

Ophiuroids (Echinodermata) Collected by the R/V *Mizuho-maru* from the Continental Shelf in the Sea of Japan

Toshihiko Fujita¹, Yoshiaki Ishida² and Yoichi Kogure³

¹ Department of Zoology, National Museum of Nature and Science,
4–1–1 Amakubo, Tsukuba-shi, Ibaraki, 305–0005 Japan
E-mail: fujita@kahaku.go.jp

² 2–20–13 Kamiogi, Suginami-ku, Tokyo, 167–0043 Japan
E-mail: y-ishida@msi.biglobe.ne.jp

³ Japan Sea National Fisheries Research Institute, Fisheries Research Agency,
1–5939–22 Suido-cho, Chuo-ku, Niigata-shi, Niigata, 951–8121 Japan
E-mail: seastar@affrc.go.jp

Abstract: We provide a taxonomic list, with taxonomic notes and photographs, of ophiuroids collected by R/V *Mizuho-maru* from the continental shelf (53–301 m) along the Japanese archipelago in the Sea of Japan. Our survey identified 41 species within 22 genera, including 12 species new to the Sea of Japan.

Key words: brittle stars, Ophiuroidea, taxonomy.

Introduction

The Sea of Japan has a unique geological history and distinct oceanographic characteristics (see Saito *et al.*, 2014), which affect the composition, abundance and distribution pattern of the species which occur there. An extremely cold water mass at depths below the continental shelf break provides the habitat for a benthic fauna composed primarily of the dominant ophiuroid, *Ophiura sarsii sarsii* Lütken, 1855 (Kogure and Nagasawa, 2004). In contrast, the continental shelf is influenced by the Tsushima Warm Current, where a wide variety of warm-water species is expected to be found.

The earliest report of the ophiuroid fauna in the Sea of Japan was that of Duncan (1879), who reported species obtained from the south and east of the Korean Peninsula. H. L. Clark (1911) described several North Pacific species including several from the Sea of Japan. Some of these species, such as *Amphiophiura oediplax* and *Ophiacantha omoplata*, have type localities in the Sea of Japan. Ishida *et al.* (2001: table 3) reported ophiuroid species from their survey of the Sea of Japan and summarized past records, including those of H. L. Clark (1911), Djakonov (1954), Irimura (1979, 1991), Irimura *et al.* (1995), Kogure (1999), Kogure and Hayashi (1998), Shin (1992, 1995), Shin and Koh (1993), Shin and Rho (1996), Ishida *et al.* (2001). Ishida *et al.* (2001) showed that 91 species were recorded in the sea by the beginning of the 21st century. Recent taxonomic works have further studied ophiuroids in the Sea of Japan (Kogure, 2001; Fujita and Kohtsuka, 2003; Fujita *et al.*, 2004; Ishida and Tamura, 2004); however, the areas investigated were localized. Information on the ophiuroid fauna in this region remains poorly understood.

As part of the “Research on Deep-Sea Fauna of the Sea of Japan” project, which was under-

taken by the National Museum of Nature and Science, we assessed ophiuroid biodiversity along the Japanese coast in the Sea of Japan. In the present paper, we present a list of collected species.

Materials and Methods

Sampling stations were located on the continental shelf (53–195 m in the depth) with the exception of one station (St. 04) on the upper slope (301 m in the depth) (Fig. 1). Ophiuroid specimens used in this paper were collected at 29 stations, using either a biological dredge with a 0.5 m or 1 m span width or a beam trawl with a 2 m span width, during two cruises of the R/V *Mizuho-maru* of the Japan Sea National Fisheries Research Institute, Fisheries Research Agency in 2009 and 2010 (Table 1). A Smith-McIntyre grab was used to collect bottom sediment samples. Ophiuroid specimens were fixed in 99% alcohol. Some specimens were dried after fixation for observation. We have determined *ca.* 6063 specimens which are treated in this preliminary paper.

We present a list of collected species with taxonomic remarks, and photographs of fresh specimens before fixation for each species collected in the study. The identified specimens are deposited in the National Museum of Nature and Science (NSMT) in Tsukuba-shi, Japan. In *Material examined*, station number (St.), catalog number, number of specimens, and range of disk diameter (dd) are shown. The station number is followed by “(SM)” when the specimens were collected by Smith-McIntyre grab. The detailed data of the stations are shown in Table 1. Disk diameter was measured with digital calipers only for intact specimens. *Depth range* indicates the depth range covered by the examined specimens in this study. We follow Smith *et al.* (1995) for the classification of ophiuroids.

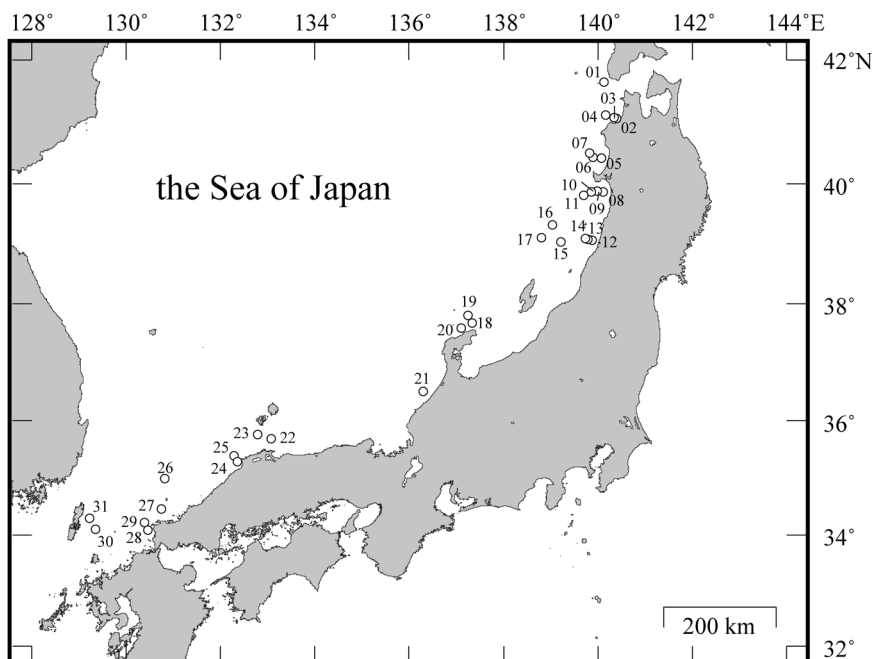


Fig. 1. Sampling stations. Open circles denote the position of sampling stations. Numerals near open circles denote serial station number. See Table 1 for greater detail.

Table 1. Station list. Abbreviations for collecting gears: 1 m, biological dredge of 1 m span; 2 m, beam trawl of 2 m span; 0.5 m, biological dredge of 0.5 m span. *These stations are not included in the material examined in this study.

Serial St. No.	Station Name	Date	Time	Start position	End position	Depth (m)	Bottom temperature (°C)	Bottom salinity (PSU)	Gear
01	MZ10-17	16 Sep. 2010	12:53-12:58	41°22.25'N 139°55.64'E	41°22.22'N 139°55.77'E	124-126	8.06	34.10	1 m
02	MZ10-14	16 Sep. 2010	07:45-08:05	40°49.32'N 140°10.52'E	40°49.58'N 140°10.97'E	53-54	25.97	33.19	2 m
03	MZ10-15	16 Sep. 2010	08:46-09:06	40°50.37'N 140°07.73'E	40°50.60'N 140°08.18'E	98-99	16.96	34.24	2 m
04	MZ10-16	15 Sep. 2010	15:24-15:39	40°52.80'N 139°57.61'E	40°52.69'N 139°57.41'E	301	2.33	33.99	2 m
05	MZ10-11	15 Sep. 2010	07:47-08:04	40°13.06'N 139°51.91'E	40°12.84'N 139°51.48'E	60-62	23.83	33.63	2 m
06	MZ10-12	15 Sep. 2010	09:17-09:32	40°13.69'N 139°41.96'E	40°14.17'N 139°42.00'E	93-94	17.34	34.30	2 m
07	MZ10-13	15 Sep. 2010	10:25-10:45	40°17.48'N 139°38.49'E	40°17.98'N 139°38.11'E	160-169	9.69	34.14	2 m
08	MZ10-07	17 Sep. 2010	12:00-12:20	39°41.67'N 139°54.74'E	39°41.37'N 139°54.76'E	61	25.77	33.55	2 m
09	MZ10-08	17 Sep. 2010	10:38-10:53	39°42.53'N 139°47.57'E	39°42.96'N 139°47.27'E	99	15.69	34.32	2 m
10	MZ10-09	17 Sep. 2010	09:12-09:27	39°41.59'N 139°39.69'E	39°41.40'N 139°39.94'E	192-195	8.71	34.09	2 m
11	MZ10-10	17 Sep. 2010	07:52-07:55	39°38.40'N 139°31.20'E	39°38.43'N 139°31.26'E	152	11.37	34.19	1 m
12*	MZ10-01	19 Sep. 2010	14:21-14:31	38°57.10'N 139°41.10'E	38°56.98'N 139°40.96'E	57-58	22.28	33.86	2 m
13*	MZ10-02	19 Sep. 2010	15:28-15:43	38°57.42'N 139°35.84'E	38°57.19'N 139°35.66'E	98-99	17.96	33.89	2 m
14	MZ10-03	19 Sep. 2010	17:05-17:20	38°58.09'N 139°32.51'E	38°58.35'N 139°32.70'E	182-185	4.34	33.99	2 m
15	MZ10-04	20 Sep. 2010	13:05-13:10	38°55.01'N 139°03.50'E	38°54.96'N 139°03.44'E	160-161	10.04	34.11	0.5 m
16	MZ10-06	20 Sep. 2010	07:53-07:58	39°10.61'N 138°53.47'E	39°10.53'N 138°53.51'E	168-170	5.42	34.05	0.5 m
17	MZ10-05	20 Sep. 2010	10:24-10:29	38°59.04'N 138°39.93'E	38°59.03'N 138°39.88'E	148	5.28	34.02	0.5 m
18	MZ09-14	18 June 2009	15:52-16:12	37°38.27'N 137°16.34'E	37°38.54'N 137°16.27'E	97-99	11.74	34.20	2 m
19	MZ09-13	18 June 2009	17:40-18:00	37°45.53'N 137°11.52'E	37°45.41'N 137°11.88'E	117-121	12.75	34.28	2 m
20	MZ09-12	18 June 2009	14:01-14:21	37°33.67'N 137°03.89'E	37°33.81'N 137°04.20'E	90-91	12.97	34.30	2 m
21	MZ09-11	17 June 2009	08:21-08:41	36°32.51'N 136°18.12'E	36°32.58'N 136°18.60'E	96-100	14.78	34.36	2 m
22	MZ09-09	16 June 2009	15:13-15:33	35°50.29'N 133°14.88'E	35°50.31'N 133°15.18'E	98	16.42	34.40	2 m
23	MZ09-10	16 June 2009	12:56-13:16	35°46.00'N 132°33.99'E	35°45.96'N 132°33.79'E	73	17.55	34.41	2 m
24	MZ09-08	15 June 2009	07:51-08:11	35°24.05'N 132°30.77'E	35°24.30'N 132°30.65'E	96-97	17.84	34.41	2 m
25	MZ09-07	15 June 2009	09:40-10:00	35°29.83'N 131°07.09'E	35°30.17'N 131°07.35'E	145-146	6.90	34.19	2 m
26	MZ09-06	14 June 2009	16:13-16:33	35°07.09'N 131°02.47'E	35°07.38'N 131°02.68'E	123	17.01	34.30	2 m
27	MZ09-05	14 June 2009	12:31-12:51	34°37.26'N 130°46.88'E	34°37.61'N 130°46.60'E	100-101	18.23	34.39	2 m
28	MZ09-04	14 June 2009	07:52-08:12	34°16.21'N 130°42.22'E	34°16.00'N 130°42.71'E	83-84	18.60	34.41	2 m
29	MZ09-03	14 June 2009	09:43-10:03	34°23.94'N 129°44.12'E	34°24.27'N 129°44.45'E	97	17.89	34.43	2 m
30	MZ09-02	13 June 2009	14:47-15:02	34°17.04'N 129°36.28'E	34°17.48'N 129°35.85'E	105	16.38	34.23	2 m
31	MZ09-01	13 June 2009	16:45-17:05	34°27.31'N	34°26.98'N	99-100	15.58	34.15	2 m

Species List

Forty-one species in 22 genera representing 9 families are presented herein. Among them, the following 12 species were new to the Sea of Japan, which were not listed by Ishida *et al.* (2001: table 3): *Astrochele laevis*, *Astrothrombus chrysanthi ornatus*, *Ophiostyracium trachyacanthum*, *Ophiosemmotes tylota*, *Ophioleuce seminudum*, *Amphioplus (Amphioplus) rhadinobranchius*, *Amphipholis sobrina*, *Amphiura (Amphiura) euopla*, *Amphiura (Amphiura) iridoides*, *Amphiura (Fellaria) econmiotata*, *Amphiura (Ophiopeltis) aestuarii*, *Ophiopenia tetracantha*.

Family Gorgonocephalidae Ljungman, 1867

Astrochele laevis H. L. Clark, 1911

(Fig. 2A–B)

Material examined. St. 01, NSMT E-7210, 4 specimens, dd 7.1–10.3 mm, NSMT E-7211, 4 specimens, dd 4.5–6.9 mm.

Depth range. 124–126 m.

Remarks. *Astrochele pacifica* has also been reported from Japanese waters recently. *Astrochele* species are distinguished by dermal ossicle morphology (Okanishi *et al.*, 2011).

Astrodendrum sagaminum (Döderlein, 1902)

(Fig. 2C–D)

Material examined. St. 01, NSMT E-7212, 3 specimens, dd 3.3–8.9 mm.

Depth range. 124–126 m.

Remarks. Only small-sized specimens were collected. Disk diameter of the present species reaches 70 mm (Irimura, 1991).

Astrothrombus chrysanthi ornatus Mortensen, 1933

(Fig. 2E)

Material examined. St. 01, NSMT E-7213, 1 specimen, dd 3.6 mm.

Depth range. 124–126 m.

Remarks. *Astrothrombus chrysanthi ornatus* was described by Mortensen (1933) as a new variety. Further studies using more material are required to clarify its status.

Family Ophiomyxidae Ljungman, 1867

Ophiomyxa australis Lütken, 1869

Material examined. St. 15, NSMT E-7214, 2 specimens, dd 3.8–18.0 mm.

Depth range. 160–161 m.

Ophiostyracium trachyacanthum H. L. Clark, 1911

(Fig. 2F–G)

Material examined. St. 20, NSMT E-7215, 1 specimen, dd 1.5 mm; St. 26, NSMT E-7216, 1 specimen, dd 2.3 mm.

Depth range. 90–123 m.

Remarks. Only small-sized specimens were collected. The holotype of the present species is 6 mm in dd collected from off Yakushima Island, in the East China Sea (H. L. Clark, 1911).

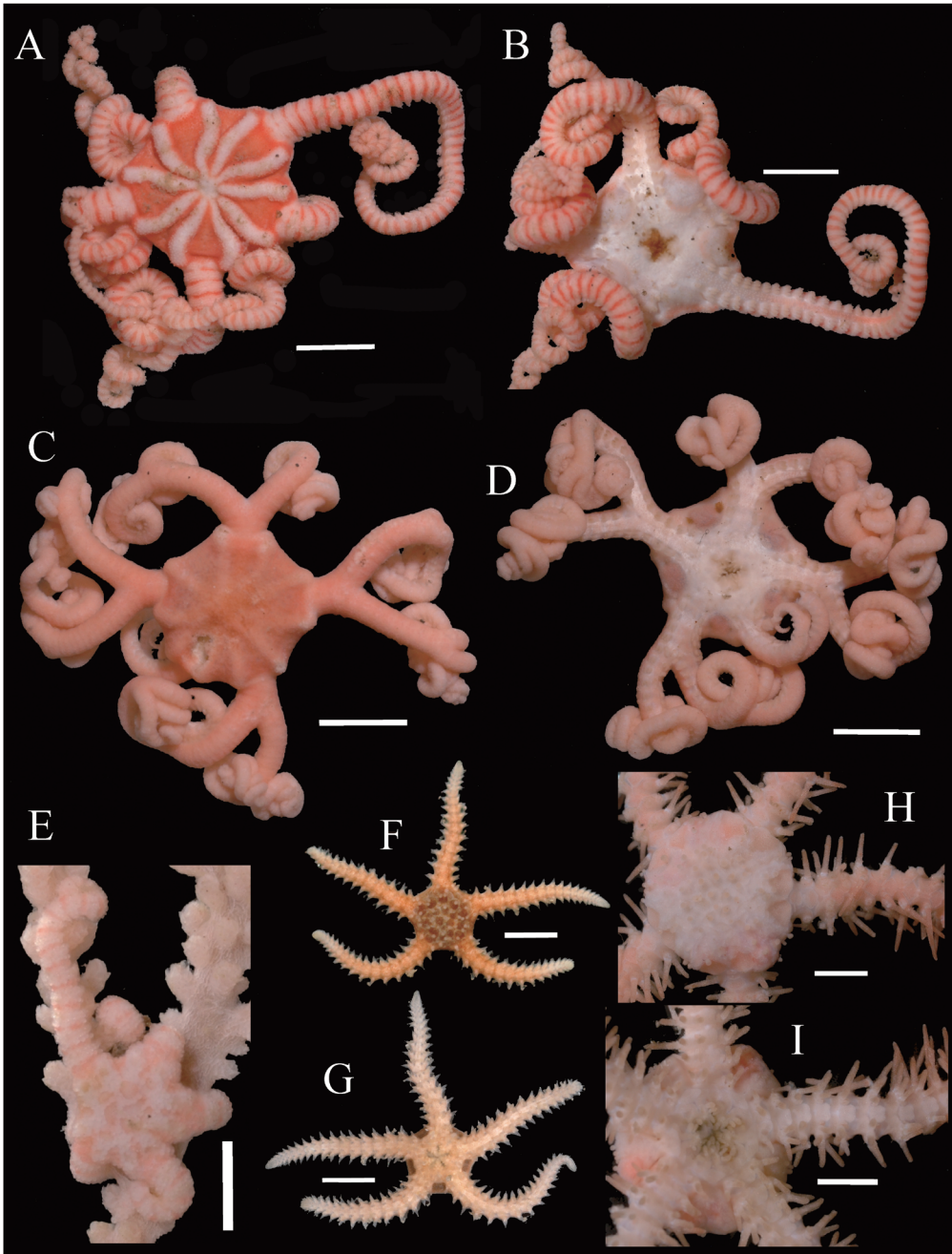


Fig. 2. Gorgonocephalidae, Ophiomyxidae, Ophiacanthidae. A–B, *Astroschele laevis* (NSMT E-7210, dd 10.3 mm); C–D, *Astrodendrum sagaminum* (NSMT E-7212, dd 8.9 mm); E, *Astrothrombus chrysanthi ornatus* attaching to a gorgonacean colony (NSMT E-7213, dd 3.6 mm); F–G, *Ophiostyracium trachyacanthum* (NSMT E-7216, dd 2.3 mm); H–I, *Ophiosemmotes tygota* (NSMT E-7222, dd 6.4 mm). Scale bars. 5 mm (A–D), 2 mm (E–I).

Family Ophiacanthidae Ljungman, 1867

Ophiacantha adiaphora H. L. Clark, 1911

Material examined. St. 16, NSMT E-7217, 1 specimen, dd 5.8 mm, NSMT E-7218, 2 specimens, dd 2.7–4.3 mm.

Depth range. 168–170 m.

Ophiacantha omoplata H. L. Clark, 1911

Material examined. St. 01, NSMT E-7219, 1 specimen, dd 3.7 mm; St. 16, NSMT E-7220, 3 specimens, dd 7.3–9.5 mm, NSMT E-7221, 3 specimens, dd 5.1–10.1 mm.

Depth range. 124–170 m.

Ophiosemmotes tylota (H. L. Clark, 1911)

(Fig. 2H–I)

Material examined. St. 01, NSMT E-7222, 1 specimen, dd 6.4 mm, NSMT E-7223, 20 specimens, dd 2.9–7.9 mm, NSMT E-7224, 2 specimens, dd 1.7–3.2 mm, NSMT E-7225, 3 specimens, dd 1.6–7.7 mm.

Depth range. 124–126 m.

Remarks. The present specimens have granule-like short spines on the disk. The scales on the disk are visible.

Family Ophiuridae Müller & Troschel, 1840

Amphiophiura megapoma (H. L. Clark, 1911)

(Fig. 3A–B)

Material examined. St. 01, NSMT E-7226, 1 specimen, dd 7.9 mm, NSMT E-7227, 1 specimen, dd 14.9 mm, NSMT E-7228, 2 specimens, dd 14.0–14.0 mm, NSMT E-7229, 6 specimens, dd 1.7–6.9 mm; St. 16, NSMT E-7230, 1 specimen, dd 15.1 mm; St. 17, NSMT E-7231, 2 specimens, dd 9.5–11.1 mm.

Depth range. 124–170 m.

Ophiochalcis aspera Koehler, 1931

Material examined. St. 21, NSMT E-7232, 1 specimen, dd 4.6 mm.

Depth range. 96–100 m.

Ophiura kinbergi (Ljungman, 1866)

(Fig. 3C–D)

Material examined. St. 02, NSMT E-7233, 13 specimens, dd 2.2–3.9 mm; St. 05, NSMT E-7234, 63 specimens, dd 1.3–3.3 mm; St. 08, NSMT E-7235, 124 specimens, dd 1.1–3.8 mm; St. 18, NSMT E-7236, 4 specimens, dd 3.8–5.1 mm; St. 18 (SM), NSMT E-7237, 6 specimens, dd 0.4–3.4 mm; St. 19, NSMT E-7238, 4 specimens, dd 2.4–4.6 mm; St. 20, NSMT E-7239, 14 specimens, dd 2.3–5.2 mm; St. 20 (SM), NSMT E-7240, 6 specimens, dd 0.4–0.6 mm; St. 21, NSMT E-7241, 22 specimens, dd 2.2–5.6 mm, NSMT E-7242, 9 specimens, dd 2.5–4.2 mm; St. 21 (SM), NSMT E-7243, 6 specimens, dd 0.4–1.5 mm; St. 22, NSMT E-7244, 1 specimen, dd 2.8 mm, NSMT E-7245, 252 specimens, dd 1.6–7.4 mm, NSMT E-7246, 19 specimens, dd 0.7–3.5 mm; St. 22 (SM), NSMT E-7247, 3 specimens, dd 0.7–3.8 mm; St. 23, NSMT E-7248, 158 specimens, dd 1.5–8.9 mm, NSMT E-7249, 141 specimens, dd 0.5–5.1 mm; St. 23 (SM), NSMT

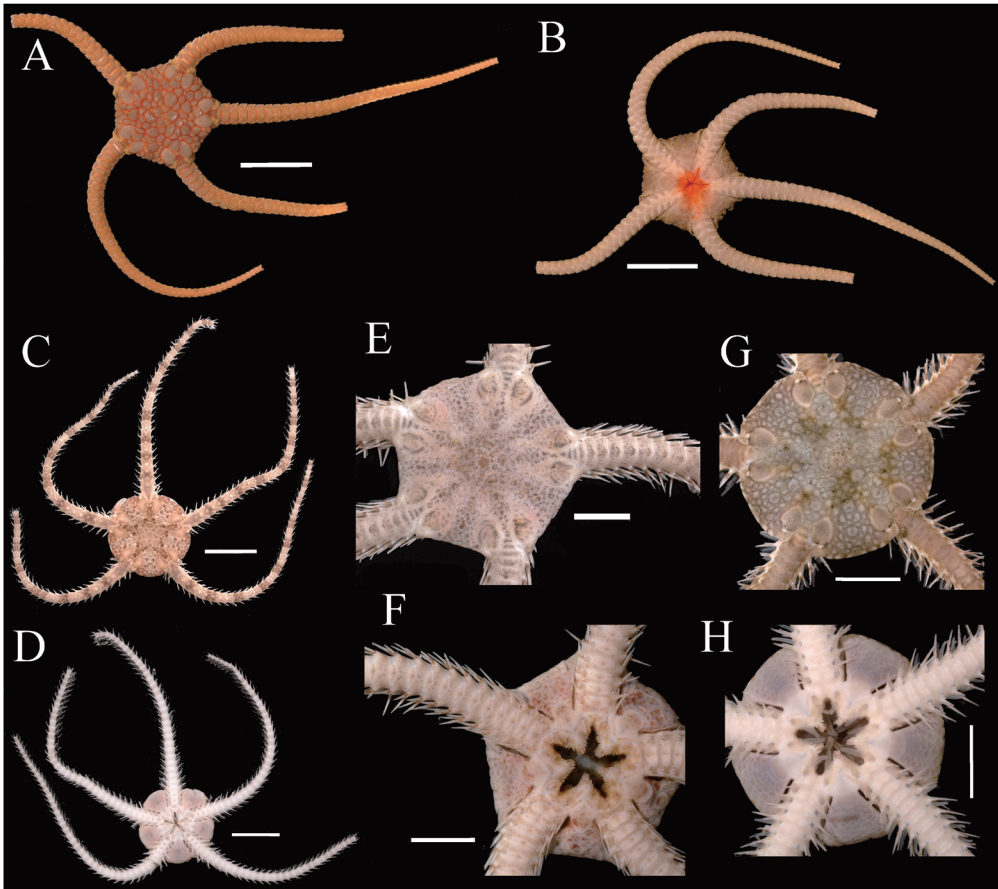


Fig. 3. Ophiuridae (Ophiurinae). A–B, *Amphiophiura megapoma* (NSMT E-7227, dd 14.9 mm); C–D, *Ophiura kinbergi* (NSMT E-7259, dd 8.1 mm); E–F, *Ophiura sarsii sarsii* (NSMT E-7275, dd 17.5 mm); G–H, *Ophiura sarsii vadicola* (NSMT E-7286, dd 14.6 mm). Scale bars. 10 mm (A–B), 5 mm (C–H).

E-7250, 1 specimen, dd 0.7 mm; St. 24, NSMT E-7251, 497 specimens, dd 1.8–10.1 mm, NSMT E-7252, 88 specimens, dd 0.7–3.0 mm; St. 25, NSMT E-7253, 4 specimens, dd 0.7–3.6 mm; St. 26, NSMT E-7254, 36 specimens, dd 1.7–7.8 mm; St. 27, NSMT E-7255, 279 specimens, dd 2.0–10.1 mm, NSMT E-7256, 1045 specimens, dd 0.7–8.5 mm; St. 27 (SM), NSMT E-7257, 2 specimens, dd 5.4–7.2 mm; St. 28, NSMT E-7258, 109 specimens, dd 2.2–9.6 mm, NSMT E-7259, 1 specimen, dd 8.1 mm, NSMT E-7260, 492 specimens, dd 1.9–10.0 mm, NSMT E-7261, 151 specimens, dd 1.1–9.0 mm, NSMT E-7262, 6 specimens, dd 0.6–1.2 mm; St. 29, NSMT E-7263, 3 specimens, dd 3.7–7.8 mm; St. 29 (SM), NSMT E-7264, 4 specimens, dd 0.5–2.2 mm; St. 30, NSMT E-7265, 5 specimens, dd 2.8–4.2 mm, NSMT E-7266, 65 specimens, dd 1.7–5.5 mm, NSMT E-7267, 1 specimen, dd 4.3 mm, NSMT E-7268, 5 specimens, dd 1.9–3.2 mm; St. 31, NSMT E-7269, 51 specimens, dd 1.3–4.2 mm; St. 31 (SM), NSMT E-7270, 1 specimen, dd 0.6 mm.

Depth range. 53–146 m.

Remarks. *Ophiura kinbergi*, *Ophiura leptoctenia*, *Ophiura sarsii sarsii*, and *Ophiura sarsii vadicola* were also collected by the survey. The genus *Ophiura* is one of the dominant ophiuroids in the Sea of Japan. The differences between these species were discussed in Fujita *et al.* (2009).

Ophiura leptoctenia H. L. Clark, 1911

Material examined. St. 04, NSMT E-7271, 15 specimens, dd 5.3–7.1 mm.

Depth range. 301 m.

Ophiura sarsii sarsii Lütken, 1855

(Fig. 3E–F)

Material examined. St. 04, NSMT E-7272, 1 specimen, dd 20.1 mm, NSMT E-7273, 62 specimens, dd 8.2–20.6 mm; St. 07, NSMT E-7274, 16 specimens, dd 12.4–22.7 mm; St. 10, NSMT E-7275, 1 specimen, dd 17.5 mm, NSMT E-7276, 13 specimens, dd 3.3–6.9 mm, NSMT E-7277, 46 specimens, dd 5.4–18.5 mm.

Depth range. 160–301 m.

Ophiura sarsii vadicola Djakonov, 1949

(Fig. 3G–H)

Material examined. St. 01, NSMT E-7278, 1 specimen, dd 17.9 mm; St. 07, NSMT E-7279, 310 specimens, dd 8.6–21.4 mm; St. 14, NSMT E-7281, 513 specimens, dd 3.7–17.9 mm, NSMT E-7282, 1 specimen, dd 9.0 mm, NSMT E-7283, 11 specimens, dd 2.6–8.0 mm, NSMT E-7284, 100 specimens, dd 4.8–16.5 mm; St. 25, NSMT E-7285, 13 specimens, dd 0.7–2.4 mm, NSMT E-7286, 5 specimens, dd 3.6–14.6 mm, NSMT E-7287, 29 specimens, dd 4.1–16.3 mm, NSMT E-7288, 11 specimens, dd 1.9–14.7 mm.

Depth range. 124–185 m.

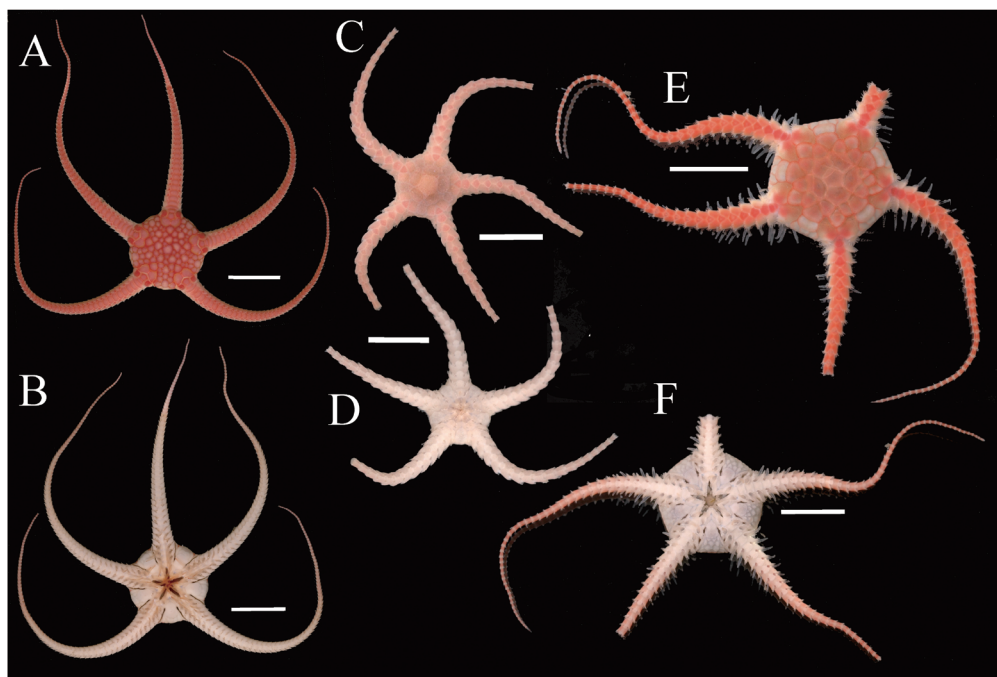


Fig. 4. Ophiuridae (Ophiurinae). A–B, *Stegophiura sladeni* (NSMT E-7291, dd 15.0 mm); C–D, *Stegophiura sterea* (NSMT E-7317, dd 2.1 mm); E–F, *Stegophiura vivipara* (NSMT E-7318, dd 7.9 mm). Scale bars. 10 mm (A–B), 2 mm (C–D), 5 mm (E–F).

Stegophiura sladeni (Duncan, 1879)

(Fig. 4A–B)

Material examined. St. 02, NSMT E-7289, 1 specimen, dd 1.5 mm; St. 19, NSMT E-7290, 2 specimens, dd 13.2–13.6 mm, NSMT E-7291, 1 specimen, dd 15.0 mm; St. 20, NSMT E-7292, 2 specimens, dd 1.2–6.0 mm; St. 21, NSMT E-7293, 2 specimens, dd 2.2–15.0 mm, NSMT E-7294, 2 specimens, dd 2.2–4.8 mm; St. 22, NSMT E-7295, 3 specimens, dd 2.8–5.2 mm, NSMT E-7296, 1 specimen, dd 3.1 mm, NSMT E-7297, 10 specimens, dd 15.9–21.5 mm; St. 23, NSMT E-7298, 1 specimen, dd 4.9 mm, NSMT E-7299, 2 specimens, dd 4.9–5.5 mm; St. 24, NSMT E-7300, 76 specimens, dd 2.1–16.4 mm, NSMT E-7301, 15 specimens, dd 2.4–6.7 mm; St. 26, NSMT E-7302, 3 specimens, dd 1.5–2.7 mm, NSMT E-7303, 1 specimen, dd 17.4 mm, NSMT E-7304, 1 specimen, dd 16.3 mm; St. 27, NSMT E-7305, 3 specimens, dd 10.6–17.3 mm; St. 28, NSMT E-7306, 1 specimen, dd 17.0 mm; St. 29, NSMT E-7307, 1 specimen, dd 10.2 mm.

Depth range. 53–123 m.

Stegophiura sterea (H. L. Clark, 1908)

(Fig. 4C–D)

Material examined. St. 07, NSMT E-7308, 38 specimens, dd 2.1–14.9 mm, NSMT E-7309, 3 specimens, dd 11.2–14.4 mm; St. 09, NSMT E-7310, 1 specimen, dd 13.5 mm; St. 10, NSMT E-7311, 3 specimens, dd 14.2–15.1 mm; St. 14, NSMT E-7312, 62 specimens, dd 7.7–16.2 mm, NSMT E-7313, 2 specimens, dd 7.8–13.5 mm; St. 25, NSMT E-7314, 19 specimens, dd 10.0–18.7 mm, NSMT E-7315, 1 specimen, dd 17.2 mm, NSMT E-7316, 1 specimen, dd 1.8 mm; St. 26, NSMT E-7317, 1 specimen, dd 2.1 mm.

Depth range. 99–195 m.

Stegophiura vivipara Matsumoto, 1915

(Fig. 4E–F)

Material examined. St. 23, NSMT E-7318, 1 specimen, dd 7.9 mm, NSMT E-7319, 1 specimen, dd 3.5 mm, NSMT E-7320, 2 specimens, dd 4.7–5.6 mm.

Depth range. 73 m.

Ophioleuce seminudum Koehler, 1904

Material examined. St. 30, NSMT E-7321, 1 specimen, dd 6.8 mm.

Depth range. 105 m.

Family Amphiuroidae Ljungman, 1867

Amphioplus (Amphioplus) ancistrotus (H. L. Clark, 1911)

(Fig. 5A–B)

Material examined. St. 04, NSMT E-7322, 3 specimens, dd 7.2 mm; St. 10, NSMT E-7323, 1 specimen, dd 7.8 mm, NSMT E-7324, 1 specimen, dd 7.9 mm, NSMT E-7325, 1 specimen, dd 5.6 mm, NSMT E-7326, 18 specimens, dd 4.8 mm; St. 14, NSMT E-7327, 1 specimen, dd 6.1 mm, NSMT E-7328, 4 specimens, dd 3.8–7.4 mm; St. 20 (SM), NSMT E-7329, 1 specimen, dd 8.1 mm.

Depth range. 90–301 m.

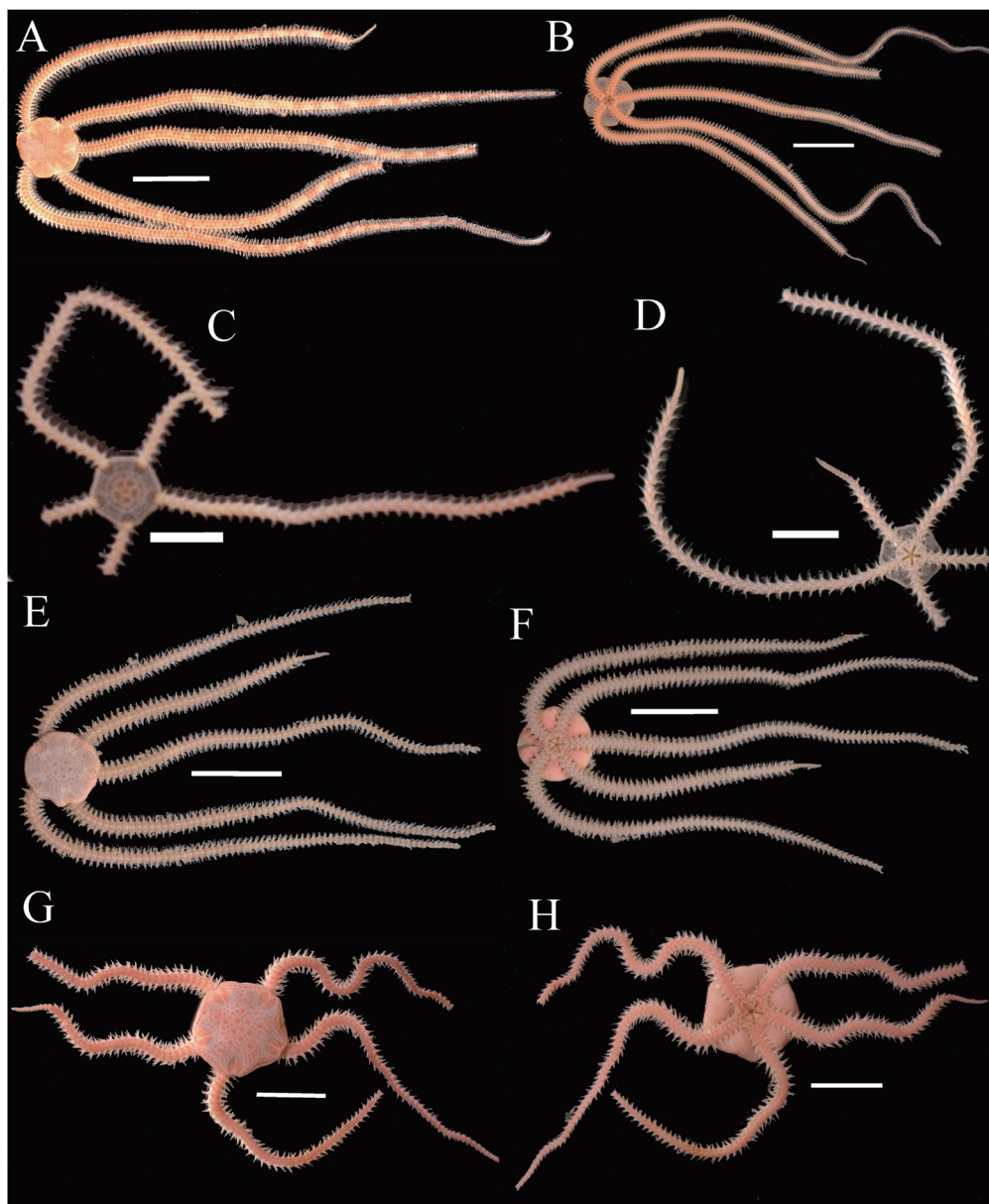


Fig. 5. Amphiuridae. A–B, *Amphioplus (Amphioplus) ancistrotus* (NSMT E-7329, dd 8.1 mm); C–D, *Amphioplus (Amphioplus) rhadinobrachus* (NSMT E-7344, dd 1.9 mm); E–F, *Amphioplus (Lymanella) japonicus* (NSMT E-7336, dd 4.4 mm); G–H, *Amphipholis tetracantha* (NSMT E-7356, dd 7.1 mm). Scale bars. 10 mm (A–B), 2 mm (C–D), 5 mm (E–H).

***Amphioplus (Amphioplus) rhadinobrachus* H. L. Clark, 1911**

(Fig. 5C–D)

Material examined. St. 03, NSMT E-7340, 3 specimens, dd 2.2–3.3 mm; St. 06, NSMT E-7341, 2 specimens; St. 09, NSMT E-7342, 1 specimen, NSMT E-7343, 1 specimen, dd 1.8 mm; St. 31 (SM), NSMT E-7344, 1 specimen, dd 1.9 mm.

Depth range. 93–100 m.

Remarks. Only small-sized specimens (smaller than 3.3 mm in disk diameter) were collected with single tentacle scale. Larger specimens (5–6 mm in disk diameter) have two tentacle scales (H. L. Clark, 1911; Irimura, 1991).

Amphioplus (Lymanella) japonicus (Matsumoto, 1915)

(Fig. 5E–F)

Material examined. St. 22, NSMT E-7330, 1 specimen, dd 1.4 mm; St. 24 (SM), NSMT E-7331, 1 specimen, dd 2.2 mm; St. 24, NSMT E-7332, 1 specimen, dd 1.9 mm; St. 27, NSMT E-7333, 8 specimens, dd 3.2–4.9 mm; St. 28, NSMT E-7334, 3 specimens, dd 3.3–4.8 mm, NSMT E-7335, 1 specimen, dd 4.2 mm, NSMT E-7336, 1 specimen, dd 4.4 mm, NSMT E-7337, 136 specimens, dd 1.4–6.8 mm, NSMT E-7338, 53 specimens, dd 2.0–4.8 mm; St. 31, NSMT E-7339, 2 specimens, dd 1.7–3.1 mm.

Depth range. 83–101 m.

Amphipholis sobrina Matsumoto, 1917

Material examined. St. 01, NSMT E-7345, 1 specimen, dd 2.8 mm; St. 11, NSMT E-7346, 1 specimen, dd 2.1 mm; St. 14, NSMT E-7347, 1 specimen, dd 2.4 mm; St. 16, NSMT E-7348, 18 specimens, dd 1.3–3.9 mm; St. 18, NSMT E-7349, 1 specimen, dd 3.2 mm; St. 20, NSMT E-7350, 5 specimens, dd 1.9–3.9 mm; St. 20 (SM), NSMT E-7351, 3 specimens, dd 1.9–2.7 mm; St. 21, NSMT E-7352, 4 specimens, dd 2.4–3.2 mm; St. 30, NSMT E-7353, 1 specimen, dd 3.4 mm; St. 31, NSMT E-7354, 2 specimens, dd 1.8 mm.

Depth range. 90–185 m.

Amphipholis tetracantha Matsumoto, 1941

(Fig. 5G–H)

Material examined. St. 09, NSMT E-7355, 1 specimen, dd 3.3 mm; St. 10, NSMT E-7356, 1 specimen, dd 7.1 mm, NSMT E-7357, 1 specimen, dd 2.6 mm, NSMT E-7358, 3 specimens, dd 3.2–4.3 mm, NSMT E-7359, 32 specimens, dd 3.2–7.7 mm; St. 14, NSMT E-7360, 5 specimens, dd 3.1–6.3 mm.

Depth range. 99–195 m.

Remarks. Matsumoto (1941) reported that radial shields are about twice as long as wide. Some of the present specimens have shorter radial shields probably because they have been regenerated.

Amphiura (Amphiura) arcystata H. L. Clark, 1911

(Fig. 6A–B)

Material examined. St. 10, NSMT E-7362, 1 specimen, dd 11.5 mm; St. 14, NSMT E-7363, 1 specimen, dd 6.2 mm, NSMT E-7364, 3 specimens, dd 6.6–10.4 mm; St. 25, NSMT E-7365, 1 specimen, dd 11.8 mm, NSMT E-7366, 7 specimens, dd 11.4–15.3 mm, NSMT E-7367, 4 specimens, dd 11.5 mm.

Depth range. 145–195 m.

Remarks. The arms have reddish and whitish-color bands alternatively. The present specimens have scales only round radial shields. The status of this species was discussed in A. M. Clark (1970).

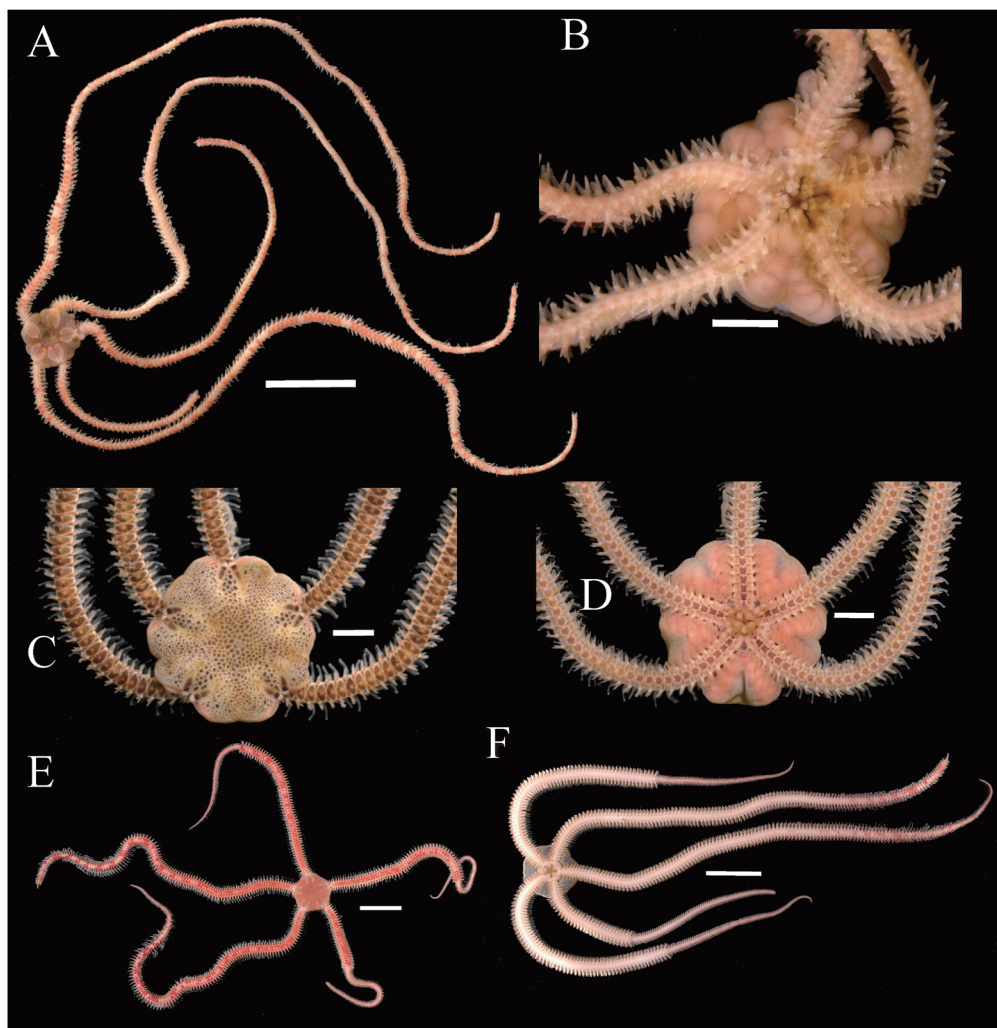


Fig. 6. Amphiuroidae. A–B, *Amphiuroida (Amphiuroida) arcystata* (NSMT E-7363, dd 6.2 mm); C–D, *Amphiuroida (Amphiuroida) digitula* (NSMT E-7376, dd 8.4 mm); E–F, *Amphiuroida (Amphiuroida) euopla* (NSMT E-7383, dd 9.2 mm). Scale bars. 10 mm (A, E–F), 2 mm (B–D).

***Amphiuroida (Amphiuroida) digitula* (H. L. Clark, 1911)**

(Fig. 6C–D)

Material examined. St. 08, NSMT E-7368, 4 specimens, dd 5.2–6.3 mm; St. 20 (SM), NSMT E-7369, 5 specimens, dd 5.0–6.3 mm; St. 20, NSMT E-7370, 1 specimen, dd 7.2 mm; St. 20 (SM), NSMT E-7371, 1 specimen, dd 3.8 mm; St. 22, NSMT E-7372, 1 specimen, dd 4.8 mm; St. 27, NSMT E-7373, 1 specimen, dd 5.5 mm, NSMT E-7374, 1 specimen, dd 3.2 mm; St. 28, NSMT E-7375, 15 specimens, dd 4.3–8.4 mm, NSMT E-7376, 1 specimen, dd 8.4 mm, NSMT E-7377, 17 specimens, dd 5.2–5.7 mm, NSMT E-7378, 11 specimens, dd 2.3–4.6 mm; St. 29, NSMT E-7379, 2 specimens.

Depth range. 61–101 m.

Amphiura (Amphiura) euopla H. L. Clark, 1911

(Fig. 6E–F)

Material examined. St. 20, NSMT E-7382, 1 specimen, dd 6.0 mm; St. 21 (SM), NSMT E-7383, 1 specimen, dd 9.2 mm; St. 31, NSMT E-7384, 1 specimen, dd 8.8 mm.

Depth range. 90–100 m.

Amphiura (Amphiura) iridooides Matsumoto, 1917

(Fig. 7A–B)

Material examined. St. 18, NSMT E-7385, 1 specimen, dd 2.5 mm; St. 19 (SM), NSMT E-7386, 3 specimens, dd 1.1–1.5 mm; St. 20, NSMT E-7387, 1 specimen, dd 4.1 mm; St. 21, NSMT E-7388, 1 specimen, dd 3.5 mm, NSMT E-7389, 1 specimen, dd 2.1 mm; St. 30, NSMT E-7390, 1 specimen, dd 3.2 mm.

Depth range. 90–121 m.

Amphiura (Amphiura) koreae Duncan, 1879

Material examined. St. 15, NSMT E-7391, 1 specimen, dd 4.0 mm.

Depth range. 160–161 m.

Amphiura (Amphiura) microdiscoida H. L. Clark, 1915

(Fig. 7C)

Material examined. St. 20, NSMT E-7392, 1 specimen, dd 2.8 mm.

Depth range. 90–91 m.

Remarks. *Hemipholis microdiscus* Duncan, 1879 was transferred to *Amphiura* by H. L. Clark (1915) when the name was changed to *Amphiura microdiscoida* to avoid the homonymy with *Amphiura microdisca* Lütken, 1856. Ventral interradiial disk has no scale like *Amphiura (Amphiura) euopla*.

Amphiura (Amphiura) psilopora H. L. Clark, 1911

(Fig. 7D–E)

Material examined. St. 21, NSMT E-7393, 1 specimen, dd 1.9 mm; St. 21 (SM), NSMT E-7394, 1 specimen, dd 1.8 mm.

Depth range. 96–100 m.

Amphiura (Fellaria) ecnomiotata H. L. Clark, 1911

Material examined. St. 26, NSMT E-7380, 1 specimen, dd 8.4 mm; St. 28, NSMT E-7381, 1 specimen, dd 4.5 mm.

Depth range. 83–123 m.

Amphiura (Ophiopeltis) aestuarii Matsumoto, 1915

Material examined. St. 14, NSMT E-7361, 2 specimens, dd 3.9–4.2 mm.

Depth range. 182–185 m.

Remarks. Most of the tentacle pores bear no tentacle scale, but some pores have single tentacle scale.

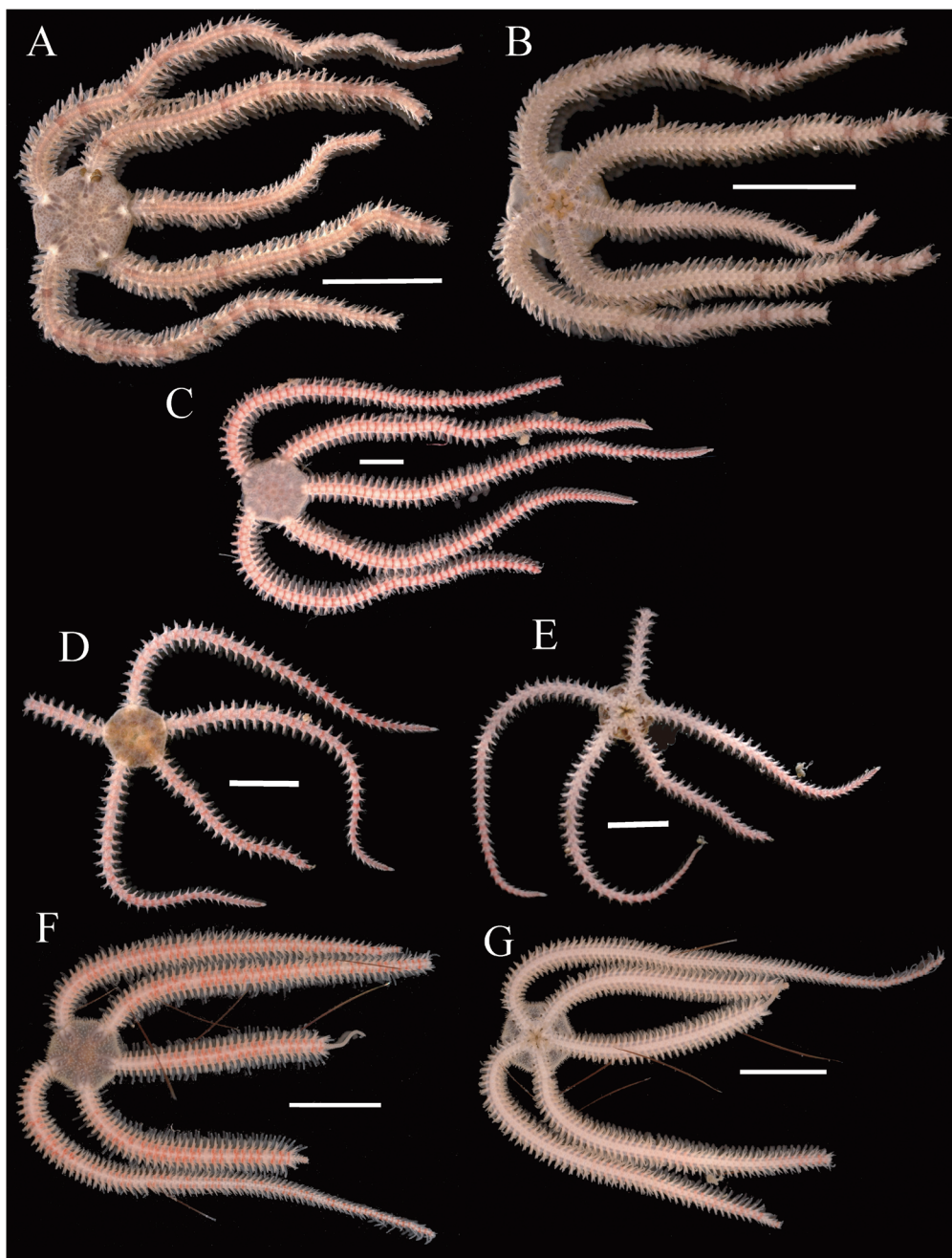


Fig. 7. Amphiuridae. A–B, *Amphiura (Amphiura) iridoidea* (NSMT E-7387, dd 4.1 mm); C, *Amphiura (Amphiura) microdiscoida* (NSMT E-7392, dd 2.8 mm); D–E, *Amphiura (Amphiura) psilopora* (NSMT E-7394, dd 1.8 mm); F–G, *Ophiocentrus koehleri* (NSMT E-7396, dd 4.9 mm). Scale bars. 5 mm (A–B, F–G), 2 mm (C–E).

***Ophiocentrus koehleri* Gislén, 1926**

(Fig. 7F–G)

Material examined. St. 27, NSMT E-7395, 1 specimen, dd 3.8 mm, NSMT E-7396, 1 speci-

men, dd 4.9 mm; St. 28, NSMT E-7397, 2 specimens, dd 2.6–6.5 mm, NSMT E-7398, 1 specimen, dd 1.8 mm; St. 31, NSMT E-7399, 5 specimens, dd 2.2–4.3 mm, NSMT E-7400, 1 specimen, dd 8.6 mm.

Depth range. 83–101 m.

Family Ophiotrichidae Ljungman, 1867

Ophiogymna fulgens (Koehler, 1905)

(Fig. 8A–B)

Material examined. St. 22, NSMT E-7401, 3 specimens, dd 3.8–7.5 mm, NSMT E-7402, 1 specimen, dd 6.5 mm.

Depth range. 98 m.

Ophiotrix (Ophiotrix) exigua Lyman, 1874

(Fig. 8C–D)

Material examined. St. 02, NSMT E-7403, 1 specimen, dd 2.2 mm; St. 21, NSMT E-7404, 5 specimens, dd 3.2–6.8 mm; St. 22, NSMT E-7405, 2 specimens, dd 2.3–3.9 mm; St. 24, NSMT E-7406, 1 specimen, dd 7.9 mm; St. 31, NSMT E-7407, 1 specimen, dd 7.8 mm, NSMT E-7408, 1 specimen, dd 7.7 mm, NSMT E-7409, 4 specimens, dd 3.0–5.4 mm.

Depth range. 53–100 m.

Remarks. Differences between *Ophiotrix exigua* and *Ophiotrix panchyendyta* are not clear for smaller individuals, but the sizes of radial shields and disk spines are slightly different (Fujita and Kohtsuka, 2003). *Ophiotrix exigua* was collected in shallower depths and *O. panchyendyta* in deeper depths.

Ophiotrix (Ophiotrix) panchyendyta H. L. Clark, 1911

(Fig. 8E–F)

Material examined. St. 11, NSMT E-7410, 16 specimens, dd 9.2–18.0 mm, NSMT E-7411, 9 specimens, dd 3.0–8.3 mm; St. 14, NSMT E-7412, 14 specimens, dd 7.5–20.8 mm; St. 15, NSMT E-7413, 17 specimens, dd 2.2–15.5 mm; St. 16, NSMT E-7414, 2 specimens, dd 4.9–7.5 mm, NSMT E-7415, 82 specimens, dd 3.7–15.9 mm, NSMT E-7416, 6 specimens, dd 2.2–3.7 mm; St. 17 (SM), NSMT E-7417, 1 specimen, dd 17.6 mm; St. 17, NSMT E-7418, 10 specimens, dd 3.6–13.7 mm; St. 18, NSMT E-7419, 2 specimens, dd 10.6–17.8 mm, NSMT E-7420, 1 specimen, dd 19.7 mm; St. 19, NSMT E-7421, 1 specimen, dd 12.6 mm; St. 21, NSMT E-7422, 1 specimen, dd 2.6 mm; St. 31, NSMT E-7423, 1 specimen, dd 6.3 mm, NSMT E-7424, 1 specimen, dd 6.5 mm, NSMT E-7425, 1 specimen, dd 7.0 mm.

Depth range. 96–185 m.

Family Ophiactidae Matsumoto, 1915

Ophiactis plana Lyman, 1869

(Fig. 8G–H)

Material examined. St. 15, NSMT E-7426, 11 specimens, dd 1.1–2.6 mm; St. 15 (SM), NSMT E-7427, 1 specimen, dd 2.7 mm; St. 16, NSMT E-7428, 1 specimen, dd 3.5 mm, NSMT E-7429, 69 specimens, dd 2.2–5.8 mm; St. 17, NSMT E-7430, 4 specimens, dd 2.2–2.7 mm; St. 20, NSMT E-7431, 1 specimen, dd 1.9 mm; St. 30, NSMT E-7432, 2 specimens, dd 1.2–1.8 mm.

Depth range. 90–170 m.

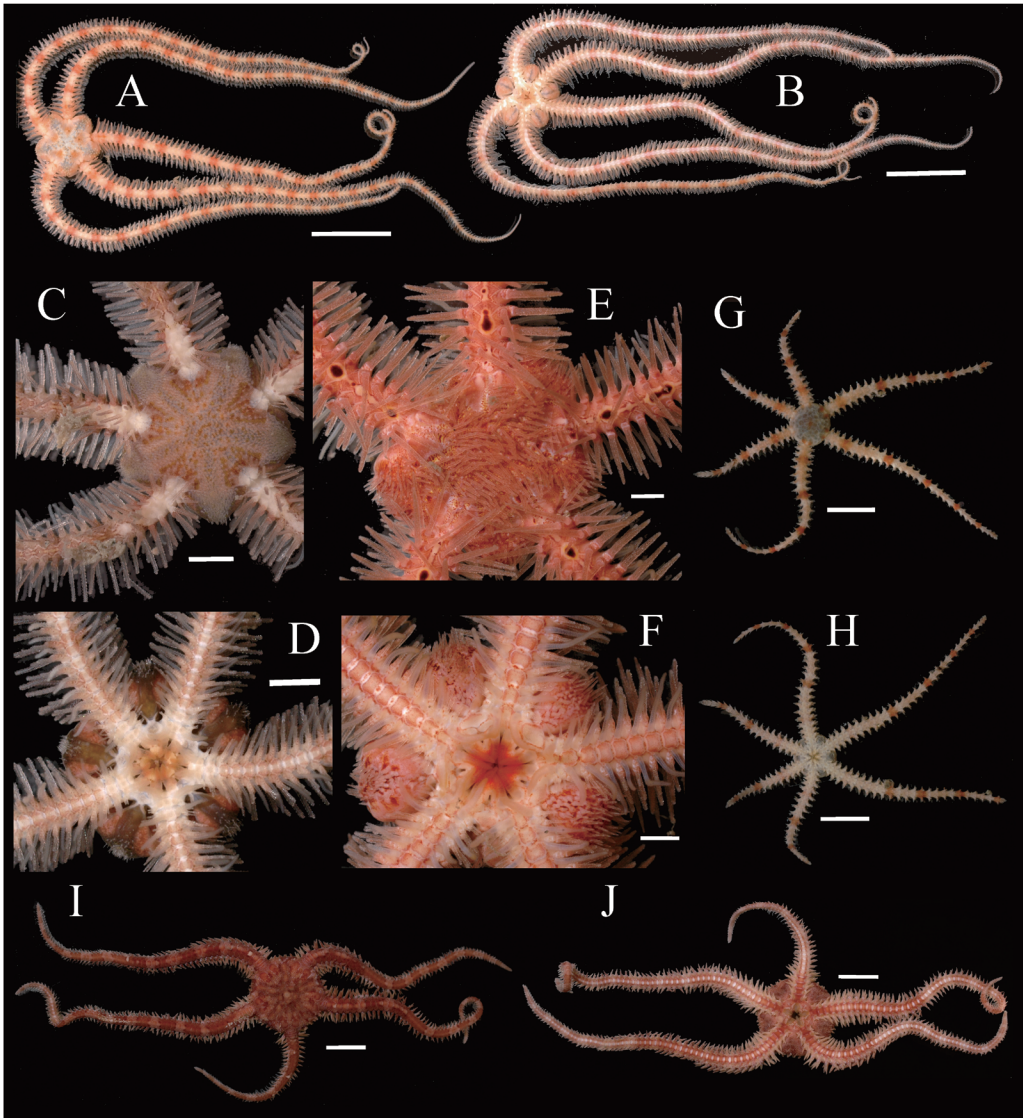


Fig. 8. Ophiotrichidae, Ophiactidae. A–B, *Ophiogymna fulgens* (NSMT E-7402, dd 6.5 mm); C–D, *Ophiothrix* (*Ophiothrix*) *exigua* (NSMT E-7407, dd 7.8 mm); E–F, *Ophiothrix* (*Ophiothrix*) *panchyendyta* (NSMT E-7421, dd 12.6 mm); G–H, *Ophactis plana* (NSMT E-7431, dd 1.9 mm); I–J, *Ophiopholis mirabilis* (NSMT E-7444, dd 9.7 mm). Scale bars. 10 mm (A–B), 2 mm (C–H), 5 mm (I–J).

***Ophiopholis japonica* Lyman, 1879**

Material examined. St. 01, NSMT E-7433, 36 specimens, dd 3.4–12.5 mm; St. 11, NSMT E-7434, 1 specimen, dd 3.4 mm; St. 14, NSMT E-7435, 1 specimen, dd 12.2 mm; St. 16, NSMT E-7436, 10 specimens, dd 2.6–4.6 mm, NSMT E-7437, 99 specimens, dd 2.2–13.4 mm, NSMT E-7438, 2 specimens, dd 7.6–10.7 mm, NSMT E-7440, 25 specimens, dd 1.6–3.7 mm; St. 16 (SM), NSMT E-7439, 1 specimen, dd 1.0 mm; St. 17, NSMT E-7441, 1 specimen, dd 5.2 mm, NSMT E-7442, 1 specimen, dd 9.5 mm.

Depth range. 124–185 m.

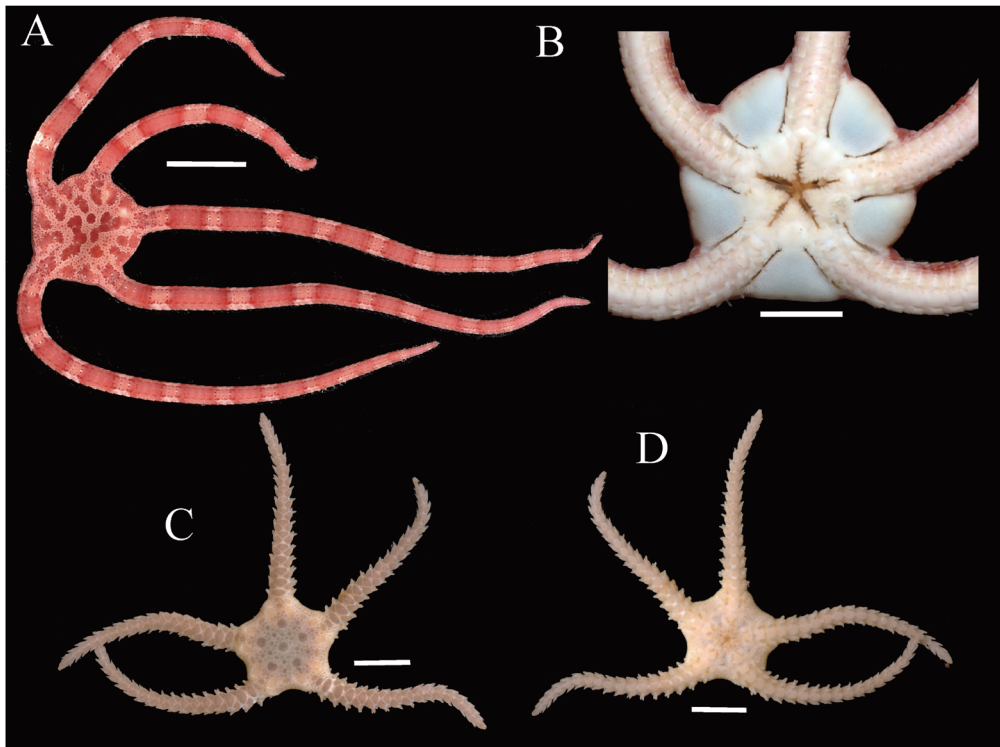


Fig. 9. Ophiidermatidae, Ophiolepididae. A–B, *Ophiopsammus anchistus* (NSMT E-7466, dd 15.0 mm); C–D, *Ophiopenia tetracantha* (NSMT E-7467, dd 3.2 mm). Scale bars. 10 mm (A), 5 mm (B), 2 mm (C–D).

Ophiopholis mirabilis (Duncan, 1879)

(Fig. 8I–J)

Material examined. St. 14, NSMT E-7443, 1 specimen, dd 7.5 mm; St. 18, NSMT E-7444, 1 specimen, dd 9.7 mm; St. 19, NSMT E-7445, 1 specimen, dd 5.9 mm; St. 20, NSMT E-7446, 1 specimen, dd 4.8 mm, NSMT E-7447, 1 specimen, dd 6.5 mm; St. 21, NSMT E-7448, 1 specimen, dd 4.5 mm.

Depth range. 90–185 m.

Family Ophiidermatidae Ljungman, 1867

Ophiopsammus anchistus (H. L. Clark, 1911)

(Fig. 9A–B)

Material examined. St. 18, NSMT E-7464, 1 specimen, dd 18.2 mm; St. 22, NSMT E-7465, 1 specimen, dd 23.0 mm; St. 26, NSMT E-7466, 1 specimen, dd 15.0 mm.

Depth range. 97–123 m.

Family Ophiolepididae Ljungman, 1867

Ophiopenia tetracantha H. L. Clark, 1911

(Fig. 9C–D)

Material examined. St. 01, NSMT E-7467, 1 specimen, dd 3.2 mm, NSMT E-7468, 2 specimens, dd 3.1–3.6 mm.

Depth range. 124–126 m.

Remarks. A closely related species, *Ophiopenia disacantha* H. L. Clark, 1911, was found in the Sea of Japan (Ishida *et al.*, 2001). *Ophiopenia disacantha* can be distinguished from *O. tetracantha* by having only 2 arm spines instead of 4 or 5.

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