



***Holothuria (Lessonothuria) insignis* Ludwig, 1875 (formally resurrected from synonymy of *H. pardalis* Selenka, 1867) and *Holothuria (Lessonothuria) lineata* Ludwig, 1875—new additions to the sea cucumber fauna of Pakistan, with a key to the subgenus *Lessonothuria* Deichmann (Echinodermata: Holothuroidea)**

QURATULAN AHMED¹, AHMED S. THANDAR^{2*} & QADEER MOHAMMAD ALI¹

¹The Marine Reference Collection and Resource Centre, University of Karachi, Karachi, Pakistan. ✉ quratulunahmed_ku@yahoo.co

ORCID: <https://orcid.org/0000-0002-7597-2483>, ✉ taxonomist@hotmail.com ORCID: <https://orcid.org/0000-0002-0499-0801>

²School of Life Sciences, University of KwaZulu-Natal, P/Bag x54001, Durban 4000, South Africa.

*Corresponding author. ✉ thandara@ukzn.ac.za ORCID: <https://orcid.org/0000-0002-7368-5560>

Abstract

Two specimens of a species herein identified as *Holothuria (Lessonothuria) insignis* Ludwig, 1875 and a single specimen identified as *Holothuria (Lessonothuria) lineata* Ludwig, 1875, were collected from the intertidal zone at low tide from two coastal localities in Karachi (*Buleji* and *Sunahri*). This paper briefly documents their morphology and habitat characteristics and formally resurrects *H. (L.) insignis* from the synonymy of *H. (L.) pardalis* Selenka, 1867, based on the observations of the ossicles assemblage deduced from current material, syntype, some material at the NHMUK (Natural History Museum, UK), and literature. *H. pardalis* is also commented on and compared with its related congeners in Pakistan, in tabular form. A key is presented of all species of the *Lessonothuria* group currently recognized in WoRMS.

Key words: Holothuriidae, *Holothuria*, *Lessonothuria*, Pakistan, new records, sea cucumbers

Introduction

All three species (*H. pardalis* Selenka, 1867, *H. insignis* Ludwig, 1875 and *H. lineata* Ludwig, 1875) were not clearly defined until recently (see for instance Samyn *et al*, 2019 for a redescription of *H. lineata*; species keyed-out against *H. insignis*, *H. pardalis*, and *H. verrucosa*) as their original descriptions are very brief and the illustrations poor and incomplete. Selenka (1867), who described *H. pardalis*, illustrated only a few tables and buttons, and although Ludwig (1875), who described both *H. insignis* and *H. lineata*, provided slightly better illustrations, also figured only a few ossicles and not the complete range in each species. Thus, many authors (notably Ludwig himself, in his subsequent papers, Panning (1935), H.L. Clark (1946), amongst many others) regarded all three species with a few others as synonymous. Rowe (in Rowe & Gates 1995), although resurrecting *H. lineata* from the synonymy of *H. pardalis*, still retained *H. insignis* as a synonym of *H. pardalis*. Among the more recent workers, Samyn (2003) recorded *H. pardalis* from Kenya and Pemba Island, while providing a detailed synonymy, distribution and history of the species and therefore there is no need to re-iterate this here. Thandar (2007) recorded both *H. pardalis* and *H. insignis* from South Africa but apparently misidentified the latter but corrected this in a subsequent paper (Thandar 2008) when describing *H. lineata* from a juvenile from False Bay, South Africa. However, this requires re-visiting when new material comes to light. Subsequently Afkhami *et al* (2015) recorded *H. insignis* from the Persian Gulf and Samyn *et al* (2019) re-described *H. lineata* from the type in the Zoological Museum, Hamburg (ZMH) and a specimen from Glorioso Islands, north of Madagascar. In the latter paper they also point out the differences between four closely related species of *Lessonothuria* (*H. pardalis*, *H. insignis*, *H. lineata* and *H. verrucosa*) and provide a key to distinguish them. It is regrettable that they ignored re-describing *H. pardalis* and *H. insignis* although they had the type materials in hand.

Deichmann (1958) designated Hawaii as the type locality of *H. pardalis* but without providing the accession numbers of Selenka's type material. Rowe (in Rowe & Gates 1995) examined numerous specimens, including some of Selenka's types and designated MCZ 677 as lectotype and MCZ 676 as paralectotypes. However, MCZ 677 came from Zanzibar while MCZ 676 came from Hawaii. According to Rowe (pers. comm.) there was possibly an erroneous

ous switch in numbers and hence MCZ 676 should be designated as the lectotype and MCZ 677 as the paralectotypes. This is here corrected in agreement with Samyn (pers. comm.), one of the reviewers.

The second author (AST) was fortunate in obtaining slides of the ossicles of one of the syntypes of *H. insignis* Ludwig, 1875 found in the collection of the ZMH (ZMH.2573) and one of the syntypes of *H. pardalis* Selenka, 1867 as found in the collection of the Zoological Museum, University of Göttingen (ZMUG. 6–23a), both from Dr. Yves Samyn of the Belgian Institute of Natural Sciences, and also having the facilities at the NHMUK to look at some reasonably identified materials of all three species here discussed. So, on the bases of this and the most recent paper of Samyn *et al.* (2019), we here provide some useful information on all the three much-confused species, some useful tips to separate them, and publish a provisional key to the 11 species currently recognized in the *Lessonothuria* group (WoRMS, accessed 10 October 2019).

While Samyn *et al.* (2019) do not explicitly mention that they are resurrecting *H. insignis* from the synonymy of *H. pardalis* this was obviously implied, as they compare all three species, together with *H. verrucosa*, and provide a key to separate them. We now formally resurrect *H. insignis* from synonymy since we believe that all the formerly three confused species are now clearly distinguishable. We conclude that *H. insignis* and *H. lineata*, like *H. pardalis*, are also now part of the Pakistan holothuroid fauna.

In the distribution list in their excellent ‘Monograph of the shallow-water Indo-West Pacific echinoderms’, Clark & Rowe (1971) recorded only 12 holothuroid species from Pakistan. Since then five more species were added by Tahera & Tirmizi (1995); Tahera (1997); Tahera & Kazmi (2005), two species by Ahmed *et al.* (2016), and one new species by Thandar (2017), raising the figure to 20 species. *Holothuria insignis* and *Holothuria lineata* can now be added as new records from Pakistan, raising the number of known species to 22¹. The table below lists all the species now known from Pakistan and the authors responsible for their records.

TABLE 1. Species currently known from the coastal waters of Pakistan

Family	Species	References
Synaptidae Burmeister, 1837	<i>Synaptula recta</i> (Semper, 1867)	Tahera, Q. (1997).
	<i>Synaptula hydriformis</i> (Lesueur, 1824)	Tahera, Q. & Kazmi, Q. (2005)
Holothuriidae Burmeister, 1837	<i>Actinopyga mauritiana</i> (Quoy & Gaimard, 1834)	Clark & Rowe (1971)
	<i>Holothuria (Halodeima) atra</i> Jaeger, 1833	Tahera, Q. & Kazmi, Q. (2005)
	<i>Holothuria (Thymiosycia) arenicola</i> Semper, 1868	Tahera, Q. & Tirmizi, N.M. (1995)
	<i>Holothuria (Semperothuria) cinerascens</i> (Brandt, 1835)	Ahmed, Q. <i>et al.</i> , (2016)
	<i>Holothuria (Platyperona) difficilis</i> Semper, 1868	Tahera, Q. & Kazmi, Q. (1995)
	<i>Holothuria (Lessonothuria) insignis</i> Ludwig, 1875	This study
	<i>Holothuria (Mertensiothuria) leucospilota</i> (Brandt, 1835)	Clark & Rowe (1971)
	<i>Holothuria (Lessonothuria) lineata</i> Ludwig, 1875	This study
	<i>Holothuria (Lessonothuria) pardalis</i> Selenka, 1867	Clark & Rowe (1971)
	<i>Holothuria (Lessonothuria) verrucosa</i> Selenka, 1867	Ahmed, Q. <i>et al.</i> (2016).
Cucumariidae Ludwig, 1894	<i>Aslia forbesi</i> (Bell, 1886)	Clark & Rowe (1971)
	<i>Staurothyone rosacea</i> (Semper, 1869)	Clark & Rowe (1971)
	<i>Actinocucumis typicus</i> Ludwig, 1875	Clark & Rowe (1971)
Phylloporidae Östergren, 1907	<i>Stolus buccalis</i> (Stimpson, 1855)	Clark & Rowe (1971)
	<i>Stolus conjungens</i> (Semper, 1867)	Clark & Rowe (1971)
	<i>Thyone dura</i> Koehler & Vaney, 1908	Clark & Rowe (1971)
	<i>Hemithyone semperi</i> (Bell, 1884)	Clark & Rowe (1971)
	<i>Thyonina rasidae</i> Thandar, 2017	Thandar (2017)
Sclerodactylidae Panning, 1949	<i>Ohshimella ehrenbergii</i> (Selenka, 1868)	Clark & Rowe (1971)
	<i>Cladolabes aciculus</i> (Semper, 1867)	Clark & Rowe (1971)

¹ Concomitant with this paper, Moazzam & Moazzam (2020) added two more species [*Holothuria (Theelothuria) hamata* Pearson, 1903 and *Stichopus hermanni* Semper, 1868] to the Pakistan fauna, and Ahmed & Ali (2020) added [*Holothuria (Theelothuria) notabilis* Ludwig, 1875], now raising the figure to 25 spp. *Leptosynapta inhaerens* (O.F. Müller, 1776), is here excluded as its identification is in doubt.

Materials and methods

During regular surveys of the coastal areas of Karachi, between November 2014 and May 2017, 172 specimens of sea cucumbers were collected from two sites in Karachi (*Buleji* $24^{\circ} 50' 20.41'' N$, $66^{\circ} 49' 24.15'' E$ and *Sunahri* $24^{\circ} 52' 33.49'' N$, $66^{\circ} 40' 40.20'' E$). Among these, two specimens, here identified as *Holothuria (Lessonothuria) insignis* and one as *Holothuria (Lessonothuria) lineata*, hitherto not recorded from Pakistan, were taken from intertidal waters. The study area is shown in the map below (Figure 1).

Before examination, following Samyn *et al.* (2006), the specimens were first anaesthetized in a 5% magnesium chloride solution for relaxation of the specimens and extension of their tentacles. For identification of materials collected, the ossicles were examined from the dorsal and ventral body wall, tentacles and podia. Slides of the ossicles were prepared by placing a small piece of skin on a slide and adding a few drops of 3.5% commercial/household bleach. The slides were then dried, rinsed with few drops of distilled water, dehydrated with alcohols, and mounted in Canada balsam. The ossicles were examined under a compound microscope and photographed using a digital camera (Fujifilm 16 MP) attached to the microscope. All materials are deposited in the repository of the Marine Reference Collection and Resource Centre, University of Karachi, under Cat. No. Holo. 19; Holo. 23.

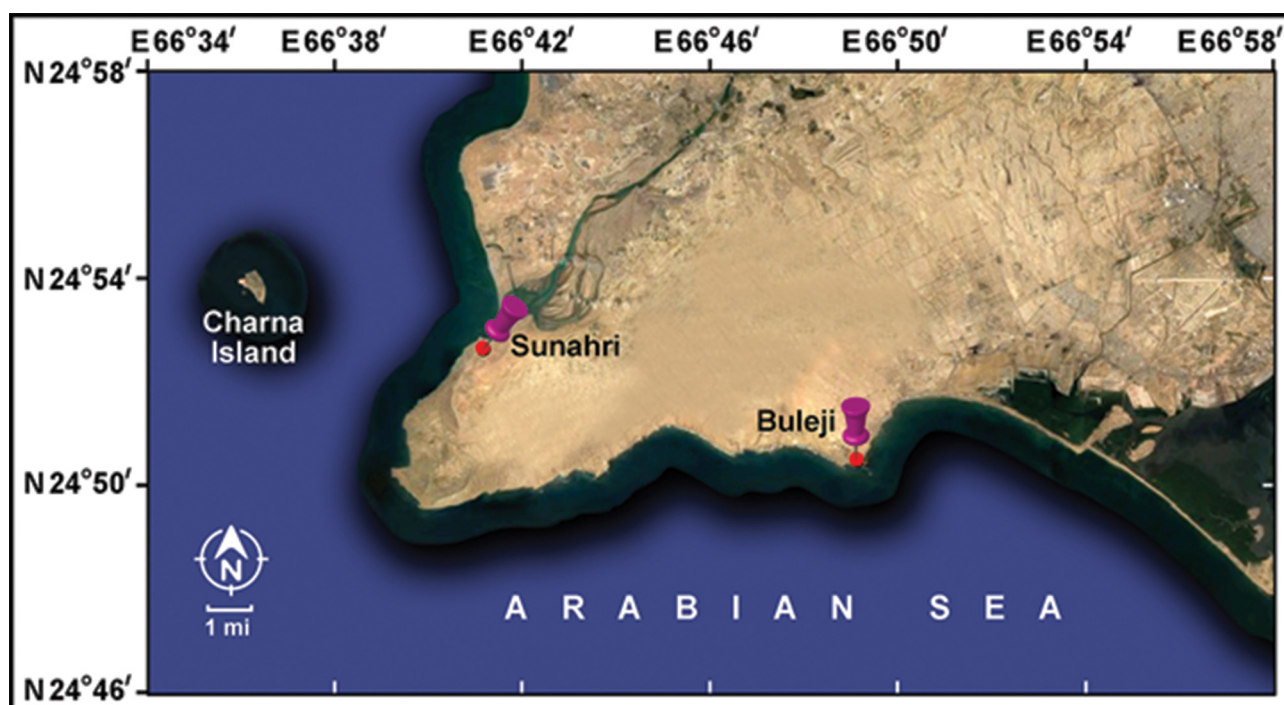


FIGURE 1. Map of study area of Pakistan (*Buleji* $24^{\circ} 50' 20.41'' N$, $66^{\circ} 49' 24.15'' E$ and *Sunahri* ($24^{\circ} 52' 33.49'' N$, $66^{\circ} 40' 40.20'' E$) Karachi Pakistan.

Results and discussion

Order Holothuriida Miller *et al.*, 2017

Family Holothuriidae Burmeister, 1837

Genus *Holothuria* Linnaeus, 1767

Subgenus *Lessonothuria* Deichmann, 1958

Holothuria (Lessonothuria) insignis Ludwig, 1875

Figure 2

Holothuria insignis Ludwig, 1875: 106, p1.7, fig.28.

Holothuria pardalis var. *insignis* Sluiter, 1890: 106.

Halodeima insignis Heding, 1934: 23.

Holothuria (Lessonothuria) insignis Rowe, 1969: 149 (passim); Clark and Rowe, 1971: 176 (distrib.), p. 194 (note); Samyn, 2003: 42 (passim); Samyn *et al.* 2019 (in remarks and key).

Holothuria (Lessonothuria) pardalis Rowe & Gates, 1995: 292 (partim); ?Cherbonnier, 1988:117, fig.47.

?non *Holothuria (Lessonothuria) insignis* Thandar 2007:16, text fig. 6 (= ?*H. lineata* Ludwig, 1875).

Material examined. Sunahri Beach, 24° 52' 33.49" N, 66° 40' 40.20" E, Holo. 19, rocky shore, 24 November 2014, 1 spec.; Buleji, 24° 50' 20.41" N, 66° 49' 24.15" E, 15 April 2015, 1 spec.

Habitat. The specimens were found attached to a rock in the intertidal zone. This species inhabits the lower mid-littoral zone on rock and sand substrate, living under boulders or hides in sand in shallow waters.

Description. Specimen from Sunahri beach was 80 mm long whereas the specimen from Buleji measured 60 mm. Both specimens are cylindrical with the dorso-ventral surfaces well arched. Colouration of live specimens was dark brown dorsally (Figure 2A) with the ventral surface light brown to creamy-white with brown blotches (Figure 2B). The dorsal body wall is only slightly thick but rough to touch. Podia are scattered over the entire body surface with the dorsal ones tipped light creamy-brown. The mouth is ventral and encircled by 18 tentacles (Figure 2C) and the anus terminal, encircled by six papillae. Both the Polian vesicle and stone single are single but the madreporite was not observed. Cuvierian tubules are present.

Body wall ossicles comprise tables (Figure 2D) and pseudo-buttons, the latter often slightly knobbed (Figure 2E). The tables, 20–86 µm, have a squarish or rounded disc usually perforated by the four central holes, rarely more and with a very spiny margin. The spire is stunted or drastically reduced, terminating in a few teeth, or absent, then teeth appear to be present on disc only; the spire terminates in usually eight teeth surrounding a central hole. Dorsally and ventrally the pseudo-buttons, 20–13 µm, are both regular (complete) and irregular (incomplete) with the latter predominating. The ventral podia are supported by elongated rods, 88–274 µm, perforated with 1–2 holes at each end (Figure 2H). The end plates of the ventral podia, 34–110 µm, are surrounded by elongated plates with undulating margin and paired series of large holes (Figure 2F); the dorsal podia have similar but slightly shorter rods (2I), 38–234 µm. The tentacle rods, 30–52 µm, may be branched at one end and perforated at the other (2G).

Remarks. *Holothuria (Lessonothuria) insignis* Ludwig, 1875 was not reported from the Pakistan coast before and hence it is new to the fauna of Pakistan. The specimens are similar to those described by Ludwig (1875) from Bowen (Australia), Lampert (1896) from East Africa, and recently by Samyn *et al.* (2006) from the Comores, and Afkhami *et al.* (2015) from the Persian Gulf (Hormuz Island). Their specimen size-range varied from 20–80 mm with the dorsal life colouration described as darkish grey or brown, striped brown, and ventral life colouration whitish.

Clark and Rowe (1971) recorded this species from the Red Sea, Eastern Africa and Madagascar, Bay of Bengal, East Indies, north Australia, Philippines, China, south Japan and south Pacific Is. Heding (1934) reported on some holothuroids from Hong Kong which included *H. insignis* which he was convinced differs significantly from *H. pardalis*. Ducarme (2016) reported *H. insignis* among 14 species of sea cucumbers encountered during the survey of nearby atolls in the Maldives.

Although Clark & Rowe (1971) included both *H. pardalis* and *H. insignis*, in their note on p. 194, question the validity of the latter but because of Heding's (1934) viewpoint, retained it as a valid species. Later, however, Rowe (in Rowe & Gates 1995) accepted *H. insignis* in the synonymy of *H. pardalis*, after examining some type material and numerous specimens from various museums and localities. A study of the ossicles of a syntype (ZMH E2573) by AST, received from Dr Samyn, revealed that the table discs of *H. insignis* usually have four central holes, hardly any marginal holes, a remarkably reduced or absent spire and with most of the buttons (ca. 60%) incomplete, or often developed with a single series of three holes on one side, not showing any sign of reduction, or are sometimes reduced to C-shaped rods, but rarely twisted. Complete buttons have three pairs of slit-like holes and rarely small terminal holes and are deeply constricted in the middle. The rods of the papillae are expanded at ends which may bear perforations or the rods are just thick, curved structures without perforations or spines. Rods of the ventral podia are straight or slightly curved, sometimes spinose, with 3–7 holes at each end. Plates associated with end plates of the ventral podia appear rounded or slightly elongated with undulating, sometimes spinose margin, with large paired series of holes unlike the plates found in *H. lineata*, which have a convincingly spinose or serrated margin. Hence, we opine that there is enough morphological evidence to resurrect *H. insignis* from the synonymy of

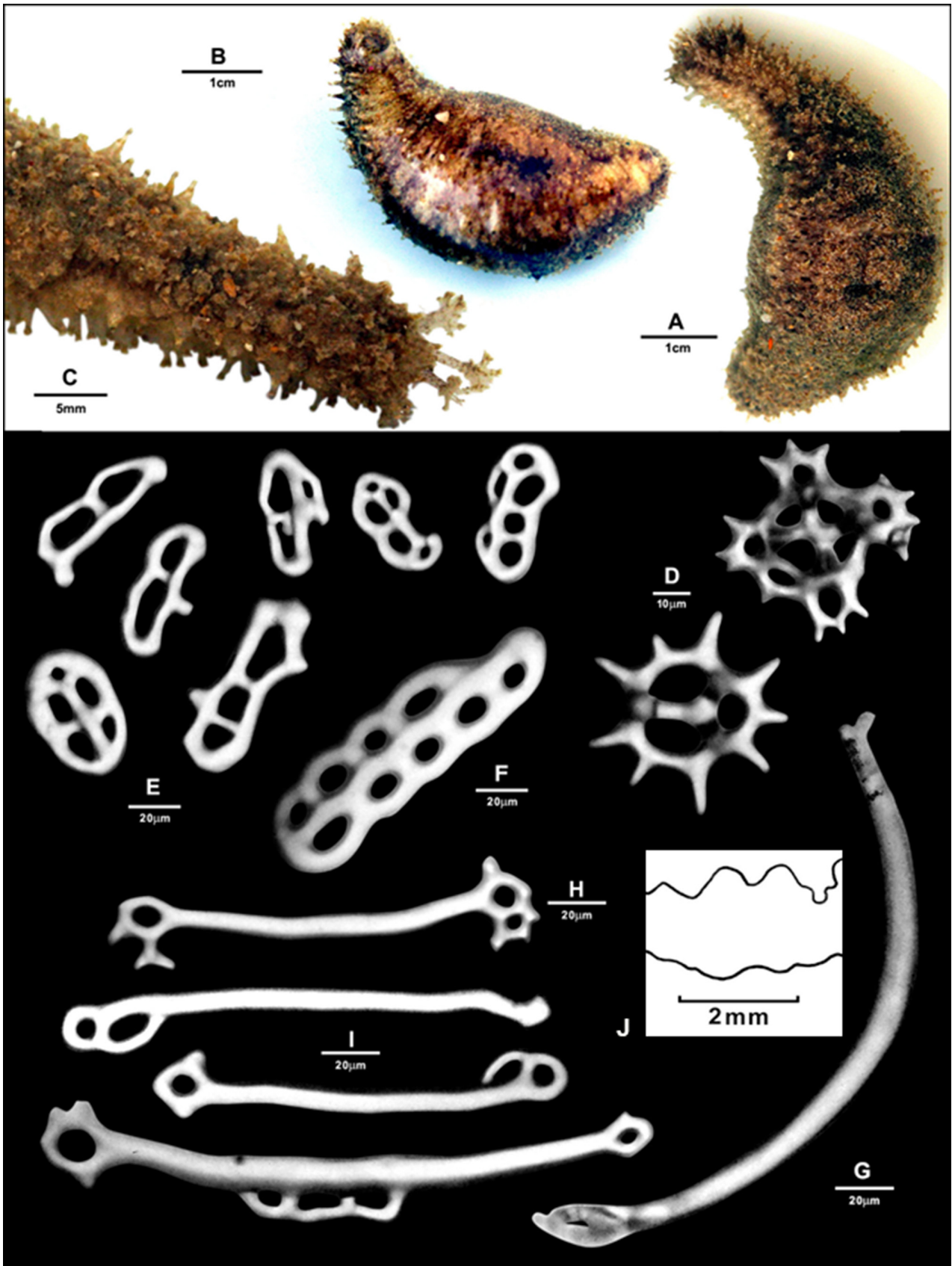


FIGURE 2. *Holothuria (Lessonothuria) insignis* Ludwig, 1875. Holo. 19. A. Dorsal view; B. Ventral view; C. Anterior end with extended tentacles; D. Tables of dorsal integument E. Regular and irregular pseudo-buttons of integument; F. Plate from ventral tube foot; G. Rod of tentacle; H. Tube feet rod; I. Papillae rods; J. Part of calcareous ring (single dorsal radial and adjoining interradial plates)

H. pardalis. This evidence is here summarized in Table 2, which compares both species. The ossicles of *H. pardalis* are illustrated in Figure 3 for the purpose of comparison. The fact that some specimens of *H. insignis* do show some plates associated with the end plate with also serrated margins as in *H. lineata*, these may be a result of hybridization, as both species are sympatric over a wide range wherever they occur, or some other factors. In this light Thandar's (2007) *H. insignis*, which was later transferred to *H. lineata*, needs re-examination on the bases of new materials and the characters here recorded, taking into account the re-description of the syntype of *H. lineata* by Samyn *et al.* (2019), as it might represent a true *H. insignis*.

Holothuria (Lessonothuria) pardalis Selenka, 1867

Figure 3

Holothuria pardalis Selenka, 1867: 336, pl. 19, fig. 85; Semper, 1868: 87, 248, 278, pl. 30, fig. 31; Fisher, 1907: 664, pl. 69, fig. 1.

Holothuria subditiva Selenka, 1867: 338, pl. 19, fig. 87.

Holothuria peregrina Ludwig, 1875: 105, pl. 7. Fig. 30.

Holothuria (Holothuria) pardalis Panning, 1935c (V): 3; fig. 106 (partim).

Lessonothuria pardalis Deichmann, 1958: 296, pl. 2, fig. 1–17.

Holothuria (Lessonothuria) pardalis Rowe, 1969: 149, fig. 15; Clark & Rowe, 1971: 176

(dist.), pl. 28, fig. 11; Rowe & Doty, 1977: 233, fig. 4e; Rowe & Gates, 1995: 292 (synonymy

partim); Samyn, 2003: 40, pl. 2G (synonymy and records before 2003), figs. 16A, 52G; Thandar, 2007: 18, text-fig. 7.

Remarks. This well-known species does not require re-description but, because of its frequent confusion with *H. insignis* and *H. lineata*., some useful notes are here added from the study of material from Pakistan, one of Selenka's syntypes (ZMUG6-23a) from the Göttingen Museum, and some reasonably well identified material at the NHMUK. Body wall tables of the syntype are typical of the species. The disc is circular, reduced, but margins distinctly spinose, especially at corners of disc where spines are longer or the only ones present. The disc has four central holes and 2–4 smaller marginal holes, ventrally slit-like. The spire is poorly developed but rarely absent, when present of low to moderate height, ending in a quadrilocular crown with about eight teeth. Buttons are complete or incomplete in a 50:50 ratio, frequently twisted. Complete buttons have 2–4 pairs of small, often slit-like holes, with the central holes sometimes very large, rarely a few buttons have only two holes, side by side. The plates associated with the end plates of the ventral podia are complete or incomplete with 3–5 pairs of large holes and an undulating margin, rarely with margins of some plates serrated. The tube feet rods appear mostly straight with few poorly developed holes. The tentacle rods are straight or slightly curved, some slightly dentate along margin and at ends which may be slightly branched but without holes. In a specimen of *H. pardalis* at the NHMUK (1979.2.5.210) collected from Kenya, the buttons, corresponding with Selenka's (1867) description, are also situated in heaps, the discs are complete with about eight holes or incomplete with fewer holes. The spire of tables, although of moderate height is well formed, terminating in about eight teeth. The plates surrounding the ventral end plates are smooth, about 300 µm long, with two series (rarely more) of holes and an undulating margin. Rods of the dorsal papillae are also long, up to 300 µm. Hence, it is certain that the deposits of the Kenyan and Pakistan specimens are identical to those of the syntype here examined and definitely referable to *H. pardalis*. In specimens described from Mozambique by Thandar (2007), the buttons are also stated to be mostly complete. Cherbonnier (1988) and Samyn (2003) do illustrate some tables with tall spires with more than a single cross-bar in material from Madagascar and Kenya respectively. These are here regarded as individual variations.

Thus *Holothuria pardalis* (Figure 3) from Pakistan shows characters as described by Samyn (2003) and Thandar (2007), *i.e.* tentacles 20, table discs of body wall circular, 31–65 µm, with a distinctly spinose rim with four central and usually a single series of smaller marginal holes, the latter often reduced, then disc incomplete; spire extremely low, terminating in eight or fewer teeth. The pseudo-buttons, 33–52 µm, are of diverse size and shape, but usually complete with 3–5 pairs of holes, sometimes incomplete with asymmetrically placed holes, sometimes

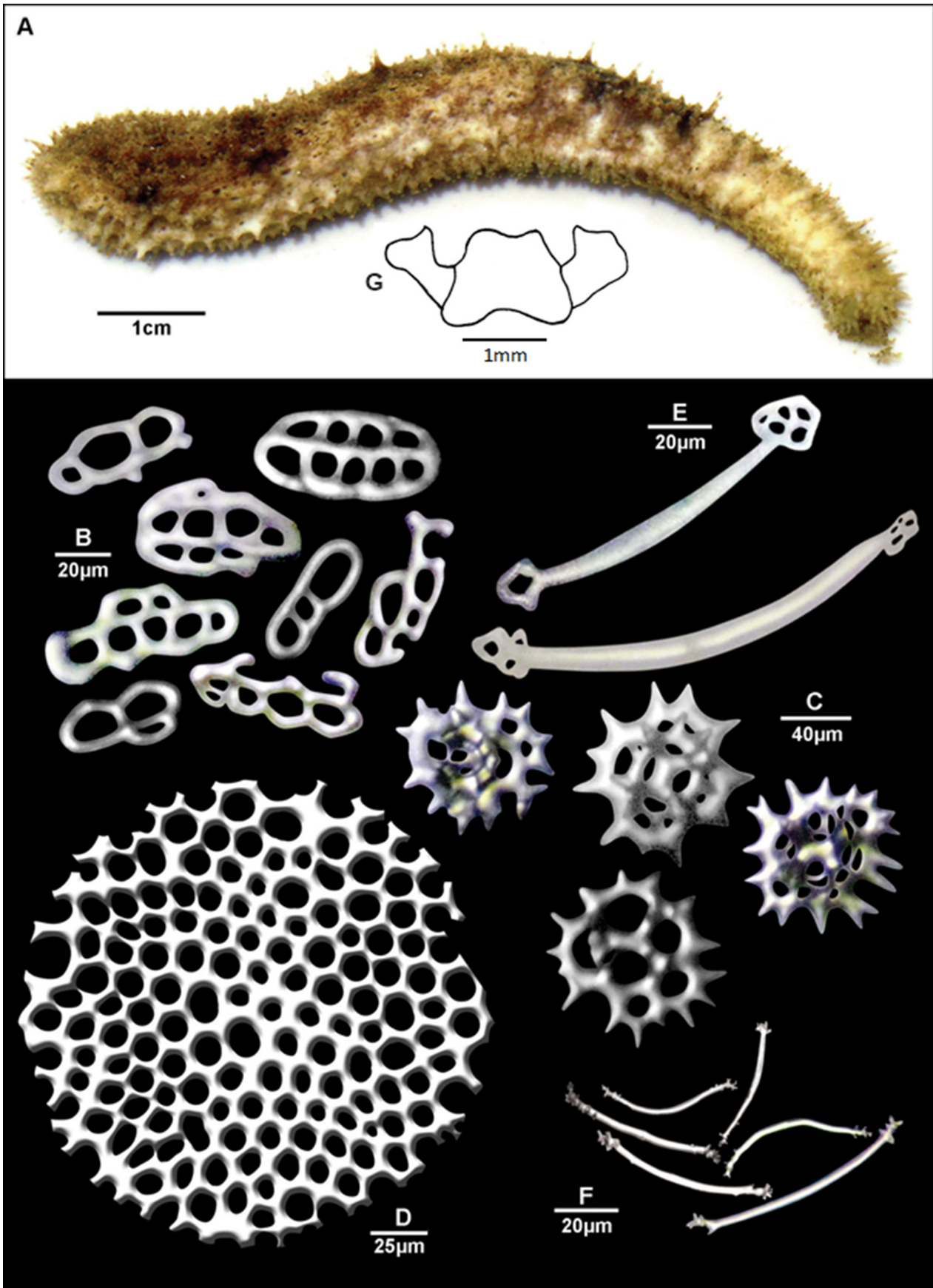


FIGURE 3. *Holothuria (Lessonothuria) pardalis* Selenka, 1867. A. Dorsal view; B. Pseudo-buttons from body wall; C. Tables from body wall; D. End-plate; E. Podial rods; F. Rods of tentacles; G. Part of calcareous ring (single dorsal radial and adjoining interradial plates).

twisted, rarely reduced to a single series of holes on one side. Podial deposits, 55–242 μm , include usually elongate, curved rods with 1–5 perforations at each end, rarely reduced to short rods with more perforations; elongated plates present in association with the end-plate but with an undulating margin and a double series of holes; end-plates present, 160–282 μm . Tentacle deposits, 33–78 μm , include only simple, slightly curved, non-perforate rods, with an uneven margin. Polian vesicle and stone canal single, the latter short, slightly curved with a globular madreporite larger than stone canal. Cuvierian tubules absent.

Both *H. pardalis* and *H. insignis* from Pakistan are compared in the Table 2 below.

TABLE 2. Comparison between *Holothuria insignis* and *Holothuria pardalis* collected from the coast of Karachi, Pakistan.

<i>Holothuria insignis</i>	<i>Holothuria pardalis</i>
Habitat: attached to rock, covered with sand.	Habitat: in crevice between boulders, no sand.
Colouration: live specimen dark brown dorsally with the ventral surface light brown to creamy-white with brown blotches.	Colouration: live specimens dark brown dorsally, with two rows of large dark brown spots; ventrally light yellowish with dark brown bands.
Ossicles:	Ossicles:
body wall tables with reduced, rounded or squarish disc with none or few marginal holes or marginal holes absent; spire reduced, hardly visible, with or without teeth; pseudo-buttons mostly incomplete, often twisted or with holes developed only on one side, rarely complete, sometimes slightly knobbed.	body wall tables with rounded disc with four distinct central and a several small marginal holes; spire of moderate height with about eight teeth; pseudo-buttons mostly complete, only few incomplete, always smooth.
ventral podia with curved rods perforated by 1–7 holes at each end plus elongated plates surrounding end plate with two series of holes and an undulating margin, rarely margin serrated.	ventral podia with curved rods with 1–5 perforations at each end, elongated plates with a double series of holes and a smooth undulating margin, never serrate
tentacle rods perforated at one end and branched at the other.	tentacle rods branched at ends, holes absent.

Holothuria (Lessonothuria) lineata Ludwig, 1875

Figure 4

Holothuria lineatea Ludwig, 1875: 77–120, pls. 6–7.

Holothuria (Lessonothuria) lineata Rowe (in Rowe & Gates, 1995): 291; ?*Holothuria (Lessonothuria) lineata* Thandar, 2008: 53, fig. 20; Samyn, Massin & VandenSpiegel, 2019: 81–91, figs. 1–4.

?*Holothuria (Lessonothuria) insignis* Thandar 2007:16, text-fig. 6) (= *H. (L.) lineata*).

Material examined. Buleji, Karachi, Buleji (24° 50' 20.41" N, 66° 49' 24.15" E), Holo. 23, 23 May 2017, 1 spec.

Habitat. The specimen was found under a rock on sand in the intertidal zone, attached to some algae and seaweeds and covered with fine sand.

Description. Length about 85 mm. Body cylindrical, dorsal surface arched. Colouration of live specimen dark chocolate brown dorsally (Figure 4A) with ventral surface light brown with white blotches and dark streaks (Figure 4B). Tube feet creamy white. Dorsal body wall rough, thin. Mouth and anus terminal; anus encircled by 16 papillae. Tentacles 19, creamy white in colour. Calcareous ring well developed (4C), radial plates larger than interradial plates, almost rhomboidal, interradial plates typical, triangular with a posterior notch. Polian vesicle and stone canal damaged. Cuvierian tubules absent. Ossicles of body wall comprise tables and pseudo-buttons. Dorsal and ventral body wall tables, 33–62 μm , with usually complete, strongly spinose disc with four central and 10–12 marginal holes (4D), some discs smooth. Pseudo-buttons, 30–54 μm , usually complete with 2–5 pairs of holes but often incomplete, especially ventrally, with holes developed only on one side, rarely twisted (4E) but not knobbed. Tube feet with curved, elongated rods, 68–228 μm , with several terminal holes (up to 10) and characteristic, multilocular plates, 110–232 μm , with serrated, jagged or spiny margins and 2–3 series of holes (4G), always accompanying reduced end-plates (4I & F). Tentacle rods, 62–148 μm , slightly curved, perforated or digitated at ends (4H).

Remarks. *Holothuria (Lessonothuria) lineata* (Ludwig, 1875) was not reported from the Pakistan coast before and hence it is new to the holothuroid fauna of Pakistan. The specimen is to some extent similar to those described

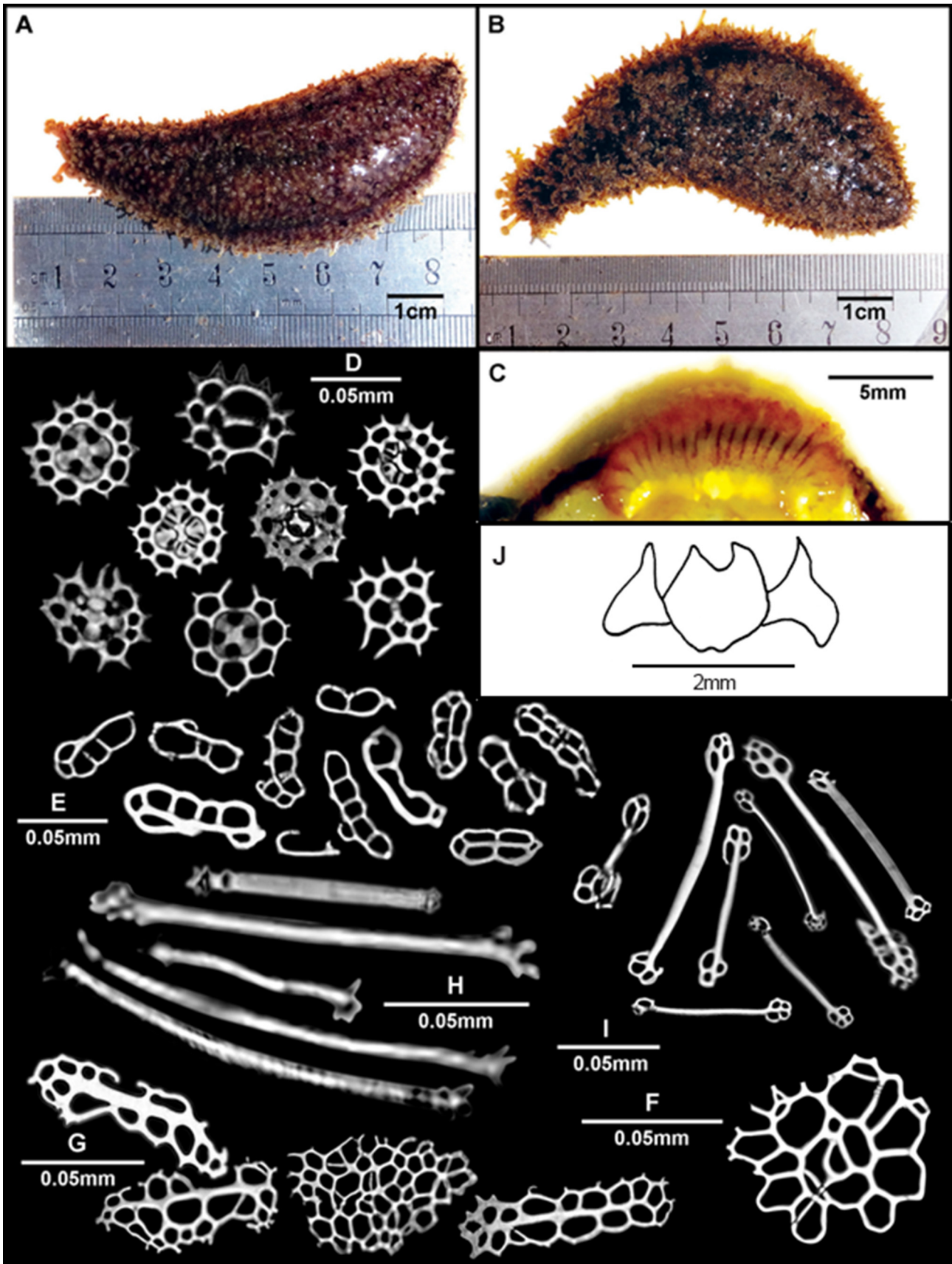


FIGURE 4. *Holothuria (Lessonothuria) lineata* Ludwig, 1875. Holo. 23. A. Ventral view; B. Dorsal view; C. Calcareous ring with tentacles; D. Tables of dorsal body wall; E. Buttons from body wall; F. End-plate from anal papillae; G. Plate from podium; H. Tentacle rods; I. Perforated rods from podia; J. Part of calcareous ring (single dorsal radial and adjoining interradiial plates).

as *H. (L.) insignis* by (Thandar, 2007), who later (Thandar 2008), after studying a juvenile of the species, referred all his materials to *H. (L.) lineata*. This action, as stated above needs to be re-visited. Rowe (in Rowe & Gates 1995) considered *H. lineata* a valid species, although it was relegated to the synonymy of *H. pardalis* by numerous workers. A re-description of the species, based on type material and a specimen taken from Glorioso Islands, Mozambique, was recently published in some detail by Samyn *et al.* (2019) who also provide an abbreviated key to separate four related species. However, we here present a key to separate all 11 currently recognized species in the *Lessonothuria* group by WoRMS (accessed 10 October 2019), but all may not necessarily belong to this subgenus as some do not appear to be consubgenera as they are based on a single specimen with a couple having a bizarre combination of characters.

Key to the species currently included in the *Lessonothuria* subgenus

1. Tentacles 20 4
- Tentacles more than 20 2
2. Tentacles 30; body wall ossicles as in *H. pardalis*, *pseudo-buttons* with three pairs of holes, rarely twisted or reduced to a single series holes on one side; single Polian vesicle, multiple stone canals *H. (L.) immobilis* Semper, 1868.
- Tentacles 25–30; body wall ossicles as tables and buttons, Polian vesicle and stone canal usually single, well developed. . . . 3
3. Tentacles 25, Polian vesicle and stone canal usually single; buttons huge with large holes; tables with smooth to spiny disc; spire sometimes with several cross-bars *H. (L.) duoturricola* Cherbonnier, 1988.
- Tentacles 25–30, multiple Polian vesicles and stone canals; tables and buttons well developed, hardly ever reduced. *H. (L.) verrucosa* Selenka, 1867.
4. Body wall tables apparently flat, rim smooth; some discs multilocular with more than one series of marginal holes, some tables modified to fenestrated spheres and buttons to fenestrated ellipsoids *H. (L.) cumulus* Clark, 1921.
- Body wall tables and buttons never modified into fenestrated bodies, although a few tables may possess a multilocular disc and a spire made up of several cross-bars 5
5. Buttons mostly complete with two series of holes, not reduced to a single series on one side; tables with multilocular, smooth to spinose, mostly rounded disc; spire often with several cross-bars; plates around end plates serrated *H. (L.) multipilala* Liao, 1975.
- Buttons complete or incomplete, holes sometimes reduced to a single series on one side; table disc with 4–8 holes, rim usually spinose, of variable form; some table spires with 1–2 cross bars, or cross bars absent; plates around ventral end plates smooth, serrated or absent 6
6. Tube feet without suckers, end plates small, no plates surrounding end plates; tables mostly complete with buttons as in *H. pardalis* but large, up to 100 µm, and with more holes; table disc multilocular, often with more than one series of holes, disc sometimes knobbed or spinose. *H. (L.) cavans* Massin & Tomascik, 1996.
- Tube feet always with suckers, end plates well developed, nearly always encircled by other often bilaterally symmetrical plates; buttons rarely up to 100 µm and never with more than 3 pairs of holes; table discs never with more than one series of marginal holes 7
7. Body wall tables of several forms with smooth, undulating rim and low spire with a single cross-bar or rims spinose without a spire or a spire with one or more cross-bars; buttons often complete but twisted or irregularly formed or of bizarre shape *Holothuria glandifera* Cherbonnier, 1955.
- Body wall tables always with a spinose margin, spire low or absent, rarely a few tables with multiple cross-bars, buttons regular or incomplete with one or two series of holes 8
8. Body covered with distinct tubercles, tables with circular, slightly spinose disc; plates of tube feet irregular, with 1–3 series of holes, never bilaterally symmetrical. *Holothuria (L.) tuberculata* Thandar, 2007.
- Body smooth or rough to the touch, tubercles absent; table disc distinctly spinose; plates surrounding end-plates of tube feet nearly always bilaterally symmetrical with 2 series of holes. 9
9. Table disc circular, spire low or moderate, ending in about eight teeth, spire rarely absent; buttons accumulated into heaps, complete and incomplete ones in a 50:50 ratio and with three pairs of holes, rarely twisted or reduced to a single series holes on one side; plates surrounding end plates of tube feet with a paired series of holes and usually an undulating margin *Holothuria (L.) pardalis* Selenka, 1867.
- Tables with low or reduced spire or spire absent; disc distinctly spinose; ventral buttons mostly reduced, often twisted; dorsal ones complete and incomplete; plates surrounding tube feet end plates either regular with undulating margin or irregular with serrated/spiny/irregular margin. 10
10. Tables with reduced disc, often with only four central holes; spire low or absent, teeth irregular, never consistently eight; buttons mostly incomplete, often twisted, and frequently developed as a single series of three holes; plates associated with end-plates bilaterally symmetrical with a series of paired holes and an undulating, rarely serrated rim *Holothuria (L.) insignis* Ludwig, 1875.
- Tables small, disc slightly spinose, pierced by only four holes or also a few small marginal holes; dorsal buttons usually complete, ventral often reduced but not twisted; plates associated with end plates always with serrated/spiny/irregular margin. . . . *Holothuria (L.) lineata* Ludwig, 1875.

Acknowledgment

Financial support from the Higher Education Commission (HEC) of Pakistan is gratefully acknowledged. We also acknowledge the assistance of Mr. Abrar Ali, photo-artist, and the field staff of the Marine Reference Collection & Resources Centre, Karachi, Pakistan. AST is indebted to the NHMUK for working space and access to materials, to Dr. Yves Samyn of the Belgium Institute of Natural Sciences for loan of slides of some type materials, and the University of KwaZulu-Natal for supporting this study.

References

- Afkhami, M., Ehsanpour, M. & Nasrolahi, A. (2015) Two sea cucumber species (*Holothuria bacilli* and *H. insignis*), first record from the Persian Gulf. *Marine Biodiversity Records*, 8, 1–5.
<https://doi.org/10.1017/S1755267215000718>.
- Ahmed, Q. & Ali, Q. A. (2020) Holothurians from Pakistan: New additions of *Holothuria (Theelothuria) notabilis* Ludwig, 1875 and *Actinocucumis typica* Ludwig, 1875] from the Karachi coast, northern Arabian Sea. *SPC Beche-de-mer Bulletin* 40, 40–42.
- Ahmed, Q., Ali, Q.M. & Conand, C. (2016) New additions to the holothurian fauna of Pakistan: *Holothuria verrucosa*, *Holothuria cinerascens* and *Ohshimella ehrenbergii*. *SPC Beche-de-mer Information Bulletin*, 36, 20–23.
- Cherbonnier, G. (1955) Holothurians récoltées en Océanie Française par G. Ranson en 1952. *Bulletin du Muséum National d'Histoire Naturelle Paris*, 27, 319–323.
- Cherbonnier, G. (1988) Echinodermes, Holothurides. Faune de Madagascar. In: *Publié les auspices du Gouvernement de la République Malgache. Vol. 70*. ORSTOM, Paris, pp. 1–292.
- Clark, A.M. & Rowe, F.W.E. (1971) *Monograph of shallow-water Indo-West Pacific echinoderms*. British Museum (Natural History), London, 238 pp.
- Clark, H.L. (1921) The echinoderm fauna of Torres Strait: its composition and its origin. *Papers of the Department of Marine Biology of Carnegie Institution of Washington*, 10, 1–233.
<https://doi.org/10.5962/bhl.title.14613>
- Clark, H.L. (1946) The Echinoderm fauna of Australia: its composition and its origin. *Carnegie Institution of Washington*, 566, 1–567.
- Deichmann, E. (1958) The Holothuroidea collected by the ‘Velero III’ and ‘IV’ during the years 1932–1954, part II, Aspidochirota. *Allan Hancock Pacific Expedition*, 11 (2), 239–349, pls. 1–9.
- Ducarme, F. (2016) Field observations of sea cucumbers in Ari Atoll, and comparison with two nearby atolls in Maldives. *SPC Beche-de-mer Information Bulletin*, 36, 9–14.
- Heding, S.G. (1934) On some holothurians from Hong Kong. *Hong Kong Naturalist*, Supplement 3, 15–25, 5 figs., pl. 9.
- Lampert, K. (1896) Die von Dr. Stuhlmann in den Jahren 1888–1889 an der Ostküste Afrikas gessammelten Holothurien. *Mitteilungen aus dem Zoologischen Staatinstitut und Zoologischen Museum, Hamburg*, 13, 49–71, 3 figs.
- Liao, Y. (1975) The echinoderms of Xisha Islands, Guangdong Province, China, I. Holothuroidea. *Studia Marina Sinica*, 10, 199–228.
- Ludwig, H. (1875) Beiträge zur Kenntniss der Holothurien. *Arbeite aus dem zoologie zootom, Institut in Würzburg*, 2, 77–220.
- Massin, C. & Tomascik, T. (1996) Two new holothurians from Kakaban Island. *Raffles Bulletin of Zoology*, 44 (1), 160–165.
- Miller, A.K., Kerr, A.M., Paulay, G., Reich, M., Wilson, N.G., Carvajal, J.I. & Rouse, G.W. (2017) Molecular phylogeny of extant Holothuroidea (Echinodermata). *Molecular Phylogenetics and Evolution*, 111, 110–131.
<https://doi.org/10.1016/j.ympev.2017.02.014>.
- Moazzam, M.K. & Moazzam, N. (2020) Annotated checklist of sea cucumbers from Pakistan with new records of *Holothuria (Theelothuria) hamata* Pearson, 1903 and *Stichopus hermanni* Semper, 1868. *SPC Beche-de-mer Information Bulletin* 40, 32–39.
- Panning, A. (1929–1935) Die Gattung *Holothuria*. *Mitteilungen aus dem Zoologischen Staatinstitut und Zoologischen Museum, Hamburg*, 44 (I [1929]), 45 (II [1934]) & 46 (1935), 91–138, 24–50 + 65–85 + 85–107 & 1–18.
- Rowe, F.W.E. & Gates, J. (1995) Echinodermata. In: Wells, A. (Ed.), *Zoological Catalogue of Australia*, 33. CSIRO Australia, Melbourne, pp. i–xiii + 1–510.
- Samyn, Y., VandenSpiegel, D. & Massin, C. (2006) A new Indo-West Pacific species of *Actinopyga* (Holothuroidea: Aspidochirota: Holothuriidae). *Zootaxa*, 1138 (1), 53–68.
<https://doi.org/10.11646/zootaxa.1138.1.3>.
- Samyn, Y., Massin, C. & Vandenspiegel, D. (2019) The sea cucumber *Holothuria lineata* Ludwig, 1875 (Holothuroidea, Aspidochirota, Holothuriidae) re-described from the newly found type. *ZooKeys*, 836, 81–91.
<https://doi.org/10.3897/zookeys.836.29932>.
- Samyn, Y. (2003) Shallow-water Holothuroidea (Echinodermata) from Kenya and Pemba Island (Tanzania). *Studies in Afro-tropical Zoology*, 292, 1–158.
- Samyn, Y., VandenSpiegel, D. & Massin, C. (2006) Taxonomie des Holothurians des Comores. *Abc Taxa*, 1, 1–130.

- Selenka, E. (1867) Nachtrag zu den Beiträgen zur Anatomie und Systematik der Holothurien. *Zeitschrift für wissenschaftliche Zoologie*, 18, 109–118.
- Semper, C. (1868) *Holothurien, Reisen im Archipel der Philippinen, Holothurien, 2*. Wissenschaftliche Resultate, Wiesbaden, Leipzig, 288 pp.
<https://doi.org/10.5962/bhl.title.11687>.
- Sluiter, C.P. (1890) Nachtrachliches über die Echinodermen-fauna des Java-Meeres. *Natuurkundig Tijdschrift Nederlande-Indië*, 49, 105–110.
- Tahera, Q. & Tirmizi, N.M. (1995) A new record of *Holothuria (Thymiosycia) arenicola* Semper, 1868 (Echinodermata: Holothuroidea) from Pakistan. *The Raffles Bulletin of Zoology*, 43 (1), 217–220.
- Tahera, Q. & Kazmi, Q.B. (2005) *Marine fauna of Pakistan. Series IV*. Marine Reference and Resource Centre, University of Karachi, Karachi, 21 pp.
- Tahera, Q. (1992) *Taxonomic studies of Northern Arabian Sea echinoderms*. Unpublished M. Phil. thesis, Institute of Marine Sciences, University of Karachi, Karachi, 192 pp.
- Tahera, Q. (1997) Note on *Synaptula recta* Semper, 1868 (Echinodermata, Holothuroidea, Synaptidae) new to Pakistan waters. *Pakistan Journal of Zoology*, 29 (1), 92–94.
- Tahera, Q. & Kazmi, Q.B. (1995) First record of *Holothuria (Platyperona) difficilis* Semper, 1868 (Echinodermata: Holothuroidea) from the northern Arabian Sea (Pakistan). *Pakistan Journal of Marine Sciences*, 4 (1), 71–73.
- Thandar, A.S. (2007) Additions to the aspidochirotid, molpadid and apodid holothuroids (Echinodermata: Holothuroidea) from the east coast of southern Africa, with descriptions of new species. *Zootaxa*, 1414 (1), 1–62.
<https://doi.org/10.11646/zootaxa.1414.1.1>.
- Thandar, A.S. (2008) Additions to the holothuroid fauna of the southern African temperate faunistic provinces, with descriptions of new species. *Zootaxa*, 1697 (1), 1–57.
<https://doi.org/10.11646/zootaxa.1697.1.1>.
- Thandar, A.S. (2017) Two new subfamilies, three new species of dendrochirotid sea cucumbers (Echinodermata: Holothuroidea). *Zootaxa*, 4365 (4), 410–420.
<https://doi.org/10.11646/zootaxa.4365.4.2>
- World Register of Marine Species (2019) WoRMS. VLIZ. Available from: <https://www.marinespecies.org> (accessed 10 October 2019)