Journal of Natural History
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tnah20

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Published online: 16 Mar 2007.

To cite this article: Yoshie Takahashi, Matthew H. Dick & Shunsuke F. Mawatari (2007) Sea spiders (Arthropoda: Pycnogonida) from waters adjacent to the Nansei Islands of Japan, Journal of Natural History, 41:1-4, 61-79, DOI: 10.1080/00222930601121783

To link to this article: http://dx.doi.org/10.1080/00222930601121783

Journal of Natural History, 2007; 41(1–4): 61–79

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(*Accepted 10 November 2006)*

Abstract
About 160 species of pycnogonids have been reported from Japan. Among these, only 18 species have been reported from the extensive archipelago of the Nansei (southwest) Islands, even though this warm-temperate to subtropical region should have a pycnogonid fauna as rich as or richer than that surrounding the Japanese main islands. We provide descriptions for five species of pycnogonids collected from depths of 52–334 m along the continental shelf adjacent to the Nansei Islands. *Rhopalorhynchus tenuissimum* (Haswell, 1884) is the first record of this genus and species for Japan, and *Pycnogonum tenue* Slater, 1879 is a new record for the Nansei Island region; we report some previously unrecognized taxonomic characters for these species. We describe as new species *Endeis leviseminentia, Hedgpethia elongata*, and *Pycnogonum spatium*.

Keywords: *Sea spider, Pycnogonida,* Endeis, Hedgpethia, Rhopalorhynchus, Pycnogonum, *Japan, new species, taxonomy*

Introduction

Class Pycnogonida of the Phylum Arthropoda is divided into nine families with 80 genera containing more than 1300 species worldwide, among which about 160 species are known from Japan. Japanese pycnogonids have been relatively well studied by various authors, ever since Böhm (1879) reported two new species, *Ascorhynchus ramipes* and *Propallene longiceps*, from Enoshima, Sagami Bay as the first records of pycnogonids from Japan. Most studies have focused on the Pacific coast of central Japan, where the cold Kurile Current and the warm Kuroshio Current meet, and consequently where a high diversity of species can be found.

There have been fewer reports of pycnogonids from waters adjacent to the Nansei (meaning ''southwest'') Islands of Japan, that is, the archipelago stretching from southernmost Kyushu Island to Yonaguni Island near Taiwan, approximately 1000 km

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Published 16 February 2007

ISSN 0022-2933 print/ISSN 1464-5262 online
DOI: 10.1080/00222930601121783

to the southwest. The Nansei archipelago includes the Satsunan Islands between Kyushu and Okinawa, and the Ryûkyû Islands from Okinawa to Yonaguni. Ohshima (1935) described the first new species from this region, *Pycnogonum benokianum*, a species parasitic on an intertidal sea anemone, and also reported *Endeis mollis* (Carpenter, 1904) from the intertidal zone of Ishigaki Island. More than 50 years later, Nakamura and Child (1988) investigated the subtidal fauna of this region and reported 11 additional species, including one new to science. Recently, Child (1996) added seven species, including one new species occurring from the intertidal to depths of 60 m. To date, 18 species in 15 genera belonging to eight families have been recorded from the Nansei Island region.

All material previously reported was collected from the intertidal zone to a depth of 60 m; there has been no research on pycnogonids from deeper water in this region. As the deep sea should harbour additional species of pycnogonids, we conducted a survey of the continental slope to depths of 334 m. In this paper, we treat five species in four genera belonging to three families. We describe three of these species, *Endeis leviseminentia*, *Hedgpethia elongata*, and *Pycnogonum spatium*, as new to science. *Rhopalorhynchus tenuissimum* (Haswell, 1884) is a new record for Japan, and *Pycnogonum tenue* Slater, 1879 is a new record for the Nansei Island region.

Material and methods

Figure 1 shows the seven sites where specimens were obtained, ranging from 52 to 334 m in depth. The first author collected most of the material during four cruises by the TRV *Toyoshio-maru*, Hiroshima University, from 21–30 May 2002, 19–29 May 2003, 17–28 May 2004, and 17–27 May 2005. Dr Susumu Ohtsuka, Hiroshima University, gave us additional material he collected on two of the same cruises on 25 May 2004 and 22 May 2005. Dr Michitaka Shimomura, Kitakyushu Museum of Natural History and Human History, provided us with pycnogonid samples he collected on 31 May 1999 on another cruise of the same vessel.

Specimens were collected by dredge, beam trawl, and sorinet. Bottom samples were washed and filtered through a 0.1 mm-mesh plankton net. Pycnogonids were hand-sorted from the residual sediment, fixed in 6–7% neutralized formalin or 70% ethanol, and then preserved in 70% ethanol. Appendages were detached from the trunk, and body parts were observed under stereoscopic and phase-contrast microscopes, illustrated with a camera lucida, and measured with an ocular micrometer. Each part was then stored separately in 70% ethanol. All descriptions are based on adult specimens. All new holotypes are complete adults, and are deposited in the Zoological Institute, Faculty of Science, Hokkaido University (ZIHU).

Taxonomy

Measurements primarily follow Fry and Hedgpeth (1969) and Stock (1958). Trunk length was measured from the base of the chelifores to the posterior extremity of the fourth lateral process. Trunk width was measured between the distal extremities of the second pair of lateral processes. Lateral process width was measured at the base of the process. The length of any segment or other structure was taken as the distance in the midline from end to end. Where the structure was curved, measurement was made of the chord of the arc. In the case of a terminal structure, the length was considered as the distance between its proximal

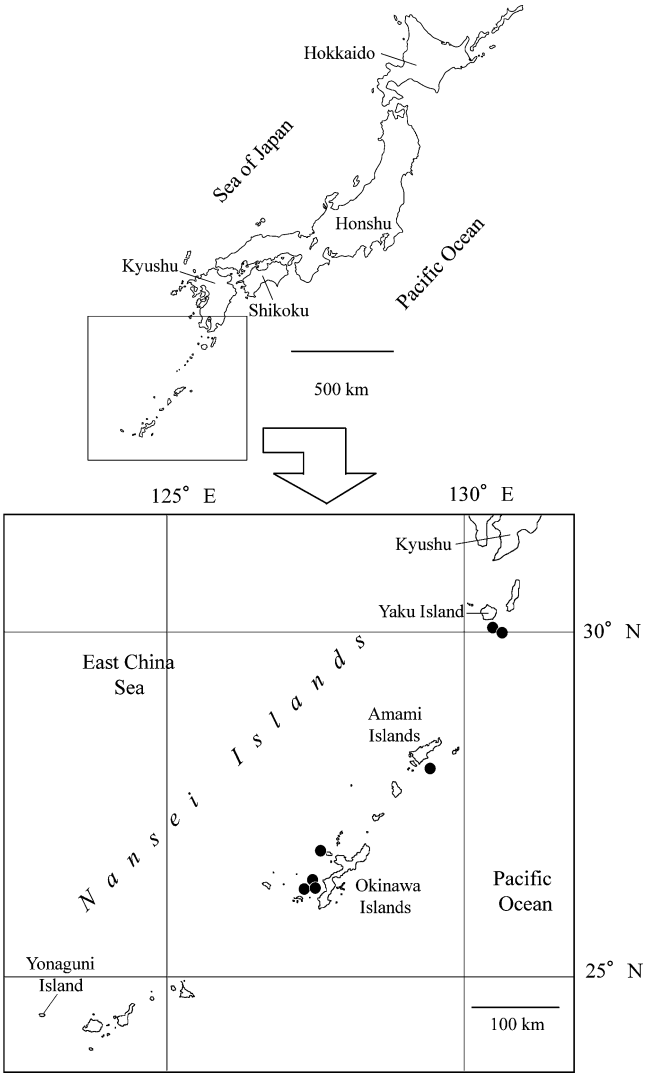

Figure 1. (Above) map of Japan showing the location of the Nansei Islands (box); (below) enlargement of box, showing the Nansei Islands and the collecting sites (filled circles).

margin in the midline and its distal extent. Proboscis and abdomen were measured from the lateral aspect, although Fry and Hedgpeth (1969) measured these from the dorsal aspect. To conserve space, authors of genera and higher taxa are not included in the References section.

Family ENDEIDAE Norman, 1908

Diagnosis. Species usually slender. Chelifores and palps lacking in adults; ovigers in males only, seven-segmented, with weak strigilis, without terminal claw; legs long and slender, with well-developed propodus and auxiliary claw. Cement gland openings a row of multiple dorsal pores or tiny ducts. Eight legs only. Worldwide.

Genus *Endeis* Philippi, 1843

Diagnosis. Trunk elongate; lateral processes well separated; neck very short, usually with collar; chelifores and palps lacking in adults; ovigers in males only, seven-segmented, usually with vestigial strigilis-like spines sparsely distributed on the terminal segment, without terminal claw; legs long and slender, tarsus short, propodus long, with well-developed heel spines and strong auxiliary claw. Cement gland opening as many dorsal pores or tiny ducts arranged in one or two rows.

Remarks. Members of this genus mostly inhabit shallow waters, with several exceptions known to live on floating seaweeds; some species have been observed to swim (Morgan 1971; Isaac & Jarvis 1973; Clark & Carpenter 1977). *Endeis* is widely distributed except in polar regions; the genus has not been reported from the Arctic Ocean, and only two species, *E. australis* (Hodgson, 1907) and *E. viridis* Pushkin, 1976, have been reported from Antarctic waters (Fry & Hedgpeth 1969; Pushkin 1993). At present there are 17 known species worldwide, generally occurring in low abundance but locally abundant in some habitats. Despite its broad distribution, this genus is morphologically uniform, though highly derived.

Most species of *Endeis* have been recorded from relatively warm waters. The three species previously known from Japanese waters, *E. mollis* (Carpenter, 1904), *E. nodosa* Hilton, 1942, and *E. meridionalis* (Böhm, 1879), have been collected south of 35°N. Of these, we did not find *E. mollis* and *E. nodosa* in our survey, though they are known from the Nansei Islands. Ohshima (1935) collected *Endeis mollis* from the Ishigaki Islands as the first *Endeis* recorded from Japan. Nakamura and Child (1983, 1988) subsequently recorded this species from Sagami Bay and Iriomote Island, and Nakamura and Child (1988) reported *Endeis nodosa* from Naha Bay. Utinomi (1971) reported *Endeis meridionalis* from Chijiwa Bay, Nagasaki; this species has an equatorial distribution in the Indian Ocean, western Atlantic Ocean, and western Pacific Ocean, with Nagasaki the northern limit of its range.

Endeis leviseminentia sp. nov.
(Figure 2)

Material examined. Holotype: male, ZIHU 03167, 26°14.63′N, 127°31.79′E, south of Nagannu Island, Okinawa, 26 May 2002, 52 m depth; collected by dredge; Y. Takahashi, collector.

Etymology. The species name *leviseminentia* (Latin, *levis*, meaning little, and *eminentia*, meaning protuberance) refers to the small dorsal protuberance on the second trunk segment.

Measurements of holotype (mm). Trunk length, 6.5; body width, 2.0; proboscis length, 3.6; length of abdomen, 0.9; third leg, coxa 1, 0.45; coxa 2, 2.45; coxa 3, 0.75; femur, 5.45; tibia 1, 5.0; tibia 2, 6.5; tarsus, 0.15; propodus, 1.1; main claw, 0.5; auxiliary claw, 0.4; oviger first article (O1), 0.54; O2, 1.07; O3, 0.55; O4, 0.88; O5, 0.91; O6, 0.64; O7, 0.41.

Description. Size large for genus; leg span about 22 mm. Trunk (Figure 2A, B) elongate, with small, mid-dorsal protuberance on second segment, protuberance shorter than wide. Lateral processes less than 1.5 times as long as their maximum width, separated by three or slightly more times their width; each armed with sharp-pointed tubercle dorsodistally. Ovigers inserted immediately anterior and ventral to bases of first lateral processes,

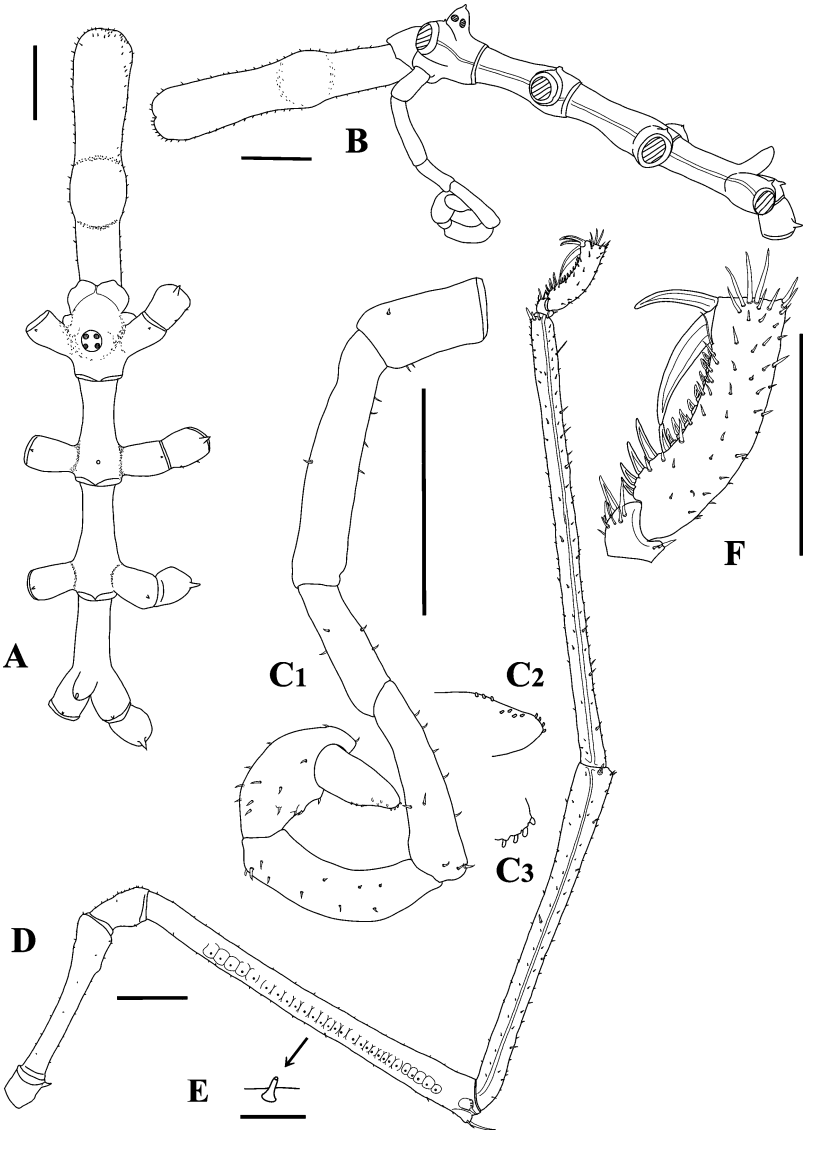

Figure 2. *Endeis leviseminentia* sp. nov., holotype, male: (A) trunk, dorsal view; (B) trunk, lateral view; (C_1) oviger; (C_2) enlargement of distal end of oviger; (C_3) enlargement of distal spines of oviger; (D) third leg; (E) enlargement of cement gland; (F) enlargement of distal segments of third leg. Scale bars: 1 mm (A–D, F); 0.1 mm (E).

touching them. Ocular tubercle about the same height as its basal width, dome-shaped with a small distal knob; eyes pigmented and situated basally on ocular tubercle. Abdomen less than 1.5 times as long as wide, cylindrical proximally, tapering to a blunt cone distally, without setae.

Proboscis (Figure 2A, B) straight, two-thirds as long as trunk, finely setose on all sides, narrowest proximally and gradually thickening distally, with a pronounced swelling proximal to middle and comprising about one-quarter the length; cylindrical at the tip, widest both at the swelling and at distal end, which is less than 1.5 times as wide as the base. Chelifores and palps absent.

Ovigers (Figure 2C$_1$) seven-segmented; second segment longest, about twice as long as first segment; third and sixth segment subequal, both a little longer than first segment; fourth segment and curved fifth segment subequal; sixth segment thickened and ovoid; seventh segment tapering distally. Proximal six segments of oviger armed with short pointed setae that are directed proximally in distal segments; sixth segment with four low protuberances each bearing short seta; seventh segment without setae but with tiny rounded spines, four at apex (Figure 2C$_3$), three endally, and four between others (Figure 2C$_2$).

Legs (Figure 2D) long and slender. First coxa short, armed with pointed, slightly curved dorsodistal tubercle, much larger than but similar in form to lateral process tubercle. Second coxa elongate, about five times as long as first coxa, sparsely setose on all sides. Third coxa less than twice length of first coxa, with single seta dorsally and densely, finely setose ventrally. Femur finely setose dorsally and ventrally, and with spine groups on dorsodistal median tubercle and adjacent smaller tubercle; 27–30 short tubular cement gland openings (Figure 2E) in a regular row. First tibia slightly shorter and second tibia longer than femur; both tibiae setose, with several larger setae intermingled, and armed with distal spines: one dorsolateral spine on tibia 1, three ventral spines on tibia 2. Tarsus short, convex ventrally with single large spine surrounded by smaller spines, few dorsal spines. Propodus (Figure 2F) gradually curving, setose, with large distal setae; heel with four large ventral spines and pair of smaller spines distally; sole with nine or 10 smaller spines and single long distal seta; main claw slightly less than half length of propodus, the long edge curved and the short edge nearly straight; auxiliary claw nearly two-thirds as long as main claw, curving distally.

Remarks. In overall appearance, *Endeis leviseminentia* sp. nov. is similar to both *E. procera* (Loman, 1908) and *E. pauciporosa* Stock, 1970, particularly in having an elongate trunk and long legs, and in the shape of the proboscis. *Endeis procera* is distributed in Philippine and Indonesian waters, near the area of our survey. However, *E. leviseminentia* differs from *E. procera* in having dorsal tubercles on both the lateral processes and first coxae, a dorsal median process on the second trunk segment, several spine groups mounted on the swellings of the femur, and relatively setose tibiae 1 and 2. *Endeis leviseminentia* is similar to *E. pauciporosa* in also having dorsal tubercles on the lateral processes, but it differs in the following characters (characters of *E. pauciporosa* in parentheses): straight femur with short setae (distorted, long), wide gap between adjacent lateral processes (narrow), and 27–30 cement gland pores (six to seven) per femur. Almost all *Endeis* species have multiple cement gland pores situated in one or two rows on the posterior side of each femur. In *E. leviseminentia*, 27–30 cement gland pores, each of tubular form with tapering tip, are arranged in a single regular row. Tubular pores have been previously reported in only one species, *E. spinosa* (Montagu, 1808), but these are not tapering, 19–26 in number, and arranged in irregular rows on a distorted femur with long setae (King 1974).

Distribution. Known only from the type locality, south of Nagannu Island, Okinawa, 52 m depth.

Family COLOSSENDEIDAE Hoek, 1881

Diagnosis. Size usually very large; trunk strong, without tubercles; lateral processes well separated; proboscis usually longer than trunk, cylindrical, held horizontally but sometimes

distally downcurved; chelifores absent in adults, except in two Antarctic genera, *Decolpoda* and *Dodecolopoda*; palps long, nine- or 10-segmented; ovigers in both sexes, very long, 10-segmented, with strong functional strigilis having several rows of spines and terminal claw; legs usually very long, slender; auxiliary claws lacking. Cement gland unknown. Contains eight-, 10- and 12-legged forms. Colossendeids tend to inhabit cold water, occurring in deep water at low latitudes but sometimes more shallowly at high latitudes.

Rhopalorhynchus Wood-Mason, 1873

Diagnosis. Trunk extremely attenuate, fully segmented; lateral processes widely spaced; abdomen minute, more or less ventral in position; proboscis very slender, spindle-shaped, with a narrow, stalk-like basal part, with single tiny tooth mid-dorsally on inflated part; chelifores lacking; palps slender, 10-segmented with very tiny second segment; oviger in both sexes, slender, 10-segmented, strigilis with rows of spatulate spines often with serrate margin, single large distal spine on tenth segment, with terminal claw; legs slender, with sparse tiny setae; femur inflated distally; tarsus and propodus cylindrical, mostly straight, without spines; auxiliary claws lacking. Cement glands unknown.

Remarks. The genus *Rhopalorhynchus* differs from most other pycnogonids in the attenuated body, the spindle-shaped proboscis with dorsal tooth and with elongated stalk, and absence of both chelifores and palps. This genus includes 11 known species.

In general, *Rhopalorhynchus* species inhabit shallow tropical waters, whereas *Hedgpethia* species occur in temperate to cool waters. Species of *Rhopalorhynchus* inhabit the Indian Ocean, from South Africa and the Red Sea to western Australia, and also the western Pacific Ocean, from the Philippines to southeast of Australia. *Rhopalorhynchus claudus* Stock, 1975 from Barbados, western Atlantic Ocean, is distributed disjunctly from the rest of the genus. We further discuss distributional differences between *Hedgpethia* and *Rhopalorhynchus* in Remarks for *Hedgpethia*.

Rhopalorhynchus tenuissimum (Haswell, 1884)
(Figure 3)

Colossendeis tenuissima Haswell 1884, p. 1029, Plate 58, Figures 5–8.
Rhopalorhynchus tenuissimus: Flynn 1919, p. 71, Plate 18, Figures 1–3.
Rhopalorhynchus tenuissimum: Stock 1958, p. 125; Staples 1982, p. 465, Figure 5A–J; Arango 2003, p. 2737, Figure 6.

Material examined. Two males, one female, 24°14.64′N, 127°31.01′E, Nagannu Island, 22 May 2005, 57 m depth, collected by dredge, S. Ohtsuka collector.

Measurements of proboscis. Using Stock's (1958) conventions (in mm), for male and female illustrated in Figure 3A–C: α, 3.63, 4.56; β, 1.48, 2.37; γ, 2.54, 3.99; δ, 2.34, 2.56; ε, 0.60, 0.80; ζ, 0.20, 0.28.

Description. Size moderate for the genus, body slender. Trunk (Figure 3A, B) elongate, attenuate, completely segmented, posterior rims inflated; lateral processes glabrous, 1.5 times as long as their basal width; first and second, second and third lateral process separated by wide intervals that are more than eight times the width of the corresponding

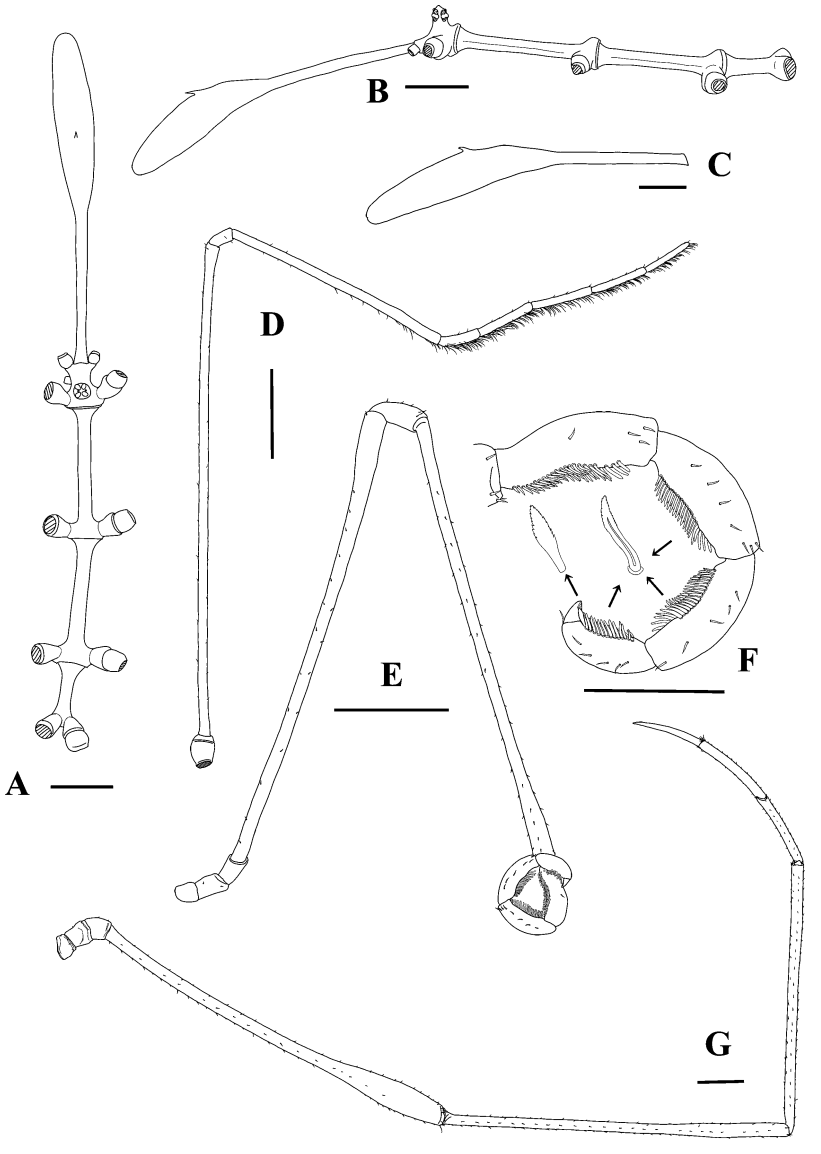

Figure 3. *Rhopalorhynchus tenuissimum* (Haswell, 1884), male, except for C: (A) trunk, dorsal view; (B) trunk, lateral view; (C) proboscis, lateral view, female; (D) palp; (E) oviger; (F) strigilis, with enlargements of two types of spines; (G) third leg. Scale bars: 1 mm (A–E, G); 0.5 mm (F).

crurigers; third and fourth lateral process separated by four times cruriger width. Ocular tubercle dome-shaped, about as high as its basal width, with a low rounded apical point above four pigmented eyes, each eye consisting of two subtle bulges. Proboscis (Figure 3A–C) club-shaped, in male (female in parentheses) 0.7–0.8 (0.8) times as long as trunk, curved downward; proximal narrow stalk 0.81–0.92 (0.64) times length of inflated part, with a dorsal tooth at about 0.44–0.50 (0.43) of total length from posterior of inflated part; lips rounded. Abdomen tiny, located on ventral side, completely hidden from dorsal view.

Palps (Figure 3D) very slender; 10-segmented, with two short basal segments; first segment glabrous, about twice as wide as other segments; second segment shortest; third

segment longest, 2.1 times length of fifth segment, straight, with sparse short setae, with a few longer setae ventrodistally; fourth segment almost as long as first and second combined; sixth segment 0.68–0.69 the length of seventh segment (0.73 in female); seventh to ninth segments equal in length; tenth segment rather longer than sixth segment; distal five segments with many ventral setae and a few dorsal setae.

Oviger (Figure 3E) very slender, 10-segmented, mounted at anterior edge of cephalon; fourth and sixth segments longest, subequal; first to third segments subequal, only second segment with a few tiny setae; fifth segment almost as long as second and third combined; strigilis (Figure 3F) curved endally, armed with sparse setae ectally, with rows of slender endal spines having serrated margins in distal half; terminal segment armed with a wider, denticulate leaf-like spine; terminal claw short, about one-fifth the length of terminal segment.

Legs (Figure 3G) slender; first to third coxae subequal; femur longest, slightly curved endally, swollen distally, with tiny setae scattered sparsely over nearly entire surface; tibiae straight; first tibia slightly shorter than femur; second tibia 0.8 times femur length; tarsus slightly shorter than propodus, with tiny setae dorsally and ventrally, propodus with dorsodistal brush of six or seven setae; tarsus ratio 77–88% (78–86% in female) (*sensu* Stock 1958), the length ratio of claw to propodus in all legs 0.69–0.85 (0.75–0.84 in female).

Remarks. Our male specimens agree well with the redescription of *Rhopalorhynchus tenuissimum* (Haswell, 1884) by Staples (1982) in the position of the dorsal tooth on the proboscis, in the length ratio of the stalk to the inflated part of the proboscis, in the tarsal ratio (*sensu* Stock 1958), and in the shape of the ocular tubercle and the distal spine of the strigilis. Our female is larger than the males (female trunk length, 8.0 mm; males, 5.9 mm and 6.7 mm), as was the case with Staples' specimens.

Distribution. Rhopalorhynchus tenuissimum has previously been recorded from Port Denison (type locality), Calliope, and Geoffrey Bay, eastern Australia (Haswell 1884; Staples 1982; Arango 2003). Our record extends the known range of *R. tenuissimum* considerably to the north; it is the first record from Japan, not only for the species but also for the genus, and represents the northernmost extent of the genus in the Pacific Ocean.

Genus *Hedgpethia* Turpaeva, 1973

Diagnosis. Trunk with lateral processes well separated like *Colossendeis*; segments with expanded ridges posteriorly; proboscis massive, usually spindle-shaped, distally tapering and rounded, or truncate; without dorsal tooth; chelifores lacking; palps 10-segmented, long and slender with very tiny second segment; ovigers 10-segmented, strigilis in both sexes usually with rows of slender spatulate spines, with terminal claw; legs slender, with tiny setae, without well-developed tubercles; tarsus and propodus cylindrical, mostly straight; auxiliary claws lacking. Cement glands unknown.

Remarks. The genus *Hedgpethia* includes 12 known species. All of these are fairly small in body size compared to most species of *Colossendeis*, the type genus of Colossendeidae. Most *Hedgpethia* species have been collected infrequently, at only a few sites, and many are known only from their type locality. Species of *Hedgpethia* have been collected from a wide range of depths, from 20 to 4294 m.

Hedgpethia is related to *Rhopalorhynchus* Wood-Mason, 1873. Stock (1958) divided *Rhopalorhynchus sensu lato* into two species groups: the *articulatum* group and the *kröyeri* group, corresponding to the present genera *Hedgpethia* and *Rhopalorhynchus sensu stricto*, respectively, and suggested that the two groups evolved from a common ancestor. Turpaeva (1973) established *Hedgpethia* for species originally in *Rhopalorhynchus* that lack a tooth on the proboscis.

In general, *Hedgpethia* species inhabit warm- to cool-temperate waters, whereas *Rhopalorhynchus* species occur in shallow tropical waters. In contrast to *Rhopalorhynchus*, species of *Hedgpethia* are distributed in the northern Pacific Ocean from California to Japan, and also occur from eastern Australia to southern New Zealand. Three geographically isolated species are also known: *H. atlanticum* (Stock, 1970) from the northeastern Atlantic Ocean, including the Mediterranean; *H. magnirostris* Arnaud and Child, 1988 from the Zululand area, South Africa; and *H. dampieri* Child, 1975, from near Lancelin Island, southwestern Australia.

In the Pacific Ocean, *Hedgpethia* is broadly distributed in both the northern and southern hemispheres, whereas in comparison *Rhopalorhynchus* is restricted to the Indo-West-Pacific. Although the two genera occur sympatrically in South Africa and western Australia, and from northern Australia to New Caledonia, they generally appear to have different but partly overlapping depth ranges, with *Rhopalorhynchus* occurring from 0 to 320 m and *Hedgpethia* from 20 to 4294 m. The two genera are now considered as having largely non-overlapping distributions in three-dimensional space.

Hedgpethia elongata sp. nov.
(Figure 4)

Material examined. Holotype: male ZIHU 03171, 26°49.50′N, 127°42.00′E, northeast of Ie Island, Okinawa, 23 May 2003, 199–202 m depth; collected by beam trawl, Y. Takahashi collector.

Measurements of holotype (mm). Trunk length, 2.92; body width, 1.12; length of abdomen, 0.12; length of palp, 6.37; first article (P1), 0.21; P2, 0.06; P3, 2.59; P4, 0.28; P5, 1.44; P6, 0.28; P7, 0.42; P8, 0.49; P9, 0.47; P10, 0.39; length of proboscis, 4.31; third leg, coxa 1, 0.32; coxa 2, 0.45; coxa 3, 0.37; femur, 5.06; tibia 1, 6.58; tibia 2, 4.84; tarsus, 1.13; propodus, 1.03; claw, 0.39; oviger, first article (O1), 0.04; O2, 0.11; O3, 0.11; O4, 1.20; O5, 0.21; O6, 1.18; O7, 0.21; O8, 0.19; O9, 0.19; O10, 0.14.

Etymology. The species name refers to the long trunk and proboscis.

Description. Moderately large in size for the genus, slender, leg span 20.2 mm. Trunk (Figure 4A, B) relatively elongate for the genus, completely segmented, posterior rims inflated, lateral processes almost as long as their basal width, separated from one another by roughly twice their basal width, glabrous. Ocular tubercle relatively tall, less than twice as high as its basal width, with pointed apex projecting forward. Four eyes of equal size, pigmented, each eye consisting of two bulges, situated at top of column of ocular tubercle. Proboscis (Figure 4A, B) 1.35 times as long as trunk, curved downward; proximal narrow stalk about one-quarter of length; remainder swollen, four times as wide as stalk; spindle-shaped distal part constricted a little less than one-third of total length from proximal expansion, tapering distally; lips rounded. Abdomen very small, located on ventral side, hidden from dorsal view.

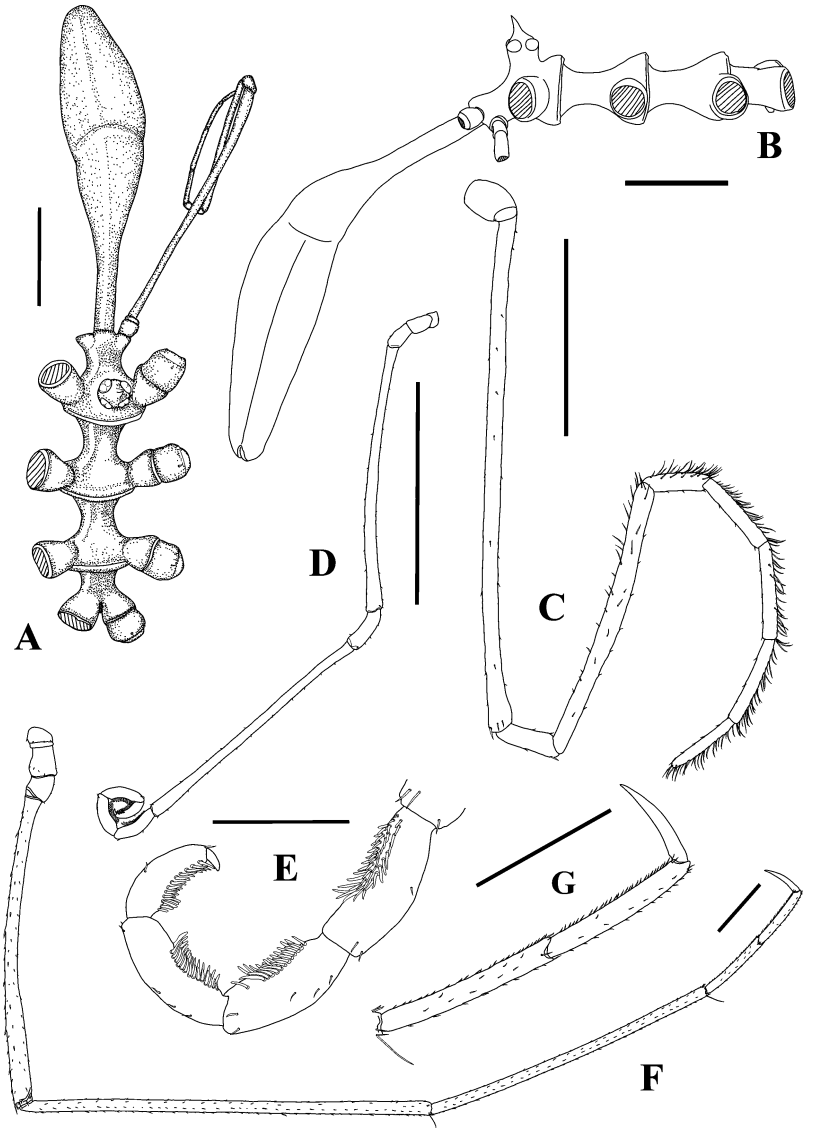

Figure 4. *Hedgpethia elongata* sp. nov., holotype, male: (A) trunk, dorsal view; (B) trunk, lateral view; (C) palp; (D) oviger; (E) strigilis; (F) third leg; (G) enlargement of distal segments of third leg. Scale bars: 1 mm (A–D, F, G); 0.2 mm (E).

Palps (Figure 4C) longer than proboscis, very slender; 10-segmented, with two short basal segments; first segment about twice as wide as other segments; second segment shortest; third segment longest, straight, with sparse short setae, with a few longer setae distally; fourth segment the same length as sixth segment; fifth segment slightly longer than half the length of third segment, with many setae over entire surface, slightly swollen in middle; seventh, eighth, and ninth segments subequal in length; terminal segment slightly longer than sixth segment; distal five segments fairly setose ventrally, setae as long as segment widths.

Oviger (Figure 4D) very slender, long, 10-segmented; fourth and sixth segments longest, with very tiny setae ectally and endally; fifth segment almost as long as second and third combined; strigilis (Figure 4E) curved endally, armed with scattered short, sparse setae ectally, with rows of slender endal spines lacking denticles; seventh segment equal to fifth segment in length; terminal segment less than two-thirds the length and width of seventh segment; terminal claw short, about one-fifth as long as terminal segment.

Legs (Figure 4F) slender, with many tiny setae over entire surface; first and third coxae subequal and shorter than second coxa; femur almost equal to second tibia in length, curved ventrally, thickened in distal half, with several longer setae on distal end; tibiae straight, with a single long seta on distal end; first tibia 1.3 times as long as femur and second tibia; tarsus slightly longer than propodus, both segments with dense, short setae ventrally and sparse, short setae dorsally; main claw about two-thirds as long as propodus.

Remarks. We have assigned this species to *Hedgpethia* because of its expanded posterior segment ridges and the massive, spindle-shaped, distally tapered proboscis without a tooth. Three species of *Hedgpethia* have been previously recorded from Japan: *H. brevitarse* (Losina-Losinsky & Turpaeva, 1958), *H. chitinosa* (Hilton, 1943), and *H. dofleini* (Loman, 1911). The latter two are very similar to one another, both in morphology and distribution (from the Aleutian Islands to west of Kyushu). Although various authors (e.g., Stock 1958; Utinomi 1955; Nakamura & Child 1983) have discussed their close similarity, Nakamura and Child (1991), referring to Hedgpeth (1949), concluded that these two nominal species are valid. Compared to *H. dofleini, H. chitinosa* has (1) a body three times as large, (2) a larger ratio of claw to terminal segment of oviger, (3) no spine in opposition to terminal claw of oviger, and (4) a shorter ratio of main claw to propodus. *Hedgpethia elongata* sp. nov. shares characters (1) (3) and (4) with *H. dofleini*, but like *H. chitinosa* it has a much smaller terminal claw (2) on the ovigers. *Hedgpethia elongata* resembles species of *Rhopalorhynchus* in having an elongate trunk and a long proboscis stalk.

Distribution. Known only from Ie Island, Okinawa, 199–202 m depth.

Family PYCNOGONIDAE Wilson, 1878

Diagnosis. Species almost always very sturdy, with short, strong legs; chelifores and palps completely lacking; ovigers in males only, reduced in size, six- to nine-segmented, with large terminal claw and without strigilis, rarely entirely absent in both sexes (subgenus *Anovigerum* Stock); legs knobby, usually without but sometimes with tiny auxiliary claws. Cement glands usually not visible. Genital pores usually opening ventrally, though sometimes dorsally, on the second coxa. Contains eight- and 10-legged forms. Worldwide in distribution.

Genus *Pycnogonum* Brunnich, 1764

Diagnosis. Trunk and legs stout, with or without reticulation, usually lumpy overall; proboscis strong, usually barrel-shaped; abdomen short, horizontal; chelifores and palps completely lacking; ovigers in males only or lacking in both sexes, reduced in size, seven- to nine-segmented, without strigilis, with large terminal claw; legs very short, stout; tarsus, propodus, and sometimes tibiae often with short, bifurcate sole spines endally; main claw

robust, well curved, generally without and sometimes with auxiliary claws. Cement glands unknown.

Remarks. The genus *Pycnogonum* differs from most other pycnogonids in the strong, lumpy body, short legs, and absence of both chelifores and palps. This genus contains at least 68 known species and has a worldwide distribution. Six species have previously been reported from Japan, including *Pycnogonum benokianum* from shallow waters in the Nansei Island region (Ohshima 1935; Hedgpeth 1949; Child 1996).

Pycnogonum spatium sp. nov.
(Figure 5)

Material examined. Holotype: female, ZIHU 03172, 28°09.20′N, 129°31.50′E, southeast of Amami Island, Kagoshima, 25 May 2004, 332–334 m depth; collected by beam trawl, Y. Takahashi collector.

Measurements of holotype (mm). Trunk length, 2.31; body width, 1.09; length of abdomen, 0.50; length of proboscis, 0.47; third leg, coxa 1, 0.30; coxa 2, 0.38; coxa 3, 0.30; femur, 1.00; tibia 1, 0.50; tibia 2, 0.37; tarsus, 0.13; propodus, 0.50; terminal claw, 0.27.

Etymology. The species name *spatium* (Latin, meaning interval) refers to the wide intervals between lateral processes.

Description. Body very small, elongate; colour vivid yellow. Trunk (Figure 5A, B) integument granular, third and fourth segments fused; anterior three segments each with flat-topped dorsal median tubercle at posterior margin, the tubercle slightly lower than its basal width. Lateral processes half as long as wide, separated from one another by almost two-thirds their basal width, more widely separated distally; each lateral process armed with a single low tubercle dorsodistally, one-quarter the height of dorsal median tubercles on trunk. Ocular tubercle placed on anterior end of trunk, angled slightly forward, about half as high as its basal width, slightly taller than dorsal median tubercles on trunk. Eyes pigmented, situated on base of ocular tubercle. Proboscis large, 1.8 times as long as its basal width, width equal to the trunk width, cylindrical, almost flat at lip, ventral side slightly longer than dorsal side; single median tubercle situated on dorsal surface one-third of total length from end, as tall as its basal width, rising sharply anteriorly, sloping posteriorly. Abdomen horizontal, articulated at base, cylindrical, moderately tapering at the tip, reaching distal end of second coxae, about three times as long as its basal width, with a pair of tiny setae dorsodistally.

Palps, chelifores and ovigers absent. Only the female is known.

Legs (Figure 5C) extremely stout; first coxa equal to third coxa in length, with a pair of dorsolateral tubercles distally (Figure 5A), anterior tubercle bearing a short seta only on fourth legs; a single seta ventrodistally on first coxa, several setae ventrally and laterally on third coxa; second coxa about 1.3 times as long as other coxae, with few setae; femur extremely stout, as long as three coxae combined, with a large, mid-dorsal projection bearing setae, and with a single long seta in the middle of distal half; femur width at projection more than the narrowest femur width; femur has two strong dorsodistal bosses (the larger bearing many strong tubercles distally) with a prominent notch between them; first tibia about three times as long as its basal width, with two dorsal tubercles each bearing

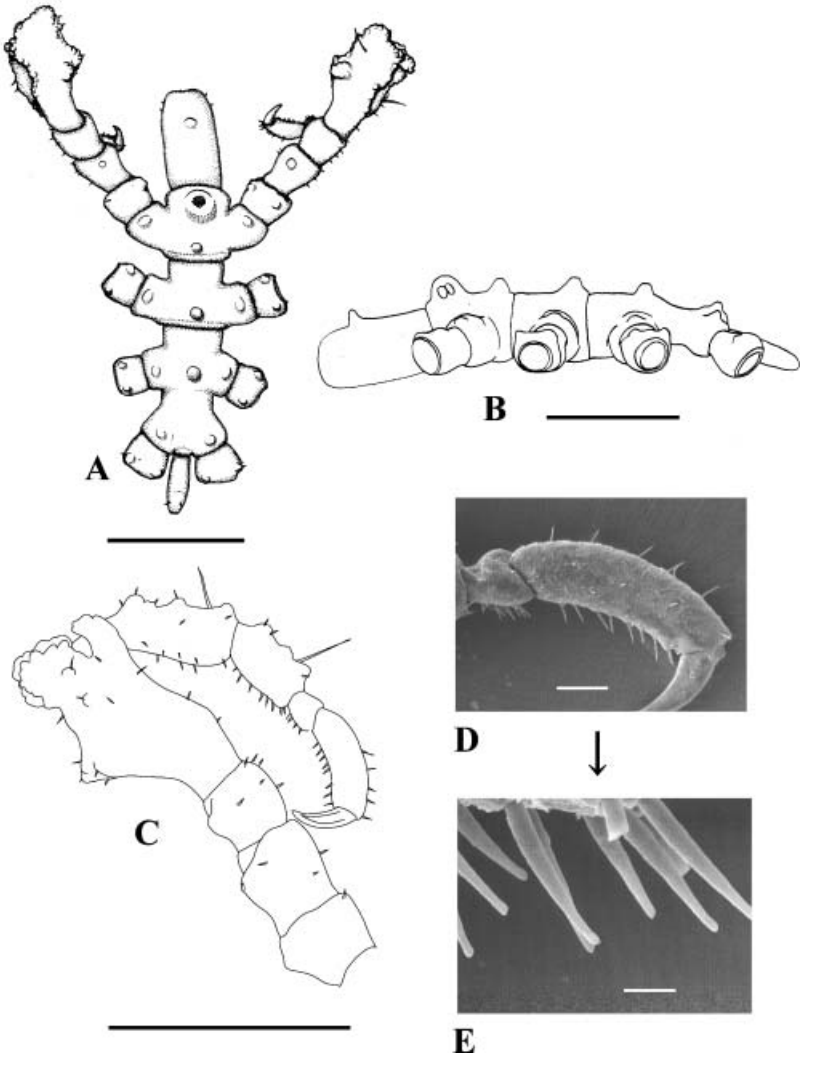

Figure 5. *Pycnogonum spatium* sp. nov., holotype, female: (A) trunk, dorsal view; (B) trunk, lateral view; (C) third leg; (D) distal segments of third leg, by SEM; (E) endal setae of third leg, by SEM. Scale bars: 1 mm (A–C); 0.1 mm (D); 0.01 mm (E).

a short seta, and with single distal tubercle lacking setae, but with single long seta proximal to it; second tibia 0.7 times as long as first tibia, narrower than first tibia, with a similar tuberculation pattern; tarsus short, rounded ventrally; propodus (Figure 5D) moderately curved, slightly shorter than first tibia, with several setae dorsally; all segments bearing short setae ventrally, these different from dorsal setae in having a rounded tip (Figure 5E); terminal claw more than half as long as propodus; auxiliary claw absent. Genital pores of female on dorsal side of second coxa on all legs.

Remarks. *Pycnogonum spatium* sp. nov. resembles *P. moolenbeeki* Stock, 1992 and *P. tuberculatum* Clark, 1963 in having a dorsal tubercle on the proboscis, basal articulation of the abdomen, and a stout femur with strong bosses. *Pycnogonum spatium*, however, differs

from *P. moolenbeeki* in having much stronger mid-dorsal tubercles on the trunk, a cylindrical proboscis with a flat lip, longer intervals between lateral processes, and a longer first tibia with ventral setae having a round tip. *Pycnogonum spatium* differs from *P. tuberculatum* as follows (characters of *P. tuberculatum* in parentheses): cylindrical proboscis with flat lip (gradually tapering towards tip, with rounded lip), wide intervals between the lateral process (relatively narrow), large trunk to proboscis length ratio (small), short first tibia (long), much stronger tubercles on femur and tibiae (strong). No other species in this genus has such wide intervals between the lateral processes as *P. spatium*. Each of the three species above is known only from its type locality: *P. spatium* from Okinawa, *P. moolenbeeki* from Oman, *P. tuberculatum* from southeastern Australia. Only females of these species have been collected; there is no information on males.

Distribution. Known only from the type locality, southeast of Amami Island, Okinawa.

Pycnogonum tenue Slater, 1879
(Figure 6)

Pycnogonum littorale Ström var. *tenue* Slater 1879, p 281.

Pycnogonum littorale Ström var. *tenue*: Ortmann 1890, p. 167; Shishido 1899, p. 200; Fukui 1919, p. 99.

Pycnogonum tenue Kishida 1927, p. 989, Figure 1905; Ohshima 1936, p. 867; Ohshima and Kishida 1947, p. 1010, Figure 2865; Hedgpeth 1949, p. 303, Figures 48b, 50c; Stock 1954, p. 162, Figure 80; Utinomi 1955, p. 36, Figures 22 and 23, 1959, p. 220, 1965, p. 338, Figure 3; Stock 1966, p. 401[key]; Utinomi 1971, p. 338; Nakamura and Child 1983, p. 64; Nakamura 1987, p. 37, Plate 34; Nakamura and Child 1991, p. 63.

Material examined. One male with eggs, one female, 26°15.80′N, 127°21.90′E, off Tokashiki Island, 31 May 1999, 95–115 m depth; collected by sorinet, M. Shimomura collector. One male, one female, 30°09.18′N, 130°36.03′E, southeast of Yaku Island, 23 May 2002, 210–214 m depth; collected by beam trawl, Y. Takahashi collector. One male, 30°09.08′N, 130°38.18′E, south of Yaku Island, 207–197 m depth; collected by beam trawl, Y. Takahashi collector.

Description. Trunk (Figure 6A, B) robust, very crowded, oval in outline, completely segmented, segments one to four each with a tall median tubercular projection dorsally, projection taller than their basal width; just posterior to ocular tubercle is an additional single low median tubercle. Lateral processes as long as wide, slightly separated from each other; first lateral processes armed with a single posterolateral tubercle at distal end; second and third lateral processes each with a pair of prominent distal tubercles; second lateral processes with an additional single, small tubercle dorsodistally; fourth lateral processes with no distinct tubercles. Ocular tubercle large, slightly lower than median projections, rounded, with four slightly pigmented eyes; anterior pair of eyes smaller than posterior. Proboscis very slender, widest proximally, tapering to middle, distal half cylindrical and almost half the basal width, with cylindrical lips and with several tiny ventral setae. Abdomen large, clavate, rounded distally, reaching middle of second coxae of fourth legs, armed with four short distal setae.

Ovigers (Figure 6C) in males short, robust, nine-segmented, with terminal claw; first, second, and fifth segments equal in length; third segment almost twice the length of fourth

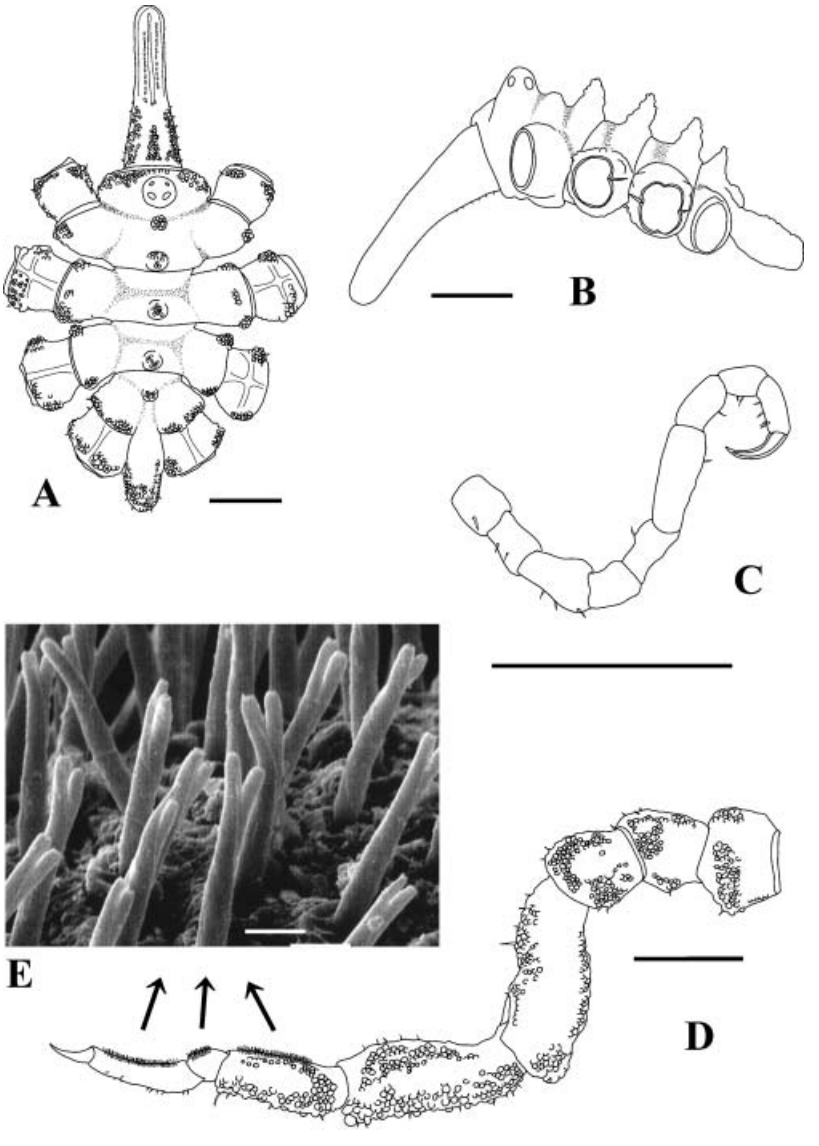

Figure 6. *Pycnogonum tenue* Slater, 1879, male: (A) trunk, dorsal view; (B) trunk, lateral view; (C) oviger; (D) third leg; (E) endal setae of third leg, by SEM. Scale bars: 1 mm (A–D); 0.01 mm (E).

segment; proximal three segments with a few setae ectally; fifth segment with single seta endally; distal four segments armed with one to four simple spines endally; sixth segment twice as long as seventh; seventh and ninth segments subequal and longer than eighth segment; terminal claw strongly curved, longer than subterminal segment.

Legs (Figure 6D) moderately short, robust, armed with several short setae; all coxae subequal in length; first coxa 1.5 times as wide as other coxae; second and third coxae as wide as long; femur and first tibia subequal in length; second tibia almost two-thirds the length of first tibia; tarsus short, rounded ventrally; propodus curved proximally, with several short setae dorsally; second tibia, tarsus, and propodus armed with numerous

bifurcate spines ventrally (Figure 6E), the rami twisted; claw about one-quarter as long as propodus. Genital pores of male situated ventrally on tubercle on second coxae of fourth pair of legs, those of female placed dorsally on second coxae of fourth legs.

Remarks. Our specimens agree well with the original description of *Pycnogonum tenue* Slater, 1879 and with the redescriptions and figures by Stock (1954) and Nakamura (1987), in the shape of trunk, proboscis, and dorsal median projections. Among congeners, *Pycnogonum tenue* can easily be recognized by its long, slender, tapering proboscis, five dorsal median projections, and the short leg segments. Some variation has been reported in this species. The size of the proboscis has been reported as being from slightly less than 2 mm to slightly more than 4 mm (Stock 1954); in our specimens it ranges from 2.38 to 2.87 mm. Some authors have reported prominent reticulation on the surface of the whole body, but others have not (e.g. Child 1991); our material has the first coxae faintly reticulated, but other parts not reticulated. Our material has clearly bifurcate setae on the propodus, tarsus, and second tibia. Such bifurcate setae have not been reported before in *P. tenue*, though some *Pycnogonum* species (e.g. *P. elephas* Stock, 1966; *P. pustulatum* Stock, 1994) are known to have such setae only on the propodus. Presence of the bifurcate setae may prove to be a useful taxonomic character to discriminate species of *Pycnogonum* in the future, after the setae have been examined in various species.

Distribution. *Pycnogonum tenue* is known from many localities in Japan: Sagami Bay, Suruga Bay, Kii Channel, and western Kyushu, ranging in depth from 7 to 416 m. This study extends the distribution of *Pycnogonum tenue* to Okinawa. The species is presently known only from Japan.

Discussion

Including the five species in the present paper, 23 species in 17 genera belonging to nine families have been recorded from the vicinity of the Nansei Islands. This is likely only a small fraction of the species that remain to be discovered there. The area is subtropical and is located in the northernmost part of the Indo-West Pacific region, where a high diversity of pycnogonids has been reported (Stock 1954, 1992), as with some other groups of marine animals. At least 30% of the approximately 1200 species of pycnogonids known worldwide have been reported from the Indo-West Pacific. The occurrence of the genera *Propallene* (Stock, 1994) and *Rhopalorhynchus* (our study) in the Nansei Islands provides evidence that the fauna of southern Japan has affinities with that of Indo-West Pacific. Pycnogonids have been relatively well studied in Japanese temperate waters, which alone contain about 13% of the total species known worldwide, including many endemics. In short, we expect that many more species than the 23 presently known from the Nansei Islands exist there.

Acknowledgements

We express our sincere gratitude to Dr. Susumu Ohtsuka, Hiroshima University, for his kindness in giving the first author the opportunity to take part in his research cruises, and for his generosity in offering us valuable specimens; to the crew of TRV *Toyoshio-Maru*, Hiroshima University, for their kind assistance in fieldwork; to Dr. Michitaka Shimomura, Kitakyushu Museum of Natural History and Human History, for his kindness in offering us

precious specimens and valuable advice; to Dr. Tetsuya Kato, Seto Marine Biological Station, Kyoto University, for his generosity in giving instructions in fieldwork; to Dr. Roger N. Bamber, the Natural History Museum, London, for his kind perusal of the manuscript and critical suggestions to improve it; to Dr. Koichiro Nakamura, Musashino, Tokyo, for his helpful advice; and to an anonymous reviewer who corrected several errors in the manuscript and whose detailed comments substantially improved it.

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