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The *Lioconcha castrensis* species group (Bivalvia : Veneridae), with the description of two new species

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Abstract

Part of the genus *Lioconcha* Mörch, 1853 is reviewed. Species strongly resembling *Lioconcha castrensis* (Linnaeus, 1758) are discussed and two new species are described: *Lioconcha arabaya* n. sp. from the Northwest Indian Ocean and *Lioconcha rumphii* n. sp. from Thailand and Sumatra. These three species, together with *Lioconcha macaulayi* Lamprell & Healy, 2002, share many morphological similarities and we suspect them to be closely related. They are referred to as the *Lioconcha castrensis* species group. Furthermore, lectotypes of *Venus castrensis* Linnaeus, 1758, and *Venus fulminea* Röding, 1798, are designated. The latter is considered a junior synonym of *V. castrensis*.

Key words: Indo-Pacific, Mollusca, Persian Gulf, Red Sea, taxonomy

Introduction

The delimitation within the tropical venerid genus *Lioconcha* Mörch, 1853, is problematic, due to high levels of intraspecific morphological variability and relatively few useful morphological characters (Lamprell and Healy 2002). Diagnostic characters often used within venerid systematics, such as the external colour patterning and the nature of the pallial sinus, are difficult to apply within the genus *Lioconcha.* Due to the extreme degree of variation in colour patterns and the vestigial nature of the pallial sinus, members of this genus are among the most difficult venerids to identify.

In the present study we focus on species that are very similar in shell characters to *Lioconcha castrensis* (Linnaeus, 1758). We use the informal term *Lioconcha castrensis* species group to denote four species: *L. castrensis, L. macaulayi* Lamprell & Healy, 2002, *L. arabaya* n. sp., and *L. rumphii* n. sp. At first, based on a few specimens in ZMA, *Lioconcha hieroglyphica* (Conrad, 1837) seemed related to the *L. castrensis* species group. This superficial similarity was also noted by Lamprell and Healy (2002). However, after studying large samples of *L. hieroglyphica* in the collection of the Californian Academy of Sciences in San Francisco (USA), this relatedness could not be confirmed. The umbonal region of *L. hieroglyphica* is more pronounced and the shell is less solid than that of species in the *L. castrensis* species group. These characteristics and the subtrigonal shape of *L. hieroglyphica* indicate its inclusion in the *L. ornata* species group as defined by Moolenbeek *et al.* (2008) (see below).

For stability of nomenclature we furthermore designate a lectotype of *Venus castrensis* Linnaeus, 1758 and *Venus fulminea* Röding, 1798.

Material and methods

For all material examined, length is the greatest distance between the anterior and posterior extremities, height is measured vertically from the umbo to the ventral margin and total width (or inflation) is the greatest distance between the external surfaces of the paired valves. For an extensive list of synonyms of figured specimens of *Lioconcha castrensis* we refer to Lamprell and Healy (2002: 103).

Abbreviations and definitions: colln.—collection; coll.—collector; lv—left valve; pv—paired valves; rv—right valve; v—valve.

AMS—Australian Museum, Sydney, Australia; BMNH—Natural History Museum, London, United Kingdom; CAS—California Academy of Sciences, San Francisco, USA; HD—Henk Dekker, Winkel, The Netherlands; MMV—Museum Miramar, Vledder, The Netherlands; MS—Muzee, Scheveningen, The Netherlands; PLP—Peter L. van Pel, Egmond aan Zee, The Netherlands; RMNH—Netherlands Centre for Biodiversity Naturalis (formerly National Museum of Natural History Naturalis), Leiden, The Netherlands; USNM—National Museum of Natural History, Smithsonian Institution, Washington DC, USA; ZMA—Netherlands Centre for Biodiversity Naturalis (formerly Zoological Museum Amsterdam), The Netherlands.

Systematics

Superfamily VENEROIDEA Rafinesque, 1815
Family VENERIDAE Rafinesque, 1815
Subfamily PITARIINAE Stewart, 1930
Genus *Lioconcha* Mörch, 1853

Type species: *Venus castrensis* Linnaeus, 1758 (by subsequent designation of Stoliczka, 1870)

Description

Equivalve, shell resembles in outline *Pitar* Römer, 1857. *Lioconcha* differs from *Pitar* in being thicker-shelled, less inflated, with poorly demarcated pallial sinus. Exterior

Lioconcha often patterned with distinctive, tent-shaped markings. Valves semicircular to elongate-trigonal, moderately inflated, sturdy hinge with prominent cardinal and lateral teeth. Lunule flat to raised, heart-shaped. Lunule's margin weakly to strongly incised. Exterior shell usually smooth, often glossy, may contain low commarginal growth lines occasionally developed as well-defined ribs, especially pronounced at anterior and posterior ends. Shells contain beautiful, complex colour patterns, ranging from reddish-brown to almost blue-black. Usually patterns include zigzag lines and triangles, occasionally replaced by radial rays. Colour of interior of shell mostly species specific, usually white, but often with yellow, brown or purple patches.

Distribution

The genus is known from (sub)tropical regions of the Indo-Pacific, ranging from the Red Sea to South Africa in the west, to Hawaii in the east.

Remarks

Lamprell and Healy (2002) revised the genus *Lioconcha*, and documented 19 species. Within the genus, there are at least two groups of species that have many shell characters in common, such as shape and thickness of the shell. These species groups are: 1) the *L. castrensis* group, discussed hereafter, and 2) the *L. ornata* group, at least including *L. ornata* (Dillwyn, 1817), *L. tigrina* (Lamarck, 1818), *L. fastigiata* (Sowerby II, 1851), *L. annettae* Lamprell & Whitehead, 1990, *L. berthaulti* Lamprell & Healy 2002, and possibly *L. hieroglyphica* (Conrad, 1837). Recently *Lioconcha lamprelli* Moolenbeek, Dekker & van der Meij, 2008, was described as a new species related to *L. ornata* and hence the *L. ornata* group (Moolenbeek *et al.* 2008). This species group is characterized by being relatively small, oblong, with a less solid shell. Generally with tent markings or blotches ranging from yellow to light brown, rarely dark brown.

Lamprell and Healy (2002) considered *L. trimaculata* (Lamarck, 1818) to be related to species like *L. philippinarum* (Hanley, 1844), *L. gordoni* (E.A. Smith, 1885), *L. dautzenbergi* (Prashad, 1932), *L. schioettei* Lamprell & Healy, 2002 and *L. sowerbyi* (Deshayes, 1853), all with concentric raised ridges. Further study could indicate one or more additional species groups, but it is beyond the scope of this paper to discuss this aspect in detail.

Lioconcha castrensis (Linnaeus, 1758)
(Fig. 1A–F)

Venus castrensis Linnaeus, 1758: 687 (refers to Chemnitz 1782: figs 367–368 and Chemnitz 1788: fig. 1662).

Venus fulminea Röding, 1798: 181, no. 295 (refers to Chemnitz 1782: fig. 369).

Cytherea castrensis.—Chenu 1847: Part 64 pl. 8 fig. 1a–b, 4; Sowerby II 1851: 642, pl. 134 figs 152–154.

Circe castrensis.—Reeve 1863: pl. 7, fig. 28a, b, d.

Lioconcha castrensis.—Römer 1868: 44; Lamprell and Healy 2002: 103–106, fig. 1A–K.

Material examined

Australia (Queensland): Little Trunk Reef (PLP 9-310, 3pv); Lady Elliot Isl. (PLP 2666, pv); Palm Isl. (dredged) (HD 11349, pv); Swains Reef, May 2009 (HD 23339, 2pv); N coast, coll. G. Pini, 1973 (ZMA Moll.167021, pv); Diamond Islets, Coral Sea Islands (dredged), coll. D.T. Thorn (HD 19886, 2pv); Fiji: Fiji, coll., C.C. Nengerman, Mar. 1978 (ZMA Moll., rv); Indonesia: Pini W Isl., Sumatra, coll. Cpt. Blaauboer, 1929, ex. colln. L. de Priester (ZMA Moll.159712, lv); Pombo, Ambon, coll. H.L. Slack, 8 - 10 Oct. 1989 (ZMA Moll., v); Waiara, Sikka region, Flores, 08°37'59.0"S 122°18'43.4"E, coll. B. Gras, 17 Jan. 2007 (ZMA Moll.167016, 2v); Flores (ZMA Moll., 4 samples); Papua (Manokwari, Japen Isl., Kaimana, Waigeo, Wasior, Wundi Isl., Biak) (ZMA Moll., 9 samples); Aru and Kei Islands, coll. E. van Ogtrop, 1900 (ZMA Moll.167040, lv); Kupang, Timor, coll. A.H. de Chaufepié, 1908 (ZMA Moll.167020, pv); Jakarta Bay, Java (ZMA Moll., 5 samples); Panaitan Isl., Java, coll. L.J.M. Butot, 22 Sep. 1951 (ZMA Moll.167024, rv); Samalona, Sulawesi, coll. Tribast, 1929 (ZMA Moll.159714, rv); Tanjung Karang, Sulawesi, coll. B. Gras, 06 Jan. 2009 (ZMA Moll., 2v); Berau Islands, Kalimantan, coll. Netherlands Berau Expedition, Oct. 2003 (ZMA Moll., 4 samples); Nunukan, Kalimantan, Mar. 2007 (HD 20111, pv); Larantoeka, Flores, coll. J. Semmelink, 1860-1861 (RMNH.MOL.116572, 4pv); Moluccas, ex. colln. Rees van Warnsinck, ex. colln. Geologisch Museum Wageningen (RMNH.MOL.116573, 4pv, rv, lv); Indian Ocean, colln. C.G.C. Reinwardt (RMNH.MOL.116574, 9pv, 2rv, 2lv); Bali, coll. L. de Priester, 11 Sep. 1928 (RMNH.MOL.116575, rv); Moluccas, ex. colln. Geologisch Museum Wageningen (RMNH.MOL.116576, pv); Tamobo, Nias, coll. E.E.W.G. Schröder (RMNH.MOL.116577, lv); Bay of Ambon, coll. R. IJzerman, Jun. 1939 (RMNH.MOL.116578, rv); Banda, coll. E.F. Jochim, 1914 (RMNH.MOL.116579, pv); Boeli and Weda Bay, Halmahera, ex. colln. Geologisch Museum Wageningen, 1918 (RMNH.MOL.116580, rv); Doreh Bay, Papua, coll. E.F. Jochim, 1914 (RMNH.MOL.116581, rv); Kelapa Isl., Java, coll. H. Boschma, Feb. 1921 (RMNH.MOL.116582,lv); Manokwari, Papua, coll. J.P.L. Everaard, Dec. 1959 - Jun. 1960, ex. colln. W. Bergmans (RMNH.MOL.116583, rv); Larantoeka, Flores, coll. Frater M. Vianney, 1959-1962 (RMNH.MOL.116584, 3pv); Manokwari, Papua, coll. M. van de Wiel, 1956, ex. colln. P. Kaas (RMNH.MOL.116585, 4rv, 2lv); Larantoeka, Flores, coll. J. Semmelink, 1861 (RMNH.MOL.116586, pv); Lankai Isl., Gugusan, Spermonde, coll. B.W. Hoeksema, 24 Jul. 1985 (RMNH.MOL.116587, lv); Bahuluang N Isl., SW Salayer, 30 Sep.–01 Oct. 1984 (RMNH.MOL.116588, pv); Melila Isl., Sumatra (USNM 654432, 3pv); Japan: Okinawa, Tokashiki, coll. M.F. Fontaine, 13 Jul. 2004 (HD 19875, pv); Nago Bay, Okinawa, May 1985 (HD 20022, pv); Malaysia: Mandi Darrah Isl., Sabah, coll. M. Saul, 1961 (ZMA Moll.010198, pv); Sapi Isl., Sabah, coll. M. Saul, 16 Nov. 1961 (ZMA Moll.010199, pv); New Caledonia: Noumea, colln. L. de Priester (ZMA Moll.159708, pv); Noumea, coll. M. Filmer, Jan. 1972 (ZMA Moll.003860, 2pv); Philippines:

Olango Isl., colln. J. van de Dussen (ZMA Moll.167033, 3pv); Cebu, colln. S. Martin (ZMA Moll.162753, 2pv); HD 4727, pv); HD 11351, pv); colln. Museum Miramar, Vledder (HD 19848, 3pv); Solomon Islands: Malaita, Ataa, colln. Collector's Cove, 1966 (HD 19931, pv); Tonga: Neiafu-Vava'u, Oct. 2001 (HD 20685, 2pv).

Type material

Lectotype *Venus castrensis* (designated herein): the specimen (a right valve) among Linnaeus' material in the 'Linnaean collection' of the Linnaean Society in Burlington House (London), that bears on the inside the hand-lettered number 105 (Fig. 1A). *Venus castrensis* is species no. 105 in Linnaeus (1758: 687).

Original description

'*V[Venus] triangulo-rotundata gibba glaberrima characteribus angularibus inscripta*'.

Description of lectotype

Shell subadult, sub-ovate, thick, solid and inflated. Umbones low and slightly prosogyrate. Exterior shell smooth, containing tan zigzag lines on generally white background. Thickness and continuity of lines variable. Interior white. Hinge plate straight and broad, with prominent venerid dentition. Valve with strong, elongate anterior lateral tooth and two strong cardinal teeth. Pallial line entire, sinus very poorly developed.

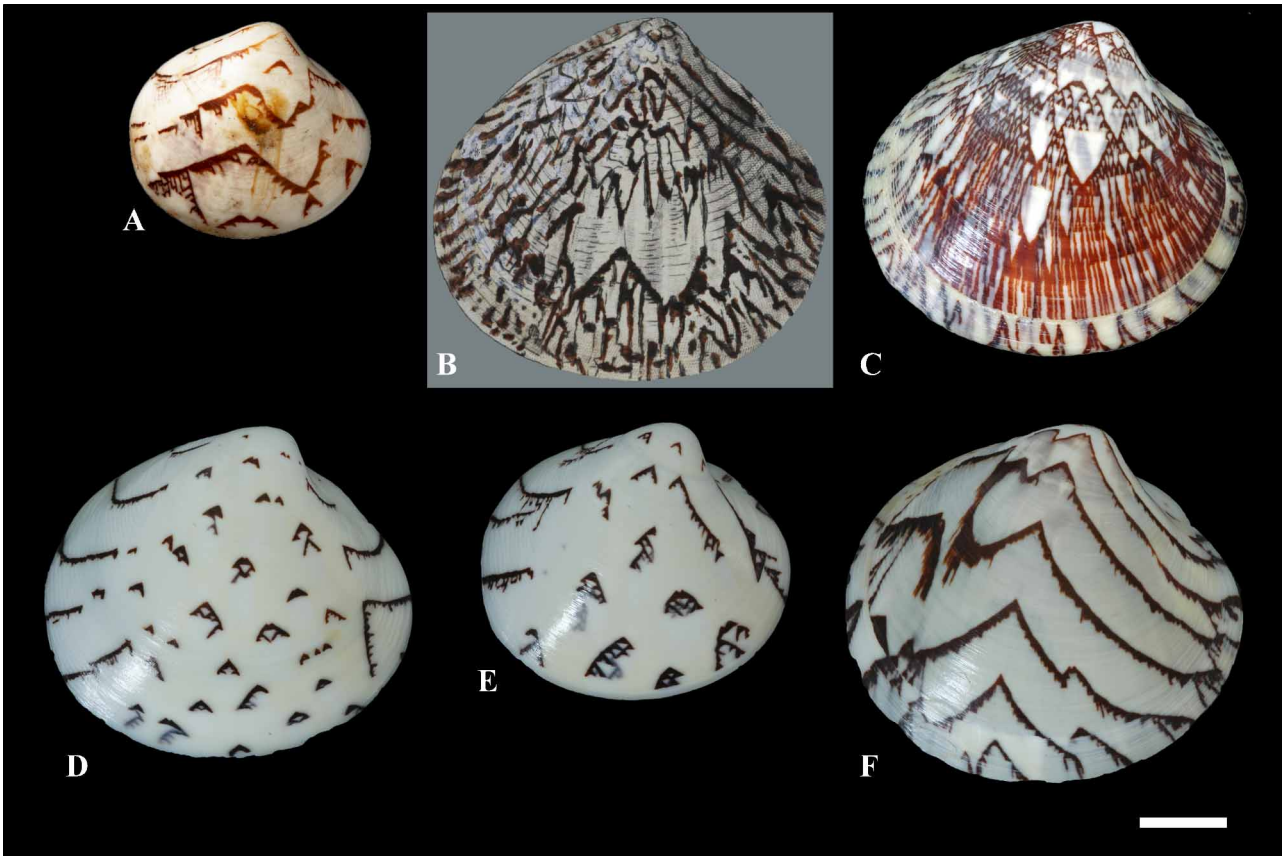

FIGURE 1: **A–F**. *Lioconcha castrensis* (Linnaeus, 1758) showing intraspecific variation. A, lectotype *Venus castrensis*, length 27.0 mm, height 24.0 mm; B, lectotype *Venus fulminea*, length 45.0 mm, height 42.0 mm (measured from drawing); C, ZMA Moll.159712, length 42.9 mm, height 37.5 mm; D, HD 19886, length 41.0 mm, height 36.6 mm; E; HD 19886, length 34.0 mm, height 31.0 mm; F, PLP 9-310/4, length 43.9 mm, height 39.8 mm. Scale: 10 mm.

General description of the taxon

See the diagnosis in Lamprell and Healy (2002: 104).

Type locality

'*in O. utriusque Indiae*' (Linnaeus 1758: 687), translated as 'both East and West Indies' in Lamprell and Healy (2002). We prefer 'in oceans on both sides of Indiae [Indonesia]', making the type locality of this species the Indo-Pacific.

Distribution

Indo-West Pacific.

Remarks (see also Table 1)

Linnaeus (1758) published this taxon as *Venus castrensis* in the 10th edition of *Systema Naturae*. In the 18th and 19th century Chemnitz (1782, 1788), Chenu (1847), Sowerby II (1851), Reeve (1863) and Römer (1868) described and figured a large variety of shells belonging to *V. castrensis*. Unfortunately, Lamprell and Healy (2002) did not stabilize the identity of *V. castrensis* Linnaeus, 1758 by designating a lectotype. According to Wallin (1993) seven possible syntypes (no. 425, 426 and 1356–1360) are present in the 'Linnaean collection' in Uppsala, Sweden. Part of the 'Linnaean collection' is curated by the Linnaean Society of

London and contains a further three potential syntypes, all of which right valves, isolated by Hanley (1855). The smallest of these specimens, bearing the hand-lettered Linnaean number 105, is herein designated as the lectotype of *Venus castrensis* Linnaeus, 1758 (Fig. 1A). The number 105 corresponds with the number for *Venus castrensis* in Linnaeus (1758: 687). This lectotype of *Lioconcha castrensis* has a colour pattern typical for the central Indo-Pacific. It shows a characteristic zigzag pattern with attached chevron or triangular marks. The specimen (a right valve) measures 27 mm in length, and 24 mm in height.

TABLE 1: Overview of the distinguishing characters of the species in the *L. castrensis* species group.

	L. castrensis	***L. macaulayi***	***L. arabaya* n. sp.**	***L. rumphii* n. sp.**
Colour pattern	Variable blue-black to tan zigzag lines on a generally white background. Density and continuity of lines variable.	Mostly white with irregular, obscure pink-orange and brown blotches (sometimes extensive), solid tents and occasional short rod-shaped markings.	Colour variable externally, in general white with numerous dark brown to tan zigzag or chevron markings forming a fine net-like pattern.	Superimposed, prominently developed chestnut-brown to tan zigzag lineaments or chevron-edged fields, occasionally containing numerous fine radial lines towards the anterior and posterior ends (resembling dripping paint) on a generally white background.
Lunule	Lunule slender and heart-shaped, bordered from remainder of shell by a fine groove.	Lunule heart-shaped and well delineated by an incised line. Lunule white with small pale red-brown spot umbonally.	Lunule heart-shaped, and delineated by a fine incised line. Lunule two-third white, one-third below the umbo brown.	Lunule slender and heart-shaped, and bordered from remainder shell by fine groove. On posterior side, a very dense area of fine straight and/or zigzag brown lines is developed.
Distribution	Indo-West Pacific.	New Caledonia and Queensland (Australia).	Northwest Indian Ocean, between Israel and Oman, possibly including East Africa and Sri Lanka.	Eastern Indian Ocean (Nicobar Islands) from West Sumatra (Indonesia) in the south to western Thailand.
Ratio length/height (SD) [min, max][1]	1.07 (± 0.02) [1.04, 1.13]	1.19 (± 0.12) [1.12, 1.50]	1.12 (± 0.04) [1.03, 1.16]	1.11 (± 0.03) [1.05, 1.18]
Ratio length/width (SD) [min, max][1]	1.69 (± 0.07) [1.55, 1.85]	1.74 (± 0.18) [1.57, 2.18]	1.57 (± 0.06) [1.49, 1.64]	1.61 (± 0.08) [1.45, 1.74]
Ratio height/width (SD) [min, max][1]	1.58 (± 0.07) [1.42, 1.75]	1.47 (± 0.06) [1.41, 1.60]	1.40 (± 0.05) [1.31, 1.46]	1.45 (± 0.05) [1.37, 1.56]

[1]Measurements based on 20 specimens (*L. castrensis*, *L. rumphii* n. sp.), respectively 9 (*L. arabaya* n. sp., *L. macaulayi*). All measurements based on (type) material from ZMA, except for 6 specimens of *L. macaulayi* which were taken from Lamprell & Healy (2002: 108).

Röding (1798: 181, no. 295) mentioned in his catalogue of the 'Bolten collection' nine specimens of '*V. fulminea*'. In this catalogue, he referred to Chemnitz (1782: 6, pl. 35 figs 369-370). The shell represented by figure 369 is what we consider to be *Lioconcha castrensis*. Therefore we designate the specimen mentioned by Chemnitz (1782: pl. 35 fig. 369) to be the lectotype for *Venus fulminea* (Fig. 1B). Lamprell and Healy (2002) consider *Venus fulminea* Röding, 1798, a junior synonym of *Lioconcha castrensis*. Figure 370 in Chemnitz (1782) represents *Lioconcha rumphii* n. sp. (Fig. 2G-K), which is described below.

Lioconcha castrensis is the largest living species of the genus *Lioconcha*, reaching a maximum length of about 55 mm. The range of morphological variation, as well as the wide distribution range, led previous authors to consider it as a single species. Material from the Fiji Islands and Tonga has very dense zigzag patterns (Lamprell and Healy 2002: fig. 1E-F). Dozens of specimens with this consistent pattern are present in the USNM collection. The RMNH collection has two specimens, locality 'Indian Ocean', strongly resembling the Sumatra specimen in the ZMA collection (Fig. 1C). The USNM collection also contains three paired valves with this pattern from Melila Island, off Sumatra. These shells show an even denser zigzag pattern than the Fiji specimens, with some white triangular marking near the umbone. Furthermore we studied specimens from Queensland, Australia, and New Caledonia with a more yellow background colour and large zigzag markings all over the shells (Fig. 1D–F). This pattern was already called the 'Australian variety' by Sowerby II (1851: 642). For now, we

regard all these forms as extreme varieties of *L. castrensis*, but additional research is needed (see Fig. 3).

Two aberrant populations, one from the Northwest Indian Ocean and one from West Thailand to Sumatra (Indonesia), differ in several characteristics. Below we describe them as new taxa.

Lioconcha macaulayi Lamprell & Healy, 2002

Lioconcha macaulayi Lamprell & Healy, 2002: 106–108, figs 2A–O, 12B, 15A.

Material examined

Australia (Queensland): Diamond Islets, Coral Sea Islands (dredged 5–10 m), coll. D.T. Thorn (HD 19885, 3 pv).

Type material

Holotype and paratypes from New Caledonia and Australia in AMS [not studied].

Type locality

New Caledonia: Crouy Reef.

Distribution

New Caledonia and Australia (Queensland), dredged in coral reef lagoons.

Remarks

This recently described species shows affinities with *L. rumphii* n. sp. However, the colour pattern in the latter is much more intense, whereas *L. macaulayi* only has obscure brown blotches. In shape *L. macaulayi* has a more truncate posterior margin, giving the shell a less ovate valve shape (see also Table 1).

Lioconcha arabaya n. sp.

(Fig. 2A–F)

Lioconcha castrensis.—Bosch *et al.*1995: 269, fig. 1208 (not Linnaeus 1758)

Lioconcha ornata.—Hosseinzadeh *et al.* 2001: 188, fig. (not Dillwyn 1817)

Lioconcha cf. *castrensis*.—Rusmore-Villaume 2008: 276–277, figs (not Linnaeus 1758)

Type material

Holotype Eilat, Israel, coll. I. Yeroslavsky, 2006, ex. colln. HD 19905 (ZMA Moll.4.07.018, pv); *paratypes* from type locality (HD 19905, 2pv).

Non-type material

Djibouti: beach, coll. G.C. Cadée, 08 Mar. 1993 (ZMA Moll.002349, lv); Egypt: Sinai, Dahab, Ras el-Kura, 28°28’18”N 034°30’12”E, coll. HD, 24 Sep. 1993 (HD 11348, lv); Dahab, coll. B. Gras, 21 Sep. 1996, colln. B. Gras (lv); Israel: Is of Fara’un, Gulf of Eilat, 28 May 1967 (USNM 779987, pv); Oman: Muscat beach, 23°35’30”N 58°36’17”E, coll. D.T. Bosch, 1978 (ZMA Moll.160616, lv, rv); Yemen: Al-Murk Isl., 15°38’N 042°38’E, coll. HD, 11 Apr. 1993 (HD 8577, lv, rv).

Non-type material *Lioconcha* cf. *arabaya*

Comoros: Moinakeli, Mayotte, 3 Nov. 1994 (HD 19876, rv); Choisil, Mayotte, 9 Apr. 1995 (HD 19877, pv); Mauritius: Cathedral, Flic en Flac, coll. R.G. Moolenbeek, 23 Jul. 2008 (ZMA Moll., rv); Trou aux Biches, coll. R.G. Moolenbeek, 22 Jul. 2008 (ZMA Moll., v); Seychelles: N of Platte Isl. atoll, coll. NIOP-E ‘Tyro’ Seychelles Expedition 1992/93, 05°49’S 55°22’E, 7–8 Jan. 1993 (RMNH.MOL.116589, lv); Sri Lanka: Nilaveli, coll. B. Gras, Jul. 1984, colln. B. Gras (2rv).

Diagnosis

Equivalve, medium-sized, comparatively inflated, oval *Lioconcha* species; overall shell colour predominantly white, chestnut brown to tan markings; colour pattern consisting of fine net-like pattern; internal surface white.

Description of holotype

Shell equivalve, sub-ovate, thick, solid and inflated, glossy. Umbones low, slightly prosogyrate, white. Escutcheon indistinct, ligament deeply sunken. Lunule heart-shaped, delineated by fine incised line. Lunule two-thirds white, one-third below umbo brown. Sculpture smooth, with three growth lines. At posterior extremity numerous fine concentric ridges, hardly visible at anterior side. Colour variable externally, in general white with numerous dark brown to tan zigzag or chevron markings forming fine net-like pattern. Shell internally white. Hinge heterodont, nearly identical to *L. castrensis*. Pallial line entire, almost without sinus.

Variability

A rather uniform species (paratypes and other material studied). Some adult specimens can have a somewhat darker brown pattern (Fig. 2D, see also Hosseinzadeh *et al.* 2001: 188, fig.).

Dimensions

	length	height	width
holotype	28.7 mm	26.6 mm	19.2 mm
paratype	35.6 mm	30.6 mm	23.3 mm
paratype	27.0 mm	23.6 mm	16.5 mm
largest specimen	48.9 mm	47.3 mm	32.5 mm

Distribution

Northwest Indian Ocean, between Israel and Oman, maybe including East Africa (see Fig. 3, remarks).

Remarks

We have studied specimens from the Comoros, the Seychelles, and Mauritius (Figs 2F, 3). These specimens seem to represent this new species, but differ in their much less dense colour pattern and yellowish internal shell surface.

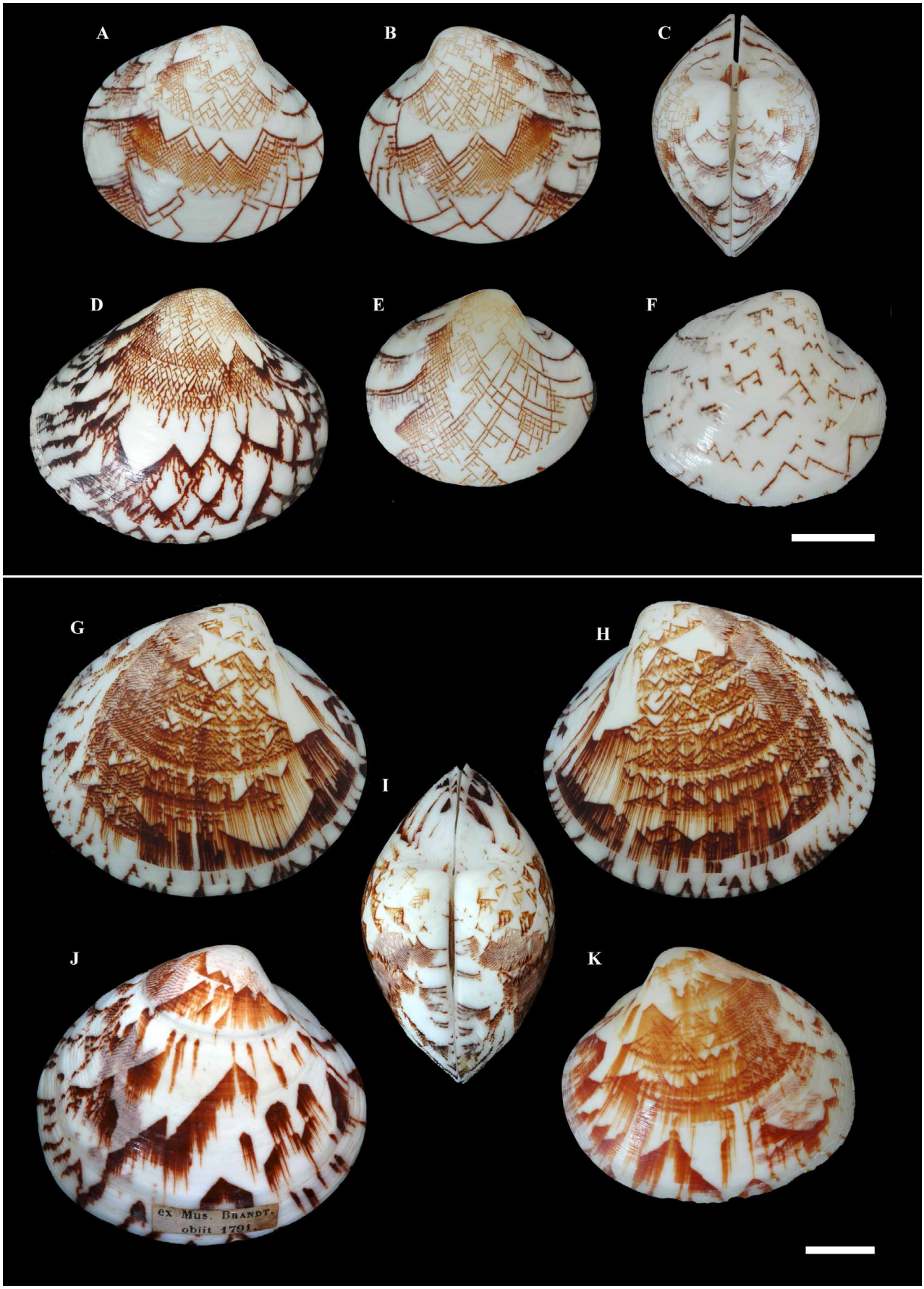

FIGURE 2: **A–F**. *Lioconcha arabaya* n. sp. A–C, holotype ZMA Moll.4.07.018, D, HD 19905, length 35.6 mm, height 30.6 mm; E, HD 199905, length 27.0 mm, height 23.6 mm; F, *Lioconcha* cf. *arabaya* n. sp. HD 19877, length 28.7 mm, height 25.9. **G–K**. *Lioconcha rumphii* n. sp. G–I, holotype ZMA Moll.4.07.017; J, ZMA Moll.159566, length 46.5 mm, height 42.5 mm; K, ZMA Moll.000489, length 41.3 mm, height 36.7 mm. Scale: 10 mm.

Whether this is another new East African species, subspecies or clinal variation of *Lioconcha arabaya* n. sp. needs more research. For now we regard them as *Lioconcha* cf. *arabaya* n. sp.

Etymology

Arabâya is the old Persian word for Arabia. It refers to the distribution of the species around Arabia (Arabian Peninsula) and Persia (Iran).

***Lioconcha rumphii* n. sp.**

(Fig. 2G–K)

'Türkische Lagermuschel'.—Chemnitz 1782: fig. 370
Cytherea castrensis.—Chenu 1847: Part 64 pl. 8 fig. 2; Sowerby II1851: pl. 134 fig. 151 (not Linnaeus 1758)
Circe castrensis.—Reeve 1863: pl. 7 fig. 28c (not Linnaeus1758)
Lioconcha castrensis.—Oliver 1992: pl. 40 fig. 1a–b (not Linnaeus 1758).

Type material

Holotype Raya Isl., Phuket, Thailand, ex. colln. HD 11347 (ZMA Moll.4.07.017, pv); *paratype* Ko Phuket, Thailand (HD 21619, 2pv); Raya Isl., Phuket, Rawai, Thailand (MS 57834, pv).

Non-type material

Indonesia: 'Molukken' [Moluccas] (ZMA Moll., 5pv, 2rv, 2lv); Weh Isl. (Iboih), 5°50'N 95°20'E, coll. L. Duiveman, 01 Aug. 1991 (ZMA Moll.000489, lv); Weh Isl. (Sabang), 5°50'N 95°30'E, coll. C.H.J. van Benthem Jutting, 1920 (ZMA Moll.159581, lv); Batu Isl., Sumatra, 0°01'S 98°17'E, coll. R.C.W. Welborn, 1908 (ZMA Moll.159561, v); Moluccas, ex colln. J.C. Brandt, 1791 (ZMA Moll.159566, pv); 'Indonesia', ex colln. M.M. Schepman (ZMA Moll.159562, pv); Batjan Isl., Moluccas, coll. H.A. Bernstein, 1864–1865 (RMNH.MOL.116590, 2rv, 2lv); no locality (RMNH.MOL.116591, lv, rv).

Diagnosis

Comparatively round and sturdy *Lioconcha* species; overall shell colour white, chestnut brown to tan markings; colour pattern consisting of triangle shapes with numerous fine radial lines; internal surface white.

Description of holotype

Shell equivalve, sub-ovate, thick, solid and inflate. Umbones low and slightly prosogyrate, escutcheon indistinct. Umbo of holotype: three growth stops evident as commarginal ridges. Ligament deeply sunken. Lunule slender and heart-shaped, and bordered from remainder of shell by fine groove. On posterior side, a very dense area of fine straight and/or zigzag brown lines is developed. Exterior white background colour. Superimposed, prominently developed chestnut-brown to tan zigzag lineaments or chevron-edged fields, occasionally containing numerous fine radial lines towards anterior and posterior ends (resembling dripping paint). Shell internally white. Hinge heterodont, identical to that of *L. castrensis.* Pallial line entire, pallial sinus diminutive. Anterior muscle adductor ovate shaped, posterior adductor scars ovate-subquadrate.

Variability

This species has a relatively narrow range of morphological variability (paratypes and other material studied). Live collected specimens tend to be brownish, whereas beach worn material becomes a more reddish brown (Fig. 2K). Some specimens show irregular brown blotches on a white background with the typical numerous radial dripping lines (Fig. 2J).

Dimensions

	length	height	width
holotype	46.3 mm	42.2 mm	27.0 mm
paratype	45.5 mm	40.4 mm	27.6 mm
paratype	19.5 mm	16.8 mm	11.4 mm
largest specimen	50.5 mm	45.0 mm	32.0 mm

Distribution

Eastern Indian Ocean (Nicobar Islands) from West Sumatra (Indonesia) in the south to West Thailand (Fig. 3).

Discussion

This article is an addition to the revision made by Lamprell and Healy (2002), but despite these revisions *Lioconcha* species remain difficult to identify. The distinguishing characters of *L. castrensis, L. macaulayi, L. arabaya* n. sp., and *L. rumphii* n. sp. are summarized in Table 1.

Further work is needed to study variation of the *Lioconcha castrensis* group, preferably including anatomical and molecular techniques. Due to the limited amount of recently collected fresh *Lioconcha* material, DNA analyses could not be used in the present study. The *Lioconcha ornata* species group is also in need of revision.

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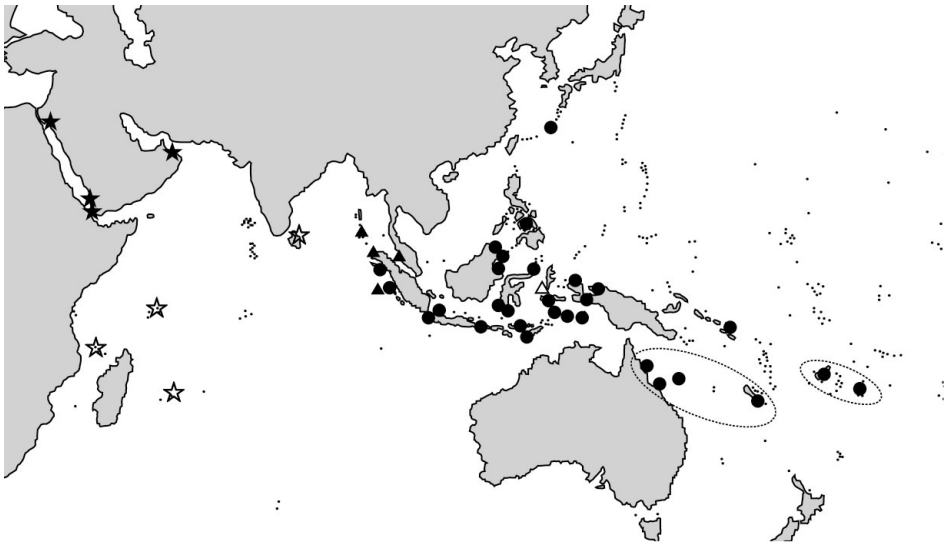

FIGURE 3: Distribution map for the *Lioconcha castrensis* species group: ★ *Lioconcha arabaya* n. sp., ☆ *Lioconcha* cf. *arabaya* n. sp., ▲ *Lioconcha rumphii* n. sp., △ *Lioconcha rumphii* n. sp. (unconfirmed locality), ● *Lioconcha castrensis.* The dotted ovals indicate the varieties of *L. castrensis* around Queensland and New Caledonia, and Fiji and Tonga.

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