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A New Species of the Genus *Rimicaris* (Alvinocarididae: Caridea: Decapoda) from the Active Hydrothermal Vent Field, "Kairei Field," on the Central Indian Ridge, the Indian Ocean

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ABSTRACT—*Rimicaris kairei* new species (Alvinocarididae: Caridea: Decapoda) is described based on materials, from the active hydrothermal vent field, "Kairei Field," on the Central Indian Ridge, the Indian Ocean. The new species is clearly distinguishable from the unique congener, *R. exoculata* Williams & Rona, 1986, which is known from the Atlantic Ocean. The following morphological differences were identified: (1) all punctations on carapace strongly ornamented by tufts of short stiff setae in *R. exoculata*, whereas without any setae in *R. kairei*; (2) antennal flagella in *R. exoculata* shorter than in *R. kairei*; (3) walking legs in *R. exoculata* more robust than in *R. kairei*.

Key words: *Rimicaris kairei*, Kairei Field, hydrothermal vent, Central Indian Ridge, new species

INTRODUCTION

The genus *Rimicaris* (Alvinocarididae: Caridea: Decapoda) was originally established for two Atlantic vent species, *R. exoculata* and *R. chacei* described by Williams and Rona (1986). So far, *R. exoculata* has been widely reported from the hydrothermal vent fields, such as TAG and Snake Pit, on the Mid Atlantic Ridge at 1700-3650 m depth (*Dèsbruyeres et al*., 2001; Martin and Hessler, 1990; Segonzac, in Dèsbruyeres and Segonzac, 1997; Shank, in Dèsbruyeres and Segonzac, 1997; Shank *et al*., 1998; Williams, 1987). The latter species, *R. chacei,* was later transferred to another genus, *Chorocaris* by Martin and Hessler (1990).

Confusion about taxonomic status of *Rimicaris exoculata* was recently dispelled based on a combination of morphological and molecular data. Two Atlantic species, *R. aurantiaca* Martin, Signorovitch, and Patel, 1997, and *Iorania concordia* Vereshchaka, 1996, were recently described on the basis of morphology and micro-distribution patterns in a hydrothermal vent field. However, these two species were determined to actually be juveniles of *R. exoculata*, based on molecular systematics data (Shank *et al*., 1998). Thus, the genus now consists of a single species, *R. exoculata*, characterized by the following morphological characteristics in the adult; (1) the strongly inflated branchial chamber, and (2) the absence of rostrum and eye stalks (Martin and Hessler, 1990; Shank *et al*., 1998).

In August 2000, the first hydrothermal vent field reported from the Indian Ocean, the "Kairei Field" (25°19.23'S, 70°02.42'E, 2415–2460 m deep), near the Rodriguez Triple Junction, Central Indian Ridge, Indian Ocean, was discovered, using the ROV *Kaiko* and R/V *Kairei*, Japan Marine Science and Technology Center, Japan (Hashimoto *et al*,. 2001). As in the Atlantic hydrothermal vent fields, the Kairei Field was characterized by numerous black smokers and dense, white *Rimicaris* swarms on the chimneys (Fig. 1). Subsequently, a similar hydrothermal vent field with huge *Rimicaris* swarms, the "Edmond Field" (23°52.68'S, 69°35.80'E, 3290–3320 m depth), was found 160-km NNW of the Kairei Field, by a U. S. –based research group in April 2001 (Van Dover *et al*., 2001).

Van Dover *et al.* (2001) reported that a partial sequence of the mitochondrial cytochrome oxidase subunit I gene (COI, 576 base pairs) is (1) completely shared between the Kairei and Edmond shrimp samples, and (2) slightly different between the Indian Ocean material and *R. exoculata* (99.1% homology). Thus, we engaged in a study on the morphological differences between the present Indian Ocean material and *R. exoculata*.

Close examination of the morphology of shrimps from

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the Kairei Field discloses that the present material from the Indian Ocean represents an undescribed species, which is hereby named *Rimicaris kairei*. The terminology for body parts in this paper primarily follows Williams and Rona (1986).

MATERIALS AND METHODS

Shrimp samples were collected with a suction sampler that was hydraulically driven and installed on the ROV *Kaiko*, together with still photographs and video recordings of their *in situ* state around active black smokers. Collected shrimps were immediately fixed in 10% neutralized formalin, and then transferred to 70% ethanol for preservation. Drawings were made with the aid of a drawing tube, which was mounted on a Nikon SMZ-U stereomicroscope.

In this paper, the following abbreviations are employed. JAMSTEC; Japan Marine Science and Technology Center (Japan): MNHN; Muséum national d'Histoire Naturelle (France): NSMT; National Science Museum, Tokyo (Japan): NTOU; National Taiwan Ocean University (Taiwan): USNM; National Museum of Natural History, Smithsonian Insitute (USA): ZRC; Zoological Reference Collection, Raffles Museum, National University of Singapore (Singapore): al; right antennal length including flagellum: cl; carapace length, anterior to posterior margins of carapace: coll.; collector: tl; total length of shrimp, anterior margin of carapace to tip of telson: maw; maximum width of carapace: miw; minimum width of carapace at posteriormost part of carapace: 3lp; merus length of third pereopod: 3wp; merus width of third pereopod.

As comparative materials, the paratypes of *Rimicaris exoculata* (the TAG site, Mid Atlantic Ridge, 3620-3650 m depth, 3 Aug 1985, coll. Peter A. Rona and team of scientists on NOAA R/V *Researcher*: 1 ♂, 1 ♀ (MNHN-Na 10534)), deposited at MNHN, were examined.

TAXONOMY

Family **Alvinocarididae**

Genus ***Rimicaris*** Williams & Rona, 1986

Rimicaris kairei new species

(Figs. 1–4)

Material

The Central Indian Ridge. Indian Ocean, the Kairei Field, 25°19.16'S, 70°02.40'E, 2454 m depth, ROV *Kaiko* Dive No. 10K#168, 26 Aug 2000, coll. authors. Holotype, ♂ (NSMT Cr-14112); 2 paratypes, 1 ♂, 1 ♀ (JAMSTEC 032688); 2 paratypes, 1 ♂, 1 ♀ (MNHN-Na 13797); 2 paratypes, 1 ♂, 1 ♀ (NSMT Cr-14113); 2 paratypes, 2 ♀♀ (NTOU 2000-8-26); 2 paratypes, 1♂, 1♀ (USNM 2026541); 2 paratypes, 1 ♂, 1 ♀ (ZRC 2001.1053).

Measurements

See table 1.

Etymology

The species is named after both the R/V *Kairei* and the hydrothermal vent field, "Kairei Field."

Diagnosis

Integument completely spineless, almost membranous but slightly firmer on abdomen. Carapace longitudinally oval in dorsal view, sparsely pitted by shallow punctations without any setae. Rostrum and eyestalks completely absent, substituted by ocular plate. Branchiostegite strongly inflated.

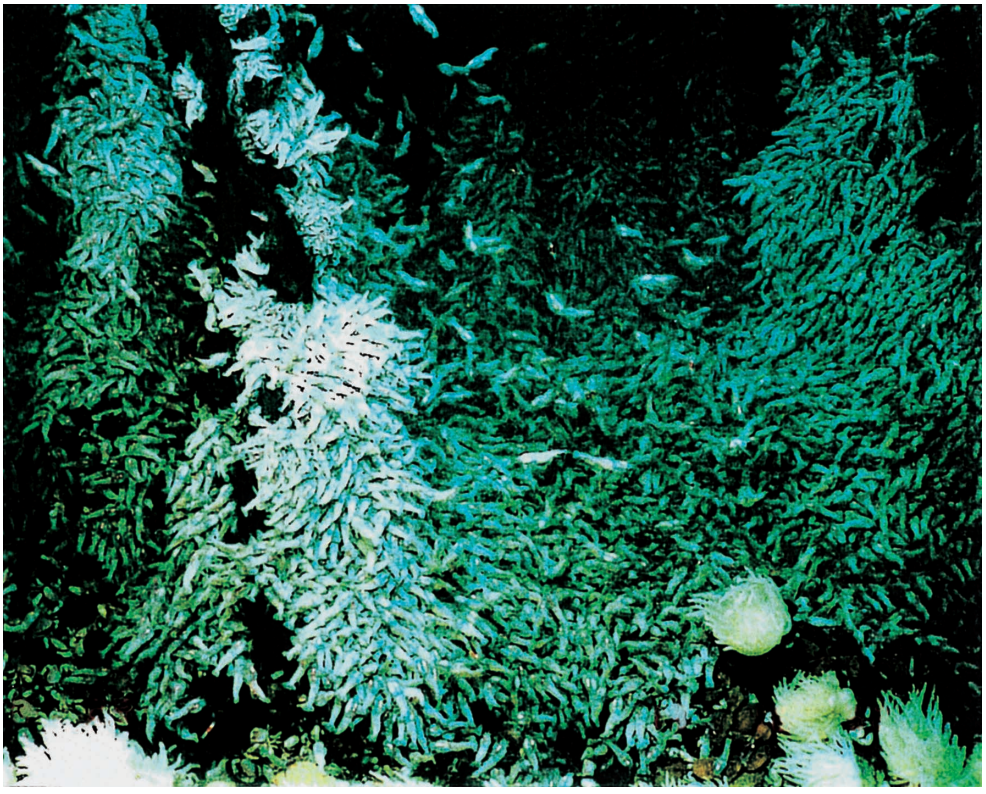

Fig. 1. *Rimicaris kairei* new species, shrimp swarm at Kairei field, Indian Ocean.

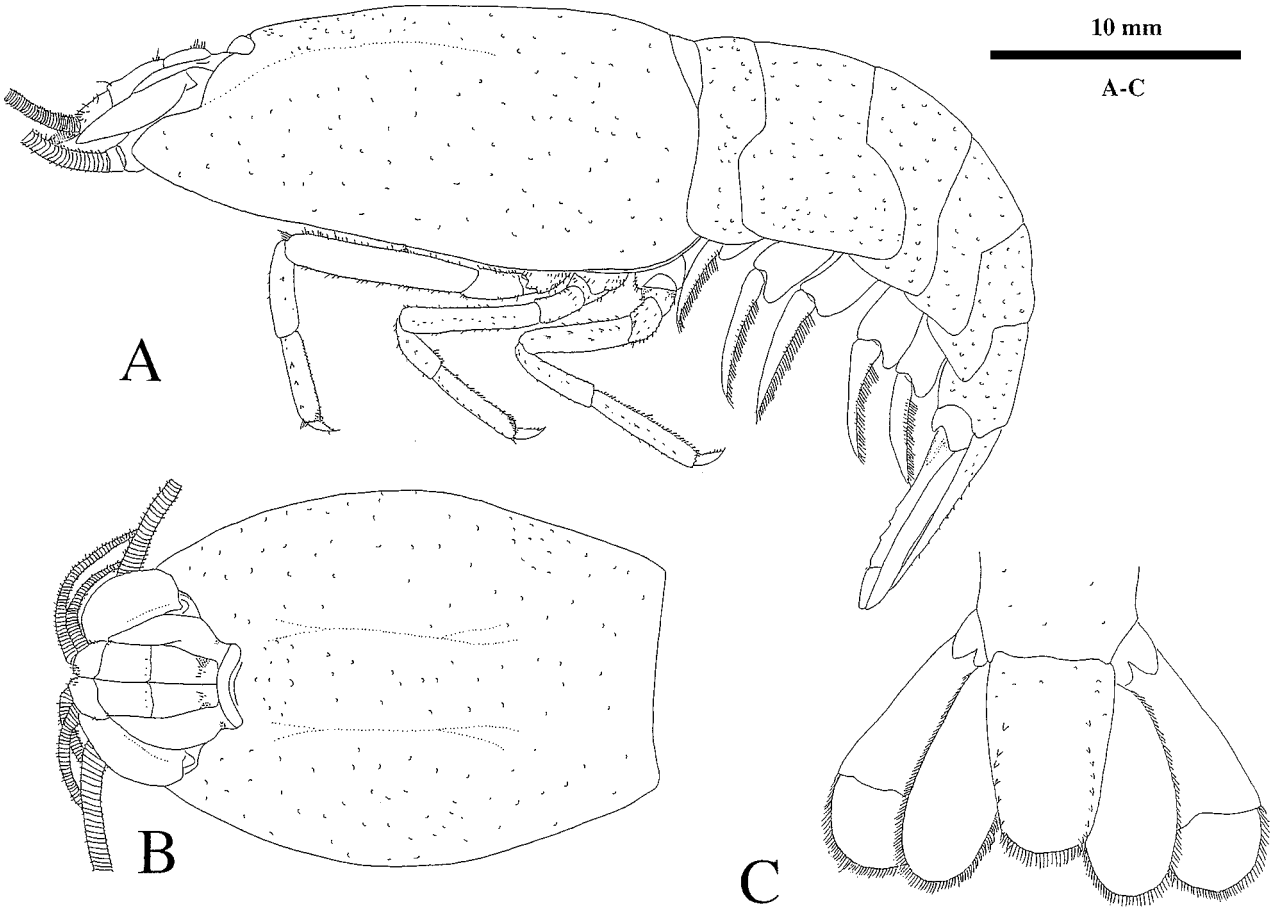

Fig. 2. *Rimicaris kairei* new species, holotype, male from Kairei Field, Indian Ocean, NSMT Cr-14112: A, entire animal, lateral view; B, carapace and cephalic appendages, dorsal view; C, telson and uropods, dorsal view.

Telson armed with 5–11 pairs of submarginal spines on dorsum, and 1 or 2 pairs of spines on terminal margin. Antennal and antennular flagella strongly developed and flattened dorsoventrally. Antennal scale enlarged, completely filling anterior margin of carapace. First and second pereopods chelate and weakly developed, usually hidden beneath branchiostegite. Third to fifth pereopods well developed, stout, similar in structure in all pairs; dactylus ending in acute horny nail, armed with small accessory spinules on posterior margin.

Description

Integument smooth, shining, almost membranous on branchiostegite but slightly thicker at abdomen. Entire surface irregularly pitted by somewhat coarse and shallow punctations, but without setae.

Carapace (Fig. 2A, B) oval in shape, broader than abdomen, approximately twice as wide as high. Frontal margin broadly convex, attached closely to posterior concavity of ocular plate. Rostrum absent. Gastrocardiac region bearing distinct middorsal, longitudinal areolar tract of row. Epigastric ridge weak, extending from near anterior margin to about anterior one-third of carapace length, narrow anteriorly, but widening and merging into gastric region posteriorly. Branchiostegites highly inflated, entirely naked, but sparsely bearing punctations; anterolateral expansion broad, reaching about distal corner of antennal peduncle; ventral margin closely approximating bases of pereopods, and reinforced by low submarginal ridge.

Abdomen (Fig. 2A) rather stout, broadly arched dorsally. Pleuron of first segment short, subrectangular; ventral margin weakly convex, anterior lobe only half as wide as posterior lobe. Second segment also subrectanglar. Third segment with ventral margin nearly straight; posterolateral angle subrectangular. Fourth and fifth segments with weakly convex ventral margins; each posteroventral angle acute. Sixth segment broadly notched for reception of uropods; posteroventral angle also acute.

Telson (Fig. 2C) broadly rounded posteriorly, both sides moderately convergent. Sinuous sublateral low of 7–10 dorsal spines on each side continuous with 1 or 2 spines at each posterolateral corner; terminal margin convex, densely bearing long setae.

Uropod (Fig. 2C) with both lami, elongate oval, exceeding distal end of telson. Outer ramus wider than inner ramus, bearing sinuous diaeresis.

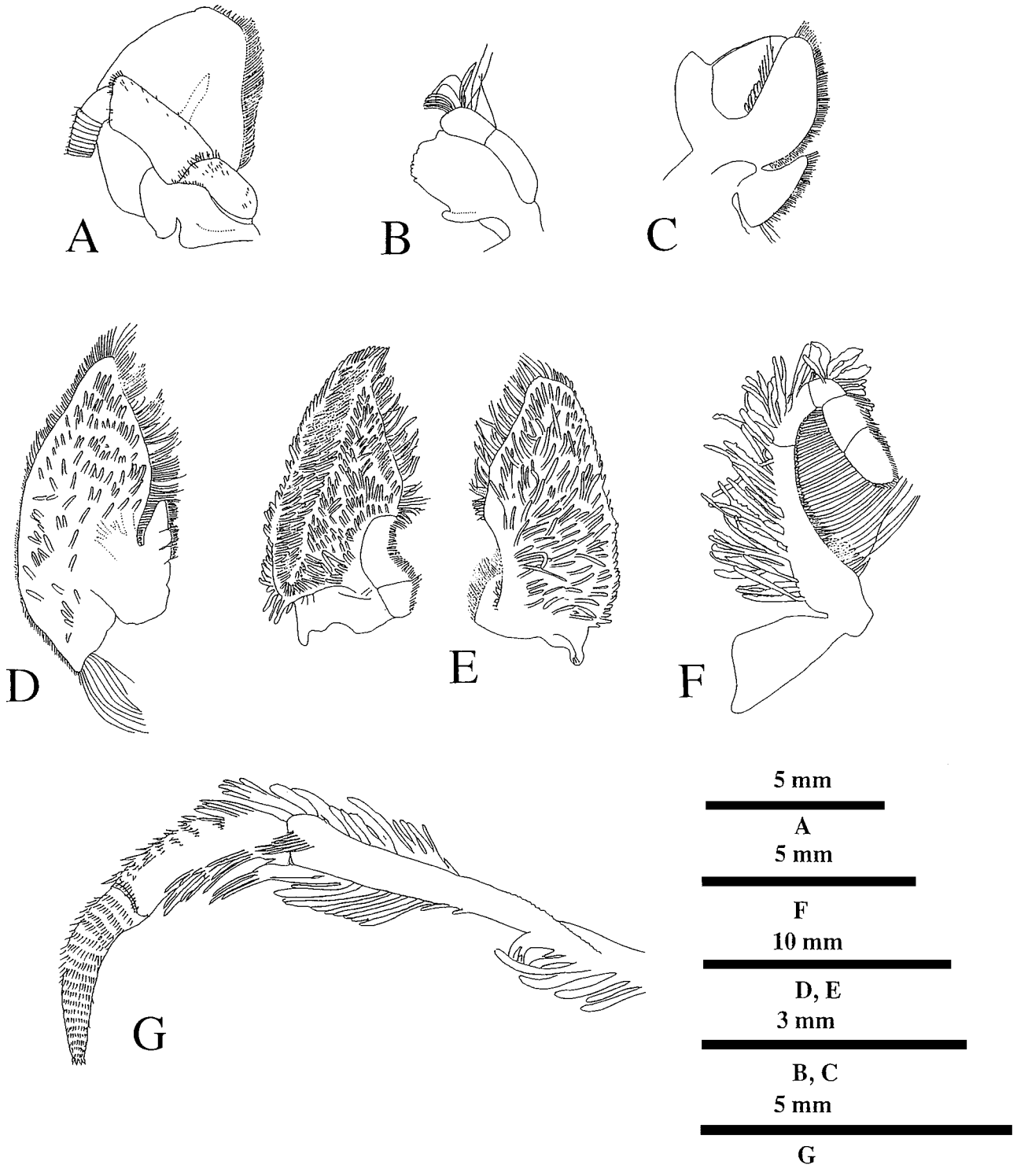

Fig. 3. *Rimicaris kairei* new species, paratype, male from Kairei Field, Indian Ocean, NSMT Cr-14113: A, right antennal peduncle, scale, and proximal part of flagellum, ventral view; B, right mandible,dorsal view; C, right first maxilla, ventral view; D, right second maxilla, ventral view; E, right first maxilliped, dorsal (left) and ventral (right) views; F, right second maxilliped, ventral view; G, right third maxilliped, mesial aspect.

Eyes (Fig. 2A, B) completely absent, without sign of eyestalk or cornea. Ocular region wholly occupied by transverse ocular plate. Ocular plate as broad as base of each antennular peduncle, convex anteriorly whereas concave posteriorly, somewhat tapered and rounded laterally.

Antennular peduncles (Fig. 2A, B) hypertrophied, flattened dorsoventrally; mesial margins closely parallel to each other. Stylocerite much enlarged, elongate triangular, extending along almost entire lateral margin of second article. Flagellum heavy, somewhat depressed dorsoventrally, and

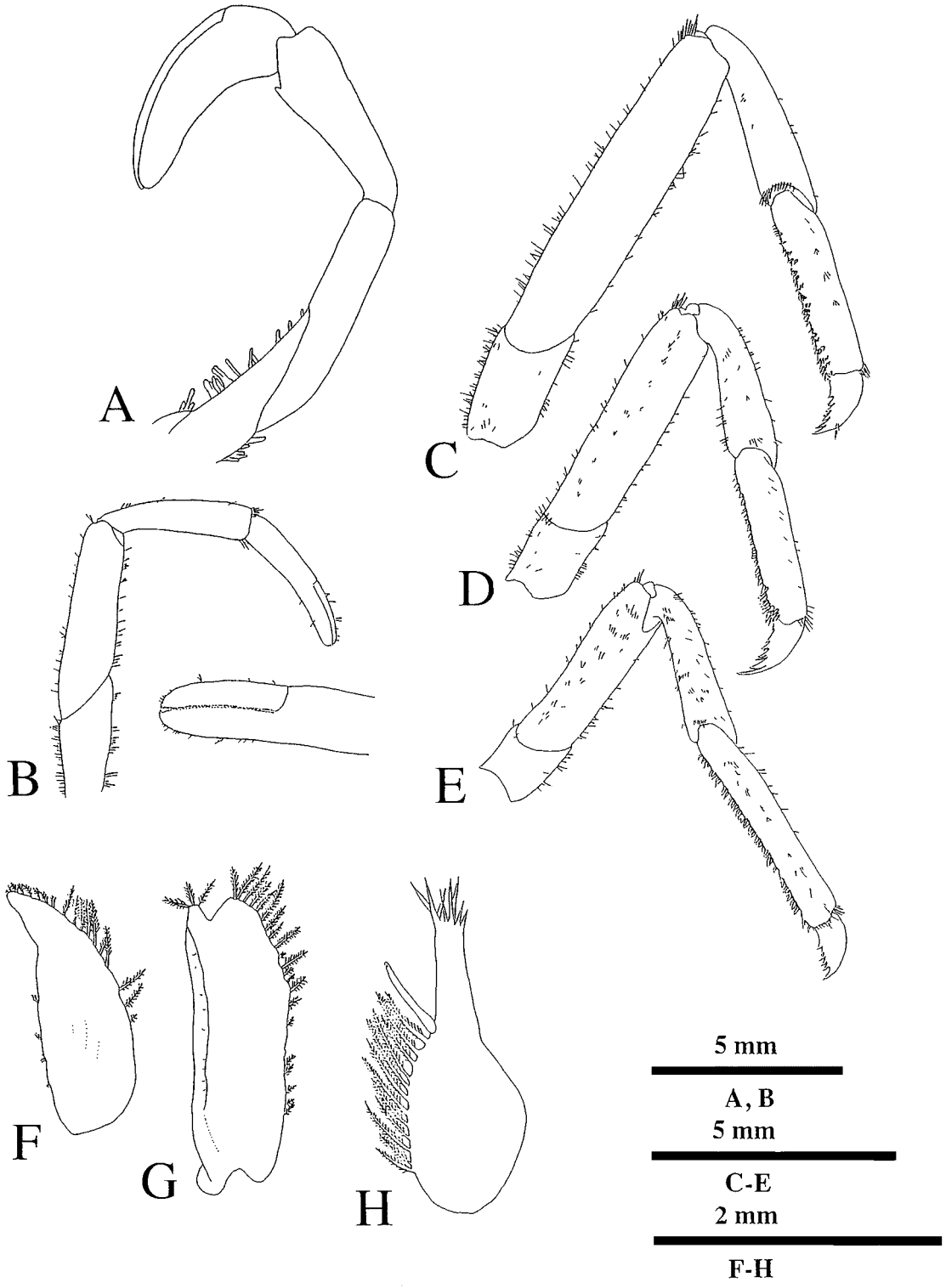

Fig. 4. *Rimicaris kairei* new species, paratypes, male and female (Fig. 4F only) from Kairei Field, Indian Ocean, NSMT Cr-14113: A, right first pereopod; B, right second pereopod, with enlarged tip of cheliped; C, right third pereopod; D, right fourth pereopod; E, right fifth pereopod from reverse side; F, endopod of right first pleopod, female, ventral view; G, endopod of right first pleopod, ventral view; H, appendix masculina and appendix interna, lateral view.

tapered; lateral ramus inserted anterolaterally on peduncular third article, terminal ramus somewhat larger at base; both rami and annuli variable in length.

Branchial formula identical to that in *Rimicaris exoculata*.

Antennal peduncles (Fig. 3A) hypertrophied. Antennal

Table 1. *Rimicaris kairei* new species and *R. exoculata* Williams & Rona, 1986. Measurements of body parts. For explanation of abbreviations, see MATERIALS AND METHODS.

species & catalogue No.	sex	al(mm)	cl(mm)	al/cl	31p(mm)	3wp(mm)	3wp/3lp	maw(mm)	miw(mm)	tl(mm)
Rimicaris kairei										
Holotype										
NSMT Cr-14112	♂	37.9	20.7	1.83	9.4	1.9	4.95	19.3	11.5	54.3
Paratype										
NSMT Cr-14113	♂	30.4	17.2	1.77	10.2	1.9	5.34	15.4	9.1	44.1
	♀	17.6	13.3	1.32	6.4	1.2	5.33	12.4	7.6	33.9
NTOU 2000-8-26	♂	30.3	17.7	1.71	8.7	1.8	4.83	16.8	8.8	44.7
	♀	20.4	12.9	1.58	6.5	1.4	4.64	11.8	6.7	31.4
MNHN-Na 13797	♂	32.3#	20.1	1.61#	9.8	1.8	5.44	15.8	9.4	49.8
	♀	19.8	14.3	1.38	6.8	1.3	5.23	12.1	7.1	34.9
USNM 2026541	♂	36.7	20.2	1.82	9.6	1.8	5.33	17.8	10.6	51.2
	♀	28.3	19.1	1.48	9.5	1.8	5.28	17.7	11.4	50.7
JAMSTEC 032688	♂	39.8	18.9	2.11	10.4	1.9	5.47	17.7	10.4	51.2
	♀	28.4	21.6	1.31	8.3	1.8	4.61	18.3	10.6	54.3
ZRC 2001.1053	♂	39.7	20.7	1.97	10.8	1.9	5.68	18.7	10.9	53.8
	♀	19.7	13.8	1.43	6.6	1.2	5.50	12.4	7.7	32.7
Rimicarls exoculata										
Paratypes										
MNHN Na-10534	♂	30.4	18.7	1.63	8.4	1.9	4.42	15.3	9.1	45.2
	♀	17.3	17.4	0.99	4.4	1.2	3.67	15.1	9.1	42.7

tip of antenna missing.

scale broad, irregularly ovate, reinforced by oblique longitudinal rib; both lateral and terminal spines absent. Flagellum similar in structure to those in antennule, slightly longer in male than in female (al/cl=1.71–1.97 in male, 1.31–1.58 in female), sweeping in gentle arc lateral to carapace and usually reaching level of midlength of first or second abdominal segments; inconspicuous sensory setae scattered at joints between annuli.

Mandible (Fig. 3B) robust, armed with 2-jointed palp. Incisor process armed with 8 marginal teeth. Molar process small.

First maxilla (Fig. 3C) armed with semitriangular coxal endite, mesial margin bearing many short setae. Basal endite broadened mesially, armed with many short setae on mesial margin. Endopod bearing long seta on distomesial corner.

Second maxilla (Fig. 3D) armed with proximal endite composed of 2 similar flat lobes. Distal endite subtriangular, elongate, flanked laterally by somewhat twisted palp. Scaphognathite enormously expanded, anterior lobe triangular, covered on all surfaces by conspicuous plumose setae. Dorsal setae more densely packed, and longer than on ventral region. Posterior lobe subtriangular, fringed on straight distomesial margin with tangled, long setae.

First maxilliped (Fig. 3E) hypertrophied, armed with irregularly fusiform endite. Palp short, concealed by enormously expanded exopod. Exopod similar in shape and ornamentation of scaphognathite. Mesial portion indistinct, representing obsolete lash on exopod. Epipod obscurely trilobed.

Second maxilliped (Fig. 3F) densely covered distomesially by long plumose setae. Ischium long, approximately 4 times as long as merus.

Third maxilliped (Fig. 3G) long and setose, reaching at level of distal one third of antennal peduncle. Distal segment tapered distally, having 3-5 terminal stiff setae.

First pereopod (Fig. 4A) somewhat small, shorter than second pereopod, usually hidden within enveloping branchiostegites, normally reaching base of distal article of antennal peduncle; surface smooth, sparsely armed with fine setae except prominent plumose setae on basis-coxa. Chela oriented toward midline at approximately right angle to axis of pereopods. In normal position, movable finger slightly overreaching immovable finger. Both movable and immovable fingers curved inward and closing completely, each armed with row of closely set setae. Each finger somewhat acute, armed with curved setal row. Immovable finger bearing elongate teeth, curving around distal edge, curved

sensory setae present mesially to each cutting edge. Carpus as long as chela, same size in diameter. Merus-ischium-basis flattened, completely fused.

Second pereopod (Fig. 4B) slender, slightly twisted, reaching base of distal article on antennal peduncle. Both fingers spatulate, slightly hooking mesially at tips; each armed with cutting teeth, almost uniform setae on lateral edge, and ending in small corneous tooth. Movable finger slightly exceeding immovable finger. Palm and carpus armed with scattered setae on each mesial surface. Merus-ischium-basis bearing dense row of setae on dorsal margin; ventral margin bearing setae arranged in short row. Elevations of caxa setose.

Third to fifth pereopods (Fig. 4C–E) morphologically similar, but not in size, slightly stouter in female than in male, especially in merus of third pereopod. Merus ornamented by dense setae like in carpus, but ventral setae arranged in marginal tracts of overlapping short oblique rows; coxa with rows of fine setae on elevations; extensor surface armed with scattered setae. Carpus slender, asymmetrically subconical, ornamentation similar to propodus on extensor surface; flexor surface armed with dense setae. Propodus bearing tract of dense stiff setae along entire flexor surface; extensor surface smooth, bearing slender, movable setae. Dactylus ending in acute corneous nail, with 4 or 5 accessory spines on posterior margin; flexor surface concave; extensor surface smooth, convex. Third pereopod (Fig. 4C) largest, normally folded at mero-carpal articulation, reaching base of antennular flagellum when extended; merus 4.95–5.68 (male) and 4.61–5.50 (female) times as long as width (see also Table 1); carpus and propodus somewhat slender, approximately 5 times as long as width, respectively. Fourth pereopod (Fig. 4D) nearly as robust as fifth pereopod; merus nearly 5 times as long as width; carpus and propodus also similar to those in third pereopod, nearly 5 times as long as width, respectively. Fifth pereopod (Fig. 4E) somewhat robust, normally flexed upon itself at mero-carpal articulation, reaching distal end of merus of third pereopod, when fully extended; merus slightly less than 5 times as long as width; carpus slender, approximately 5 times as long as width; propodus also slender, more than 6 times as long as width.

First and second pleopods well developed. First pleopod bearing endopod (Fig. 4F, G), less than half length of exopod; endopod with asymmetrical distal notch at extremity in male, whereas simply ending in blunt apex in female. In male, second pleopod armed with well developed appendix masculina (Fig. 4H). Appendix interna (Fig. 4H) provided with many coupling hooks in subapical, mesial region, successively stronger in third to fifth pleopod.

Coloration

In life, entire animal milky white. Frequently, branchial chamber slightly blackened by metal sulfide and probably episymbiotic bacteria. Dorsal eyes (*sensu* Van Dover, 2000: 210–214, Fig. 7. 21, 22, and 24) highly reflective, pale orange. Third to fifth pereopods ending in pale brown nails.

Distribution

Kairei Field (type locality) and Edmond Field, near the Rodriguez Triple Junction, Central Indian Ridge, Indian Ocean, 2415–3320 m depth.

Remarks

From both morphological and genetic aspects, *Rimicaris kairei* and *R. exoculata* are very close. However, the following three morphological characteristics appear to be useful to distinguish *R. kairei* from *R. exoculata*. The latter two seem to also exhibit the sexual dimorphism in the genus *Rimicaris* (see Table 1). First, punctations on the entire surface of the carapace are ornamented strongly by a tuft of short stiff setae in *R. exoculata*, whereas there are no setae in *R. kairei*. The second, third to fifth pereopods are more robust in *R. exoculata* than in *R. kairei*. Among them, the difference is most apparent in the third pereopod, and is useful to distinguish the two species from each other. The merus of the third pereopod is less than 4.5 times as long as wide in *R. exoculata* (3wp/3lp=4.42 in male, 3.67 in female), but nearly or over 5 times as long as wide in *R. kairei* (3wp/3lp=4.95–5.68 in male, 4.61–5.50 in female). Finally, the antennal flagellae are somewhat shorter (al/cl=1.63 in male, 0.99 in female) in *R. exoculata* than in *R. kairei* (al/cl=1.71–1.97 in male, 1.31–1.58 in female).

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