Three species of the shallow-water comatulids from Okinawa Island, new records in Japan (Crinoidea: Comatulida)

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沖縄島の浅海より得られた日本初記録のウミシダ類3種

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抄録：沖縄島中部西岸のサンゴ礁域より得られたウミシダ類のうち、北部西太平洋域では比較的稀に棲息する3種、Himerometra bartschi A.H. Clark, 1908, Stephanometra tenuipinna (Hartlaub, 1890), 及び S. echinus (A.H. Clark, 1908) を日本初記録種として記載した。また、これら各種について生時の色彩、棲息場所での観察によって判明した生態、及び共生動物等について付記する。

Abstract: This paper deals with 3 comatulid species, Himerometra bartschi A.H. Clark, 1908, Stephanometra tenuipinna (Hartlaub, 1890), and S. echinus (A.H. Clark, 1908) collected from shallow-water of Okinawa Island, the Ryukyu Islands. These species are comparatively rare in the north-western Pacific, and are recognized as new to the Japanese crinoid fauna. Their external features together with colors in life are described. In addition, ecological notes observed at their natural habitats and their symbionts are reported.

Key Words: comatulid crinoids, taxonomy, ecology, symbionts, Ryukyu Islands.

Among the Japanese waters, the Ryukyu Islands are most notable for their characteristic crinoid fauna which involves many southern-originating comatulids inhabiting the reef of shallow waters. In spite of the abundance of comatulids, their faunas have not been revealed clearly as yet. First systematic study was carried out by Tamura (1983) who reported 17 comatulids of the middle and southern Okinawa Island as a result of survey using SCUBA. Fujita (1998), the junior author, treated 25 species of comatulids which were collected from the middle region of the same island for his ecological study. As to other locality of the Ryukyu Islands, 13 species of comatulids were captured by Katsutoshi Ito, an underwater photographer, at the Kerama Islands in 1988 (Kogo, 1998).

Recently, the senior author examined over 900 bottles of crinoid specimens deposited in the Osaka Museum of Natural History (OMNH) which were collected from Japanese and its
adjacent waters. As results, 29 comatulid species among the total of 114 Japanese crinoids were revealed to be distributed in the Ryukyu Islands (Kogo, 1998).

The present paper deals with 3 comatulids, namely, *Himerometra bartschi* A.H. Clark, 1908, *Stephanometra tenupinna* (Hartlaub, 1890), and *S. echinus* (A.H. Clark, 1908) which were found during studies of the crinoid-decapod relationship in the Ryukyu Islands by the junior author. These species are recognized as new to the Japanese crinoid fauna.

**Materials and Methods**

The collections and ecological observations were conducted by the junior author in coastal waters of Okinawa Island (three locations on the west coast: Maeda-misaki, Zanpa-misaki, and Udui near Manzamo) by SCUBA diving in the day and at night during the years 1997 to 1999 (Fig.1).

After captured, the animals were fixed and preserved in 70 % ethanol. To compare the variation within a species, two specimens are described in the article 'Description'. The morphological terms for comatulid external features are followed A.H. Clark (1915). A pattern of comparative length of pinnules on an arm proposed by Kogo (1998) is adopted in this paper. The specimens are labeled individually by 'Iv (invertebrates) number' and are deposited in the Osaka Museum of Natural History.

Fig. 1. Map showing sampling sites. 1, Udui; 2, Maeda-misaki; 3, Zanpa-misaki.
Family Himerometridae

Himerometra bartschi A.H. Clark, 1908
(Figs. 2 and 5A)

New Japanese name: Hosobane-jabara-umishida


Description of Iv 3121: Centrodorsal thick discoidal, 7.5 mm in diameter, 3.0 mm high. Polar area mostly flat, slightly concave, 4.0 mm across. Radials perfectly concealed by centrodorsal. Cirrus sockets clearly circular, compactly arranged in 3 rows.

Cirri long, linear, and stout, about IL, 46-52 segments, up to 42 mm long. Whole cirrus segments subequal, broader than long (about 4/5 times as long as broad). Dorsal spines prominent in distal half segments of cirrus.

Division series in lateral contact. IBr series 2, IBr₁ perfectly united laterally. IIBr series

Fig. 2. Himerometra bartschi A.H. Clark. A, centrodorsal and proximal arms; B, proximal pinnules; C, cirrus. Scale equal 5.0 mm. (Iv 3121)
4(3+4) in 6 cases and 2 in 4 cases. IIIBr series showing typical arrangement in 2 cases of 5 rays, namely, 2 on inner sides and 4(3+4) on outer sides, though in remainder 3 cases showing confused arrangement. IVBr series ordinarily 4(3+4) in 13 cases, and very exceptionally 2, and 3 (irregular arrangement) each one case. Elements of division series mostly smooth laterally with somewhat dorsally everted articulations.

Arms numerous, 55 in number, about 90 mm long, 1.5-1.7 mm wide at first syzygy. Syzygial pairs occur at 3+4, 37+38, 59+60..., and at intervals of 17-24 muscular articulations in distal arm.

Pinnules stout proximally, flagelliform distally, not stiffened. Proximal segments (second to fourth or fifth) of proximal pinnules provided with prominent dorsal carinations. Pδ carinate at proximal segments with everted distal margin, about 32 segments, 19.0-20.2 mm long; Pσ 26-31, 16.0-16.2 mm; P1 34-35, 15.0-17.2 mm; P2 27-28, 10.2-10.7 mm; P3 ca. 21, 8.6 mm; P4 ca. 19, 6.0 mm; P5 ca. 13, 4.5 mm; Pm 13, 9.0-10.0 mm; Pd 20-27, 8.2-10.5 mm; Pa present, 26-34, 11.5-14.0 mm. Pattern of relative length of pinnules: P1>>P2>P3>P4>P5<Pm=Pd.

**Description of Iv 3110**: Centrodorsal 8.6 mm in diameter, 3.0 mm high. Polar area 4.2 mm across. Radials perfectly concealed. Cirrus sockets arranged in 3 rows.

Cirri long, linear, and stout, ILVI, 36-40 segments, up to 34 mm long. Dorsal spines prominent, occurring beyond 17-20th segments.

Division series in lateral contact. IBBr series 2, IIIBr series 4(3+4) in 7 cases and 2 in 2 cases, and 1 very unusual case such as 7(3+4, 6+7). IIIIBr series typically arranged in 3 case, e.g. 4(3+4) on outer sides and 2 on inner sides, and irregularly arranged in 2 cases. IVBr series mostly 4(3+4) in 7 cases, and 2 in 1 case.

Arms 46 in number, 75-95 mm long, 1.5-1.8 mm wide. Syzygial pairs arising at 3+4, 31+32,..., and at intervals of 12-16 muscular articulations in distal arm.

Pinnules flagelliform distally. Pδ carinate at proximal segments, composed of 29-32 segments, ca. 20.0 mm long; Pσ 30, 19.0 mm; P1 23-29, 13.0-16.0 mm; P2 21, 7.0 mm; P3 17, 6.5 mm; P4 14, 4.6 mm; P5 14, 4.5 mm; Pm 14-18, 4.5-5.5 mm; Pd 19, 5.0 mm; Pa present. Pattern of relative length of pinnules: P1>>P2>P3>P4=P5<Pm=Pd.

**Color**: Both specimens (Iv 3121 and Iv 3110) at hand showing same coloration. Ground body color reddish brown. Arms darker than division series and centrodorsal. Disk and pinnules dark reddish purple. Pinnules tips white or yellow. Cirri pale reddish purplish (see Fig. 5A).

**Ecological notes**: This species were observed to attach to the substratum by the cirri with their body fully exposed in the daytime. Three species of pontoniid shrimps, *Periclimenes commensalis* Borradaile, *P. tenuis* Bruce and *Periclimenes* sp., and an anomuran crab, *Allogalathea elegans* (Adams and White), were found in association with *H. bartschi*. Unidentified scaleworms and myzostomid worms were also found.

**Remarks**: This species is easily distinguishable from other species of *Himerometra* by its carinate earlier segments of proximal pinnules. The specimen of Iv 3121 resembles closely to
Clark's type specimen from the Sulu Archipelago, whereas another specimen of Iv 3110 is somewhat different from these for having shorter proximal pinnules (especially P₁, composed of fewer segments and shorter than those of Iv 3121). However, this less-development of pinnules is considered to be staying within the individual variations of the species.

Distribution and depth: From Philippines to Singapore southward to Amboina, and Kei Islands (Clark, 1941), eastward to Papua New Guinea (Messing, 1998), and northward to Ryukyu Islands (new record in Japan). Shoreline down to 51 m deep.

Family Mariametridae

*Stephanometra tenuipinna* (Hartlaub, 1890)
(Figs. 3, 5B and 5C)
New Japanese name: Hoso-toge-umishida

*Antedon tenuipinna* Hartlaub, 1890, p.178 (type locality, New Britain).


Material examined: 1 specimen (Iv 3119), Udui, Onna-son, Okinawa Is., 28.4 m in depth, 3 June 1999, coll. by Y. Fujita; 1 specimen (Iv 3118), same locality, 31.3 m in depth, 3 June 1999, coll. by Y. Fujita.

Description of Iv 3119: Centrodorsal low hemispherical, 2.1 mm in diameter, 1.0 mm

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![Fig. 3. *Stephanometra tenuipinna* (Hartlaub). A, centrodorsal and proximal arms; B, proximal pinnules; C, distal pinnules; D, cirrus. Scale equal 2.0 mm. (Iv 3119)]
high. Polar area bare, slightly convex, 0.7 mm across. Cirrus sockets arranged in 1 or partly alternative 2 rows.

Cirri rather small and slender, XV (including 2 rudimentals), 18-20 segments, 9.5-10.2 mm long. First 2 segments broader than long, third segment longer than broad, followings increasing in length, fifth and sixth, longest segments, about 2 times as long as broad, succeeding segments decreasing in length to as long as broad. Dorsal spines arising beyond sixth segment, very prominent in distal half of cirrus. No transition segment. Opposing spine very prominent.

Division series narrow, widely separated from neighboring series without ventro-lateral expansion at all. Radials oblong, 3 times as broad as long; IBr series 2, IBr₂ 1.5 times as broad as long, IBr₁ pentagonal; IIBr and IIIBr series all 2. Each element of division series smooth dorsally, entirely free laterally.

Arms slender, 22 in number, varing in length between 26.0 and 53.0 mm, 0.5-0.6 mm wide at first syzygy. Brachials smooth, longer than broad in distal arm. Syzygial pairs occurring at 3+4, 9±10, 15±16, 20±21, 23±24, 29±30... on arm arising from IBr series, and 3+4, 18±19 or 19±20, 29±30... on arm arising from IIIBr series, and distally at intervals of 3-9 or 8-11 muscular articulations.

Proximal pinnules erect, composed of a few segments. P₁ 8 segments, 4.5 mm long; P₂ 7, 3.6 mm; P₃ 6, 3.2 mm; P₄ 6, 2.5 mm; P₅ 10, 3.2 mm; Pm 11-12, 3.8-5.0 mm; Pd composed of elongated segments about 4 times as long as broad, 16-17, 6.5 mm; Pa present, 8, 4.0 mm. Pattern of relative length of pinnules: P₁>P₂>P₃=P₄<P₅<Pm<Pd.

Description of Iv 3118: Centrodorsal low hemispherical, 1.5 mm in diameter, 0.6 mm high. Polar area 0.7 mm across. Cirrus sockets compactly arranged in a single row.

Cirri XIV, 18-20 segments, 8.0-10.2 mm long. Fifth and sixth segments, longest ones, about 1.6 times as long as broad, succeeding segments decreasing in length to as long as broad each with a sharp dorsal spine.

Division series narrow, widely separated. Radials oblong, 3 times as broad as long; IBr series 2, IBr₁ oblong, 1.5 times as broad as long, IBr₂ pentagonal; IIBr and IIIBr series all 2. Elements of division series smooth laterally without ventro-lateral expansions at all.

Arms slender, 15 in number, up to 47.0 mm long, 0.6-0.9 mm wide at first syzygy. Syzygial pairs occurring at 3+4, 9±10, 15±16, 20±21, 26±27, 33±34..., and at intervals of 3-7 muscular articulations on distal arm.

Proximal Pinnules composed of a few segments. P₁ and P₂ erect. P₁ 9-10 segments, 6.0-6.2 mm long; P₂ 8-9, 4.6 mm; P₃ and following pinnules subequal, excessively minute, 6-7, 2.2-2.6 mm; P₄ 13, 3.0 mm; Pm 11-12, about 4.6 mm; Pd composed of very long segments, 4 times as long as broad, about 18, 6.5 mm; Pa 8, 4.2 mm. Pattern of relative length of pinnules: P₁>P₂>P₃=P₄<P₅<Pm<Pd.

Color: Both specimens at hand revealed different colorations. Pattern 1 (Iv 3119): Centrodorsal, division series, cirri, and oral disk bright yellowish orange. Arms and pinnules on basal to middle part all bright yellowish orange, sometimes with pink tips. Those on
middle to distal part of arms entirely whitish pink (Fig. 5B); Pattern 2 (Iv 3118): Centrodorsal, division series, cirri, and oral disk entirely yellow. Basal part of arms also yellow, and middle to distal part dark reddish purple and yellow alternately. Coloration of pinnules depending on arm color mentioned above (Fig. 5C).

Ecological notes: Both specimens were found under dead coral rubble in the daytime. Symbiotic animals were not recorded.

Remarks: Among the species of *Stephanometra*, both of *tenuipinna* and *echinus* are easily distinguished from others for having outer cirrus segments with long and prominent dorsal spines. According to Clark's key, these species are distinguished as follows: *tenuipinna* has more narrow and smooth division series, and fewer arms (16-24) than those of *echinus* (33-40 arms). The specimens of Iv 3119 and Iv 3118 have 22 and 15 arms, respectively. They correspond in detail to the Clark's description (1941). The difference of colors among these specimens described in 'Color' are regarded as the representatives of variations within the species.

Distribution and depth: From Philippines to New Britain, and westward to Singapore and Ceylon (Clark, 1941), Papua New Guinea (Messing, 1998), South Pacific (Clark and Rowe, 1971), and northward to Ryukyu Isls. (new record in Japan). Shoreline down to 48 m deep.

Fig. 4. *Stephanometra echinus* (A.H. Clark). A, centrodorsal and proximal arms; B, proximal pinnules; C, cirrus. Scale equal 5.0 mm. (Iv 3094)
**Stephanometra echinus** (A.H. Clark, 1908)
(Figs. 4, 5D, 5E and 5F)

New Japanese name: Futo-toge-umishida

*Himerometra echinus* A.H. Clark, 1908, p.218 (type locality, Sulu Archipelago).

*Stephanometra echinus*: A.H. Clark, 1941, p.409, pls.45-47 (Luzon, Mindoro, and Paternoster Isls.);

**Material examined**: 1 specimen (Iv 3094), Maeda-misaki, Onna-son, Okinawa Is., 8.5 m in depth, 22 November 1997, coll. by Y. Fujita; 1 specimen (Iv 3111), Udui, Onna-son, Okinawa Is., 14.2 m in depth, 31 July 1999, coll. by Y. Fujita; 1 specimen (Iv 3112), Udui, Onna-son, Okinawa Is., 12.5 m in depth, 2 June 1999, coll. by Y. Fujita.

**Description of Iv 3094**: Centrodorsal thick discoidal, 5.0 mm in diameter, 2.4 mm high. Polar area concave, 2.5 mm across. Cirrus sockets closely arranged in alternating 2, partly 3 rows.

Cirri stout, XXXVII, 27-31 segments, up to 20.5 mm long. Cirrus segments rather short, seventh-tenth, longest segments, about as long as broad. Prominent dorsal spines occurring beyond twelfth cirrus segment.

Division series ragged, with constricted articulations laterally, separated from neighboring series. Elements of each division series provided with thick articular tubercles, and producing large ventro-lateral expansions. Radials perfectly concealed by centrodorsal. IBr-IIIBr series all 2. IBr1 contact with neighbors at proximal portion, and separated laterally in distal portion, about 4 times as broad as long; IBr2 low pentagonal, twice as broad as long; IIIBr and IIIIBr subequal. Inner side of IIIBr series axillaries often arising a single arm only.

Arms stout, 29 in number, 110.0 mm long, varying in width, 1.5-2.2 mm wide at first syzygy. Syzygial pairs occurring at 3+4, and succeeded by 51+52 and 70+71, and at intervals of 6-8 muscular articulations in distal arm.

Pinnules stiff and erect in proximal part of arm, P1 composed of 13-15 large segments, 13.0-16.0 mm long; P2 11-13, 10.5-14.0 mm; P3 9-11, 8.3-9.0 mm; P4 8, 5.4-6.5 mm; P5 7, 4.6-5.1 mm; Pm 16-17, 8.0-9.0 mm; Pd composed of not excessively elongated segments, about 2 times as long as broad, 16, 7.5 mm; Pa present, 10-13, 9.0-14.0 mm. Longest segments of proximal pinnules cylindrical, about 2.2 times as long as broad. Pattern of relative pinnule length: P1 ≥ P1 > P2 > P3 > P4 > P5 = Pm < Pd.

**Description of Iv 3112**: Centrodorsal hemispherical, 7.2 mm in diameter, 3.5 mm high. Polar area narrow, depressed, 1.5-3.0 mm across. Cirrus sockets compactly arranged in 2-3 rows.

Cirri stout, ILII, up to 32 segments, up to 27.0 mm long. Cirrus segments rather short, 6-12th segments, longest ones, 1.2 times as long as broad. Prominent dorsal spines occurring beyond transition segment (between 11th and 14th).
Division series rugged. Elements of division series provided with thick articular tubercles dorsally, and producing large ventro-lateral expansions laterally. Radials mostly concealed by centrodorsal, slightly visible at corners. IBr, IIBr, and IIIBr series all 2.

Arms stout, 35 in number, reaching to 160.0 mm long, 1.3-2.0 mm wide at first syzygy. Syzygial pairs occurring at 3+4, 26+27, 38+39, 50+51, 68+69..., and 8-11 muscular articulations in distal arm.

Fig. 5. A, Himerometra hartschi A.H. Clark (Iv 3110), Central portion of body (dorsal view). B, Stephanometra tenupinna (Hartlaub) (Iv 3119), Color pattern 1 typed specimen (dorsal view). C, Stephanometra tenupinna (Hartlaub) (Iv 3118), Color pattern 2 typed specimen (ventral view). D. Stephanometra echinus (A.H. Clark) (Iv 3094), Living posture at night. E. Stephanometra echinus (A.H. Clark) (Iv 3111), Color pattern 1 typed specimen (dorsal view). F. Stephanometra echinus (A.H. Clark) (Iv 3112), Color pattern 2 typed specimen (dorsal view).
Proximal pinnules stiff and erect. P₁ about 15 segments, about 17.0 mm long; P₂ 11, 13.2 mm (exceptional one 14, 17.0 mm); P₃ 8, 11.0 mm; P₄ 7-8, 7.5 mm; P₅ resembling P₄, 8-9, 6.0-6.5 mm; P₆ 17, about 9.3 mm; Pd 22, 10.5 mm; Pa present, 9, 6.0 mm. Longest segments of proximal pinnules about 2.2 times as long as broad. Pattern of relative pinnule length: P₁>P₂>P₃>P₄>P₅=P₆<Pm<Pd.

**Color** : Following two color patterns recognized; Pattern 1 (Iv 3094, Fig. 5D and Iv 3111, Fig. 5E): Centrodorsal, cirri, division series and arms blotchy combinations of pink and orange, with small white spots. Pinnules on basal to middle part of arms banded with pink and orange, or pink, orange, and yellowish white, with small white spots. Pinnules on distal arms banded with orange and white or pink, orange and white; Pattern 2 (Iv 3112, Fig. 5F): Cirri banded with orange and pale yellow. Arms dark red with yellowish white band or blotch, sometimes with orange blotch and spots. Coloration of division series similar to that of arms but lighter. Pinnules solid dark red, or solid yellowish white, or banded with dark red, white, yellowish white and dark brown in random combination, and sometimes with yellow tips on distal arms.

![Map](image)

Fig. 6. Map of the distribution of 3 comatulid crinoids in the west Pacific. © *Himerometra bartschi*, ★ *Stephanometra tenuipinna*, ▲ *Stephanometra echinus*. Locations except Okinawa area are based on Clark, A.H. (1908 and 1941), Clark, A.M. and Rowe (1971), Hartlaub (1890), Messing (1998), Meyer and Macurda (1980), and Rowe and Gates (1995).
Ecological notes: The specimen of Iv 3094 collected at Maeda-misaki was clinging on the top of coral heads and attached by the cirri to the substratum with their body fully exposed at night (Fig. 5D). In contrast, the specimens of Iv 3111 and Iv 3112 collected at Udui were perfectly concealed within the reef structure in the daytime. Thus it seems that *S. echinus* is a nocturnal species.

Three species of decapod crustaceans, *Periclimenes* cf. *ceratophthalmus* Boraidaile, *P. commensalis* Boraidaile, and *Allogalathea elegans* (Adams and White), were found in association with *S. echinus*. Unidentified scaleworms and myzostomid worms were also found.

Remarks: This species is easily distinguished from other species of *Stephanometra* by its sharp dorsal spines at distal cirrus segments and many arms (about 30 or more). The following features of the specimens from Okinawa Island, such as rugged elements of division series with thick ventro-lateral expansions, cirri with prominent dorsal spines, and arms with stiffened proximal pinnules composed of about 10 cylindrical segments, agree with Clark's key and description (Clark, A.H., 1941). On the other hand, in his specimens, the cirri vary in number such as XIV (specimen from Bala Balakam Is., Indonesia) and XXXIV (that of Vietnam), while the present specimens have many cirri (e.g. XXXVII and ILII) than those of Clark's. This excess of cirrus number is, however, considered to be included in the range of individual variations within a species.

Distribution and depth: From southern Luzon to Paternoster Isls. (Clark, A.H., 1941), Sulu Sea (Messing, 1998), westward to Ceylon? (Clark, A.H., 1941), southward to Great Barrier Reef (Rowe and Gates, 1995), eastward to Palau Isls. (Meyer and Macurda, 1980), Truk Isls. (Chuuk Atoll) and Papua New Guinea (Messing, 1998), and northward to Ryukyu Isls. (new record in Japan). Shoreline down to 38 m deep.

Discussion

The richness of the shallow-water crinoid fauna in the west Pacific has been revealed through many investigations. Concerning the former works after Clark, A.H. (1941), Clark, A.M. and Rowe (1971) listed 48 comatulid species from China and southern Japan. Meyer and Macurda (1980) listed 22 comatulid species of the Palau Islands and 8 species including one stalked crinoid of Guam. Clark, A.M. (1982) revealed that 11 shallow-water comatulids distributed in the shallow coast near Hong Kong. Liao (1983) described 3 species collected at the Xisha Islands, South China Sea. Chen et al. (1988) reported 20 comatulids of 5 families collected at shallow-waters in the Kenting National Park, southern extremity of Taiwan. Recently, Liao and Clark (1995) listed 72 species including 3 stalked crinoids from southern China between Vietnam and southern Japan, and Messing (1998) revealed 48 shallow-water comatulids from Papua New Guinea, 38 species from the Sulu Sea, and 22 species from the Chuuk Atoll in the Truk Islands. In most of the papers mentioned above, the present 3 species, *Himerometra bartschi*, *Stephanometra tenuipinna* and *S. echinus*, are not reported at all.

As shown in the map (Fig. 6), the present comatulid species, namely, *Himerometra bartschi*, *Stephanometra tenuipinna*, and *S. echinus*, are concentrated in distribution to the
Philippines: Luzon Island, Mindoro, and Sulu Archipelago, and from there dispersing to the adjoining areas (Singapore and Banda Sea), and to the disconnected areas (New Britain Island, Palau Islands, and Truk Islands). Thus, these species are distributed mainly to the tropical waters of Indo-West Pacific. Therefore, the occurrence of these 3 comatulids in the Ryukyu Islands are regarded as comparatively rare for the north-western Pacific. This apparent inclination of distribution is considered to be caused by a constant northward flow by the Japan (Kuroshio) current.

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Literature cited


