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Brittle stars of Ophiodermatidae and Ophiolepididae (Echinodermata: Ophiuroidea: Ophiurida: Ophiurina) collected from the Singapore Strait

Toshihiko Fujita

Abstract. Brittlestars were collected from the intertidal seashore by hand, and from the subtidal seabed using dredges and trawls as well as by scuba diving around St. John's Island in the Singapore Strait, during the Workshop from 20 May to 7 June 2013. Five species in two ophiurine families of brittlestars Ophiodermatidae and Ophiolepididae were identified from the Strait of Singapore. The Ophiodermatidae comprised *Ophiarachnella gorgonia*, *Ophioconis permixta*, and *Ophiodyscrita instrata*. The latter two ophiodermatid species were new records for Singapore. The Ophiolepididae identified were *Ophiolepis cincta cincta* and *Ophiolepis nodosa*. Members of the two families appear to be confined to the Singapore Strait and were not found in the Johor Straits.

INTRODUCTION

The Singapore Strait Marine Biodiversity Workshop was conducted by the National University of Singapore and National Parks Board in 2013 in the Singapore Strait following the previous workshop in the Johor Straits. This workshop series was held to explore the biodiversity in Singapore waters. From the collection of the first workshop in the Johor Strait, a preliminary list of ophiuroid species was reported, including 22 species from 6 families, Ophiuridae, Amphiuridae, Ophiotrichidae, Ophiactidae, Ophionereididae, and Ophiocomidae (see Table 1 in Fujita & Irimura, 2015). The identification of the ophiuroid specimens is now in progress, but the new collection from the Singapore Strait includes two families which were not recognised from the Johor Straits in the in the first workshop. They are Ophiodermatidae and Ophiolepididae in the suborder Ophiurina, and the identification results and taxonomic comments of these two families are presented in this study.

Four species of Ophiodermatidae and Ophiolepididae were listed from Singapore waters in the recent species list of marine organisms by Wee & Ng (1994): *Ophiarachnella gorgonia* (Ophiodermatidae); *Ophiolepis cincta cincta*, *O. nodosa*, and *O. superba* (Ophiolepididae). Additionally, *O. cincta cincta* was also reported by Lim & Chou (1988) and Lane & VandenSpiegel (2004). However, these studies listed species names without any taxonomic information. In this study, the workshop team collected three species, namely *O. gorgonia*, *O. cincta cincta*, and *O. nodosa*, and two more ophiodermatid species. A list of synonyms, photographs, and taxonomic comments for each species collected is provided.

National Museum of Nature and Science, Japan; Email: fujita@kahaku.go.jp

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MATERIAL AND METHODS

Specimens of ophiodermatid and ophiolepidid ophiuroids were collected using dredges and trawls deployed from the National University of Singapore research vessel, RV Galaxea from the Singapore Strait, by hand picking from intertidal waters and by scuba diving in subtidal waters around St. John's Island (Pulau Sakijang Bendera) in the Singapore Strait, during the Workshop from 20 May to 7 June 2013 (Table 1). Collected specimens were relaxed in magnesium chloride solution, photographed, and preserved in 95% ethanol. The specimens were deposited at the Zoological Reference Collection, Lee Kong Chian Natural History Museum, National University of Singapore and the National Museum of Nature and Science, Tsukuba-shi, Japan.

Systematics and current valid species names follow the World Ophiuroidea Database (Stöhr et al, 2014).

TAXONOMY

Order Ophiurida

Suborder Ophiurina

Family Ophiodermatidae Ljungman, 1867

Ophiarachnella gorgonia (Müller & Troschel, 1842)

(Fig. 1A, B)

Ophiarachna gorgonia Müller & Troschel, 1842: 105. Lyman, 1865: 39.

Pectinura gorgonia – Lütken, 1869: 33; Martens, 1870: 245; Lyman, 1882: 15; Bell, 1884: 134; Brock, 1888: 471–472; Dödelein, 1888: 830; de Loriol, 1893b: 397; Koehler, 1898: 59, pl. 2 figs. 1, 2; Koehler, 1900: pl. 15 figs. 1, 2; Pfeffer, 1900: 83; Koehler, 1905: 8–9; Koehler, 1907a: 284–285; Koehler, 1907b: 243; H. L. Clark, 1908: 289; M'Intosh, 1911: 157–158.

Ophiarachnella gorgonia – H. L. Clark, 1909: 123–124; H. L. Clark, 1911: 25; H. L. Clark, 1915: 305; Matsumoto, 1917: 323–324; H. L. Clark, 1921: 141, pl. 12 fig. 5, pl. 35 figs. 4, 5; Koehler, 1922: 339–340; H. L. Clark, 1928: 443–444; Koehler, 1931: 273; H. L. Clark, 1938: 346, pl. 15 fig. 1; Murakami, 1942: 33; Murakami, 1943a: 187 fig. 9; Murakami, 1943b: 214; Murakami, 1944: 272; H. L. Clark, 1946: 260–261; Murakami, 1963: 180; Chang et al., 1964: 124; A. M. Clark, 1965: 66; Domantay & Domantay, 1966: 60–61; Domantay & Conlu, 1968: 166–167; Irimura, 1969: 45; A. M. Clark & Rowe, 1971: 88–89, 125, pl. 20 fig. 2; Kikuchi, 1977: 128, 134; Gibbs et al., 1976: 129; Cherbonnier & Guille, 1978: 217–218, pl. 15 figs. 5, 6; Liao, 1978: 93; Irimura, 1979: 5; Rho, 1979: 36–37; Sloan et al., 1979: 111; A. M. Clark, 1980: 535; Irimura, 1981: 43–44; A. M. Clark, 1982: 488; Irimura, 1982: 66–67, fig.39, pl.13 fig. 6; Saba et al., 1982: 29–30, pl.18 fig.4; Guille & Vadon, 1985: 64; Guille et al., 1986: 192–193, pl.; Rho & Shin, 1987: 216; Yi & Irimura, 1987: 130; Chao et al., 1991: 123–124, fig. 2G, H; Marsh et al., 1993: 62; Nomura, 1993: 25; Liao & A. M. Clark, 1995: 281–282, fig. 156; Rowe & Gates, 1995: 396; Shin & Rho, 1996: 448, pl. 92; Jeng, 1998: 143, fig. 22; Rowe & Richmond, 2004: 3294.
Ophiarachnella marmorata Lyman, 1874: 222–223, pl. 5 figs. 1–7; Lyman, 1882: 17; H. L. Clark, 1915: 305.
Pectinura megaloplax Bell, 1884: 134–135.
Pectinura intermedia Bell, 1888: 386.
Pectinura stearnsii Ives, 1891: 21–213, pl. 11 figs. 1–5.
Pectinura venusta de Loriol, 1893a: 16–19, pl. 23 fig. 3a–h.
Ophiarachnella rugosa H. L. Clark, 1938: 352–354, figs. 32–34.

Type specimen. Unknown. Probably in Muséum national d'Histoire naturelle, Paris (Rowe & Gates, 1995).

Type locality. Unknown (A. M. Clark & Rowe, 1971: 125).

Material examined. 12 specimens (disc diameter 8.2–14.8 mm); St. IT86, IT93; intertidal.

Distribution. Widely distributed in tropical Indian Ocean and west and central Pacific Ocean (see A. M. Clark & Rowe, 1971; Rowe & Gates, 1995).

Remarks. Liao & A. M. Clark (1995) reported that Japanese specimens are not conspecific with Chinese specimens. They suggested Japanese specimens are *O. sternsii* described from Japan (Ives, 1891) although H. L. Clark (1909) synonymized this species with *O. gorgonia*. Irimura & Fujita (unpublished data; see also Irimura & Fujita, 2010) suggested that Japanese specimens are different species from *O. gorgonia* with completely different coloration, but the taxonomic decision requires further studies.

Ophioconis permixta Koehler, 1905
(Fig. 1C, D)

Ophioconis permixta Koehler 1905: 14–15, pl. 2 figs. 4, 7; H. L. Clark, 1915: 219; A. M. Clark, 1965: 63–64; A. M. Clark & Rowe, 1971: 88–89, 127; Cherbonnier & Guille, 1978: 223–224, pl. 16 figs. 5, 6 ; Sloan et al., 1979: 115.
Ophiurodon permixta – Matsumoto, 1915: 84; Matsumoto, 1917: 315.
Ophiurodon permixtus – Koehler, 1922: 352.
Ophiurodon permixtum – Koehler, 1931: 278.

Type specimen. Unknown.

Type locality. Sunda Archipelago (Koehler, 1905).

Material examined. 2 specimens (disc diameter 2.4–2.9 mm); St. SB41; 5 m deep; coral rubbles, rock.

Distribution. East Africa and Madagascar (A. M. Clark, 1965; Cherbonnier & Guille, 1978; Sloan et al., 1979). Philippines: Cebu (45 m deep) (Koehler, 1922). Indonesia: Sunda Archipelago (35–90 m deep) (Koehler, 1905, 1931). Singapore (5 m deep) (this study).

Remarks. A. M. Clark (1965) showed this species belongs to *Ophioconis* instead of *Ophiurodon*. She also suggested *Ophioconis cincta* Brock, 1888 was a junior synonym of this species. The Singapore specimens agree with the previous descriptions. They have spinelets both at disc margin and on dorsal disc. That distinguishes this species from the other common Indo-west Pacific congeners, *O. cincta* and *O. cupida* Koehler, 1905 (A. M. Clark & Rowe, 1971) though A. M. Clark (1965) suggested the occurrence of disc spinelets is variable.

Ophiodyscrita instrata (Murakami, 1944)
(Fig. 1E, F)

Ophiarachnella infernalis – Matsumoto, 1917: 324–325, fig. 90. *Ophiarachnella infernalis* (Müller & Troschel, 1842) is valid.
Ophiostegastes instratus Murakami, 1944: 273–274, fig. 4; A. M. Clark, 1968: 320.
Ophiocormus instratus – Irimura, 1969: 45.
Ophiodyscrita instratus – Price & Rowe, 1996: 78–79.
Ophiostegastus novaecaledoniae Guille & Vadon, 1985: 67–69, figs. 1, 2, pl. 2 figs. A, B; Guille et al., 1986: 194–195, pl.; Fujita, 1998: 226–228, figs. 3A–H.

Type specimen. Probably lost (unpublished data).

Type locality. Amakusa, Kumamoto Prefecture, Kyushu, Japan (Murakami, 1944).

Material examined. 12 specimens (disc diameter 5.2–10.9 mm); St. DR70, IT82, IT93, DR112, DR125, SB132, SD133; intertidal to 34 m deep; sandy, broken shells, coral rubble, laterite gravel.

Distribution. Japan: Kyushu (about 3–25 m deep) (Murakami, 1944; Fujita, 1998). New Caledonia: Nouméa (18–25 m deep) (Guille & Vadon, 1985; Guille et al., 1986). Singapore (0–34 m deep) (this study). Sri Lanka: Galle (10–15 m deep) (Price & Rowe, 1996)

Remarks. This species was originally described as *Ophiostegastes instratus* from Japan (Murakami, 1944). In Fell's (1960) key to species, *Ophiostegastes* was synonymized with *Ophiocormus* confirming that both genera have two tentacle scales, and these genera were distinguished from *Ophiodyscrita* with a single tentacle scale. Accordingly Irimura (1969) transferred this species to *Ophiocormus*. But actually, the type species *Ophiodyscrita acosmeta* H. L. Clark,

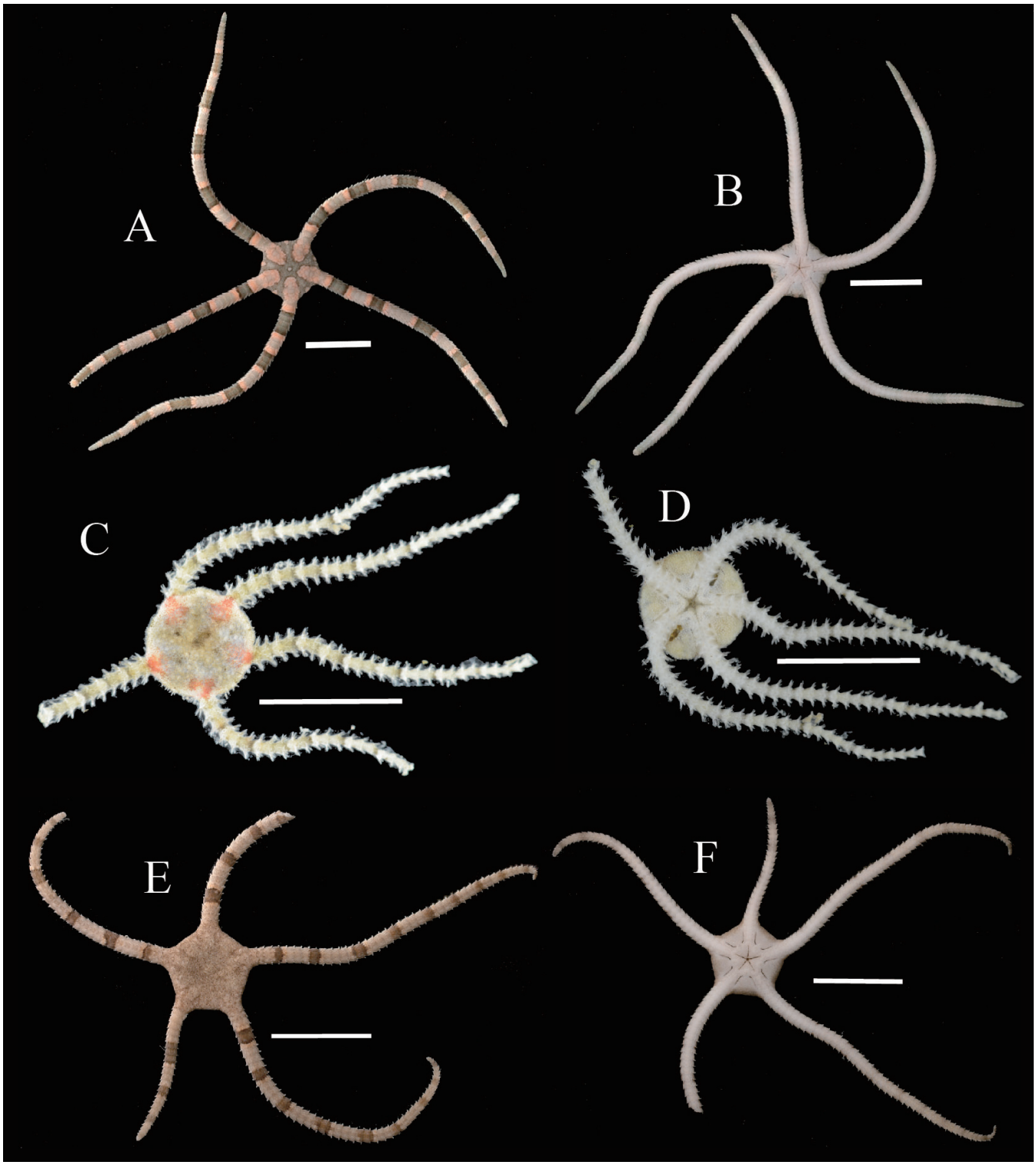

Fig. 1. Ophiodermatidae. A, B, *Ophiarachnella gorgonia*. C, D, *Ophioconis permixta*. E, F, *Ophiodyscrita instrata*. A, C, E, dorsal surface, B, D, F, ventral surface. Scale bars = 1 cm (A, B, E, F), 5 mm (C, D).

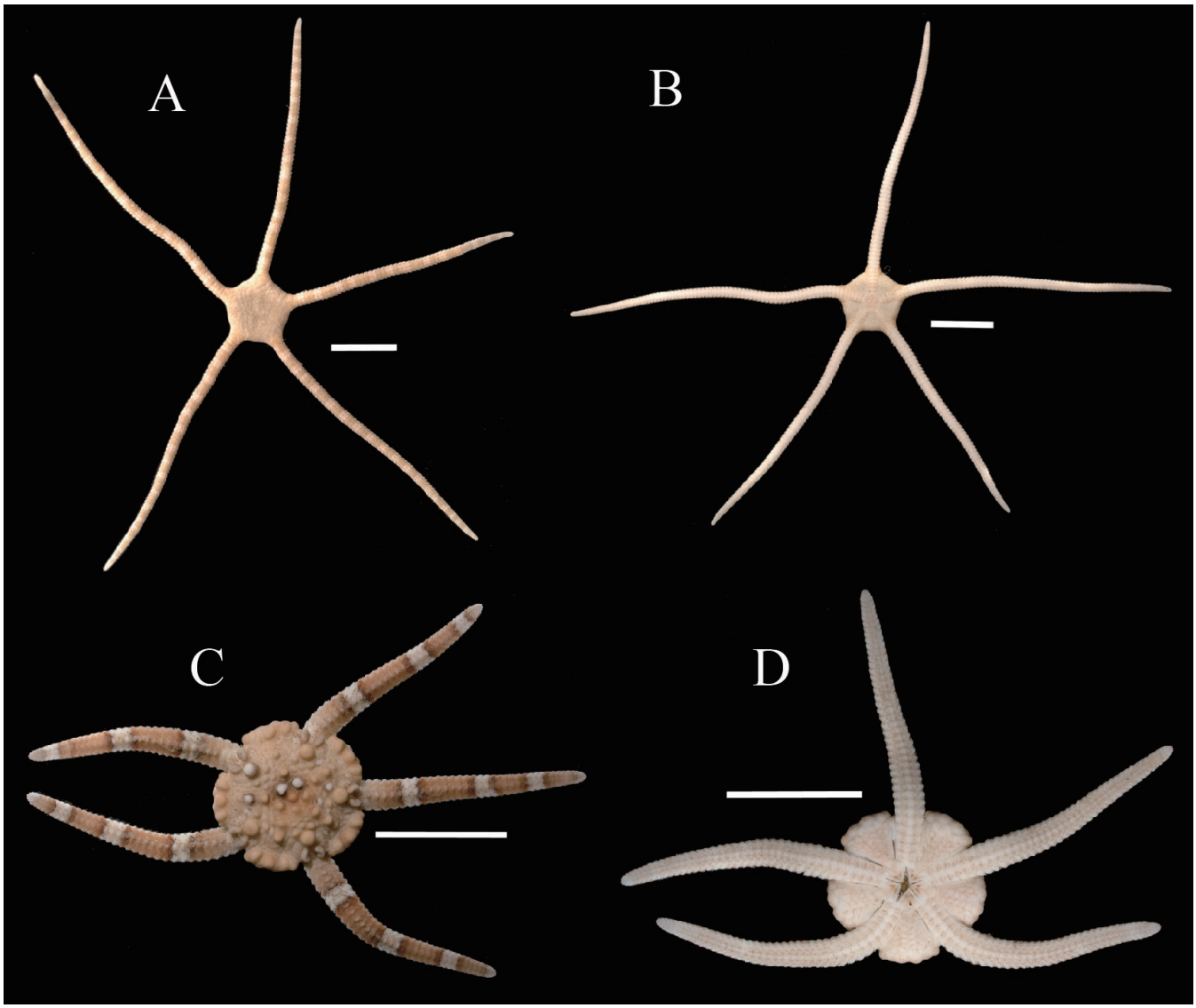

Fig. 2. Ophiolepididae. A, B, *Ophiolepis cincta cincta*. C, D, *Ophiolepis nodosa*. A, C, dorsal surface, B, D, ventral surface. Scale bars = 1 cm.

1938 has also 2 (or 3) tentacle scales (H. L. Clark, 1938; A. M. Clark & Rowe, 1971). Price & Rowe (1996) considered *Ophiostegastes* is a junior synonym of *Ophiodyscrita* and transferred this species to *Ophiodyscrita*.

Two species of *Ophiodyscrita* are distinguished by disc granulation. Disc granulation of the Singapore specimens of *Ophiodyscrita instrata* was variable as like Price & Rowe (1996) suggested. The dorsal disc was completely covered by granules or radial shields and some other plates were naked or partly naked. On the ventral disc, adoral plates and supplementary oral shields were naked or partly naked. However, oral shields were never concealed for the Singapore specimens. On the other hand, *O. acosmeta* has granulation almost completely covering the whole disc only except part of oral shields sometimes (Price & Rowe, 1996). The Singapore specimens has supplementary oral shields and *O. acosmeta* has probably no supplementary oral shield (Price & Rowe, 1996).

Family Ophiolepididae Ljungman, 1867

***Ophiolepis cincta cincta* Müller & Troschel, 1842**
(Fig. 2A, B)

Ophiolepis cincta Müller & Troschel, 1842: 90; Lütken, 1859: 101, pl. 2 figs. 6a, b; Lyman, 1865: 60; Lyman, 1882: 19, pl. 37 figs. 7–9; Brock, 1888: 475; Bell, 1888: 388; Koehler, 1898: 67; de Loriol, 1893b: 398; Koehler, 1905: 16–17; H. L. Clark, 1946: 273; A. M. Clark & Rowe, 1971; 90–91, 129, fig. 46c, pl. 22 fig. 2; Marsh et al., 1993: 62; Rowe & Gates, 1995: 432.
Ophioelegans cincta – James, 1981: 15–17, pl. 1A; James, 1989: 112.
Ophiolepis garretti Lyman, 1862: 72–78; Lyman, 1865: 61–62, pl. 2 fig. 4.

Type specimen. Unknown. Probably MCZ (Rowe & Gates, 1995).

Type locality. Red Sea (Rowe & Gates, 1995).

Table 1. Sampling sites.

Station	Date	Time	Locality	Coordinates	Water Depth	Sampling Method	Habitat
SB41	23 May 2013	1133	west of Semakau Island	1°12.389'N, 103°45.24'E	5 m	coral brushing (scuba diving)	coral rubbles, rock
DR70	25 May 2013	1046–1056	near Sudong Island and Semakau Island	1°13.134'N, 103°44.283'E	20.6–22.6 m	rectangular dredge	sandy
IT82	26 May 2013	0330–0730	Beting Bemban Besar	1°12.149'N, 103°44.989'E	intertidal	hand collection	Reef flat
IT86	27 May 2013	0430–0830	Cyrene Reef	1°15.374'N, 103°44.816'E	intertidal	hand collection	Reef flat
IT93	28 May 2013	0530–0930	Jong Island	1°12.901'N, 103°47.194'E	intertidal	hand collection	Reef flat
IT94	28 May 2013	0530–0930	Cyrene Reef	1°15.374'N, 103°44.816'E	intertidal	hand collection	Reef flat
IT95	28 May 2013	0530–0930	Raffles Light House	1°09.600'N, 103°44.456'E	intertidal	hand collection	Reef flat
IT108	29 May 2013	0600–1000	Raffles Light House	1°09.600'N, 103°44.456'E	intertidal	hand collection	Reef flat
DR112	29 May 2013	1235–1237	Southern Fairway	1°12.024'N, 103°50.170'E	33.6–34.4 m	rectangular dredge	broken shells, coral rubble
IT124	30 May 2013	0700–1100	Terumbu Pempang Laut	1°13.912'N, 103°43.402'E	intertidal	hand collection	Reef flat
DR125	30 May 2013	0935–0940	beside Sister's Island	1°12.416'N, 103°49.858'E	30.8–25.3 m	rectangular dredge	laterite gravel, sandy
SB132	31 May 2013	1053	south of Kusu Island	1°13.260'N, 103°51.683'E	8 m	coral brushing (scuba diving)	Silty
SD133	31 May 2013	1053	south of Kusu Island	1°13.260'N, 103°51.683'E	11 m	hand collection (scuba diving)	Silty

Material examined. 2 specimens (disc diameter 10.2–13.0 mm); St. IT94, IT108; intertidal.

Distribution. Widely distributed in tropical intertidal and subtidal waters in Indian Ocean and west and central Pacific Ocean (see A. M. Clark & Rowe, 1971; Rowe & Gates, 1995).

Remarks. *Ophiolepis garretti* was synonymized by Lyman (1882). However, it is accepted as a valid subspecies of *Ophiolepis cincta* by Stöhr (2014), who suggested this species be represented as *Ophiolepis cincta cincta*, instead of *Ophiolepis cincta*.

Ophiolepis nodosa Duncan, 1887
(Fig. 2C, D)

Ophiolepis nodosa Duncan, 1887: 86–88, pl. 8 figs. 1–3; Bell, 1888: 388; Koehler, 1905: 18; H. L. Clark, 1946: 273–274; A. M. Clark & Rowe, 1971: 90–91, 128; Baker, 1979: 28, fig. 3f; Rowe & Gates, 1995: 432; Pineda-Enriquez et al., 2014: 249.
Ophioteichus nodosa – James, 1981: 15.

Type specimen. Holotype, Indian Museum, Calcutta? (Rowe & Gates, 1995).

Type locality. Elphinstone Island, Mergui Archipelago, Burma (Duncan, 1887).

Material examined. 2 specimens (disc diameter 11.4–14.3 mm); St. IT95, IT124; intertidal.

Distribution. Australia: Great Barrier Reef (0–15 m deep) (H. L. Clark, 1946; Baker, 1979; Rowe & Gates, 1995). Burma: Bay of Bengal (Duncan, 1887). Indonesia: Sulu Archipelago, Ambon (Koehler, 1905). Singapore (intertidal) (this study).

Remarks. The genus *Ophioteichus* was established by H. L. Clark (1938). *Ophiolepis nodosa* was transferred to the genus *Ophioteichus* by James (1981), but Pineda-Enriquez et al. (2014) rejected that in their revision of the genus. *Ophiolepis nodosa* is different from *Ophioteichus* species in having a tubercle on each dorsal arm plate, imbricated dorsal disc scales, unclearly separated tubercles along the interradial margins, and an additional plate proximal to oral shield. Pineda-Enriquez et al. (2014) also suggested *Ophiolepis nodosa* was not included in *Ophiolepis*. The Singapore specimens agreed with the descriptions and figures by Duncan (1887) and Baker (1979). They have characteristic tubercles on the disc and arms.

DISCUSSION

Three species of Ophiodermatidae and two species of Ophiolepididae were collected during the Singapore Strait workshop. Members of the two families were lacking in the collection of the Johor Strait workshop in 2012 (Fujita & Irimura, 2015). The other families are not included in this study, but some species absent in the Johor Straits were collected from the Singapore Strait (unpublished data). This suggests the ophiuroid fauna in the Singapore Strait is more diverse than in the Johor Straits.

Two ophiodermatid species, *Ophioconis permixta* and *Ophiodyscrita instrata*, were new records for Singapore. Both species are probably widely distributed in the Indo-West Pacific region, but they have not been found frequently. In addition to *Ophiarachnella gorgonia* already reported from Singapore by Wee & Ng (1994), only three species are recorded in Singapore waters. In their review, A. M. Clark & Rowe (1971) listed 34 ophiodermatid species from the Indo-West Pacific region, and Lane et al. (2000) listed 23 ophiodermatid species from the South China Sea. More species in the family Ophiodermatidae are expected from Singapore with additional collecting effort.

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