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First Molecularly Confirmed Conspecific Male and Female Pair in Konariinae (Crustacea: Tanaidacea), with the Description of a New Species

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We describe *Parakonarus kajii* sp. nov. from near Iriomote Island, Ryukyu Islands, southwestern Japan. This is the first record of *Parakonarus* from the North Pacific. As members in this genus show great sexual dimorphism, we checked our male and female specimens for conspecificity by using partial sequences of the cytochrome *c* oxidase subunit I (COI) gene. The two individuals differed by two nucleotide substitutions in 661 nt (0.3% K2P distance), indicating they are the same species. This species closely resembles *P. kopure* reported from New Zealand, but differs in having the ventral process on the chelipedal carpus longer than wide, the inner comb-row on the chelipedal propodus composed of 16 setae, and the dactylus and unguis of pereopods 4–6 fused in the male; and the carpi of pereopods 2 and 3 without a ventrodistal spiniform seta, the propodal palm of the cheliped with two inner simple setae at the insertion of the dactylus, and article 2 of the maxillipedal palp with one mid-outer and one outer distal simple setae in the female. On the inner surface of the chelipeds in male *P. kajii*, we observed an elongate plate-like structure that could be a reduced ischium.

Key Words: Peracarida, Paratanaoidea, Leptocheliidae, *Parakonarus*, sexual dimorphism, subchelate, DNA barcoding, North Pacific.

Introduction

Tanaidacean crustaceans generally show sexual dimorphism. In the family Tanaididae, a group with moderate sexual differences, for example, males and females differ in the length/size/shape of the antennules, antennae, carapace, and cheliped but are otherwise similar (Sieg 1980), and thus there is little difficulty in recognizing conspecific male-female pairs. In groups with large sexual dimorphism, however, it is quite difficult to recognize conspecific pairs from their morphology. The most extreme case is that of species having swimming (or natatory) males (*e.g.*, figs 3A, 9, 10, 13 in Błażewicz-Paszkowycz *et al*. 2014; fig. 1 in Kakui 2016). In these cases, it is nearly impossible to recognize which male is conspecific with a particular female based on morphology alone, and molecular confirmation is necessary. Recently, Błażewicz-Paszkowycz *et al*. (2014) first utilized cytochrome *c* oxidase subunit I (COI) barcode sequences in the identification of swimming males and successfully identified some conspecific male-female pairs in several paratanaoid families.

Konariinae, one of three subfamilies in the family Leptocheliidae, comprises seven genera and 17 species (Anderson 2016; Guţu 2016; Guţu and Bird 2017). Konariine species have been reported from shallow waters (<75 m in depth) in the western Atlantic, Indian, and western Pacific Oceans (Fig. 1) (G. O. Sars 1882; Dollfus 1898; Stebbing 1905; Smith 1906; Lang 1973; Băcescu 1977; Riggio 1996; Bamber 2005, 2006, 2008, 2013; Bird 2011; Araújo-Silva and Larsen 2012; Błażewicz-Paszkowycz and Bamber 2012; Edgar 2012; Morales-Núñez *et al*. 2013; Bamber and Marshall 2015; Guţu 2016). Among the seven genera, *Parakonarus* is the most species rich to date, with eight members: *P. corrigendum* Bamber, 2013 (=a male of Błażewicz-Paszkowycz and Bamber's [2012] *Pseudoleptochelia occiporta*; *cf*. Bamber [2013]) from southeastern Australia; *P. fairgo* (Bamber, 2005) from western Australia; *P. juliae* (Morales-Núñez *et al*., 2013) from Puerto Rico, Caribbean; *P. kopure* Bird, 2011 (type species for the genus) from New Zealand; *P. oregmus* Bamber, 2013 from eastern Australia; *P. provincialis* (Dollfus, 1898) from southeastern France, Mediterranean; *P. robertsoni* Edgar, 2012 from western Australia; and *P. sozo* Bamber, 2013 (=males and "small" females of Lang's [1973] *Pseudoleptochelia mortenseni*; *cf.* Bamber [2013]) from Tobago, Caribbean.

Males in *Parakonarus* differ greatly from females in having large eyes, antennules bearing a multiarticulate "flagellum" with numerous aesthetascs, reduced mouthparts, subchelate chelipeds with a ventral projection on the carpus,

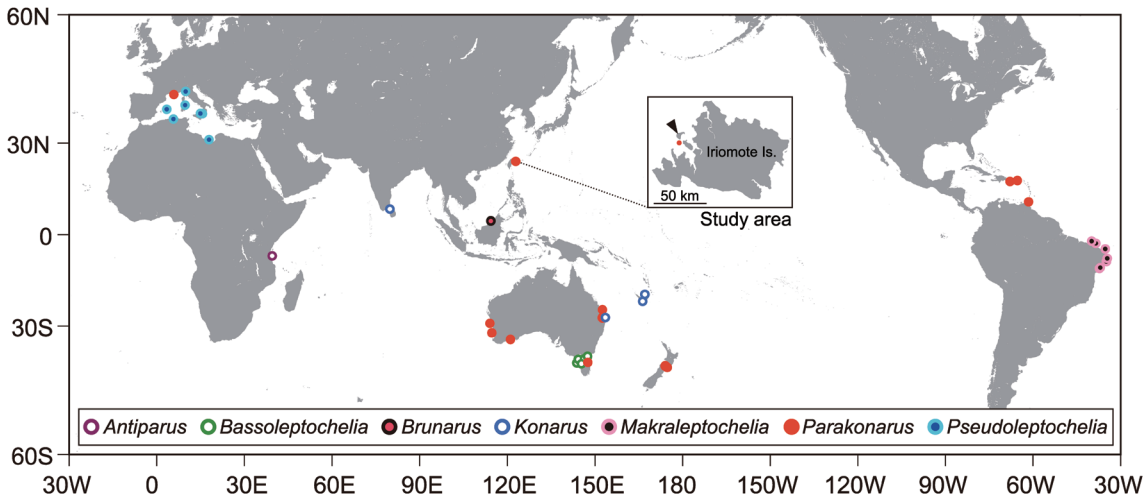

Fig. 1. Map showing the global distribution of Konariinae. Arrowhead, Sotopanari Island. Based on data from G. O. Sars (1882), Dollfus (1898), Stebbing (1905), Smith (1906), Lang (1973), Băcescu (1977), Riggio (1996), Bamber (2005, 2006, 2008, 2013), Bird (2011), Araújo-Silva and Larsen (2012), Błażewicz-Paszkowycz and Bamber (2012), Edgar (2012), Morales-Núñez *et al.* (2013), Bamber and Marshall (2015), Guţu (2016), and this study. The map and plots (except the insert) were generated with GMT5 software (Wessel *et al.* 2013). The raw data for the plots are available in the figshare repository (Kakui 2018).

and pereopods with setal arrangements different from those in females. On the basis of morphology, it is thus difficult to pair conspecific males and females in *Parakonarus*, and as in cases of species with swimming males, a DNA barcoding approach is necessary.

During a 2016 survey of the crustacean fauna in shallow waters around Iriomote Island, Ryukyu Islands, southwestern Japan, one male and one female *Parakonarus* individuals were collected. This is the first record of *Parakonarus* from the North Pacific. On the basis of morphology, they both turned out to be undescribed, but as with congeners, their conspecificity was uncertain due to their marked morphological differences. In this study, we used COI sequences to confirm their conspecificity and described this species as new.

Materials and Methods

Two konariine tanaidacean individuals were collected off the south coast of Sotopanari Island, a small island northwest of Iriomote Island (Fig. 1), on August 10, 2016. A cluster of sponges on a rock, collected by a scuba diving at a depth of 40 m, was rinsed in tap water to detach epibionts, and the effluent was sieved through a 0.3 mm-mesh plankton net. Tanaidaceans were picked from the debris with forceps, and fixed and preserved in 99% ethanol. The methods used for dissection, preparation of slides, light microscopy, and drawing were as described by Kakui and Angsupanich (2012).

Orientation and terminology here follow Larsen (2003), except that the term "plumose sensory seta" (PSS; Bird 2011) was used instead of "broom seta"; the setal terms "step-tipped plumose seta" (Kakui *et al.* 2010) and "tubercle-mounted seta" (Bamber 2013) were also used. Body length (BL) was measured from the base of the antennules to the tip of the pleotelson, and body width at the widest portion of the cephalothorax (CW, cephalothorax width). Measurements were made axially with ImageJ (Rasband 2018) on digital illustrations: dorsally on the body, antennules, antennae, and uropods; laterally on the pereopods and pleopods. Length and width of congeners were measured from original illustrations if those were not provided in the description.

Total DNA was extracted from the right cheliped of the holotype and the left cheliped of the allotype by using a NucleoSpin Tissue XS kit (TaKaRa Bio, Japan); after extraction, the exoskeletons were recovered and each mounted on a slide. Part of the COI gene was amplified by PCR with the primers LCO-1490 and HCO-2198 (Folmer *et al.* 1994). PCR amplification conditions with TaKaRa Ex Taq DNA polymerase (TaKaRa Bio) were 94°C for 1 min; 35 cycles of 98°C for 10 s, 42°C for 30 min, and 72°C for 50 sec; and 72°C for 2 min. Methods for sequencing and sequence assembly were as described by Tomioka *et al.* (2016). The sequences obtained were submitted to the International Nucleotide Sequence Database (INSD) through the DNA Data Bank of Japan (DDBJ). The type specimens were deposited in the crustacean collection of the National Museum of Nature and Science (NSMT), Tsukuba, Japan. The suffixes in the Japanese names, *viz.*, "-ka", "-aka", and "-zoku", represent the taxonomic ranks family, subfamily, and genus, respectively, in the Japanese language.

Results

Comparison of partial COI sequences

Partial COI sequences (661 nt, encoding 220 amino acids) were determined from the holotype (male) and allotype (female) specimens. Their INSD accession numbers are LC473040 and LC473041, respectively. The sequence in

the INSD most similar to our COI sequences, as determined by BLAST searches (Altschul *et al*. 1990), was from the tanaidacean *Pseudoleptochelia* sp. DD-2010 (Leptocheliidae; Drumm 2010) (identity score 81%, query cover 80%). The two sequences we obtained differ by only two synonymous nucleotide substitutions, and both the uncorrected *p*-distance and Kimura's 2 parameter (K2P; Kimura 1980) distance between them were 0.3%. Drumm and Kreiser (2012), the only population genetic study focusing on tanaidaceans to date, reported the maximum uncorrected *p*-distance among COI sequences in a population of the kalliapseudid *Mesokalliapseudes macsweenyi* (Drumm, 2003) (representing a different suborder than *Parakonarus* species) to be 3%. A recent review study (Raupach *et al*. 2015) reported mean intraspecific K2P distances for 179 marine crustacean species (not including any tanaidaceans) from the North Sea and adjacent regions, and the average of the mean distances was 0.48% (*cf*. table S1 in Raupach *et al*. 2015; the range was 0–6.9%). While there is no information on intra/interspecific COI variation in *Parakonarus* species, the distance we obtained was lower than maximum intraspecific distance in *M. macsweenyi* and the above average intraspecific distance in crustaceans, and we concluded that our two specimens are conspecific.

Family **Leptocheliidae** Lang, 1973
[Japanese name: Hosotsume-tanaisu-ka]
Subfamily **Konariinae** Bamber, 2013
[New Japanese name: Kamakiri-tanaisu-aka]
Genus ***Parakonarus*** Bird, 2011
[New Japanese name: Haridashi-Kamakiri-tanaisu-zoku]
Parakonarus kajii sp. nov.
[New Japanese name: Haridashi-Kamakiri-tanaisu]
(Figs 2–7)

Diagnosis. Male: outer ventral digitiform process on chelipedal carpus long, 1.50 times as long as wide, with one ventro-subproximal, one outer, and one inner simple setae in basal half of process; chelipedal dactylus with ventroproximal triangular process; dactylus and unguis of pereopods 4–6 fused to claw. Female: all pereonites wider than long; antennule 0.59 times as long as cephalothorax; chelipedal merus with six ventral simple setae; dactylus and unguis of pereopods 4–6 fused to claw; propodal palm of cheliped with two inner simple setae at insertion of dactylus.

Etymology. This species-group name is a noun in genitive and named for Tomonari Kaji, a researcher in the evolutionary and functional morphology of arthropods and a friend of the first author.

Material Examined. Holotype: male, NSMT-Cr 26209 (BL 1.88 mm, CW 0.32 mm), dissected, 6 slides and 1 vial; INSD accession number LC473040; off south coast of Sotopanari Island, Ryukyu Islands, southwestern Japan, 40 m depth, among cluster of sponges, 10.viii.2016, collected by D. Uyeno. Allotype: female without developing/developed

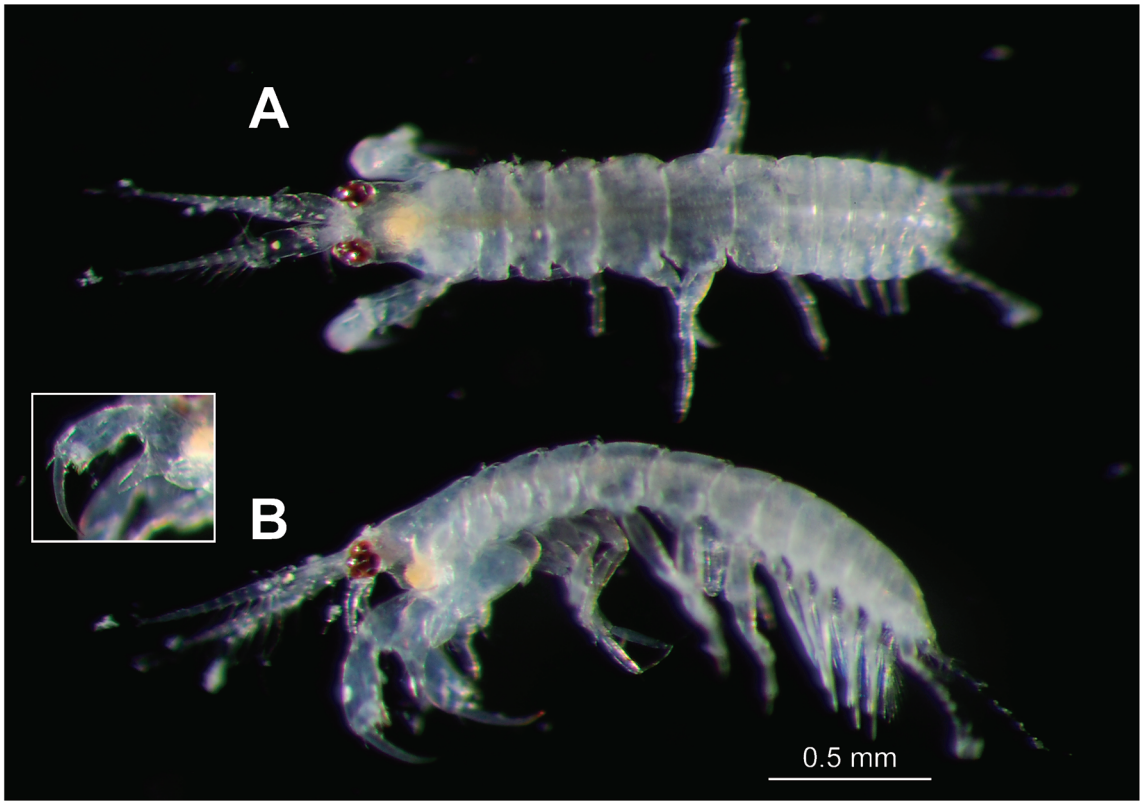

Fig. 2. Living male *Parakonarus kajii* sp. nov. (holotype), dorsal (A) and left (B) views. Insert shows outer view of distal half of left cheliped.

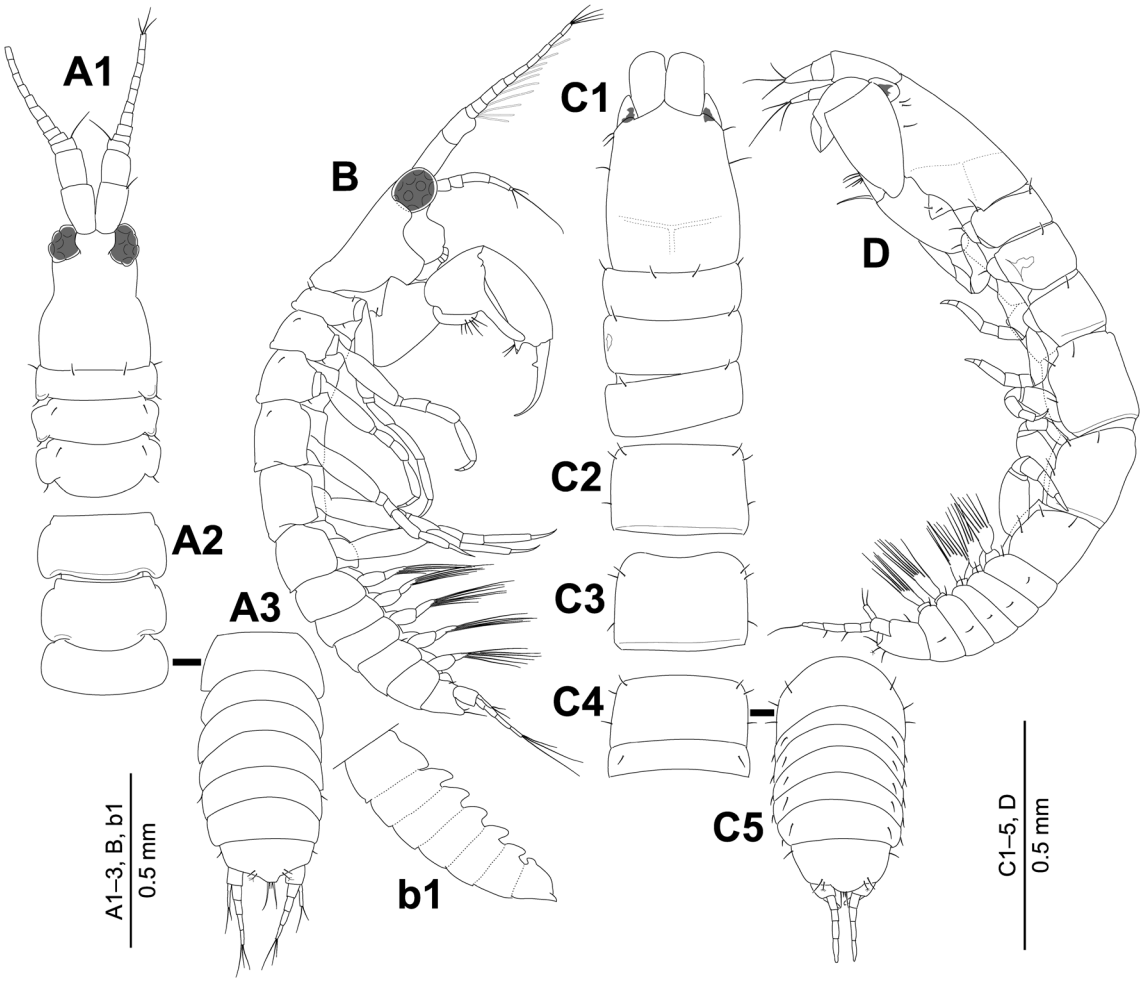

Fig. 3. *Parakonarus kajii* sp. nov. A, B, holotype, male; C, D, allotype, female. A1–3, body, dorsal views from different angles (at the front of carapace, pereonite 4, and pleotelson, respectively); B, body, right view; b1, ventral keel on pleon, right view; C1–5, body, dorsal views from different angles (at the front of carapace, pereonites 4, 5, 6, and pleotelson, respectively); D, body, left view. Solid lines link same segment.

oostegites, NSMT-Cr 26210 (BL 1.66 mm, CW 0.29 mm), dissected, 9 slides and 1 vial; INSD accession number LC473041; same collection data as for holotype.

Description of male. Based on holotype (NSMT-Cr 26209).

Body (Figs 2, 3A1–3, B, b1) slightly dorsoventrally flattened, 5.82 times as long as CW, translucent when alive (Fig. 2). Cephalothorax 0.22 times as long as BL, 1.27 times as long as wide, pear-shaped in dorsal view, naked; eyes well developed, dark brown when alive (Fig. 2). Pereonites 1–6, with length ratio of 1.00 : 1.49 : 1.89 : 2.25 : 2.33 : 2.09; all wider than long, with posterior lateral expansion; pereonite 1 with pair of dorsal setae and pair of lateral setae in anterior region, and pair of lateral setae in posterior region; pereonites 2 and 3 each with pair of anterior dorsolateral setae and pair of posterior lateral setae; pereonites 4–6 naked. Pleon 0.32 times as long as BL. Pleonites as wide as pereonite 6; all wider than long, similar in shape, with ventral keel (Fig. 3b1); pleonite 4 with pair of lateral setae. Pleotelson 0.43 times as long as wide, narrower than pleonite 5, pentangular in dorsal view, with pair of lateral setae, pair of posterior lateral setae, two pairs of posterior setae, and pair of posterior lateral PSS.

Antennules (Fig. 4A, a1, a2) with 13 articles, 1.59 times as long as cephalothorax; articles 1–13 with length ratio of 1.00 : 0.72 : 0.15 : 0.26 : 0.28 : 0.31 : 0.27 : 0.31 : 0.33 : 0.31 : 0.35 : 0.29 : 0.08. Article 1 with one outer subdistal and one inner subdistal simple setae and three outer subdistal PSS. Article 2 with outer subdistal simple seta and three outer subdistal PSS. Article 3 with inner distal simple seta. Article 4 with three ventral rows of aesthetascs (Fig. 4a1). Articles 5–12 each with ventral row of aesthetascs. Article 13 with six simple setae, two PSS, and aesthetasc (Fig. 4a2). Antenna (Fig. 4B) with six articles, 0.39 times as long as antennule; articles 1–6 with length ratio of 1.00 : 1.65 : 1.00 : 2.99 : 2.26 : 0.28. Article 1 naked. Article 2 with one dorsodistal and one ventrodistal simple setae. Article 3 with dorsodistal simple seta. Article 4 with three subdistal simple setae and several PSS. Article 5 with two distal simple setae. Article 6 with six distal simple setae (two longest setae slightly shorter than antenna length).

Maxillipeds (Fig. 4C) with basis bearing three ventrodistal simple setae. Palp with four articles, naked.

Chelipeds (Fig. 4D, d1) subchelate, with triangular articulation with cephalothorax via sclerite; sclerite with simple seta (Fig. 3B). Basis longer than wide, with free pos-

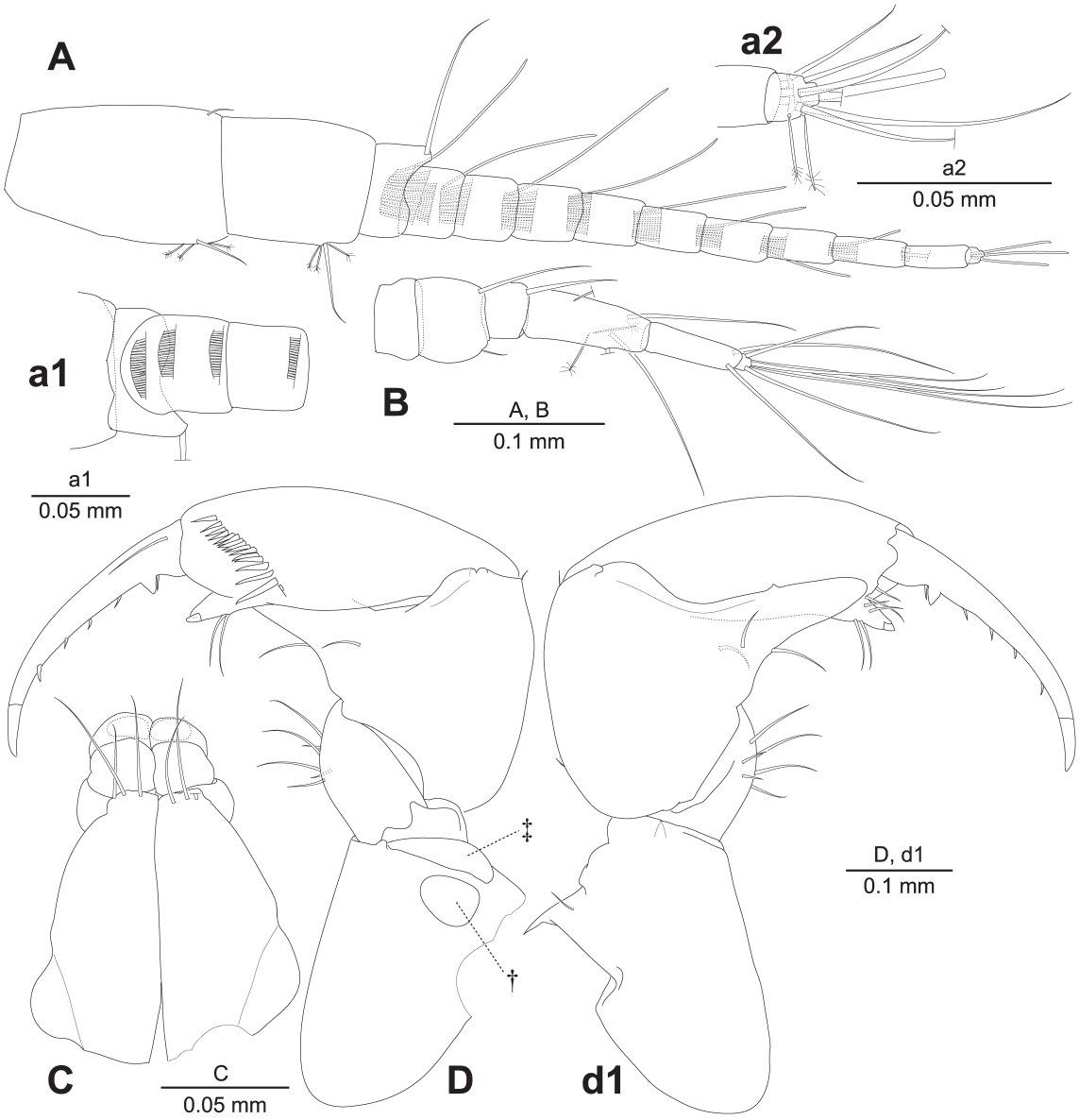

Fig. 4. *Parakonarus kajii* sp. nov., holotype, male. A, right antennule, dorsal view; a1, same, article 2 (distal portion) and articles 3–5, ventral view; a2, same, article 12 (distal portion) and article 13, dorsal view; B, right antenna, outer view; C, maxillipeds, ventral view; D, right cheliped, inner view; d1, same, outer view. †, inner oval plate-like structure; ‡, inner elongate plate-like structure.

terior portion and outer dorsal simple seta; inner side with oval plate-like structure (Fig. 4D: †) and elongate plate-like structure (Fig. 4D: ‡). Merus with six ventral simple setae. Carpus with one dorsoproximal and one dorsodistal simple setae and outer ventral digitiform process; digitiform process 1.50 times as long as wide, with one ventrosubproximal, one outer, and one inner simple setae in basal half of process. Propodus more than twice as long as wide. Propodal palm with simple seta at insertion of dactylus, and inner comb-row of 16 setae; comb-row almost perpendicular to dorsal margin of propodal palm. Fixed finger short, with two ventral and three dorsal simple setae, and cone-shaped claw. Dactylus-unguis far longer than fixed finger, and almost as long as propodal palm; dactylus with inner proximal simple seta, five ventral spiniform setae, and ventroproximal triangular process; unguis conic, 0.22 times as long as dactylus.

Pereopods 1–6 cylindrical, with length ratio of 1.00 : 0.73 : 0 : 65 : 0.80 : 0.85 : 0.82. Pereopod 1 (Fig. 5A, a1) 0.43 times as long as BL, with length ratio of basis, ischium, merus, carpus, propodus, and dactylus-unguis 1.00 : 0.05 : 0.35 : 0.51 : 0.68 : 0.58. Coxa with simple seta. Basis cylindrical, narrow, 4.80 times as long as wide, with dorsoproximal simple seta. Ischium wider than long, with two ventral simple setae. Merus 2.20 times as long as wide, with inner, ventrodistal tiny spiniform seta (Fig. 5a1). Carpus 3.82 times as long as wide, with four subdistal simple setae and inner subdistal spiniform seta. Propodus 5.70 times as long as wide, serrate dorsally, with two dorsosubdistal simple setae and ventrosubdistal spiniform seta. Dactylus setulate proximally, with proximal simple seta. Unguis 1.43 times as long as dactylus, naked. Pereopod 2 (Fig. 5B, b1) with length ratio of articles from basis to dactylus-unguis 1.00 : 0.09 : 0.37 : 0.41 : 0.60 : 0.28; similar to pereopod 1, except carpus with inner distal

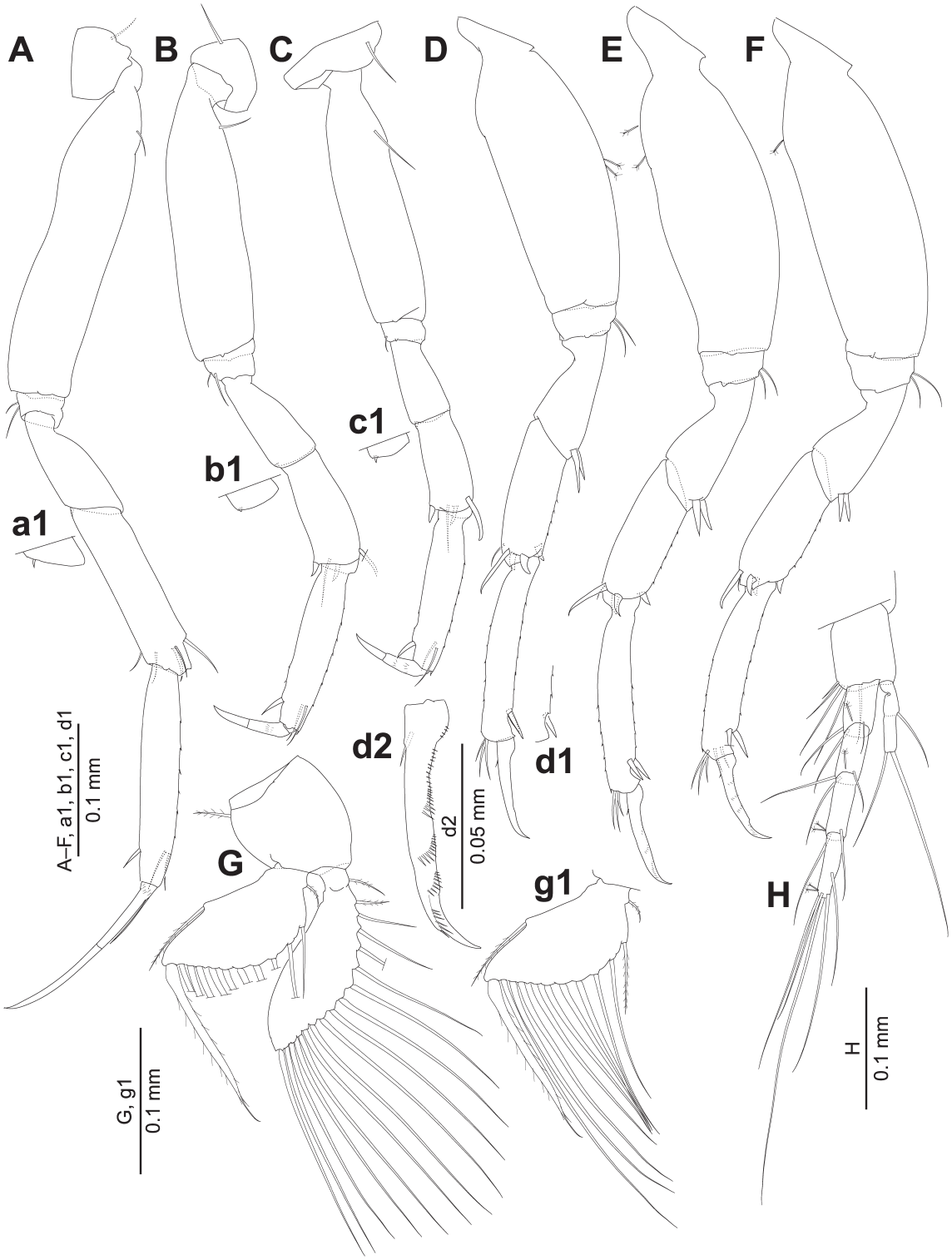

Fig. 5. *Parakonarus kajii* sp. nov., holotype, male. A–F, right pereopods 1–6, outer view; a1, b1, c1, inner, ventrodistal tiny spiniform seta on merus of pereopods 1–3, respectively; d1, inner spiniform seta in ventrodistal region of pereopod-4 propodus, outer view, outer spiniform seta omitted; d2, pereopod-4 dactylus-unguis, outer view; G, right pleopod 1, posterior view, most setal ornamentation omitted; g1, same, endopod, posterior view, most setal ornamentation omitted; H, right uropod, dorsal view.

simple seta and one dorsodistal, one inner distal, and one ventrodistal spiniform setae (dorsodistal one broken distally); propodus with ventral serrations; and unguis subequal length to dactylus. Pereopod 3 (Fig. 5C, c1) with length ratio of articles from basis to dactylus-unguis 1.00 : 0.08 : 0.33 : 0.38 : 0.64 : 0.30; similar to pereopod 2, except ischium with ventral seta. Pereopod 4 (Fig. 5D, d1, d2) without coxa. Length ratio of articles from basis to dactylus-unguis 1.00 : 0.10 : 0.41 : 0.41 : 0.67 : 0.37. Basis cylindrical, 2.65 times as long as wide, with two midventral PSS. Ischium wider than long, with two ventral simple setae. Merus 2.11 times as long as wide, with two ventrodistal spiniform setae. Carpus

Table 1. Setal numbers/conditions on pleopods. Arabic number=number of plumose setae. Roman number=number of step-tipped plumose setae. Numbers left to semicolon for inner setae, the others for outer setae. br, broken

	Pleopods (holotype, male)					Pleopods (allotype, female)				
	1	2	3	4	5	1	2	3	4	5
Basal article	1;0	1;0	1;0	1;0	1;0	1;0	1;0	1;0	1;0	br;0
Endopod: vestigial proximal article (?) (*cf.* Bird 2012)	0;1	0;1	0;1	0;1	0;1	0;1	0;1	0;1	0;1	0;1
Endopod: other region	1;I+10	1;I+10	br;I+10	1;I+10	1;I+9	1;I+7	1;I+7	1;I+8	1;I+7	1;I+7
Exopod: vestigial proximal article	0;1	0;1	0;1	0;1	0;1	0;1	0;1	0;1	0;1	0;1
Exopod: other region	0;16	0;16	0;16	0;15	0;16	0;14	0;15	0;14	0;15	0;15

2.55 times as long as wide, serrate ventrally, with dorsodistal simple seta and one longer and three shorter distal spiniform setae. Propodus 6.33 times as long as wide, serrate dorsally and ventrally, with two longer and one shorter dorsodistal simple setae, and two ventrosubdistal spiniform setae. Dactylus and unguis fused to claw; claw nearly straight, with dorsosubproximal simple seta and ventral serrations (Fig. 5d2). Pereopod 5 (Fig. 5E) with length ratio of articles from basis to dactylus-unguis 1.00:0.10:0.39:0.35:0.60:0.32; similar to pereopod 4, except basis with two dorsal PSS but lacking ventral PSS. Pereopod 6 (Fig. 5F) with length ratio of articles from basis to dactylus-unguis 1.00:0.09:0.33:0.39:0.56:0.32; similar to pereopod 4, except basis with dorsal PSS but lacking ventral PSS; and propodus with two inner distal simple setae.

Pleopods (Fig. 5G, g1) five pairs, all similar. Setal numbers/conditions summarized in Table 1.

Uropod (Fig. 5H) with basal article bearing five inner distal simple setae. Endopod with four articles; articles 1 and 2 each with three distal simple setae and distal PSS; article 3 with two distal simple setae and two distal PSS; article 4 with one middle and four distal simple setae and two distal PSS. Exopod uniarticulate (pseudoarticulation present), longer than endopodal article 1, with one middle and two distal simple setae.

Description of female. Based on allotype (NSMT-Cr 26210).

Body (Fig. 3C1–5, D) slightly dorsoventrally flattened, 5.71 times as long as CW. Cephalothorax 0.20 times as long as BL, 1.19 times as long as wide, almost rectangular in dorsal view, with one or two pairs of lateral simple setae posterior to eye, and pair of mid-lateral simple setae; dorsal demarcation of second thoracomere present; eye with colored ommatidia. Pereonites 1–6 with length ratio of 1.00:1.09:1.08:1.80:1.83:1.29; all wider than long, rectangular; pereonite 1 with pair of dorsal setae and pair of lateral setae in anterior region; pereonites 2 and 3 each with pair of anterior dorsolateral setae; pereonites 4–6 with two pairs of anterior dorsolateral setae and pair of lateral setae. Pleon 0.27 times as long as BL. Pleonites as wide as pereonite 6; all wider than long, similar in shape, with pair of dorsolateral simple setae and pair of lateral simple setae. Pleotelson 0.58 times as long as wide, narrower than pleonite 5, trapezoid in dorsal view, with rounded posterior expansion; setation similar to male.

Antennules (Fig. 6A) with four articles (article 4 cap-like), stout, 2.82 times as long as wide, 0.59 times as long as cephalothorax; articles 1–4 with length ratio of 1.00:0.24:0.41:0.03. Article 1 with one mid-outer, one mid-ventral, one mid-inner, and one outer distal simple setae, four outer distal PSS, and several ventroproximal fine setae. Article 2 with one outer distal and one inner distal simple setae, and inner distal PSS. Article 3 with two simple setae, PSS, and aesthetasc in distal region. Article 4 with two distal simple setae (one subequal length to article 1) and distal PSS. Antenna (Fig. 6B) with six articles, 0.80 times as long as antennule; articles 1–6 with length ratio of 1.00:1.00:0.76:2.13:1.08:0.21. Articles 1–4 similar to those of male (dorsodistal seta on article 3 partly broken). Article 5 with distal PSS. Article 6 with five distal simple setae (two longest setae longer than or as long as combined length of articles 3–6).

Labrum (Fig. 6C) not projecting anteriorly, setulate. Mandibles (Fig. 6D, E) with molar well developed; masticatory region broad. Incisor of left mandible (Fig. 6D) with slightly bifurcate tip; lacinia mobilis with four small and one large teeth. Incisor of right mandible (Fig. 6E) bifurcate distally, with anterior subdistal crenulation. Labium (Fig. 6F) bilobed; inner and outer lobes setulate. Maxillulae (Fig. 6G, g1) with setulate endite bearing nine (left) or 10 (right) distal spines; palp biarticulate, with one subdistal and one distal simple setae. Maxilla lost during dissection. Maxillipeds (Fig. 6H, h1) with bases not fused medially, each bearing four (left) or three (right) simple setae at insertion of palp. Endites not fused medially, reaching distal margin of palp article 1, each with long incurving simple seta in outer distal region, three distal spiniform setae (two outer ones spatulate; other one rounded, with serrate tip), and one long and one short spiniform setae in inner dorsal region; outer distal margin setulate. Palp article 1 naked; article 2 with one mid-outer and one outer distal simple setae, and three inner distal spiniform setae; article 3 with seven inner simple setae; article 4 with one outer and six distal simple setae and distal bipinnate seta. Epignath (Fig. 6I) elongate, slender, setulate.

Chelipeds (Fig. 6J, j1) chelate, with triangular articulation with cephalothorax via sclerite; sclerite with two simple setae (Fig. 3D). Basis longer than wide, with free posterior portion and outer dorsal simple seta; inner side with oval plate-like structure (Fig. 6J: †). Merus with six ventral simple setae. Carpus 1.86 times as long as wide, slightly longer than basis, with one dorsodistal and three ventral simple setae, and several inner dorsal tiny spiniform setae (Fig. 6j1); outer ventrodistal margin extending as cuff over proximal region of propodus. Propodal palm with one outer and

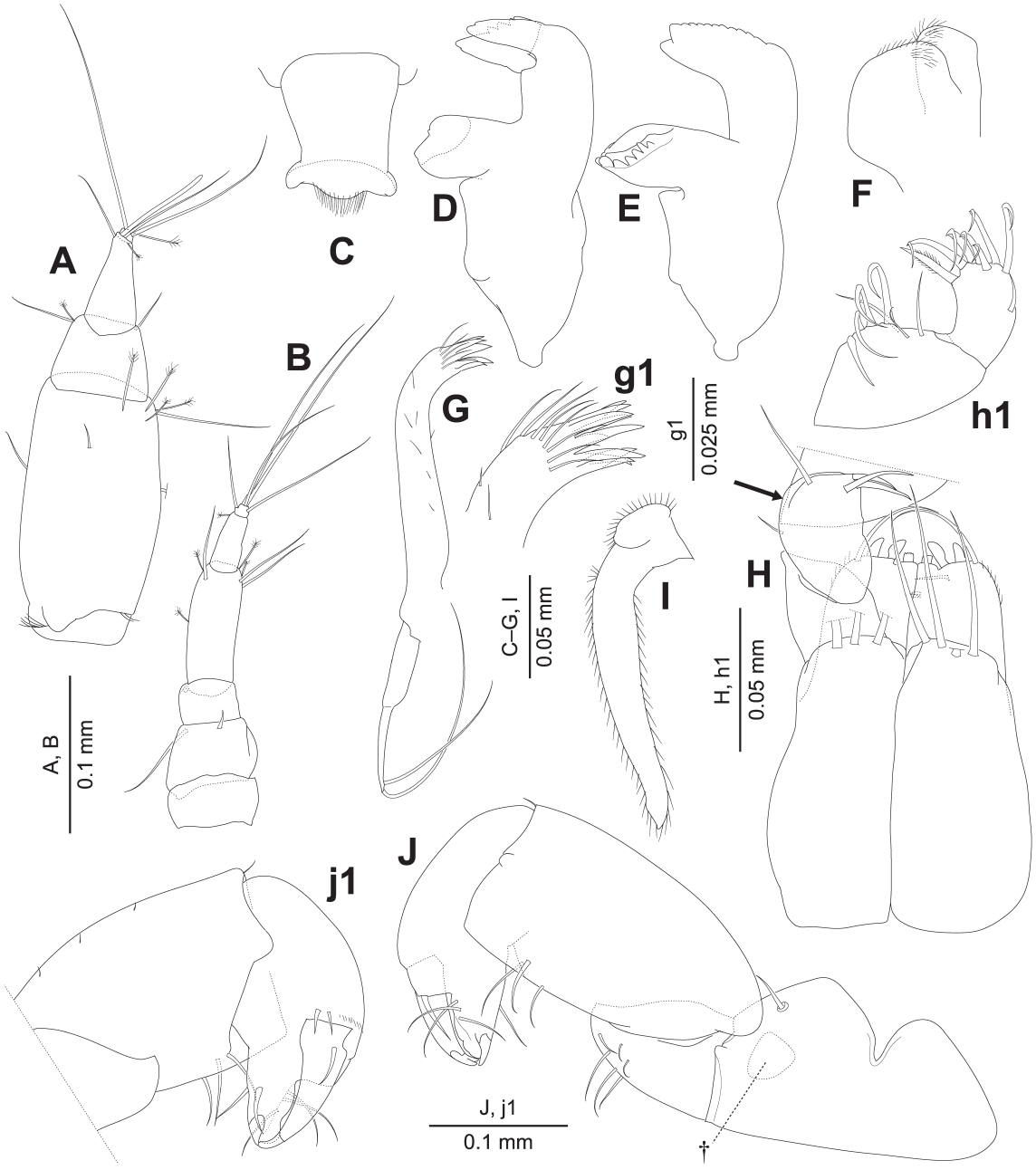

Fig. 6. *Parakonarus kajii* sp. nov., allotype, female. A, left antennule, ventral view; B, left antenna, inner ventral view; C, labrum, anterior view; D, E, left and right mandibles, respectively; F, left labium; G, right maxillule; g1, same, distal portion of endite; H, maxillipeds, ventral view, left palp and right palpal articles 3 (distal half) and 4 omitted (palp artificially bent 180 degrees at arrowed point); h1, same, right palpal articles 3 and 4, dorsal view; I, right epignath; J, left cheliped, outer view; j1, same, distal half, inner view. †, inner oval plate-like structure.

two inner simple setae at insertion of dactylus. Fixed finger with two ventral and three dorsal simple setae, and cone-shaped claw. Dactylus-unguis as long as fixed finger; dactylus with inner proximal simple seta (Fig. 6j1); unguis as long as claw on fixed finger, bifurcate at tip.

Pereopods 1–6 cylindrical, with length ratio of 1.00 : 0.65 : 0.57 : 0.57 : 0.60 : 0.60. Pereopod 1 (Fig. 7A) 0.33 times as long as BL, with length ratio of articles from basis to dactylus-unguis 1.00 : 0.08 : 0.36 : 0.63 : 0.72 : 0.94. Coxa naked. Basis slightly arched, 3.72 times as long as wide, with dorsoproximal simple seta and dorsoproximal PSS. Ischium wider than long, with ventral simple seta. Merus 1.60 times as long as wide, with ventrodistal short (0.28 times as long as merus width) simple seta. Carpus 2.54 times as long as wide, with four distal simple setae. Propodus 3.30 times as long as wide, serrate dorsally, with three dorsosubdistal and one ventrosubdistal simple setae. Dactylus with proximal simple seta. Unguis 1.35 times as long as dactylus, naked. Pereopod 2 (Fig. 7B) with length ratio of articles from basis to dactylus-unguis 1.00 : 0.06 : 0.33 : 0.34 : 0.48 : 0.36. Coxa with simple seta. Basis cylindrical, 2.95 times as long as wide, with mid-dorsal simple seta and two mid-dorsal PSS. Ischium wider than long, with two ventral simple setae. Merus 1.38 times as long as wide, naked. Carpus 1.20 times as long as wide, with one dorsodistal and one ventrodistal simple setae. Propodus 2.40 times as long as wide, serrate

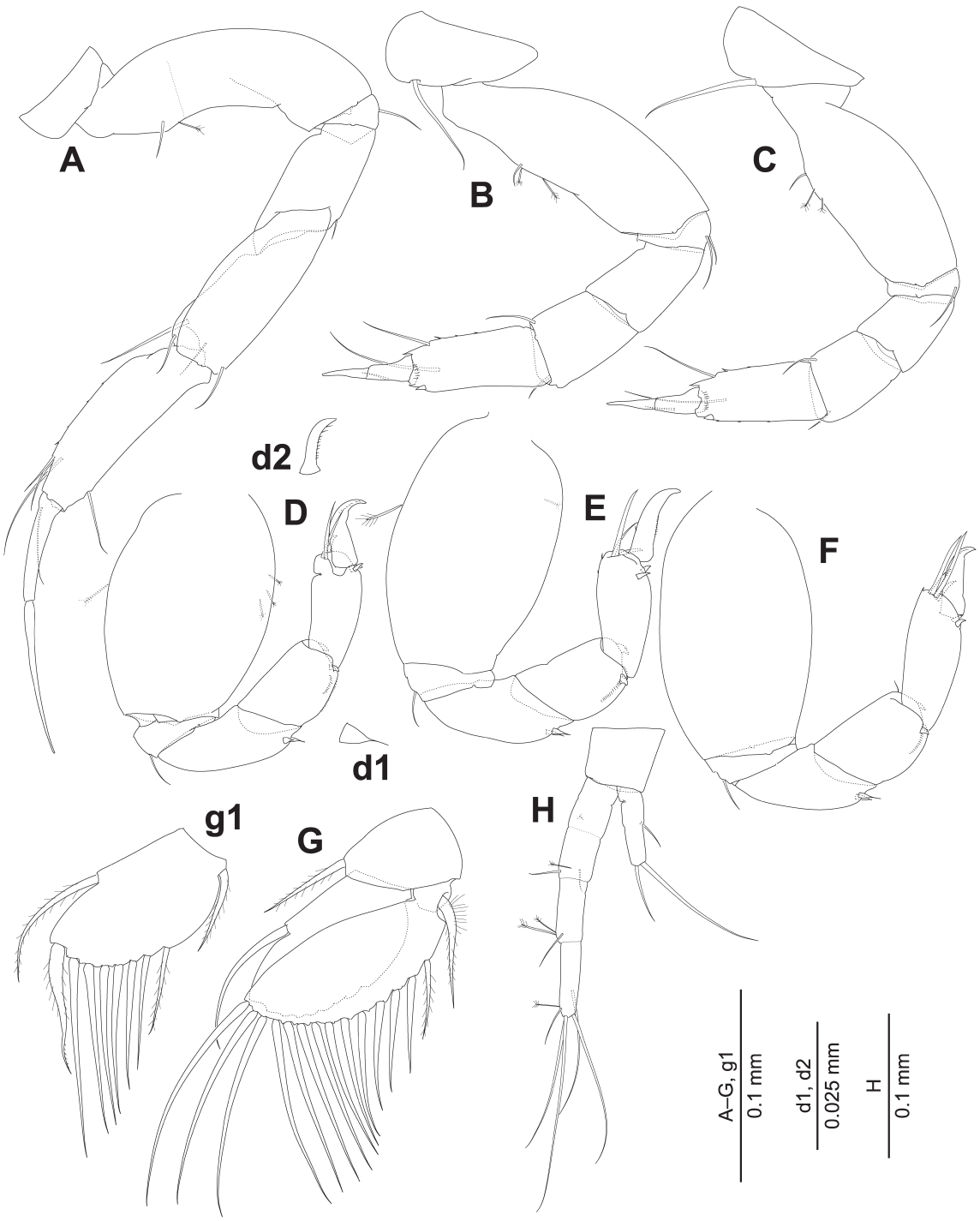

Fig. 7. *Parakonarus kajii* sp. nov., allotype, female. A–F, left pereopods 1–6, outer view; d1, tubercle-mounted seta; d2, serrated spiniform seta; G, left pleopod 1, anterior view, most setae on endopod and most setal ornamentation omitted; g1, same, endopod, anterior view, most setal ornamentation omitted; H, left uropod, ventral view.

dorsally, with one dorsosubdistal and one inner subdistal simple setae, and ventrodistal spiniform seta. Dactylus with middle simple seta. Unguis 0.94 times as long as dactylus, naked. Pereopod 3 (Fig. 7C) with length ratio of articles from basis to dactylus-unguis 1.00 : 0.05 : 0.30 : 0.34 : 0.52 : 0.42; similar to pereopod 2, except ischium with ventral seta. Pereopod 4 (Fig. 7D, d1, d2) without coxa. Length ratio of articles from basis to dactylus-unguis 1.00 : 0.09 : 0.37 : 0.35 : 0.39 : 0.38. Basis thick, 1.43 times as long as wide, with three dorsal and one ventral PSS. Ischium wider than long, with ventral simple seta. Merus 1.44 times as long as wide, with two ventrodistal tubercle-mounted setae (Fig. 7d1). Carpus 1.30 times as long as wide, with two distal spiniform setae. Propodus 1.80 times as long as wide, with two dorsodistal simple setae, two ventrodistal spiniform setae, and dorsodistal serrated spiniform seta (Fig. 7d2). Dactylus and unguis fused to claw; claw nearly straight, with dorsosubproximal simple seta and serrations. Pereopod 5 (Fig. 7E) with length ratio of articles from basis to dactylus-unguis 1.00 : 0.06 : 0.37 : 0.32 : 0.45 : 0.36; similar to pereopod 4, ex-

cept basis with one dorsal PSS. Pereopod 6 (Fig. 7F) with length ratio of articles from basis to dactylus-unguis 1.00: 0.07:0.32:0.35:0.42:0.29; similar to pereopod 4, except basis naked, carpus with dorsodistal simple seta, and propodus with two serrated spiniform setae.

Pleopods (Fig. 7G, g1) five pairs, all similar. Setal numbers/conditions summarized in Table 1.

Uropod (Fig. 7H) with basal article naked. Endopod with four articles (articulation between articles 1 and 2 very slight); article 1 with PSS; article 2 with two distal simple setae and distal PSS; article 3 with distal simple seta and two distal PSS; article 4 with one subdistal and four distal simple setae and distal PSS. Exopod uniarticulate, longer than endopodal article 1, with one middle and two distal simple setae.

Distribution. So far known only from the type locality.

Remarks. *Parakonarus kajii* sp. nov. is the ninth species described in this genus (*cf.* Anderson 2016). Among its eight congeners, both sexes have been described in six species: *P. fairgo* (Bamber, 2005), *P. juliae* (Morales-Núñez *et al*., 2013), *P. kopure* Bird, 2011, *P. provincialis* (Dollfus, 1898), *P. robertsoni* Edgar, 2012, and *P. sozo* Bamber, 2013. *Parakonarus corrigendum* Bamber, 2013 lacks information from females, and *P. oregmus* Bamber, 2013 lacks information from males. *Parakonarus kajii* is the seventh member with male and female information, and the first case where the male and female pair was confirmed by molecular data.

Male *P. kajii* has a well-developed digitiform process on the ventral margin of the chelipedal carpus (Fig. 4D, d1). This feature is also found in male *P. juliae* (Morales-Núñez *et al*. 2013); however, the positions of the three simple setae on the process are different between the two species. In *P. kajii*, one ventro-subproximal, one outer, and one inner setae are distributed in the basal half of the process. In contrast, in *P. juliae*, one seta is placed at the tip of process, and the other two are located near the base of the process and distal to the process (Morales-Núñez *et al*. 2013: fig. 8B, C); this pattern is also found in *P. corrigendum*, *P. fairgo*, and *P. sozo* (Błażewicz-Paszkowycz and Bamber 2012; Morales-Núñez *et al*. 2013). These differences indicate that, even though the shape of the process is similar, the region of origin of the process is not identical: the process in *P. kajii* must form as an expansion of the exoskeleton originating more distally on the carpus than in *P. juliae*.

In terms of the setal positions, male *P. kajii* closely resembles male *P. kopure* (Bird 2011), but can be distinguished from the latter by having the ventral process on the chelipedal carpus longer than wide (wider than long in *P. kopure*); the inner comb-row on the chelipedal propodus comprising 16 setae (about nine in *P. kopure*); and the dactylus and unguis of pereopods 4–6 fused (separate in *P. kopure*).

Parakonarus robertsoni has more than 10 ventral simple setae on the chelipedal merus in both sexes, and males have four ventral simple setae on the chelipedal carpus (based on figs 13CH and 17CH in Edgar 2012), which distinguish this species from *P. kajii*.

Very limited morphological information is available for *P. provincialis*, but it differs from *P. kajii* in that the ventral process on the chelipedal carpus is wider than long (longer than wide in *P. kajii*), the chelipedal dactylus lacks a ventroproximal triangular process (present in *P. kajii*), and the uropodal endopod has five articles (four in *P. kajii*) (Dollfus 1898).

Among the eight species with information on females, the females of *P. kajii*, *P. kopure*, *P. robertsoni*, and *P. sozo* have a short body, with pereonite 4 shorter than wide. Female *P. kajii* differs from female *P. kopure* in that the ventrodistal seta on the pereopod-1 merus is short, or 0.28 times as long as the merus width (long, or 1.20 times as long as the merus width in *P. kopure*); the pereopod-1 unguis is 1.35 times as long as the dactylus (1.77 times as long as the dactylus in *P. kopure*); the carpi of pereopods 2 and 3 lack the ventrodistal spiniform seta (present in *P. kopure*); the propodal palm of the cheliped has two inner simple setae at the insertion of the dactylus (five in *P. kopure*); and article 2 of the maxillipedal palp has one mid-outer and one outer distal simple setae (one mid-outer seta only in *P. kopure*) (Bird 2011). Female *P. kajii* differs from female *P. robertsoni* in having the chelipedal merus and carpus respectively bearing six and three ventral simple setae (more than 10 [merus] and five or six [carpus] in *P. robertsoni*) (Edgar 2012). Female *P. kajii* differs from female *P. sozo* in having six ventral simple setae on the chelipedal merus (four in *P. sozo*), and the dactylus-unguis fused in pereopods 4–6 (not fused in *P. sozo*) (Bamber 2013).

Female *P. kajii* differs from *P. oregmus*, a congener for which only information on females is available, in having all pereonites wider than long (pereonites 4 and 5 longer than wide in *P. oregmus*); the chelipedal merus with six ventral simple setae (nine in *P. oregmus*); the pereopod 1 dactylus-unguis 1.3 times as long as that of the pereopod-1 propodus (1.7 times as long in *P. oregmus*); and the dactylus and unguis of pereopods 4–6 fused (not fused in *P. oregmus*) (Bamber 2013). Information on the morphology of *P. provincialis* females is very limited, but this species has the antennule being longer than the cephalothorax length (Dollfus 1898: fig. 4b) whereas it is shorter in *P. kajii*.

Our specimens showed an unusual feature on the inner surface of the chelipeds: an oval plate-like structure present in both sexes (Figs 4D†, 6J†) and an elongate plate-like structure present in males (Fig. 4D‡). The elongate plate-like structure may be a reduced ischium. In Tanaidacea, the ischium has been noted to occur on the chelipeds in only three taxa in two superfamilies (Neotanaoidea and Tanaidoidea) to date: Neotanaidae (*cf.* Larsen *et al*. 2015: fig. 59.19B), and the two tanaidoid genera *Arctotanais* (*cf.* Kakui *et al*. 2012: fig. 5) and *Tanais* (*cf.* Lauterbach 1970: fig. 25) (Kakui *et al*. 2012). In these taxa, the ischia comprise a narrow, incomplete ring or arc, and are sometimes overlooked by researchers (*e.g.*, Sieg 1980). The structure we found in *P. kajii* resembles the ischium in *Arctotanais* and *Tanais*. Morales-Núñez *et al*. (2013: fig. 7A) illustrated a similar structure in male *P. juliae*. There have been no reports of a chelipedal ischium in the superfamily Paratanaoidea, which includes *Parakonarus*, although this article may be present but has just been overlooked in some paratanaoid species.

Instead of the ischium-like structure, it is uncertain about what the oval plate-like structure is.

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