

Shrimps of the crangonid genus *Paracrangon* Dana (Crustacea: Decapoda: Caridea) from the northwestern Pacific: taxonomic review and description of a new species from Japan*

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SUMMARY: The northwestern Pacific species of the crangonid genus *Paracrangon* Dana, 1852 are reviewed. Five species, including one new species, are recognised from the region: *P. echinata* Dana, 1852 (type species of the genus), *P. abei* Kubo, 1937, *P. furcata* Kubo, 1937, *P. okutanii* Ohé and Takeda, 1986, and *P. ostlingos* sp. nov. The geographical range of *P. okutanii* is extended to the northern South China Sea off southwestern Taiwan, representing the first discovery of species of the genus from tropical waters in the western Pacific. These species are diagnosed and illustrated. They are classified into two informal species groups, the *P. echinata* species group (including *P. echinata*, *P. abei* and *P. okutanii*, and two species from other regions, *P. areolata* Faxon, 1893 and *P. australis* Hanamura, Wadley and Taylor, 1999) and the *P. furcata* species group (*P. furcata* and *P. ostlingos* sp. nov.). New findings on the morphology of the genus are presented. The monophyly of *Paracrangon* is highly corroborated by a number of autapomorphic characters, but its relationship to other crangonid genera remains obscure. A revised key to aid in the identification of the species of *Paracrangon* is presented.

Key words: Crustacea, Caridea, Crangonidae, *Paracrangon*, northwestern Pacific, new species, key to species

RESUMEN: CAMARONES DEL GÉNERO CRANGÓNIDO *PARACRANGON* DANA (CRUSTACEA: DECAPODA: CARIDEA) DEL PACÍFICO NOROCCIDENTAL: REVISIÓN TAXONÓMICA Y DESCRIPCIÓN DE UNA NUEVA ESPECIE DE JAPÓN. – Las especies del género crangónido *Paracrangon* Dana, 1852 del Pacífico noroccidental son revisadas taxonómicamente en este trabajo. Cinco especies, incluyendo una nueva especie, se reconocen en esta región: *P. echinata* Dana, 1852 (especie tipo del género), *P. abei* Kubo, 1937, *P. furcata* Kubo, 1937, *P. okutanii* Ohé and Takeda, 1986, and *P. ostlingos* sp. nov. El rango geográfico de *P. okutanii* se extiende hasta el norte del Mar del Sur de China al suroeste de Taiwan, representando el primer descubrimiento de una especie de este género en aguas tropicales del Pacífico oeste. Se presenta la diagnosis e ilustración de todas las especies mencionadas. Se clasifican en dos grupos informales de especies, el grupo de especies *P. echinata* (que incluye a *P. echinata*, *P. abei* y *P. okutanii*, y dos especies de otras regiones, *P. areolata* Faxon, 1893 y *P. australis* Hanamura, Wadley y Taylor, 1999) y el grupo de especies *P. furcata* (*P. furcata* y *P. ostlingos* sp. nov.). Se presentan nuevos descubrimientos sobre la morfología del género. La monofilia de *Paracrangon* es altamente corroborada por un número de caracteres autapomórficos, pero su relación con otros géneros de crangónidos sigue siendo oscura. Se presenta una clave revisada para ayudar en la identificación de las especies de *Paracrangon*.

Palabras clave: Crustacea, Caridea, Crangonidae, *Paracrangon*, Pacífico noroccidental, nueva especie, clave de especies.

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INTRODUCTION

The peculiar crangonid genus *Paracrangon* Dana, 1852 is generally considered to be rare except for the type species, *P. echinata* Dana, 1852. Six species are known in the world (Hanamura *et al.*, 1999), of which four species have been reported from the northwestern Pacific: *P. echinata*, *P. abei* Kubo, 1937, *P. furcata* Kubo, 1937 and *P. okutanii* Ohé and Takeda, 1986. Only *P. echinata* is common, having been reported from the northeastern and northwestern Pacific by numerous authors (e.g. Rathbun, 1904; Brashnikov, 1907; Schmitt, 1921; Yokoya, 1933; Kubo, 1937; Igarashi, 1969; Kim, 1977; Butler, 1980; Miyake, 1998). Other species are known only from the original descriptions and a few subsequent reports. A study of a series of collections from various sources, including the putative type material of *P. abei* and *P. furcata*, enabled us to diagnose all the known species precisely. A new species, *P. ostlingos*, is described from Boso Peninsula and Izu Islands, on the Pacific coast of central Japan. The new species is most closely related to *P. furcata*. *Paracrangon okutanii*, known only from the type series from Sagaminada, was discovered from Taiwan, extending the geographical range of the species to the South China Sea. This represents the first discovery of a species of *Paracrangon* from the tropical region in the western Pacific. In addition to these named species, two unidentified species have been reported from Japanese waters (Fujikura *et al.*, 1995, 1996), one from Sagami Bay (as *Paracrangon* sp. 1) and one from a hydrothermally influenced field on the Minami Ensei Knoll, Okinawa Trough (as *Paracrangon* sp. 2). The taxonomic status of these two taxa remains undetermined.

It was generally believed that one of the characteristics of *Paracrangon* is the absence of the second pereopod (cf. Holthuis, 1955, 1993; Burukovsky, 1985; Christoffersen, 1988), until Hanamura *et al.* (1999) reported the presence of a rudimentary second pereopod in *P. australis* Hanamura, Wadley and Taylor, 1999. Our examination has revealed that the rudimentary second pereopod is actually present in *P. echinata*, *P. abei* and *P. okutanii*, while the second pereopod is completely absent in *P. furcata* and *P. ostlingos* sp. nov. The genus is highly specialised with many autapomorphic characters, but estimation of the sister group remains difficult.

MATERIAL AND METHODS

The material examined herein is deposited in the collections in the following institutions: Institute of Marine Biology, National Taiwan Ocean University, Keelung (NTOU); Invertebrate Zoology Laboratory, Department of Marine Biology, Pukyong National University, Busan (PUIZ); Kitakyushu Museum and Institute of Natural History and Human History, Kitakyushu (KMNH, with a code of IvR); Laboratory of Marine Zoology, Faculty of Fisheries, Hokkaido University, Hakodate (HUMZ, with a code of C); Muséum national d'Histoire naturelle, Paris (MNHN, with a code of Na); National Fisheries University, Shimonoseki (NFU); Natural History Museum and Institute, Chiba (CBM, with a code of ZC); Tokyo University of Marine Science and Technology (formerly Tokyo University of Fisheries, TUF); Zoological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka (ZLKU); and Zoologische Staatssammlung München (ZSM).

The terminology for teeth on the carapace generally follows that of Butler (1980: 96, Fig. 14) except for the use of tooth (teeth), instead of spine(s). The terminology used for carinae on the carapace is defined in Figure 1. An indication of specimen size is provided by the postorbital carapace length (CL), taken to the nearest 0.1 mm. The pubescence on the body and appendages are omitted or only partially illustrated on the figures.

SYSTEMATICS

Family CRANGONIDAE

Genus *Paracrangon* Dana, 1852

Paracrangon Dana, 1852a: 16; Kingsley, 1899: 715; Holmes, 1900: 176; Balss, 1914: 72; Schmitt, 1921: 103; Butler, 1980: 75; Christoffersen, 1988: 46; Komai, 1994: 99.

Type species. *Paracrangon echinatus* Dana, 1852, original designation by monotypy. Gender: feminine.

General description. Body robust, weakly compressed laterally; integument firm, covered with short pubescence or curved setae, but devoid of scale-like structures, surface strongly sculptured.

Rostrum long and slender for crangonids, obliquely erect, compressed laterally, terminating acutely; ventral margin with strong, recurved tooth subproximally; rostral lateral carina blunt, occasionally obsolete, extending to orbital margin. Carapace principally with 4 teeth on middorsal carina, second

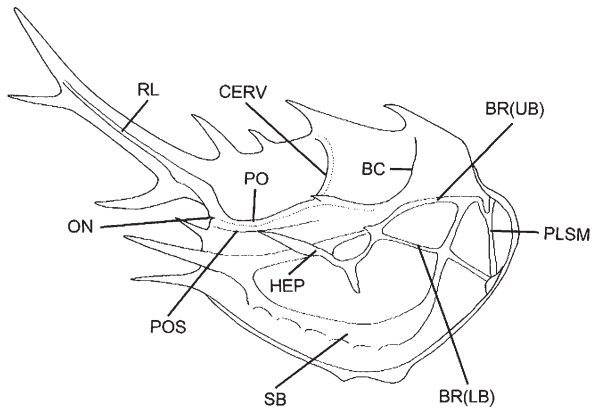


FIG. 1. – Schematic drawing of carapace of *Paracrangon* in lateral view, showing terminology for carinae and other structure. BC, branchiocardiac carina; BR(LB), branchial carina (lower branch); BR(UB), branchial carina (upper branch); CERV, cervical carina; HEP, hepatic carina; ON, orbital notch; PLSM, posterolateral submarginal carina; PO, postorbital carina; POS, postorbital suture; RL, rostral lateral carina; SB, subbranchial carina.

tooth much smaller than others, occasionally reduced, fourth tooth on cardiac region also occasionally reduced; lateral surface with several carinae termed as follows: postorbital carina, hepatic carina, branchial carina, subbranchial carina, submarginal carina, cervical carina and branchiocardiac carina (Fig. 1). Postorbital carina connected with cervical carina, delineating shallowly depressed gastric region; hepatic carina supporting hepatic tooth, confluent with 2-branched branchial carina; subbranchial carina connected with branchiostegal tooth, extending posteriorly along ventral margin of carapace, occasionally connected with branchial carina posteriorly; branchiocardiac carina lying from base of fourth median tooth across cardiac region, confluent with postorbital carina; submarginal carina bordering ventral margin of carapace, accompanied by shallow groove. Orbital margin evenly concave, occasionally with small notch dorsal of base of antennal tooth. Branchiostegal tooth strong, weakly to strongly divergent; pterygostomial tooth small to strong, reaching or overreaching anterior margin of antennal basicerite, overlapped by branchiostegal tooth in lateral view. Postorbital suture extending from just superior to base of antennal tooth to about midlength of carapace. Thoracic sternum narrow, with 4 forwardly directed teeth decreasing in size posteriorly in males and non-spawning females (teeth corresponding to fifth to eighth thoracic somites); somites separated by distinct transverse sutures; in spawning females, posterior part of thoracic sternum deeply concave, posterior 2 sternal teeth completely reduced.

Abdomen with middorsal carinae at least on third to fifth somites, highest middorsal carina on third somite, sixth somite with 2 narrowly separated submedian carinae. First to fifth somites each with conspicuous lateral projection. Anterodorsal margin of first somite deeply concave; posterodorsal margin of second, fourth and fifth somites widely notched, that of third somite weakly produced posteriorly. Dorsolateral parts of terga of first to fifth somites each with broad transverse sulcus extending onto posterior part of pleuron. Pleura of first to fifth somites strongly produced ventrally, each usually terminating in acute tooth (except for *P. ostlingos* sp. nov.), decreasing in width toward posterior from second somite; lateral faces each with broad vertical sulcus on anterior part. Sixth somite with conspicuous posterolateral process; posteroventral tooth strong, flared laterally. First to fifth somites each with very strong sternal tooth (sternal teeth on first to third somites somewhat shortened in spawning females); sixth somite with pair of submedian teeth, being shorter than preceding sternal teeth. Telson tapering to acute tip; dorsal surface shallowly sulcate medially, with 3 pairs of small dorsolateral spines in posterior half.

Eye-stalk short, slightly constricted at middle, without tubercles on dorsal surface; cornea well developed, darkly pigmented.

Antennular peduncles long, slender, overreaching midlength of scaphocerite; first segment longer than distal 2 segments combined, with short, rounded stylocerite bearing fringe of long setae. Flagella sexually dimorphic as in other crangonids; lateral flagellum longer in males than in females; mesial flagellum very short, slightly longer in males than in females.

Antenna with unarmed basicerite. Carpocerite (fifth segment) elongate, distinctly overreaching distal margin of scaphocerite. Scaphocerite about half length of carapace, with concave lateral margin; blade broadly rounded, exceeding distolateral tooth. Flagellum slender, shorter than body.

Mouthparts typical of family. Mandible (Fig. 3A) consisting only of slender, curved molar process; distal part 4-toothed. Maxillule (Fig. 3B) with ovate coxal endite fringed with sparse setae; basal endite suboval, with row of slender spines on mesial margin; endopod nearly straight, terminally bilobed. Maxilla (Fig. 3C) with poorly developed endites each represented by low, broadly rounded lobe; endopod moderately slender, twisted, proximomesial margin weakly expanded;

scaphognathite moderately broad, posterior lobe well developed, but not strongly elongate, fringed with very long setae on posterior margin. First maxilliped (Fig. 3D) with endites greatly reduced, separated by faint notch, each with row of sparse setae on mesial margin; endopod long, reaching nearly distal margin of exopod; exopod moderately slender, with well developed lash; epipod large, feebly bilobed, each lobe terminating subacutely. Second maxilliped (Fig. 3E) 6-segmented with ischium and basis fused; dactylus-propodus articulation oblique; dactylus with numerous dense short setae and sparse longer setae on mesial margin; exopod long, with well developed lash; epipod large, sickle-shaped, lacking podobranch. Third maxilliped (Fig. 3F) 4-segmented; distal 2 segments flattened dorsoventrally; ultimate segment terminating bluntly, lateral margin with short to long setae, mesial margin with numerous spiniform setae; penultimate segment (= carpus) shorter than ultimate segment, with dense setae on mesial margin; antepenultimate segment (merus-ischium-basis fused segment) sinuously curved in dorsal view, margins with short to long setae, proximo-mesial margin forming low lobe; coxa with oval-shaped, setose lobe on lateral face, presumably originating from epipod; exopod reaching midlength of antepenultimate segment, somewhat tapering distally, with well developed lash.

First pereopod subchelate, long, overreaching distal margin of scaphocerite; dactylus somewhat curved; palm somewhat compressed dorsoventrally, with basally articulated distomesial spine (= pollex); cutting edge oblique, markedly convex; merus usually unarmed. Second pereopod greatly reduced in short, slender lobe terminating acutely or completely absent. Third pereopod slender, overreaching distal margin of scaphocerite at least by length of distal 2 segments; dactylus very short, less than 0.25 length of propodus; propodus less than 0.30 length of carpus; carpus elongate, longer than merus; coxa stout, unarmed. Fourth and fifth pereopods similar, rather slender; dactyli compressed laterally, weakly curved, each terminating in simple, acuminate unguis; propodi each with row of slender spines at least in distal 0.30 (distal 4-5 spines increasing in size toward proximal); carpi shorter than propodi, each with short dorsodistal projection; meri and ischia unarmed.

Pleopods lacking appendices internae. Endopod of male first pleopod (Fig. 3J, K) 0.35-0.40 length of exopod, spatulate, with row of simple, spiniform

setae on mesial margin, distal margin rounded. Appendix masculina on second pleopod (Fig. 3L) bearing 8-10 long bristles in distal 0.30-0.40.

Exopod of uropod bearing variously formed distolateral lobe, instead of acute distolateral tooth usually found in other crangonid species.

Composition: *Paracrangon echinata* Dana, 1852; *P. areolata* Faxon, 1893; *P. abei* Kubo, 1937; *P. furcata* Kubo, 1937; *P. okutanii* Ohé and Takeda, 1986; *P. australis* Hanamura, Wadley and Taylor, 1999; and *P. ostlingos* sp. nov. In addition, two unidentified species are known from Sagami Bay and Minami Ensei Knoll, Okinawa Trough, respectively (Fujikura *et al.*, 1995, 1996).

Distribution: Northwestern Pacific southward to Taiwan; northeastern and southeastern Pacific southward to Peru; southwestern Pacific off southeastern Australia; sublittoral to 1400 m.

Remarks: The genus *Paracrangon* is quite distinctive within the Crangonidae, and there is little doubt that the genus is monophyletic, as Christoffersen (1988) hypothesised. Autapomorphic characters of the genus include: greatly or completely reduced second pereopod; dorsally flexible abdomen which enables the shrimp to have a cataleptic position; strongly produced ventral margins of the first to sixth abdominal somites; the sixth abdominal somite armed with a pair of submedian teeth on the sternum proximally; densely setose cutting edge of the first chela; and exopod of the uropod bearing a distolateral lobe, instead of normal distolateral tooth (Christoffersen, 1988; present study). Possibly homoplastic characters are as follows: strongly erect rostrum with at least one strong ventral tooth (a similar character state is found in *Rhynocrangon sharpi* (Ortmann, 1895) and *Sclerocrangon unidentata* Komai and Takeda, 1989); unarmed posterior part of the telson (a similar character is found in species of *Aegaeon* and *Pontocaris*); basicerite unarmed at the ventrolateral distal angle (a similar character is found in *Prionocrangon*); strongly elongate carpocerite distinctly overreaching the antennal scale (a similar character is seen in *Prionocrangon*); the basally articulated distomesial spine ("pollex") of the subchela (a similar character is seen in several species of *Philocheiras* and two species of *Syncrangon*; De Man, 1920; Kim and Hayashi, 2003); the presence of a dorsodistal projection on the carpi of the

fourth and fifth pereopods (a similar character is found in species of *Rhynocrangon*; unpublished data); and the presence of a row of slender spines on the ventral margins of the propodi of the fourth and fifth pereopods (a similar character is found in *Rhynocrangon*; unpublished data).

It had been considered that the second pereopod was absent in the genus until Hanamura *et al.* (1999) demonstrated the presence of a rudimentary bud of the second pereopod in *P. australis*. This study demonstrates that the degree of the reduction of the second pereopods varies within the genus. In *P. furcata* and *P. ostlingos* sp. nov., the second pereopod is completely absent, while in the other species examined in this study, the second pereopod is represented by a rudimentary bud like in *P. australis*. It is worth mentioning that the reduction of the second pereopods is not accompanied by a reduction of the fifth thoracic sternite. The fifth thoracic sternite of *Paracrangon* species is well developed, bearing a strong median tooth, like other crangonid species.

In spite of the well-established monophyly of the genus, it is not easy to establish its sister group. Christoffersen (1988) hypothesised that the sister group of *Paracrangon* is a clade containing *Prionocrangon* and *Vercoia*. However, this hypothesis was based only on homoplastic characters. Our preliminary attempt to identify sister taxon of *Paracrangon* using the above mentioned apomorphic characters was not successful. It may be impossible to establish a sister group to *Paracrangon* without comprehensive molecular or genetic study.

In order to facilitate comparison between species, the homology of the median teeth on the carapace should be discussed. Judging from the different sizes of the teeth, we assume that there are four median teeth principally in species of *Paracrangon*. The second tooth is much smaller than the others, which are occasionally reduced according to species. For example, the second tooth is frequently absent in *P. abei*, while in *P. furcata* and *P. ostlingos* sp. nov., the fourth tooth on the cardiac region is reduced. The presence of five teeth in *P. australis* seems to be due to the further division of the third tooth into two teeth.

The genus can be subdivided into two informal species groups by a number of characters, the first group (*P. echinata* species group) including *P. echinata*, *P. areolata*, *P. abei*, *P. okutanii*, and *P. australis*, and the second group (*P. furcata* species

group) including *P. furcata* and *P. ostlingos* sp. nov. The characters distinguishing the two groups include: the development of the fourth median tooth on the carapace (well developed, acute in the *P. echinata* group versus greatly reduced in the *P. furcata* group); armature on the lateral face of the carapace (some additional teeth other than hepatic tooth present in the *P. echinata* group, versus only hepatic tooth present in the *P. furcata* group); structure of the subbranchial carina on the carapace (faintly branched to distinctly areolate in the *P. echinata* group versus simple in the *P. furcata* group); armature of the sixth abdominal somite (one or two lateral teeth present in the *P. echinata* group versus unarmed in the *P. furcata* group); shape of the telson (gradually tapering posteriorly in the *P. echinata* group versus rather abruptly tapering at the anterior 0.30 in the *P. furcata* group); armature of the dorsal surface of the telson (armed with a pair of submedian teeth or tubercles near the base in the *P. echinata* group versus unarmed in the *P. furcata* group); setation of the eye (lacking setae on the eye-stalk covering the corneal surface in the *P. echinata* group versus having numerous curved setae on the eye-stalk covering the corneal surface in the *P. furcata* group); development of the second pereopod (strap-like rudimentary bud in the *P. echinata* group versus completely reduced in the *P. furcata* group); structure of the propodus of the third pereopod (slender, naked in the *P. echinata* group versus relatively stout, setose in the *P. furcata* group); shape of the distolateral lobe of the uropodal exopod (narrow, variously dentate or lobate in the *P. echinata* group versus broad, obliquely truncate posteriorly in the *P. furcata* group).

Fujikura *et al.* (1995, 1996) reported the occurrence of two non-identified species of *Paracrangon* from Sagami Bay and from a hydrothermally influenced area of the Minami Ensei Knoll, Okinawa Trough, respectively. The specific status of these two species remains unclear, as voucher specimens were not available for study.

Key to species

1. Branchial region of carapace with strong teeth posterior to hepatic tooth; sixth abdominal somite armed with 1 or 2 teeth on lateral face; telson with pair of submedian teeth or tubercles on dorsal surface near base 2
1. Branchial region of carapace without teeth posterior to hepatic tooth; sixth abdominal somite

- unarmed on lateral face; telson unarmed on dorsal surface near base6
2. Subbranchial carina forming distinct irregular reticulate structure; sixth abdominal somite with 1 tooth on lateral face anteroventrally; telson with pair of submedian tubercles anteriorly; carpi of fourth and fifth pereopods subequal in length to propodi ..
.....3
2. Subbranchial carina faintly branched or reticulate; sixth abdominal somite with 2 teeth on lateral face; telson with pair of submedian teeth anteriorly; carpi of fourth and fifth pereopods distinctly shorter than propodi 5
3. Posteriormost (fourth) median tooth on carapace obsolescent; dactylus of fifth pereopod 0.30-0.40 times as long as propodus..... *P. areolata*
(eastern Pacific from off Mexico to Peru; 650-1200 m)
3. Posteriormost median tooth on carapace distinct, acute; dactylus of fifth pereopod 0.15-0.25 times as long as propodus 4
4. Carapace with 2 median teeth posterior to midlength; distolateral lobe of uropodal exopod truncate or weakly bilobed distally *P. okutanii*
(Pacific coast of central Japan from Boso Peninsula to Kii Peninsula and northeastern Taiwan; 350-1400 m)
4. Carapace with 3 median teeth posterior to midlength; distolateral lobe of uropodal exopod rounded..... *P. australis*
(southeastern Australia; 363-1422 m)
5. First median tooth on carapace acuminate
..... *P. echinata*
(North Pacific from California to northern Japan and the Sea of Japan; sublittoral to 250 m)
5. First median tooth on carapace terminally bifid or multifid *P. abei*
(Kumano-nada and Sea of Japan; 50-311 m)
6. Third median tooth on carapace acute; antennal tooth elongate, reaching distal margin of cornea of eye; pleura of second to fifth abdominal somites acute *P. furcata*
(Pacific coast of southern Japan from Kumano-nada to Tosa Bay; 200-400 m)
6. Third median tooth on carapace subacute at most, occasionally reduced; antennal tooth short, not reaching distal margin of cornea of eye; pleura of second to fifth abdominal somites blunt or subacute
.....*P. ostlingos* sp. nov.
(central Japan; 257-323 m)

Paracrangon echinata species group

Paracrangon echinata Dana, 1852 (Figs. 2-4)

- Paracrangon echinatus* Dana, 1852a: 20 (type locality: Puget Sound, northwest coast of North America); 1852b: 538; 1855: pl. 33, Fig. 6; Miers, 1879: 52; Ortmann, 1895: 189; Kingsley, 1899: 715 (key), Fig. 54; Holmes, 1900: 176, pl. 2, Figs. 36, 37.
- Paracrangon echinata* - Rathbun, 1904: 143; Brashnikov, 1907: 95, text-Fig. 10a-g, pl. 2, Figs. 5, 6; De Man, 1920: 257 (list); Schmitt, 1921: 103, Fig. 72; Yokoya, 1933: 42; Derjugin and Kobjakova, 1935: 142 (list); Kobjakova, 1936: 212 (list); 1937: 139; Kubo, 1937: 1, Fig. 1a-d; Nishimura, 1939: 383; Urita, 1942: 38; Vinogradov, 1947: 99; 1950: 221, pl. 21, Fig. 94; Kobjakova, 1958a: 230; 1958b: 253 (list); Miyake *et al.*, 1962: 124; Igarashi, 1969: 11, pl. 12, fig 35, pl. 20, Fig. 64a, b; Kim and Park, 1972: 208, pl. 6, Fig. 1; Hayashi, 1976: 15; Kim, 1976: 146; 1977: 312, pl. 33, Fig. 67, text-Figs. 140, 141; Butler, 1980: 75, unnumbered Fig.; Gamo *et al.*, 1980: 30; Miyake, 1982: 67, pl. 23, Fig. 2, 188 (list); Ohé and Takeda, 1986: 80 (key); Miyake, 1991: 67, pl. 23, Fig. 2, 188 (list); Komai *et al.*, 1992: 195; Holthuis, 1993: Fig. 29; Komai, 1994: 82 (list), 99; Miyake, 1998: 67, pl. 23, Fig. 2, 189 (list); Hanamura *et al.*, 1999: 316 (key).
- Not *Paracrangon echinata* - Balss, 1914: 72 (= *Paracrangon okutanii* Ohé and Takeda, 1986).

Material examined: Pacific coast of Japan. Off Usujiri, Minami Kayabe, southern Hokkaido, 15-30 m, 19 August 1993, dredge, coll. F. Muto, 1 juvenile (cl 5.9 mm) (CBM-ZC 271); off Rokkasho Village, Aomori Prefecture, 40°54.8'N, 141°29.9'E, 198 m, 14 October 1994, RV *Wakataka-maru*, trawl, coll. D. Tsutsui, 1 male (cl 12.7 mm), 5 ovigerous females (cl 12.7-18.5 mm) (CBM-ZC 1119); RV *Soyo-maru*, stn 58, off Todogasaki, Miyako, Iwate Prefecture, 177 m, 18 July 1926, 4 males (cl 8.8-12.3 mm), 5 females (cl 7.7-9.3 mm) (KMNH); off Miyako, Iwate Prefecture, 150-200 m, December 1983, commercial trawler, coll. T. Komai, 1 male (cl 13.3 mm) (HUMZ-C 175); similar locality, 150-200 m, March 1987, commercial trawler, coll. T. Komai, 4 females (cl 13.4-16.7 mm), 3 ovigerous females (cl 16.0-16.9 mm) (HUMZ-C 42). Sea of Japan. Vladivostok, Peter the Great Bay, 1890, coll. Issaef, 2 males (cl 10.9, 12.2 mm) (ZSM 435/3); Peter the Great Bay, 43°23.0'N, 135°05.0'E, 150-200 m, 30 May 1996, trawl, coll. Y. M. Yakovlev, 1 ovigerous female (cl 16.1 mm) (CBM-ZC 4991); Korean coast, 36°12'N, 129°29'E, 50-60 m, trawl, 13 November 1995, coll. J. H. Choi, 5 ovigerous females (cl 14.1-15.9 mm) (PUIZ 70); off Sakata, Yamagata Prefecture, 38°53.2'N, 139°31.6'E, 215-223 m, 5 September 1994, deep-water resource survey by the Japan Sea National Research Institute of Fishery Sciences, stn Y-2, coll. S. Kanamaru, 5 males (cl 12.0-12.8 mm), 4 females (cl 8.3-14.4 mm), 2 ovigerous females (cl 14.6, 16.2 mm) (CBM-ZC 6640); Uozu, Toyama Bay, 5 June 1973, commercial shrimp trap, coll. N. Horii, 1 female (cl 21.1 mm) (NFU 530-2-2248); off Himi, Toyama Bay, coll. N. Horii, 1 male (cl 10.6 mm), 1 female (cl 11.7 mm) (NFU 530-2-2249); Toyama Bay, 17-24 July 1974, coll. N. Horii, 7 males (cl 10.2-14.1 mm), 14 females (cl 11.0-20.8 mm) (NFU 530-2-2250); Wakasa Bay, 35°48.00'N, 135°24.64'E, 130-132 m, 15-16 May 2000, trawl, coll. Y. Hamanaka, 1 ovigerous female (cl 13.6 mm) (NFU 530-2-2251); Wakasa Bay, 35°50.72'N, 135°22.56'E, 136-148 m, 03-04 July 2000, trawl, coll. Y. Hamanaka, 2 females (cl 10.6, 11.0 mm) (NFU 530-2-2252). Korea Strait. 34°58.6'N, 129°20.3'E, 112 m, 23 September 2002, TS "Kaya", otter trawl, coll. J. H. Choi, 4 females (cl 14.3-18.0 mm), 4 ovigerous females (cl 13.0-17.1 mm) (PUIZ 158); 35°18.8'N, 129°58.9'E, 120-130 m, 22 October 2002, RV "Tamgu 1", otter trawl, coll. J. N. Kim, 2 ovigerous females (cl 12.6, 13.2 mm) (PUIZ 159). Alaska. Bare Island, 1 female (cl 7.2 mm) (ZSM 435/4).

Type material: Puget Sound, Oregon, 1 specimen, one and three-quarter inches in body length. Presumably destroyed by the Chicago fire in 1871 (Evans, 1967).

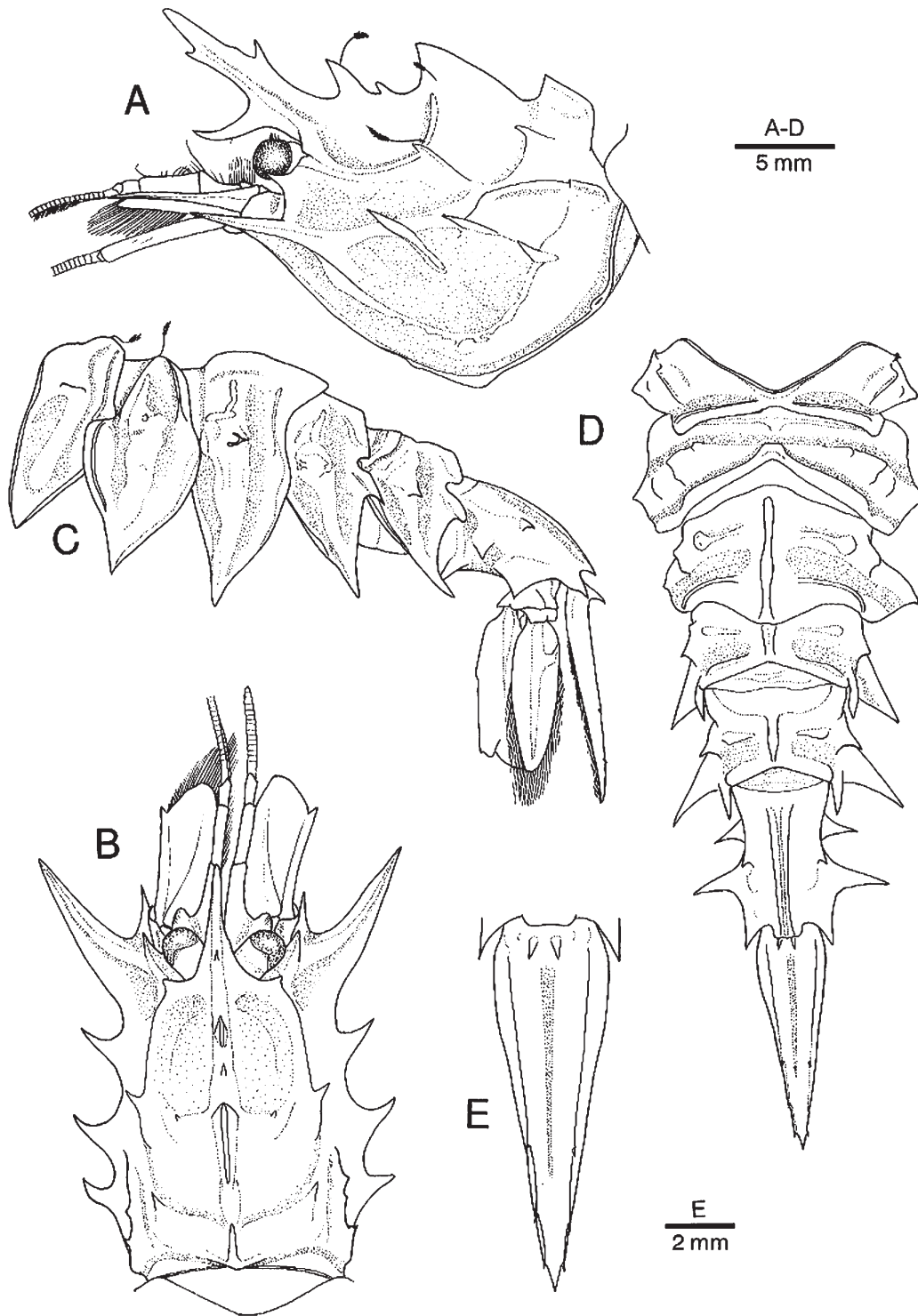


FIG. 2. – *Paracrangon echinata* Dana, 1851. A, carapace and cephalic appendages, lateral; B, same, dorsal; C, abdomen, lateral (pleopods omitted); D, same dorsal; E, telson, dorsal. Female (cl 15.2 mm) from off Sakata, Sea of Japan (CBM-ZC 6640).

Description: Rostrum (Fig. 2A) straight, 0.60-0.90 times as long as carapace (0.60-0.70 times in spawning females); dorsal margin with 1 small tooth arising at about midlength; ventral margin subproximally with slightly recurved tooth reaching distal

margin of basal segment of antennular peduncle and subdistally with 1 much smaller additional tooth.

Carapace (Fig. 2A, B) armed with 4 median teeth; first tooth acute, distinctly smaller than third tooth; second tooth conspicuous; third tooth

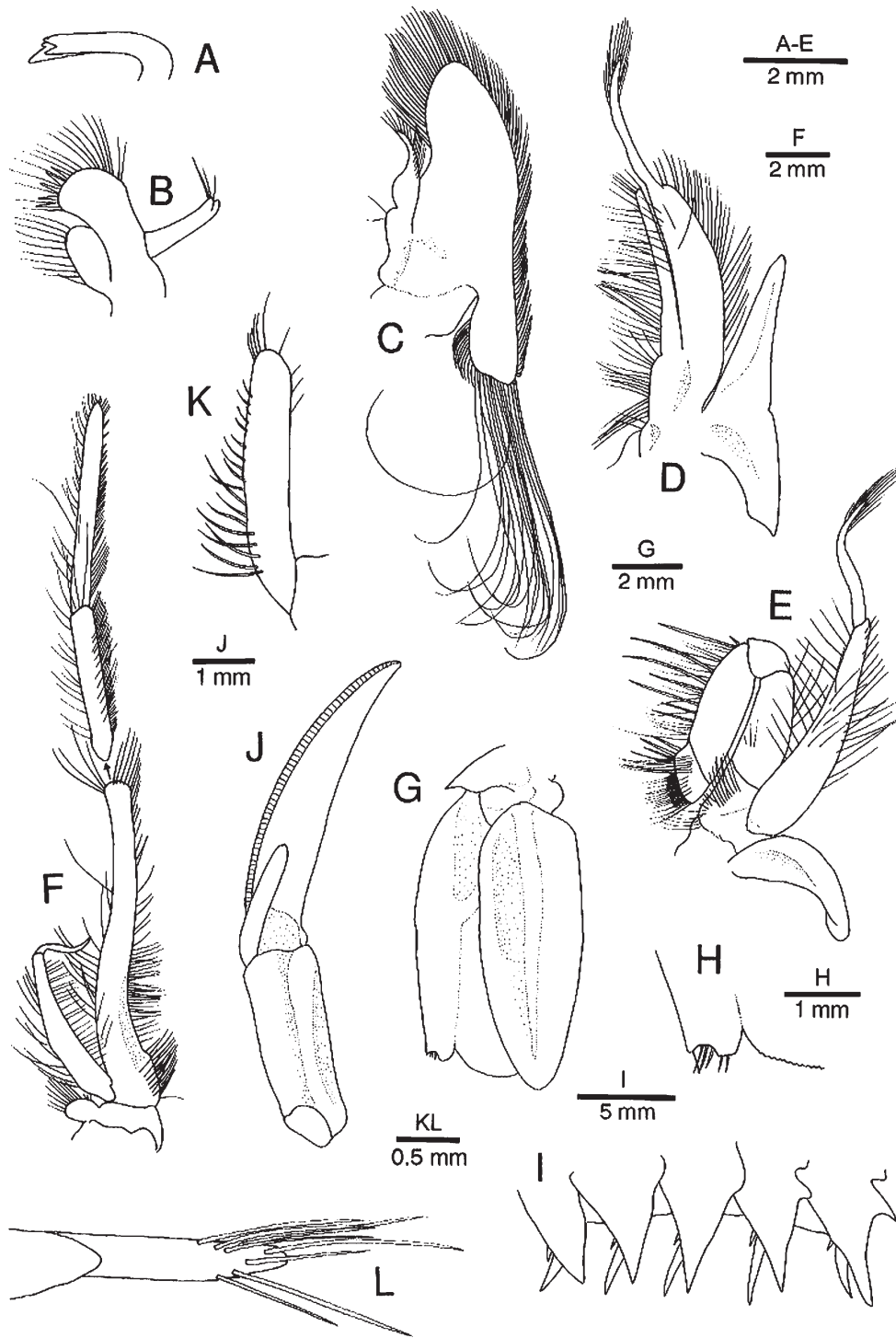


FIG. 3. – *Paracrangon echinata* Dana, 1851. A, right mandible, dorsal; B, left maxillule, ventral; C, left maxilla, ventral; D, left first maxilliped, ventral; E, left second maxilliped, ventral; F, left third maxilliped, dorsal; G, left uropod, dorsal (setae omitted); H, distolateral lobe of uropodal exopod, dorsal; I, pleura of first to fifth abdominal somites, showing armature; J, left first pleopod, ventral (setae omitted); K, endopod of left first pleopod, ventral; L, appendix masculina of second pleopod, mesial. A-H, female (cl 15.2 mm) from off Sakata, Sea of Japan (CBM-ZC 6640); I-L, male (cl 13.1 mm) from same lot.

strongest, acute; fourth tooth prominent, acute, broader than first; antennal tooth moderately long, somewhat diverging, not reaching or reaching distal margin of cornea of eye; branchiostegal tooth strong, diverging, reaching or slightly overreaching

level of distal margin of basal segment of antennular peduncle; pterygostomian tooth larger than antennal tooth, distinctly overreaching anterior margin of antennal basicerite; hepatic tooth strong, buttressed by short, oblique carina. Orbital notch present. Pos-

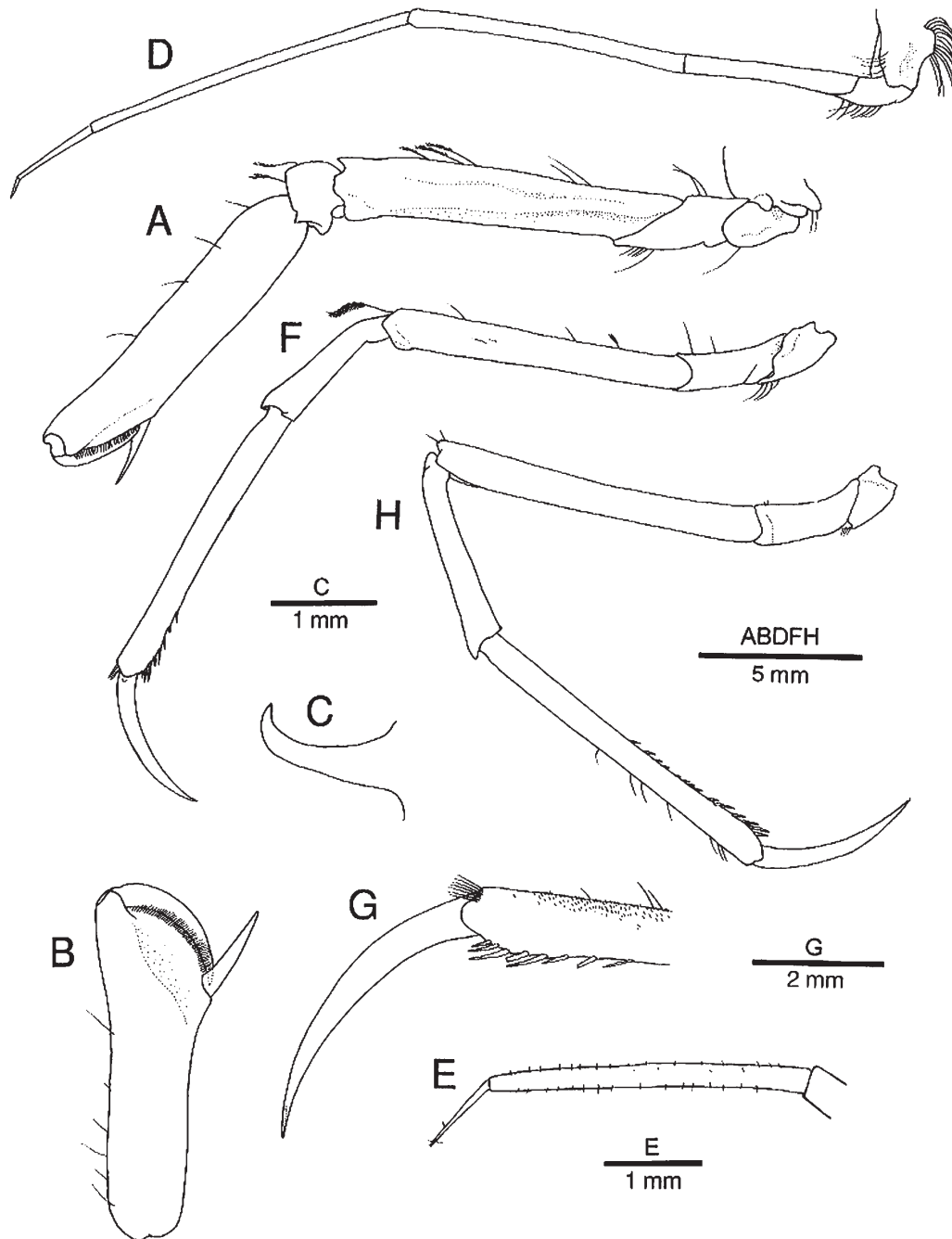


FIG. 4. — *Paracrangon echinata* Dana, 1851. Left pereopods. A, first pereopod, lateral; B, subchela of first pereopod, dorsal; C, second pereopod; D, third pereopod, lateral; E, dactylus and propodus of third pereopod, lateral; F, fourth pereopod, lateral; G, dactylus and distal part of propodus of fourth pereopod, lateral; H, fifth pereopod. Female (cl 15.2 mm) from off Sakata, Sea of Japan (CBM-ZC 6640).

torbital carina armed with 1 small tooth at cross point with cervical carina; branchiocardiac carina armed with moderately small tooth on either side of cardiac region; hepatic carina confluent with branchiostegal tooth; upper branch of branchial carina usually with 1-3 small tubercles or spinules, lower branch with 2 strong teeth, not extending to posterolateral angle of carapace; subbranchial carina faintly branched; posterolateral submarginal carina distinct.

Intercarinal spaces deeply depressed below. Posterolateral corner somewhat flared laterally.

Abdomen (Fig. 2C, D) with first somite rounded dorsally, second to fifth somites each with distinct median carinae (median carina on second somite broad, confluent with broad posterior marginal carina), posterodorsal margin of third somite weakly produced; transverse carinae on second to fifth somites conspicuous. Lateral tubercles on first to

fifth somites conspicuous, often spiniform. Pleura of first to fifth somites acutely produced ventrally, strongly flared laterally or posterolaterally, decreasing in width toward posterior, occasionally each with additional small tooth on anterior margin (Fig. 3I); median pleural carinae broad, not sharply ridged; posterolateral margins of fourth and fifth somites each with blunt to acute tooth near articular knob. Sixth somite with 2 median carinae separated by distinct median groove; posterodorsal margin produced as subquadrate lobe; lateral surface with 2 greatly unequal teeth (dorsal tooth small, arising from level of midlength of somite; ventral tooth strong, directed laterally, arising somewhat anterior to dorsal tooth); posteroventral tooth very strong, directed laterally. Telson (Fig. 2E) gradually tapering posteriorly, with 1 pair of submedian teeth on dorsal surface near base.

Eye-stalk (Fig. 2A, B) without setae covering corneal surface; cornea moderately large, not dilated.

Antennular peduncle (Fig. 2A, B) moderately slender, not reaching to slightly overreaching distal margin of antennal scale in females, overreaching it by length of third segment in males. Lateral flagellum composed of 15-24 articles in females, 26-41 articles in males; mesial flagellum composed of 9-10 articles in females, 10-14 articles in males.

Antennal scale (Fig. 2B) about 2.40 times as long as wide, with strongly produced blade far overreaching distolateral tooth.

Mouthparts and third maxilliped as illustrated (Fig. 3A-F).

First pereopod (Fig. 4A) moderately slender; merus with short dorsodistal tooth, unarmed on ventromesial margin; palm (Fig. 4B) about 3.60 times as long as width across base of pollex, proximal part of palm not widened distally. Second pereopod (Fig. 4C) represented by strap-like rudimentary bud. Third pereopod (Fig. 4D) slender, overreaching distal margin of scaphocerite by length of dactylus, propodus and 0.20-0.30 of carpus; propodus (Fig. 4E) slightly tapering distally, about 0.25 times as long as carpus, distal width not much greater than basal width dactylus, with scattered short setae. Fourth pereopod (Fig. 4F) overreaching distal margin of scaphocerite by length of dactylus and 0.30-0.40 of propodus; carpus 0.40-0.50 times as long as propodus, with blunt dorsodistal process; propodus (Fig. 4G) not broadened subdistally, with row of 9-15 moderately long spines on distal 0.40; dactylus (Fig. 4G) long, 0.45-0.60 times as long as propodus. Fifth pereopod (Fig. 4H) similar to fourth; propodus

with row of 16-23 spines on ventral margin in distal 0.40-0.50; dactylus 0.50-0.55 times as long as propodus.

Uropodal exopod (Fig. 3G) with convex lateral margin; distolateral lobe (Fig. 3H) narrow, terminating in 2 unequal lobules (lateral lobe acute, mesial lobe rounded), occasionally with 1 movable spinule flanked by two lobes, only with short setae distally.

Colour in life: Body generally light brown, overlaid with small brown or black spots; distinct larger spots of same hue along dorsal and ventral margins of carapace and abdomen; gastric region of carapace translucent, thus gut visible throughout integument.

Distribution: Northwest coast of North America from Alaska to La Jolla, California; Sea of Okhotsk, Sea of Japan southward to Korea Strait, Pacific coast of northern Japan southward to Iwate Prefecture; at depths of 18-250 m (Butler, 1980; present study).

Remarks: *Paracrangon echinata* is most closely related to *P. abei*. Differences between the two species are discussed under the account of the latter species.

Paracrangon echinata has been reported from both western and eastern sides of the North Pacific Ocean, although there have been no records from the intervening Bering Sea. Our comparison between the East Asian specimens with a single specimen from Alaska revealed no significant morphological differences between them. Therefore, the lack of records of *P. echinata* from the Bering Sea may simply reflect insufficient collecting efforts. Reexamination of the specimens (two males) from Sagami Bay, central Japan, referred to *P. echinata* by Bals (1914), has revealed that they actually represent *P. okutanii*. The available information strongly suggests that *P. echinata* is a cold water species, restricted to northern Japan (Hokkaido and Tohoku District) in the Pacific coast of Japanese mainland. The bathymetric range of the species is also restricted to sublittoral to 250 m.

Paracrangon abei Kubo, 1937 (Figs. 5, 6)

Paracrangon abei Kubo, 1937: 3, Figs. 2, 3 (type locality: Kumano-nada off Nagashima, Mie Prefecture, Japan); 1965: 623, Fig. 1007; Miyake *et al.*, 1962: 124; Ouchi, 1960: 180; Miyake, 1982: 67, unnumbered Fig., 189 (list); Ohé and Takeda, 1986: 80 (key); Doi, 1989: 54, 59, 60; Miyake, 1991: 67, unnumbered Fig., 188 (list); Komai, 1994: 83 (list), 99; Miyake, 1998: 67, unnumbered Fig., 189 (list); Hanamura *et al.*, 1999: 316 (key).

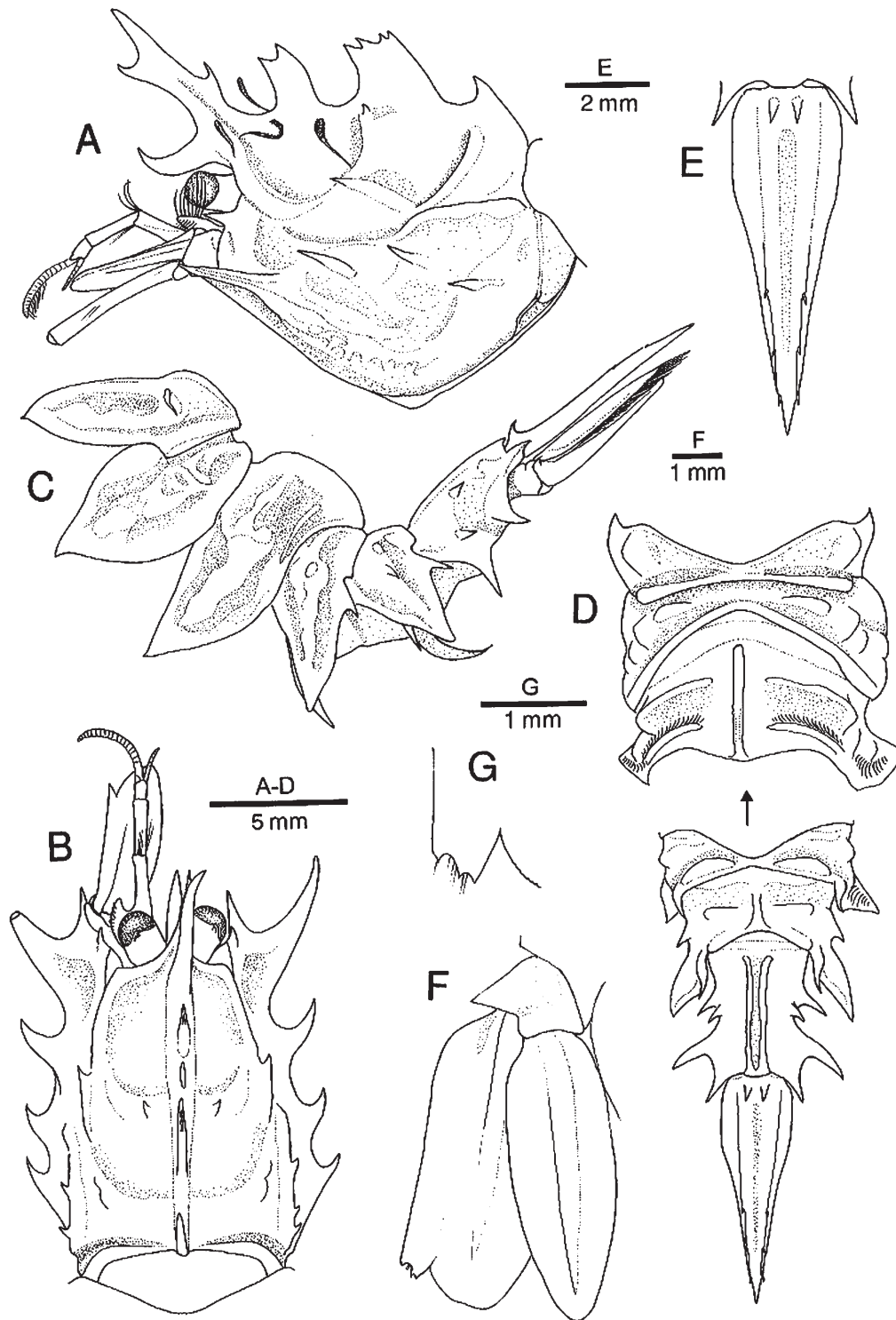


FIG. 5. — *Paracrangon abei* Kubo, 1937. A, carapace and cephalic appendages, lateral; B, same, dorsal; C, abdomen, lateral (pleopods omitted); D, same, dorsal; E, telson, dorsal; F, left uropod, dorsal; G, distolateral lobe of uropodal exopod, dorsal. Ovigerous female (cl 10.2 mm) from off Gamo, Sea of Japan (KMNH).

Material examined: Pacific coast of Japan. Data not given, 1 male (cl 9.3 mm), 1 ovigerous female (cl 10.3 mm) (putative syntypes; TUF).

Sea of Japan. Off Gamo, Yamagata Prefecture, 94 m, 13 June 1958, 1 male (cl 8.7 mm), 1 ovigerous female (cl 10.2 mm), KMNH (formerly ZLKU 1298-1299); Tsushima Strait, 50-100 m, 01 August 1968, RV "Genkai-maru", dredge, 1 male (cl 7.2 mm) (KMNH-IvR 000009).

Type material: Syntypes. Kumano-nada off Nagashima, Mie Prefecture, 311 m, 2 males, 3 ovigerous females (TUF).

Description: Rostrum (Figs. 5A, 6A-C) straight, 0.60-1.00 times as long as carapace (0.60-0.70 times in spawning females); dorsal margin with 1 or

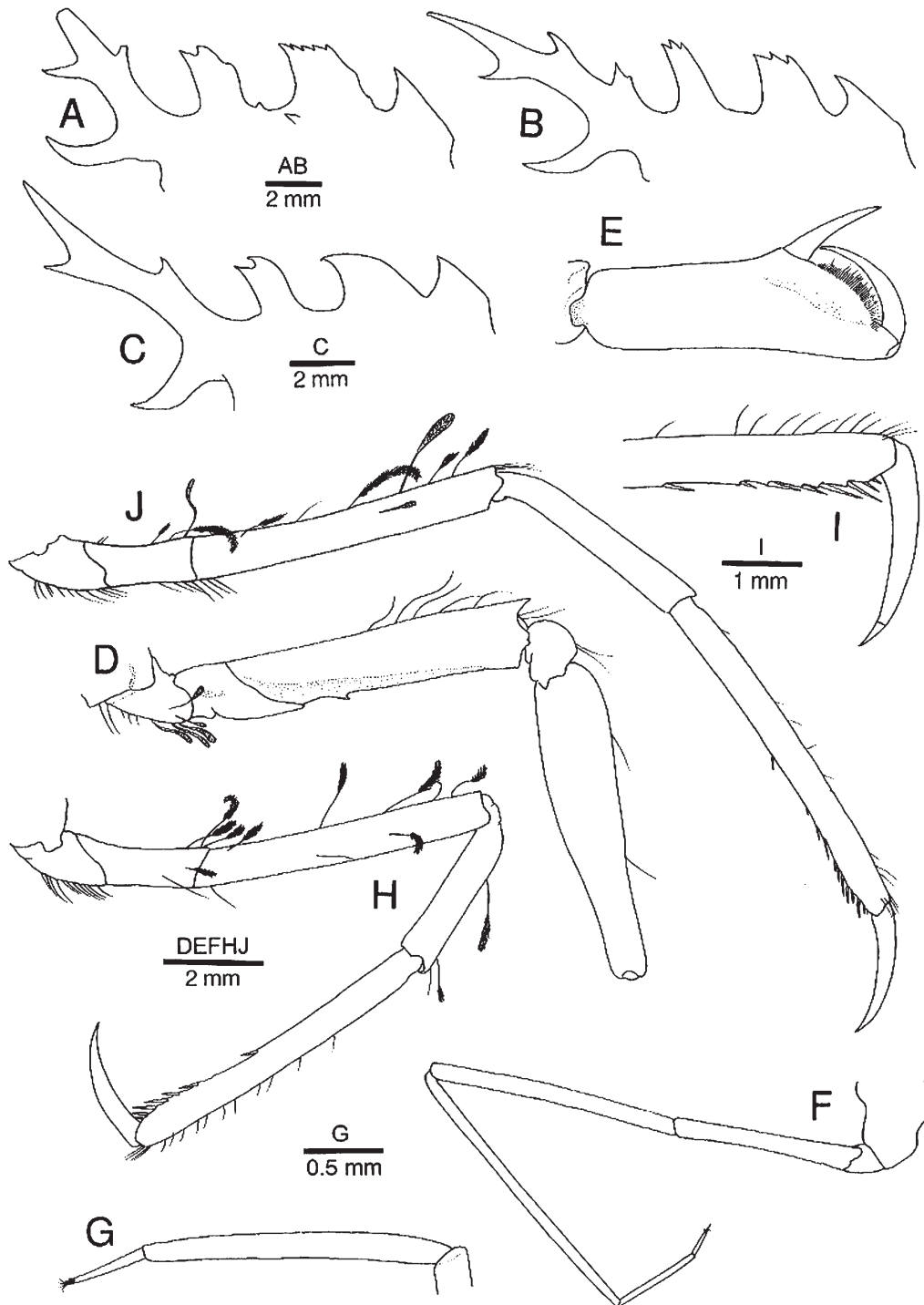


FIG. 6. — *Paracrangon abei* Kubo, 1937. A-C, rostrum and dorsal part of carapace in lateral view, showing variation of armature; D, right first pereopod, lateral; E, subchela of right first pereopod, dorsal; F, left second pereopod, lateral; G, dactylus and propodus of left second pereopod, lateral; H, left fourth pereopod, lateral; I, dactylus and distal part of propodus of right fourth pereopod, lateral; J, right fifth pereopod, lateral. A, ovigerous female (cl 10.3 mm), putative syntype (TUF); B, male (cl 9.3 mm) from same lot; C, male (cl 8.7 mm) from off Gamo, Sea of Japan (KMNH); D-J, ovigerous female (cl 10.2 mm) from same lot.

2 small teeth, first tooth arising from midlength or somewhat proximal to midlength of rostrum; ventral margin subproximally with recurved tooth reaching distal margin of basal segment of antennular peduncle (ventral margin of tooth convex, but

not protuberant) and subdistally with 1 smaller additional tooth.

Carapace (Figs. 5A, B, 6A-C) armed with 3 or 4 median teeth over entire length, size unequal; first tooth narrower, but nearly as long as third tooth, dis-

tally with 2 or 3 small teeth; second tooth absent or tiny; third tooth largest, acuminate or subtruncate with 3-5 small teeth; fourth tooth much smaller than preceding teeth, acute; antennal tooth short, directed forward, not reaching distal margin of eye; branchiostegal tooth strong, diverging, not reaching level of distal margin of basal segment of antennular peduncle; pterygostomial tooth larger than antennal tooth, distinctly overreaching anterior margin of antennal basicerite; hepatic tooth strong, curved anteriorly, buttressed by short, oblique carina; 2 strong branchial teeth present. Orbital notch present. Postorbital carina armed with 1 small tooth at cross point with cervical carina; branchiocardiac carina unarmed or armed with 1 small tooth; hepatic carina confluent with branchiostegal tooth; upper branch of branchial carina usually with 1-3 small tubercles or spinules, lower branch with 2 strong teeth, not extending to posterolateral angle of carapace; subbranchial carina faintly branched; posterolateral submarginal carina less distinct. Intercarinal spaces deeply depressed below. Posterolateral corner somewhat flared laterally.

Abdomen (Fig. 5C, D) with first and second somites rounded dorsally, third to fifth somites each with distinct median carina, highest carina on third somite; posterodorsal margin of third somite weakly produced; transverse carinae on second to fifth somites conspicuous. Lateral tubercles on first to fourth somites blunt, that of fifth spiniform. Pleura of first to fifth somites acutely produced ventrally, somewhat to strongly flared laterally or posterolaterally, decreasing in width toward posterior from second somite, without additional small tooth on anterior margin, accompanying median pleural carinae broad, not sharply ridged; posterolateral margins of fourth and fifth somites each with acute tooth near articular knob. Sixth somite with 2 median carinae separated by distinct median groove; posterodorsal margin produced as subquadrate lobe; lateral surface with 2 greatly unequal teeth (dorsal tooth weak, arising from level of midlength of somite; ventral tooth strong, directed posterolaterally, arising slightly anterior to dorsal tooth); posteroventral tooth very strong, directed laterally. Telson (Fig. 5E) tapering posteriorly, with 1 pair of submedian teeth on dorsal surface near base.

Eye-stalk (Fig. 5A, B) without setae covering corneal surface; cornea moderately large, not dilated.

Antennular peduncle (Fig. 5A, B) moderately slender, not reaching distal margin of antennal scale in females, overreaching it by half length of third

segment in males. Lateral flagellum composed of 15 articles in females, 22-31 articles in males; mesial flagellum composed of 6 articles in females, 8-10 articles in males.

Antennal scale (Fig. 5B) about 3.00-3.10 times as long as wide, with strongly produced blade far overreaching distolateral tooth.

First pereopod (Fig. 6D) moderately slender; merus with short dorsodistal tooth, unarmed or armed with tiny tooth on ventromesial margin; palm (Fig. 6E) about 3.50 times as long as width across base of pollex, proximal part of palm not widened distally. Second pereopod represented by strap-like rudimentary bud. Third pereopod (Fig. 6F) slender, overreaching distal margin of scaphocerite by length of dactylus, propodus and 0.20-0.30 of carpus; propodus (Fig. 6G) slightly tapering distally, about 0.25 times as long as carpus, distal width not much greater than basal width dactylus, without short setae on surfaces. Fourth pereopod (Fig. 6H) moderately slender, overreaching distal margin of scaphocerite by length of dactylus and 0.30 of propodus; carpus 0.40-0.50 times as long as propodus, with blunt dorsodistal process; propodus (Fig. 6I) not broadened subdistally, with row of 8-15 spines on ventral margin in distal 0.40-0.80; dactylus (Fig. 6I) moderately long, 0.37 times as long as propodus. Fifth pereopod (Fig. 6J) similar to fourth; propodus with row of 7-10 spines on ventral margin in distal 0.30; dactylus 0.38-0.43 times as long as propodus.

Uropodal exopod (Fig. 5F) with weakly sinuous lateral margin; distolateral lobe (Fig. 5G) narrow, tridentate distally, only with short setae distally.

Color in life: Unknown.

Distribution: Known only from Kumano-nada off Mie Prefecture and southern part of the Sea of Japan; at depths of 50-311 m.

Remarks: Kubo (1937) described *P. abei* based on five specimens, including two males and three ovigerous females. A holotype was not designated, and thus the specimens are syntypes. One lot containing one male and one ovigerous female labeled as "*Paracrangon abei* sp. nov." was located in the collection studied by I. Kubo, which is housed in the Tokyo University of Marine Science and Technology. Although no further information is given in the attached label, we assume that these specimens are part of the syntypes, as they agree well with the original description of *P. abei*.

Paracrangon abei is most closely related to *P. echinata*. The two species share the following features: the faintly branched or reticulate subbranchial carina on the carapace; and the possession of two lateral teeth on the sixth abdominal somite. However, *P. abei* differs from *P. echinata* in the following particulars. The first median tooth on the carapace of *P. abei* extends dorsally as far as the third tooth and distally two- or three-toothed. In *P. echinata*, the first tooth on the carapace is shorter than the third tooth, and is simply acute. The second median tooth on the carapace of *P. abei* is absent or greatly reduced in minute tubercle, while it is conspicuous, acute in *P. echinata*. The distolateral lobe of the uropodal exopod is distally three-toothed in *P. abei*, while the lobe of *P. echinata* is divided into two projections, of which lateral one is an acute tooth, and the mesial one is rounded lobule. The dactylus of the fifth pereopod may be shorter in *P. abei* than in *P. echinata* (0.38-0.43 times as long as the propodus versus 0.50-0.55 times as long). Further, the spination of the third median tooth on the carapace is useful in distinguishing the two species, although this is not reliable because of variation in *P. abei*. The third tooth of *P. abei* is occasionally three- to five-toothed distally, rather than always simply acute in *P. echinata*. In addition, it is suggested that the body size of *P. abei* is smaller than that of *P. echinata*. Ovigerous females of *P. abei* are 10.2-10.3 mm in cl, while those of *P. echinata* are 13.6-20.8 mm in cl. The two specimens from the Sea of Japan identified by Miyake *et al.* (1961) as *P. abei* have been examined, and their identification is confirmed. Therefore, the two previous records of *P. abei* from the Sea of Japan (Ouchi, 1960; Doi, 1986) are considered correct, although the specimens used by them were not available for study.

***Paracrangon okutanii* Ohé and Takeda, 1986**
(Figs. 7, 8)

Paracrangon echinata - Balss, 1914: 72. Not *Paracrangon echinata* Dana, 1852.

Paracrangon sp. - Okutani, 1969, pl. 1, Fig. 4.

Paracrangon okutanii Ohé and Takeda, 1986: 76, Figs. 2, 3 (type locality: Sagami Bay, Japan); Komai, 1994: 99 (list); Miyake, 1998: 189 (list); Hanamura *et al.*, 1999: 316 (key).

Material examined: Pacific coast of Japan. Sagami Bay, stn 4, 1400 m, 1904, coll. F. Doflein, 1 male (cephalothorax badly damaged, not measured) (ZSM 435/1); Sagami Bay, stn 13, 350 m, 1904, coll. F. Doflein, 1 male (cl 13.2 mm) (ZSM 435/2); off Shionomisaki, Kii Peninsula, 450 m, 9 February 1993, dredge, coll. S. Nagai, 1 juvenile (cl 5.3 mm) (CBM-ZC 1241); SW of Shionomisaki, Kii Peninsula, 33°23.9'N, 135°38.9'E, 700 m, 2 October 1997, dredge, coll. S. Nagai, 1 female (cl 13.3 mm), 1 ovigerous female (cl 13.2 mm) (CBM-ZC 3863).

Taiwan. TAIWAN 2000: stn DW 45, South China Sea west of Ping-Tong County, 22°48.3'N, 121°27.4'E, 423-439 m, 2 August 2000, dredge, 1 male (cl 10.5 mm) (NTOU).

TAIWAN 2001: stn CP 111, E of Tai-Pei County, 24°52.24'N, 122°04.35'E, 540-700m, 21 May 2001, beam trawl, 1 female (cl 14.7 mm) (NTOU); stn CD 141, South China Sea west of Ping-Tong County, 22°12.04'N, 119°59.96'E, 985-1110 m, otter trawl, coll. T.-Y. Chan, 1 male (cl 14.9 mm) (NTOU).

Type material: Holotype. RV "Soyo-maru", stn T29, Sagami Bay, 35°04.1'N, 139°28.4'E, 770-930 m, 12 August 1959, male cl 13.4 mm (National Science Museum, Tokyo, NSMT-Cr 9232). Not examined.

Paratypes. Same data as holotype, 1 male (cl 13.0 mm), 1 female (cl 16.1 mm) (NSMT-Cr 9233); stn T11, Sagami Bay, 35°05.5'N, 139°29.0'E, 690-780 m, 01 October 1965, 1 female (cl 17.3 mm) (NSMT-Cr 9234); stn B2, E of Niiijima Island, Izu Islands, 34°22.2'N, 139°41.9'E, 1080-1205 m, 11 December 1965, 1 female (cl 17.0 mm) (NSMT-Cr 9235); stn T10, Sagami Bay, 35°04.8'N, 139°11.1'E, 425 m, 27 July 1974, 1 female (cl 16.4 mm) (NSMT-Cr 9236). Not examined.

Description: Rostrum (Fig. 7A) straight or slightly curved, elongate, 0.90-1.20 times as long as carapace (0.90-1.10 times in spawning females); dorsal margin unarmed; ventral margin with 2 slender teeth, subproximal tooth slightly recurved, reaching level of distal margin of basal segment of antennular peduncle (ventral margin of tooth not protuberant, naked), subdistal tooth slightly shorter than subproximal tooth in adults.

Carapace (Fig. 7A, B) armed with 4 median teeth over entire length; first tooth narrower, but slightly longer than third tooth, acute; second tooth much smaller than others, usually with small accessory projection on anterior margin; third tooth acute; fourth tooth slightly shorter than third tooth, acute, rarely reduced to small tubercle; antennal tooth short to moderately long, somewhat diverging, not reaching distal margin of eye; branchiostegal tooth long and slender, strongly diverging, but not reaching level of distal margin of basal segment of antennular peduncle; pterygostomial tooth much longer than antennal tooth, reaching to proximal 0.20-0.25 of antennal scale; hepatic tooth strong, confluent with branchial carina. Orbital notch absent. Postorbital carina armed with 1 small tooth at cross point with cervical carina; branchiocardiac carina unarmed or armed with 1 small tubercle or tooth; upper branch of branchial carina unarmed; lower branch armed with 2 strong teeth, extending to posterolateral angle of carapace; subbranchial carina forming distinct reticulate structure, connected with branchial carina; posterolateral submarginal carina distinct. Intercarinal spaces deeply depressed below. Posterolateral angle somewhat flared laterally.

Abdomen (Fig. 7C, D) with first to fifth somites each with distinct median carina, those on third to fifth somites relatively broad; posterodorsal margin

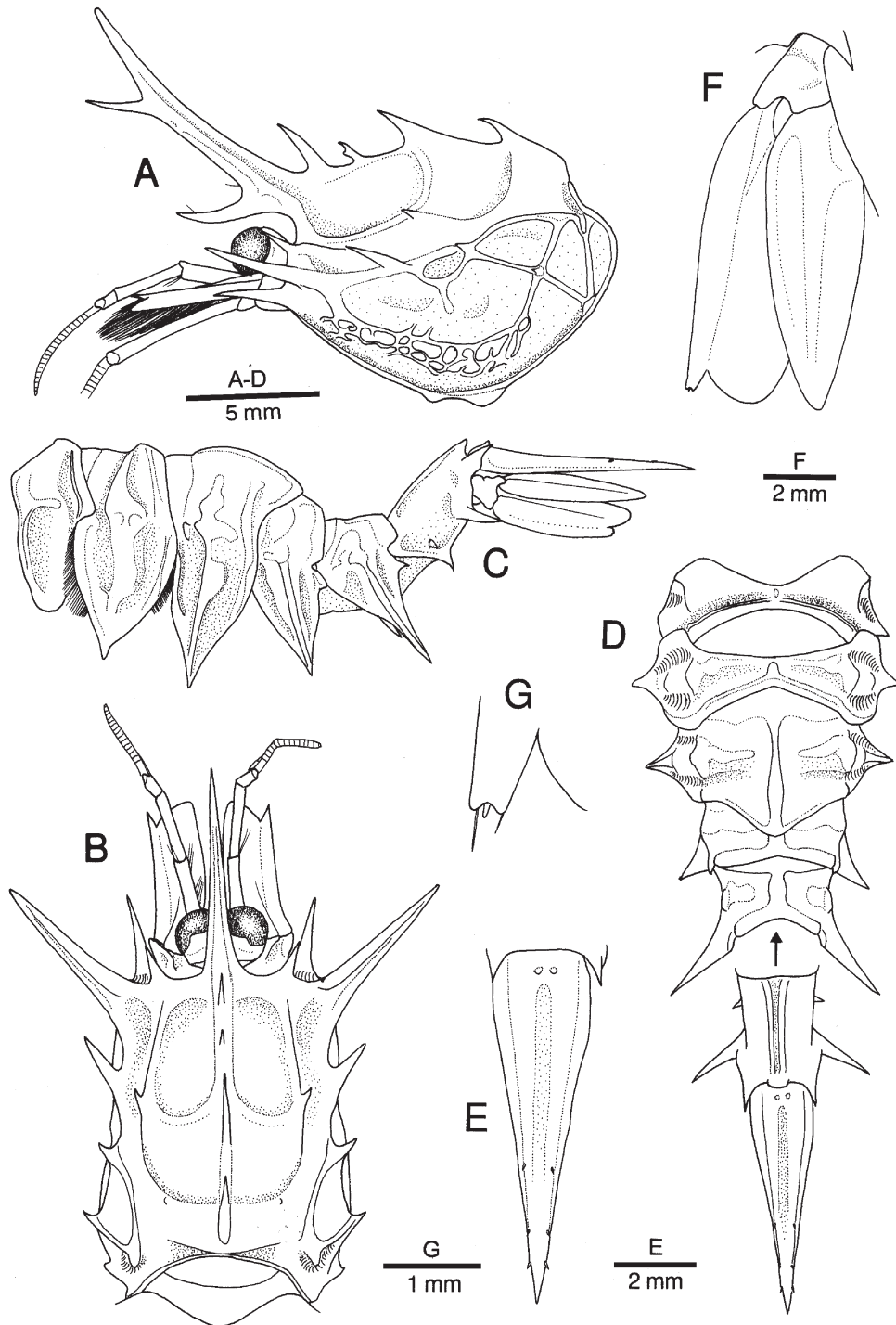


FIG. 7. — *Paracrangon okutanii* Ohé and Takeda, 1986. A, carapace and cephalic appendages, lateral; B, same, dorsal; C, abdomen, lateral (pleopods omitted); D, same, dorsal; E, telson, dorsal; F, left uropod, dorsal; G, distolateral lobe of left uropodal exopod, dorsal. Ovigerous female (cl 13.2 mm) from Kii Peninsula, Japan (CBM-ZC 3863).

of third somite somewhat produced; transverse carinae on second to fifth somites blunt. Lateral tubercles on first to fifth somites blunt. Pleura of first to fifth somites acutely produced ventrally, somewhat to strongly flared laterally or posterolaterally, occa-

sionally with additional small tooth on anterior margins, accompanying median pleural carinae narrow, sharp; posterolateral margins of fourth and fifth somites each with acute tooth near articular knob. Sixth somite with 2 median carinae separated by dis-

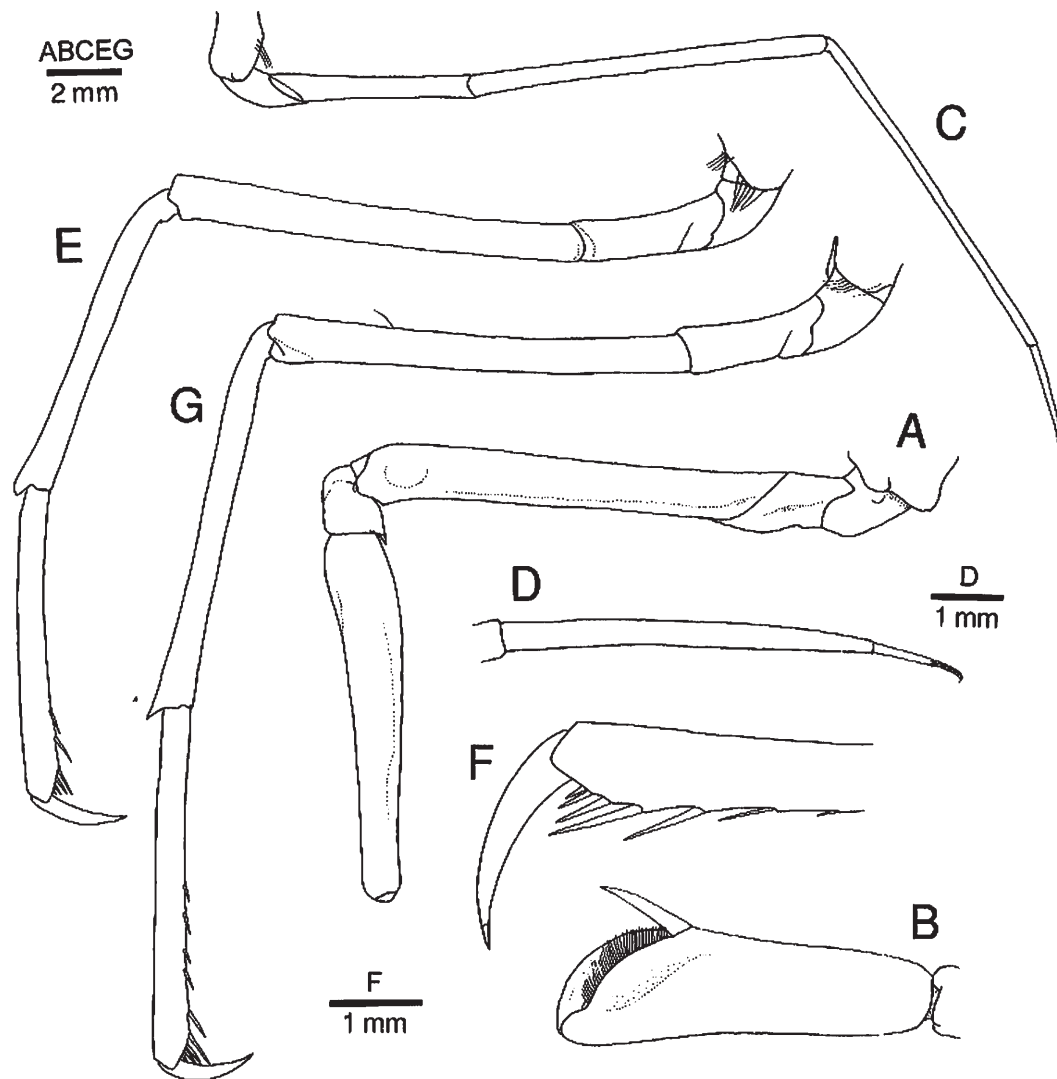


FIG. 8. — *Paracrangon okutanii* Ohé and Takeda, 1986. A, left first pereopod, lateral; B, subchela of left first pereopod, dorsal; C, right third pereopod, lateral; D, dactylus and propodus of right third pereopod, lateral; E, left fourth pereopod, lateral; F, dactylus and distal part of propodus of left fourth pereopod, lateral; G, left fifth pereopod, lateral. Ovigerous female (cl 13.2 mm) from Kii Peninsula, Japan (CBM-ZC 3863).

tinct median groove; posterodorsal margin produced as subquadrate lobe; lateral face armed with 1 tooth anteroventrally; posteroventral tooth long, slender, directed posterolaterally. Telson (Fig. 7E) gradually tapering posteriorly, with 1 pair of submedian tubercles on dorsal surface near base.

Eye-stalk (Fig. 7A, B) without setae covering corneal surface; cornea relatively large, slightly dilated.

Antennular peduncle (Fig. 7A, B) slender, overreaching distal margin of antennal scale by length of third segment and 0.25-0.30 of second segment in females and males. Lateral flagellum composed of 18-21 articles in females, 34-35 articles in males; mesial flagellum composed of 6-9 articles in females, 11-14 articles in males.

Antennal scale (Fig. 7B) 2.80-3.00 times as long as wide, with strongly produced blade far overreaching distolateral tooth.

First pereopod (Fig. 8A) relatively slender; merus with small dorsodistal tooth (occasionally reduced in females), unarmed on ventromesial margin; palm (Fig. 8B) about 3.30 times as long as width across base of pollex, proximal part of palm slightly widened distally. Second pereopod represented by strap-like rudimentary bud. Third pereopod (Fig. 8C) slender, overreaching distal margin of scaphocerite by length of dactylus, propodus and 0.20-0.30 of carpus; propodus (Fig. 8D) slightly tapering distally, about 0.30 times as long as carpus, distal width not much greater than basal width

dactylus, without short setae on surfaces. Fourth pereopod (Fig. 8E) relatively slender, overreaching distal margin of scaphocerite by length of dactylus and half to full of propodus; carpus 0.95-1.10 times as long as propodus, with acute or subacute dorsodistal process; propodus (Fig. 8F) slightly broadened subdistally, subprehensile, with row of 8-10 spines or spinules on ventral margin (distalmost 4 spines closely set); dactylus (Fig. 8F) short, 0.25-0.31 times as long as propodus. Fifth pereopod (Fig. 8G) similar to fourth; propodus with row of 9-14 spines on ventral margin; dactylus 0.20-0.25 times as long as propodus.

Uropodal exopod (Fig. 7F) with faintly sinuous lateral margin; distolateral lobe (Fig. 7G) narrow, with 1 movable spinule flanked by 2 rounded distal lobules.

Color in life: Body generally light brown, with darker tint on rostrum and pleural teeth; pereopods brown.

Distribution: Pacific coast of central Japan from Sagami-nada to Kii Peninsula and northeastern Taiwan; at depths of 350-1400 m.

Remarks: The present specimens agree well with the original description of *P. okutanii* by Ohé and Takeda (1986), so there was no necessity to reexamine the type specimens. The specimens from southwestern Taiwan greatly extend the geographical range of this species to the northern part of the South China Sea. This species is the first representative of the genus occurring in tropical waters in the western Pacific.

As Hanamura *et al.* (1999) mentioned, *P. okutanii* appears close to two geographically greatly separated species, *P. areolata* from the eastern Pacific and *P. australis* from southeastern Australia. These three species share a similar pattern of armature and sculpture on the carapace, the sharp median carinae on the second to fifth abdominal pleura, the presence of a single lateral tooth on the sixth abdominal somite, and the elongate carpi of the fourth and fifth pereopods being subequal in length to the propodi. Further, the three species usually occur in deep-water. *Paracrangon okutanii* can be distinguished from *P. areolata* by the conspicuous fourth median tooth on the carapace and the shorter dactylus of the fifth pereopod (0.20-0.25 times as long as the propodus versus 0.30 or more times as long). The fourth median tooth of *P. areolata* is greatly

reduced. From *P. australis*, *P. okutanii* seems to differ in the simple third median tooth on the carapace and the shape of the distolateral lobe of the uropodal exopod. In *P. australis*, the third median tooth on the carapace is further subdivided into two acute teeth, raising the total number of the median teeth to five. The distolateral lobe of the uropodal exopod of *P. okutanii* bears a minute basally articulated spine flanked by two rounded lobules on the distal margin, while it is simply rounded in *P. australis*.

Paracrangon okutanii is immediately separated from other northwestern Pacific species of the genus by the distinctly reticulate subbranchial carina on the carapace and the possession of a single lateral tooth on the sixth abdominal somite.

As mentioned before, the specimens from Sagami Bay identified as *P. echinata* by Balss (1914) actually represent *P. okutanii*.

Paracrangon furcata species group

Paracrangon furcata Kubo, 1937

(Figs. 9, 10)

Paracrangon furcata Kubo, 1937: 7, Figs. 4, 5 (type locality: Kumano-nada off Nagashima, Mie Prefecture, Japan); Hayashi, 1986: 143, 276, Fig. 94; Ohé and Takeda, 1986: 80 (key); Komai, 1994: 99 (list); Miyake, 1998: 189 (list); Hanamura *et al.*, 1999: 316 (key); Sakaji, 2001: 211, pl. 2C.

Pontocaris rathbuni - Hayashi, 1986: 146, Fig. 97. Not *Pontocaris rathbuni* (De Man, 1918).

Material examined: Pacific coast of Japan. No data, 1 ovigerous female (putative syntype, badly damaged; TUF); Kumano-nada off Kushimoto, depth unknown, 25 April 1993, commercial trawler, coll. S. Nagai, 4 females (cl 6.9-11.3 mm) (CBM-ZC 2409); Tosa Bay, 200-250 m, 21 January 1963, commercial trawler, coll. K. Sakai, 1 ovigerous female (cl 9.2 mm) (KMNH IvR 0000007); similar locality, 400 m, 07 May 1985, trawl (RV *Kotaka-maru*), coll. M. Toriyama, 1 ovigerous female (cl 11.4 mm) (NFU-530-2-1098); off Cape Ashizuri, Tosa Bay (landed at Toai Fishing Port, Tosa-Shimizu), 350 m, 10 March 1988, commercial trawler, coll. K. Sakai, 1 female (cl 8.2 mm) (MNHN-Na).

Type material: Syntypes. Kumano-nada off Nagashima, Mie Prefecture, 311 m, 1 male, 10 ovigerous females (TUF).

Description: Rostrum (Fig. 9A) slightly curved dorsally, 0.60-0.80 times as long as carapace (0.60-0.70 times in spawning females); dorsal margin unarmed; ventral margin 2 teeth, subproximal tooth not recurved, reaching level of distal margin of basal segment of antennular peduncle, with somewhat protuberant ventral margin bearing fringe of long setae, subdistal tooth slender, slightly shorter than proximal tooth.

Carapace (Fig. 9A, B) armed with 2 or 3 acute median teeth in anterior half; first and third teeth relatively small compared to those of species of *P.*

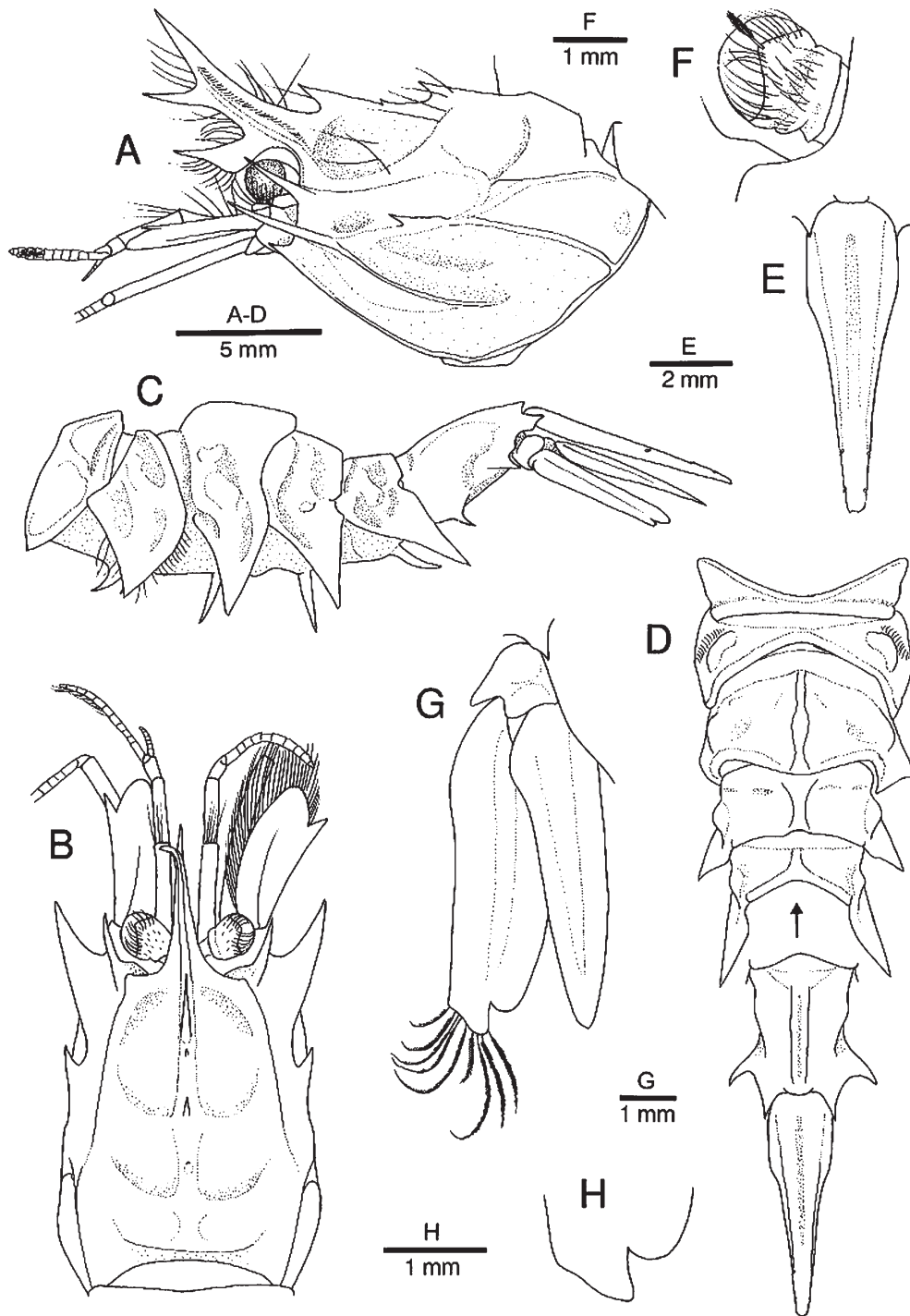


FIG. 9. – *Paracrangon furcata* Kubo, 1937. A, carapace and cephalic appendages, lateral; B, same, dorsal; C, abdomen, lateral (pleopods omitted); D, same, dorsal; E, telson, dorsal (posterior part broken off); F, left eye, dorsal; G, left uropod, dorsal; H, distal part of left uropodal exopod, dorsal. Female (cl 9.6 mm) from Kumano-nada, Japan (CBM-ZC 2409).

echinata group, subequal, acute; second tooth tiny, occasionally reduced; obsolete tubercle occasionally on cardiac region; antennal tooth long, slightly diverging, reaching distal margin of eye; branchiostegal tooth relatively weak, weakly diverging, not reaching level of distal margin of basal segment

of antennular peduncle; pterygostomian tooth smaller than antennal tooth, not reaching anterior margin of antennal basicerite; lateral surface of carapace unarmed other than relatively weak hepatic tooth. Orbital notch absent. Hepatic carina not extending to branchiostegal tooth; lower branch of branchial

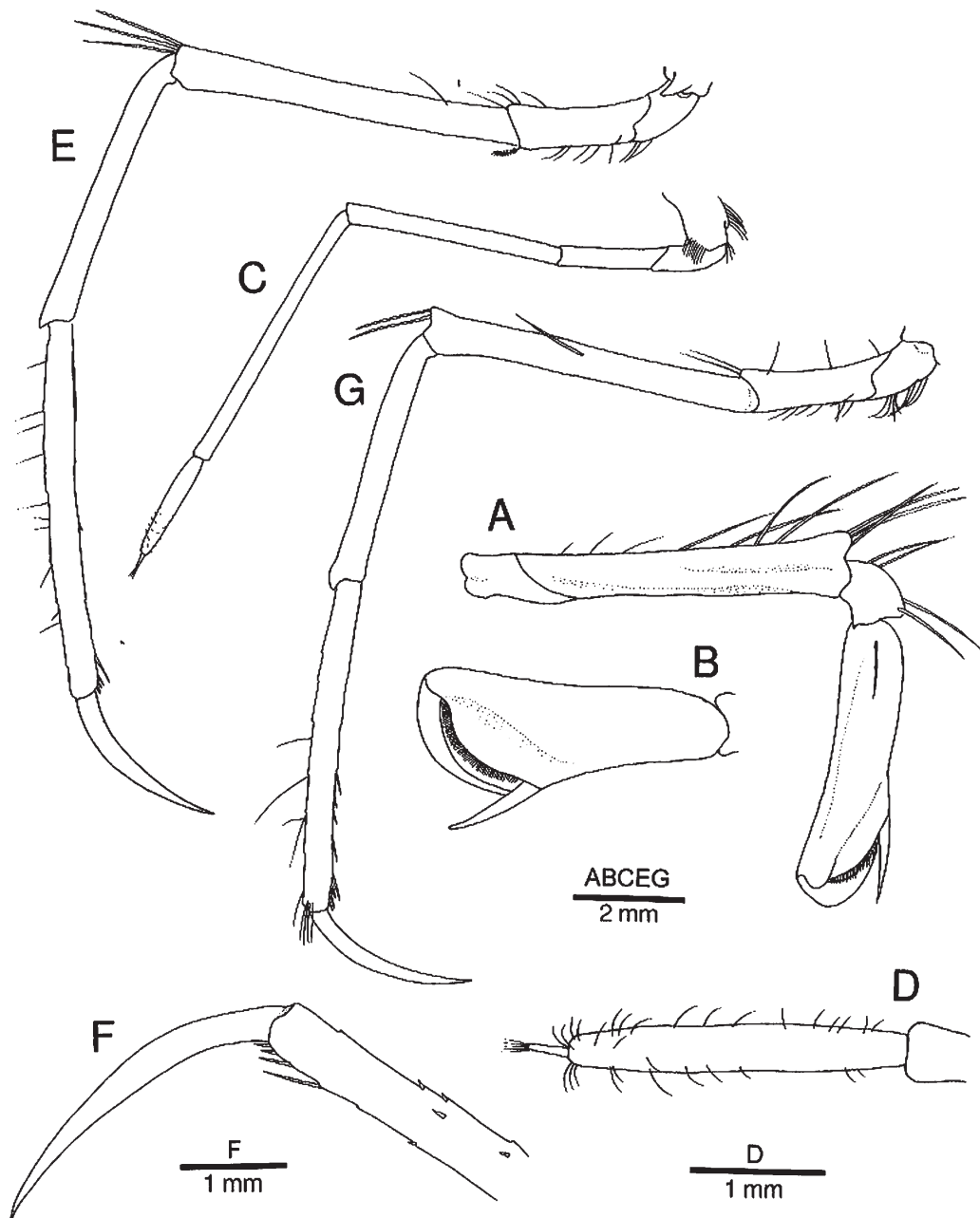


FIG. 10. — *Paracrangon furcata* Kubo, 1937. A, right first pereopod, lateral; B, subchela of right first pereopod, dorsal; C, left third pereopod, lateral; D, dactylus and propodus of left third pereopod, lateral; E, left fourth pereopod, lateral; F, dactylus and distal part of propodus of left fourth pereopod, lateral; G, left fifth pereopod, lateral. Female (cl 9.6 mm) from Kumano-nada, Japan (CBM-ZC 2409).

carina extending to posterolateral angle of carapace; subbranchial carina simple, not reticulate or branched; posterolateral submarginal carina absent. Intercarinal spaces shallowly depressed below. Posterolateral angle faintly flared laterally.

Abdomen (Fig. 9C, D) with first and second somites rounded dorsally, third to fifth somites each with distinct median carinae, median carinae on fourth and fifth somites relatively broad, former increasing in width anteriorly; posterodorsal margin

of third somite weakly produced; transverse carinae on second to fifth somites low, rather obsolete. Lateral tubercles on first to fifth somites low, blunt. Pleura of first to fifth somites acutely produced ventrally, somewhat flared laterally or posterolaterally, without additional small tooth on anterior margins, accompanying median pleural carinae broad, not sharply ridged; posterolateral margins of fourth and fifth somites each with low, blunt projection near articular knob. Sixth somite with 2 median carinae

separated by faint median groove; posterodorsal margin slightly produced; lateral surface unarmed; posteroventral tooth strong, directed posterolaterally. Telson (Fig. 9E) rather abruptly tapering in posterior 0.70, lacking submedian pair of teeth on dorsal surface near base.

Eye-stalk (Fig. 9F) with numerous long curved setae covering corneal surface; cornea moderately large, not dilated.

Antennular peduncle (Fig. 9A, B) moderately slender, reaching distal margin of antennal scale in females. Outer flagellum composed of 11-13 articles in females; inner flagellum composed of 4-6 articles in females.

Antennal scale (Fig. 9B) 2.90-3.10 times as long as wide, with produced blade distinctly overreaching distolateral tooth.

First pereopod (Fig. 10A) moderately slender; merus with dorsodistal lobe bearing several long setae, unarmed on ventromesial margin; palm (Fig. 10B) about 3.00 times as long as width across base of pollex, proximal part of palm gradually widened distally. Second pereopod completely reduced. Third pereopod (Fig. 10C) relatively stout, overreaching distal margin of scaphocerite by length of dactylus, propodus and 0.15-0.25 of carpus; propodus (Fig. 10D) not tapering distally, 0.35-0.40 times as long as carpus, distal width much greater than basal width of dactylus, with scattered short, recurved setae on surfaces. Fourth pereopod (Fig. 10E) overreaching distal margin of scaphocerite by length of dactylus and half of propodus; carpus 0.70-0.80 times as long as propodus, with blunt dorsodistal process; propodus (Fig. 10F) not broadened subdistally, with row of 5-10 slender spines or spinules on ventral margin; dactylus (Fig. 10F) long, 0.45-0.54 times as long as propodus. Fifth pereopod (Fig. 10G) similar to fourth; propodus with row of 7-9 spines or spinules on ventral margin; dactylus 0.50-0.54 times as long as propodus.

Uropodal exopod (Fig. 9G) with sinuous lateral margin; distolateral lobe (Fig. 9H) broad, obliquely truncate, with fringe of long plumose setae distally.

Coloration in life: Body entirely reddish brown (Hayashi, 1986) or light yellowish brown (Sakaji, 2001), rostrum and distal parts of pereopods transparent.

Distribution: Known only from Kumano-nada and Tosa Bay, Pacific coast of southwest Japan; at depths of 200-400 m.

Remarks: This species was described on the basis of a syntypic series of ten specimens, including one male and nine ovigerous females (Kubo, 1937). One lot containing a single ovigerous female specimen, labelled as "*Paracrangon furcata* sp. nov.", was located in the crustacean collection studied by I. Kubo, housed in Tokyo University of Marine Science and Technology. The specimen is dried, and extremely in poor condition; and no further data is given on the attached label. Nevertheless, the presence of two prominent median teeth on the carapace and the acute pleura of the first to fifth somites are still evident in the specimen. We assume this specimen as one of the syntypes of *P. furcata*. Fortunately, several supplemental specimens, including four topotypic specimens from Kumano-nada, have been available during the present study.

Although the supplemental specimens agree generally with the original description by Kubo (1937), inconsistencies are found in the shape of the subproximal ventral tooth of the rostrum and the armature of the propodi of the fourth and fifth pereopods. Kubo (1937) noted that the subproximal tooth of the rostrum is "forked". However, none of the present specimens has a "forked" subproximal tooth, although the ventral margin of the tooth is somewhat produced, protuberant. The female syntype illustrated by Kubo (1937) was not located, and it is difficult to determine whether or not this discrepancy is due to misinterpretation by Kubo (1937). Kubo (1937) mentioned that there were no spines on the ventral margins of the propodi of the fourth and fifth pereopods. In the present specimens, however, the propodi are armed with row of slender spines like other congeneric species, though these spines are easily broken off. Although either or both of the two characters were used as key characters by previous authors (Kubo, 1937; Ohé and Takeda, 1986; Hanamura *et al.*, 1999), it has been revealed that they are not reliable.

As mentioned before, *P. furcata* and *P. ostlingos* sp. nov. are closely related. Differences between the two species are discussed under the account of the latter species.

Komai (2001) suggested that the specimen referred to *Aegaeon rathbuni* (De Man, 1918) by Hayashi (1986: 146, Fig. 97; as *Pontocaris*) most probably represented a species of *Paracrangon*. Although unavailable for study, we believe that the specimen depicted by Hayashi (1986) represents *P. furcata*, because of the presence of two median teeth on the carapace and the long antennal tooth reaching

the distal margin of the eye, both clearly evident from the photograph.

Paracrangon ostlingos sp. nov.
(Figs. 11-13)

Material examined: Pacific coast of Japan. RV *Tansei-maru*: KT95-05 cruise, stn TB-14, SE of Taito-saki, Boso Peninsula, 35°09.4'N, 140°49.0'E, 311-323 m, 26 April 1995, beam trawl, coll. T. Komai, 1 male (cl 7.5 mm) (holotype; CBM-ZC 7588); KT97-01 cruise, stn OS-1, SW of Izu Oshima Island, Sagami-nada, 278-300 m, 27 February 1997, dredge, coll. E. Tsuchida, 1 male (cl 7.5 mm) (paratype; CBM-ZC 7589); KT98-14 cruise, stn 2, W of Izu Oshima Island, 34°44.538'N, 139°19.723'E, 257-264 m, 29 August 1998, dredge, coll. T. Komai, 1 male (cl 7.3 mm) (paratype; CBM-ZC 7590).

Type material: See above.

Description: Rostrum (Figs. 11, 12A; broken in holotype) 0.60 times as long as carapace, slightly curved; dorsal margin unarmed; ventral margin subproximally with stout, slightly recurved tooth not reaching level of distal margin of basal segment of antennular peduncle (ventral margin of tooth convex, but not protuberant) and subdistally with 1 smaller additional tooth.

Carapace (Figs. 11, 12A, B) armed with 3 median teeth on anterior half, fourth tooth on cardiac region completely reduced or represented by tiny tubercle; first and third teeth relatively small compared with those of *P. echinata* species group, first tooth acute, third tooth weaker than first tooth, acute or subacute; second tooth tiny, occasionally reduced

to tubercle; antennal tooth short, slightly diverging, not reaching distal margin of eye; branchiostegal tooth relatively weak, slightly diverging, not reaching level of distal margin of basal segment of antennular peduncle; pterygostomial tooth weaker than antennal tooth, not reaching anterior margin of antennal basicerite; lateral surface of carapace unarmed other than relatively weak hepatic tooth; hepatic tooth continuous with branchial carina. Orbital notch absent. Hepatic carina not extending to branchiostegal tooth; lower branch of branchial carina extending to posterolateral angle of carapace; subbranchial carina simple, not reticulate or branched; posterolateral submarginal carina absent. Intercarinal spaces shallowly depressed below. Posterolateral angle faintly flared laterally.

Abdomen (Figs. 11, 12C, D) with first and second somites lacking median carina, third to fifth somites each with rather broad median carinae; posterodorsal margin of third somite weakly produced; transverse carinae on second, fourth and fifth somites conspicuous. Lateral tubercles on first to fifth somites low, blunt. Pleura of first to fifth somites (Figs. 11, 12C, 13A) produced ventrally, weakly to somewhat flared laterally or posterolaterally; ventral margins generally blunt, but occasionally terminating in very small tooth; anterior margins without additional tooth; median pleural carinae broad, not sharply ridged; posterolateral margins of fourth and fifth somites unarmed. Sixth

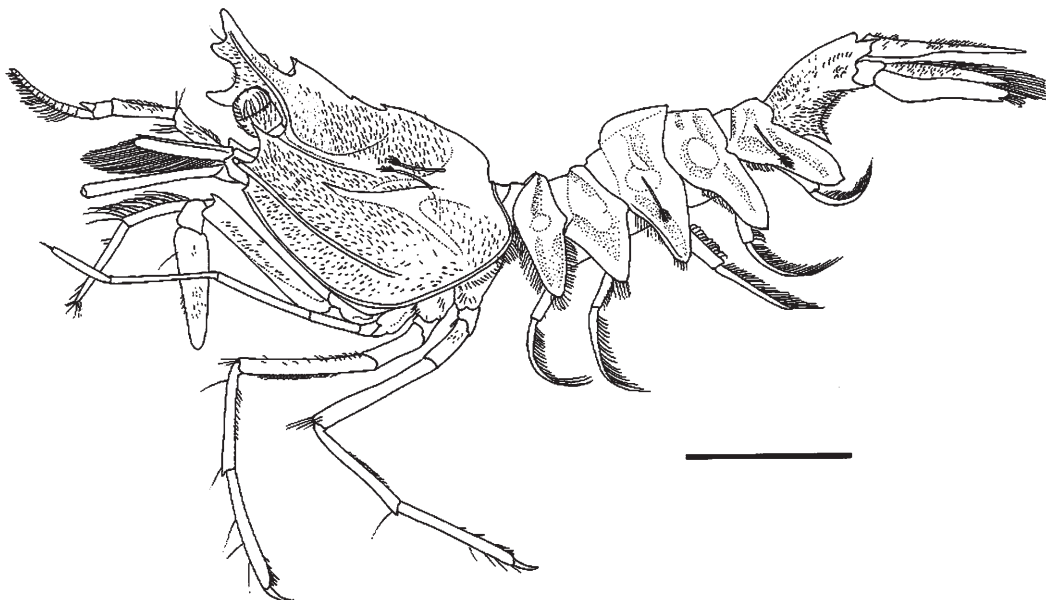


FIG. 11. – *Paracrangon ostlingos* sp. nov. Entire animal in lateral view (short setae on abdomen partially omitted in order to show sculpture). Paratype, male (cl 7.3 mm) from Izu Islands (CBM-ZC 7590). Scale bar: 5 mm.

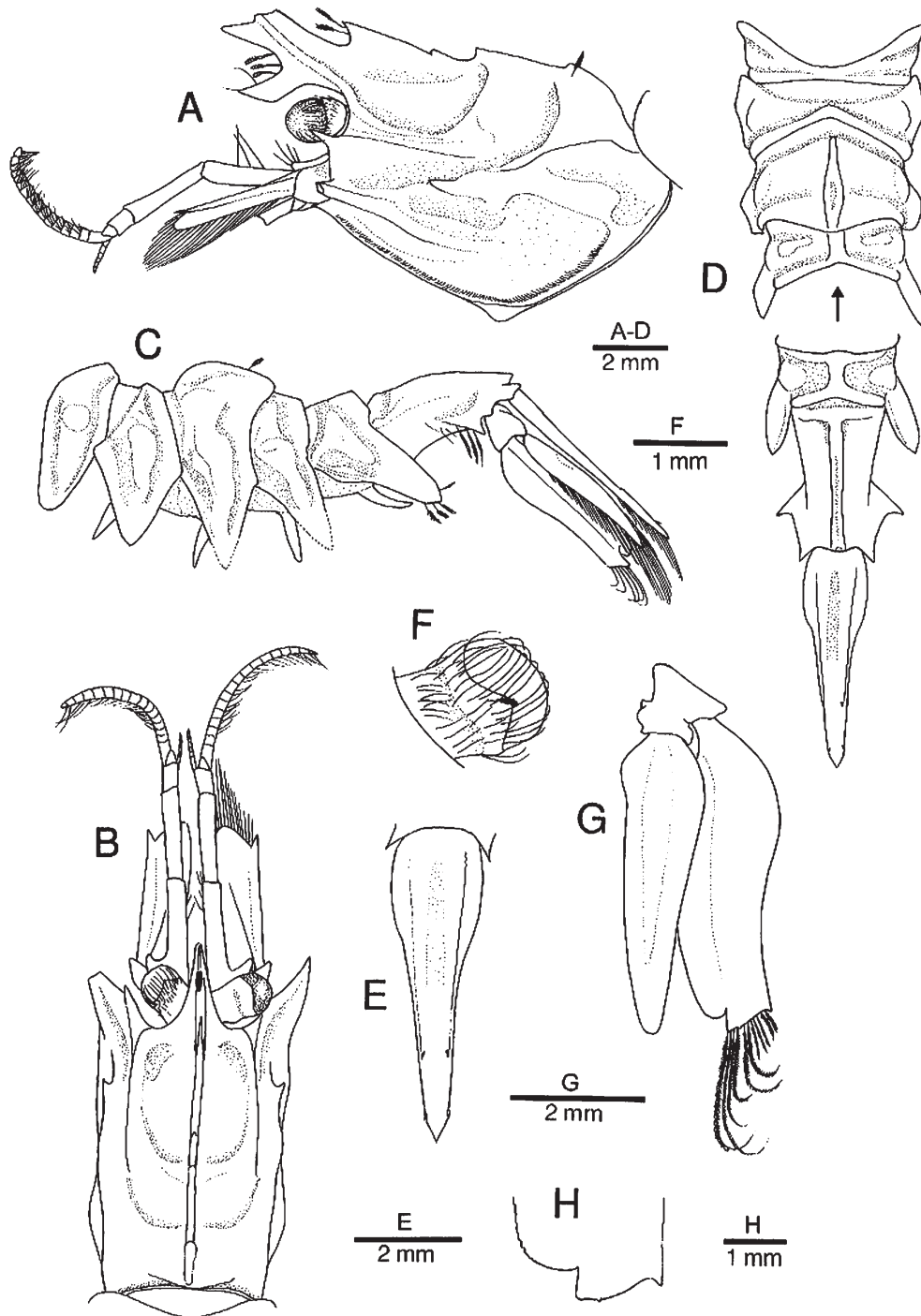


FIG. 12. – *Paracrangon ostlingos* sp. nov. A, carapace and cephalic appendages, lateral; B, same, dorsal; C, abdomen, lateral (pleopods omitted); D, same, dorsal; E, telson, dorsal (posteriormost pair of spines missing); F, left eye, dorsal; G, right uropod, dorsal; H, distal part of right uropodal exopod, dorsal. Holotype, male (cl 7.5 mm) from off Boso Peninsula, Japan (CBM-ZC 7588).

somite with 2 median carinae separated by faint median groove; posterodorsal margin slightly produced; lateral surface unarmed; posteroventral tooth relatively weak, directed laterally. Telson (Fig. 12E) rather abruptly tapering at anterior 0.30, with median pair of low tubercles on dorsal surface near base.

Eye-stalk (Fig. 12F) with numerous long curved setae covering corneal surface; cornea moderately large, not dilated.

Antennular peduncle (Fig. 12A, B) slender, overreaching distal margin of antennal scale by length of third segment and 0.40 of second segment in males.

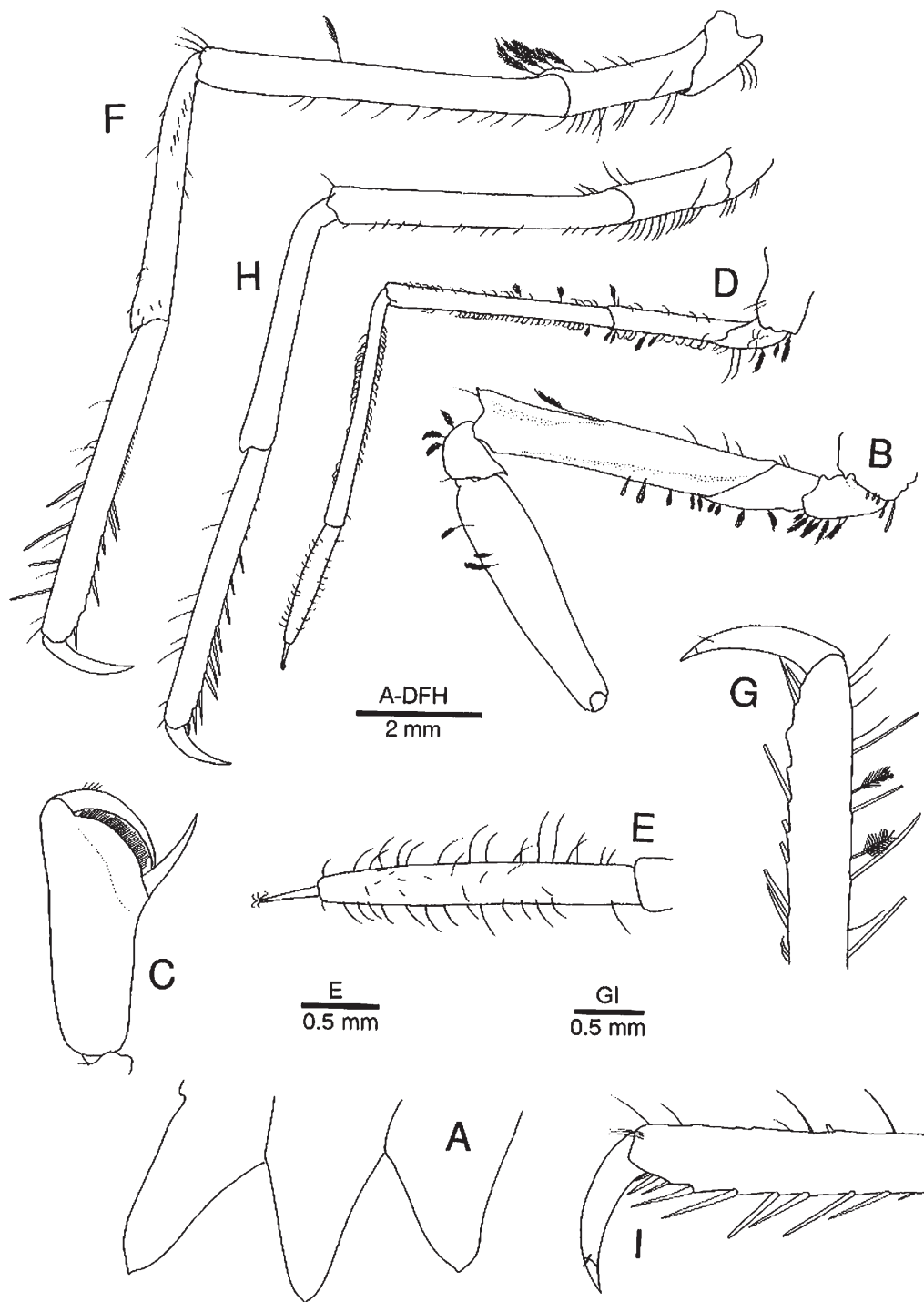


FIG. 13. – *Paracrangon ostlingos* sp. nov. A, pleura of second to fourth abdominal somites, lateral; B, left first pereopod, lateral; C, subchela of left first pereopod, dorsal; D, left third pereopod, lateral; E, dactylus and propodus of left third pereopod, lateral; F, left fourth pereopod, lateral; G, dactylus and distal part of propodus of left fourth pereopod, lateral; H, left fifth pereopod, lateral; I, dactylus and distal part of propodus of left fifth pereopod, lateral. Holotype, male (cl 7.5 mm) from off Boso Peninsula, Japan (CBM-ZC 7588).

Outer flagellum composed of 16-18 articles in males; inner flagellum composed of 4-6 articles in males.

Antennal scale (Fig. 12B) 2.90-3.10 times as long as wide, with produced blade distinctly overreaching distolateral tooth.

First pereopod (Fig. 13B) moderately slender; merus with stout dorsodistal tooth, unarmed on ventromesial margin; palm (Fig. 13C) 2.70-2.80 times as long as width across base of pollex, proximal part of palm slightly widened distally. Second pereopod absent. Third pereopod (Fig. 13D) relatively stout,

overreaching distal margin of scaphocerite by length of dactylus, propodus and 0.15-0.25 of carpus; propodus (Fig. 13E) very slightly tapering distally, 0.50 times as long as carpus, distal width greater than basal width of dactylus, with scattered short, recurved setae on surfaces. Fourth pereopod (Fig. 13F) moderately slender, overreaching distal margin of scaphocerite by length of dactylus and half of propodus; carpus 0.70-0.80 times as long as propodus, with blunt dorsodistal process; propodus (Fig. 13G) not broadened subdistally, with row of 8 long spines or spinules on ventral margin; dactylus (Fig. 13G) short, 0.27 times as long as propodus. Fifth pereopod (Fig. 13H) similar to fourth; propodus (Fig. 13I) with row of 8-14 spines or spinules on ventral margin; dactylus 0.26 times as long as propodus.

Uropodal exopod (Fig. 12G) with sinuous lateral margin; distolateral lobe (Fig. 12H) broad, obliquely truncate with spinule at lateral angle, with fringe of long setae distally.

Color in life: Body and appendages generally light brown.

Distribution: Known only from Boso Peninsula and Sagami-nada, Pacific coast of central Japan; at depths of 257-323 m.

Etymology: From the Greek *ostlingos*, meaning curled hair, denoting the curling setae on the eye-stalk partially obscuring the corneal surface.

Remarks: As mentioned before, this new species is closely related to *P. furcata*. The new species is readily separated from *P. furcata* by the rather blunt pleura of the first to fifth abdominal somites and the shorter dactyli of the fourth and fifth pereopods (0.20-0.27 times as long as the propodus versus 0.50-0.54 times as long). Further, the size of the antennal tooth and the relative length of the propodus of the third pereopod serve to distinguish the two species. The antennal and pterygostomial teeth are much shorter in the new species than in *P. furcata*. The propodus of the third pereopod is proportionally longer in *P. ostlingos* than in *P. furcata* (0.50 times as long as the carpus versus 0.35-0.40 times as long). Although this comparison is made between different sexes, these differences are not the subject of sexual dimorphism in other species of *Paracrangon*, and therefore the specific separation is warranted. Furthermore, habitats of the two species

appear different. The specimens of *P. ostlingos* sp. nov. have been collected from hard bottom with rich sponge and gorgonian growth (personal observation), while the specimens of *P. furcata* came from fishery grounds of commercial trawlers (Kubo, 1937; Hayashi, 1986; Sakaji, 2001; present study).

DISCUSSION

Hanamura *et al.* (1999) briefly discussed the biogeography of *Paracrangon*. The currently available data suggests that *Paracrangon* is exclusively distributed in the Pacific Ocean. The highest species richness is found in temperate East Asian waters, where five of the seven known species occur, while there is no species endemic to the tropical region. Four of the five species (*P. abei*, *P. furcata*, *P. okutanii* and *P. ostlingos* sp. nov.) are endemic to East Asian waters, while *P. echinata* appears to be widely distributed in the northern North Pacific, extending to the northwest coast of United States. As mentioned above, *P. okutanii* extends the geographical range to the northern part of the South China Sea, representing a sole representative of the genus occurring in tropical waters in the western Pacific. The relatively recent discovery of *P. australis* from southern Australian waters by Hanamura *et al.* (1999) is highly remarkable, as all other known species are distributed in the North Pacific except for *P. areolata* that occurs also in the southeastern Pacific. Morphological similarities discussed would seem to suggest that the speciation events in *Paracrangon* were caused by complex processes of global tectonic movements in the Pacific Ocean and local isolation of populations in the northwest Pacific region. Future studies on phylogeny of *Paracrangon* will be of great interest in the biogeographical aspects.

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