



Two new species of *Richardina* A. Milne-Edwards, 1881 (Crustacea: Decapoda: Stenopodidea: Stenopodidae), representing the first occurrences of the genus from the Pacific

TOMOMI SAITO¹ & HIRONORI KOMATSU²

¹Port of Nagoya Public Aquarium, Minato-ku, Nagoya 455-0033, Japan. E-mail: t-saito@nagoyaminato.or.jp

²National Museum of Nature and Science, 3-23-1 Hyakunincho, Shinjuku-ku, Tokyo 169-0073, Japan.

E-mail: h-komatu@kahaku.go.jp

Abstract

More than a century after the description of *Richardina fredericii* Lo Bianco, 1903, two new species of the stenopodid genus *Richardina* A. Milne-Edwards, 1881, are described and illustrated. *Richardina ohtsukai* n. sp. was collected from the Nansei Islands, southwestern Japan at depths of 655 – 730 m and *R. parvioculata* n. sp. was collected from off Tosa Bay, western Japan at a depth of 517 m. To our knowledge, these are the first occurrences of the genus from the Pacific and greatly extend its known geographical range, as the genus *Richardina* is previously known only from the Atlantic Ocean and Mediterranean Sea. Species of *Richardina* are very similar to each other with few morphological differences. *R. ohtsukai* is unique in having additional movable spines on the dorsal margins of the dactyli of the fourth and fifth pereopods. *R. parvioculata* is distinguished from congeners by way of its generally reduced armament of the carapace and pleon as follows: it lacks the median row of spines on the posterior margin of the cervical groove, has a relatively large eyestalk and small-sized cornea, and blunt spines on the dorsolateral carinae of the telson.

Key words: Crustacea, Decapoda, Stenopodidea, Stenopodidae, *Richardina*, new species, Pacific, Nansei Islands, Tosa Bay, Japan

Introduction

The species of Stenopodidae occurring on rocks, coral reefs or sometimes associated with other marine invertebrates are generally small in size and have cryptic habits. Owing to several recent taxonomic and faunal studies on the crustaceans of the deep waters around the western Pacific, our knowledge of stenopodidean shrimp fauna of this region has increased. During the benthic faunal survey around Shikoku, western Japan, conducted by the RV *Hakuho-maru* of the Ocean Research Institute, University of Tokyo, otter trawl samplings were made. At station KH02-3, one male and one ovigerous female specimen of an undescribed species of the genus *Richardina* A. Milne-Edwards, 1881 were collected. Furthermore the benthic faunal survey around the Nansei Islands, southwestern Japan, conducted by the TV *Toyoshio-maru* of Hiroshima University, collected a large number of another undescribed species of *Richardina* among the stations near Amami-oshima Island and Kerama Islands. In addition to their geographical distribution, several morphological characteristics also distinguish these specimens from the other members of the genus.

To our knowledge, these new species are the first representative of the genus found to occur in the Pacific Ocean. The stenopodid genus *Richardina* has been known only from the Atlantic Ocean and Mediterranean Sea by the following two species (Table 1), *R. spinicincta* A. Milne-Edwards, 1881 from depths of 455–1230 m in the North Atlantic, such as the waters off Ireland, Gulf of Gascogne, the Bay of Biscay, and around the Gulf of Mexico (A. Milne-Edwards 1881; Kemp 1910; Holthuis 1946; Zariquiey Alvarez 1968; Goy 1982;

d'Udekem d'Acoz 1999; Wicksten & Packard 2005), and *R. fredericii* Lo Bianco, 1903 from depths of 400–1110 m in the west to east Mediterranean, such as off Barcelona, Catalogne, off the Island of Capri near Naples, Corsica, and Aegean Sea (Lo Bianco 1903; Zariquiey Alvarez 1968; MacPherson 1978; Cartes 1993; d'Udekem d'Acoz 1999; Abelló *et al.* 2002; Kocataş & Katağan 2003; Morales-Nin *et al.* 2003).

The specimens examined in this study are deposited in the National Museum of Nature and Science, Tokyo (NSMT). The postorbital carapace length is abbreviated as 'cl' in the text. For comparison, the following specimens were examined:

Richardina spinicineta A. Milne-Edwards, 1881. Holotype: Draguages du "TRAVAILLEUR", Bay of Biscay, female (cl 2.0 mm) (MNHN-2943); Atlantic Ocean, United States, Florida, Dry Tortugas, SW of Tortugas #69+70, 3 August 1932, male (cl 6.3 mm) (USNM 184548).

TABLE 1. Geographical and bathymetrical ranges of the *Richardina* species.

Name	Geographical range	Bathymetric ranges	References
<i>R. fredericii</i>	Eastern to western Mediterranean Sea	400–1110 m	Lo Bianco 1903; MacPherson 1978; Cartes 1993
<i>R. spinicineta</i>	North Atlantic, Bay of Biscay, Gulf of Mexico	455–1230 m	A. Milne-Edwards 1881; Kemp 1910; Goy 1982
<i>R. ohtsukai</i> n. sp.	Nansei Islands, southwestern Japan (sponge-associated)	655–730 m	This study
<i>R. parvioculata</i> n. sp.	Off Tosa Bay, western Japan (sponge-associated)	517 m	This study

Taxonomic account

Richardina ohtsukai n. sp.

[New Japanese name: ohtsuka-ryu-jin-ebi]

(Figs. 1–6)

Type material. HOLOTYPE: NSMT-Cr 20835, female (cl 5.0 mm), TV *Toyoshio-maru*, 2007-05 cruise, stn 09, Kerama Islands, N of Nagan-nu Island, 26°23.15N, 127°30.09E, 730–728 m, 26 May 2007, coll. H. Komatsu.

PARATYPES: NSMT-Cr 20836, 6 males (cl 3.6–4.9 mm), 4 females (cl 4.5–5.1 mm), 1 ovigerous female (cl 4.4 mm), same data as holotype. NSMT-Cr 20837, male (cl 4.0 mm), TV *Toyoshio-maru*, 2007-05 cruise, stn 07, Amami-oshima Island, W of Utsuzaki, 28°24.88N, 129°14.57E, 655 m, 28 May 2007, coll. H. Komatsu. NSMT-Cr 20838, 4 males (cl 2.6–5.1 mm), ovigerous female (cl 5.1 mm), TV *Toyoshio-maru*, 2008-04 cruise, stn 08(1), Kerama Islands, N of Kuroshima Island, 26°20.00N, 127°23.53E, 722–715 m, 25 May 2008, coll. H. Komatsu.

Description of females. Body slender and compressed. Integument of carapace and pleon glabrous (Figure 1).

Rostrum (Figure 2A, B) slender, directed forward, reaching proximal third of antennal scale, 0.34 of cl, narrowly triangular in dorsal view; dorsal margin armed with 8–11 teeth, proximal tooth posterior to postorbital margin; ventral margin with 1–2 teeth subdistally; lateral margin often with 1–2 tiny teeth at midlength.

Carapace (Figure 2A, B) with postrostral median ridge extending to gastric region; postrostral submedian spine relatively small, straight, directed anteriorly; postorbital region armed with a few stout spines directed anteriorly; orbital margin concave, inferior orbital angle rounded; antennal spine small and acuminate, marginal; anterolateral margin rounded with several minute spines; cervical groove distinct, posterior margin

armed with cincture of many spines of various sizes, large in lateral part, small in dorsal part, directed anteriorly; hepatic groove present.

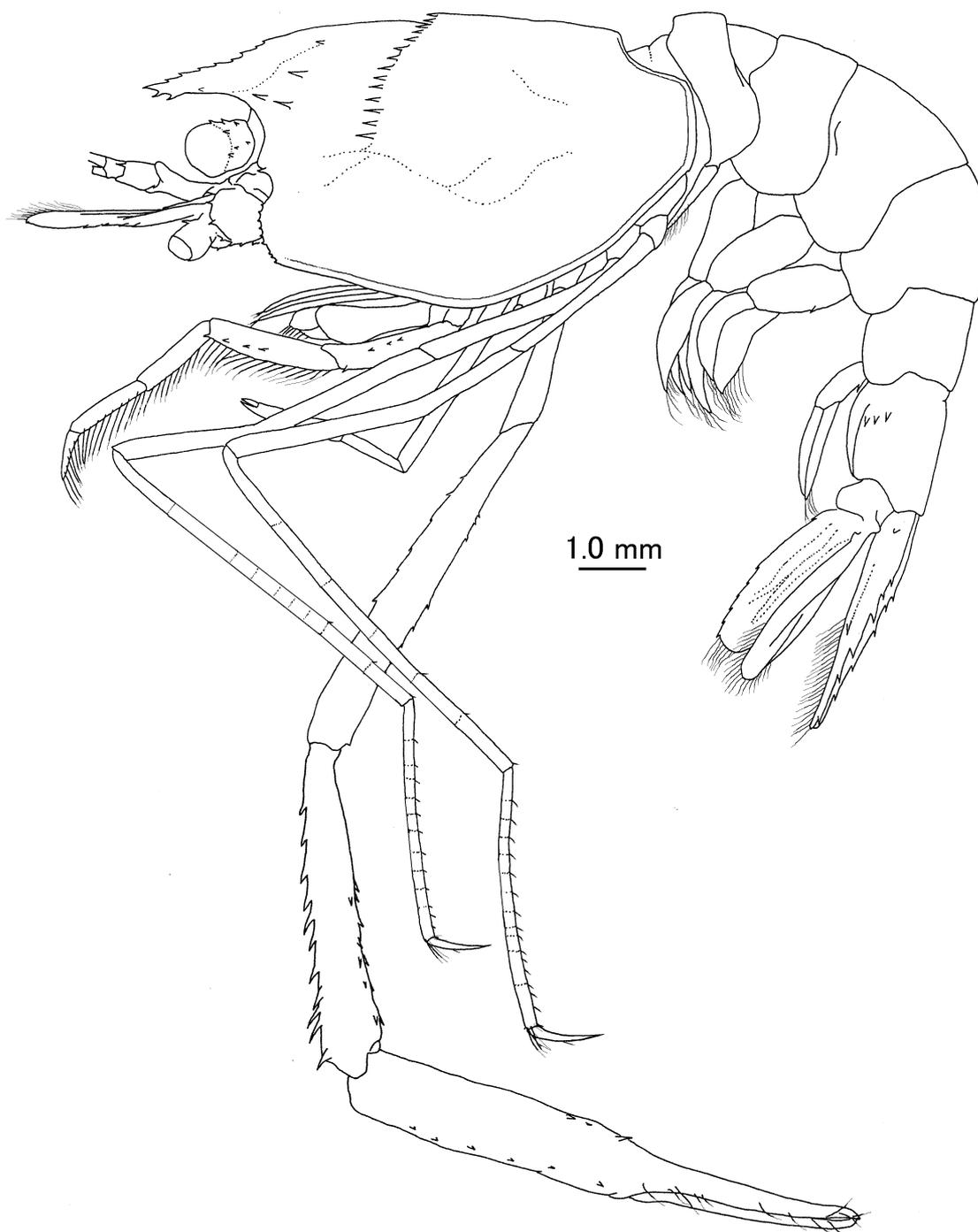


FIGURE 1. *Richardina ohtsukai* n. sp., holotype female, (cl 5.0 mm), NSMT- Cr 20835.

Sixth thoracic sternite (Figure 2C) with paired narrow lobes, each lateral margin unarmed, ventral surface concave. Seventh sternite with paired, broad trapezoid lobes, each distolateral angle weakly produced, ventral surface concave, unarmed. Eighth sternite with paired narrow plates, each distolateral angle rounded, ventral surface concave, unarmed.

Pleonal somites (Figure 1) not sculptured; ventral margins unarmed. First pleonal somite short, divided in two sections by distinct transverse carina; anterior section with pleuron unarmed laterally, posterior section with pleuron unarmed laterally, posteroventral margin unarmed. Second somite with anterior transverse carina

ending at base of pleuron. Third somite longest, posterodorsal margin somewhat posteriorly produced; pleuron unarmed laterally. Sixth somite (Figures 1, 2E) armed with 2–4 strong lateral spines on either side. Telson (Figure 2E) lanceolate, proximally narrowed between widest part and basal joint, tapering distally, 2.6 times longer than broad; dorsal surface with median groove flanked by two dorsolateral carinae, each provided with row of usually 5 strong, rather symmetrically situated spines, inner margin with 2–3 spines subproximally; lateral margins convex subproximally, armed with strong spine at midlength; posterior margin convex, unarmed, posterolateral angle armed with posterolateral spine.

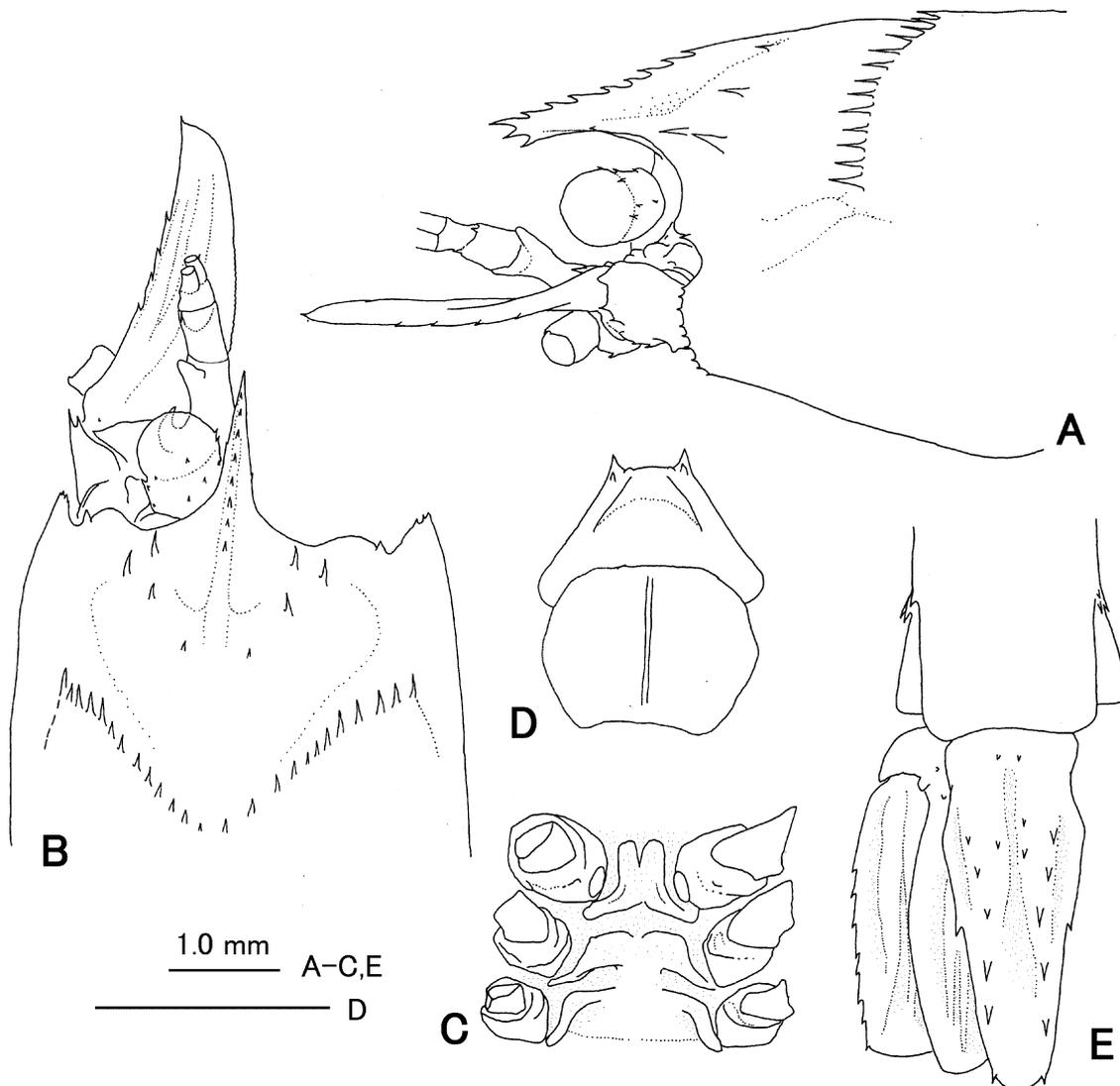


FIGURE 2. *Richardina ohtsukai* n. sp., holotype female, (cl 5.0 mm), NSMT-Cr 20835. A, anterior part of carapace and eyes, lateral; B, same, dorsal; C, sixth to eighth thoracic sternites, ventral; D, epistome, ventral; E, telson and left uropod, dorsal, marginal setae omitted.

Eye (Figure 2A, B) well developed, cornea hemispherical, red pigmented; eyestalk armed with 5–7 small spines along base of cornea, dorsally with several scattered small spines, 0.7 of cornea in length. Antennular peduncle (Figures 2B, 3A) reaching to midlength of antennal scale; first segment subequal to distal two segments combined, with longitudinal, distolateral row of setae; stylocerite acute, curved; second segment armed with 1 strong dorsolateral and 2 strong ventromesial spines; third segment with rounded distal margin. Antenna (Figures 2B, 3B) with stout basicerite armed with moderately large spine at distolateral angle, and with few additional small spines on ventrolateral margin; antennal scale 3.2 times longer than broad, lateral

margin nearly straight, armed with 5–7 teeth, dorsal surface with 2 distinct longitudinal carinae; carpoperite short, reaching to level of first segment of antennular peduncle, armed with 1 spine.

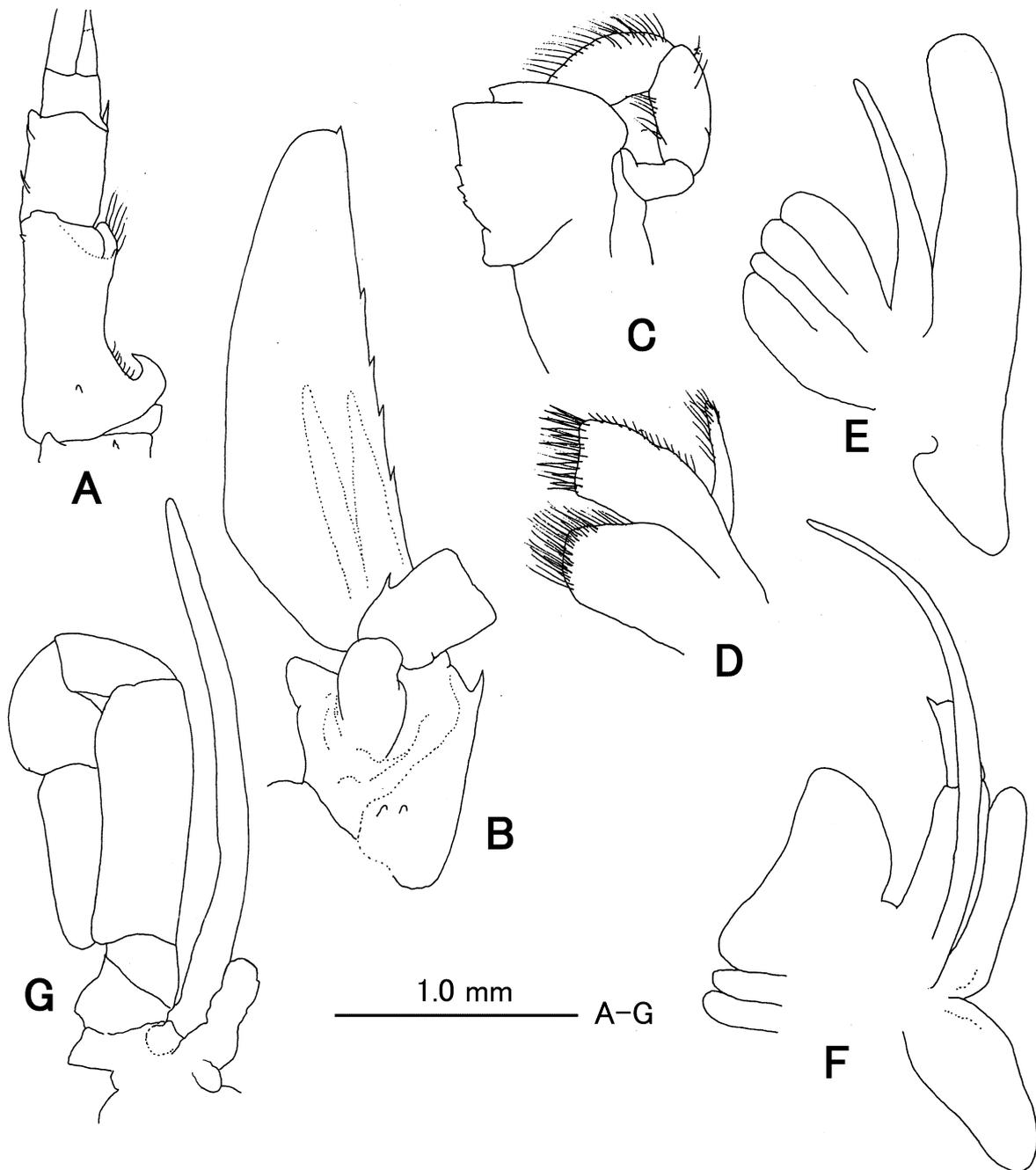


FIGURE 3. *Richardina ohtsukai* n. sp., holotype female, (cl 5.0 mm), NSMT- Cr 20835. A, left antennular peduncle, ventral; B, left antenna, ventral; C, left mandible, lateral; D, left maxillule, ventral; E, left maxilla, ventral; F, left first maxilliped, ventral; G, left second maxilliped, ventral. B, E–G, marginal setae omitted.

Epistome (Figure 2D) triangular anteriorly, armed with 2 distolateral spines and 2 smaller subdistal spines; labrum normally developed. Paragnath bilobed, separated by median fissure.

Mandible (Figure 3C) robust, with palp consisting of 3 articles, distal article oval, furnished with dense setae, intermediate article longest, distally with tuft of setae; molar and incisor processes clearly separated; molar surface oval, without distinct tooth, distal margin of incisor process truncated, armed with short, stout teeth. Maxillule (Figure 3D) with simple, slender endopod tapering distally; basal endite moderately broad, truncated distally with several slender spines and sparse, long spiniform setae; coxal endite suboval, with

submarginal row of stiff setae on outer surface. Maxilla (Figure 3E) with curved, slender endopod; basal and coxal endites both bilobed; scaphognathite well developed, anterior lobe rounded distally, posterior lobe short, widened posteriorly. First maxilliped (Figure 3F) with broad endopod consisting of 2 articles, distal article narrow, tapering distally with blunt distal spine; proximal article subquadrate; basal endite large, subtriangular, with concave mesial margin; coxal endite bilobed; exopod with well-developed flagellum; epipod large, feebly bilobed. Second maxilliped (Figure 3G) with endopod composed of 7 segments; dactylus tapering distally; propodus anteromesially truncated, 0.7 of dactylus in length; carpus cap-shaped, subequal in length to propodus; merus about twice as long as carpus, oblong, mesial margin pectinate; ischium and basis very short, obliquely demarcated; coxa with small tubercles laterally, epipod cylindrical with small podobranch; exopod with well-developed flagellum. Third maxilliped (Figure 4A) with slender endopod, composed of 7 segments, reaching tip of antennal scale by lengths of dactylus and half of propodus; dactylus tapering distally, lateral margins of dactylus and propodus furnished with long setae, distomesial surface with shallow depression fringed with dense grooming setae; carpus unarmed, ventrodistal margin somewhat produced; merus with distolateral row of 4–6 stout spines; ischium compressed, armed with ventral row of several small spines, interspaced with pectines, and with 1 dorsolateral spine; basis short; coxa with short epipod; exopod with well developed, unsegmented flagellum, distally with dense setae.

Branchial formula shown in Table 2.

TABLE 2. *Richardina ohtsukai* n. sp. and *R. parvioculata* n. sp. Branchial formula.

	Maxillipeds			Pereopods				
	1	2	3	1	2	3	4	5
Pleurobranches	-	-	1	1	1	1	1	1
Arthrobranches	1	1	2	2	2	2	2	-
Podobranch	-	1	-	-	-	-	-	-
Epipods	1	1	1	1	1	1	1	-
Exopods	1	1	1	-	-	-	-	-

First pereopod (Figure 4B) small, slender, unarmed, reaching tip of antennal scale by length of dactylus, with well developed grooming apparatus; dactylus 0.4 of chela length; palm subcylindrical; carpus slender, 1.7 of chela length; merus 0.9 of carpal length; ischium 0.6 of meral length. Second pereopod (Figure 4C) longer than first pereopod, unarmed, overreaching tip of antennal scale by lengths of chela and half of carpus; dactylus 0.4 of chela length; palm subcylindrical; carpus slender, about twice as long as chela length; merus 0.8 of carpal length; ischium about half of meral length. Third pereopod (Figure 4D, E) strongest of pereopods, overreaching tip of antennal scale by lengths of chela and carpus; dactylus 0.4 of chela length, terminating hooked unguis, unarmed on dorsal and lateral margins, cutting edge armed proximally with stout, triangular tooth, remaining parts entire; fixed finger generally similar to dactylus, cutting edge armed with blunt teeth opposed into depression on dactylus; palm subcylindrical, 2.5 times longer than wide, mesial margin armed with row of several small spines, lateral surface armed with 1–2 rows of several small spines mesially and laterally, ventrolateral margin armed with short row of a few small spines anteriorly; carpus slightly widened distally, about 4.2 times longer than wide, 0.6 of chela length, dorsal surface armed with two rows of 2–9 stout spines, ventral margin armed with 2 rows of 5–6 smaller spines; merus subequal to carpus, dorsal margin armed with row of 7 spines, ventral margin armed with row of 9 smaller spines; ischium 0.6 of meral length, unarmed.

Fourth and fifth pereopods (Figure 4F, G, H) similar, very long and slender; fourth pereopod reaching tip of antennal scale by lengths of dactylus, propodus and carpus; dactyli (Figure 4G, H) compressed laterally, about 4 times longer than wide, uniunguiculate, dorsal margin usually with 1 movable spine at midlength; propodi 4 times as long as dactyli, subdivided into 8–15 articles, ventral margin armed with small spine on

ventrodistal angle of each article; carpi 1.6 times as long as propodi, subdivided into 10–12 articles, ventral surfaces armed with small spine on ventrodistal angle of each article; meri 0.7 of carpal length; ischia entire, 0.6 of meral length.

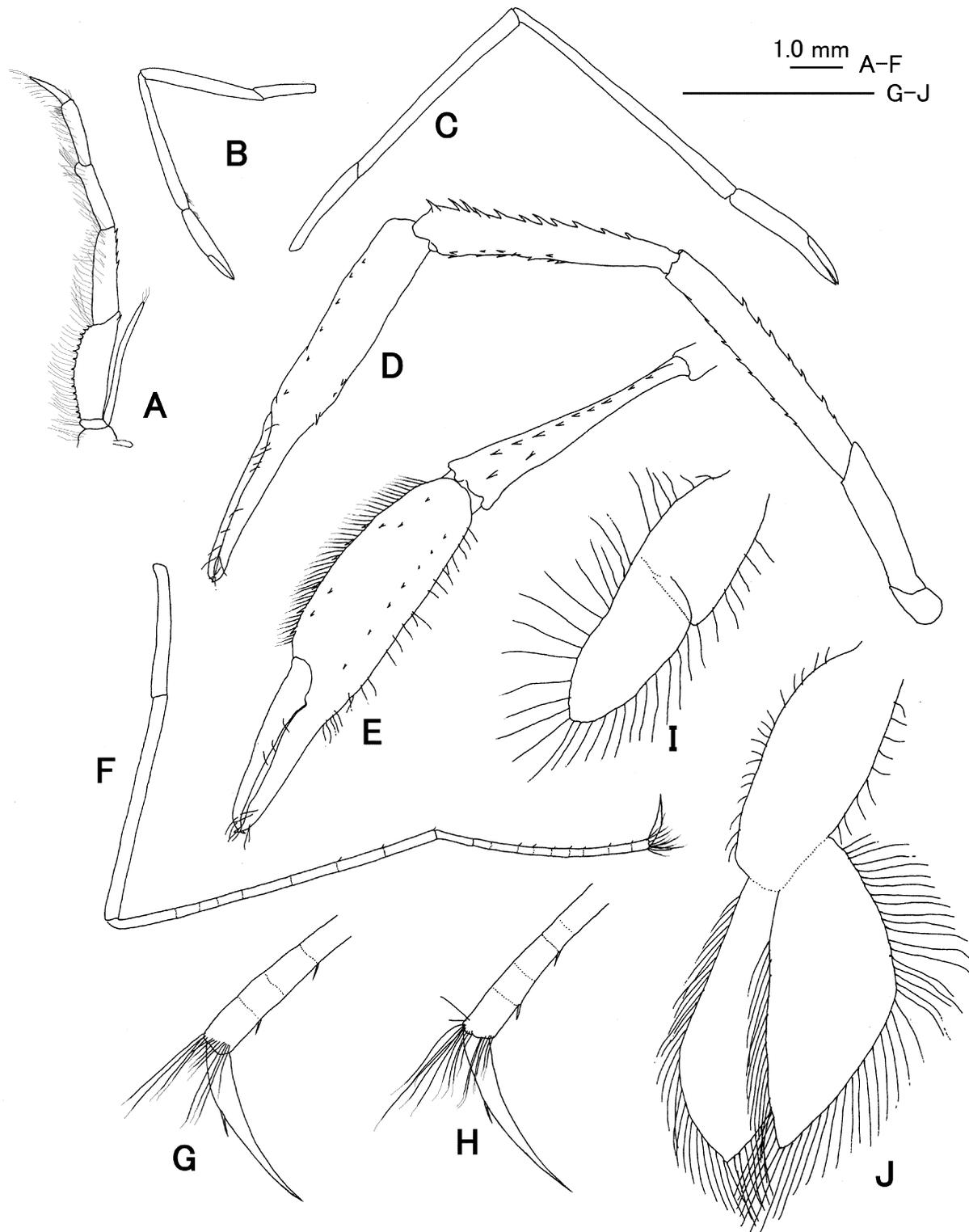


FIGURE 4. *Richardina ohtsukai* n. sp., holotype female, (cl 5.0 mm), NSMT- Cr 20835. A, left third maxilliped, ventral; B, left first pereopod, lateral; C, right second pereopod, lateral; D, left third pereopod, lateral; E, same, dorsal; F, left fifth pereopod, lateral; G, left fourth pereopod, dactylus, lateral; H, left fifth pereopod, dactylus, lateral; I, left first pleopod; J, left second pleopod.

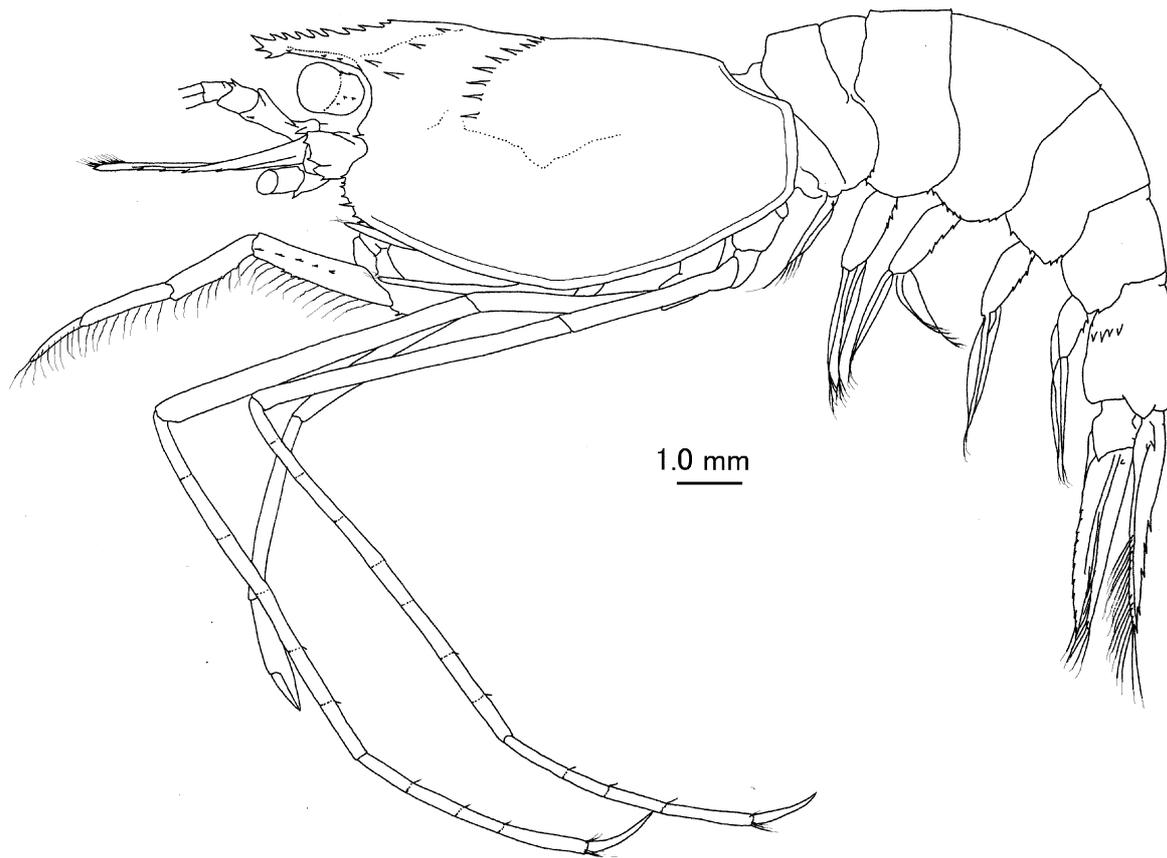


FIGURE 5. *Richardina ohtsukai* n. sp., paratype male, (cl 4.9 mm), NSMT- Cr 20838.

Pleopods without any appendices. First pleopods uniramous (Figure 4I), shortest. Second to fifth pleopods biramous. Second pleopod (Figure 4J) with basipodite shorter than exopodite, but as long as endopodite, mesial margin unarmed. Third to fifth pleopods generally similar, decreasing in size posteriorly, often armed with a few teeth on ventral margins of basipodites.

Uropod (Figure 2E) with protopodite stout, lateral margin terminating in acute process; exopod broad, falling slightly short of posterior margin of endopod, lateral margin nearly straight, terminating in acute tooth, with row of 7–10 acute teeth, dorsal surface with 2 smooth longitudinal carinae, unarmed; endopod tapering distally, falling slightly short of posterior margin of telson, lateral margin unarmed, dorsal surface with 2 smooth longitudinal carinae, unarmed.

Eggs counting 2, diameter 1.5–1.6 mm (example: ovig. female, cl 4.4 mm, NSMT-Cr 20836).

Male characteristics. Rostrum (Figure 5) relatively longer than that of female, 0.36 of cl; dorsal margin armed with 9 teeth, proximal 2 teeth posterior to postorbital margin; ventral margin with 2 subterminal teeth; lateral margin with few tiny teeth at midlength. Sixth thoracic sternite (Figure 6A) with slender, strongly bifurcated lobes, lateral angle terminating in acute spine, mesial angle denticulate; seventh sternite with relatively broad subquadrangular lobes directed anterolaterally, each anterolateral angle terminating in acute spine; eighth sternite with triangular lobes directed anterolaterally, each anterolateral angle terminating in acute spine. Pleura of first to sixth pleonal somites (Figure 5) armed with several teeth anteroventrally and/or posteroventrally. Third pereopod (Figure 6B, C) with palm about twice as long as wide, dorsal margin armed with a few irregular rows of several spines of various sizes, basal surface of immovable finger armed with some small spines or tubercles, ventrolateral surface of palm armed with 1–2 rows of several small spines; carpus widened distally, about 3.1 times longer than wide, 0.6 of chela length, dorsolateral surface armed with 1 distal spine and two rows of 1–4 spines, mesial margin armed with row of 5 smaller spines; merus subequal

to carpus, dorsal margin armed with row of 5–7 spines, ventral margin armed with row of 7 spines; ischium 0.7 of meral length, unarmed. Second to fifth pleopods (Figure 5) armed with some teeth on ventral margins of basipodites.

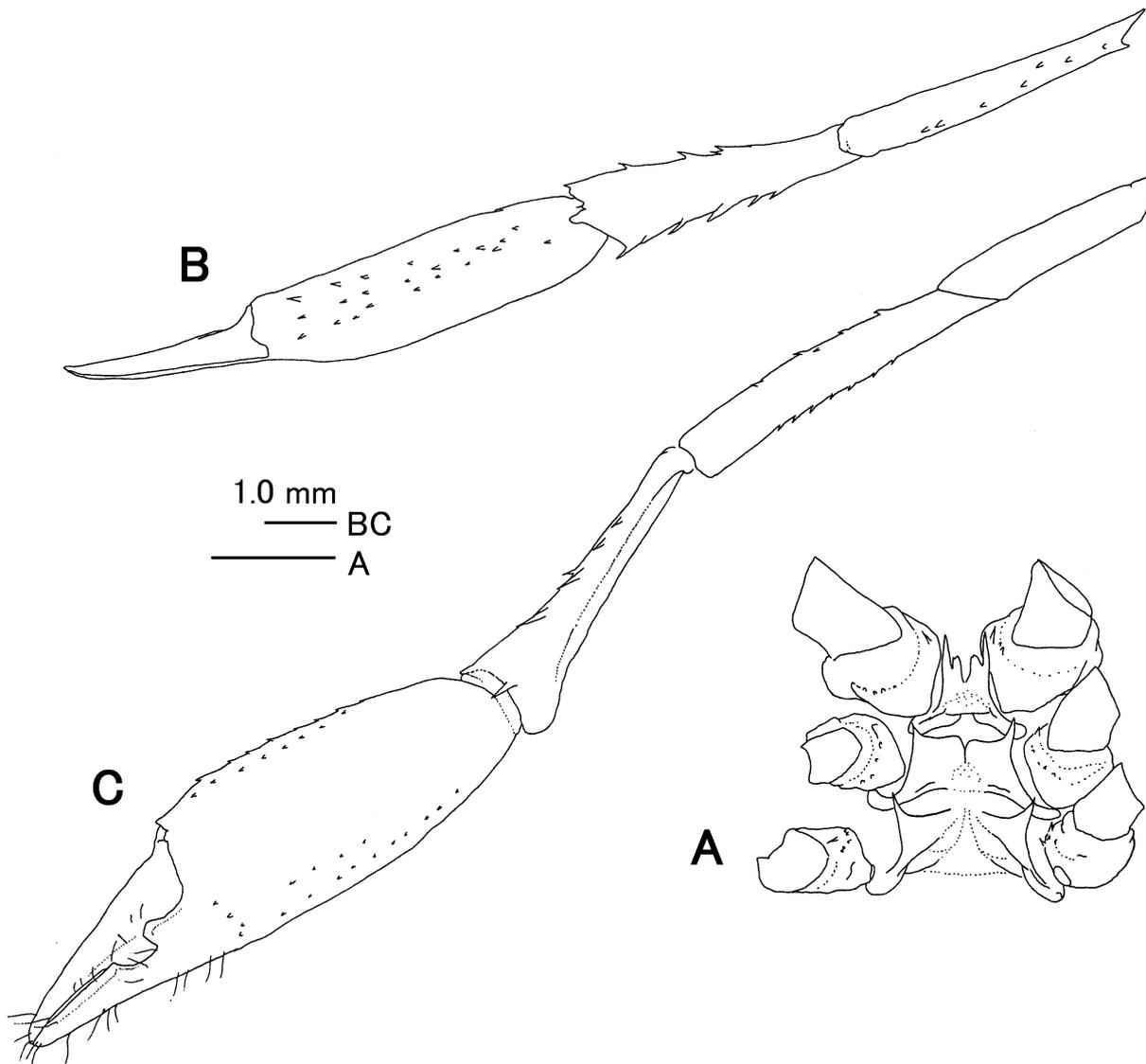


FIGURE 6. *Richardina ohtsukai* n. sp., paratype male, (cl 4.9 mm), NSMT- Cr 20838. A, sixth to eighth thoracic sternites, ventral; B, left third pereopod, dorsal; C, left third pereopod, lateral.

Color in life. Body and appendages generally pinkish transparent. Rostrum transparent. Carapace generally transparent with anterolateral to hepatic regions of cephalothorax reddish and with red spots on posterior margin. First to sixth pleonal somites each with red transverse band posteriorly. Eyestalk red. Second and third maxillipeds almost red. Telson and uropods generally transparent but with lateral margins and carinae red.

Etymology. Specifically named after Prof. Susumu Ohtsuka of Hiroshima University, the project leader of TV *Toyoshio-maru* Research Cruise, for his great contributions to the phylogeny and systematics of Crustaceans.

Distribution. So far known from off Amami-oshima Island and Kerama Islands, southwestern Japan.

Ecological notes. *Richardina ohtsukai* n. sp. is collected from the gastric cavity of hexactinellid sponges.

Remarks. *Richardina ohtsukai* n. sp. appears unique within the genus in having the additional movable spine on the dorsal margins of the dactyli of the fourth and fifth pereopods. *R. ohtsukai* is most similar to the

Atlantic species *R. spinicineta* in the median row of spines on the posterior margin of the cervical groove and its numbers. Comparison with the type material of *R. spinicineta* has revealed that the new species is easily distinguished from *R. spinicineta* by the following characters: (1) lateral teeth on the rostrum are present in *R. ohtsukai*, whereas they are entirely absent in *R. spinicineta*; (2) the length ratio of cornea and eyestalk is 1: 0.7 in *R. ohtsukai*, whereas it is 1: 2.7 in *R. spinicineta*; (3) the eyestalk has relatively reduced armament in *R. ohtsukai*, but it is armed with many large spines in *R. spinicineta*; (4) the propodi and carpi of the fourth and fifth pereopods are subdivided into 8–15 and 10–12 articles, respectively, in *R. ohtsukai*, rather than into the 4 and 5 articles in *R. spinicineta* (cf. Kemp 1910; Forest & Holthuis 1997).

***Richardina parvioculata* n. sp.**

[new Japanese name: komanako-ryu-jin-ebi]

(Figs. 7–9)

Type material. HOLOTYPE: NSMT-Cr 20839, ovigerous female (cl 5.4 mm), off Tosa Bay, western Japan, 32°56.45N, 133°30.52E (KH02-3, leg. 1, St. TA-2), 3 m ORE B.T., 517 m, 11 Sep. 2002, coll. M. Mitsuhashi. ALLOTYPE: NSMT-Cr 20840, male (cl 5.1 mm), same data as holotype.

Description of holotype female. Body slender and compressed. Integument of carapace and pleon glabrous. Rostrum (Figure 7A, B) slender, directed forward, tip slightly upward, reaching proximal third of antennal scale, 0.30 of cl, narrowly triangular in dorsal view; dorsal margin armed with 8 teeth, all anterior to postorbital margin; ventral margin with 1 tooth subdistally; lateral margin unarmed.

Carapace (Figure 7A, B) with postrostral median ridge extending to gastric region; 1 (left) or 2 (right) postrostral submedian spines relatively small, straight, directed forward; postorbital region armed with 2 stout spines directed anteriorly; orbital margin concave, inferior orbital angle rounded; antennal spine small and acuminate, marginal; anterolateral margin rounded with several minute spines; cervical groove distinct, posterior margin armed with cincture of several spines, directed anteriorly, increasing in size gradually in lateral surface, but unarmed on posterodorsal part.

Sixth thoracic sternite (Figure 7C) with paired narrow lobes, each lateral margin unarmed, ventral surface concave. Seventh sternite with paired, broad semicircular lobes, each distolateral angle rounded, ventral surface concave, unarmed. Eighth sternite with paired triangular plates, each distolateral angle rounded, ventral surface concave, unarmed.

Pleonal somites not sculptured; ventral margins unarmed. First pleonal somite short, divided in two sections by distinct transverse carina; anterior section with pleuron unarmed laterally, posterior section with pleuron unarmed laterally, posteroventral margin unarmed. Second somite with anterior transverse carina ending at base of pleuron. Third somite longest, posterodorsal margin somewhat posteriorly produced; pleuron unarmed laterally. Sixth somite (Figure 7D) armed with 1 strong lateral spine on either side. Telson (Figure 7D) lanceolate, proximally narrowed between widest part and basal joint, tapering distally, 2.3 times longer than broad; dorsal surface with median groove flanked by two dorsolateral carinae each provided with row of 3 or 4, rather symmetrically situated dull, rudimentary spines, inner margin with 3 or 4 dull, rudimentary small spines; lateral margins convex subproximally, armed with small spine proximally and strong spine at midlength; posterior margin convex, armed with small posterior spine, posterolateral angle armed with small posterolateral spine.

Eye (Figure 7A, B) well developed, cornea hemispherical, red pigmented; eyestalk armed with 4 small spines along base of cornea, laterally with several small spines, 2.8 times as long as cornea. Antennular peduncle (Figure 7A, B) reaching midlength of antennal scale; first segment subequal to distal two segments combined, with longitudinal, distolateral row of setae; stylocerite acute, curved; second segment armed with 1 strong dorsolateral spine; third segment with rounded distal margin; flagella slender. Antenna (Figure 7A, B) with stout basicerite armed with moderately large spine at distolateral angle, and with a few additional spines on ventrolateral margin; antennal scale 3.3 times longer than broad, lateral margin nearly straight, armed with

4 teeth, dorsal surface with 2 distinct longitudinal carinae; carpocerite short, reaching level of first segment of antennular peduncle, armed with 1 spine on distolateral angle.

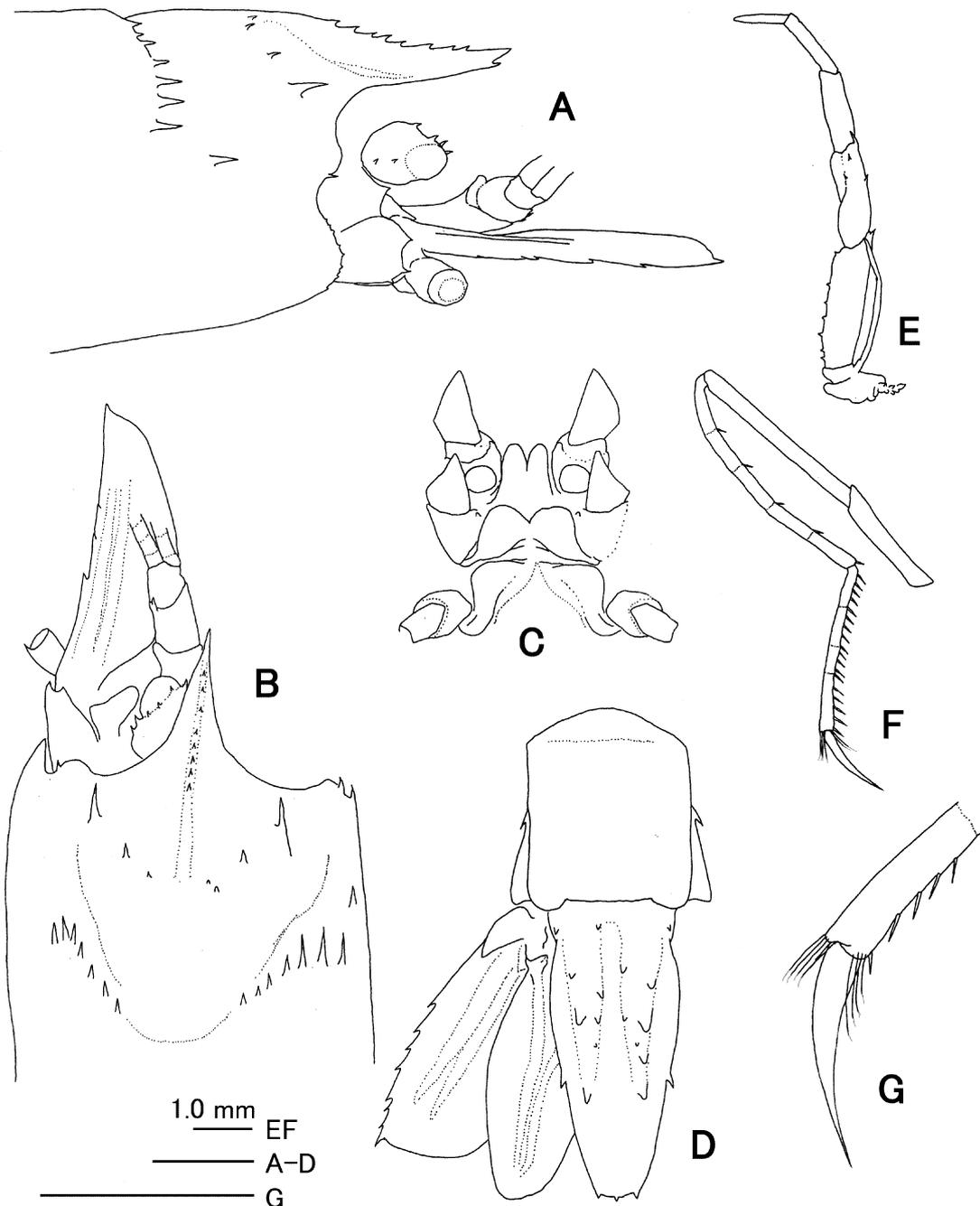


FIGURE 7. *Richardina parvioculata* n. sp., holotype female, (cl 5.4 mm), NSMT-Cr 20839. A, anterior part of carapace and eyes, lateral; B, anterior part of carapace and eyes, dorsal; C, sixth to eighth thoracic sternites, ventral; D, telson and uropod, dorsal; E, left third maxilliped, ventral; F, left fourth pereopod, lateral; G, same, dactylus, lateral. D, E, marginal setae omitted.

Mouth parts similar to those of *R. ohtsukai* n. sp. Third maxilliped (Figure 7E) with endopod slender, composed of 7 segments, reaching tip of antennal scale by lengths of dactylus and half of propodus; dactylus tapering distally, lateral margins of dactylus and propodus furnished with long setae, distomesial surface with shallow depression fringed with dense grooming setae; carpus unarmed; merus with distolateral and lateral rows of 2 stout spines; ischium compressed, armed with 1 dorsolateral spine and ventral row of several small spines, interspaced with pectines; basis short; coxa with short epipod; exopod with well-developed, unsegmented flagellum, distally with dense setae.

Branchial formula shown in Table 2.

First and second pereopods similar to those of *R. ohtsukai* **n. sp.** Third pereopod missing.

Fourth and fifth pereopods (Figure 7F, G) similar, very long and slender; fourth pereopod reaching tip of antennal scale by lengths of dactylus, propodus and carpus; dactyli (Figure 7G) compressed laterally, about 6 times longer than wide, uniunguiculate; propodi about twice as long as dactyli, subdivided into 4 articles, ventral margin armed with several small movable spines; carpi 1.5 times as long as propodi, subdivided into 5–6 articles, ventral surfaces armed with small spine on ventrodistal angle of each article, meri 0.8 of carpal length; ischia entire, 0.6 of meral length.

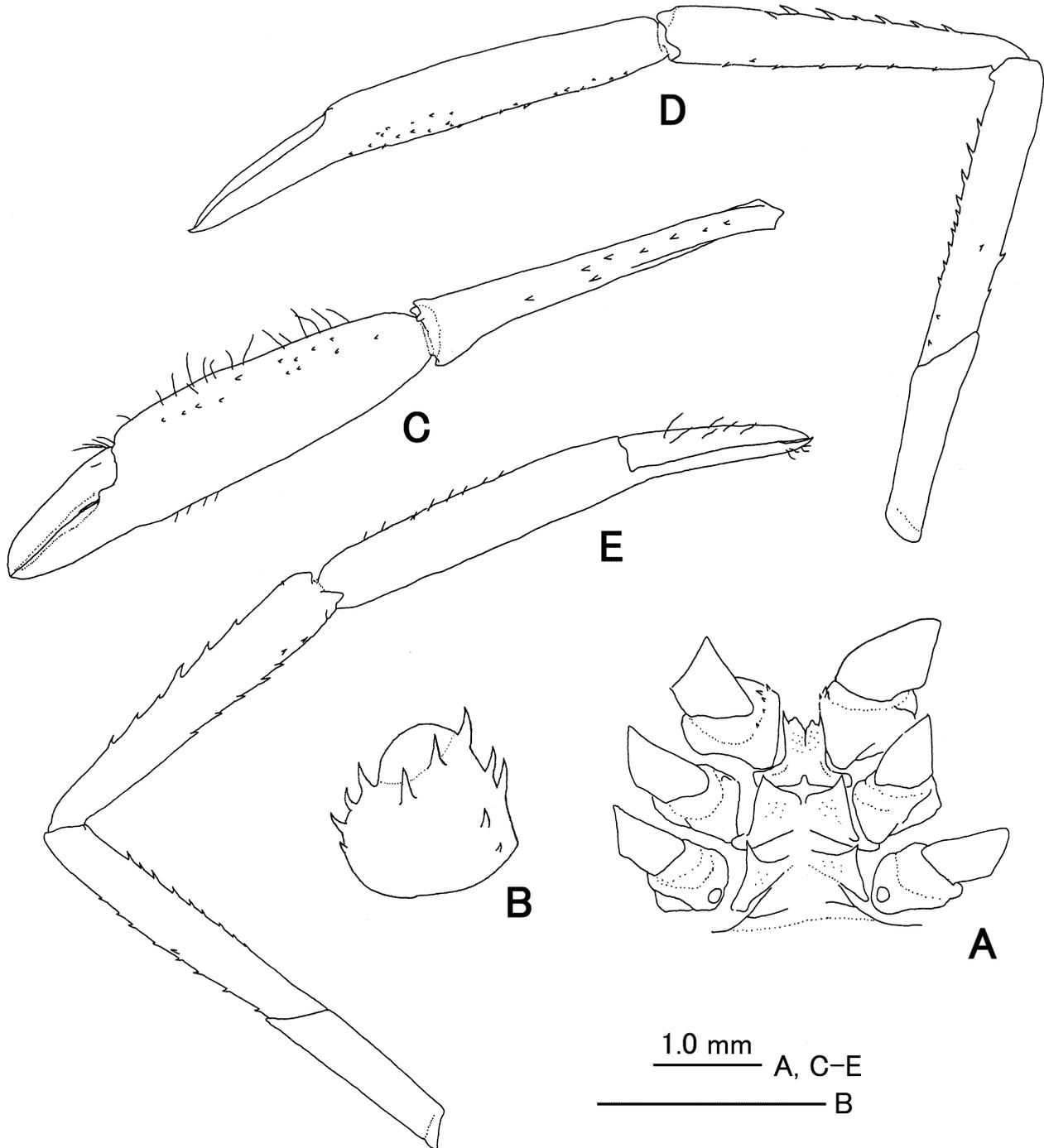


FIGURE 8. *Richardina parvioculata* **n. sp.**, allotype male, (cl 5.1 mm), NSMT- Cr 20840. A, sixth to eighth thoracic sternites, ventral; B, left eye, dorsal; C, left third pereopod, dorsal; D, same, lateral; E, same, mesial.

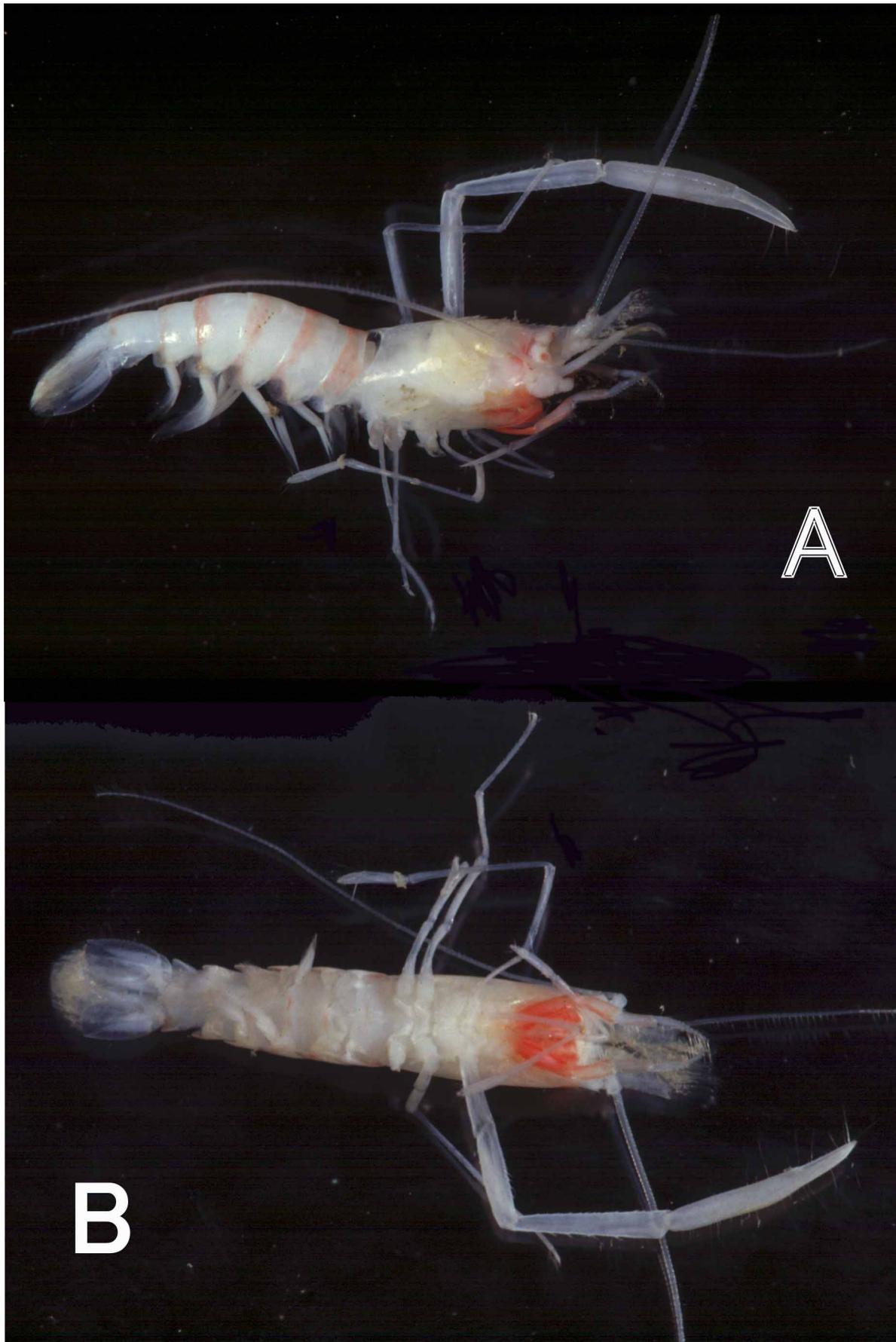


FIGURE 9. Fresh specimen. *Richardina parvioculata* n. sp., allotype male (cl 5.1 mm), NSMT-Cr 20840. A, entire specimen, lateral view; B, same, ventral view.

Pleopods without any appendices. First pleopods uniramous, shortest. Second to fifth pleopods biramous, with basipodite shorter than exopodite, but as long as endopodite, mesial margin unarmed. Third to fifth pleopods generally similar, decreasing in size posteriorly, unarmed.

Uropod (Figure 7D) with protopodite stout, lateral margin terminating in acute process; exopod broad, falling slightly short of posterior margin of endopod, lateral margin nearly straight, terminating in acute tooth, with row of 8 (left) or 7 (right) acute teeth, dorsal surface with 2 smooth longitudinal carinae, unarmed; endopod tapering distally, slightly overreaching posterior margin of telson, lateral margin unarmed, dorsal surface with 2 smooth longitudinal carinae, unarmed.

Eggs very few, diameter 2.0 mm (example: ovigerous female, cl 5.4 mm, NSMT-Cr 20839).

Male allotype characteristics. Rostrum as long as that of female, 0.31 of cl; dorsal margin with 6 teeth, proximal 2 teeth posterior to orbital margin; ventral and lateral margins unarmed. Sixth thoracic sternite (Figure 8A) with slender, bifurcate lobes, lateral angle terminating in acute spine, mesial angle denticulate; seventh sternite with relatively broad triangular lobes directed anterolaterally, each anterolateral angle produced; eighth sternite with triangular lobes directed anterolaterally, each anterolateral angle terminating in acute spine. Pleura of first to sixth pleonal somites armed with some teeth anteroventrally and/or posteroventrally. Eye (Figure 8B) well developed, cornea hemispherical, red pigmented, 0.3 times as long as stalk; eyestalk armed with 4 strong spines along base of cornea, mesial and lateral margins with several strong spines. Third pereopod (Figure 8C, D, E) with palm 2.9 times as long as wide, dorsomesial surface armed with a few rows of several spines of various sizes or tubercles, ventrolateral surface armed with a few rows of several small spines; carpus slightly widened distally, about 5.5 times longer than wide, 0.8 of chela length, dorsal surface armed with two rows of 2–6 spines, ventral margin armed with row of 7 smaller spines; merus 0.9 of carpal length, dorsal margin armed with row of 2 spines proximally, lateral surface with a few tiny spines, ventral margin armed with row of 9 spines; ischium 0.7 of meral length, unarmed. Second to fifth pleopods armed with some teeth on ventral margins of basipodites.

Color in life (Figure 9). Just as in the figure provided by Lo Bianco (1903), the color pattern of this species is quite similar to *R. fredericii*. Body and appendages generally pinkish transparent. Rostrum transparent. Carapace pinkish transparent with red mark on anterolateral region, and red spot on postorbital region. First to sixth pleonal somites each with red transverse band posteriorly. Eye cornea red, stalk pinkish transparent. Second maxilliped almost red. Third maxilliped with carpus, merus and ischium red. Telson and uropods generally transparent, but lateral margins and carinae red.

Etymology. The specific name is derived from the Latin, parvus (=small) and oculus (=eyed), in reference to the relatively small eye of this new species.

Distribution. So far known only from off Tosa Bay, western Japan.

Ecological notes. The present specimens were collected from the gastric cavity of hexactinellid sponges.

Remarks. Although the female specimen lacks the third pereopods, the assignment of the new species to *Richardina* is justified by the presence of uniunguiculate dactyli on the fourth and fifth pereopods and the lack of any spines on pleonal somites. The new species is described only from a single damaged female and a single male specimen. Assessment of diagnostic characteristics of this species will be made more precisely when more specimens become available. *Richardina parvioculata* n. sp. appears unique within the genus in lacking the median row of spines on the posterior margin of the cervical groove, having the large eyestalk and contrasting small-sized cornea, as well as the blunt spines on the dorsolateral carinae of the telson. The new species is most similar to the Mediterranean species *R. fredericii*, in the general armature of the carapace and pleonal somites, the number of cinctures of spines on the posterior margin of the cervical groove, and the number of articles of the propodi and carpi of the fourth and fifth pereopods. But the new species is easily distinguished from *R. fredericii* by the following characteristics: (1) the lateral teeth on the rostrum are absent in *R. parvioculata*, whereas there are 1–3 in *R. fredericii*; (2) the length ratio of cornea and eyestalk is 1: 2.8 in *R. parvioculata*, against 1: 1.9 in *R. fredericii*; (3) the length ratio of dactyli, propodi, carpi, meri, ischia of fourth and fifth pereopods is 1: 2: 3: 2.3: 1.5 in *R. parvioculata*, against the relatively longer 1: 4: 6.6: 5.2: 2.5 in *R. fredericii* (cf. Lo Bianco 1903; MacPherson 1978).

Discussion

In the present study, *Richardina ohtsukai* n. sp. appears unique within the genus in having the additional movable spine on the dorsal margins of the dactyli of the fourth and fifth pereopods. Such shape in the ambulatory legs is unique among stenopodid shrimps. The shape and armature of the dactyli of the ambulatory pereopods have been considered as a constant characteristic in stenopodids to provide diagnostic characteristics of generic significance (e.g., Holthuis 1993). At present, four genera are recognized in the Stenopodidae: *Juxtastenopus* Goy, 2009, *Odontozona* Holthuis, 1946, *Richardina* and *Stenopus* Latreille, 1819. *Odontozona* and *Stenopus* have biunguiculate dactyli in the fourth and fifth pereopods, whereas those of *Juxtastenopus* and *Richardina* are uniunguiculate. However, variations in the number of ungues are found in the newly described species of *Stenopus*, sometimes even among the pereopods of the same specimen (Saito *et al.* 2009). In this respect, it may well be worth pointing out that *Odontozona edwardsi* (Bouvier, 1908), *O. foresti* Hendrickx, 2002, and *O. spongicola* (Alcock & Anderson, 1899) appear closer to *Richardina* rather than *Odontozona*. Those species have the biunguiculate dactyli in the fourth and fifth pereopods and are assigned to *Odontozona*, but they are very similar to the species of *Richardina* in almost all of the diagnostic characteristics. In this phase, DNA analyses are essential to conclude the systematic positions of these species. With more material of this family found in recent years, many key characteristics previously used have become inapplicable for proper generic diagnosis.

The present material enables a rough description of the geographical distribution of the species of *Richardina* (Table 1). All of the species are distributed in tropical to warm temperate waters, not penetrating cold waters. The northern limit is off southwest Ireland, in the Atlantic and the southernmost record is southwest of the Dry Tortugas, Florida. Most species of the genus are restricted in their distributional range. The most widely distributed species is *R. spinicincta*, recorded from the North Atlantic to the Gulf of Mexico. On the other hand, *R. fredericii* is limited to the Mediterranean Sea and *R. ohtsukai* is so far known only from the Nansei Islands, western Pacific. The geographical range of *R. parvioculata* remains unclear, because this species is represented only by the type specimens from a single locality.

Kemp (1910) reported that *R. spinicincta* had very few, large-sized eggs hatching as postlarva or later stage since the late embryo had all the appendages except uropods and the telson was deeply cleft. The mode of development contrasts with that of shallow water stenopodid shrimps, of the genus *Stenopus*, which has planktonic larvae dispersing far away (Gurney 1942). Although little distribution data are available, it is quite intriguing that the *Richardina* distributes widely from Atlantic, Mediterranean to Pacific, yet each of their species is endemic to a specific region with no overlap in geographical ranges. It may be considered that the *Richardina* is a very old group, which originated in the tropical Tethys and distributed widely to all oceans. Although the genus is still not known from the Indian Ocean, an as yet undescribed species of *Richardina* could be discovered.

Bathymetric ranges of the species are summarized in Table 1. All species are included in the depth range of 400–1230 m. *Richardina fredericii* and *R. spinicincta* extend to depths greater than 1000 m. The latter represents the deepest record among the *Richardina* species. They also have rather wide bathymetric ranges, the former ranging from 400 to 1110 m, and the latter from 455 to 1230 m, but this may merely reflect the relatively large sample size of the two species. The precise range of *R. parvioculata* remains unknown, as the species is represented only by a few type specimens. Among the Stenopodidae, the *Richardina* is the deeper living genus, being collected from the continental slope or from gastric cavities of sponges, where dredge or trawl are difficult to operate. To date, original descriptions of the previously known species of *Richardina* are based only on insufficient descriptions and a few subsequent reports, more or less damaged, so that the morphological variations of species are poorly understood. *Richardina ohtsukai* and *R. parvioculata* are confirmed in association with a species of hexactinellid sponge, whereas there are no records of *R. spinicincta* and *R. fredericii* in association with sponges. If the specimens are made available in good condition using newly developed instruments and technique, both of which are advantageous and essential for studying animal diversity in deep-sea, their habitat can be observed directly and specimens of deep-sea animals can be collected even more effectively.

Acknowledgements

We gratefully acknowledge the assistance of the Captains, crew and staff of the RV *Hakuho-maru* and TV *Toyoshio-maru* and Prof. S. Ohtsuka of Hiroshima University. We are indebted to Drs. Alain Crosnier and R. Cleve of the Muséum National d'Histoire Naturelle, Paris for allowing us to study the rich and very interesting collections obtained during the French expeditions to various tropical regions of the Pacific and Indian Oceans. We would like to thank Drs. J. C. Walker, U.S. National Museum of Natural History, for the loan of comparative material, T. Komai of Natural History Museum and Institute, Chiba, H. Karasawa of Mizunami Fossil Museum, M. Mitsuhashi of Osaka Institute of Technology and M. Takeda of Teikyo Heisei University for valuable comments for improvements. Cordial thanks are extended to Drs. J. W. Goy of Harding University and J. Okuno of Coastal Branch of Natural History Museum and Institute, Chiba for critical reviewing the manuscript. This study was partially supported by research grants from the Research Institute of Marine Invertebrates Foundation to the first author. This study was also supported by a grant by the Narishige Zoological Science Award to the first author. We also thank the staff of the aquarium for technical advice and encouragement.

References

- Abelló, P., Carbonell, A. & Torres, P. (2002) Biogeography of epibenthic crustaceans on the shelf and upper slope off the Iberian Peninsula Mediterranean coasts: implications for the establishment of natural management areas. *Scientina Marina*, 66(Supplement 2), 183–198.
- Alcock, A. & Anderson, A.R. (1899) Natural history notes from H. M. Royal Indian Marine Survey Ship *Investigator*, commander T.H. Heming, R.N. Series III, No. 2. An account of the deep-sea Crustacea dredged during the surveying-season of 1897–98. *Annals and Magazine of Natural History*, series 7, 3, 1–27, 278–292.
- Cartes, J.E. (1993) Deep-sea decapod fauna of the western Mediterranean: Bathymetric distribution and biogeographic aspects. *Crustaceana* 65(1), 29–40.
- D'Udekem D'Acoz, C. (1999) *Inventaire et distribution des crustacés décapodes de l'Atlantique nord-oriental, de la Méditerranée et des eaux continentales adjacentes au nord de 25°N*. Collection Patrimoines Naturels, Paris, 40, 1–383.
- Forest, J. & Holthuis, L.B. (1997) *Milne-Edwards, A., 1883: Recueil de figures de Crustacés nouveaux ou peu connus. Nouvelle édition en fac-simile avec des commentaires et annotations = new facimile edition with comments and annotations / par / by Jacques Forest et L.B. Holthuis*. Backhuys Publishers, Leiden, 1–128.
- Goy, J.W. (1982) Studies on West Indian Stenopodidae, 2. Occurrence of *Richardina spinicincta* A. Milne-Edwards, 1881 (Crustacea: Decapoda: Stenopodidea) off the Dry Tortugas. *Bulletin of Marine Science*, 32(1), 344–347.
- Goy, J.W. (2009) A review of the genus *Engystenopus* (Crustacea: Decapoda: Stenopodidea): *Juxtastenopus*, gen. nov., a new combination for *E. spinulatus* Holthuis, 1946, and transfer of *E. palmipes* Alcock and Anderson, 1894 to the family Spongicolidae Schram, 1986. *Zootaxa* (in press).
- Gurney, R. (1942) *Larvae of Decapod Crustacea*. Ray Society, London, 129, 306 pp.
- Hendrickx, M.E. (2002) A new deep water species of *Odontozona* Holthuis (Decapoda, Stenopodidae) from the southern Gulf of California, Mexico. *Crustaceana*, 75(3–4), 405–412.
- Holthuis, L.B. (1946) The Decapoda Macrura of the Snellius Expedition. 1. The Stenopodidae, Nephropsidae, Scyllaridae and Palinuridae. Biological results of the Snellius Expedition, XIV. *Temminckia*, 7, 1–178, pls. 1–11.
- Holthuis, L.B. (1993) *The Recent Genera of the Caridean and Stenopodidean Shrimps (Crustacea, Decapoda): with an Appendix of the Order Amphionidacea*. Nationaal Natuurhistorisch Museum, Leiden, 328 pp.
- Kemp, S. (1910) The Decapoda Natantia of the Coasts of Ireland. *Scientific Investigation Fisheries Board for Ireland 1908*, (1), 1–190.
- Kocataş, A. & Katağan, T. (2003) Decapod crustacean fauna of the Turkish seas. *Zoology in the Middle East*, 29, 63–74
- Lo Bianco, S. (1903) Le pesche abissali eseguite da F. A. Krupp col Yacht Puritan nelle adiacenze di Capri ed in altre località del Mediterraneo. *Mitteilungen aus der Zoologischen Station zu Neapel*, 16, 109–279.
- MacPherson, E. (1978) On the occurrence of *Richardina fredericii* Lo Bianco, 1903 (Decapoda; Stenopodidae) in Spanish waters. *Crustaceana*, 35(1), 107–109.
- Milne-Edwards, A. (1881) Compte rendu sommaire d'une exploration zoologique faite dans l'Atlantique à bord du navire le Travailleur. *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences Paris*, 93, 931–940.
- Morales-Nin, B., Maynou, F., Cartes, J., Moranta, J., Massutí, E., Company, J., Rotllant, G. Bozzano, A. & Stefanescu, C.

TERMS OF USE

This pdf is provided by Magnolia Press for private/research use.

Commercial sale or deposition in a public library or website is prohibited.

- (2003) Size influence in zonation patterns in fishes and crustaceans from deep-water communities of the western Mediterranean. *Journal of Northwest Atlantic Fishery Science*, 31, 413–430.
- Saito, T., Okuno, J., & Chan, T.-Y. (2009) A new species of *Stenopus* from the Indo-west Pacific, with a redefinition of the genus (Crustacea: Decapoda: Stenopodidae). *Raffles Bulletin of Zoology* (in press).
- Wicksten, M.K. & Packard, J.M. (2005) A qualitative zoogeographic analysis of decapod crustaceans of the continental slopes and abyssal plain of the Gulf of Mexico. *Deep-Sea Research I*, 52, 1745–1765.
- Zariquiey Alvarez, R. (1968) *Crustáceos Decápodos Ibéricos*. Investigación Pesquera, Barcelona, 32, 1–150.