

Ophiuroids (Echinodermata) of Genus *Ophiura* Collected from Deep Waters off Pacific Coast of Northern Japan

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Abstract: Ophiuroids of the genus *Ophiura* were studied using the specimens collected from deep-waters (65–5680 m) off the Pacific coast of northern Japan. Ten species were identified including a probably undescribed species. Short descriptions and photographs of each species and a tabular key to the species in this area are given.

Key words: deep sea, brittle stars, Ophiuroidea, taxonomy

Introduction

The genus *Ophiura* Lamarck, 1816 is a very large and heterogeneous genus and many scientists have pointed the necessity of the revision and tried some subdivisions by establishing genera and subgenera (H. L. Clark, 1911; Matsumoto, 1917; Tommasi, 1976). This genus, however, still includes 84 valid species (Stöhr and O'Hara, 2007), and the past revisions are not satisfactory. For further revisional studies on this genus, taxonomical information for as many species as possible should be accumulated.

In the deep waters off the Pacific coast of northern Japan, ecological studies of dense populations of *Ophiura sarsii* and its related species have been relatively well studied (Fujita, 1988, 1992, 1996, 2003; Fujita and Ohta, 1989, 1990; Horikoshi *et al.*, 1990; Stancyk *et al.*, 1998; Ishida and Fujita, 1999), but there have been few taxonomical works in this area. Only Matsumoto (1941) studied the ophiuroid fauna off Kinkasan, and reported 10 ophiuroid species including only one *Ophiura* species.

We collected enormous number of ophiuroid specimens in this area, mainly by the project "Research on Deep-sea Fauna and Pollutants off Pacific Coast of Northern Japan" conducted by the National Museum of Nature and Science, Tokyo, and from past research cruises. In the present paper, we focused on this still confusing genus *Ophiura*. We give short descriptions and taxonomical notes with photographs of each species of *Ophiura* in this paper.

Materials and Methods

The study area was located on the shelf and the slope off north Honshu and Hokkaido, northern Japan (Fig. 1). Ophiuroid specimens used in this paper were collected at 170 stations by a baited trap cage, a bottom otter trawl, three types of beam trawls, and a biological dredge during cruises of the R/Vs *Soyo-maru* and *Wakataka-maru* of the Fisheries Research Agency in 1991–2005 (Table 1). Depths ranged from 65 to 5680 m. Ophiuroid specimens were fixed with buffered 10%

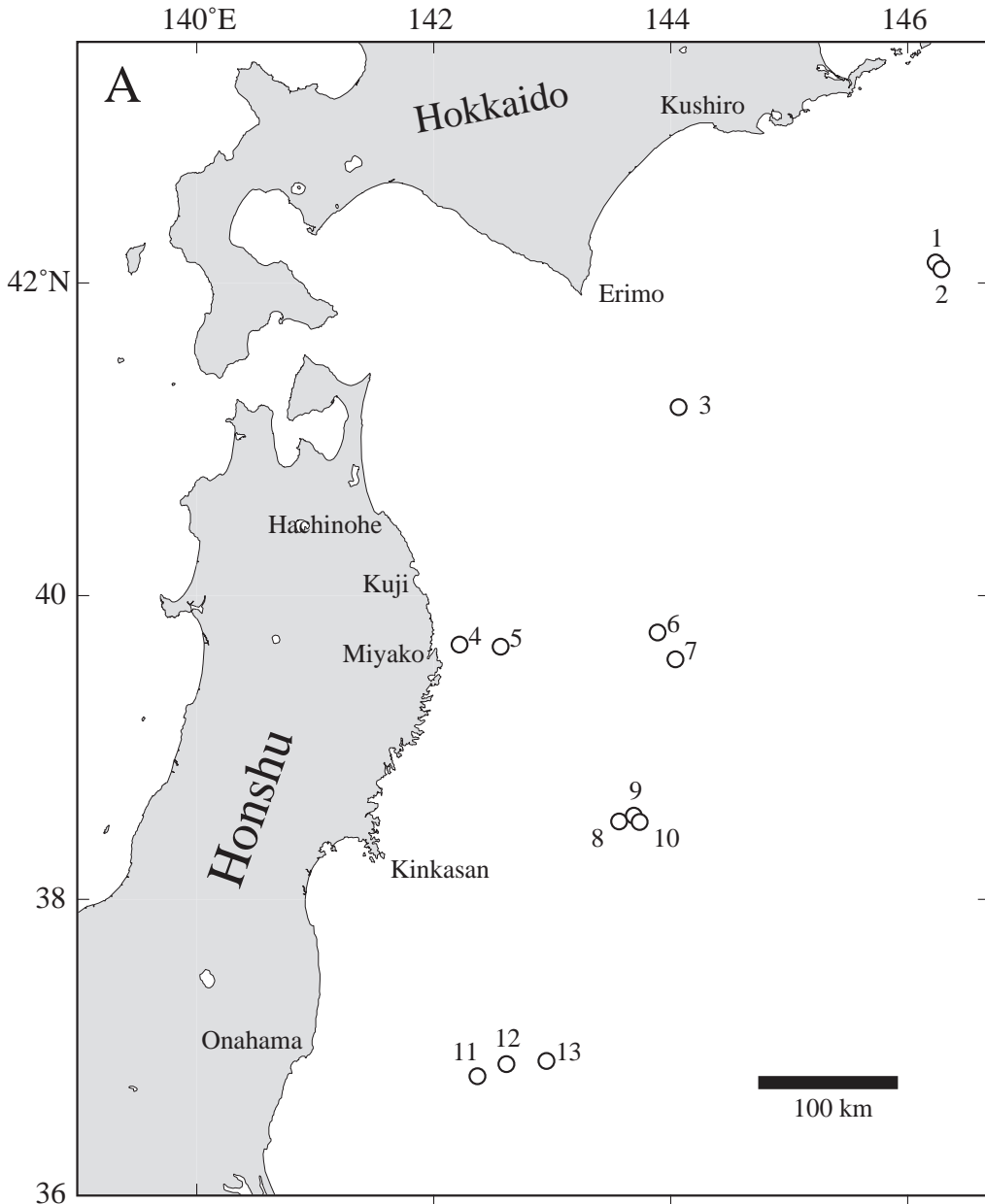


Fig. 1. Sampling stations. Open circles denote the position of sampling stations. See Table 1 for greater detail. A, sampling stations by R/V *Soyo-maru*. Numerals near open circles denote station number; B–E, sampling stations by R/V *Wakataka-maru* in each area, locality names and station number are shown.

sea water formalin on board and later transferred to 70% ethanol, or directly immersed in 99% alcohol. Some specimens are completely dried for observation of ossicles, or dried and sputter-coated with gold-palladium for SEM observation. The specimens collected are still being examined, and only the specimens already identified (ca. 53000) were treated in this preliminary paper. We give a list of essential synonyms, a short description, taxonomical remarks, geographical distribution, and photographs for each species collected in this study. The descriptions include the formula of tentacle scales proposed for Ophiurinae by Paterson (1985). Each pore is given a number starting with the first arm pore AP1. Numbers of tentacle scales arising on the lateral arm plate and of those arising on the ventral arm plate are shown by L and V, respectively. The numbers show intraspecific variation, but a typical pattern is shown for each species. The identified specimens are deposited in the National Museum of Nature and Science (formerly National Science Museum), Tokyo (NSMT). In material examined, serial station number (see Table 1 for the detailed data) and number of specimens are shown by “St.” and “×”, respectively.

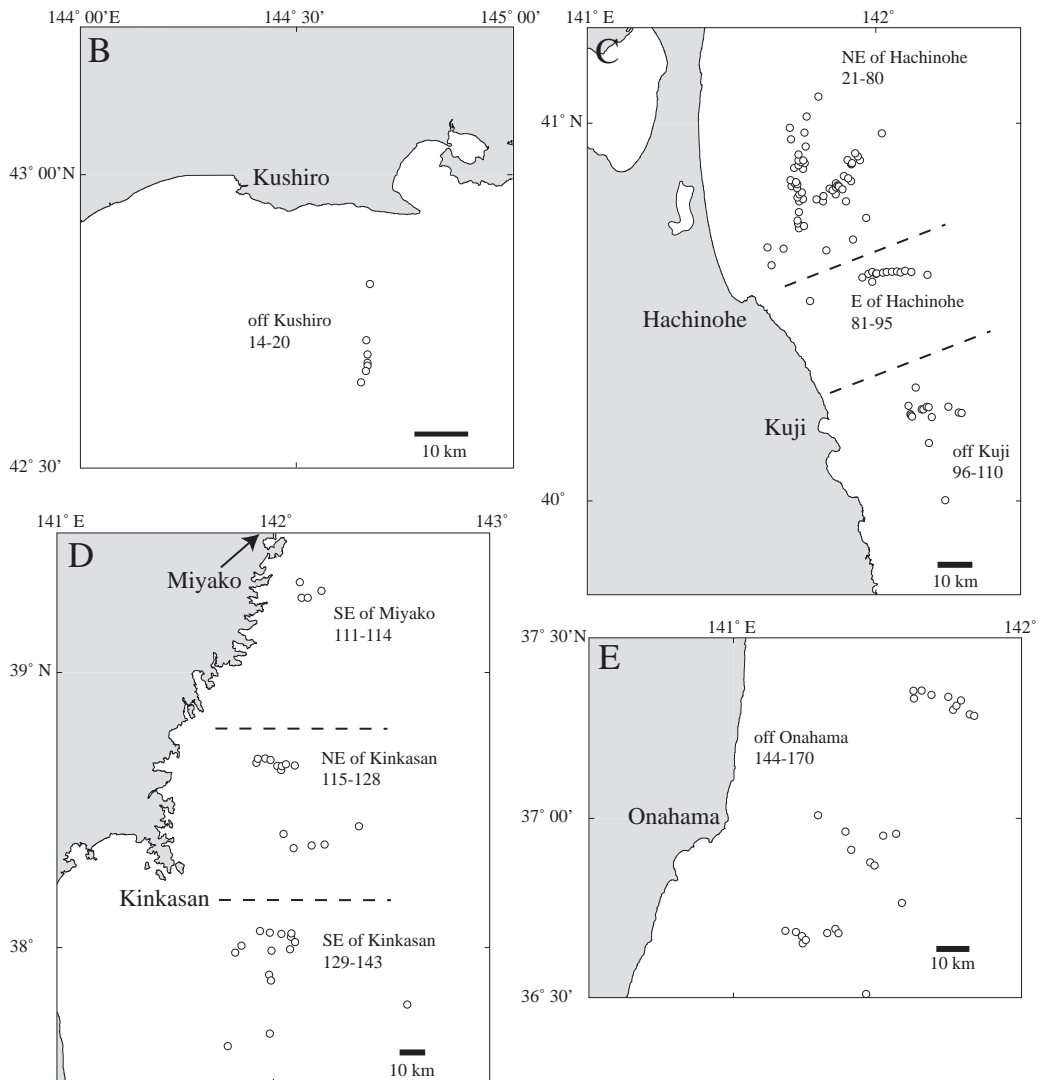


Fig. 1. (Continued)

Table 1. Sampling stations of R/Vs *Soyo-maru* (Nos. 1-13) and *Wakataka-maru* (Nos. 14-170). Abbreviations for sampling gears: C, baited trap cage; BT(BN), beam trawl designed by National Fisheries Research Institute; BT(FF), beam trawl designed for collecting flat fish of 2 m span; BT(SA), Sigby-Agassiz type beam trawl of 2 m span; DR, ORI type biological dredge of 1 m span; OT, otter trawl. See Saito *et al.* (2009) for more detailed descriptions of some sampling gears.

No.	Date	Cruise	Station	Gear	Locality	Depth (m)	Ship position
1	2007.8.2	SO07	C6-C	C	off Kushiro	5676-5680	42°07.4'N, 146°13.0'E; 42°08.2'N, 146°15.2'E
2	2007.8.1	SO07	C6-B	BT(BN)	off Kushiro	5670	42°04.6'N, 146°16.9'E; 42°05.9'N, 146°17.0'E
3	1992.6.27	SO92	SBN-3	BT(BN)	off Erimo	3100-3222	41°13.9'N, 144°04.3'E; 41°11.6'N, 144°03.6'E
4	2007.8.6	SO07	C8-C	C	off Miyako	216	39°41.0'N, 142°12.9'E; 39°40.8'N, 142°13.1'E
5	2007.8.5	SO07	C7-B	BT(BN)	off Miyako	816-820	39°40.0'N, 142°34.0'E; 39°40.0'N, 142°33.9'E
6	2006.7.17	SO06	3-2	BT(BN)	off Miyako	3960	39°45.7'N, 143°53.4'E; 39°45.7'N, 143°53.4'E
7	2006.7.17	SO07	4	BT(BN)	off Miyako	4951	39°35.2'N, 144°02.4'E; 39°35.2'N, 144°02.4'E
8	2007.8.6	SO07	K2	BT(BN)	off Kinkasan	2968-3032	38°31.2'N, 143°33.6'E; 38°31.1'N, 143°34.2'E
9	2007.8.7	SO07	K3	BT(BN)	off Kinkasan	4105-4181	38°33.7'N, 143°41.2'E; 38°33.2'N, 143°41.5'E
10	2007.8.7	SO07	K4	BT(BN)	off Kinkasan	4953-5175	38°30.4'N, 143°43.6'E; 38°31.5'N, 143°44.7'E
11	2007.8.8	SO07	O2	BT(BN)	off Onahama	2948-2991	36°48.3'N, 142°22.3'E; 36°48.7'N, 142°22.1'E
12	2007.8.8	SO07	O3	BT(BN)	off Onahama	4094-4128	36°53.4'N, 142°37.0'E; 36°53.6'N, 142°36.8'E
13	2007.8.7	SO07	O4	BT(BN)	off Onahama	5219-5268	36°54.0'N, 142°56.6'E; 36°55.5'N, 142°57.3'E
14	1992.8.29	WA9204	K1	DR	off Kushiro	100-100	42°48.9'N, 144°40.1'E; 42°48.8'N, 144°40.3'E
15	1992.8.29	WA9204	K2	DR	off Kushiro	153-153	42°43.1'N, 144°39.7'E; 42°43.1'N, 144°39.7'E
16	1992.8.29	WA9204	K3	DR	off Kushiro	177-179	42°41.7'N, 144°39.9'E; 42°41.6'N, 144°39.8'E
17	1992.8.29	WA9204	K4	DR	off Kushiro	237-252	42°40.8'N, 144°40.1'E; 42°40.8'N, 144°39.6'E
18	1992.8.29	WA9204	K5	DR	off Kushiro	348-350	42°40.5'N, 144°40.1'E; 42°40.5'N, 144°39.6'E
19	1992.8.29	WA9204	K6	DR	off Kushiro	446-450	42°40.0'N, 144°40.0'E; 42°39.9'N, 144°39.3'E
20	1992.8.29	WA9204	K7-2	DR	off Kushiro	549-550	42°38.8'N, 144°39.2'E; 42°38.8'N, 144°38.7'E
21	1992.2.13	WA9201	1	BT(FF)	NE of Hachinohe	65-66	40°37.8'N, 141°38.3'E; 40°37.3'N, 141°38.3'E
22	1992.11.5	WA9206	A41	DR	NE of Hachinohe	68-69	40°40.2'N, 141°37.6'E; 40°40.5'N, 141°37.3'E
23	1992.5.8	WA9202	A1	BT(FF)	NE of Hachinohe	80-80	40°40.1'N, 141°40.6'E; 40°40.2'N, 141°41.0'E
24	1991.10.20	WA9101	5	BT(FF)	NE of Hachinohe	95-97	40°40.0'N, 141°49.8'E; 40°39.8'N, 141°49.6'E
25	1992.5.8	WA9202	A2	BT(FF)	NE of Hachinohe	97-97	40°43.4'N, 141°43.7'E; 40°43.4'N, 141°44.3'E
26	1992.10.1	WA9205	A31	DR	NE of Hachinohe	99-99	40°44.2'N, 141°43.6'E; 40°44.1'N, 141°44.0'E
27	1992.2.13	WA9201	2	BT(FF)	NE of Hachinohe	100-101	40°43.7'N, 141°44.4'E; 40°43.8'N, 141°45.7'E
28	1992.11.5	WA9206	A42	DR	NE of Hachinohe	102-106	40°44.4'N, 141°44.1'E; 40°44.8'N, 141°44.3'E
29	1992.5.8	WA9202	A3	BT(FF)	NE of Hachinohe	125-125	40°46.0'N, 141°43.8'E; 40°45.9'N, 141°44.2'E
30	1991.10.20	WA9101	4	BT(FF)	NE of Hachinohe	135-137	40°42.0'N, 141°55.3'E; 40°41.2'N, 141°55.2'E
31	1992.5.8	WA9202	A4	BT(FF)	NE of Hachinohe	142-142	40°47.6'N, 141°43.9'E; 40°47.7'N, 141°44.2'E

Table 1. (Continued)

No.	Date	Cruise	Station	Gear	Locality	Depth (m)	Ship position
32	1992.2.13	WA9201	3	BT(FF)	NE of Hachinohe	150-151	40°48.1'N, 141°44.5'E; 40°47.9'N, 141°45.2'E
33	1992.10.1	WA9205	A32	DR	NE of Hachinohe	150-152	40°47.7'N, 141°48.8'E; 40°47.6'N, 141°49.2'E
34	1993.2.20	WA9301	A62	DR	NE of Hachinohe	151-151	40°48.3'N, 141°43.5'E; 40°48.2'N, 141°43.9'E
35	1992.11.5	WA9206	A43	DR	NE of Hachinohe	151-154	40°48.0'N, 141°47.9'E; 40°47.9'N, 141°47.4'E
36	1992.5.8	WA9202	A5	BT(FF)	NE of Hachinohe	160-160	40°48.8'N, 141°43.9'E; 40°48.7'N, 141°44.3'E
37	1992.12.11	WA9207	A52	DR	NE of Hachinohe	170-176	40°48.3'N, 141°49.2'E; 40°48.7'N, 141°49.0'E
38	1992.7.7	WA9203	A11	DR	NE of Hachinohe	173-173	40°49.1'N, 141°44.5'E; 40°49.0'N, 141°44.7'E
39	1992.5.8	WA9202	A6	BT(FF)	NE of Hachinohe	182-185	40°50.0'N, 141°42.7'E; 40°50.1'N, 141°42.2'E
40	1992.7.7	WA9203	A12	DR	NE of Hachinohe	185-190	40°49.8'N, 141°43.4'E; 40°49.7'N, 141°43.8'E
41	1992.7.7	WA9203	A13	DR	NE of Hachinohe	196-199	40°50.3'N, 141°43.3'E; 40°50.6'N, 141°43.0'E
42	1992.2.12	WA9201	4	BT(FF)	NE of Hachinohe	200-202	40°50.9'N, 141°42.6'E; 40°51.1'N, 141°41.9'E
43	1992.11.5	WA9206	A44	DR	NE of Hachinohe	200-205	40°49.6'N, 141°50.6'E; 40°49.7'N, 141°50.2'E
44	1991.10.20	WA9101	3	BT(FF)	NE of Hachinohe	200-210	40°45.3'N, 141°57.5'E; 40°44.8'N, 141°58.5'E
45	1992.5.8	WA9202	A7	BT(FF)	NE of Hachinohe	201-205	40°50.4'N, 141°43.5'E; 40°50.3'N, 141°43.8'E
46	1992.12.11	WA9207	A53	DR	NE of Hachinohe	202-203	40°48.9'N, 141°51.4'E; 40°48.6'N, 141°51.9'E
47	1993.2.20	WA9301	A64	DR	NE of Hachinohe	203-204	40°50.5'N, 141°43.5'E; 40°50.9'N, 141°43.3'E
48	1992.10.1	WA9205	A33	DR	NE of Hachinohe	205-207	40°49.5'N, 141°50.8'E; 40°49.3'N, 141°51.2'E
49	1992.10.1	WA9205	A34	DR	NE of Hachinohe	227-229	40°49.9'N, 141°51.5'E; 40°49.8'N, 141°51.9'E
50	1991.10.20	WA9101	2	BT(FF)	NE of Hachinohe	240-243	40°47.9'N, 141°51.6'E; 40°47.4'N, 141°56.0'E
51	1992.11.5	WA9206	A45-1	DR	NE of Hachinohe	242-243	40°50.4'N, 141°51.6'E; 40°50.6'N, 141°51.8'E
52	1992.8.28	WA9204	A21	DR	NE of Hachinohe	248-248	40°50.2'N, 141°51.9'E; 40°50.1'N, 141°52.1'E
53	1992.10.1	WA9205	A35	DR	NE of Hachinohe	248-250	40°50.2'N, 141°52.1'E; 40°50.0'N, 141°52.4'E
54	1993.2.20	WA9301	A65	DR	NE of Hachinohe	248-251	40°52.9'N, 141°43.4'E; 40°53.0'N, 141°42.6'E
55	1992.11.6	WA9206	A45-2	BT(SA)	NE of Hachinohe	250-251	40°50.2'N, 141°52.1'E; 40°49.8'N, 141°52.5'E
56	1992.2.12	WA9203	5	BT(FF)	NE of Hachinohe	251-260	40°52.8'N, 141°44.6'E; 40°52.8'N, 141°45.1'E
57	1992.7.7	WA9203	A14	DR	NE of Hachinohe	253-256	40°53.0'N, 141°44.0'E; 40°53.7'N, 141°43.8'E
58	1992.12.13	WA9207	A54	DR	NE of Hachinohe	261-263	40°49.7'N, 141°52.9'E; 40°49.4'N, 141°53.2'E
59	1992.5.8	WA9202	A9	DR	NE of Hachinohe	296-298	40°53.8'N, 141°45.0'E; 40°53.6'N, 141°45.4'E
60	1992.2.12	WA9201	6-2	DR	NE of Hachinohe	298-305	40°53.8'N, 141°44.2'E; 40°53.9'N, 141°44.6'E
61	1992.7.7	WA9203	A15	DR	NE of Hachinohe	300-302	40°54.1'N, 141°43.8'E; 40°54.1'N, 141°44.0'E
62	1992.2.12	WA9201	6-1	BT(FF)	NE of Hachinohe	300-310	40°54.1'N, 141°44.6'E; 40°54.1'N, 141°45.2'E
63	1992.11.5	WA9206	A47	DR	NE of Hachinohe	338-343	40°51.7'N, 141°53.2'E; 40°51.6'N, 141°53.5'E
64	1992.12.13	WA9207	A55	DR	NE of Hachinohe	348-349	40°50.8'N, 141°54.9'E; 40°50.9'N, 141°54.8'E

Table 1. (Continued)

No.	Date	Cruise	Station	Gear	Locality	Depth (m)	Ship position
65	1992.10.1	WA9205	A36	DR	NE of Hachinohe	348-353	40°51.4'N, 141°54.0'E; 40°51.2'N, 141°54.5'E
66	1992.7.7	WA9203	A16	DR	NE of Hachinohe	353-358	40°55.1'N, 141°43.7'E; 40°55.0'N, 141°44.1'E
67	1992.5.9	WA9203	A10	BT(FF)	NE of Hachinohe	391-400	40°57.3'N, 141°42.4'E; 40°57.6'N, 141°42.3'E
68	1992.7.7	WA9203	A17	DR	NE of Hachinohe	394-394	40°56.3'N, 141°45.2'E; 40°56.3'N, 141°45.6'E
69	1992.8.28	WA9204	A23	DR	NE of Hachinohe	443-447	40°53.5'N, 141°55.0'E; 40°53.5'N, 141°54.8'E
70	1992.11.5	WA9206	A48	DR	NE of Hachinohe	447-447	40°53.5'N, 141°55.0'E; 40°53.8'N, 141°54.7'E
71	1993.2.21	WA9301	A68	DR	NE of Hachinohe	447-448	40°59.2'N, 141°42.2'E; 40°59.3'N, 141°42.0'E
72	1992.10.2	WA9205	A37	DR	NE of Hachinohe	453-457	40°54.2'N, 141°54.0'E; 40°54.2'N, 141°54.2'E
73	1992.12.13	WA9207	A56	DR	NE of Hachinohe	456-461	40°53.6'N, 141°55.1'E; 40°53.8'N, 141°55.0'E
74	1992.7.7	WA9203	A18	DR	NE of Hachinohe	466-466	40°58.6'N, 141°45.0'E; 40°58.4'N, 141°45.3'E
75	1992.7.7	WA9203	A19	DR	NE of Hachinohe	506-510	41°01.0'N, 141°45.5'E; 41°01.1'N, 141°45.7'E
76	1992.8.28	WA9204	A24	DR	NE of Hachinohe	544-550	40°54.0'N, 141°56.7'E; 40°54.3'N, 141°56.7'E
77	1992.11.5	WA9206	A49	DR	NE of Hachinohe	547-549	40°54.6'N, 141°56.4'E; 40°54.9'N, 141°56.1'E
78	1992.10.2	WA9205	A38	DR	NE of Hachinohe	550-551	40°55.4'N, 141°55.6'E; 40°55.1'N, 141°55.8'E
79	1992.7.7	WA9203	A20	DR	NE of Hachinohe	618-623	41°04.2'N, 142°01.2'E; 41°04.2'N, 141°48.2'E
80	1992.10.2	WA9205	A39	DR	NE of Hachinohe	815-816	40°58.4'N, 142°01.2'E; 40°58.4'N, 142°01.3'E
81	1992.5.10	WA9202	B1	BT(FF)	E of Hachinohe	80-82	40°31.9'N, 141°46.2'E; 40°31.8'N, 141°46.4'E
82	1992.5.9	WA9202	B4	BT(FF)	E of Hachinohe	138-138	40°35.5'N, 141°57.2'E; 40°35.7'N, 141°57.2'E
83	1992.5.9	WA9202	B5	BT(FF)	E of Hachinohe	156-158	40°36.0'N, 141°58.5'E; 40°36.3'N, 141°58.4'E
84	1992.5.9	WA9202	B6	BT(FF)	E of Hachinohe	170-174	40°35.2'N, 141°59.2'E; 40°34.6'N, 141°59.3'E
85	1992.7.8	WA9203	B11	DR	E of Hachinohe	174-176	40°36.4'N, 141°59.2'E; 40°36.5'N, 141°59.3'E
86	1992.5.9	WA9202	B7	BT(FF)	E of Hachinohe	198-200	40°36.0'N, 142°00.1'E; 40°36.3'N, 142°00.0'E
87	1992.7.8	WA9202	B13	DR	E of Hachinohe	201-204	40°36.2'N, 142°00.2'E; 40°36.3'N, 142°00.1'E
88	1992.5.9	WA9202	B8	BT(FF)	E of Hachinohe	248-250	40°36.2'N, 142°01.5'E; 40°36.5'N, 142°01.5'E
89	1992.7.8	WA9203	B14	DR	E of Hachinohe	276-277	40°36.4'N, 142°02.2'E; 40°36.5'N, 142°02.3'E
90	1992.7.8	WA9203	B15	DR	E of Hachinohe	320-323	40°36.4'N, 142°03.4'E; 40°36.6'N, 142°03.3'E
91	1992.7.8	WA9203	B16	DR	E of Hachinohe	366-368	40°36.5'N, 142°04.4'E; 40°36.6'N, 142°04.4'E
92	1992.7.8	WA9203	B17	DR	E of Hachinohe	400-401	40°36.3'N, 142°05.2'E; 40°36.5'N, 142°05.1'E
93	1992.7.8	WA9203	B18	DR	E of Hachinohe	451-455	40°36.5'N, 142°06.2'E; 40°36.8'N, 142°06.0'E
94	1992.7.8	WA9203	B19	DR	E of Hachinohe	500-500	40°36.3'N, 142°07.5'E; 40°36.6'N, 142°07.3'E
95	1992.7.8	WA9203	B20	DR	E of Hachinohe	612-612	40°35.9'N, 142°10.8'E; 40°36.1'N, 142°10.7'E
96	1993.10.3	WA9312	K32D	DR	off Kuji	150-150	40°13.8'N, 142°07.2'E; 40°13.9'N, 142°07.2'E
97	1993.8.7	WA9308	K22D	DR	off Kuji	152-153	40°15.1'N, 142°06.8'E; 40°15.3'N, 142°06.8'E

Table 1. (Continued)

No.	Date	Cruise	Station	Gear	Locality	Depth (m)	Ship position
98	1993.11.30	WA9316	K42D	DR	off Kuji	152-153	40°13.6'N, 142°07.4'E; 40°13.7'N, 142°07.3'E
99	1993.5.29	WA9303	K12	DR	off Kuji	155-156	40°13.6'N, 142°07.5'E; 40°13.3'N, 142°07.6'E
100	1992.5.10	WA9202	S3	BT(FF)	off Kuji	196-198	40°00.0'N, 142°14.5'E; 40°00.2'N, 142°14.4'E
101	1992.5.10	WA9202	S1	BT(FF)	off Kuji	200-200	40°18.4'N, 142°08.2'E; 40°17.8'N, 142°08.4'E
102	1992.5.10	WA9202	S2	BT(FF)	off Kuji	200-200	40°09.5'N, 142°11.0'E; 40°09.0'N, 142°11.1'E
103	1993.5.29	WA9303	K14	DR	off Kuji	200-200	40°14.8'N, 142°09.5'E; 40°14.4'N, 142°09.6'E
104	1993.10.3	WA9312	K34D	DR	off Kuji	204-207	40°14.7'N, 142°10.0'E; 40°14.5'N, 142°09.8'E
105	1993.8.7	WA9308	K25D	DR	off Kuji	247-248	40°15.0'N, 142°10.6'E; 40°15.1'N, 142°10.6'E
106	1993.10.3	WA9312	K35D	DR	off Kuji	251-268	40°15.0'N, 142°10.8'E; 40°14.9'N, 142°11.2'E
107	1993.4.17	WA9302	K05	DR	off Kuji	267-272	40°13.2'N, 142°11.7'E; 40°13.6'N, 142°11.6'E
108	1993.5.29	WA9303	K18	DR	off Kuji	450-450	40°15.0'N, 142°15.1'E; 40°15.1'N, 142°15.1'E
109	1993.5.29	WA9303	K19	DR	off Kuji	529-534	40°14.2'N, 142°17.3'E; 40°14.0'N, 142°17.2'E
110	1993.4.17	WA9302	K09	DR	off Kuji	560-561	40°14.2'N, 142°17.8'E; 40°13.9'N, 142°17.9'E
111	1992.5.11	WA9202	S7	BT(FF)	off Miyako	200-201	39°19.6'N, 142°07.4'E; 39°19.4'N, 142°07.3'E
112	1993.8.7	WA9308	S12D	DR	off Miyako	248-250	39°16.1'N, 142°07.7'E; 39°16.2'N, 142°07.9'E
113	1993.8.7	WA9308	S13D	DR	off Miyako	307-307	39°16.3'N, 142°09.6'E; 39°16.0'N, 142°09.5'E
114	1992.8.31	WA9204	S13	DR	off Miyako	449-450	39°17.6'N, 142°13.3'E; 39°17.7'N, 142°13.3'E
115	2005.11.19	WA2005	DE250D	DR	NE of Kinkasan	249-249	38°40.6'N, 141°55.3'E; 38°40.2'N, 141°55.1'E
116	2005.11.19	WA2005	DE250	OT	NE of Kinkasan	251-252	38°42.1'N, 141°56.0'E; 38°40.5'N, 141°55.4'E
117	2005.11.19	WA2005	DE280	OT	NE of Kinkasan	281-282	38°40.5'N, 141°57.5'E; 38°42.1'N, 141°58.0'E
118	2005.11.19	WA2005	DE310	OT	NE of Kinkasan	306-309	38°40.2'N, 141°58.9'E; 38°41.8'N, 141°59.5'E
119	2005.11.20	WA2005	DE350	OT	NE of Kinkasan	345-347	38°40.6'N, 142°01.2'E; 38°38.9'N, 142°00.9'E
120	2005.11.19	WA2005	DE380D	DR	NE of Kinkasan	373-375	38°39.1'N, 142°02.2'E; 38°38.6'N, 142°02.1'E
121	2005.11.19	WA2005	DE380	OT	NE of Kinkasan	376-377	38°38.9'N, 142°02.3'E; 38°40.5'N, 142°02.4'E
122	2005.11.20	WA2005	DE410	OT	NE of Kinkasan	404-407	38°39.3'N, 142°03.4'E; 38°40.9'N, 142°03.5'E
123	2005.10.25	WA2005	E425	OT	NE of Kinkasan	424-425	38°24.1'N, 142°03.0'E; 38°25.7'N, 142°02.6'E
124	2005.11.21	WA2005	DE480	OT	NE of Kinkasan	473-477	38°39.0'N, 142°05.8'E; 38°40.6'N, 142°06.1'E
125	2005.10.25	WA2005	E480	OT	NE of Kinkasan	482-483	38°22.6'N, 142°05.3'E; 38°20.9'N, 142°06.0'E
126	2005.10.26	WA2005	E650	OT	NE of Kinkasan	657-658	38°23.0'N, 142°10.7'E; 38°21.8'N, 142°10.6'E
127	2005.10.26	WA2005	E750	OT	NE of Kinkasan	753-758	38°22.1'N, 142°13.9'E; 38°23.1'N, 142°14.5'E
128	2005.10.26	WA2005	E1000D	DR	NE of Kinkasan	1004-1005	38°26.7'N, 142°23.8'E; 38°26.4'N, 142°23.7'E
129	2005.11.17	WA2005	EF250	OT	SE of Kinkasan	251-252	37°59.8'N, 141°50.5'E; 38°01.0'N, 141°51.7'E
130	2005.11.17	WA2005	EF250D	DR	SE of Kinkasan	253-259	37°58.7'N, 141°49.3'E; 37°59.0'N, 141°49.4'E

Table 1. (Continued)

No.	Date	Cruise	Station	Gear	Locality	Depth (m)	Ship position
131	2005.11.17	WA2005	EF280	OT	SE of Kinkasan	278-285	38°02.9'N, 141°56.4'E; 38°04.4'N, 141°56.0'E
132	2005.11.17	WA2005	EF310	OT	SE of Kinkasan	314-317	38°02.5'N, 141°59.4'E; 38°04.0'N, 141°58.7'E
133	2005.11.04	WA2005	F350	OT	SE of Kinkasan	351-355	37°37.5'N, 141°47.3'E; 37°39.2'N, 141°47.4'E
134	2005.11.17	WA2005	EF350	OT	SE of Kinkasan	358-359	37°58.5'N, 141°59.1'E; 38°00.1'N, 141°59.8'E
135	2005.11.17	WA2005	EF380	OT	SE of Kinkasan	376-382	38°02.3'N, 142°02.1'E; 38°03.7'N, 142°02.4'E
136	2005.11.18	WA2005	EF410	OT	SE of Kinkasan	411-412	37°43.1'N, 141°53.9'E; 38°05.0'N, 142°03.7'E
137	2005.11.18	WA2005	EF425	OT	SE of Kinkasan	418-433	37°44.3'N, 141°54.8'E; 38°01.2'N, 142°03.8'E
138	2005.11.18	WA2005	EF450D	DR	SE of Kinkasan	452-454	38°02.2'N, 142°04.8'E; 38°02.6'N, 142°04.9'E
139	2005.11.18	WA2005	EF450	OT	SE of Kinkasan	454-454	38°04.0'N, 142°05.1'E; 38°02.2'N, 142°04.9'E
140	2005.10.27	WA2005	F480	OT	SE of Kinkasan	480-484	37°41.9'N, 141°59.0'E; 37°40.2'N, 141°59.0'E
141	2005.11.16	WA2005	EF480	OT	SE of Kinkasan	486-487	38°00.4'N, 142°05.2'E; 37°58.9'N, 142°04.1'E
142	2005.11.16	WA2005	EF510	OT	SE of Kinkasan	505-514	38°00.8'N, 142°05.7'E; 38°01.7'N, 142°06.3'E
143	2005.10.28	WA2005	F1200	OT	SE of Kinkasan	1196-1196	37°47.6'N, 142°37.1'E; 37°47.4'N, 142°37.2'E
144	2005.10.29	WA2005	G150	OT	off Onahama	150-151	36°59.8'N, 141°17.4'E; 37°01.3'N, 141°17.8'E
145	2005.10.30	WA2005	H150	OT	off Onahama	154-156	36°29.9'N, 140°57.0'E; 36°31.3'N, 141°58.1'E
146	2005.10.29	WA2005	G210	OT	off Onahama	210-211	36°57.1'N, 141°22.8'E; 36°58.5'N, 141°23.9'E
147	2005.11.11	WA2005	GH250	OT	off Onahama	249-251	36°41.9'N, 141°11.4'E; 36°40.5'N, 141°10.2'E
148	2005.11.14	WA2005	FG250	OT	off Onahama	251-254	37°22.2'N, 141°37.4'E; 37°20.4'N, 141°37.6'E
149	2005.11.14	WA2005	FG250D	DR	off Onahama	253-255	37°19.9'N, 141°37.7'E; 37°20.0'N, 141°37.4'E
150	2005.11.15	WA2005	FG280	OT	off Onahama	276-279	37°20.5'N, 141°39.2'E; 37°22.1'N, 141°39.2'E
151	2005.10.29	WA2005	G280	OT	off Onahama	277-279	36°55.4'N, 141°24.9'E; 36°54.0'N, 141°24.2'E
152	2005.11.11	WA2005	GH310	OT	off Onahama	308-309	36°40.3'N, 141°12.4'E; 36°41.7'N, 141°13.6'E
153	2005.11.15	WA2005	FG310	OT	off Onahama	311-312	37°21.5'N, 141°41.2'E; 37°19.7'N, 141°41.2'E
154	2005.11.11	WA2005	GH350	OT	off Onahama	344-351	36°39.7'N, 141°13.5'E; 36°41.0'N, 141°15.0'E
155	2005.10.29	WA2005	G350	OT	off Onahama	356-373	36°56.3'N, 141°30.9'E; 36°58.0'N, 141°31.5'E
156	2005.11.12	WA2005	GH380D	DR	off Onahama	373-378	36°39.0'N, 141°14.3'E; 36°39.3'N, 141°14.6'E
157	2005.11.12	WA2005	GH380	OT	off Onahama	376-381	36°40.4'N, 141°15.6'E; 36°39.0'N, 141°14.5'E
158	2005.11.15	WA2005	FG380	OT	off Onahama	383-383	37°19.5'N, 141°44.6'E; 37°21.1'N, 141°44.8'E
159	2005.11.14	WA2005	FG410	OT	off Onahama	410-411	37°18.9'N, 141°45.8'E; 37°17.3'N, 141°45.5'E
160	2005.11.13	WA2005	G410	OT	off Onahama	411-411	36°56.8'N, 141°33.3'E; 36°58.1'N, 141°34.4'E
161	2005.11.09	WA2005	G425	OT	off Onahama	418-427	36°53.2'N, 141°29.2'E; 36°52.1'N, 141°27.7'E
162	2005.11.15	WA2005	FG425	OT	off Onahama	426-426	37°19.6'N, 141°46.5'E; 37°17.9'N, 141°46.2'E
163	2005.11.14	WA2005	FG450	OT	off Onahama	446-450	37°18.8'N, 141°47.2'E; 37°20.5'N, 141°47.5'E

Table 1. (Continued)

No.	Date	Cruise	Station	Gear	Locality	Depth (m)	Ship position
164	2005.11.09	WA2005	G450	OT	off Onahama	448-454	36°51.6'N, 141°28.7'E; 36°52.8'N, 141°30.0'E
165	2005.11.13	WA2005	GH450	OT	off Onahama	452-454	36°41.6'N, 141°20.1'E; 36°40.2'N, 141°19.0'E
166	2005.11.13	WA2005	GH480	OT	off Onahama	479-482	36°40.8'N, 141°20.8'E; 36°42.3'N, 141°21.6'E
167	2005.11.14	WA2005	FG480	OT	off Onahama	480-480	37°18.1'N, 141°49.4'E; 37°16.5'N, 141°48.9'E
168	2005.11.11	WA2005	GH510	OT	off Onahama	509-511	36°40.3'N, 141°21.6'E; 36°41.3'N, 141°22.2'E
169	2005.11.15	WA2005	FG510D	DR	off Onahama	515-516	37°16.9'N, 141°50.0'E; 37°17.3'N, 141°50.2'E
170	2005.11.10	WA2005	G750	OT	off Onahama	750-750	36°46.2'N, 141°35.4'E; 36°45.6'N, 141°34.8'E

Results and Discussion

Ten *Ophiura* species including probably undescribed one were determined. Key to the species is given by showing distinguishing characters in Table 2.

Genus *Ophiura* Lamarck, 1816
Ophiura cryptolepis H. L. Clark, 1911
 (Figs. 2A-B, 3)

Ophiura cryptolepis H. L. Clark, 1911: 69-70, fig. 19; Djakonov, 1949: 60, fig. 91.

Ophiura cryptolepis; Baranova, 1957: 207.

Material examined. Disk diameter range is 17.2-18.8 mm. St. 5, off Miyako, 816-820 m (NSMT E-5792, ×1); St. 143, SE of Kinkasan, 1196-1196 m (NSMT E-5802, ×1).

Description. Disk is circular or rounded pentagonal and completely covered by skin containing densely fine granules except a few bare scales. Disk scales are not visible from outside but their outline partly recognized under the granules. Arm comb is well developed, not united over the

Table 2. Tabular key of the characters distinguishing *Ophiura* species in this study.

Species	Disk armature	Radial shields	Arm comb papillae	Maximum number and form of arm spines	Figures
<i>Ophiura cryptolepis</i>	covered by granules	concealed	squarish	9; short, peg-like, and closely packed	2A-B, 3
<i>Ophiura flagellata</i>	covered by skin, partly no scale	rounded triangular, small, widely separated	very long, slender	3; flat, often spatulate	2C-E, 4
<i>Ophiura</i> sp.	covered by skin, completely scales	oval or hexagonal, slightly wider than long, slightly contacted	moderately long, slender	3; flat	2F-G, 5
<i>Ophiura atacta</i>	naked scales only, central and primary ones with central boss	triangular with round distal edge, slightly longer than wide, slightly contacted	squarish	4; short, conical, pointed	6
<i>Ophiura kinbergi</i>	naked scales only	rounded triangular, longer than wide	long, fine	3; conical, tapering	7A-B, 8
<i>Ophiura sarsii sarsii</i>	naked scales only	oval with acute proximal edge, longer than wide, separated	short, leaf like	3; long, slender	7C-D, 9A-B, 10
<i>Ophiura sarsii vadicola</i>	naked scales only	oval, a little longer than wide, separated	moderately long, leaf like, with basal constriction	3; long, slender	7E-F, 9C, 11
<i>Ophiura quadrispina</i>	sparse spinelets	triangular with rounded adradial edge, slightly longer than wide, slightly contacted	short, pointed, and of unequal length	4; long, slender, sharp	12A-B, 13A-B, 14
<i>Ophiura leptoctenia</i>	sparse spinelets	oval with acute proximal edge, longer than wide, slightly contacted	long, slender	3; slender, sharp	12C-D, 13C-D, 15
<i>Ophiura bathybia</i>	many fine and long spinelets	crescentric, 3 times as long as wide, separated	long, very fine	3; very fine	12E-F, 13E-F, 16

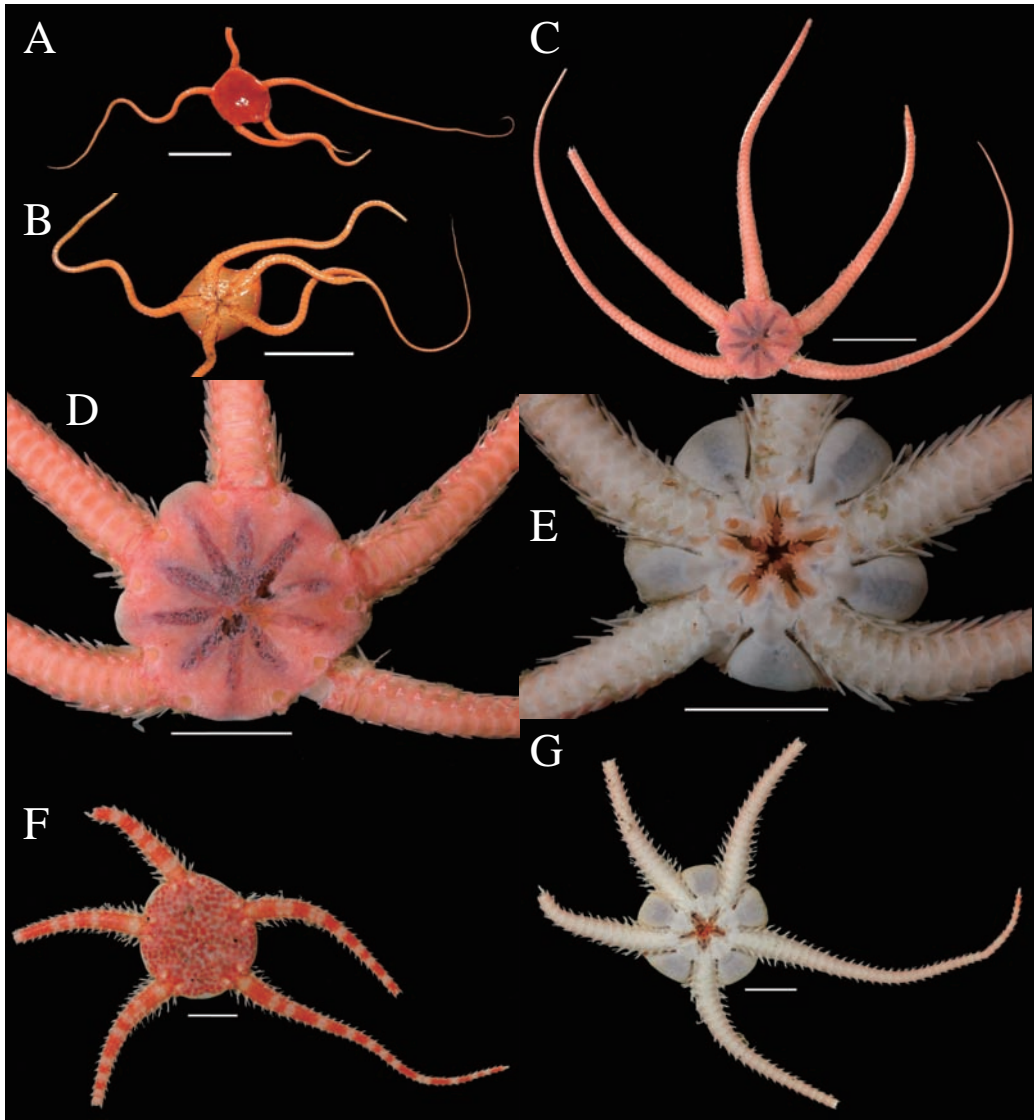


Fig. 2. Color photographs of fresh specimens. A-B, *Ophiura cryptolepis* (NSMT E-5792, dd 18.8 mm); C-E, *Ophiura flagellata* (NSMT E-5809, dd 18.6 mm); F-G, *Ophiura* sp. (Tentative specimen no. W0720, collected by R/V *Wakataka-maru*, St. A150D, off Hachinohe, 146-147 m deep, 9 Oct. 2006, dd 12.1 mm). Scale bars: 2 cm (A-C), 1 cm (D-E), 5 mm (F-G).

arms but there are a few small papillae irregularly arranged. Comb papillae are flat and squarish. Oral interradial areas are covered by scales similar to aboral ones. Genital papillae are also squarish forming a continuous row. Oral shields are somewhat pentagonal or spade-shaped, a little longer than wide. Adoral shields are long and narrow, contacting radially with each other. Oral plates are roundish parallelogram-shaped. Oral papillae are 4-5 in number on each side, rather irregular shaped. Teeth are similar to oral papillae in shape. Second oral tentacle pores are long opening into the mouth slit, with 6-8 long, rectangular, flat scales on each side. Dorsal arm plates are pentagonal or angular fan-shaped, wider than long for basal 2-3 plates but longer than wide for more distal ones. Ventral arm plates are rounded pentagonal, wider than long. First 3-4 plates are

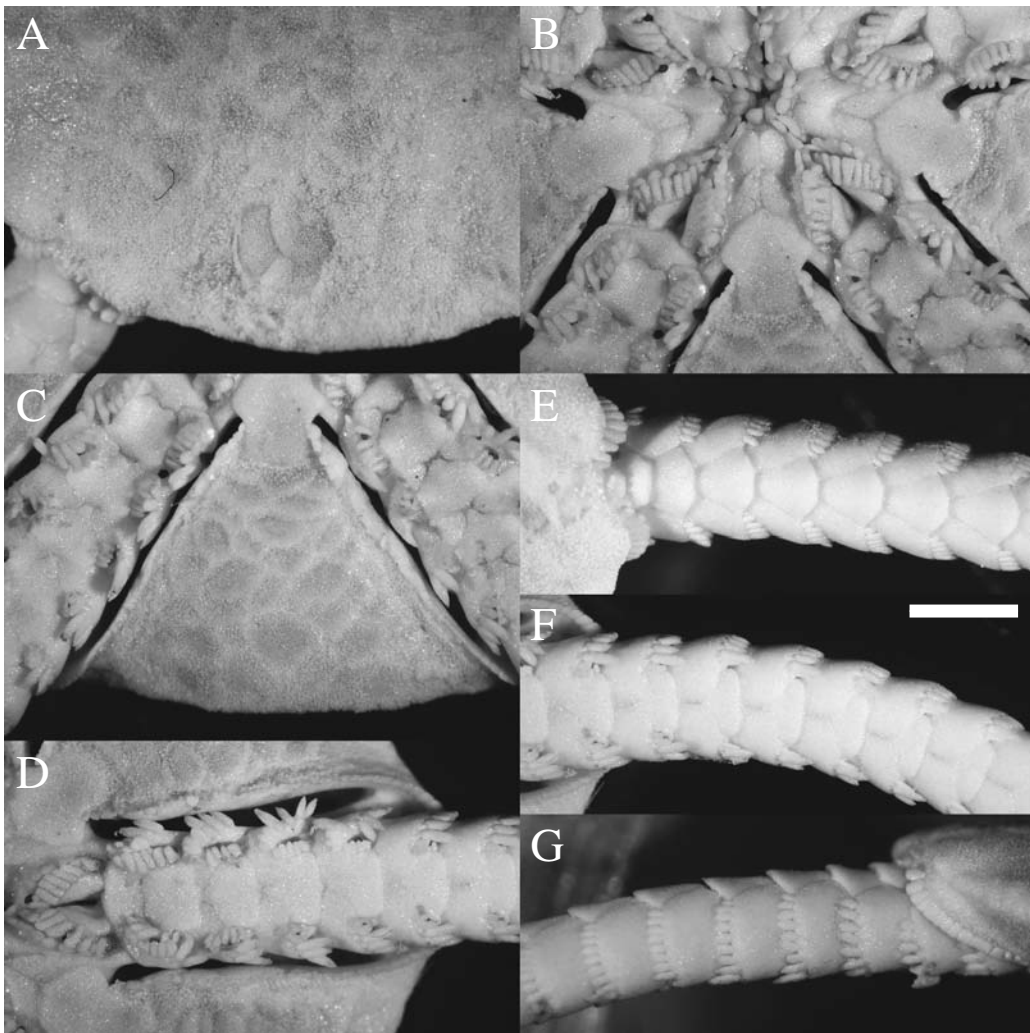


Fig. 3. *Ophiura cryptolepis*. (NSMT E-5802, dd 17.2 mm). A, a part of disk and arm base, aboral view; B, central part of disk, oral view; C, interradial part of disk, oral view; D, radial part of disk, oral view; E, basal part of the arm, aboral view; F, basal part of the arm, oral view; G, basal part of the arm, lateral view. Dried specimen. Scale bar: 2 mm (A-G).

contact with each other, but more distal plates are not contact and being shortened gradually. Number of tentacle scales decreases from about 10 to 1 over 6 basal tentacle pores although tentacle scales are relatively difficult to be distinguished from arm spines. Typical tentacle scale formula is AP1: L3-5, V6; AP2: L2-3, V5-6; AP3: L2-3, V4-5; AP4: L2-3, V3-4; AP5-6: L2-3, V1-2; AP7: L1-2, V1-2; AP8+: L1, V0. Maximum number of arm spines are 9 in basal part of arms, short and peg-like, closely packed. The oral most arm spine is the largest. Preserved specimens are nearly white in color.

Remarks. Djakonov (1954: 123-124, fig. 45) described a subspecies, *O. cryptolepis claripeltata*, having a much coarser aboral disk granules with bare areas, almost square arm comb papillae, and 6-8 arm spines instead of 9 ones. The present specimens have squarish oral papillae similar to those of *O. cryptolepis claripeltata*, but agree well with the description of *O. cryptolepis* by H. L. Clark (1911). It seems that there is no substantial difference between them, and the status of the

subspecies by Djakonov (1954) should be revised by further studies.

Distribution. Eastern North Pacific: off Washington, Alaska Peninsular, Aleutian Islands (H. L. Clark, 1911). Japan: off Omai-zaki, central Japan (H. L. Clark, 1911), off northern Honshu (Present study). Bathymetrical range is 421–1164 m (H. L. Clark, 1911). *Ophiura cryptolepis claripeltata* is reported from the Sea of Okhotsk at 515 m (Djakonov, 1954).

Ophiura flagellata (Lyman, 1878)

(Figs. 2C–E, 4)

Ophioglypha flagellata Lyman, 1878: 69, pl. 2 fig. 49–51.

Ophioglypha flagellata; 1882: 42, pl. 4 fig. 16–18; Koehler, 1897: 299; 1899: 18–19; Meissner, 1901: 925; Koehler, 1904: 56; 1906a: 6; 1906b: 261; 1907: 294.

Ophiura flagellata; H. L. Clark, 1911: 60–62, fig. 15; Matsumoto, 1917: 273–274; Koehler, 1922: 375–377, pl. 85 fig. 1, 6–7, pl. 86 fig. 1–4, 10; H. L. Clark, 1923: 359–360; Mortensen, 1933: 383–384; Murakami, 1942: 28; Djakonov, 1949: 60, fig. 89; Baranova, 1957: 206–207; Baker, 1979: 32, fig. 1a,c,e; Guille, 1981: 449; Irimura, 1982: 87–89, fig. 54, pl. 15 fig. 6; Paterson, 1985, 120, fig. 44; Irimura, 1990: 97, pl.; Fujita *et al.*, 1997: 266, pl. 1 fig. H; Liao, 2004: 387–389, fig. 233; Fujita and Irimura, 2005: 376.

Ophiura (Ophiura) flagellata; A. M. Clark and Courtman-Stock, 1976: 193–194; Alva and Vadon, 1989: 841.

Gymnophiura caerulescens Lütken and Mortensen, 1899: 114–116, pl. 7 fig. 5–7.

Material examined. Disk diameter range is 6.8–23.8 mm. St. 67, NE of Hachinohe, 391–400 m (NSMT E-5803, ×2); St. 70, NE of Hachinohe, 447–447 m (NSMT E-5804, ×1); St. 73, NE of Hachinohe, 456–461 m (NSMT E-5805, ×4); St. 77, NE of Hachinohe, 547–549 m (NSMT E-5806, ×3); St. 147, off Onahama, 249–251 m (NSMT E-5807, ×8); St. 152, off Onahama, 308–309 m (NSMT E-5808, ×1); St. 154, off Onahama, 344–351 m (NSMT E-5809, ×1; NSMT E-5810, ×7); St. 155, off Onahama, 356–373 m (NSMT E-5811, ×1); St. 164, off Onahama, 448–454 m (NSMT E-5812, ×1); St. 165, off Onahama, 452–454 m (NSMT E-5813, ×2); St. 166, off Onahama, 479–482 m (NSMT E-5814, ×7; NSMT E-5815, ×1); St. 167, off Onahama, 480–480 m (NSMT E-5816, ×3); St. 168, off Onahama, 509–511 m (NSMT E-5817, ×3).

Description. Disk is circular often with 5 interradial lobes and covered by a skin obscuring disk scales, but fine scales are faintly visible when dried near disk edge and oral interradial parts. A radiating area without scales is observed on aboral disk. Radial shields are small and triangular and widely separated. Arm comb papillae are long and slender.

Oral shields are nearly pentagonal, almost as long as wide. Adoral shields are narrow and contact interradially with each other. Oral plates are longer than wide. Oral papillae are 4–5 on each side. Teeth are larger than oral papillae. Second oral tentacle pores open almost into the mouth slit, armed with 4–5 flat scales on each side. Dorsal arm plates are hexagonal, wider than long in basal part of arms, contact with each other. Ventral arm plates are triangular, and contact with each other in basal part of arms. Tentacles scales decrease in number from about 7 in proximal part of arms to finally 1 in distal part of arms. Typical tentacle scale formula is AP1: L2–3, V2; AP2: L3, V1–2; AP3: L3–4, V1–2; AP4: L4, V1; AP5–6: L4, V0; AP7+: L3, V0. Lateral arm plates have 3 flat arm spines, sometimes spatulate in shape, most aboral spine is usually the longest and longer than the length of the corresponding arm segment.

Remarks. *Ophiura flagellata* was well described by many works. The species is easily distinguished from the congeners by the following features: the disk is covered with a skin and the disk scales are visible only when dried; a radiating area without scales is present on aboral disk (at least in the present specimens larger than 6.8 mm in disk diameter) observed clearly when dried; arm spines are flat and often spatulate. However, H. L. Clark (1911) pointed out large morphological variation, and in young individuals, dorsal and ventral arm plates are relatively longer than those of adults, and comb papillae are much longer and more slender than in adults (see also the next

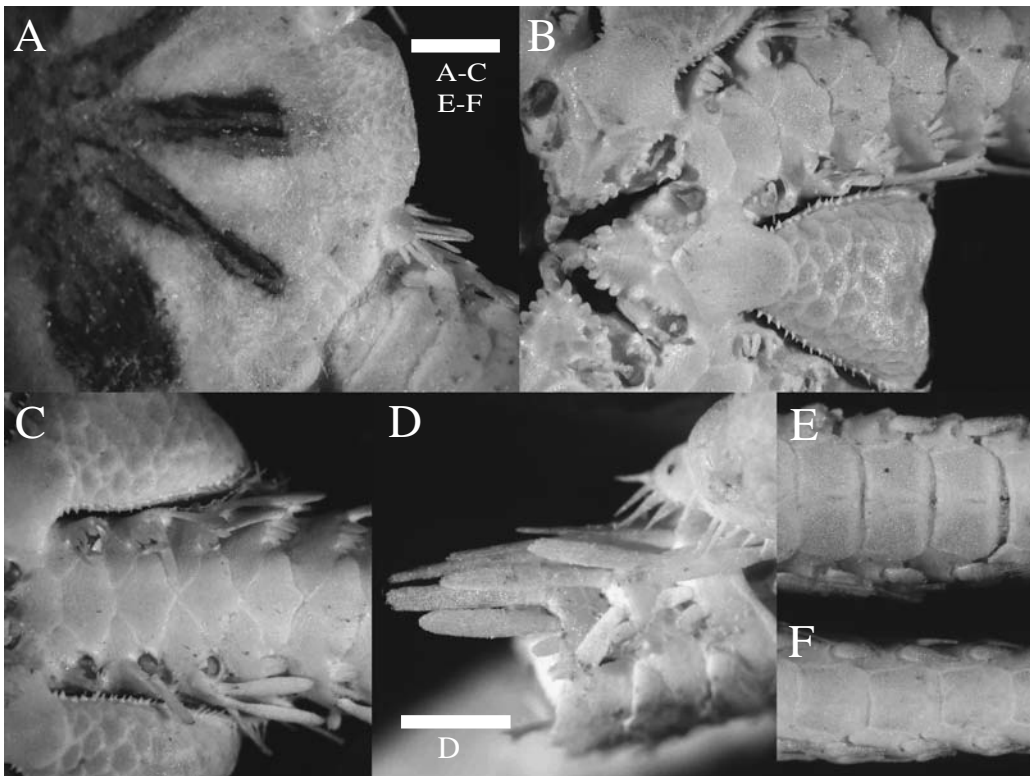


Fig. 4. *Ophiura flagellata* (NSMT E-5817, dd 13.0 mm). A, a part of disk, aboral view; B, a part of disk, oral view; C, arm base, oral view; D, arm comb papillae, arm spines and tentacle scales, lateral view; E, dorsal arm plates, basal part of the arm; F, dorsal arm plates, distal part of the arm. Dried specimens. Scale bars: 2 mm.

species, *Ophiura* sp.).

Distribution. Western Pacific from the Aleutian Islands to Malaysian waters (Irimura, 1982). Atlantic Ocean and Indian Ocean (Paterson, 1985). Bathymetrical range is 96–2330 m (Baker, 1979)

***Ophiura* sp.**
(Figs. 2F–G, 5)

? *Ophiura flagellata*; H. L. Clark, 1911: 60–62, fig. 15 (part).

Material examined. Disk diameter range is 2.5–14.2 mm. St. 21, NE of Hachinohe, 65–66 m (NSMT E-6155, ×2); St. 24, NE of Hachinohe, 95–97 m (NSMT E-6156, ×3); St. 25, NE of Hachinohe, 97–97 m (NSMT E-6157, ×8); St. 27, NE of Hachinohe, 100–101 m (NSMT E-6158, ×7; NSMT E-6159, ×88); St. 28, NE of Hachinohe, 102–106 m (NSMT E-6160, ×100); St. 29, NE of Hachinohe, 125–125 m (NSMT E-6161, ×247; NSMT E-6162, ×1); St. 30, NE of Hachinohe, 135–137 m (NSMT E-6163, ×1; NSMT E-6164, ×3); St. 31, NE of Hachinohe, 142–142 m (NSMT E-6165, ×157); St. 32, NE of Hachinohe, 150–151 m (NSMT E-6166, ×17); St. 33, NE of Hachinohe, 150–152 m (NSMT E-6167, ×3); St. 34, NE of Hachinohe, 151–151 m (NSMT E-6168, ×1); St. 36, NE of Hachinohe, 160–160 m (NSMT E-6169, ×13); St. 39, NE of Hachinohe, 182–185 m (NSMT E-6170, ×2); St. 82, E of Hachinohe, 138–138 m (NSMT E-6171, ×21); St. 83, E of Hachinohe, 156–158 m (NSMT E-6172, ×3); St. 144, off Onahama, 150–151 m (NSMT E-6173, ×1); St.

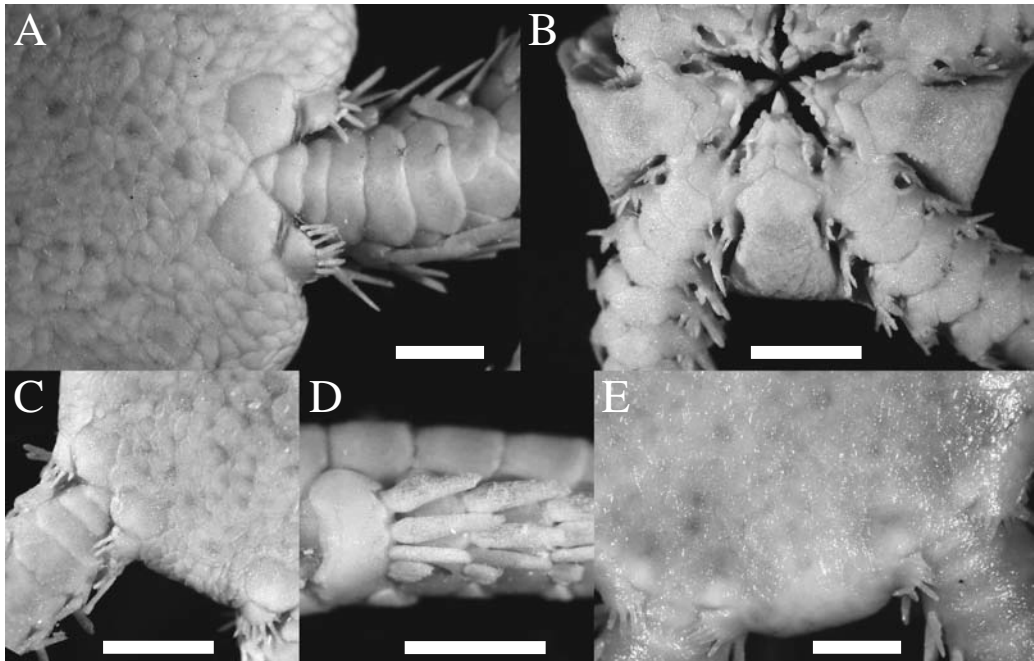


Fig. 5. *Ophiura* sp. A, a part of disk and arm base, aboral view (NSMT E-6172, dd 14.2 mm); B, a part of disk and arm base, oral view (NSMT E-6172, dd 6.1 mm); C, a part of disk and arm base, aboral view (NSMT E-6172, dd 6.1 mm); D, arm spines at basal part of the arm (NSMT E-6172, dd 14.2 mm); E, a part of disk and arm base, aboral view (NSMT E-6164, dd 10.4 mm). A-D, dried specimens; E, alcohol specimen. Scale bars: 2 mm.

145, off Onahama, 154–156 m (NSMT E-6174, $\times 1$).

Description. Disk is circular and covered by a skin obscuring disk scales (Fig. 5E), but coarse scales are clearly visible when dried (Fig. 5A). Central and primary plates are inconspicuous. Radial shields are polygonal or oval and usually separated from each other but slightly contact for small specimens. Arm comb papillae are moderately long, slender and cylindrical, slightly separated from each other.

Oral interradial areas are covered by scales similar to aboral ones. Oral shields are nearly pentagonal, with concave lateral edges and round distal edge, almost as long as wide. Adoral shields are long and narrow contact interradially with each other, and contact with first ventral arm plate radially. Oral plates are longer than wide. Oral papillae are oval, squarish or triangular and slightly flat, 4 on each side. Teeth are cone shaped and larger than oral papillae. Second oral tentacle pores open almost into the mouth slit, armed with 4–5 flat scales on each side, which are triangular or squarish with pointed tip.

Dorsal arm plates are trapezoidal with convex distal margin, about 2–3 times wider than long in basal part of arms and as long as wide in middle part of arms. Dorsal arm plates are contact with each other throughout the arm. First ventral arm plates are semicircular or rounded pentagonal. The other ventral arm plates are fan-shaped and contact with each other in basal part of arms, and irregular rhomboid-shaped and separated from each other in distal part of arms. Tentacles scales are flat and oval, 2 in basal part of arms and 1 in distal part of arms. Typical tentacle scale formula is AP1: L4–5, V3; AP2: L5, V3; AP3: L3, V2–3; AP4: L2, V1–2; AP5–9: L2, V0–1; AP10+: L1, V0. Lateral arm plates have 3 flat arm spines, most aboral one is usually the longest and longer than the length of the corresponding arm segment.

Remarks. The specimens are similar to *Ophiura flagellata* in having skin covering scales and flat arm spines. However, they have no radiating area without scales on the aboral disk, and relatively coarse and thick scales on the disk. H. L. Clark (1911) reported large morphological variation of *Ophiura flagellata* and the individuals with fully calcified disk. For the specimens collected in this study, the present specimens and *Ophiura flagellata* look completely different with no intermediate form. Depth distribution range in the present study area is also different: 65–185 m for this form and 249–549 m for *Ophiura flagellata*. The present specimens are possibly an undescribed species.

Distribution. Japan: off Hachinohe (present study). Bathymetrical range is 65–185 m (present study).

Ophiura atacta H. L. Clark, 1911

(Fig. 6)

Ophiura atacta H. L. Clark, 1911: 85–87, fig. 27.

Ophiura atacta; Djakonov, 1954: 122–123.

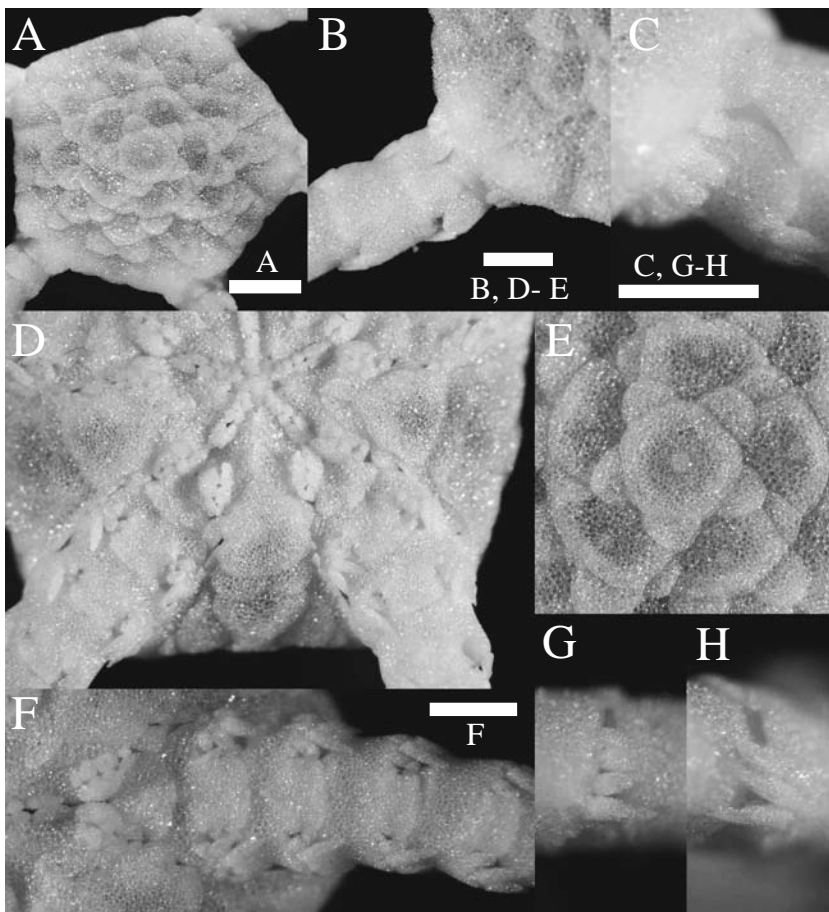


Fig. 6. *Ophiura atacta*. (NSMT E-5801, dd 4.0 mm). A, disk, aboral view; B, a part of disk and arm base, aboral view; C, arm comb; D, radial part of disk and arm base, oral view; E, primary plates; F, radial part of disk and arm base, oral view; G, arm spines at basal part of the arm; H, arm spines at basal part of the arm. Dried specimen. Scale bars: 0.5 mm (A), 1 mm (B, D, E), 0.5 mm (C, G, H), 0.5 mm (F).

Material examined. Disk diameter is 3.8 mm. St. 143, SE of Kinkasan, 1196–1196 m (NSMT E-5801, ×1)

Description. Disk is pentagonal and covered by a relatively small number of overlapping scales mostly regularly arranged. Central and primary plates are conspicuous with a small boss. Radial shields are moderate size and triangular with rounded outer edge, and a little longer than wide, well separated proximally but touching each other at distal edge. Arm combs are present below radial shields, and the papillae are rectangular, closely contact with each other, continuous to the flat, oval or rectangular genital papillae.

Oral shields are nearly pentagonal, almost as long as wide. Adoral shields are narrow contact interradially with each other. Oral plates are longer than wide. Oral papillae are almost squarish, 4 on each side, and most distal one is wider than the others. Teeth are oval with pointed tip, larger than the oral papillae. Second oral tentacle pores open almost into the mouth slit, armed with about 4 squalish scales on both side. Oral interradiation areas are covered by scales similar to aboral ones.

Dorsal arm plates are triangular, longer than wide, with convex distal margin. Only first and second dorsal arm plates are contact with each other. First ventral arm plates are fan-shaped and the others are pentagonal with rounded distal edge. They are apart from each other. Tentacles scales are oval, 2 for the first pore and 1 for the remaining pores. Tentacle scale formula is AP1-3: L2, V1; AP4+: L1, V0. Lateral arm plates have 3–4 short conical and pointed arm spines, not so well separated, and the length is about one third of the length of the corresponding arm segment.

Remarks. Only one specimen was collected. It looks very similar to the description of *Ophiura atacta* based on one specimen (dd 6 mm) by H. L. Clark (1911). But, the present specimen differs from *O. atacta* mainly by the following points: disk scales are large and primary scales have a central boss; distal most oral papillae are bigger than the other papillae. Further taxonomical decision probably requires additional specimens.

Distribution. Off Aleutian Islands (H. L. Clark, 1911). Japan: off northern Japan (present study). Bathymetrical range is 1144–1196 m (H. L. Clark, 1911; present study).

Ophiura kinbergi (Ljungman, 1867)

(Figs. 7A–B, 8)

Ophioglypha kinbergi Ljungman, 1867: 166.

Ophioglypha kinbergi; Lyman, 1882: 38–39, pl. 4 fig. 7.

Ophiura kinbergi; Meissner, 1901: 925; H. L. Clark, 1911: 37, fig. 9; Matsumoto, 1917: 271–272, fig. 73; H. L. Clark, 1921: 142; Koehler, 1922: 381–383; Matsumoto, 1941: 343–344, fig. 10; Murakami, 1942: 28; 1943: 233–234; 1944: 269–270; A. H. Clark, 1949b: 55; Djakonov, 1949: 59, fig. 90; A. H. Clark, 1952: 298; Djakonov, 1954: 113, fig. 39; A. M. Clark and Rowe, 1971: 128, fig. 46b, pl. 22 fig. 5–6; Devaney, 1974: 187–188; Guille and Jangoux, 1978: 71; Irimura, 1979: 4; 1981: 40; 1982: 89–90, fig. 55, pl. 14 fig. 3; 1990: 96; Fujita and Kohtsuka, 2003: 29; Fujita *et al.*, 2004: 193; Fujita and Irimura, 2005: 370.

Ophioglypha sinensis Lyman, 1871: 12–14, pl. 1 fig. 1–2; 1878: 99; Koehler, 1898: 60.

Ophioglypha ferruginea Lyman, 1878: 68, pl. 3 fig. 9.

Material examined. Disk diameter range is 1.9–7.8 mm. St. 22, NE of Hachinohe, 68–69 m (NSMT E-5818, ×57).

Description. Disk is circular and covered by scales of various sizes. Radial shields are rounded triangular, longer than wide, separated or slightly contact at distal edge. Arm comb papillae are long and slender.

Oral interradiation areas are covered by scales similar to aboral ones. Oral shields are nearly pentagonal with rounded distal edge and lateral lobes, slightly longer than wide. Adoral shields are narrow and long, contact interradially with each other. Oral plates are longer than wide. Oral papillae are pointed with an acute tip, 3–4 on each side. Teeth are a little larger than the oral papillae.

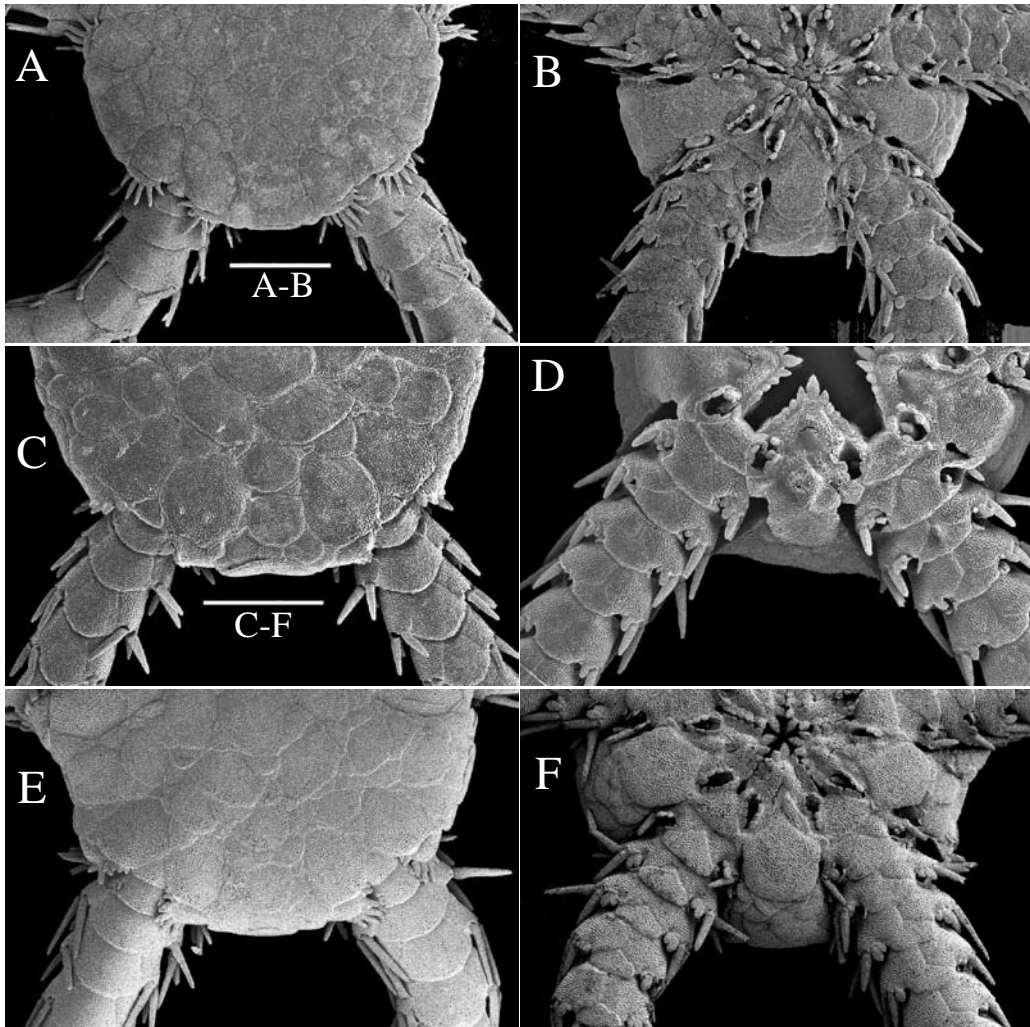


Fig. 7. SEM photographs. A-B, *Ophiura kinbergi* (NSMT E-5818; A, dd 3.1 mm, aboral view; B, the same individual, oral view); C-D, *Ophiura sarsii sarsii* (NSMT E-6087; A, dd 3.9 mm, aboral view; B, dd 4.1 mm, oral view); E-F, *Ophiura sarsii vadicola* (NSMT E-6122; C, dd 3.9 mm, aboral view; D, the same individual, oral view). Scale bars: 1 mm.

Second oral tentacle pores open almost into the mouth slit, armed with about 4 flat scales on each side.

Dorsal arm plates are trapezoidal or pentagonal, longer than wide, and contact with each other. Ventral arm plates are rounded triangular or elliptical, and apart from each other. Tentacle scales are flat and oval, about 4 for the first pore, and the number is decreasing to 1. Typical tentacle scale formula is AP1: L2-3, V3-4; AP2: L2-3, V2-3; AP3: L2, V13; AP4: L1, V1; AP5+: L1, V0. Lateral arm plates have 3 conical arm spines tapering toward tips. The most aboral one is longer than the others, and the length is about as long as the length of the corresponding arm segment.

Remarks. In the present study, *Ophiura kinbergi* was collected only at the shallowest station (68-69 m) off Hachinohe which is located at almost northern distribution limit of this widespread species. Disk is covered by naked scales without thick skin, granules nor spinelets. Arms are

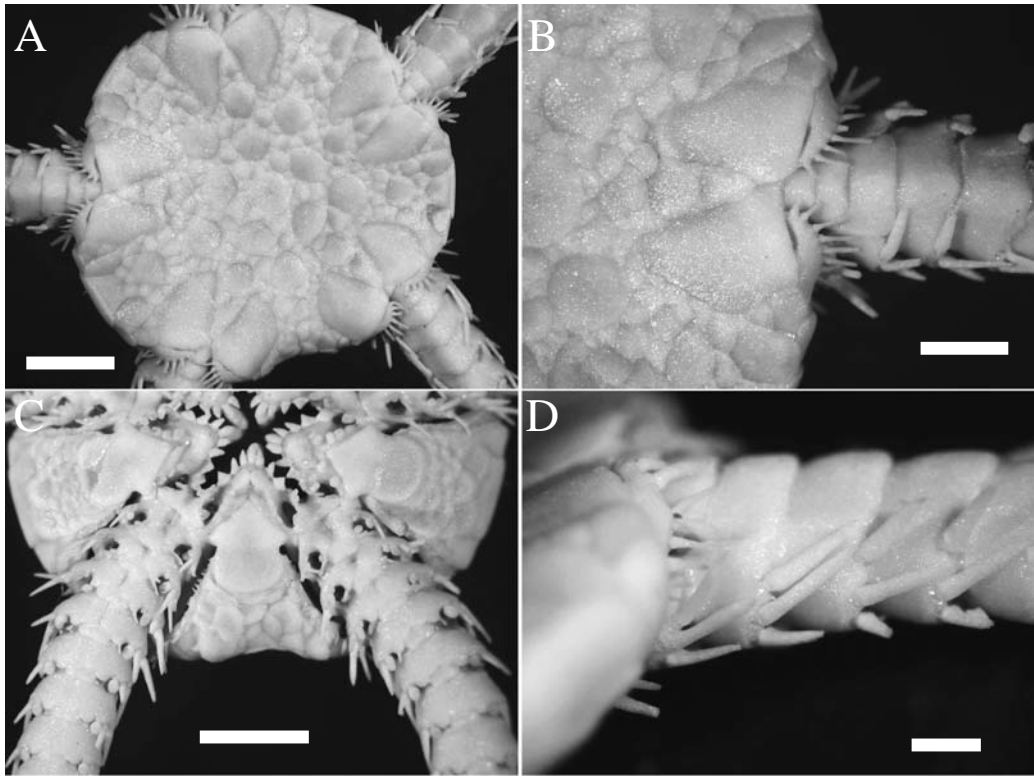


Fig. 8. *Ophiura kinbergi* (NSMT E-5818, dd 6.9 mm). A, disk, aboral view; B, a part of disk and arm base, aboral view; C, part of disk and arm base, oral view; D, arm spines, lateral view. Dried specimen. Scale bars: 2 mm (A, C), 1 mm (B), 0.5 mm (D).

flattened, and the width is larger than the height in the basal part of the arm. This species have three arm spines almost as long as the length of the corresponding arm segment. In the basal part of arms, the width of the arm is larger than the height of the arm. Arm comb papillae are fine and long, and different from those of *Ophiura sarsii sarsii* and *Ophiura sarsii vadicola*.

Distribution. Widespread in the Indo-West Pacific Region (Irimura, 1990). Japan: Honshu and more southern area. Bathymetrical range is 8-128 m (Irimura, 1990).

***Ophiura sarsii sarsii* Lütken, 1855**
(Figs. 7C-D, 9A-B, 10)

Ophiura sarsii Lütken, 1855: 101.

Ophiura sarsii; Lütken, 1858: 42-44, pl. 1 fig. 3-4; H. L. Clark, 1911: 37-45; Matsumoto, 1917: 272-273, fig. 74; 1918: 479; Koehler, 1922: 386; A. H. Clark, 1920, 13; A. H. Clark, 1940: 427; Chang, 1948: 65-66, fig. 17, pl. 10 fig. 3-4; A. H. Clark, 1949a: 376; Chang and Woo, 1954: 127-128; Djakonov, 1954: 109-111, fig. 35; Fujita and Kohtsuka, 2003: 29; Kogure and Nagasawa, 2004: 17-25.

Ophiura sarsi: Michailovskij, 1902: 489-490; Grieg, 1900: 261-262; 1903: 21-23; 1907: 15-18, pl. 1 fig. 6-8; Süßbach and Breckner, 1910: 248-249; Grieg, 1916: 8; Mortensen, 1927: 238-240, fig. 128, 1-2; 1933: 72-75; Djakonov, 1933: 101, fig. 45; Djakonov, 1949: 59, fig. 85, 86c; Baranova, 1971: 261; Paterson, 1985: fig. 43; Smirnov and Smirnov, 1990: 452-454; Yoo *et al.*, 1995: fig. 4.

Ophiura sarsi sarsi; Kogure and Hayashi, 1998: 6, 16, pl. 1D.

Ophiura (Ophioglypha) sarsii; Mortensen, 1913: 348-349.

Ophioglypha sarsii; Lyman, 1865: 41-44, fig. 2-3; Ludwig, 1886: 282-283; Grieg, 1893: 4-6; Mortensen, 1909: 82-83; Koehler, 1914: 23

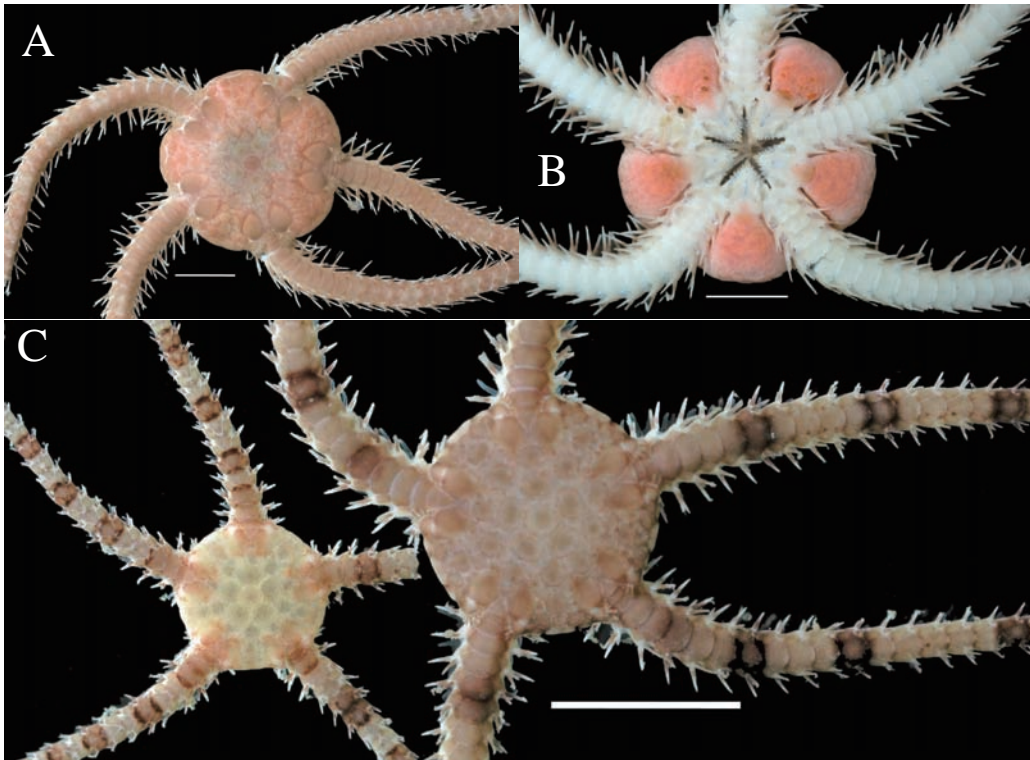


Fig. 9. Color photographs of fresh specimens. A-B, *Ophiura sarsii sarsii* (NSMT E-6092, dd 15.1 mm); C, *Ophiura sarsii vadicola* (Tentative specimen no. W0596, collected by R/V *Wakataka-maru*, St. A150D, off Hachinohe, 146-147 m deep, 9 Oct. 2006, dd 3.9 mm, 6.2 mm). Scale bars: 5 mm.

Ophioglypha sarsi; Koehler, 1909: 155-156, pl. 7 fig. 3

Ophiura coriacea Lütken, 1855: 101.

Ophiura arctica Lütken, 1855: 101.

Material examined. Disk diameter range is ca. 2 mm or larger. St. 4, off Miyako, 216 m (NSMT E-5797, $\times 5$; NSMT E-5798, $\times 12$; NSMT E-5799, $\times 1$; NSMT E-5800, $\times 10$); St. 15, off Kushiro, 153-153 m (NSMT E-5963, $\times 137$; NSMT E-5964, $\times 62$); St. 16, off Kushiro, 177-179 m (NSMT E-5965, $\times 35$; NSMT E-5966, $\times 208$); St. 17, off Kushiro, 237-252 m (NSMT E-5967, $\times 614$); St. 18, off Kushiro, 348-350 m (NSMT E-5968, $\times 697$); St. 19, off Kushiro, 446-450 m (NSMT E-5969, $\times 179$); St. 20, off Kushiro, 549-550 m (NSMT E-5970, $\times 100$); St. 40, NE of Hachinohe, 185-190 m (NSMT E-5971, $\times 388$); St. 41, NE of Hachinohe, 196-199 m (NSMT E-5972, $\times 1$); St. 42, NE of Hachinohe, 200-202 m (NSMT E-5973, $\times 874$; NSMT E-5974, $\times 1$; NSMT E-5975, $\times 266$); St. 44, NE of Hachinohe, 200-210 m (NSMT E-5976, $\times 364$; NSMT E-5977, $\times 371$); St. 45, NE of Hachinohe, 201-205 m (NSMT E-5978, $\times 270$); St. 47, NE of Hachinohe, 203-204 m (NSMT E-5979, $\times 695$); St. 48, NE of Hachinohe, 205-207 m (NSMT E-5980, $\times 742$; NSMT E-5981, $\times 1$); St. 49, NE of Hachinohe, 227-229 m (NSMT E-5982, $\times 915$); St. 50, NE of Hachinohe, 240-243 m (NSMT E-5983, $\times 65$); St. 51, NE of Hachinohe, 242-243 m (NSMT E-5984, $\times 1920$; NSMT E-5985, $\times 1$); St. 52, NE of Hachinohe, 248-248 m (NSMT E-5986, $\times 490$); St. 53, NE of Hachinohe, 248-250 m (NSMT E-5987, $\times 872$); St. 54, NE of Hachinohe, 248-251 m (NSMT E-5988, $\times 1114$); St. 55, NE of Hachinohe, 250-251 m (NSMT E-5989, $\times 160$); St. 56, NE of Hachinohe, 251-260 m (NSMT E-5990, $\times 885$; NSMT E-5991, $\times 137$); St. 57, NE of Hachinohe, 253-256 m (NSMT E-5992, $\times 1580$); St. 58, NE of Hachinohe, 261-263 m (NSMT E-5993, $\times 673$);

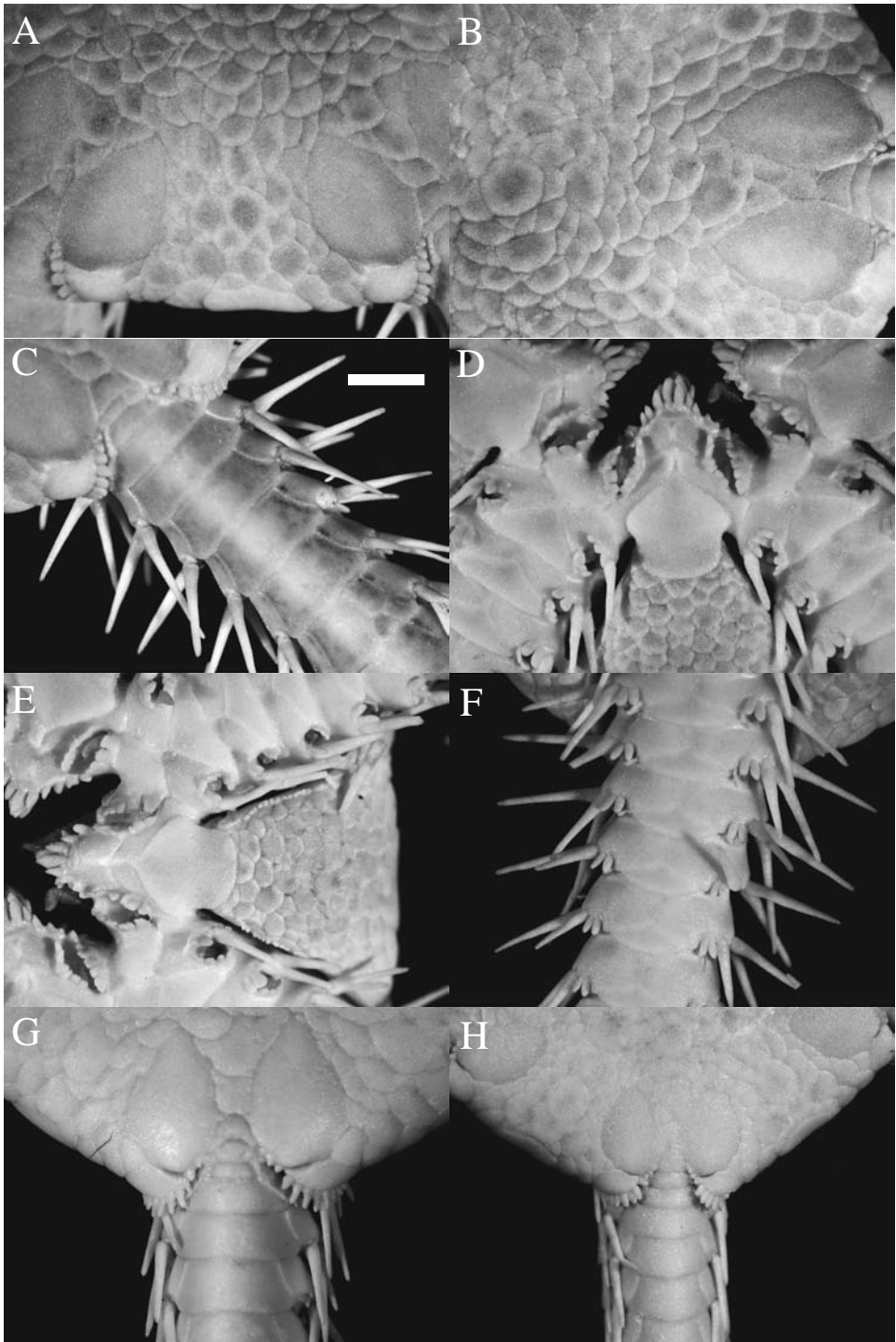


Fig. 10. *Ophiura sarsii sarsii* (A-F, NSMT E-6093, dd 16.1 mm; G, NSMT E-5980, dd 14.5 mm; H, NSMT E-5963, dd 10.2 mm). A, interradial part of disk, aboral view; B, radial part of disk, aboral view; C, arm base, aboral view; D, central part of disk, oral view; E, interradial part of disk, oral view; F, arm base, oral view; G, a part of disk and arm base, aboral view; H, a part of disk and arm base, aboral view. Dried specimens. Scale bars: 2 mm.

St. 59, NE of Hachinohe, 296-298 m (NSMT E-5994, ×7); St. 60, NE of Hachinohe, 298-305 m (NSMT E-5995, ×1534; NSMT E-5996, ×2); St. 61, NE of Hachinohe, 300-302 m (NSMT E-5997, ×553); St. 62, NE of Hachinohe, 300-310 m (NSMT E-5998, ×534; NSMT E-5999, ×9; NSMT E-6000, ×197; NSMT E-6001, ×3); St. 63, NE of Hachinohe, 338-343 m (NSMT E-6002, ×1353; NSMT E-6003, ×1); St. 64, NE of Hachinohe, 348-349 m (NSMT E-6004, ×4; NSMT E-6005, ×3; NSMT E-6006, ×1881); St. 65, NE of Hachinohe, 348-353 m (NSMT E-6007, ×3; NSMT E-6008, ×1263); St. 66, NE of Hachinohe, 353-358 m (NSMT E-6009, ×2154); St. 67, NE of Hachinohe, 391-400 m (NSMT E-6010, ×21; NSMT E-6011, ×58; NSMT E-6012, ×8); St. 68, NE of Hachinohe, 394-394 m (NSMT E-6013, ×797); St. 69, NE of Hachinohe, 443-447 m (NSMT E-6014, ×370); St. 70, NE of Hachinohe, 447-447 m (NSMT E-6015, ×739; NSMT E-6016, ×5); St. 71, NE of Hachinohe, 447-448 m (NSMT E-6017, ×76); St. 72, NE of Hachinohe, 453-457 m (NSMT E-6018, ×385); St. 73, NE of Hachinohe, 456-461 m (NSMT E-6019, ×1; NSMT E-6020, ×44; NSMT E-6021, ×1166); St. 74, NE of Hachinohe, 466-466 m (NSMT E-6022, ×282); St. 75, NE of Hachinohe, 506-510 m (NSMT E-6023, ×13); St. 76, NE of Hachinohe, 544-550 m (NSMT E-6024, ×4); St. 77, NE of Hachinohe, 547-549 m (NSMT E-6025, ×1; NSMT E-6026, ×85); St. 78, NE of Hachinohe, 550-551 m (NSMT E-6027, ×2); St. 80, NE of Hachinohe, 815-816 m (NSMT E-6028, ×2); St. 86, E of Hachinohe, 198-200 m (NSMT E-6029, ×55); St. 89, E of Hachinohe, 276-277 m (NSMT E-6030, ×1262); St. 90, E of Hachinohe, 320-323 m (NSMT E-6031, ×846); St. 91, E of Hachinohe, 366-368 m (NSMT E-6032, ×1506); St. 92, E of Hachinohe, 400-401 m (NSMT E-6033, ×813; NSMT E-6034, ×1); St. 93, E of Hachinohe, 451-455 m (NSMT E-6035, ×335); St. 94, E of Hachinohe, 500-500 m (NSMT E-6036, ×435); St. 95, E of Hachinohe, 612-612 m (NSMT E-6037, ×3; NSMT E-6038, ×1); St. 100, off Kuji, 196-198 m (NSMT E-6049, ×123); St. 101, off Kuji, 200-200 m (NSMT E-6039, ×37); St. 104, off Kuji, 204-207 m (NSMT E-6040, ×247); St. 105, off Kuji, 247-248 m (NSMT E-6041, ×457); St. 106, off Kuji, 251-268 m (NSMT E-6042, ×282); St. 107, off Kuji, 267-272 m (NSMT E-6043, ×549); St. 108, off Kuji, 450-450 m (NSMT E-6044, ×129; NSMT E-6045, ×1; NSMT E-6046, ×1); St. 109, off Kuji, 529-534 m (NSMT E-6047, ×120); St. 110, off Kuji, 560-561 m (NSMT E-6048, ×71); St. 111, off Miyako, 200-201 m (NSMT E-6050, ×363); St. 112, off Miyako, 248-250 m (NSMT E-6051, ×1304; NSMT E-6052, ×1); St. 113, off Miyako, 307-307 m (NSMT E-6053, ×1); St. 114, off Miyako, 449-450 m (NSMT E-6054, ×692); St. 115, NE of Kinkasan, 249-249 m (NSMT E-6055, ×392; NSMT E-6056, ×1; NSMT E-6057, ×163; NSMT E-6058, ×438; NSMT E-6059, ×41; NSMT E-6060, ×1; NSMT E-6061, ×8; NSMT E-6062, ×2; NSMT E-6063, ×187); St. 116, NE of Kinkasan, 251-252 m (NSMT E-6064, ×32; NSMT E-6065, ×1); St. 117, NE of Kinkasan, 281-282 m (NSMT E-6066, ×46); St. 118, NE of Kinkasan, 306-309 m (NSMT E-6067, ×21); St. 119, NE of Kinkasan, 345-347 m (NSMT E-6068, ×3); St. 120, NE of Kinkasan, 373-375 m (NSMT E-6069, ×12; NSMT E-6070, ×54; NSMT E-6071, ×1; NSMT E-6072, ×27; NSMT E-6073, ×1); St. 121, NE of Kinkasan, 376-377 m (NSMT E-6074, ×29); St. 122, NE of Kinkasan, 404-407 m (NSMT E-6075, ×12); St. 123, NE of Kinkasan, 424-425 m (NSMT E-6076, ×2); St. 124, NE of Kinkasan, 473-477 m (NSMT E-6077, ×10); St. 129, SE of Kinkasan, 251-252 m (NSMT E-6078, ×9); St. 130, SE of Kinkasan, 253-259 m (NSMT E-6079, ×3; NSMT E-6080, ×1); St. 131, SE of Kinkasan, 278-285 m (NSMT E-6081, ×21); St. 132, SE of Kinkasan, 314-317 m (NSMT E-6082, ×20); St. 133, SE of Kinkasan, 351-355 m (NSMT E-6083, ×3); St. 134, SE of Kinkasan, 358-359 m (NSMT E-6084, ×19); St. 135, SE of Kinkasan, 376-382 m (NSMT E-6085, ×22); St. 136, SE of Kinkasan, 411-412 m (NSMT E-6086, ×13); St. 138, SE of Kinkasan, 452-454 m (NSMT E-6087, ×4; NSMT E-6088, ×32); St. 139, SE of Kinkasan, 454-454 m (NSMT E-6089, ×4); St. 141, SE of Kinkasan, 486-487 m (NSMT E-6090, ×25; NSMT E-6091, ×1); St. 147, off Onahama, 249-251 m (NSMT E-6092, ×1); St. 148, off Onahama, 251-254 m (NSMT E-6093, ×26); St. 149, off Onahama, 253-255 m (NSMT E-6094, ×1; NSMT E-6095, ×2); St. 150, off Onahama, 276-279

m (NSMT E-6096, $\times 14$; NSMT E-6097, $\times 4$; NSMT E-6098, $\times 20$); St. 151, off Onahama, 277-279 m (NSMT E-6099, $\times 2$); St. 152, off Onahama, 308-309 m (NSMT E-6100, $\times 3$); St. 153, off Onahama, 311-312 m (NSMT E-6101, $\times 20$; NSMT E-6102, $\times 2$); St. 158, off Onahama, 383-383 m (NSMT E-6103, $\times 20$); St. 159, off Onahama, 410-411 m (NSMT E-6104, $\times 1$); St. 166, off Onahama, 479-482 m (NSMT E-6105, $\times 1$; NSMT E-6106, $\times 2$).

Description. Disk is circular and covered by small scales with a distinguishable central plate. Radial shields are oval with angular proximal edge, longer than wide, well separated. Arm comb papillae are short and leaf like.

Oral interradiar areas are covered by scales similar to aboral ones. Oral shields are nearly pentagonal, slightly longer than wide. Adoral shields are narrow contact interradiarally with each other. Oral plates are longer than wide. Oral papillae are long with an acute tip, 4 on each side. Teeth are a little larger than the oral papillae. Second oral tentacle pores open almost into the mouth slit, armed with about 7 flat scales on each side.

Dorsal arm plates are trapezoidal, longer than wide, and contact with each other. Ventral arm plates are broad triangular or elliptical, and apart from each other. Tentacles scales are flat and oval, about 6 for the first pore, and the number is decreasing to 1. Typical tentacle scale formula is AP1: L2-3, V3-4; AP2: L3, V2-4; AP3-10: L3, V2; AP11+: L2, V1. Lateral arm plates have 3 long and slender arm spines with sharp and pointed tips. Two aboral ones are longer than the oral most one, and the length is about 1.5-2 times as long as the length of the corresponding arm segment.

Remarks. *Ophiura sarsii sarsii* is very common and widespread species in boreal waters. Disk is covered by naked scales without thick skin, granules nor spinelets. Arms are flattened, and the width is larger than the height in the basal part of arms. This species have 3 arm spines longer than the corresponding arm segment. In the basal part of arms, the width of the arm is larger than the height of the arm. Arm comb papillae are not squalish, but very short and leaf like. A subspecies *Ophiura sarsii vadicola* is distinguished from *O. sarsii sarsii* (Djakonov, 1954; see the next species, *Ophiura sarsii vadicola*). This species often occurs in huge numbers, in some area together with *Ophiura leptoctenia*.

Distribution. Widespread in the northern hemisphere, circumpolar in arctic waters to about 35°N (Djakonov, 1954). Bathymetrical range is 3-3000 m (Djakonov, 1954).

Ophiura sarsii vadicola Djakonov, 1949

(Figs. 7E-F, 9C, 11)

Ophiura sarsi f. *vadicola* Djakonov, 1949: 59, fig. 86a-b.

Ophiura sarsii vadicola; Djakonov, 1954: 111, fig. 36; Yoo *et al.*, 1995: fig. 5; Liao, 2004: 396-398, fig. 240.

Ophiura sarsi vadicola; Baranova, 1971: 261-263; Kogure, 1999: 62.

Material examined. Disk diameter range is ca. 2 mm or larger. St. 14, off Kushiro, 100-100 m (NSMT E-6107, $\times 43$); St. 21, NE of Hachinohe, 65-66 m (NSMT E-6108, $\times 1$); St. 22, NE of Hachinohe, 68-69 m (NSMT E-6109, $\times 4$); St. 23, NE of Hachinohe, 80-80 m (NSMT E-6111, $\times 64$); St. 25, NE of Hachinohe, 97-97 m (NSMT E-6112, $\times 6$); St. 26, NE of Hachinohe, 99-99 m (NSMT E-6113, $\times 115$); St. 27, NE of Hachinohe, 100-101 m (NSMT E-6114, $\times 27$); St. 28, NE of Hachinohe, 102-106 m (NSMT E-6115, $\times 4$); St. 29, NE of Hachinohe, 125-125 m (NSMT E-6116, $\times 9$); St. 30, NE of Hachinohe, 135-137 m (NSMT E-6117, $\times 10$; NSMT E-6118, $\times 5$); St. 31, NE of Hachinohe, 142-142 m (NSMT E-6119, $\times 179$); St. 32, NE of Hachinohe, 150-151 m (NSMT E-6120, $\times 334$); St. 33, NE of Hachinohe, 150-152 m (NSMT E-6121, $\times 49$; NSMT E-6122, $\times 18$); St. 34, NE of Hachinohe, 151-151 m (NSMT E-6123, $\times 58$); St. 35, NE of Hachinohe, 151-154 m (NSMT E-6124, $\times 3$); St. 36, NE of Hachinohe, 160-160 m (NSMT E-6125, $\times 1$; NSMT E-6126,

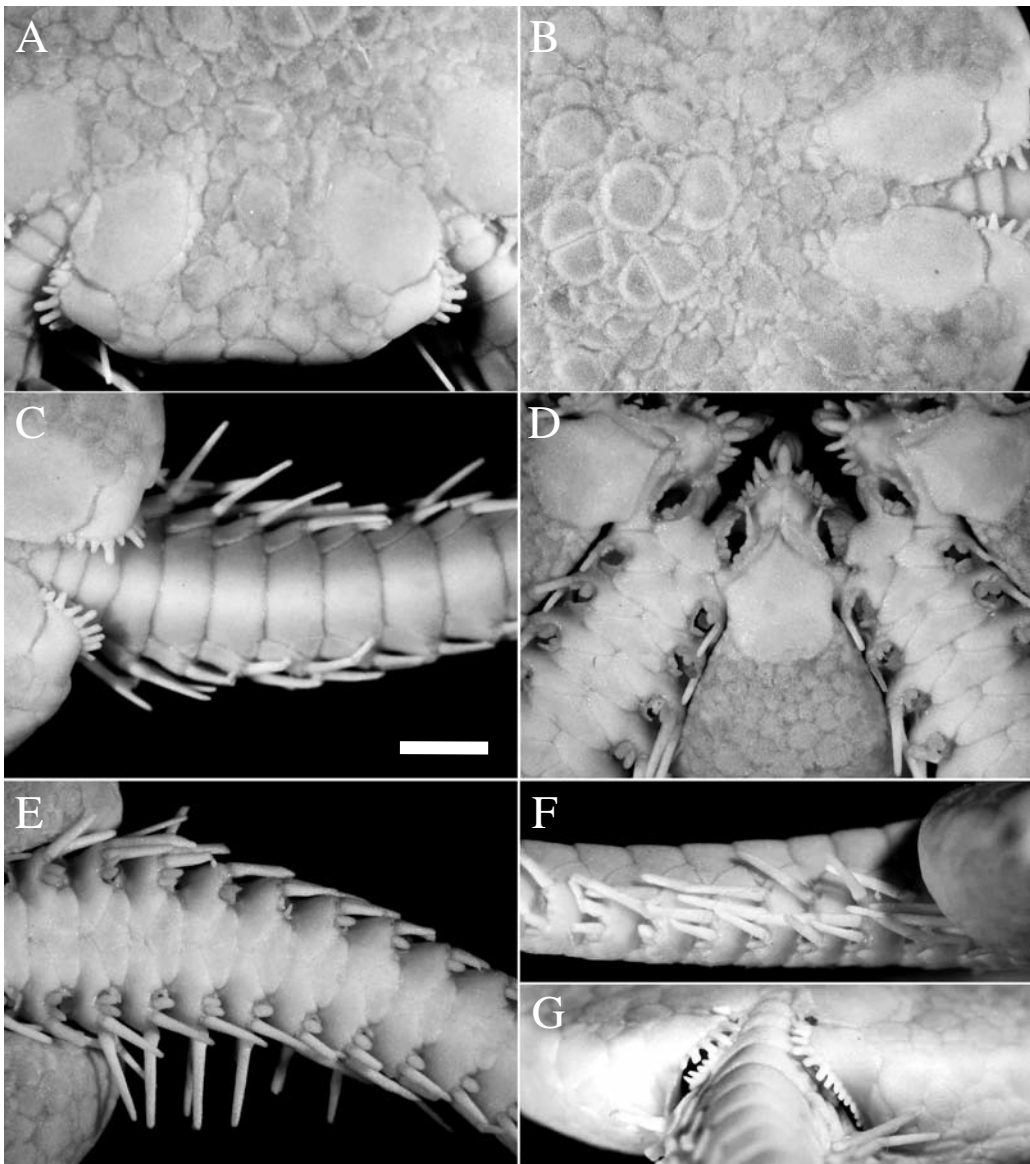


Fig. 11. *Ophiura sarsii vadicola* (NSMT E-6118, dd 14.6 mm). A, interradiation part of disk, aboral view; B, radial part of disk, aboral view; C, arm base, aboral view; D, a part of disk, oral view; E, arm base, oral view; F, arm base, lateral view; G, arm comb, lateral view. Dried specimen. Scale bar: 2 mm.

×1; NSMT E-6127, ×182); St. 37, NE of Hachinohe, 170-176 m (NSMT E-6128, ×89); St. 38, NE of Hachinohe, 173-173 m (NSMT E-6129, ×173); St. 39, NE of Hachinohe, 182-185 m (NSMT E-6130, ×17; NSMT E-6131, ×85); St. 40, NE of Hachinohe, 185-190 m (NSMT E-6132, ×56); St. 41, NE of Hachinohe, 196-199 m (NSMT E-6133, ×980); St. 42, NE of Hachinohe, 200-202 m (NSMT E-6134, ×1); St. 43, NE of Hachinohe, 200-205 m (NSMT E-6135, ×50); St. 44, NE of Hachinohe, 200-210 m (NSMT E-6136, ×1); St. 46, NE of Hachinohe, 202-203 m (NSMT E-6137, ×283; NSMT E-6138, ×1); St. 48, NE of Hachinohe, 205-207 m (NSMT E-6139, ×15); St. 81, E of Hachinohe, 80-82 m (NSMT E-6140, ×9); St. 82, E of Hachinohe, 138-138 m (NSMT E-6141, ×7); St. 83, E of Hachinohe, 156-158 m (NSMT E-6142, ×58); St. 84, E of Hachinohe, 170-174 m

(NSMT E-6143, ×9); St. 85, E of Hachinohe, 174–176 m (NSMT E-6144, ×1); St. 86, E of Hachinohe, 198–200 m (NSMT E-6145, ×1); St. 87, E of Hachinohe, 201–204 m (NSMT E-6146, ×30); St. 96, off Kuji, 150–150 m (NSMT E-6147, ×52); St. 97, off Kuji, 152–153 m (NSMT E-6148, ×129); St. 98, off Kuji, 152–153 m (NSMT E-6149, ×24); St. 99, off Kuji, 155–156 m (NSMT E-6150, ×30); St. 102, off Kuji, 200–200 m (NSMT E-6151, ×16); St. 103, off Kuji, 200–200 m (NSMT E-6152, ×185); St. 145, off Onahama, 154–156 m (NSMT E-6153, ×38); St. 146, off Onahama, 210–211 m (NSMT E-6154, ×4).

Description. Disk is circular and covered by small scales of relatively various sizes with primary plates. Radial shields are oval, slightly longer than wide, well separated. Arm comb papillae are moderate in length, often with a slight basal constriction.

Oral interradial areas are covered by scales similar to aboral ones. Oral shields are nearly pentagonal, slightly longer than wide. Adoral shields are narrow and in contact with each other. Oral plates are longer than wide. Oral papillae are long with an acute tip, 4 on each side. Teeth are a little larger than the oral papillae. Second oral tentacle pores open almost into the mouth slit, armed with about 5–6 flat scales on both side.

Dorsal arm plates are trapezoidal, longer than wide, and contact with each other. Ventral arm plates are broad triangular or elliptical, and separated from each other. Tentacles scales are flat and oval, about 6 for the first pore, and decrease to 1 on the distal arm segments. Typical tentacle scale formula is AP1: L2, V3; AP2–3: L2, V2; AP4: L2, V1–2; AP5–6: L1–2, V1; AP7–9: L1, V1; AP10+: L1, V0. Lateral arm plates have 3 long, slender arm spines with relatively obtuse tips. Two aboral ones are longer than the other, and the length is about 1.5–2 times as long as the length of the corresponding arm segment.

Remarks. Djakonov (1954) mentioned this subspecies is distinguished from *Ophiura sarsii* by following characters. Arm comb papillae are longer and more slender, subacute, usually with a slight basal constriction. Radial shields are shorter, usually oval or round, almost as long as width. Arm spines are shorter and more obtuse. Color is more variegated. Yoo *et al.* (1995) made numerical multivariate analyses using 20 morphometric variables to show clear morphological differences among three related species, *O. kinbergi*, *O. sarsii sarsii* and *O. sarsii vadicola*. Depth distribution range in the present study area is also different among the three species: 68–69 m for *O. kinbergi*, 65–211 m for *O. sarsii vadicola* and 153–816 m for *O. sarsii sarsii*.

Distribution. Tatar Strait (Djakonov, 1954), the Sea of Japan (Djakonov, 1954; Yoo *et al.* 1995). Japan: the Sea of Japan (Kogure, 1999), off Pacific Coast of northern Honshu (present study). Bathymetrical range is 40–211 m (Djakonov, 1954; Kogure, 1999; present study).

Ophiura quadrispina H. L. Clark, 1911

(Figs. 12A–B, 13A–B, 14)

Ophiura quadrispina H. L. Clark, 1911: 55–58, fig. 13.

Ophiura quadrispina; Djakonov, 1949: 60, fig. 87b; Djakonov, 1954: 117; Fujita and Kohtsuka, 2003: 29.

Material examined. Disk diameter range is ca. 2 mm or larger. St. 3, off Erimo, 3100–3222 m (NSMT E-5796, ×2); St. 17, off Kushiro, 237–252 m (NSMT E-5901, ×6); St. 19, off Kushiro, 446–450 m (NSMT E-5902, ×1); St. 53, NE of Hachinohe, 248–250 m (NSMT E-5903, ×1); St. 63, NE of Hachinohe, 338–343 m (NSMT E-5904, ×6); St. 64, NE of Hachinohe, 348–349 m (NSMT E-5905, ×26; NSMT E-5906, ×1); St. 65, NE of Hachinohe, 348–353 m (NSMT E-5907, ×9); St. 66, NE of Hachinohe, 353–358 m (NSMT E-5908, ×4); St. 67, NE of Hachinohe, 391–400 m (NSMT E-5909, ×250); St. 68, NE of Hachinohe, 394–394 m (NSMT E-5910, ×156); St. 69, NE of Hachinohe, 443–447 m (NSMT E-5911, ×157); St. 70, NE of Hachinohe, 447–447 m (NSMT

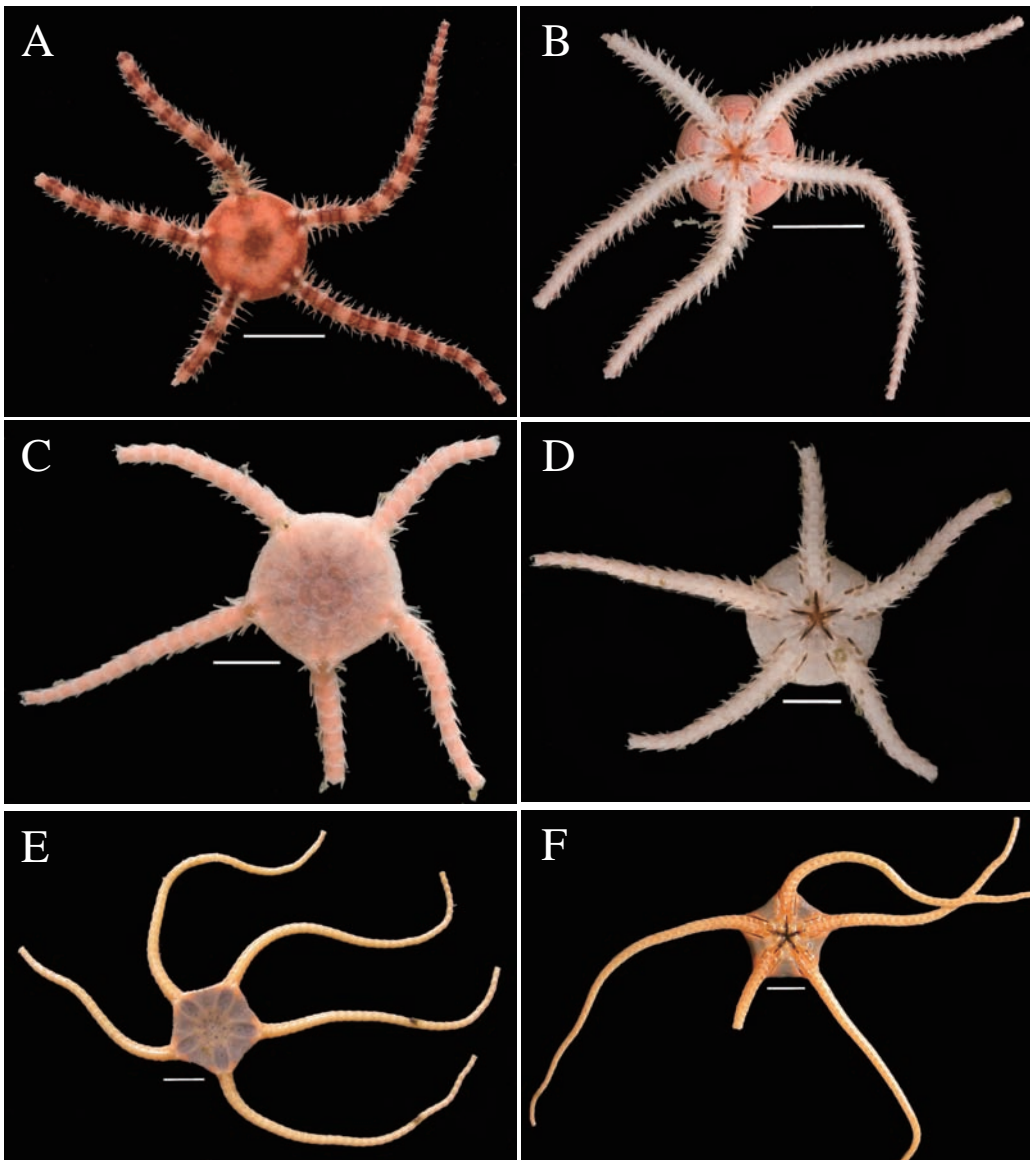


Fig. 12. Color photographs of fresh specimens. A–B, *Ophiura quadrispina* (NSMT E-5929, dd 6.7 mm); C–D, *Ophiura leptoctenia* (Tentative specimen no. W0399, collected by R/V *Wakataka-maru*, St. FG450, off Onahama, 446–450 m, 14 Nov. 2005, dd 4.5 mm); E–F, *Ophiura bathybia* (NSMT E-5763, dd 11.0 mm). Scale bars: 5 mm (A–B, E–F), 2 mm (C–D)

E-5912, $\times 138$); St. 72, NE of Hachinohe, 453–457 m (NSMT E-5913, $\times 16$); St. 73, NE of Hachinohe, 456–461 m (NSMT E-5914, $\times 175$; NSMT E-5915, $\times 12$); St. 74, NE of Hachinohe, 466–466 m (NSMT E-5916, $\times 2$); St. 76, NE of Hachinohe, 544–550 m (NSMT E-5917, $\times 1$); St. 77, NE of Hachinohe, 547–549 m (NSMT E-5918, $\times 31$); St. 88, E of Hachinohe, 248–250 m (NSMT E-5919, $\times 1$); St. 90, E of Hachinohe, 320–323 m (NSMT E-5920, $\times 1$); St. 93, E of Hachinohe, 451–455 m (NSMT E-5921, $\times 5$); St. 94, E of Hachinohe, 500–500 m (NSMT E-5922, $\times 1$); St. 108, off Kuji, 450–450 m (NSMT E-5923, $\times 7$); St. 115, NE of Kinkasan, 249–249 m (NSMT E-5924, $\times 1$; NSMT E-5925, $\times 1$; NSMT E-5926, $\times 1$); St. 124, NE of Kinkasan, 473–477 m (NSMT E-5927, $\times 1$); St.

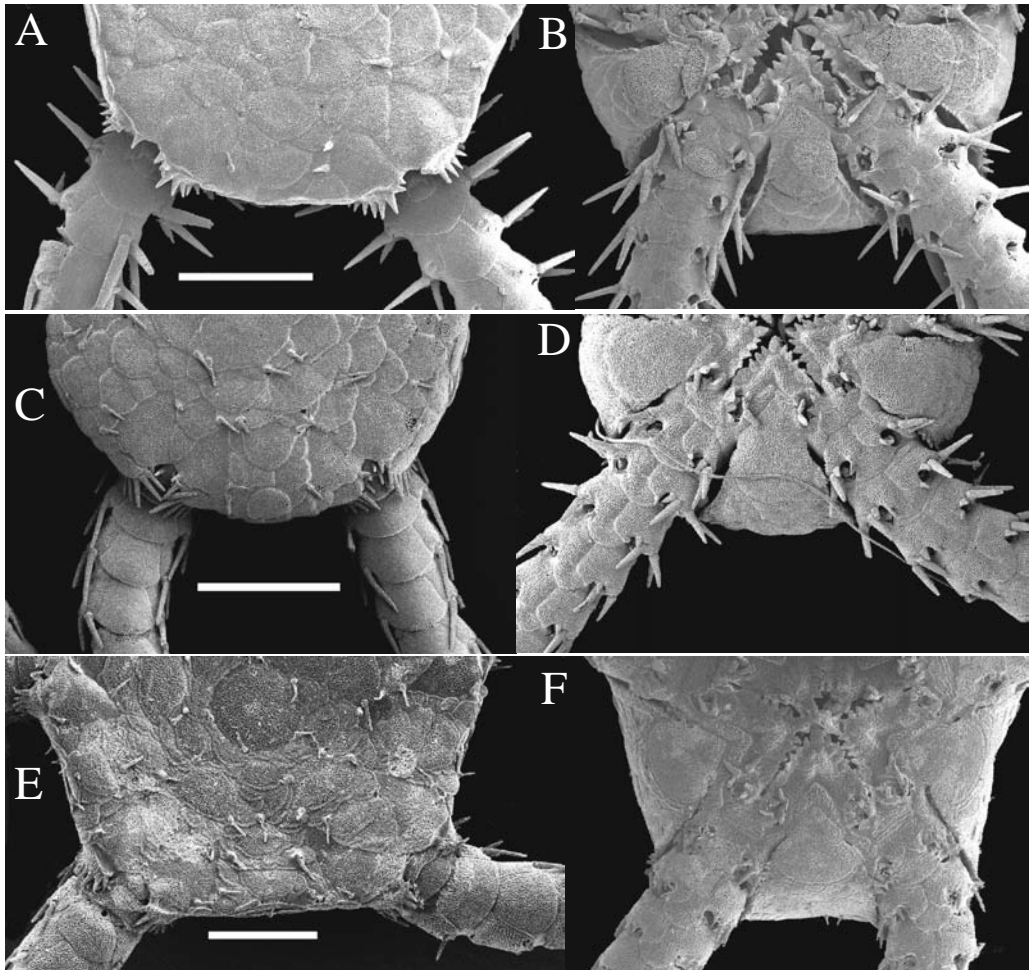


Fig. 13. SEM photographs. A-B, *Ophiura quadrispina* (NSMT E-5954; A, dd 3.8 mm, aboral view; B, dd 3.4 mm, oral view); C-D, *Ophiura leptoctenia* (NSMT E-5883; C, dd 3.1 mm, aboral view; D, dd 3.1 mm, oral view); E-F, *Ophiura bathybia* (NSMT E-5783; E, dd 3.8 mm, aboral view; F, the same individual, oral view). Scale bars: 1 mm.

129, SE of Kinkasan, 251-252 m (NSMT E-5928, $\times 1$); St. 130, SE of Kinkasan, 253-259 m (NSMT E-5929, $\times 1$; NSMT E-5930, $\times 1$; NSMT E-5936, $\times 38$; NSMT E-5937, $\times 8$); St. 137, SE of Kinkasan, 418-433 m (NSMT E-5931, $\times 1$); St. 138, SE of Kinkasan, 452-454 m (NSMT E-5932, $\times 5$); St. 139, SE of Kinkasan, 454-454 m (NSMT E-5933, $\times 1$; NSMT E-5934, $\times 1$); St. 140, SE of Kinkasan, 480-484 m (NSMT E-5935, $\times 1$); St. 151, off Onahama, 277-279 m (NSMT E-5938, $\times 1$); St. 153, off Onahama, 311-312 m (NSMT E-5939, $\times 1$); St. 154, off Onahama, 344-351 m (NSMT E-5940, $\times 2$; NSMT E-5941, $\times 1$; NSMT E-5942, $\times 1$); St. 157, off Onahama, 376-381 m (NSMT E-5943, $\times 1$; NSMT E-5944, $\times 1$); St. 158, off Onahama, 383-383 m (NSMT E-5945, $\times 1$; NSMT E-5946, $\times 6$); St. 159, off Onahama, 410-411 m (NSMT E-5947, $\times 19$; NSMT E-5948, $\times 1$); St. 160, off Onahama, 411-411 m (NSMT E-5949, $\times 1$); St. 161, off Onahama, 418-427 m (NSMT E-5950, $\times 1$); St. 162, off Onahama, 426-426 m (NSMT E-5951, $\times 1$; NSMT E-5952, $\times 7$; NSMT E-5953, $\times 2$; NSMT E-5954, $\times 38$); St. 163, off Onahama, 446-450 m (NSMT E-5955, $\times 2$; NSMT E-5956, $\times 4$); St. 164, off Onahama, 448-454 m (NSMT E-5957, $\times 1$); St. 165, off Onahama, 452-454 m (NSMT E-5958, $\times 3$); St. 166, off Onahama, 479-482 m (NSMT E-5959, $\times 11$; NSMT E-5960, $\times 1$);

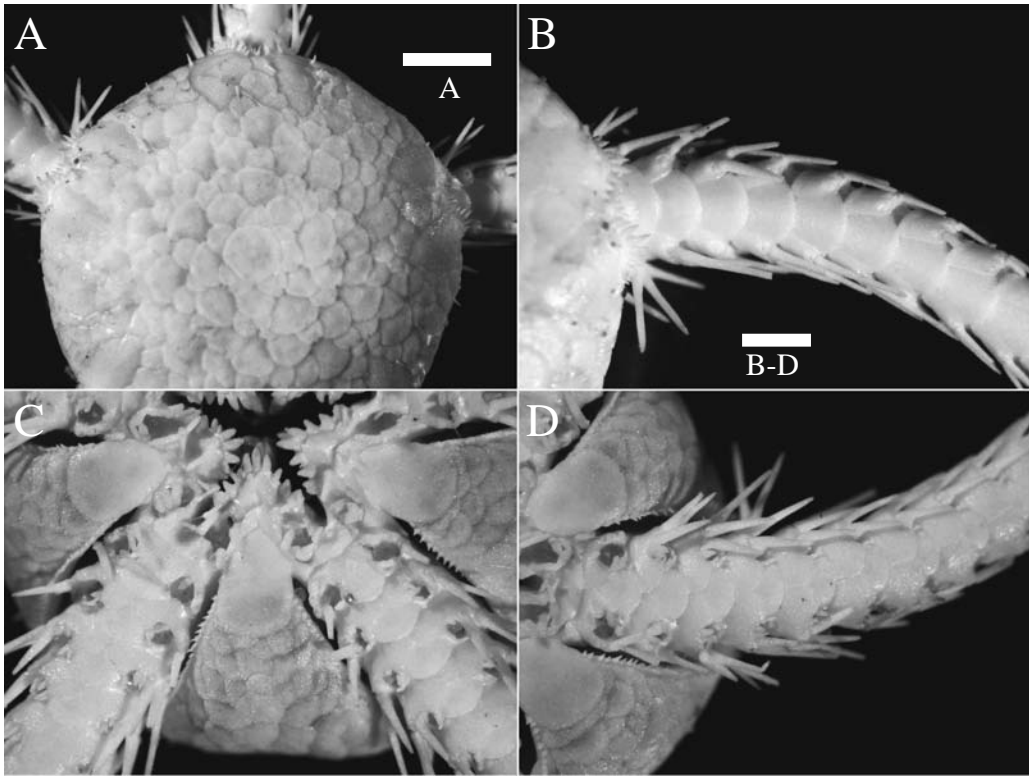


Fig. 14. *Ophiura quadrispina* (NSMT E-5948, dd 7.4 mm). A, disk, aboral view; B, arm base, aboral view; C, a part of disk, oral view; D, arm base, oral view. Dried specimen. Scale bars: 2 mm (A), 1 mm (B-D).

St. 167, off Onahama, 480-480 m (NSMT E-5961, $\times 12$; NSMT E-5962, $\times 26$).

Description. Disk is circular and covered by scales of various sizes, bearing sparse spinelets. Radial shields are triangular with rounded adradial edge, slightly longer than wide, slightly contact distally with each other. Arm comb papillae are minute and pointed, and of unequal length. Secondary arm comb is sometimes observed under the arm comb.

Oral interradial areas are covered by scales similar to aboral ones. Oral shields are somewhat pentagonal, much longer than wide with a curved distal margin. Oral papillae are 5-6 on each side. Teeth are similar to the oral papillae. Second oral tentacle pores open almost into the mouth slit, armed with about 4-6 flat scales on each side which are slightly larger than oral papillae.

Dorsal arm plates are tetragonal with curved distal edge, and slightly wider than long in basal part of arms. Ventral arm plates are wider than long, well separated from each other. Tentacle scales are sharp, about 6 in basal part of arms and the number is decreasing to 1 finally in distal part of arms. Typical tentacle scale formula is AP1-3: L2-3, V2-3; AP4-6: L2, V1-2; AP7+: L2, V0. Arm spines are long, slender and sharp, 4 in number, the uppermost one is conspicuously longest, 1.5-2 times as long as the length of corresponding arm segment.

Remarks. *Ophiura quadrispina* was well described by H. L. Clark (1911). This species is following distinguishing features. Disk has sparse small spinelets. Number of arm spines is 4 in the basal part of arms, and the most aboral one is the longest, about 1.5-2 times as long as the length of the corresponding arm segment. Arm comb papillae are pointed and of unequal length. Djakonov (1954) reported the body color in life, as the disk is pink with violet stripes and the arms are pink with violet lateral arm plates. The present specimens show different color patterns. The disk

is pinkish or light brown with dark brown central part and marginal parts, and the arms have dark and light transverse bands. Smaller individuals of the present specimens have often three arm spines only.

Distribution. Widespread in the North Pacific (Djakonov, 1954). Bathymetrical range is 40–3222 m (Djakonov, 1954; present study).

***Ophiura leptoctenia* H. L. Clark, 1911**

(Figs. 12C–D, 13C–D, 15)

Ophiura leptoctenia H. L. Clark, 1911: 51–55, fig. 12.

Ophiura leptoctenia; Djakonov, 1949: 59, fig. 87a; Djakonov, 1954: 116–117; Kogure and Hayashi, 1998: 6, 16; Fujita and Kohtsuka, 2003: 29.

Material examined. Disk diameter range is about 2 mm or larger. St. 3, off Erimo, 3100–3222 m (NSMT E-5795, $\times 1$); St. 5, off Miyako, 816–820 m (NSMT E-5793, $\times 33$; NSMT E-5794, $\times 67$); St. 8, off Kinkasan, 2968–3032 m (NSMT E-5777, $\times 20$; NSMT E-5778, $\times 20$; NSMT E-5779, $\times 1$); St. 18, off Kushiro, 348–350 m (NSMT E-5819, $\times 182$); St. 19, off Kushiro, 446–450 m (NSMT E-5820, $\times 2096$); St. 20, off Kushiro, 549–550 m (NSMT E-5821, $\times 1348$); St. 63, NE of Hachinohe, 338–343 m (NSMT E-5822, $\times 1$); St. 64, NE of Hachinohe, 348–349 m (NSMT E-5823, $\times 80$; NSMT E-5824, $\times 1$); St. 65, NE of Hachinohe, 348–353 m (NSMT E-5825, $\times 11$); St. 66, NE of Hachinohe, 353–358 m (NSMT E-5826, $\times 5$); St. 67, NE of Hachinohe, 391–400 m (NSMT E-5827, $\times 17$; NSMT E-5828, $\times 6$); St. 68, NE of Hachinohe, 394–394 m (NSMT E-5829, $\times 182$; NSMT E-5830, $\times 3$); St.

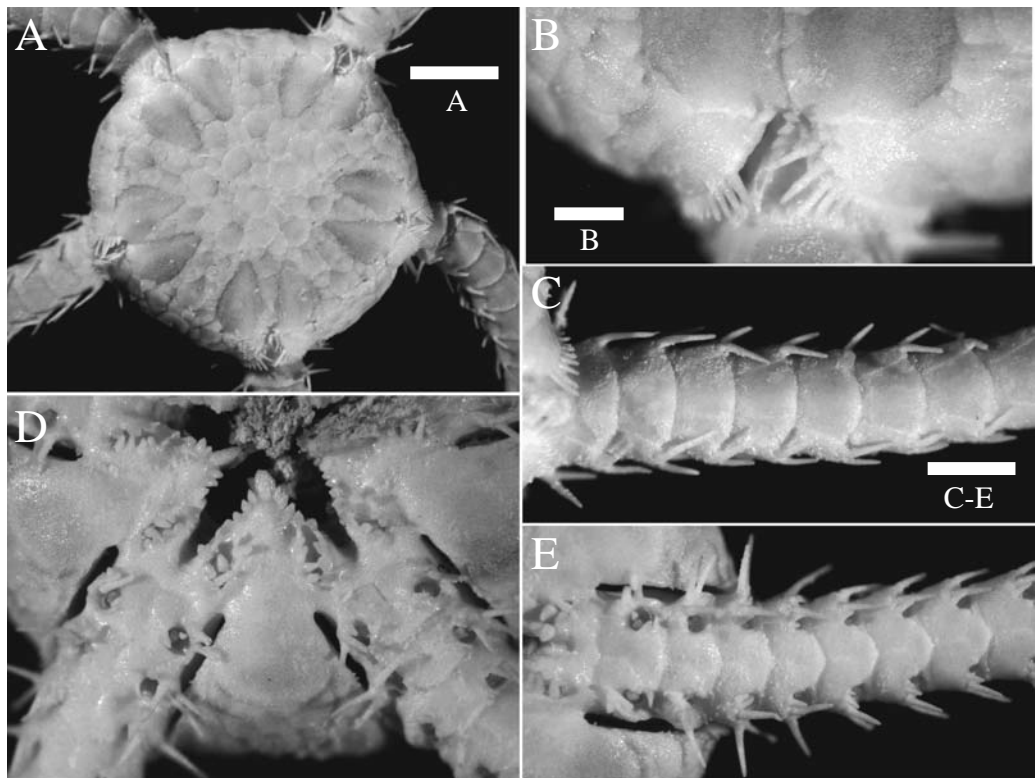


Fig. 15. *Ophiura leptoctenia* (NSMT E-5861, dd 6.0 mm). A, disk, aboral view; B, arm comb, obliquely aboral view; C, arm base, aboral view; D, a part of disk, oral view; E, arm base, oral view. Dried specimen. Scale bars: 2 mm (A), 1 mm (C–E), 0.5 mm (B).

69, NE of Hachinohe, 443-447 m (NSMT E-5831, ×88); St. 70, NE of Hachinohe, 447-447 m (NSMT E-5832, ×101); St. 71, NE of Hachinohe, 447-448 m (NSMT E-5833, ×2); St. 72, NE of Hachinohe, 453-457 m (NSMT E-5834, ×104); St. 73, NE of Hachinohe, 456-461 m (NSMT E-5835, ×1; NSMT E-5836, ×756; NSMT E-5837, ×17); St. 74, NE of Hachinohe, 466-466 m (NSMT E-5838, ×2); St. 76, NE of Hachinohe, 544-550 m (NSMT E-5839, ×1); St. 77, NE of Hachinohe, 547-549 m (NSMT E-5840, ×17); St. 79, NE of Hachinohe, 618-623 m (NSMT E-5841, ×201); St. 80, NE of Hachinohe, 815-816 m (NSMT E-5842, ×137); St. 90, E of Hachinohe, 320-323 m (NSMT E-5843, ×1); St. 91, E of Hachinohe, 366-368 m (NSMT E-5844, ×39); St. 92, E of Hachinohe, 400-401 m (NSMT E-5845, ×40); St. 93, E of Hachinohe, 451-455 m (NSMT E-5846, ×37); St. 94, E of Hachinohe, 500-500 m (NSMT E-5847, ×131); St. 95, E of Hachinohe, 612-612 m (NSMT E-5848, ×1); St. 108, off Kuji, 450-450 m (NSMT E-5849, ×1; NSMT E-5850, ×70); St. 109, off Kuji, 529-534 m (NSMT E-5851, ×22); St. 112, off Miyako, 248-250 m (NSMT E-5852, ×194); St. 113, off Miyako, 307-307 m (NSMT E-5853, ×11); St. 114, off Miyako, 449-450 m (NSMT E-5854, ×543); St. 115, NE of Kinkasan, 249-249 m (NSMT E-5855, ×3; NSMT E-5856, ×13; NSMT E-5857, ×1; NSMT E-5858, ×28); St. 117, NE of Kinkasan, 281-282 m (NSMT E-5859, ×78); St. 119, NE of Kinkasan, 345-347 m (NSMT E-5860, ×28); St. 120, NE of Kinkasan, 373-375 m (NSMT E-5861, ×2; NSMT E-5862, ×130; NSMT E-5863, ×5; NSMT E-5864, ×1); St. 122, NE of Kinkasan, 404-407 m (NSMT E-5865, ×2); St. 124, NE of Kinkasan, 473-477 m (NSMT E-5866, ×2); St. 125, NE of Kinkasan, 482-483 m (NSMT E-5867, ×1); St. 126, NE of Kinkasan, 657-658 m (NSMT E-5868, ×21); St. 127, NE of Kinkasan, 753-758 m (NSMT E-5869, ×5); St. 128, NE of Kinkasan, 1004-1005 m (NSMT E-5870, ×4); St. 130, SE of Kinkasan, 253-259 m (NSMT E-5871, ×1; NSMT E-5880, ×13); St. 136, SE of Kinkasan, 411-412 m (NSMT E-5872, ×7); St. 137, SE of Kinkasan, 418-433 m (NSMT E-5873, ×1); St. 138, SE of Kinkasan, 452-454 m (NSMT E-5874, ×1; NSMT E-5875, ×261); St. 139, SE of Kinkasan, 454-454 m (NSMT E-5876, ×14); St. 141, SE of Kinkasan, 486-487 m (NSMT E-5877, ×5; NSMT E-5878, ×2); St. 142, SE of Kinkasan, 505-514 m (NSMT E-5879, ×4); St. 151, off Onahama, 277-279 m (NSMT E-5881, ×1; NSMT E-5882, ×1; NSMT E-5883, ×9); St. 153, off Onahama, 311-312 m (NSMT E-5884, ×49); St. 156, off Onahama, 373-378 m (NSMT E-5885, ×1); St. 158, off Onahama, 383-383 m (NSMT E-5886, ×14; NSMT E-5887, ×1); St. 159, off Onahama, 410-411 m (NSMT E-5888, ×9); St. 160, off Onahama, 411-411 m (NSMT E-5889, ×1); St. 161, off Onahama, 418-427 m (NSMT E-5890, ×1); St. 162, off Onahama, 426-426 m (NSMT E-5891, ×2; NSMT E-5892, ×12); St. 163, off Onahama, 446-450 m (NSMT E-5893, ×1; NSMT E-5894, ×1); St. 164, off Onahama, 448-454 m (NSMT E-5895, ×1; NSMT E-5896, ×1; NSMT E-5897, ×1); St. 166, off Onahama, 479-482 m (NSMT E-5898, ×9); St. 169, off Onahama, 515-516 m (NSMT E-5899, ×2); St. 170, off Onahama, 750-750 m (NSMT E-5900, ×2).

Description. Disk is circular and covered by scales of various sizes, bearing sparse spinelets. Radial shields are large, semicircular, longer than wide, contact distally with each other. Arm comb papillae are long and slender, arranged rather vertically. Secondary comb of short acute papillae is well developed and often observed under the arm comb.

Oral interradial areas are covered by scales similar to aboral ones. Oral shields are much longer than wide with a curved distal margin. Oral papillae are 5-6 on each side. Teeth are longer and thicker than oral papillae. Second oral tentacle pores open almost into the mouth slit, armed with about 5-6 scales on each side which are longer than oral papillae.

Dorsal arm plates are tetragonal with curved distal edge, and wider than long in basal part of arms. Ventral arm plates are wider than long, well separated from each other. Tentacles scales are fine and pointed, 3-4 in basal part of arms, and decrease to 1 on distal arm segments. Typical tentacle scale formula is AP1: L1, V2-3; AP2-4: L1-2, V0-1; AP5+: L1, V0. Arm spines are slender and sharp, 3 in number.

Remarks. *Ophiura leptoctenia* was well described by H. L. Clark (1911). This species is similar to *Ophiura quadripinna*. However, arm comb papillae are more slender and acicular and arranged rather vertically. Slender arm spines are almost equal to the length of the corresponding arm joint, and 3 in number. This species often occurs in huge numbers like *Ophiura sarsii sarsii*.

Distribution. Widespread in the North Pacific (Djakonov, 1954). Bathymetrical range is 16–3240 m (Djakonov, 1954).

Ophiura bathybia H. L. Clark, 1911

(Figs. 12E-F, 13E-F, 16)

Ophiura bathybia H. L. Clark, 1911: 58, fig. 14.

Ophiura bathybia; Djakonov, 1954:117-118; Baranova, 1957: 205-206; Belyaev and Litvinova, 1972: 13-14.

Material examined. Disk diameter range is 2.7–18.3 mm. St. 1, off Kushiro, 5676–5680 m (NSMT E-5762, $\times 14$; NSMT E-5763, $\times 2$; NSMT E-5764, $\times 12$; NSMT E-5765, $\times 1$); St. 2, off Kushiro, 5670 m (NSMT E-5766, $\times 6$; NSMT E-5767, $\times 19$; NSMT E-5768, $\times 1$; NSMT E-5769, $\times 43$; NSMT E-5770, $\times 20$); St. 6, off Miyako, 3960 m (NSMT E-5771, $\times 1$; NSMT E-5772, $\times 8$); St. 7, off Miyako, 4951 m (NSMT E-5773, $\times 243$); St. 8, off Kinkasan, 2968–3032 m (NSMT E-5774, $\times 1$; NSMT E-5775, $\times 8$; NSMT E-5776, $\times 7$); St. 9, off Kinkasan, 4105–4181 m (NSMT E-5780, $\times 8$; NSMT E-5781, $\times 17$; NSMT E-5782, $\times 8$; NSMT E-5783, $\times 9$); St. 10, off Kinkasan, 4953–5175 m (NSMT E-5784, $\times 17$; NSMT E-5785, $\times 2$); St. 11, off Onahama, 2948–2991 m (NSMT E-5788, $\times 14$); St. 12, off Onahama, 4094–4128 m (NSMT E-5786, $\times 20$; NSMT E-5789, $\times 9$); St. 13, off Onahama, 5219–5268 m (NSMT E-5787, $\times 10$; NSMT E-5790, $\times 21$; NSMT E-5791, $\times 10$).

Description. Disk is pentagonal and covered numerous small scales, many of which carry very slender spinelets; these spinelets are easily rubbed off. Radial shields are crescent-shaped, about three times as long as wide, widest at the other end, separated with each other. Arm comb papillae are very fine.

Oral interradial parts bear scarce spinelets. Oral shields are rounded triangular, a little wider than long. Oral papillae are 5 on each side. Second oral tentacle pores open almost into the mouth slit, armed with about 3–5 scales on each side which are longer than oral papillae, and leaf-shaped or sometimes abnormally subdivided to two slender cylindrical parts in distal half.

Dorsal arm plates are quadrangular with curved distal edge, and wider than long at the proximal part of the arms. Ventral arm plates are wider than long, and separated from each other. Typical tentacle scale formula is AP1–3: L2–3, V2–3; AP4–6: L2, V1–2; AP7+: L2, V0. Tentacle scales are fine and pointed. Typical tentacle scale formula is AP1: L3–5, V3–4; AP2–6: L2–3, V2–3; AP7–8: L2–3, V0–1; A97+: L2, V0. Three arm spines are very fine and slender. Adoral one is longer than the other spines and well separated from them, and the length is longer than that of the corresponding arm segment.

Remarks. *Ophiura bathybia* was well described by H. L. Clark (1911). He suggested *Ophiura bathybia* is most close to *Ophiura leptoctenia*. This is a relatively larger species compared with *O. leptoctenia*. H. L. Clark (1911) mentioned this species is distinguished from *O. leptoctenia* by its crescent-shaped radial shields, smaller and more numerous disk scales, numerous disk spinelets, larger and more spaced oral papillae.

Distribution. North Pacific (H. L. Clark, 1911; Djakonov, 1954; Baranova, 1957; Belyaev and Litvinova, 1972). Bathymetrical range is 2870–5680 m (Belyaev and Litvinova, 1972; present study).

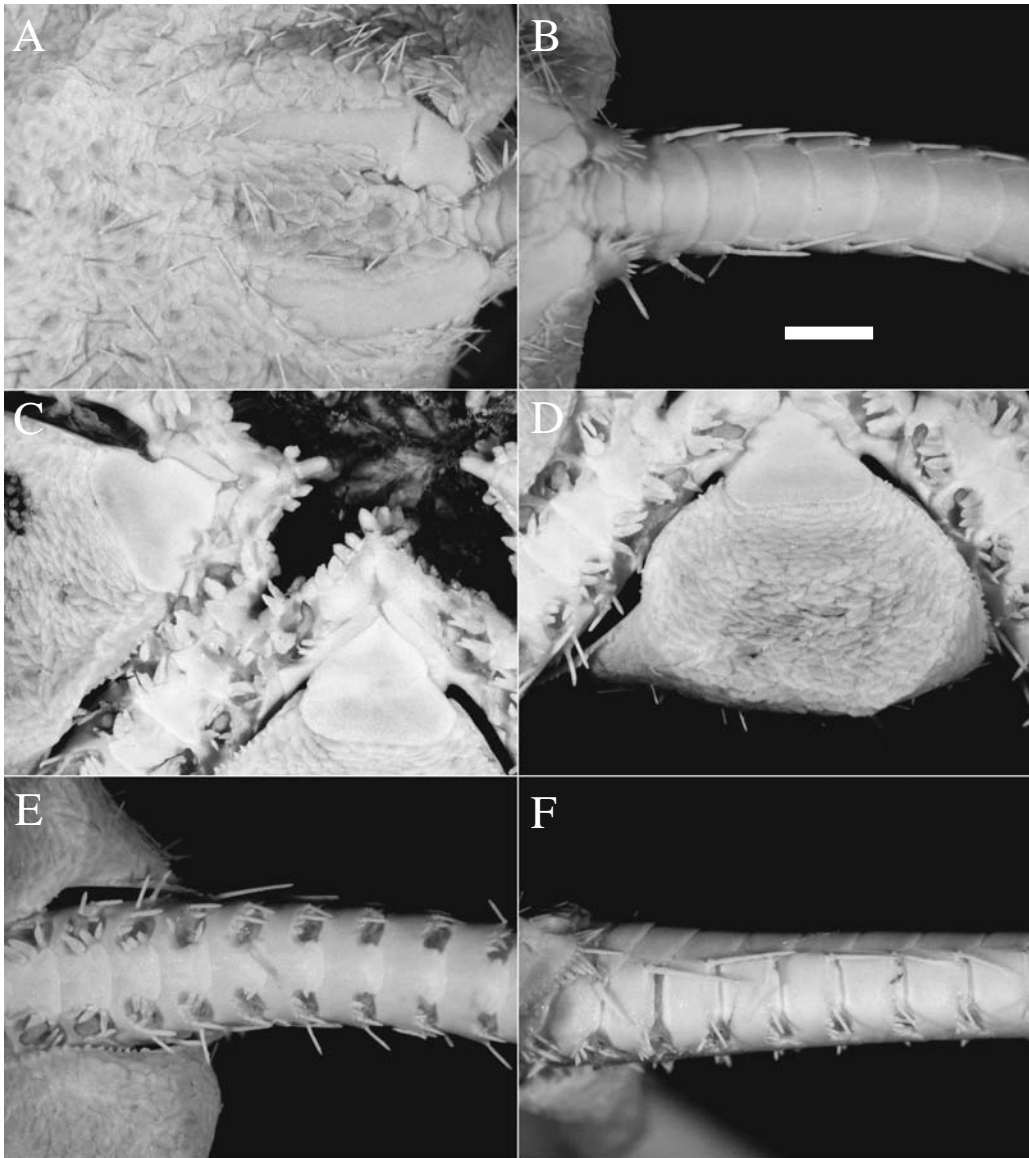


Fig. 16. *Ophiura bathybia* (NSMT E-5785, dd 17.5 mm). A, a part of disk, aboral view; B, arm base, aboral view; C, a part of disk, oral view; D, interradial part of disk, oral view; E, arm base, oral view; F, arm base, lateral view. Dried specimen. Scale bar: 2 mm.

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References

- Alva, V. and C. Vadon, 1989. Ophiuroids from the western coast of Africa (Namibia and Guinea-Bissau). *Scientia Marina*, Barcelona, **53**: 827-845.
- Baker, A. N., 1979. Ophiuroidea from the Tasman Sea and adjacent waters. *New Zealand Journal of Zoology*, **6**: 21-51.
- Baranova, Z. I., 1957. Echinoderms of the Bering Sea. *Issledovaniia Dalny-Vostok Morei USSR*, **4**: 149-266. (In Russian.)
- Baranova, Z. I., 1971. Echinoderms from the Possjt Bay of the Sea of Japan. *Issledovaniia fauny Morei*, **8**: 242-264. (In Russian.)
- Belyaev, G. M. and N. M. Litvinova, 1972. New genera and species of deep-sea Ophiuroidea. *Biulleten Moskovskoe Observato Ispytatelej Prirody Otdel Biologicheskii*, **27**(3): 5-19. (In Russian with English Summary.)
- Chang, F.-Y., 1948. Echinoderms of Tsingtao. *Contributions from the Institute of Zoology, National Academy of Peiping*, **4**(2): 33-104, 11pls.
- Chang, F.-Y. and P.-L. Woo, 1954. On the echinoderms of Dairen and its vicinity. *Acta Zoologica Sinica*, **6**: 123-146.
- Clark, A. H., 1920. Additional data for the report on echinoderms of the Canadian Arctic Expedition, based upon specimens from the “Neptune” and other Eastern Arctic Expeditions. *Report of the Canadian Arctic Expedition 1913-18, Part C, Echinoderms*, **8**: 11-13.
- Clark, A. H., 1940. Echinoderms from Greenland collected by Capt. Robert A. Bartlett. *Proceedings of the United States National Museum*, **89**: 425-433, pl. 58-59.
- Clark, A. H., 1949a. Echinoderms from the mid-Atlantic dredged by the Atlantis in the summer of 1948. *Journal of the Washington Academy of Sciences*, **39**: 371-377.
- Clark, A. H., 1949b. Ophiuroidea of the Hawaiian Islands. *Bernice P. Bishop Museum, Bulletin*, **195**: 1-133.
- Clark, A. H., 1952. Echinoderms from the Marshall Islands. *Proceedings of the United States National Museum*, **102**: 265-303.
- Clark, A. M. and J. Courtman-Stock, 1976. The echinoderms of southern Africa. 277 pp. British Museum (Natural History), London.
- Clark, A. M. and F. W. E. Rowe, 1971. Monograph of Shallow-Water Indo-West Pacific Echinoderms. 238 pp., 31 pls. Trustees of the British Museum (Natural History), London.
- Clark, H. L., 1911. North Pacific ophiurans in the collection of the United States National Museum. *Bulletin of the United States National Museum*, **75**: 1-301.
- Clark, H. L., 1921. The echinoderm fauna of Torres Strait. *Papers from the Department of Marine Biology of the Carnegie Institution of Washington*, **10**: VI+223 pp., 38 pls.
- Clark, H. L., 1923. The echinoderm fauna of South Africa. *Annals of the South African Museum*, **13**: 221-435, pls. 8-23.
- Devaney, D. M., 1974. Shallow-water asterozoans of southeastern Polynesia. II. Ophiuroidea. *Micronesica*, **10**: 105-204.
- Djakonov, A. M., 1933. Iglokozhiye severnykh morei. Opredeliteli po faune SSSR (Echinoderms of the Northern Seas. Keys to the Fauna of the USSR). *Zoologicheskii Institut Akademii Nauk SSSR*, (8):7-163.
- Djakonov, A. M., 1949. Key to the Echinoderms of the Far Eastern Seas. *Izvestiya Tikhookeanskogo Instituta Rybnogo Khozyaistva i Okeanografii*, (30): 1-127.
- Djakonov, A. M., 1954. Ophiuroids of the USSR Seas. 132 pp. Izdatel'stvo Akademii Nauk SSSR, Moskva. (English translation by Israel Program for Scientific Translation, 1967)
- Fujita, T., 1988. Ecology of deep-sea ophiuroids. *Benthos Research*, (33/34): 61-73. (In Japanese with English Abstract).
- Fujita, T., 1992. Dense beds of ophiuroids from the Paleozoic to the Recent: the significance of bathyal populations. *Otsuchi Marine Research Center Report*, (18): 25-41.
- Fujita, T., 1996. Bathymetric distribution of ophiuroids (Echinodermata) off Sendai Bay, Northern Japan, with notes on the diet of the roughscale sole *Clidoderma asperrimum* (Pisces, Pleuronectidae). *Memoir of the National Science Museum, Tokyo*, (29): 209-222.
- Fujita, T., 2003. Arm regeneration frequency in bathyal populations of *Ophiura sarsii* off northern Japan. In: Feral, J.-P. (ed.), *Echinoderm research 2001*, pp. 221-227. Swetz & Zeillinger, Lisse.
- Fujita, T. and S. Irimura, 2005. Ophiuroids (Echinodermata) collected by R/V Yoko-Maru off southwestern Japan in the East China Sea. *National Science Museum Monographs*, (29): 357-384.
- Fujita, T., Y. Ishida, Y. and S. Irimura, 1997. Ophiuroids collected from the deep waters of Suruga Bay, central Japan. *National Science Museum Monographs*, (12): 257-268, 1 pl.
- Fujita, T., Y. Ishida, T. Kato and S. Irimura, 2004. Ophiuroids (Echinodermata) collected from the Oki Islands in the Sea of Japan. *Bulletin of the National Science Museum, Series A (Zoology)*, **30**: 191-218.
- Fujita, T. and H. Kohtsuka, 2003. Ophiuroids (Echinodermata) from Notojima Island and its adjacent waters in the Sea of

- Japan. *Report of the Noto Marine Center*, (9): 25-38. (In Japanese with English Abstract.)
- Fujita, T. and S. Ohta, 1989. Spatial structure within a dense bed of the brittle star *Ophiura sarsi* (Ophiuroidea: Echinodermata) in the bathyal zone off Otsuchi, northeastern Japan. *Journal of the Oceanographical Society of Japan*, **45**: 289-300.
- Fujita, T. and S. Ohta, 1990. Size structure of dense populations of the brittle star *Ophiura sarsii* (Ophiuroidea: Echinodermata) in the bathyal zone around Japan. *Marine Ecology Progress Series*, **64**: 1-2.
- Grieg, J. A., 1893. Ophiuroidea. *Den Norske Nordhavs-Expedition 1876-1878 Zoologi*, **5**: 1-41, 2 pls., 1 map.
- Grieg, J. A., 1900. Die Ophiuriden der Arktis. *Fauna Arctica*, **1**: 259-286.
- Grieg, J. A., 1903. Echinodermen von den norwegischen Fischereidampfer "Michael Sars" in den Jahren 1900-1903 gesammelt. I. Ophiuroidea. *Bergens Museums Aarbog*, **3**: 1-45.
- Grieg, J. A., 1907. Echinodermata. *Report of the Second Norwegian Arctic Expedition in the "Fram" 1898-1902*, (13): 1,4-28, 3 pls.
- Grieg, J. A., 1916. Echinodermter indsamlet av "Michael Sars" sommeren 1914. *Archiv for Matematik og Naturvidenskab, Kristiania*, **34**(10): 1-11.
- Guille, A., 1981. Résultats des Campagnes Musorstom. 1. Philippines (18-28 Mars 1976). Echinoderms: Ophiurides. *Memoires ORSTOM*, (91): 413-456.
- Guille, A. and M. Jangoux, 1978. Asterides et ophiurides littorales de la region d'Amboine (Indonesie). *Annales de l'Institut Oceanographique, Paris*, **54**: 47-74.
- Horikoshi, M., T. Fujita, and S. Ohta, 1990. Benthic associations in bathyal and hadal depths off the Pacific coast of north eastern Japan: physiognomies and site factors. *Progress in Oceanography*, **24**: 331-339.
- Irimura, S., 1979. Ophiuroidea of Sado Island, the Sea of Japan. *Annual Report of the Sado Marine Biological Station, Niigata University*, (9): 1-6.
- Irimura, S., 1981. Ophiurans from Tanabe Bay and its vicinity, with the description of a new species of *Ophiocentrus*. *Publications of the Seto Marine Biological Laboratory*, **26**: 15-49.
- Irimura, S., 1982. The Brittle-stars of Sagami Bay. xii+95+53 pp., 15 pls., 1 map. Biological Laboratory, Imperial Household, Tokyo.
- Irimura, S., 1990. Ophiuroidea. In: *Echinoderms from Continental Shelf and Slope around Japan Vol. I*, pp. 65-100. Japan Fisheries Resource Conservation Association, Tokyo.
- Ishida, Y. and T. Fujita, 1999. Dense populations of fossil and extant *Ophiura sarsii* (Echinodermata, Ophiuroidea) in Japan. In: Carnevali, M. D. C. and F. Bonasoro (eds.), *Echinoderm Research 1998*, pp. 293-298. Balkema, Rotterdam.
- Koehler, R., 1897. Échinodermes recueillis par "l'Investigator" dans l'Océan Indien. Les Ophiures de mer profonde. *Annales des Sciences Naturelles Zoologie*, **8**(4): 277-372, 4 pls.
- Koehler, R., 1898. Échinodermes recueillis par "l'Investigator" dans l'Océan Indien. Les Ophiures littorales. *Bulletin Scientifique de la France et la Belgique*, **31**: 55-125, 4 pls.
- Koehler, R., 1899. Ophiures recueillies par l'Investigator dans l'Océan Indien. I. Les ophiures de mer profonde. 76+ii pp., 14 pls., Calcutta.
- Koehler, R., 1904. Ophiures de l'Expedition du Siboga. 1e Partie Ophiures de mer profonde. *Siboga Expeditie*, **45a**: 1-176, 36 pls.
- Koehler, R., 1906a. Description des ophiures nouvelles recueillies par le Travailleur et le Talisman pendant les campagnes de 1880, 1881, 1882, & 1883. *Memoires de la Societe Zoologique de France*, **19**: 1-35, 3 pls.
- Koehler, R., 1906b. Ophiures. *Expeditions Scientifiques du "Travailleur" et du "Talisman" pendant les annees 1880, 1881, 1882, 1883*: 245-311, pl. 18-21.
- Koehler, R., 1907. Revision de la collection des ophiures du Museum d'Histoire Naturelle de Paris. *Bulletin Scientifique, France et Belg*, **41**: 279-315.
- Koehler, R., 1909. Échinodermes provenant des campagnes du yacht Princesse-Alice (Astéries, Ophiures, Échinides et Crinoïdes). *Résultats des Campagnes Scientifiques accomplies sur son Yacht par Albert Ier Prince Souverain de Monaco*, **34**: 1-317, 32 pls.
- Koehler, R., 1914. A contribution to the study of the ophiurans of the United States National Museum. *Bulletin, United States National Museum*, (84): 1-146, 18 pls.
- Koehler, R., 1922. Ophiurans of the Philippine Seas and adjacent waters. *Bulletin Smithsonian Institution United States National Museum*, **100**: 1-486, 103 pls.
- Kogure, Y., 1999. Echinoderms from the lower-sublittoral zone on the north-western coasts of Sado Island, the Japan Sea. *Bulletin of the Japan Sea National Fisheries Research Institute*, (49): 57-67. (In Japanese with English abstract.)
- Kogure, Y. and I. Hayashi, 1998. Bathymetric distribution pattern of echinoderms in the Sado Strait, the Japan Sea. *Bulletin of the Japan Sea National Fisheries Research Institute*, (48): 1-16.
- Kogure, Y. and T. Nagasawa, 2004. Relationship between the distribution of *Ophiura sarsii* (Echinodermata, Ophiuroidea) and benthic environmental variables in the sea of Japan. *Biogeography*, **6**: 17-26.
- Liao, Y., 2004. Fauna Sinica. Invertebrata vol. 40. Echinodermata. Ophiuroidea. 505 pp., 5 pls. Science Press, Beijing. (In

- Chinese.)
- Ljungman, A. V., 1867. Om några nya arter af Ophiurider. *Ofversigt of Kongliga Vetenskaps-Akademiens Forhandlingar, Stockholm*, **1866**: 163-166.
- Ludwig, H., 1886. Echinodermen des Beringsmeeres. *Zoologische Jahrbucher*, **1**: 275-296.
- Lütken, C. F., 1855. Bidrag til Kundskab om Slangestjernerne. I. Forelobig Oversigt over Gronlandshavets Ophiurer. *Videnskabelige meddelelser fra den naturhistoriske Forening i Kjöbenhavn*, **1854**: 95-104.
- Lütken, C. F., 1858. Addimenta ad historiam Ophiuridarum. Beskrivelser af nye eller hidtil kun ufuldstaendigt kjendte Arter af Slangestjerner. Anden Afdeling. *Kongelige Danske Videnskabernes selskabs skrifter*, **5**(5): 1-74, 2 pls.
- Lütken, C. F. and T. Mortensen, 1899. The Ophiuridae. *Memoirs of the Museum of Comparative Zoology*, **23**: 97-208.
- Lyman, T., 1865. Illustrated Catalogue of the Museum of Comparative Zoölogy, at Harvard College. No. 1. Ophiuridae and Astrophytidae. 200 pp., 2 pls. Sever and Francis, Cambridge.
- Lyman, T., 1871. Supplement to the Ophiuridae and Astrophytidae. *Illustrated Catalogue of the Museum of Comparative Zoölogy at Harvard College*, (6): 1-17, 2 pls.
- Lyman, T., 1878. Ophiuridae and Astrophytidae of the Exploring Voyage of H. M. S. Challenger, under Prof. Sir Wyville Thomson, F. R. S. Part I. *Bulletin of the Museum of Comparative Zoology*, **5**: 65-168, 10 pls.
- Lyman, T., 1882. Report on the Ophiuroidea dredged by H. M. S. Challenger during the years 1873-76. *Report on the Scientific Results of the Voyage of H. M. S. Challenger during the Years 1873-76, Zoology*, **5**: 1-386, 48 pls.
- Matsumoto, H., 1917. A monograph of Japanese Ophiuroidea, arranged according to a new classification. *Journal of the College of Science, Imperial University of Tokyo*, **38**(2): 1-408, 7 pls.
- Matsumoto, H., 1918. On a collection of ophiurans from the vicinity of Kinkwasan, with description of a new species. *Annotationes Zoologicae Japonenses*, **9**: 475-480.
- Matsumoto, H., 1941. Report of the biological survey of Mutsu Bay. 36. Ophiuroidea of the Mutsu Bay and vicinities. *Science Reports of the Tôhoku Imperial University, Series 4, Biology*, **16**: 331-344.
- Meissner, M., 1901. Die Schlangensterne. Systematik. *Dr. H. G. Bronn's Klassen und Ordnungen des Thier-reichs*, **2**(3) Bucher 3: 902-966.
- Michailovskij, M., 1902. Zoologische Ergebnisse der Russischen Expeditionen nach Spitzbergen. Echinodermen. (Holothuroidea, Echinoidea, Asteroidea, Ophiuroidea und Crinoidea). *Ezhgodnik Zoologicheskago Muzeya Imperatorskoi Akademii Nauk. St. Petersburg*, **7**: 460-546.
- Mortensen, T., 1909. Echinoderms from east Greenland. *Meddelelser om Grønland*, **29**: 65-89, 2 pls.
- Mortensen, T., 1913. Grønlands Echinodermer. *Meddelelser om Grønland*, **29**: 301-379.
- Mortensen, T., 1927. Handbook of the Echinoderms of the British Isles. ix+471 pp. Oxford University Press, London.
- Mortensen, T., 1933. Ophiuroidea. *The Danish Ingolf-Expedition*, **4**: 1-121, 3 pls., 1 Table.
- Murakami, S., 1942. Ophiurans of Izu, Japan. *Journal of the Department of Agriculture, Kyūsyū Imperial University*, **7**: 1-36.
- Murakami, S., 1943. Ophiurans from some gulfs and bays of Nippon. *Journal of the Department of Agriculture, Kyūsyū Imperial University*, **7**: 223-234.
- Murakami, S., 1944. Note on the ophiurans of Amakusa, Kyūsyū. *Journal of the Department of Agriculture, Kyūsyū Imperial University*, **7**: 259-280, 1 pl.
- Paterson, G. L. J., 1985. The deep-sea Ophiuroidea of the North Atlantic Ocean. *Bulletin of the British Museum (Natural History), Zoology*, **49**: 1-162.
- Smirnov, A. V. and I. S. Smirnov, 1990. Echinoderms from the Laptev Sea. In: Golikov, A. N. (ed.), *Ecosystems of the New Siberian shoals and fauna of the Laptev Sea and adjacent waters of the Arctic Ocean*, pp. 411-462. Nauka, Leningrad.
- Stancyk, S. E., T. Fujita and C. Muir, 1998. Predation behavior on swimming organisms by Ophiura sarsii. In: Mooi, R. and M. Telford (eds.), *Echinoderms: San Francisco*, pp. 425-429. Balkema, Rotterdam.
- Stöhr, S. and T. O'Hara, 2007. World Ophiuroidea database. Available online at <http://www.marinespecies.org/ophiuroidea>. Consulted on 2008-06-28
- Süssbach, S. and A. Breckner, 1910. Die Siegel, Seesterne und Schlangensterne der Nord- und Ostsee. *Wissenschaftliche Meeresuntersuchungen, Neue Folge, Abtheilung Kiel*, **12**: 167-300.
- Tommasi, L. R., 1976. Ophiuroidea collected in the Peru-Chile Trench by the USNS "Eltanin" during cruise III. *Papeis Avulsos de Zoologia, Sao Paulo*, **29**(28): 281-318.
- Yoo, J.-W., J.-S. Hong and H.-S. Park, 1995. A taxonomical reconsideration on the three species of genus *Ophiura* from Korean waters. *The Korean Journal of Systematic Zoology*, **11**: 417-434. (In Korean with English abstract.)