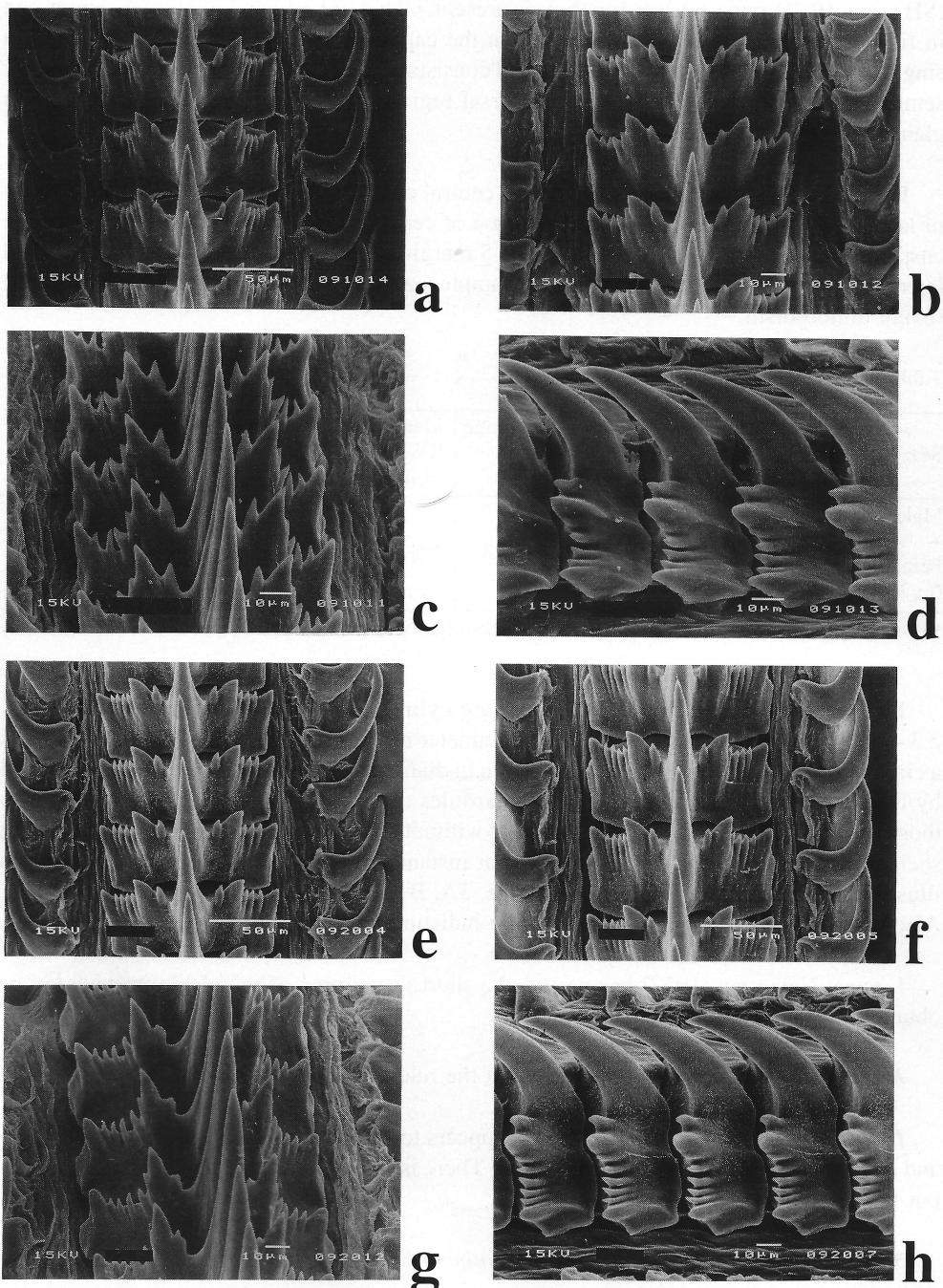


Fig. 9. Radulae of *Thais tissoti* (a-d) and *T. blanfordi* (e-h): (a-d) Kolaba Fort, Alibag, India; (a) SH= 21.6 mm, female; (b-d) SH= 18.1 mm, female; (e, h) SH= 25.7 mm, female; (f) SH= 28.9 mm, female; (g) SH= 25.0 mm, male; (a, b, e, f) 90° view; (c, g) 45° view; (d, h) side 45° view.

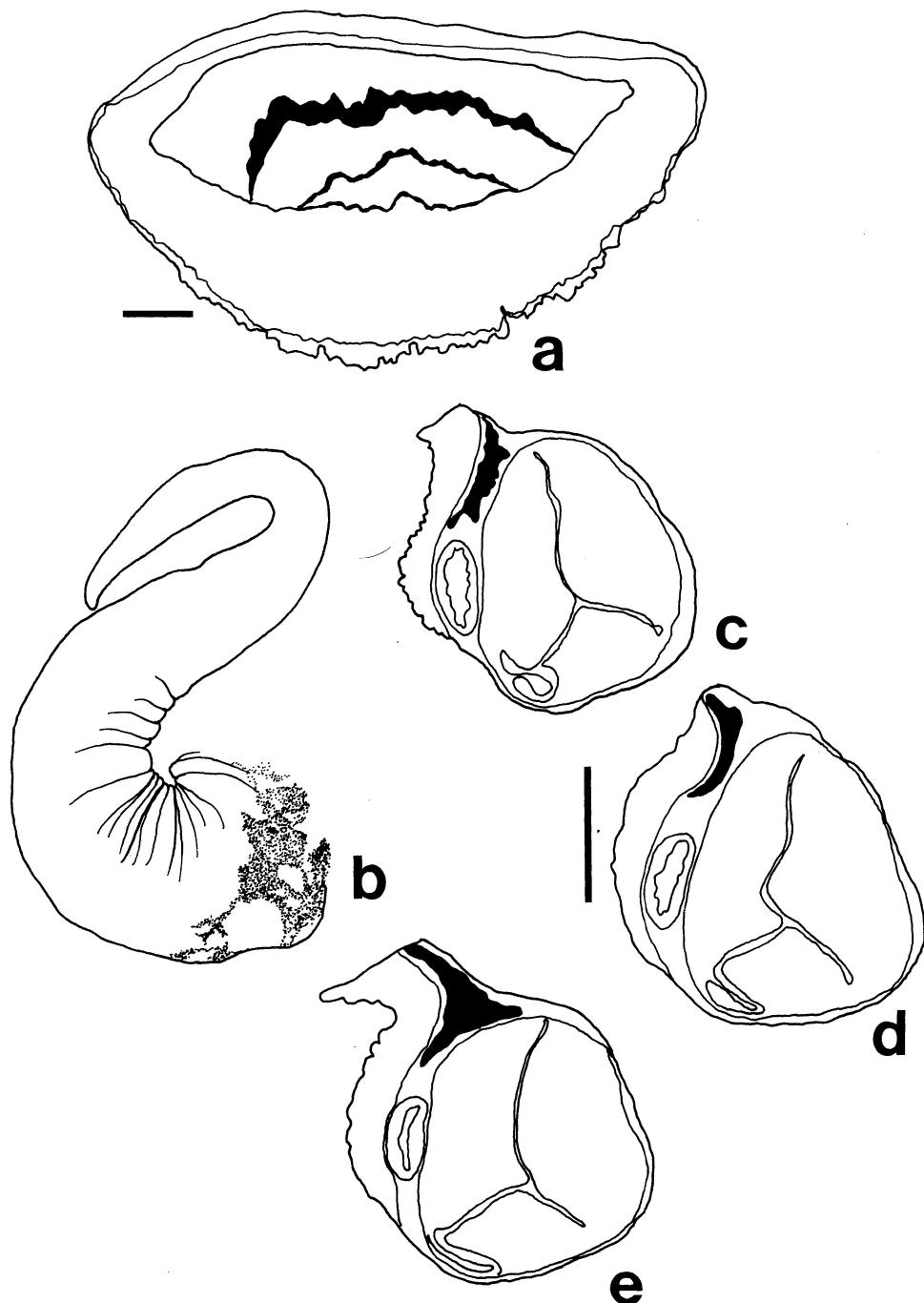


Fig. 10. *Thais blanfordi*, Mahim Bay, India (TKS): (a) operculum, attached surface; (b) penis; (c-e) serial transverse sections of capsule gland viewed from the posterior; (c) is anteriormost. Scale bar = 1 mm.

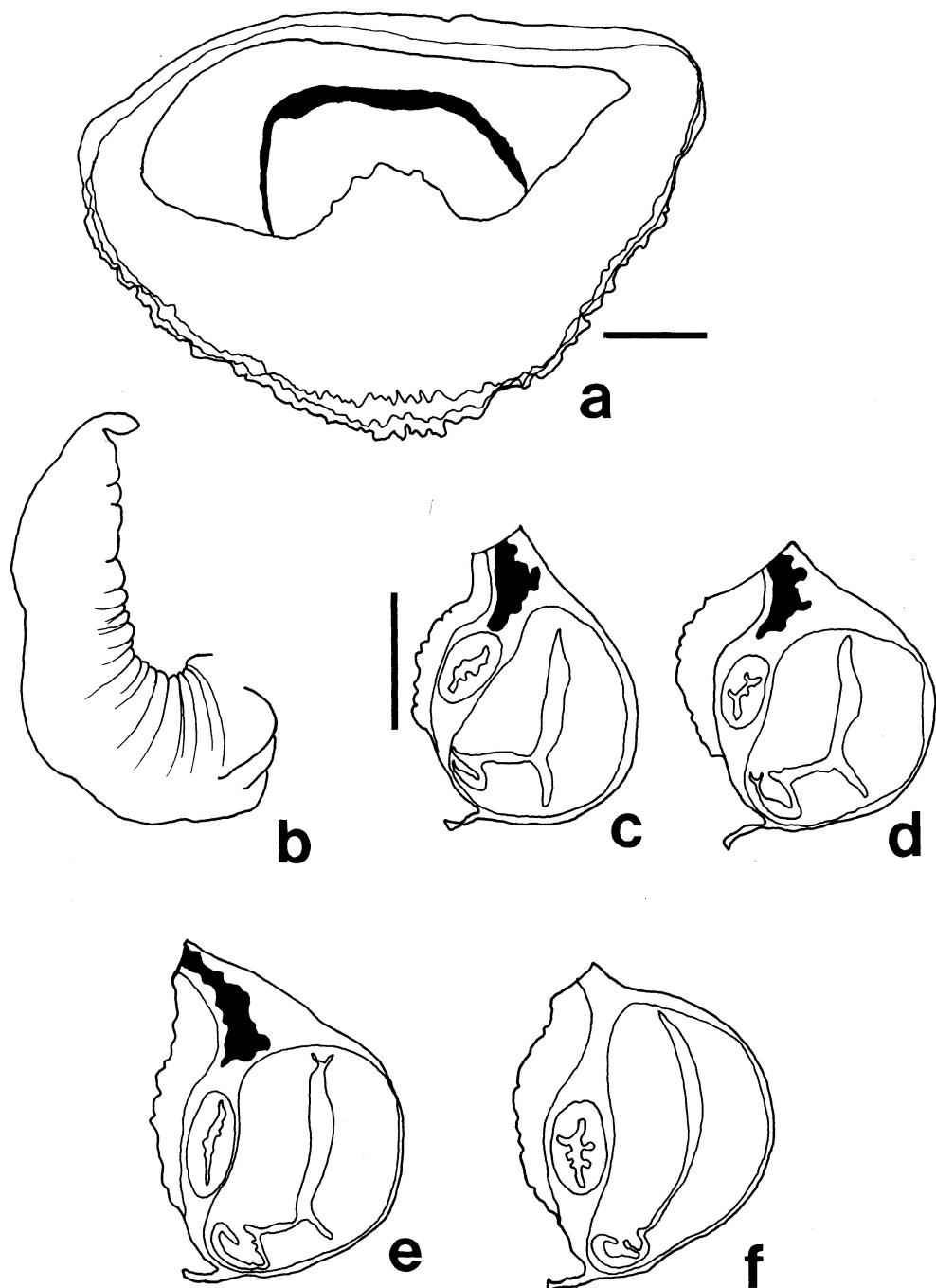


Fig. 11. *Thais tissoti*: (a) operculum, attached surface, Mahim Bay, Bombay, India; (b) penis, Alibag, India; (c-f) serial transverse sections of capsule gland viewed from the posterior; (c) is anteriormost. Mahim Bay, Bombay, India. Scale bar = 1 mm.

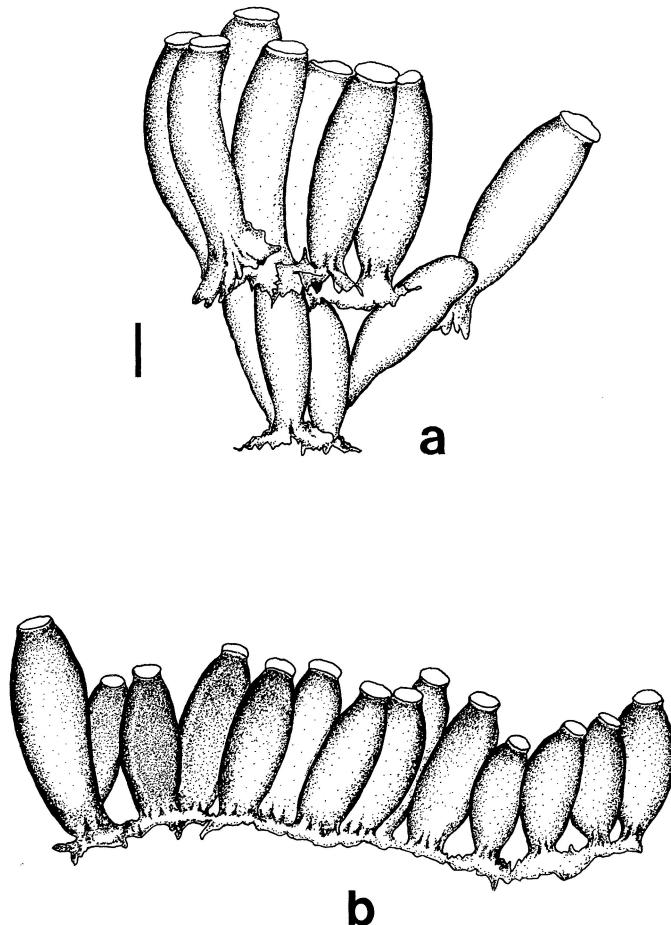


Fig. 12. Egg capsules of *Thais blanfordi* (a) and *T. tissoti* (b); Alibag, India (TKS). (In [b], the large capsule on the left is probably that of *T. blanfordi*). Scale bar = 1 mm.

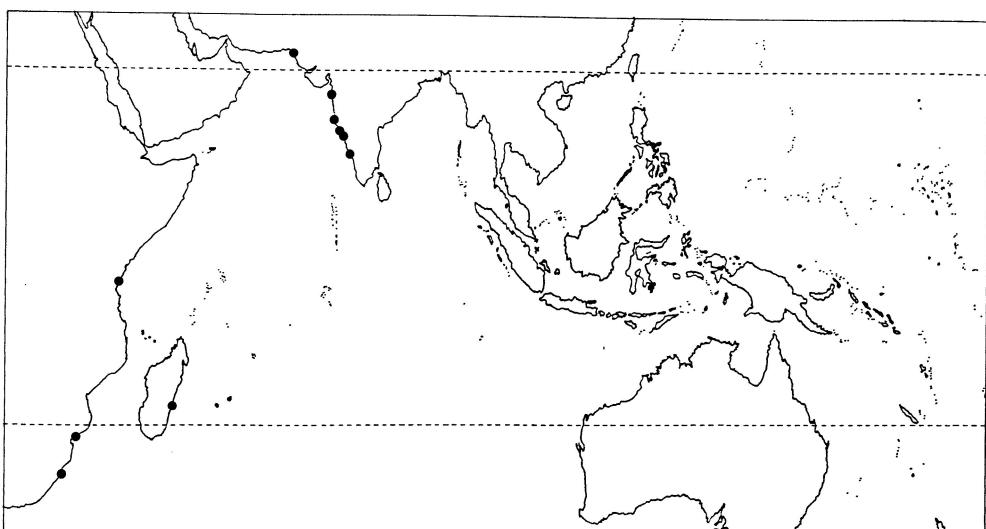


Fig. 13. Distribution of *Thais blanfordi*.

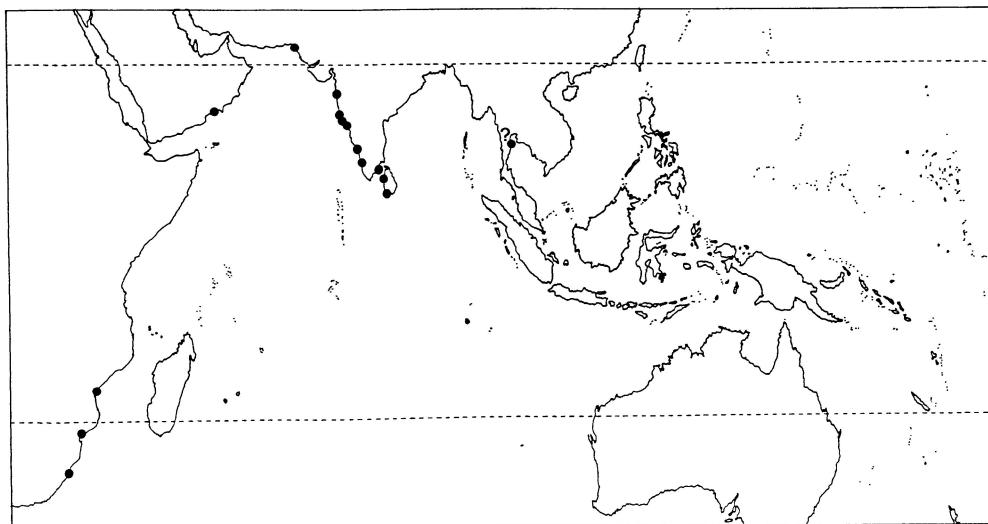


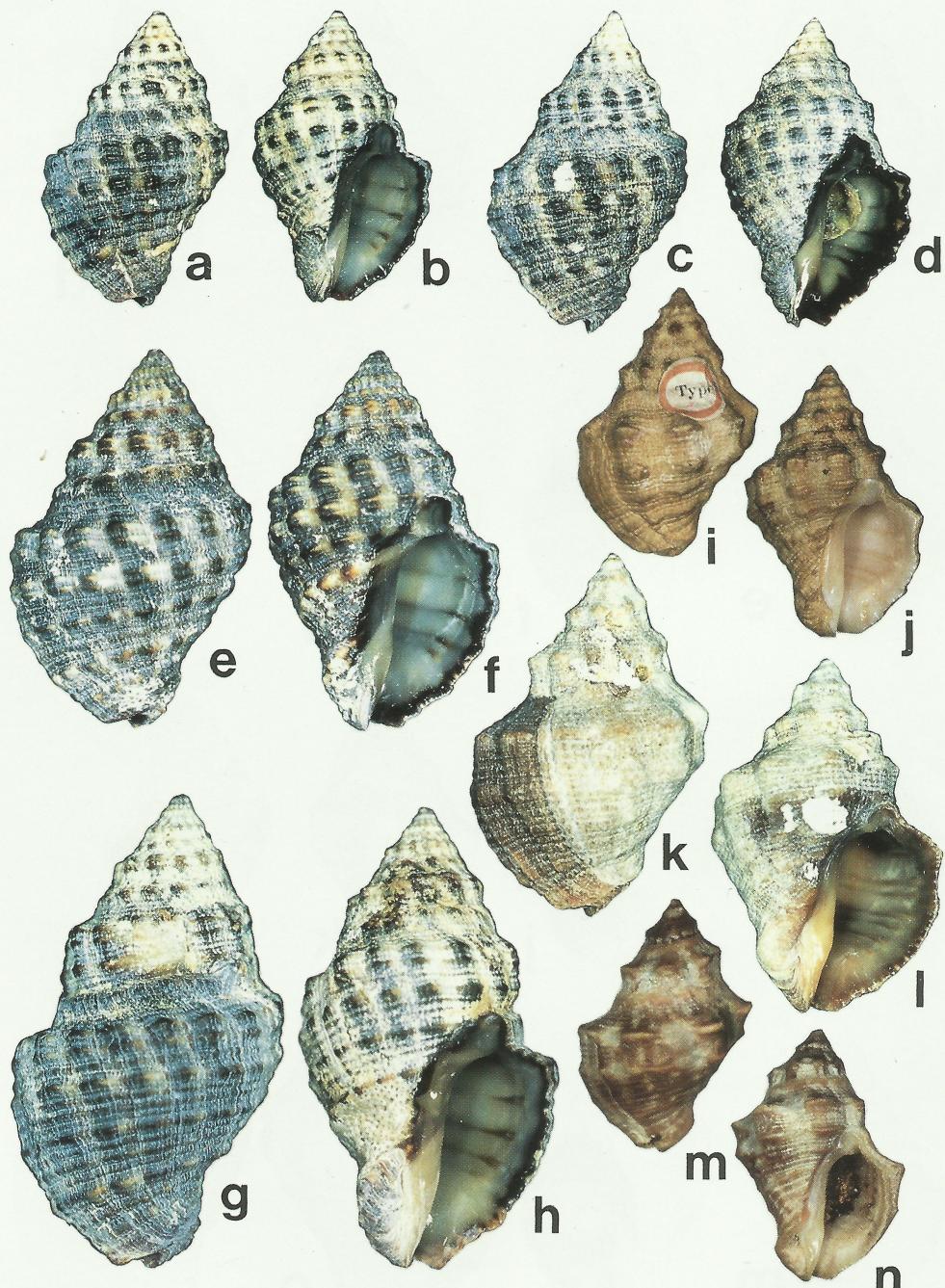
Fig. 14. Distribution of *Thais tissoti*.

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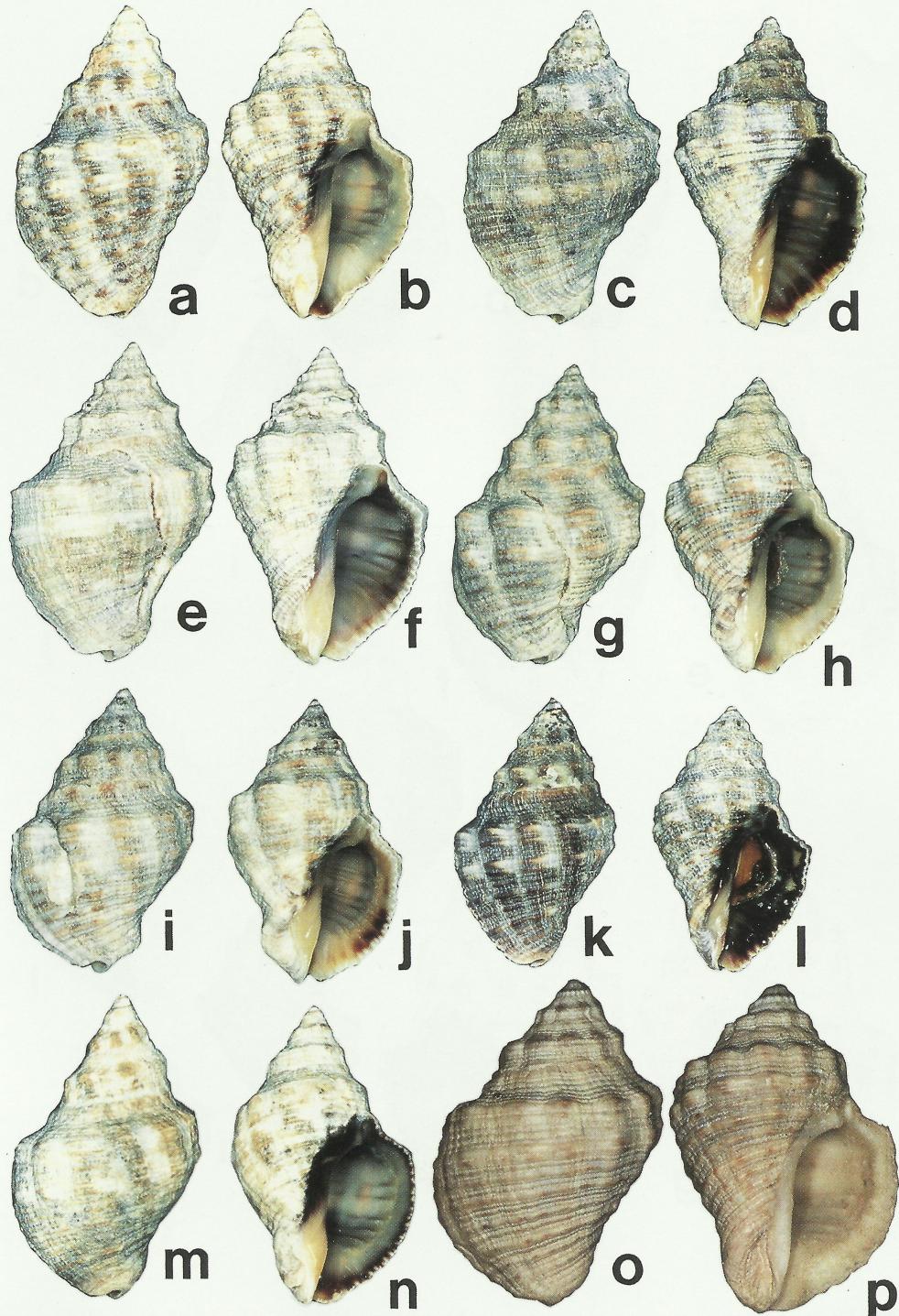
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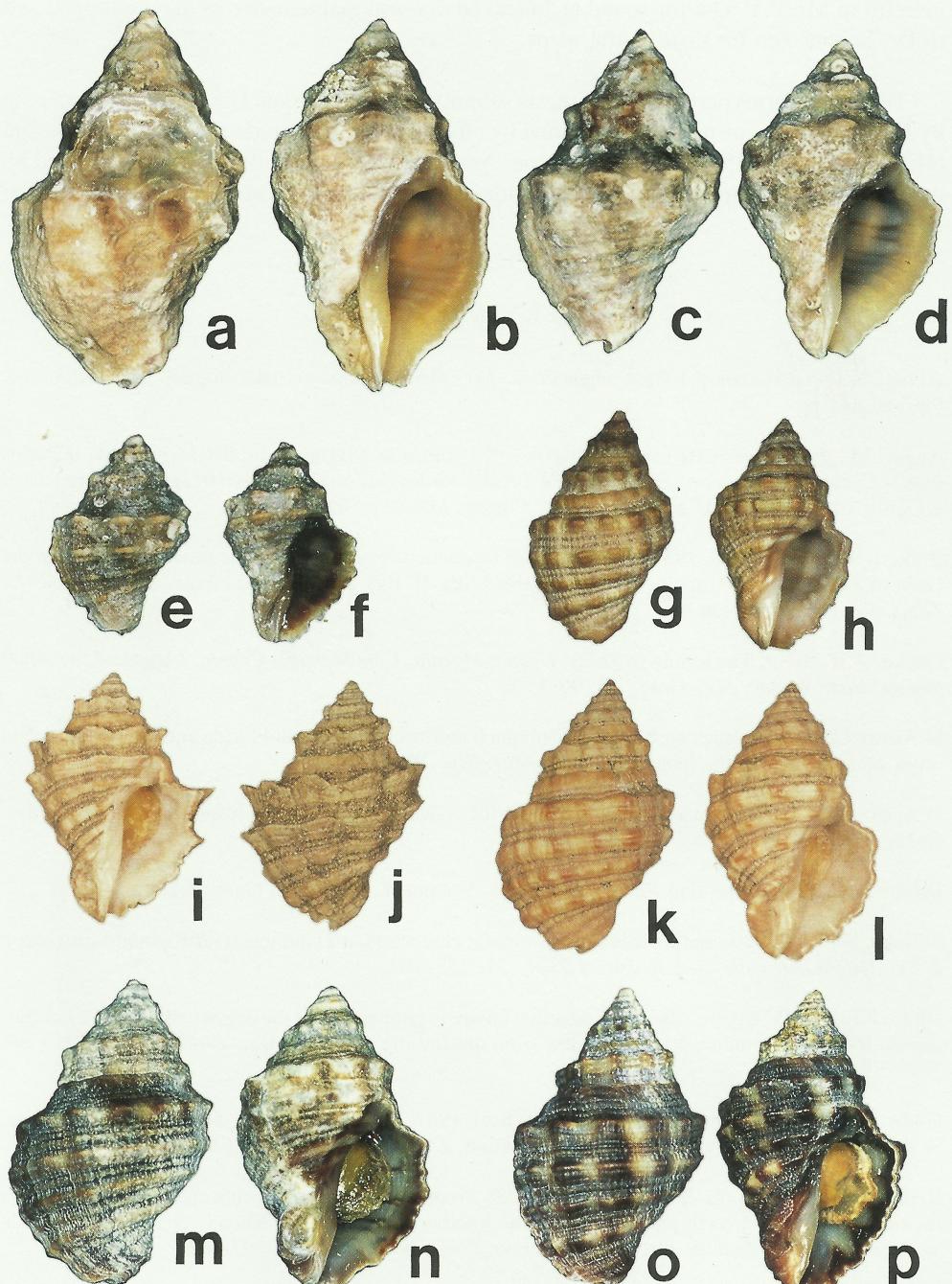
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Pl. 1. Shells of *Thais pinangensis*, new species. (a-h) and *Thais blanfordi* (Melvill) (i-n): (a-d) Tanjung Hantu, Perak, Malaysia (TKS); (a, b) SH= 19.8 mm; (c, d) SH= 21.4 mm; (e, f) holotype of *Thais pinangensis*, new species. Tanjung Huma, Pulau Pinang, Malaysia, SH= 16.2 mm, male (ZRC 1996.49); (g, h) paratype, Tanjung Huma, Pulau Pinang, Malaysia, SH= 19.7 mm, female (ZRC 1996.50); (i, j) holotype of *Purpura blanfordi* Melvill, 1893, Bombay, SH= 27.9 mm (BMNH 1893.2.16.2); (k, l) Mahim Bay, Bombay, India, SH= 27.3 mm (TKS); (m, n) syntype of *Purpura tissoti* Petit, Bombay, SH= 19.9 mm (MNHN) now referred to *T. blanfordi* (Melvill).



Pl. 2. *Thais rufotincta*, new species: (a, b) holotype of *Thais rufotincta*, new species, Labrador, Singapore, SH= 26.7 mm, male (ZRC 1996.51); (c, d) Pasir Ris, Singapore, SH= 26.7 mm (TKS); (e, f) Tuas, Singapore, SH= 26.9 mm (TKS); (g–j) Teluk Batik, Lumut, Perak, Malaysia; (g, h) SH= 25.5 mm; (i, j) SH= 24.2 mm; (k, l) Gertak Sanggul, Pulau Pinang, Malaysia, SH= 23.0 mm (TKS); (m, n) Tanjung Kubu, Pulau Langkawi, Kedah, Malaysia. SH= 26.0 mm (TKS); (o, p) Vanikoro Id., SH= 27.4 mm (NMW).



Pl. 3. Shells of *Thais rufotincta* new species (a-f) and *T. tissoti* (Petit) (g-p): (a-f) Wu Kwai Sha, Tolo Channel, Hong Kong (BMNH); (a, b) SH= 25.2 mm; (c, d) SH= 21.6 mm; (e, f) SH= 13.3 mm; (g, h) lectotype of *Purpura tissoti* Petit, 1852, Bombay, India, SH= 18.5 mm (MNHN); (i-l) Bombay, India (BMNH); (i, j) SH= 20.9 mm; (k, l) SH= 23.1 mm; (m-p) Alibag, India (TKS); (m, n) SH= 21.2 mm; (o, p) juvenile; SH= 13.4 mm.

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