

**TAXONOMIC RE-EVALUATION OF *SARIKA DIADEMA* (DALL, 1897) AND *S. ASAMURAI* (PANHA, 1997), TWO ENDEMIC LAND SNAILS FROM THAILAND
(PULMONATA: ARIOPHANTIDAE: MACROCHLAMYDINAE)**

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ABSTRACT. – The taxonomic status and distribution of two endemic, allopatric land snails from southern Thailand, *Sarika diadema* (Dall, 1897) and *S. asamurai* (Panha, 1997) was investigated. Two key morphological features allow the two species to be discriminated: i) the dart apparatus is located centrally on the vagina in *S. diadema* but proximally on the vagina in *S. asamurai*; and ii) *Sarika diadema* has one spine at the junction of the spermatophore tail filament and sperm sac, whilst *S. asamurai* has two spines.

KEY WORDS. – *Sarika*, *Macrochlamys*, Ariophantidae, endemic species, Pulmonata, Thailand.

INTRODUCTION

Most Asian snails with polished, flattened, semi-transparent and closely coiled shells were initially grouped within *Macrochlamys* sensu stricto Benson, 1832 (e.g. Godwin-Austen, 1883). Although investigations of genital morphology within *Macrochlamys* sensu lato revealed a large number of distinct groups (Godwin-Austen, 1907, Blanford & Godwin Austen, 1908), most species within *Macrochlamys* sensu stricto are known only from their shells and relatively few generic placements have been critically determined by examination of the reproductive organs (Godwin-Austen, 1907; Blanford & Godwin-Austen, 1908; Solem, 1966; Schileyko, 2002). Since *Sarika* Godwin-Austen, 1907, was recognized as a distinct genus on the basis of the reproductive anatomy of its type species, *S. resplendens* (Philippi, 1846) some 10 species have been placed in *Sarika* but to date, only Solem (1966) has confirmed that an additional species, *S. hainesii* (Pfeiffer, 1856), belongs in *Sarika* by examination of the reproductive organs. Where only shell characters have been relied on, generic placements continued to be incorrect (Abbott, 1989; Panha, 1995, 1996). The shell of *S. resplendens*, the type species of *Sarika*, is similar in form to typical *Macrochlamys* whereas *S. diadema* (Dall, 1897) and *S. asamurai* (Panha, 1997) have a striking appearance with a beautifully glossy shell covered in transverse radiations of curved ridges; they also possess remarkable body colouration and pattern.

MATERIALS AND METHODS

Areas were surveyed throughout southern peninsular Thailand and Peninsular Malaysia. Collection localities are shown in Fig. 1. Living snails were drowned in water and transferred into 70% (v/v) ethanol for fixation and preservation. The genitalia of 15 specimens of each species were examined. Radulae were extracted, and examined under a Scanning Electron Microscope (JEOL, JSM-5410 LV). Radula shape and teeth formulae were described.

Anatomical abbreviations. – Except where specified otherwise, terms proximal and distal are with reference to the position of the genital orifice. The following abbreviations are used: ag, albumin gland; at, atrium; da, dart apparatus; e, ephiphallus; ec, ephiphallic caecum fl, flagellum; fo, free oviduct; gs, gametolytic sac; hd, hermaphroditic duct; hf, head filament of spermatophore; hg, hermaphroditic gland; ov, oviduct; p, penis; pg, prostate gland; pp, penial pilaster; prm, penial retractor muscle; ps, penial sheath; pv, penial verge; pvo, penial verge opening; so, spermoviduct; ss, sperm sac; tf, tail filament of spermatophore; v, vagina; vd, vas deferens.

Institutional abbreviations. – CUMZ, Chulalongkorn University, Museum of Zoology, Bangkok, Thailand; FMNH, The Field Museum of Natural History, Chicago; USNM, United States National Museum, Smithsonian Institution, Washington, D.C.

Table 1. The information on seven land snails species that have been placed in the genus *Sarika*.

Species	<i>Sarika</i> : evidence of status	Locality	Reference for generic placement
<i>Helix resplendens</i> Philippi, 1846	Type species of genus based on genitalia	Mergui, Myanmar	Godwin-Austen, 1907: 179-181
<i>Helix burmana</i> Pfeiffer, 1857	Shell only	Myanmar	Blanford & Godwin-Austen, 1908: 278-279
<i>Helix hainesii</i> Pfeiffer, 1856	Reproductive anatomy	Thailand	Solem, 1966: 38-39
<i>Nanina obesior</i> Martens, 1867	Shell only	Thailand	Solem, 1966: 36-38
<i>Helix dohrniana</i> Pfeiffer, 1860	Reproductive anatomy from partial remains	Thailand	Godwin-Austen, 1907: 181-182
<i>Helix pumicata</i> Morelet, 1875	Reproductive anatomy from re-hydrated specimen	Thailand	Godwin-Austen, 1907: 181
<i>Macrochlamys dugasti</i> Morlet, 1891	Reproductive anatomy	Thailand, Laos	Maneewong, 2000: 30-31

SYSTEMATICS

Family Ariophantidae

Subfamily Macrochlamyinae

Sarika Godwin-Austen, 1907

Type species. – *Helix resplendens* Philippi, 1846; by original designation in Godwin-Austen, 1907: 179.

Diagnosis. – Shell thin, translucent, corneous to light brown, dextral, depressed to slightly convex and rimate. Shell surface smooth, glossy, with very fine growth lines or rarely with radial grooves. Whorls 6–8, increasing regularly, flat to slightly convex. Last whorl well-rounded to slightly shouldered. Aperture crescentic with simple lip. Animal with right and left mantle-lobes, flaps, blackish or grayish (rarely with bright colour). Genitalia with long penial appendage; penial retractor muscle large and attached to head of penial appendage. Spermatophore long with no spine on tail filament. Lateral foot margin, caudal foss and caudal horn

present.

Remark. – We have information on only seven species placed in *Sarika* (Table 1) but according to Schileyko (2002) some 10 species have been attributed to *Sarika* with a distribution ranging from southern China to Burma, Vietnam, Laos, Cambodia, Thailand and Peninsular Malaysia.

Sarika diadema (Dall, 1897)

(Figs. 2A, B; 3A–E; 4A–C)

Nanina (*Macrochlamys*) *diadema* Dall, 1897: 37–38. (Type locality: Prang, Malay Peninsula); Dall, 1902: 499, Pl. 27 Figs. 1–3 (USNM 150277); Boss, Rosewater & Ruhoff, 1968: 104.

Macrochlamys diadema – Gude, 1903: 50

Syama diadema – Abbott, 1989: 23, 133 (text figure); Panha, 1996: 102–104, Fig. 2b2 (Holotype, USNM 150277).

Type material. – Prang, Malay Peninsula: Holotype USNM 150277,

Other material examined. – Khao Wang Meng, Patthalung: USNM 420342; Kao Poo-Khao Ya National Park, Patthalung: CUMZ 2582, 3642; Khao Auk-Taru, Pattalung: CUMZ 2579; Botanic Garden, Trang: CUMZ 2580, 2583, 2585, 2587, 3616, 3619, 3620; Khao Chong, Trang: CUMZ 2581, 2588; Tam Sumano, Trang: CUMZ 3538, 3638; Tam Puttha Kodome, Trang: CUMZ 3639; Wat Khao Huy Haeng, Trang: CUMZ 3537; Tam Hong, Khao Nan National Park, Nakhonsrithammarat: CUMZ 3631; Tam Luang, Khao Nan National Park, Nakhonsrithammarat: CUMZ 3632; Tam Lord, Khao Nan National Park, Nakhonsrithammarat: CUMZ 3633; Tam Khun-Klang, Nakhonsrithammarat: CUMZ 3634; Tam Pannara, Nakhonsrithammarat: CUMZ 3536, 3539, 3643; Wat Nasarn, Suratthani: CUMZ 2592.

Shell. – Shell depressed conic, thin, translucent, polished, brownish, dextral and perforate (Fig. 2A). Whorls 6–7, increasing regularly, slightly convex, with wide and deep channel at suture. Spire convex; apex acute; embryonic shell smooth; following whorls structured with deep sinuously curved radial channels, which disappear below the periphery; descending whorls slightly elevated from suture, last whorl shouldered; aperture crescentic; lip simple. Columella slightly dilated; parietal callus thin and translucent.

Genitalia. – Atrium (at) very short to nearly absent (Fig. 3A).

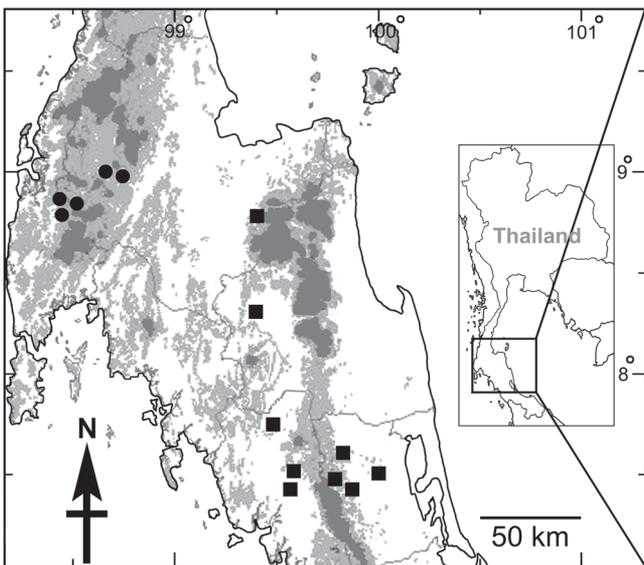


Fig. 1. The collecting sites of *S. diadema* (■) and *S. asamurai* (●) within southern Thailand. Shading represents mountainous areas with an altitude higher than 50 m (light grey) and 500 m (dark grey).

Penis (p): proximally enlarged, cylindrical, with thin penial sheath (ps). Epiphallallic caecum (ec) short, straight and located about half way along the length of the epiphallallic complex. Penial retractor muscle (prm) short, thick and attached at the tip of epiphallallic caecum. Epiphallus (e) long and slender tube, about twice length of penis; flagellum (fl) short. Vas deference (vd) small, relatively short, connected between free oviduct (fo) and distal end of epiphallus. Internal wall of penis nearly smooth; proximally around one-third of chamber with thin longitudinal pilasters (pp); distally with very thin and oblique wrinkled sculpture. Penial verge (pv) small, short conic and smooth (Fig. 3B).

Vagina (v) short and cylindrical. Dart apparatus (da) large, long, cylindrical and located at middle length of vagina. Gametolytic sac (gs) long, cylindrical and slightly swollen distally. Oviduct (ov) with large lobules; prostate gland (pg) runs alongside oviduct. Albumen gland (ag) short and enlarged. Hermaphroditic duct (hd) small and convoluted (Fig. 3A).

Allospematophores (n = 14) long-needle shaped with three recognizable sections. (1) head filament (hf) rather short, thinning to terminal point (Fig. 3C). (2) cylindrical sperm

sac (ss) containing sperm mass (3) tail filament (tf) long thick-walled tube with small hole in cross section (see also Fig. 3H). Tail filament proximal to sperm sac with long and short spines. The gametolytic sacs of several individual specimens contained one or more spermatophores; four with one, four with two and one with three spermatophores (Fig. 3D).

Radula and jaw. – Teeth arranged in V-shaped rows with approximately 141 (69-(16-17)-1-(15-17)-70) teeth. Central tooth symmetric tricuspid, mesocone large with pointed cusp, ectocones small and located in middle of tooth (Fig. 4A). Lateral teeth asymmetric tricuspid, mesocone large, approximately half of tooth height with pointed cusp, endocone small and placed near tip of tooth (Fig. 4B). Marginal teeth start from 15–17, elongated and obliquely bicuspid; outermost marginals progressively shorter (Fig. 4C).

Jaw smooth (without vertical ribs), crescentic, anteriorly convex with cutting margin (Fig. 3E).

External features. – Animal with long and narrow foot. Lung cavity visible through translucent shell. Tentacles long and blackish. Skin reticulated with yellowish stripe in middle of the body running from head to caudal foss. Foot lateral margin

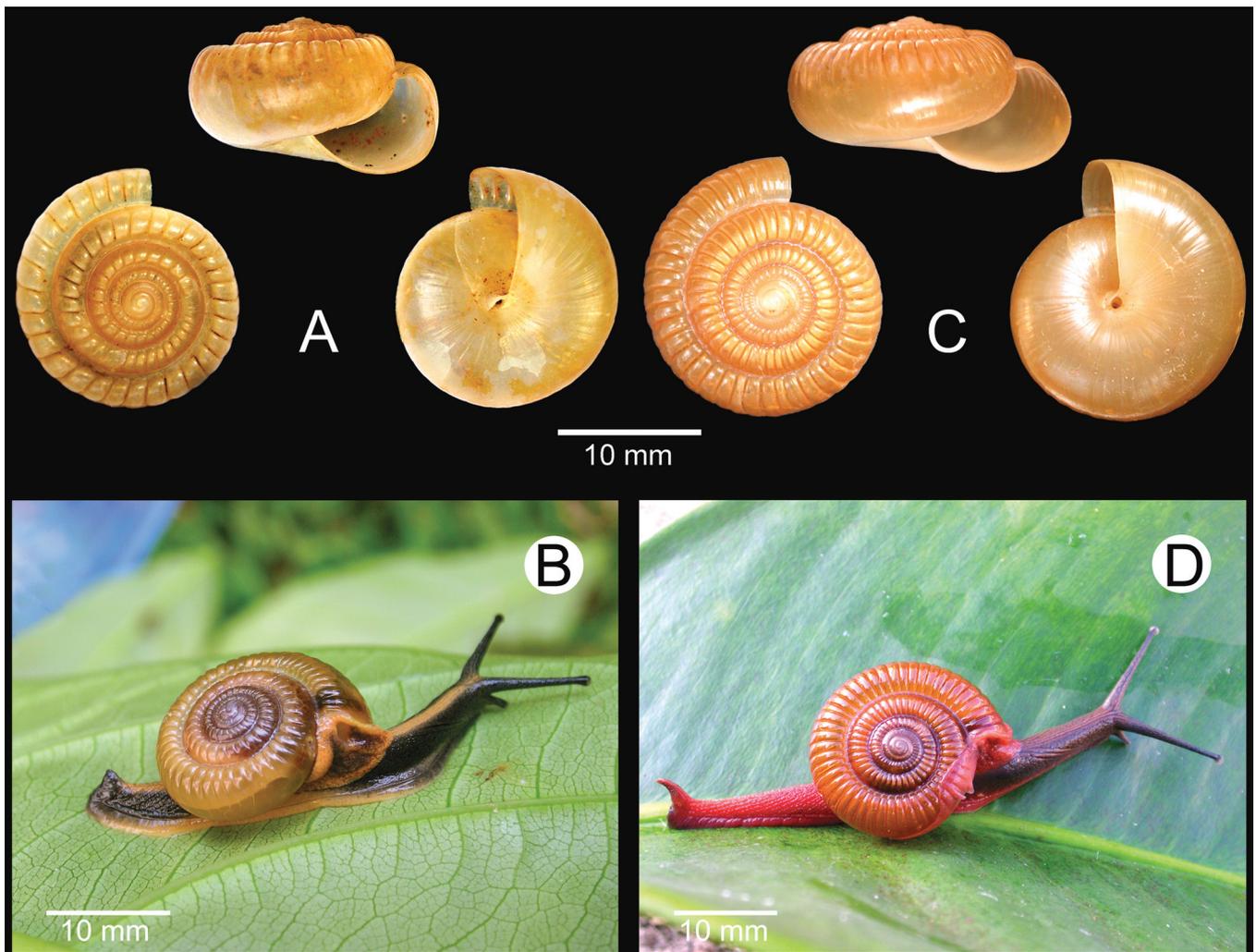


Fig. 2. *Sarika diadema* from Khao Poo-Khao Ya National Park, Pattalung: A, shell morphology; B, body colour in live specimen. *Sarika asamurai* from Ban Takun, Suratthani: C, shell morphology; D, body colour in live specimen.

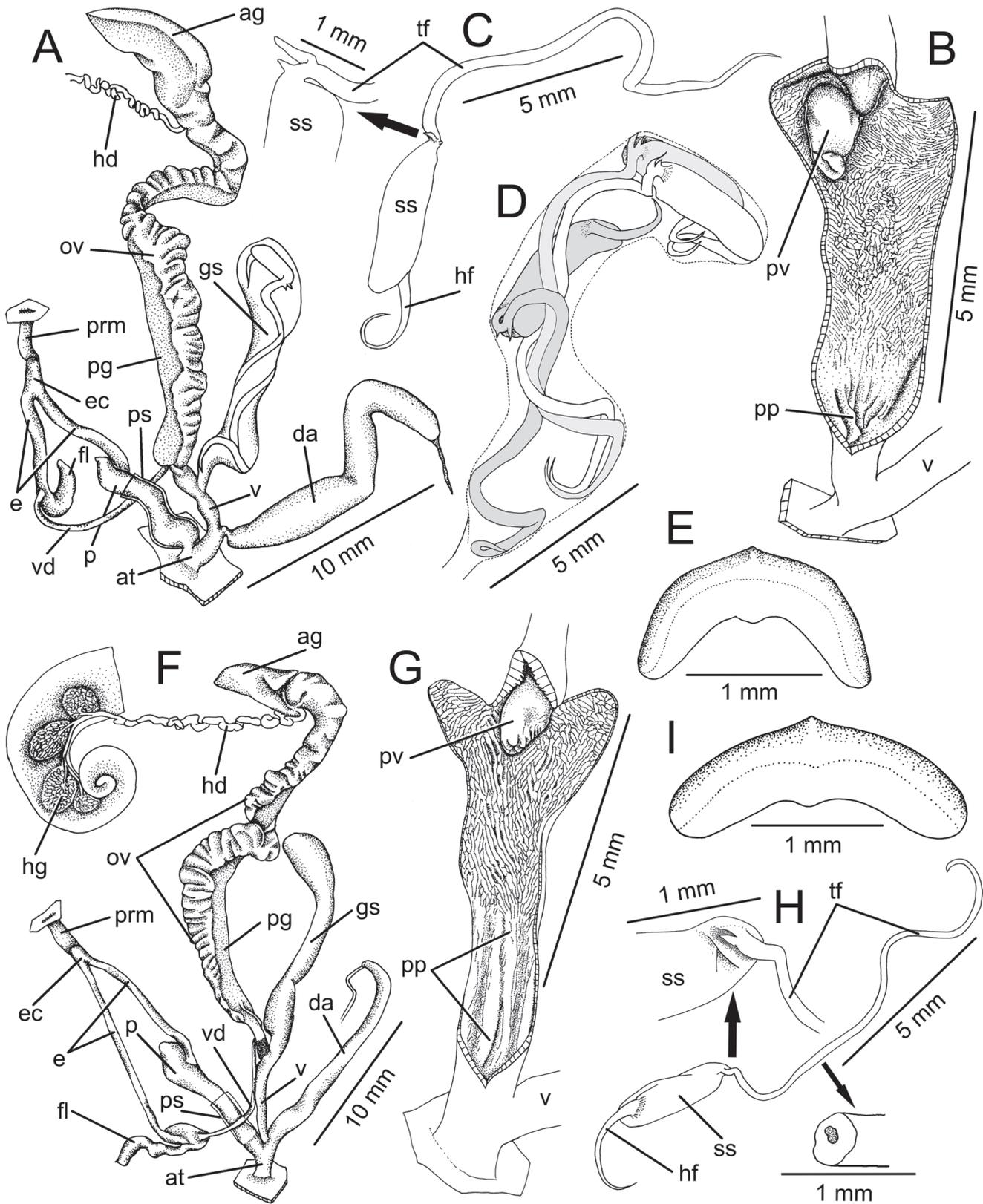


Fig. 3. Genitalia and jaw of *S. diadema* and *S. asamurai*. *Sarika diadema* from Botanic Garden, Trang: A, whole genital system; B, interior structure of penis; C, single spermatophore with detail of spines between sperm sac and tail filament; D, arrangement of three spermatophores in gametolytic sac; E, jaw. *Sarika asamurai* from Klong Phanom National Park, Suratthani: F, whole genital system; G, internal structure of penis; H, spermatophore with detail of spines between sperm sac and tail filament and cross section of tail filament; I, jaw. Abbreviations used in the figures are listed under 'anatomical abbreviations' in the materials and methods

blackish, sole of foot creamy to brownish; foot sole tripartite; caudal foss and caudal horn moderately long and blackish. Mantle collar yellowish or blackish (with yellowish edge); mantle flaps yellowish (Fig. 2B). Only blackish pigmentation retained in ethanol preserved specimens.

Distribution. – The original locality was given as in the vicinity of Prang, Malay Peninsula (Dall, 1897). However, multiple field surveys in northern Peninsular Malaysia (Perlis, Perak, Ipoh and Kelantan) from 1999 to 2002 found no *S. diadema* (J. B. Burch, pers. comm.). One explanation might be that ‘Prang’ in the original description was confused with ‘Trang’ in southern peninsular Thailand and that *S. diadema* is restricted to southern Thailand ranging from Nakhonsrithammarat, Trang, Pattalung to the Songkhla Provinces (Fig. 1).

***Sarika asamurai* (Panha, 1997)**

(Figs. 2C, D; 3E–I; 4D–F)

Macrochlamys asamurai Panha, 1996[1997]: 101–105, Figs. 2a, 2b1 (Takun Village, Suratthani, Thailand; Holotype CUMZ 6325).

Type material. – Takun Village, Suratthani: Holotype CUMZ 6325; Paratype: CUMZ 6326, 6327; FMNH 285043; USNM 892000

Other material examined. – Klong Saeng, Suratthani: CUMZ 2584, 2589, 2593, 3617; Wat Tam Wararam, Suratthani: CUMZ 2586, 2590, 2591, 2594, 3618, 4640, 3641; Wat Tam Sok Panthurat, Suratthani: CUMZ 3623, 3624, 3625, 3626; Klong Phanom National Park, Suratthani: CUMZ 3644.

Shell. – Shell (Fig. 2C) similar to that of *S. diadema* but slightly larger; transverse sculpture on the upper periphery more dense; descending whorls slightly elevated from suture without shoulder.

Genitalia. – Atrium (at) somewhat short. Penis (p) cylindrical, distally thickened from site of penial verge, proximally enclosed in thin penial sheath (ps).

Ephiphallic caecum (ec) short, straight and located about half way along the length of the ephiphallic complex. Penial retractor muscle (prm) short, thick and attached at the tip of ephiphallic caecum. Epiphallus (e) small, and slender tube, about twice length of penis; flagellum (fl) short. Vas deference (vd) a small tube running from the spermoviduct and entering at the epiphallus/flagellum junction. (Fig. 3F). Internal sculpture of penis similar to that in *S. diadema*, the most notable difference being a distinctly longer penial pilaster (pp) (about half of penial chamber) in *S. asamurai*(Fig. 3G).

The female genital tracts are generally similar to those of *S. diadema* but with the significant difference that the dart apparatus (da) is located proximally on the vagina at the genital atrium and is covered in black pigmentation (Fig. 3F).

Allospematophores (n = 10); only one short spine present at the sperm sac and the tail filament junction(Fig. 3H). Five specimens contained spermatophores, each with two in the gametolytic sac.

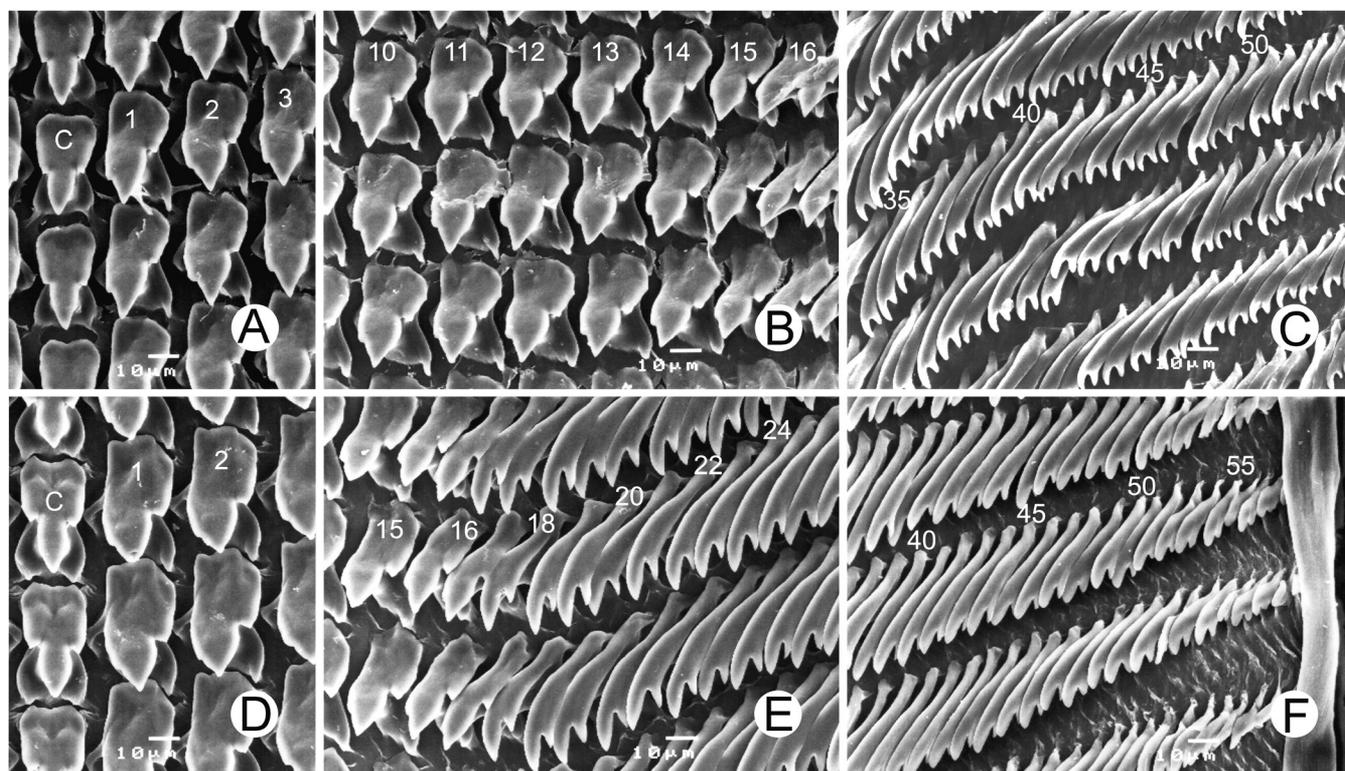


Fig. 4. Radula morphology. *Sarika diadema* from Botanic Garden, Trang: A, central tooth with first to third lateral teeth; B, lateral teeth with bicuspid marginal teeth transition; C, outermost marginal teeth. *Sarika asamurai* from Klong Phanom National Park, Suratthani: D, central tooth with first and second lateral teeth; E, lateral teeth with bicuspid marginal teeth transition; F, outermost marginal teeth. Numbers indicated order of lateral and marginal teeth. Central tooth indicated by ‘C’.

Radula and jaw. – Each row contained about 125 (65-(17-16)-1-(15-16)-59) teeth. Central and lateral teeth with triangular tricuspid (Fig. 4D). Bicuspid marginal teeth from 15–17 (Fig. 4E). Radula teeth morphology very similar to that described for *S. diadema*; the jaw exhibits significantly less curvature (Figs. 3I and 4F).

External features. – Head/foot similar in form but markedly different in colour to that of *S. diadema*. Anterior body black; foot sole reddish and tripartite; mantle collar and thin mantle flaps reddish to dark red. Posterior of body usually entirely reddish or with blackish caudal foss and caudal horn (Fig. 2D). Only the anterior and/or caudal end black pigmentation is retained in ethanol preserved specimens.

Distribution. – *Sarika asamurai* has a narrower distribution than *S. diadema* (Fig. 1). Current records are restricted to the following limestone karst area of Suratthani Province: Klong Phanom and Khao Sok National Parks; Ban Takun village (type locality); Wat Tam Sok Panthurat; Wat Tam Wararam.

CONCLUSION & DISCUSSION

Sarika asamurai is very similar to *S. diadema*, and was previously distinguished on the basis of minor differences in shell sculpture and shell diameter; *S. asamurai* possessing numerically more features of radial sculpture and a slightly larger shell diameter than *S. diadema* (see also Panha, 1996). In this study we describe features of the reproductive system that provide a robust basis for distinguishing the two species and confirm their placement in *Sarika* rather than in *Macrochlamys* sensu stricto which exhibits a very distinctive coiled penial caecum and a spermatophore with a spine on the tail filament (Godwin-Austen, 1907; Muratov, 1991). However, *S. diadema* and *S. asamurai* appear to exhibit differences in the verge region of the penis, penis extension/epiphallus complex and also lack the proximal caecum-like structure on the proximal dart sac (amatorial organ sensu Blanford & Godwin-Austen) figured by Blanford & Godwin-Austen (1908) for *S. resplendens*, the type species of *Sarika*. Taken together with the very different shell of the type species there may be a basis for recognizing subgeneric status for *S. diadema* and *S. asamurai* but this will require fresh investigation of *S. resplendens*.

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