Bull. Natl. Mus. Nat. Sci., Ser. A, 37(4), pp. 209–215, December 22, 2011

Rediscovery and Redescription of a Rare Japanese Brittle Star, *Amphiura multispina* (Echinodermata, Ophiuroidea, Amphiuridae)

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(Received 22 July 2011; accepted 28 September 2011)

Abstract *Amphiura multispina,* first obtained from Tokyo Bay in 1878, was known only from its holotype prior to the present report. In this contribution, *A. multispina* is redescribed based on an examination of the holotype and of specimens of the species from a recently discovered population in Shizugawa Bay, Honshu, Japan. In addition, the first photographs of living *A. multispina,* and novel observations on the burrowing ophiuroids in their natural habitat, are discussed with regard to the biology of the species.

Key words: Ophiuroidea, Amphiuridae, *Amphipholis kochii*, *Amphiura multispina*, brittle star, Japan.

Introduction

Amphiura multispina H. L. Clark, 1915, was originally described based on a single specimen from the mouth of Tokyo Bay, Japan, which was obtained in 1878 by Edward Sylvester Morse, the pioneering American zoologist and orientalist. H. L. Clark (1915) provided a short description of *A. multispina* and two, indistinct photographs of the holotype in his "Catalogue of Recent ophiurans." Unfortunately, Matsumoto did not receive Clark's Catalogue before his groundbreaking "Monograph of Japanese Ophiuroidea" went to press, and *A. multispina* was omitted from the otherwise comprehensive account (Matsumoto, 1917:384). The species also escaped mention in subsequent publications, including major systematic works on the Amphiuridae (e.g., Fell, 1962; A. M. Clark, 1970). In fact, the present contribution represents the first account of *A. multispina* since the description of the species nearly 100 years ago.

Our study site, Shizugawa Bay, is located at Minamisanriku-cho on the coast of northeastern Honshu, the Japanese mainland. It is a semi-enclosed basin facing the Pacific Ocean, with an area of approximately 47 km^2, an average depth of 15 m, and a maximum depth of 54 m at the mouth. In 2001, the Shizugawa Nature Center initiated a survey of the marine fauna and flora of Shizugawa Bay, collecting specimens using snorkeling and SCUBA. Beginning in 2009, a study of the echinoderm fauna was begun as there had been no prior survey of the group in the bay. To this date, 12 species of asteroids and 8 species of ophiuroids have been identified (O. Kawase, unpubl. data), including numerous specimens of *A. multispina* that are the subject of our study.

In the present report, we redescribe *A. multispina* and provide photomicrographs showing morphological details of preserved specimens. In addition, we discuss the first color photographs

of living individuals and the first underwater photographs of the animals in their natural habitat. The holotype, which is redescribed and illustrated herein, was borrowed from the Museum of Comparative Zoology, Harvard University (MCZ). Specimens from Shizugawa Bay have been deposited in the National Museum of Nature and Science, Tokyo (NSMT).

Taxonomy

Family **Amphiuridae** Ljungman, 1867

Genus ***Amphiura*** Forbes, 1843

Amphiura (*Amphiura*) *multispina* H. L. Clark, 1915

[New Japanese name: Tashin-suna-kumohitode]

(Figs. 1–3)

Amphiura multispina H. L. Clark, 1915: 229–230, pl. 5 figs. 3–4.

Material examined. MCZ 1360 (holotype), dried from alcohol, mouth of the Bay of Yeddo (=Tokyo Bay), collection of E. S. Morse, 1878. NSMT E-6539 (1 alcoholic specimen), Shirane, Shizugawa Bay, Minamisanriku-cho, Miyagi Prefecture, 38°40.074′N, 141°29.722′E, 15 m deep, water temperature 4.5°C, 9 March 2010, collect-

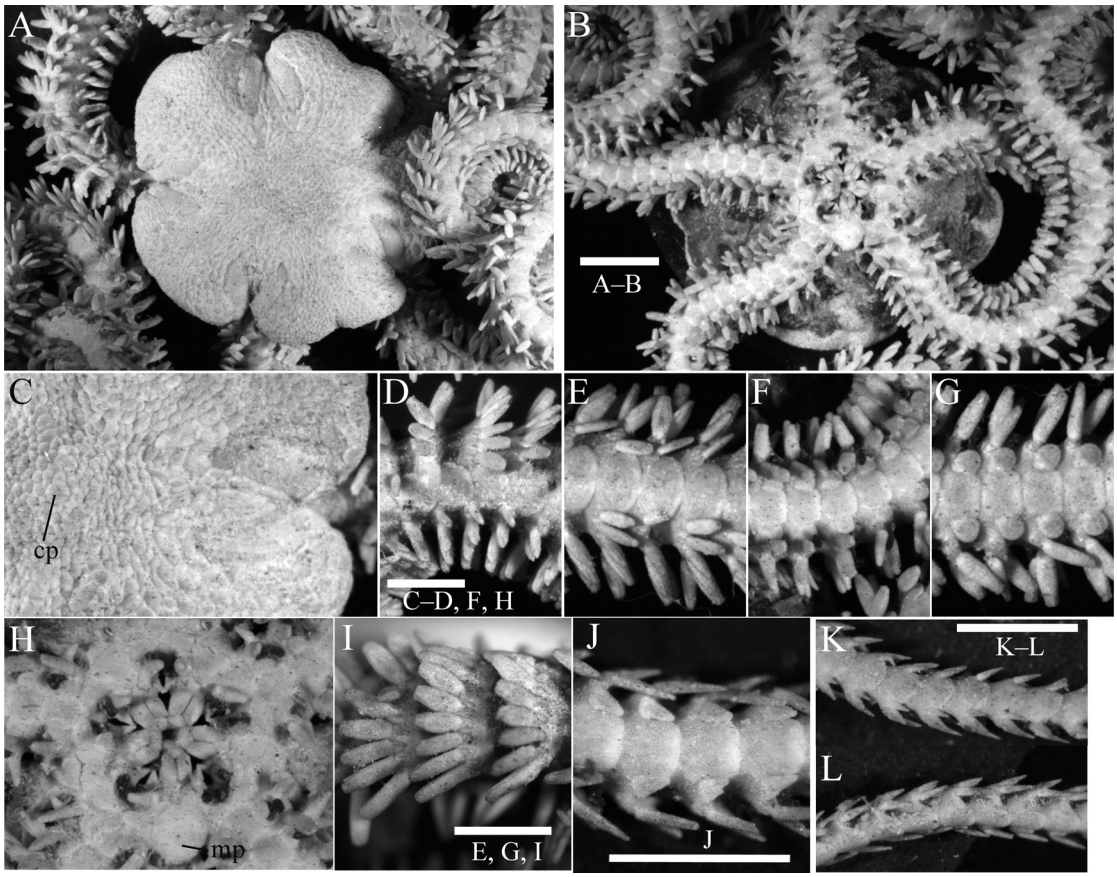

Fig. 1. *Amphiura multispina*. MCZ 1360 (holotype).—A, Disk and base of arms, dorsal view; B, disk and base of arms, ventral view; C, detail of disk, dorsal view, showing scales and radial shields; D, base of arm, near disk, dorsal view; E, middle part of arm, dorsal view; F, basal part of arm, ventral view; G, middle part of arm, ventral view; H, center of disk, ventral view; I, arm spines at base of arm, lateral view; J, distal part of arm, ventral view; K, near tip of arm, dorsal view; L, near tip of arm, oblique ventral view. Abbreviations: cp, central primary plate; mp, madreporite. Scales: A–B, 2 mm; C–L, 1 mm.

ed by A. Dazai and O. Kawase. NSMT E-6540 (3 alcoholic specimens), Shirane, Shizugawa Bay, Minamisanriku-cho, Miyagi Prefecture, 38°40.074′N, 141°29.722′E, 15 m deep, 23 March 2010, collected by A. Dazai and O. Kawase. NSMT E-6541 (13 alcoholic specimens), Shirane, Shizugawa Bay, Minamisanriku-cho, Miyagi Prefecture, 38°40.074′N, 141°29.722′E, 12–14 m deep, water temperature 4.6°C, 1 April 2010, collected by A. Dazai and O. Kawase.

Description of holotype (Fig. 1). Disk diameter approximately 7.2 mm. Arms broken, but length of 90–95 mm specified in original description (H. L. Clark, 1915).

Disk with five swollen, peripheral lobes demarcated by radial notches; dorsal surface covered by numerous, small, opaque, imbricating scales; largest scales bordering radial shields. Central primary plate conspicuous; radial primary plates indiscernible. Radial shields slightly bowed, tapering toward both ends, diverging, approximately 2 times longer than wide, length approximately one-half that of disk radius. Distal end of radial shield broader and more rounded than proximal end; distal ends of paired shields separated by narrow notch in edge of disk; proximal ends separated by wedge of 10–15 scales of which some longer than wide; scales inserted between radial shields particularly long and slender. Single, large, triangular scale separates paired shields of a single radius (Fig. 1A at top, Fig. 1C).

Ventral interradii naked except for scattered scales; imbricating scales extending halfway to oral shields in a single interradius (Fig. 1B at bottom). Some gonads visible through body wall of interradii. Bursal slits long, extending from oral shield to edge of disk. Oral shields ovoid or angular-ovoid, slightly longer than wide. Madreporite tumid, as long as wide, markedly larger than other oral shields. Adoral shields with concave proximal edge; radial lobe of shield large, with broadly rounded outer edge. Adoral shields separated by first ventral arm plate and by proximal edge of oral shield. Paired infradental papillae large, blocklike, closely appressed. Buccal scales (*sensu* Hendler, 1988) triangular; apex of scale reaches infradental papilla. Distal oral papillae robust, subconical, gradually tapering to bluntly rounded tip; distal papilla borne on adoral shield; tip of distal papilla reaches infradental papilla. Teeth nearly rectangular; tip of tooth with irregularly-shaped, microscopically roughened edge.

Dorsal arm plates broadly in contact; plates on segments near disk round, slightly longer than wide, subsequent plates becoming larger; plates at middle part of arm ellipsoidal, markedly wider than long; plates becoming smaller, relatively narrower, slightly longer near tip of arm. First ventral arm plates within oral gape small, inconspicuous; other ventral arm plates broadly in contact, quadrate with rounded corners, nearly as long as wide, becoming longer than wide near tip of arm. Tentacle scales articulating on lateral arm plate, single, large, oval or nearly circular at base of arm, becoming triangular towards distal end of arm, lacking at tip of arm. Lateral arm plates in contact neither dorsally nor ventrally, except at tip of arm. Arm spines up to 7 or 8 in number on most arms (9 maximum), decreasing to 2 near tip of arm. Basal arm spines short, broad, proximodistally compressed, tapering somewhat from center toward ends, with bluntly rounded or truncate tip. Spines about as long as arm segment, increasing very gradually in length ventrad. Distal arm spines slender, subequal; ventral spine longest, nearly 1.5 times length of corresponding arm segment.

Disk of dried specimen pale gray; arms pale brown.

Notes on new material. Specimens from Shizugawa Bay are similar in appearance to the holotype (Fig. 2). Disk diameters of all 17 specimens (NSMT E-6539, 6540, 6541) range from 5.8 to 8.8 mm. The interradial region of the disk is medially indented and considerably less enlarged than in the holotype, possibly because the new specimens have less voluminous gonadal tissue. Arm lengths of 14 specimens (NSMT E-6539, 6541) with intact arms and with disk diameters of 6.0 to 8.8 mm are 38 to 66 mm. The arm

length/disk diameter ratios of the new specimens, which range from 5.5 to 8.5, are all lower than the ratio of 11.9 calculated using H. L. Clark's (1915) measurements of the holotype. His data cannot be verified because the holotype's arms have fallen to pieces. However, it appears that Clark overestimated the length of the arms, because the photograph of the intact holotype (H. L. Clark, 1915: Pl. 5 fig. 3) shows that the ratio was approximately 6.6, similar to that of the new specimens.

Variations in some features were noted among the specimens from Shizugawa Bay. The central and radial primary plates are present in some specimens, although in several specimens only a central plate is discernable, and other specimens appear to lack any primary plates. The paired radial shields of some specimens are in contact at

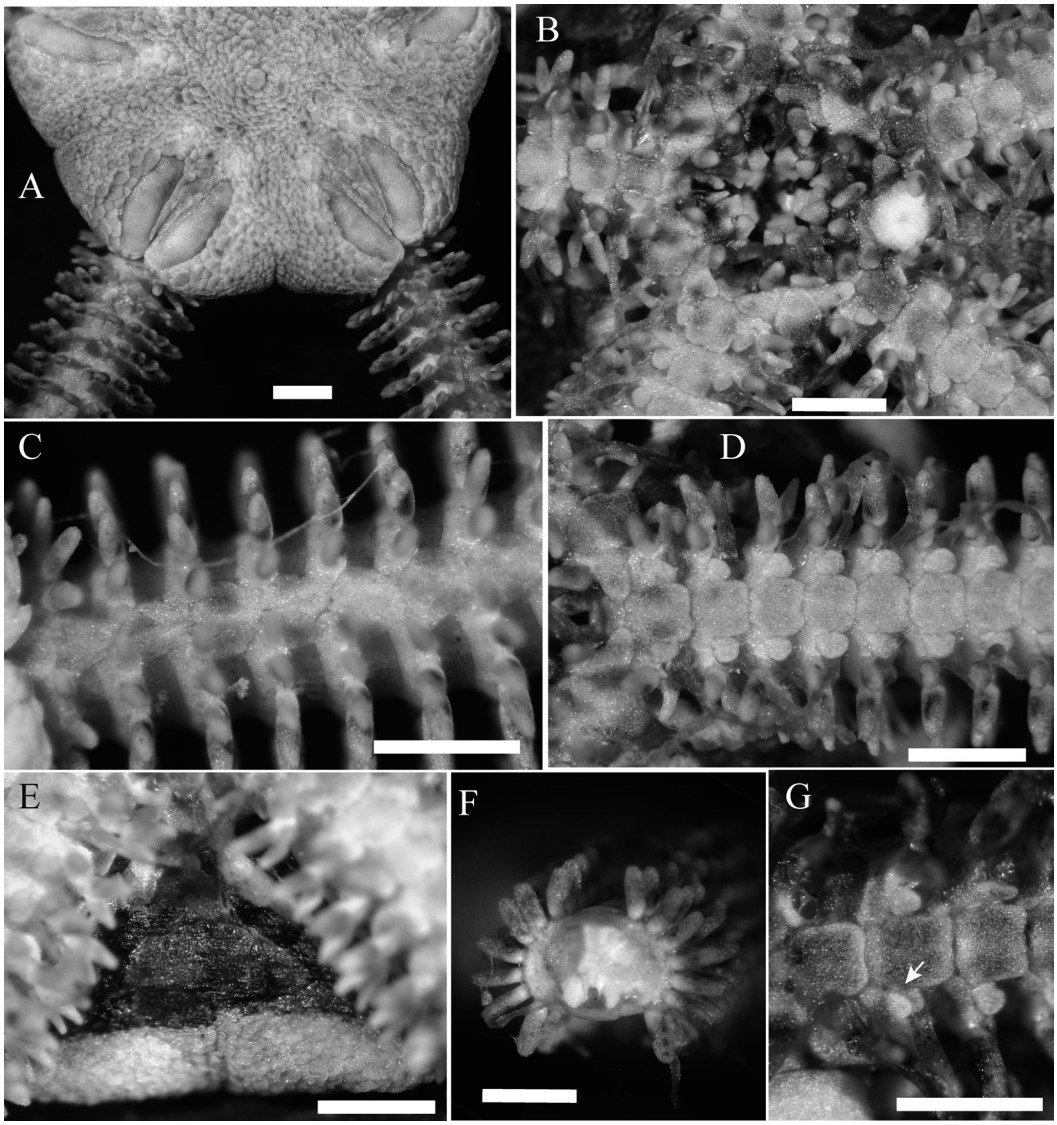

Fig. 2. *Amphiura multispina.* A–F, NSMT E-6541-1; G, NSMT E-6541-3.—A, disk and base of arms, dorsal view; B, center of disk, ventral view; C, basal part of arm, dorsal view; D, basal part of arm, ventral view; E, ventral interradius of disk; F, basal part of arm, showing distal surface of arm segment and arm spines; G, basal part of arm, ventral view, two tentacle scales indicated by arrow. Scales: 1 mm.

their distal ends, and in others they are separated by a slender gap. Naked integument on the ventral interradii of the disk may be restricted to near the oral shields, or cover practically the entire interradius. The portion of the interradius covered by naked integument tends to be directly proportional to an individual's body size. However, the interradii of an individual may not all be identical in appearance. Tips of the teeth of the specimens are smooth, truncate, and slightly concave, which suggests that the roughened teeth of the holotype may have deteriorated during preservation and storage. Dorsal arm plates near the disk of most specimens are round, slightly longer than wide, and they are smaller than the dorsal plates near the middle of the arm. All the specimens examined have a maximum number of 7 or 8 arm spines. The tentacle scales typically are single, but some specimens have a few segments with pairs of tentacle scales (Fig. 2G)

Color of living animals. Individuals are variegated, primarily with greenish-gray, blue, brown, gray, and reddish or orange pigmentation (Fig. 3A–D). Portions of the arms may be an intense orange color (Fig. 3A–B, H). Traversing the dorsal arm plates there is a conspicuous median stripe of orange or salmon pigmentation bounded laterally by grayish stripes. The dorsal arm stripes stand out against the pale lateral arm plates and dark greenish or bluish-gray arm spines. The ventral arm surface has a corresponding median longitudinal stripe because of the purple-gray, violet-gray, or orange color of the ventral arm plates. In addition, small groups of deeply pigmented arm segments create narrow, dark bands that cross the arms at irregular intervals. Specimens preserved in ethanol fade to ochre, with some ossicles such as the arm spines retaining a dark gray or brown tinge, and distal portions of some arms are noticeably pale (Fig. 3E–G) .

Underwater observations at Shizugawa Bay. At the study site, *A. multispina* is common at depths of 10–15 m. Individuals live in scattered patches of silty to sandy sediment which are completely blanketed by pebbles and cobbles that are approximately 5–20 cm in diameter. In these deposits, the disk of the ophiuroid is submerged within the sediment and the distal portion of the arms projects from between the pebbles and cobbles, and extends into the water above them. It is not known if the animals suspension feed, but tube feet protrude from the sides of their arms, extending beyond the arm spines, and the arms are moved back and forth by water currents (Fig. 3H). Although *A. multispina* is the dominant ophiuroid species at the study site, it may occur together with *Amphipholis kochii* Lütken, 1872. Both species assume a strikingly similar posture, but underwater we could distinguish the arms of *A. multispina* from those of *A. kochii* by virtue of their dense spination and orange coloration. *Ophionereis dubia* (Müller and Troschel, 1842) and *Ophionereis eurybrachiplax* H. L. Clark, 1911 also occur in the bay, but in habitats with coarse sediment covered with pebbles, where amphiurids are absent (O. Kawase, unpubl. data). Many individuals of *A. multispina* have regenerating arms, possibly caused by predation, however instances of predation were not directly observed.

Distribution. Known only from Tokyo Bay in central Japan, the type locality (H. L. Clark, 1915), and Shizugawa Bay, in northern Japan (present study).

Remarks. H. L. Clark (1915: 230) indicated that *A. multispina* is a well-characterized species "owing to the large number of arm-spines and the conspicuous tentacle scales." The mature ophiuroids larger than about 6 mm disk diameter are readily distinguished from other *Amphiura* species by the naked ventral interradii, the single large tentacle scale, and 7–9 blunt arm spines, but the juvenile individuals of *A. multispina* have not yet been characterized. Juvenile specimens were not collected in Shizugawa Bay. However, specimens as small as 2 mm disk diameter that are thought to be *A. multispina* but which could not be identified with certainty were collected, using a Smith-McIntyre grab, from the Ariake Sea (Kyushu) at 9–32 m depth and near the Kitan Channel of Osaka Bay (Honshu) from an un-

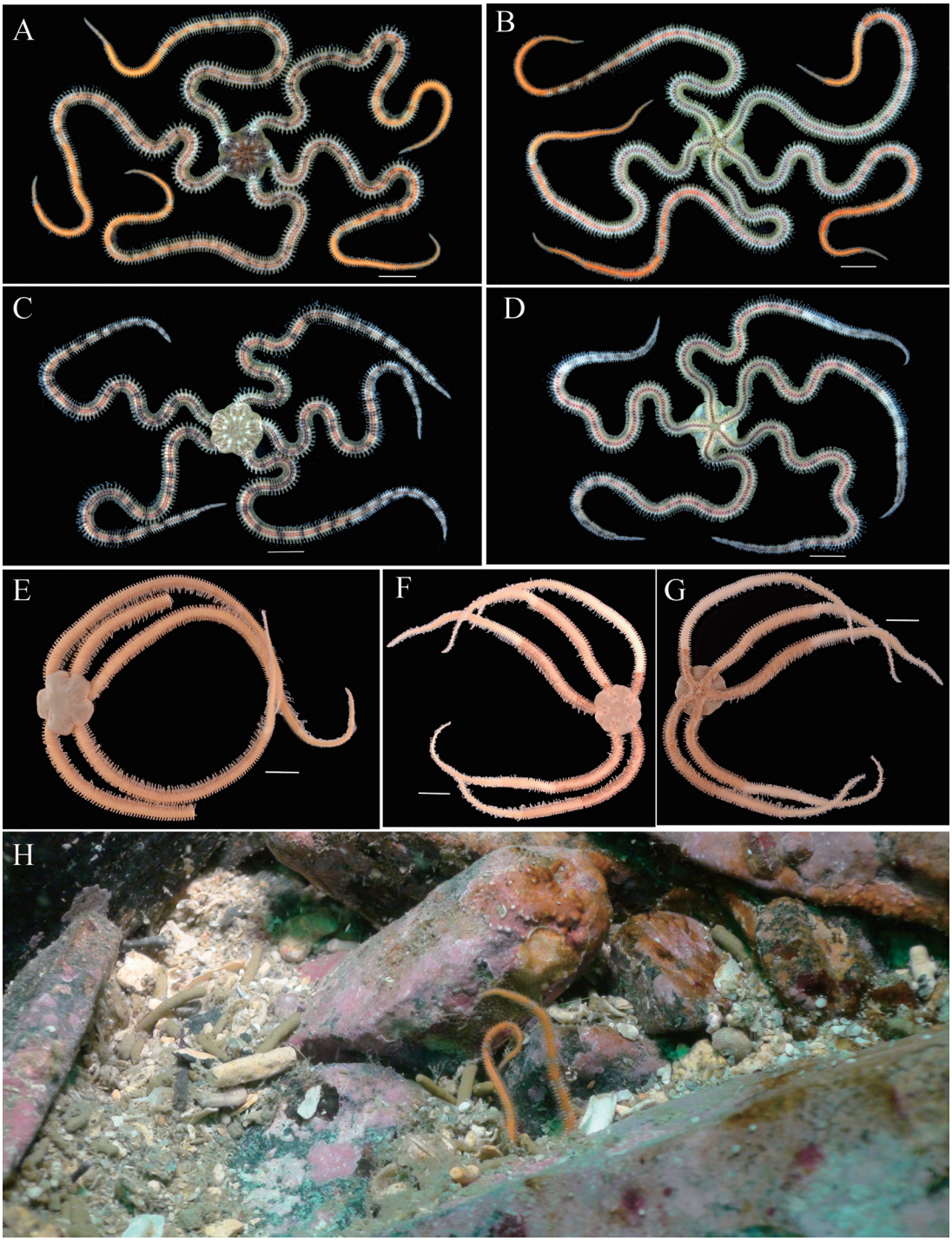

Fig. 3. *Amphiura multispina*. A–B, NSMT E-6541-6; C–D, NSMT E-6541-5; E, NSMT E-6541-4; F–G, NSMT E-6541-7.—A, Living specimen, dorsal view; B, living specimen, ventral view; C, living specimen, dorsal view; D, living specimen, ventral view; E, alcoholic specimen, dorsal view; F, alcoholic specimen, dorsal view; G, alcoholic specimen, ventral view; H, *Amphiura multispina* at 12–14 m depth in Shizugawa Bay. Orange-colored tips of two of the ophiuroid's arms extend from sandy sediment, between pebbles covered with coralline algae.

known depth (T. Fujita, unpubl. data).

Etymology of the Japanese name. *Tashin*, meaning "many spines" refers to a distinguishing feature of the species and to its scientific epithet. The term *suna-kumohitode* (literally, "sand spider-starfish") denotes the family of amphiurid brittle stars.

Acknowledgements

We would like to thank Robert Woollacott and Adam Baldinger (Museum of Comparative Zoology) for loaning the type specimen of *A. multispina*. We are grateful to Osamu Abe, Akihiro Dazai, Junko Miura, and Masanori Sato (Shizugawa Nature Center) for helping us collect living animals. Shizugawa Nature Center, a municipal marine biological institute, was destroyed by the Eastern Japan Great Earthquake Disaster on 11 March 2011. We greatly appreciate the past generous support provided to the nature center by the people of Minamisanriku-cho, and we offer our deep sympathy to the victims of the disaster. It is our sincere hope that the Shizugawa Nature Center will be revived and will flourish again in the future.

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