THE RAFFLES BULLETIN OF ZOOLOGY 2004 **52**(1): 147-170

GAMMARUS SPECIES FROM TIBET PLATEAU, CHINA (CRUSTACEA: AMPHIPODA: GAMMARIDAE)

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***ABSTRACT.* –** Species of the genus *Gammarus* from Tibet Plateau are reported in the present paper. Three new species, *G. frigidus*, new species, *G. jaspidus*, new species, and *G. sinuolatus*, new species, were found in this area and are reported in the present paper. A detailed description of these freshwater amphipods is given and differences with related species are discussed.

***KEY WORDS.* –** China, Tibet, Amphipoda, *Gammarus*, taxonomy, new species.

INTRODUCTION

With an average elevation of 4,000 meters, Tibet is widely known as the "Roof of the World'', an ancient but mysterious place in many people's minds. Although the natural conditions are really severe for mankind, Tibet is a paradise to some wild animals. It teems with many rare animals such as black-necked cranes (*Grus nigricollis*), wild yaks (*Bos grunniens*), Tibetan gazelles (*Procapra picticaudata*), and white-lipped deer (*Cervus albirostris*). In order to better understand the biodiversity of this plateau, international scientists carried out many studies (China Society of the Qinghai-Tibetan Plateau Research, 1995). With regard to the species of the amphipod genus *Gammarus*, Tattersall (1914) and Uéno (1934) reported *G. pulex* from Pamir and Cashimir. Schellenberg (1937) recorded *G. lacustris* from western and northern Tibet. Karaman & Pinkster (1977) mentioned *G. lacustris* from the Indian Himalayas mountain range. Barnard & Dai (1988) described *G. lasaensis* from Lhasa.

To investigate the diversity of *Gammarus* in the hitherto unstudied eastern part of the Tibet Plateau, an expedition was organized by the authors, from the 2nd of August till the 27th of September, 2001. Along the Sichuan-Tibet highway, we reached Lhasa by car, the capital of the Tibet Autonomous Region. Then we visited Nyalam, a city on the southern hillside of the Himalayan Mountains. After that, we returned to Lhasa, and left the Tibet Plateau along the Qinghai-Tibet highway. The collection was made at each possible stop during the travel, but only in 4 localities *Gammarus* Amphipoda was found (Map 1).

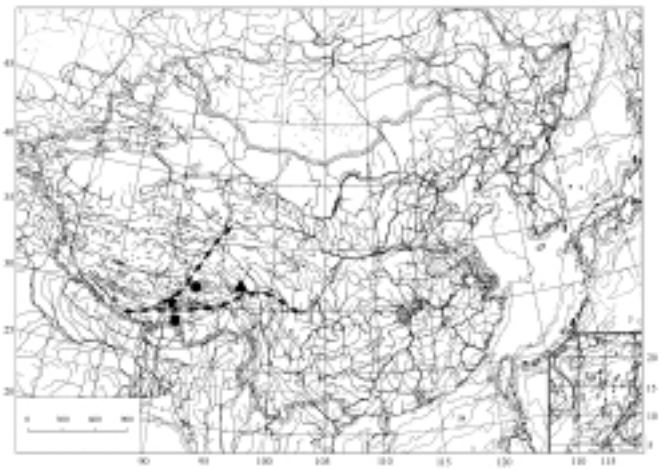
Three new species of the genus *Gammarus* were found after checking the collection and described in the present paper. The fourth species, *Gammarus lasaensis* Barnard & Dai, 1988 was studied based on the collection of the Institute of Zoology, Chinese Academy of Sciences, Beijing (IZCAS).

All holotypes and parts of paratypes of this study are deposited in IZCAS. Parts of paratypes are deposited in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research, National University of Singapore, Singapore.

SYSTEMATICS

Gammarus Fabricius, 1775

***Diagnosis.* –** Antenna 1: primary flagellum longer than peduncle, accessory flagellum with more than 2 articles.



Map 1. Localities of freshwater amphipods from Tibet. Circle = *Gammarus frigidus*, new species; triangle = *G. sinuolatus*, new species; square = *G. jaspidus*, new species; pentangle = *G. lasaensis* Barnard & Dai, 1988.

Antenna 2: shorter than antenna 1, flagellum with or without calceoli. Maxilla 1: left and right palps asymmetric. Maxilla 2: inner plate with a diagonal row of plumose setae. Gnathopods 1 and 2: palm of gnathopod 1 more oblique than palm of gnathopod 2, palms with one or more median spines. Uropod 1: peduncle with 1 basofacial spine. Telson: deeply cleft. Coxal gills: present in pereopods 2-7.

Species Composition. – *Gammarus* is represented by about 130 species worldwide now. Barnard & Barnard (1983) reviewed the freshwater Amphipoda worldwide and 117 species were listed under the genus *Gammarus*. After 1983, more than 20 species have been reported by several authors (Karaman & Pinkster, 1987; Barnard & Dai, 1988; Morino & Whitman, 1995; Stock et al., 1998; Hou & Li, 2002a, b, 2003a, b, c, d; Hou, Li & Zheng, 2002; Hou, Li & Morino, 2002; Hou, Li & Koenemann, 2002). Because the genus *Gammarus* is based on specimens collected from limited areas of the world, it is expected that the genus *Gammarus* will overrun 200 species.

Gammarus lasaensis, Barnard & Dai, 1988

Gammarus lasaensis Barnard & Dai, 1988: 85-112, figs. 11-13.

Material examined. – 21 males, 21 female and 2 juveniles, Lhasa, Tibet, China, collected by Mr. Yinheng Han (IZCAS), 21 May.1980.

Diagnosis. – Gnathopods: propodus of gnathopods 1 and 2 with 2 and 3 median palmar spines, respectively. Epimeral plates: epimeral plates 2 and 3 with moderate tooth on posterodistal corners. Uropod 3: inner ramus reaching about 75% of article 1 of outer ramus, both inner and outer rami armed with plumose setae.

Distribution. – Lhasa, Tibet, China.

Gammarus frigidus, new species
(Figs. 1-5)

Material examined. – Holotype - male, 13.1 mm (IZCAS-I-A0069), altitude 4500 m, living in a swamp of Nagqu County (31.4°N, 92.0°E), Tibet, China, 9 Sep.2001.

Paratypes - 15 males, 7 females, 2 juveniles (IZCAS), 8 males, 3 females (ZRC), same data as holotype.

Diagnosis. – Gnathopod 1: propodus ovate, palm not deeply oblique, similar to that of female in shape. Uropod 3: inner ramus about 90% of article 1 of outer ramus, article 2 distinct, both rami fringed with plumose setae. Telson: with distal spines, but no dorsal spines. Maxilla 1: inner plate with about 19 plumose setae. Maxilla 2: inner plate densely setose, with a row of 32 plumose setae on inner face.

Description. – Holotype, 13.1 mm. Head (Fig. 3A): cephalic lateral lobe truncate, inferior antennal sinus deep, eyes ovate and medium in size. Antenna 1 (Fig. 4A): peduncular articles 1-3 in length ratio 1 : 0.55: 0.3, with some distal setae; primary flagellum with 21 articles, most with aesthetascs; accessory flagellum with 3 articles. Antenna 2 (Fig. 4B): gland cone attaining peduncular article 3, article 4 about as long as article 5, both with 3 groups of setae on posterior margins; flagellum with 12 articles, some articles with calceoli.

Upper lip (Fig. 1G): subrounded, bearing minute setae. Mandibles (Figs. 1A, C), left incisor 5-dentate, lacinia mobilis with 4 teeth, molar triturative, article 2 of palp with 15 stiff setae, article 3 about 75% of article 2 in length, with 3 A-setae on outer face, 3 B-setae on inner face, about 15 D-setae and 5 E-setae; right incisor 4-dentate, lacinia mobilis bifurcate. Lower lip (Fig. 1B): inner lobe lacking. Maxilla 1 (Figs. 1E, F): inner plate with 19 plumose setae, article 2 of left palp with 7 slender spines and 2 stiff setae; article 2 of right palp with 5 blunt spines and 1 stiff seta. Maxilla 2 (Fig. 1D): inner plate densely setose, with 32 plumose setae, which are subparallel to inner margin; outer plate broad, bearing apical setae. Maxilliped (Fig. 1H): inner plate with 3 apical spines, outer plate with 11 spines on medial margin and 5 apical pectinate setae, palp with 4 articles.

Coxal plates: coxal plates 1-3 subrectangular (Figs. 2A, C, 3C), with 1-3 setae on anterior corner and 1 seta on posterior corner; coxal plate 4 excavated (Fig. 3D), as wide as long, with 2 and 5 setae on anterior corner and posterior margin, respectively; anterior lobe of coxal plates 5 and 6 small (Figs. 5A, B), posterior margin with 1-2 short setae; coxal plate 7 (Fig. 5C) with 6 setae on posterior corner.

Gnathopod 1 (Figs. 2C, D): basis short, with long setae on anterior and posterior margins; carpus about 75% of length of propodus; propodus pyriform, palm not very oblique, bearing 1 medial spine, and 9 spines on posterior margin; dactylus about half of posterior margin of propodus, with 1 seta on outer margin. Gnathopod 2 (Figs. 2A, B): carpus and propodus longer than those of gnathopod 1, carpus a little shorter than propodus, with subparallel margins; propodus subrectangular, palm transverse, bearing 1 medial spine and 4 spines on posterior corner; dactylus fitting the palm, with 1 seta on outer margin.

Pereopods 3 and 4 (Figs. 3C, D, H, I): pereopods 3 and 4 with long straight setae on posterior margins, articles 5 and 6 accompanied by several spines on posterior margin, dactylus slender, with 1 seta on anterior margin and 1-2 setae at joint of nail.

Pereopods 5-7 (Figs. 5A-F): subequal in length, anterior margin of bases weakly convex, with 5 short spines and several long setae proximally, posterior margin nearly straight in pereopod 5, weakly concave distally in pereopod 6, processed in pereopod 7, with a row of 13 short setae, inner face of pereopod 7 with a small seta; articles 4 and 5 mainly with 2-3 groups of spines along anterior and posterior margins; article 6 with 4-5 clusters of spines on anterior margin and some short setae on posterior margins; dactylus slender, with 1 seta on posterior margin and 2 setae at joint of nail.

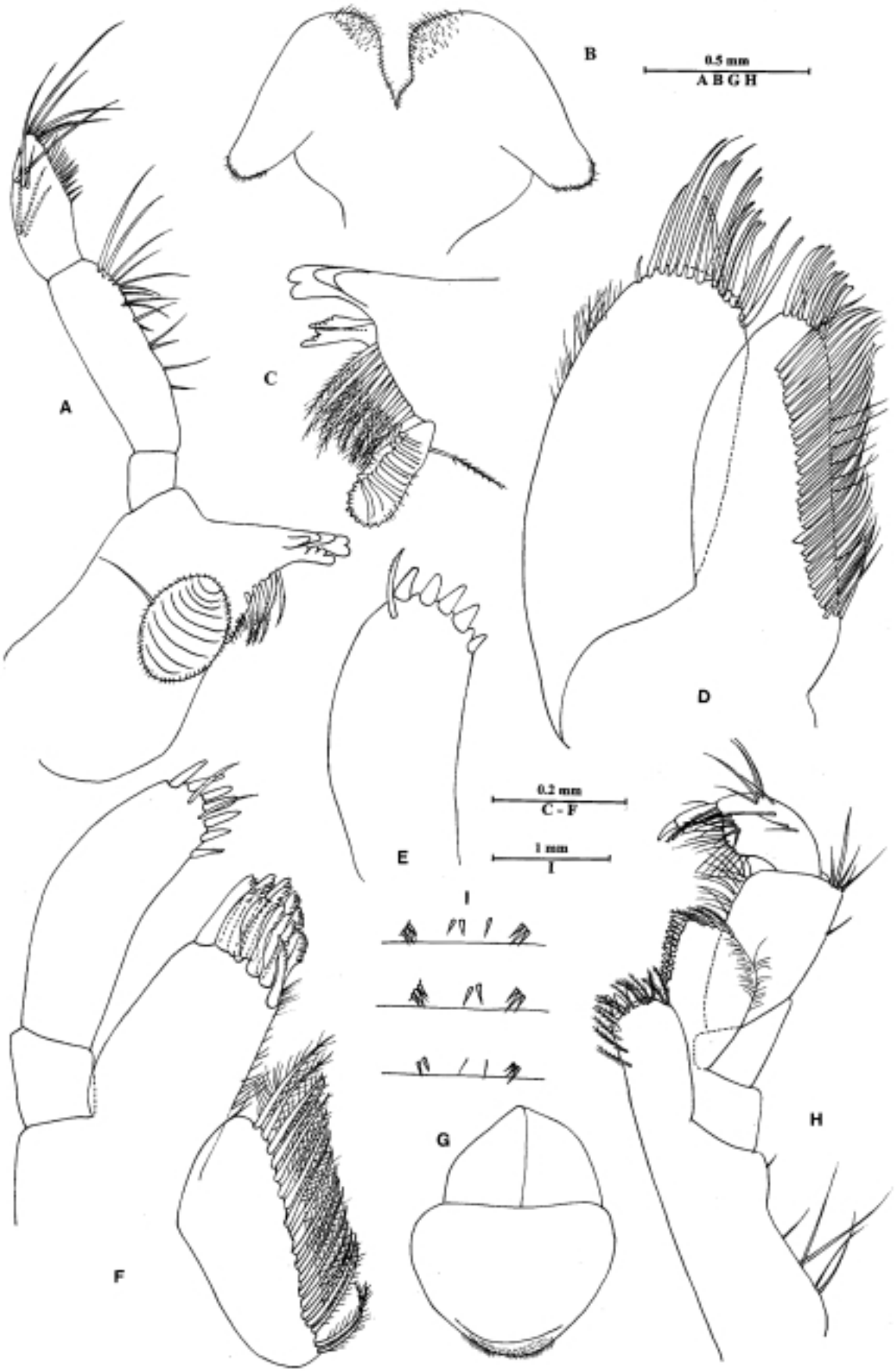


Fig. 1. *Gammarus frigidus*, new species, male, holotype. A. left mandible, B. lower lip, C. incisor of right mandible, D. maxilla 2, E. palp of right maxilla 1, F. left maxilla 1, G. upper lip, H. maxilliped, I. urosomites 1-3 (dorsal view).

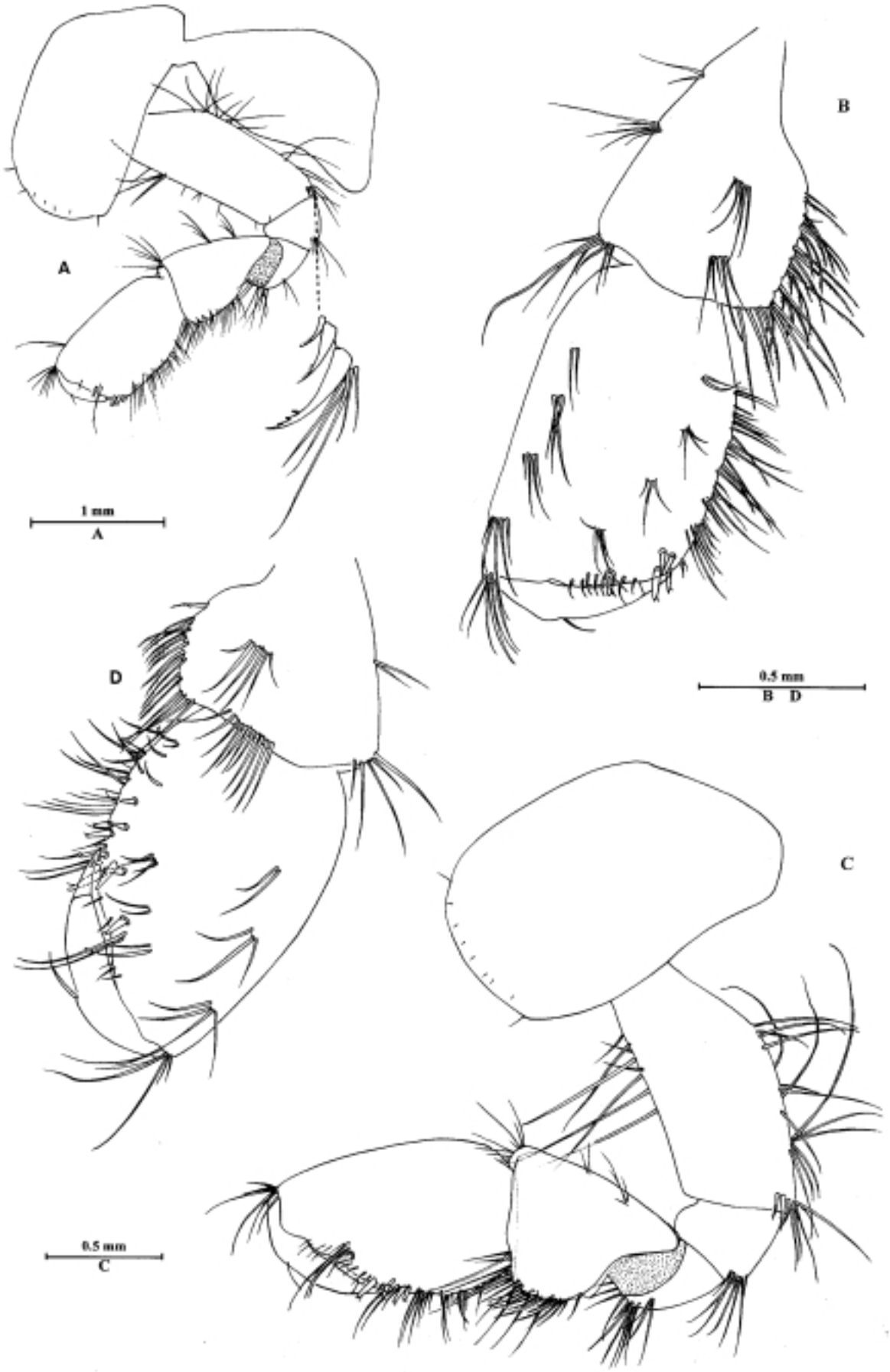


Fig. 2. *Gammarus frigidus*, new species, male, holotype. A. gnathopod 2, B. propodus of gnathopod 2, C. gnathopod 1, D. propodus of gnathopod 1.

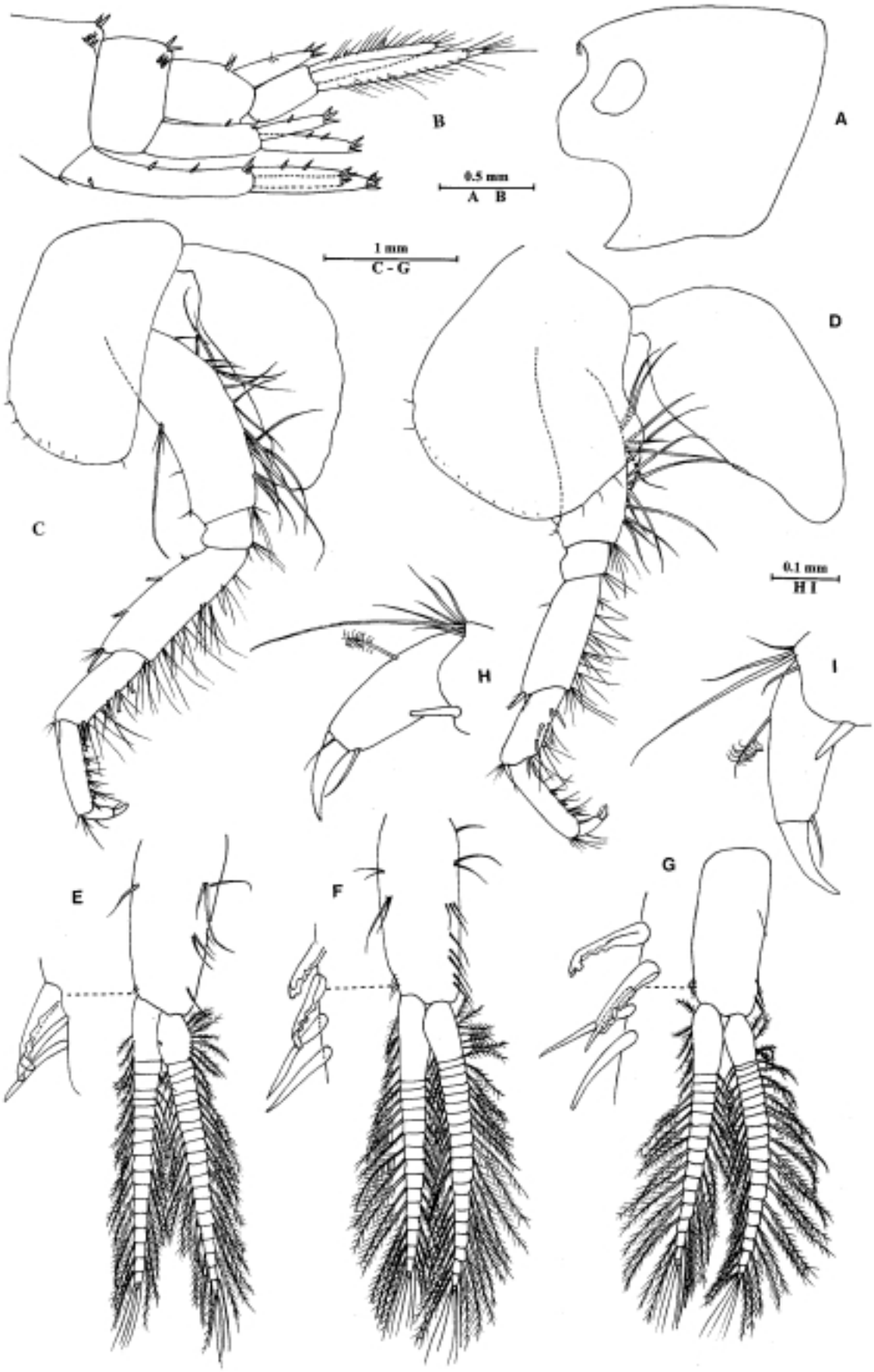


Fig. 3. *Gammarus frigidus*, new species, male, holotype. A. head, B. urosomites 1-3 (lateral view), C. pereopod 3, D. pereopod 4, E. pleopod 1, F. pleopod 2, G. pleopod 3, H. dactylus of pereopod 3, I. dactylus of pereopod 4.

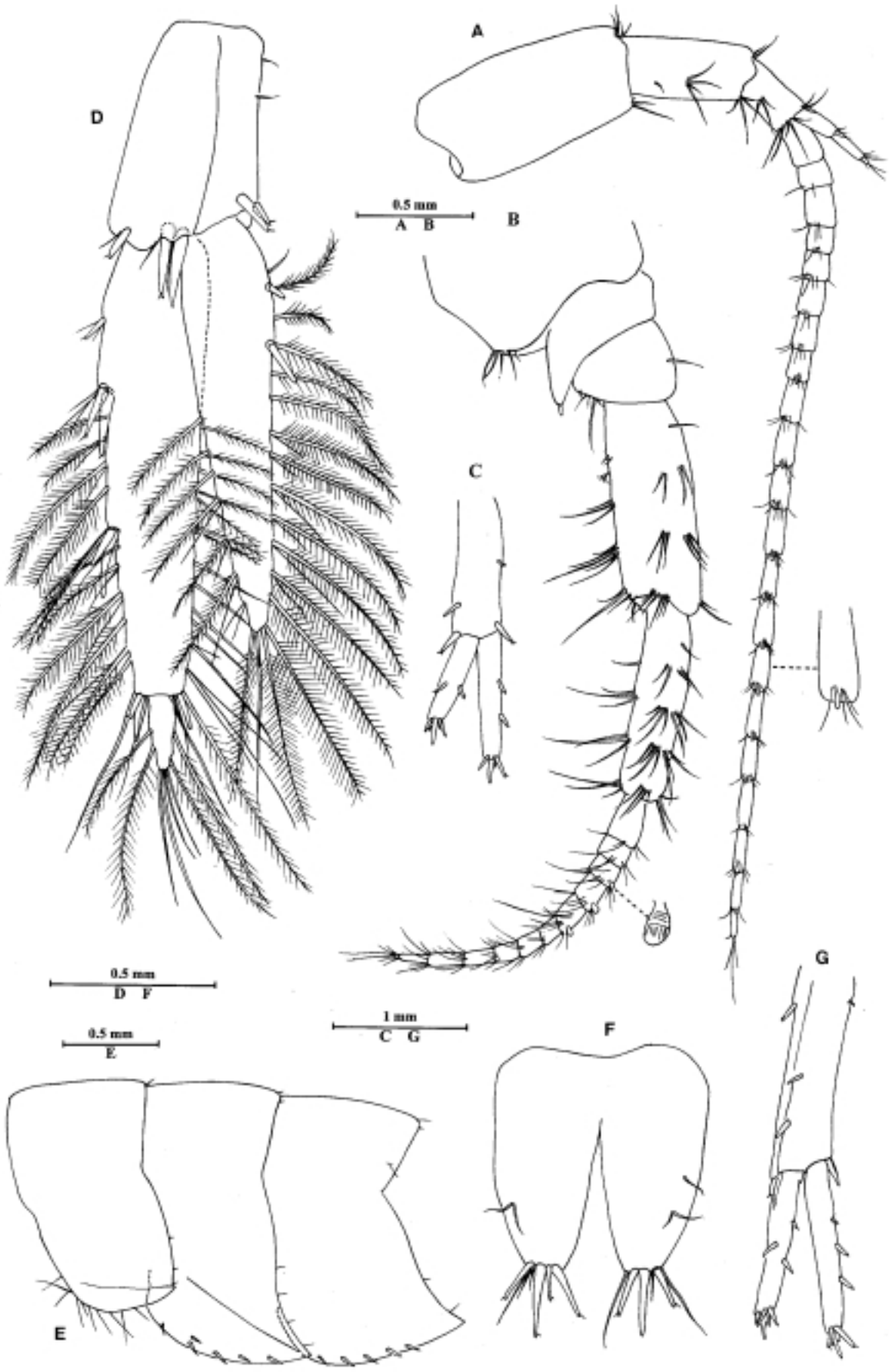


Fig. 4. *Gammarus frigidus*, new species, male, holotype. A. antenna 1, B. antenna 2, C. uropod 2, D. uropod 3, E. epimeral plates 1-3, F. telson, G. uropod 1.

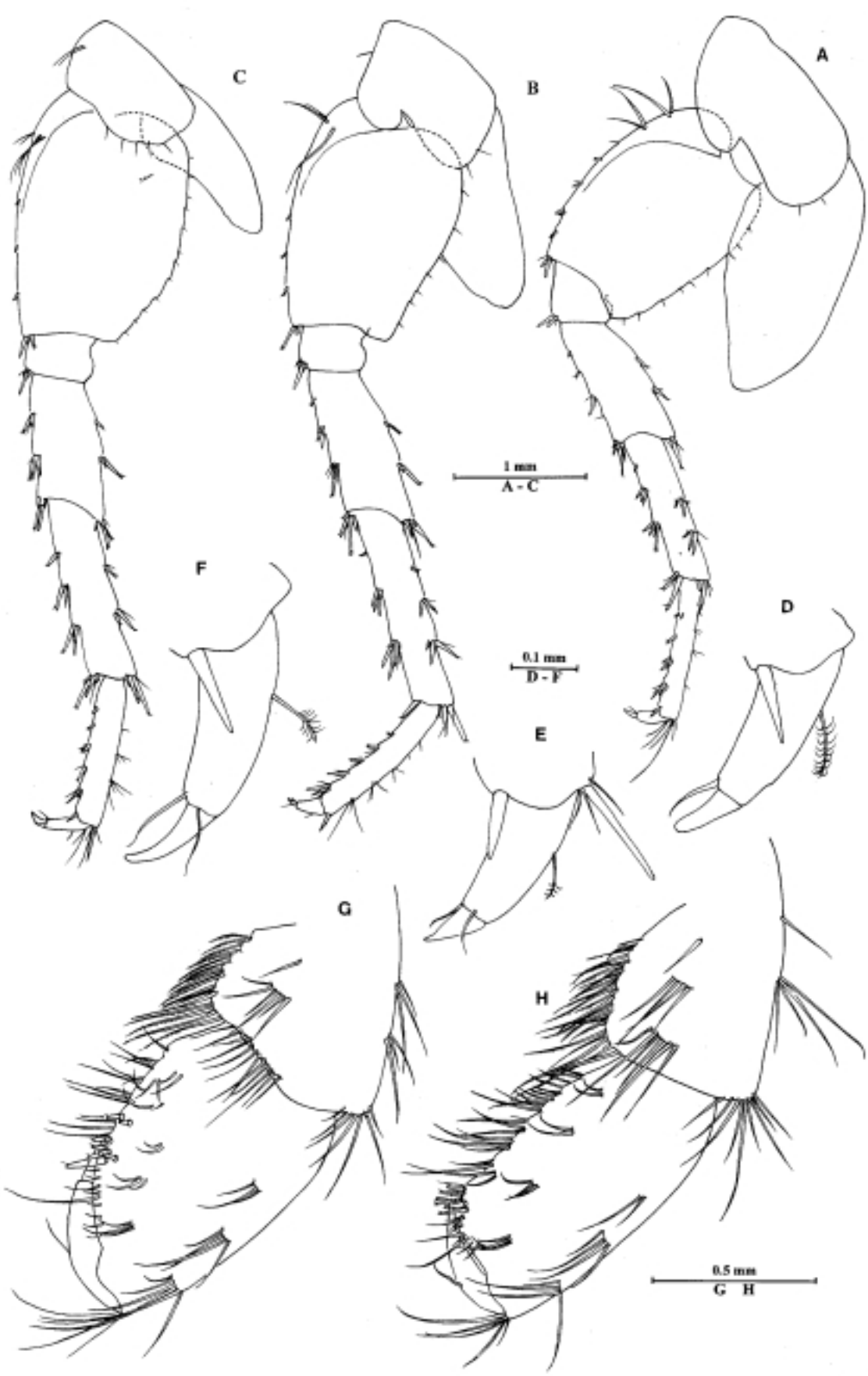


Fig. 5. *Gammarus frigidus*, new species, male: A - F; female: G, H. A. pereopod 5, B. pereopod 6, C. pereopod 7, D. dactylus of pereopod 5, E. dactylus of pereopod 6, F. dactylus of pereopod 7, G. propodus of gnathopod 1, H. propodus of gnathopod 2.

Coxal gills (Figs. 2A, 3C, D, 5A-C): coxal gills of pereopods 2-7 flat.

Epimeral plates (Fig. 4E): epimeral plates 1-3 progressively acuminate on posterior corner, with 2-4 short setae on posterior margins; epimeral plate 1 ventrally rounded, with 10 setae on anterior corner; epimeral plate 2 with 5 spines on ventral margin and 1 subventral spine; epimeral plate 3 with 5 ventral spines. Pleopods (Figs. 3E-G): subequal in length, peduncle with some dorsal setae, bearing 2 retinacula accompanied by 1-3 setae; rami with about 22 articles, fringed with plumose setae.

Urosomites (Figs. 1I, 3B): urosomites 1 and 2 slightly elevated. Urosomite 1 with 3-2-1-3 spines on dorsal margin from left to right, urosomite 2 with 3-2-3 spines on dorsal margin, urosomite 3 with 2 spines-2 setae-2 spines on dorsal margin. Uropod 1 (Fig. 4G): peduncle longer than rami, with 1-1-2 and 1-1 spines on outer and inner margins, respectively; outer ramus with 1 and 2 spines on outer and inner margins, respectively; inner ramus with 3 spines on outer margin. Uropod 2 (Fig. 4C): peduncle with 2 spines on each side; outer ramus shorter than inner ramus, with 1 spine on each side; inner ramus with 2 spines on outer margin. Uropod 3 (Fig. 4D): peduncle with distal spines; length of inner ramus about 90% of article 1 of outer ramus, with 2 lateral spines; article 1 of outer ramus with 1-2-2 spines on outer margin and 3 distal spines, article 2 about 17% of length of article 1, both rami armed with plumose setae.

Telson cleft (Fig. 4F), each lobe with 3-4 distal spines accompanied by 3 setae and 2-3 dorsal short setae.

Female. **–** Body length 10.05 mm. Gnathopod 1 (Fig. 5G): similar to that of male in shape, with 2 spines on posterior margin and 5 spines on posterior corner. Gnathopod 2 (Fig. 5H): carpus and propodus elongate, propodus subrectangular, length about two times width, palm truncate, with 6 slender spines on posterior corner. Oostegites: present on pereopods 2-5.

Etymology. **–** The specific name comes from its biotope, the high altitude and frigid climate.

Remarks. **–** *Gammarus frigidus* belongs to the *G. pulex*-group (Karaman & Pinkster, 1977). *Gammarus frigidus* is closely related to *G. lasaensis* Barnard & Dai, 1988 in that maxilla 2 of both species have more than 30 plumose setae on the inner plate and their telsons are with few setae. *Gammarus frigidus* is separated from *G. lasaensis* by having an ovate propodus in the gnathopod 1 and an elongate inner ramus of the uropod 3, with nearly reaching the end of article 1 of outer ramus.

Gammarus frigidus is also similar to *G. stagnarius* Hou, Li & Morino, 2002, in pereopods 3 and 4 with long straight setae on posterior margins, and the shape of epimeral plates 1-3. *Gammarus frigidus* is distinguished from *G. stagnarius* by antenna 2 with calcoli, propodus of gnathopod 1 ovate, and inner ramus of uropod 3 reaching about 90% of article 1 of outer ramus.

Distribution. **–** Nagqu, Tibet, China (present study).

Gammarus jaspidus, new species

(Figs. 6-11)

Material examined. **–** Holotype - male, 11.5 mm (IZCAS-I-A0067), altitude 4500 m, the Lake YamzhoYumco (about 8 km away from Yarlung Zangbo River), (28.8°N, 91.0°E), Nagarze County, 28 Aug.2001.

Paratypes - 4 males, 3 females, 3 juveniles (IZCAS), 2 males, 1 female (ZRC), same data as holotype.

Diagnosis. **–** Pleonites: pleonites 1-3 weakly elevated. Urosomites: urosomites 1 and 2 with laterally compressed, dorsal elevations, bearing 3-3-1 and 2-2-2 spines on dorsal margin, respectively.

Description. **–** Holotype, 11.5 mm. Head (Fig. 6A): cephalic lateral lobe truncate, inferior antennal sinus distinct, eyes subreniform. Antenna 1 (Fig. 6D): peduncular articles 1-3 in length ratio 1 : 0.59 : 0.34, with distal setae; flagellum with 24 articles, most articles with aesthetascs; accessory flagellum with 3 articles, article 3 small. Antenna 2 (Figs. 9D, E): peduncular article 4 about as long as article 5, both with 3 clusters of short setae along both margins; flagellum with 12 articles, some articles with calceoli.

Upper lip (Fig. 6E) subrounded, with minute setae. Mandibles (Figs. 6F, G): left incisor 5-dentate, lacinia mobilis with 4 dentitions, molar triturative, article 2 of palp with 12 setae, length of article 3 about 73% of article 2, with 4 A-setae on inner face, 4 B-setae on outer face, a row of D-setae and 5 E-setae; right incisor 4-dentate, lacinia mobilis bifurcate, molar triturative, with 1 seta. Lower lip (Fig. 6I): inner plate lacking. Maxilla 1 (Figs. 6J, K): inner plate with 17 plumose setae, article 2 of left palp broad, with 8 slender spines and 2 stiff setae; article 2 of right palp broader, with 5 blunt spines and 2 stiff setae. Maxilla 2 (Fig. 6L): inner plate with a row of 27 plumose setae on inner face; outer plate broad, with apical setae. Maxilliped (Fig. 6H): inner plate with 3 apical spines and 1 subapical spine, outer plate with 10 slender spines on medial margin and 4 pectinate setae apically, article 4 of palp slender.

Coxal plates: coxal plates of pereopods 1-3 subrectangular (Figs. 7A, B, 8D), with 1-3 setae on anterior corner and 1 seta on posterior corner; coxal plate 4 excavated (Fig. 8E), with 1 anterior seta and 4 setae on posterior margin; coxal plates 5 and 6 (Figs. 8A, B): anterior lobes small, posterior lobe with 2-3 short setae on posterior corners; coxal plate 7 (Fig. 8C) with 4 setae on posterior corner.

Gnathopod 1 (Figs. 7A, E): basis with long setae on anterior and posterior margins, and 5 spinulate setae on distal margin; carpus triangular, about 70% of propodus in length; propodus pyriform, palm oblique, bearing 1 median palmar spine, with 10 spines on posterior margin and 6 facial spines; dactylus with 1 seta on outer margin. Gnathopod 2 (Figs. 7B, F): carpus about 70% of propodus in length, parallel-sided; palm of

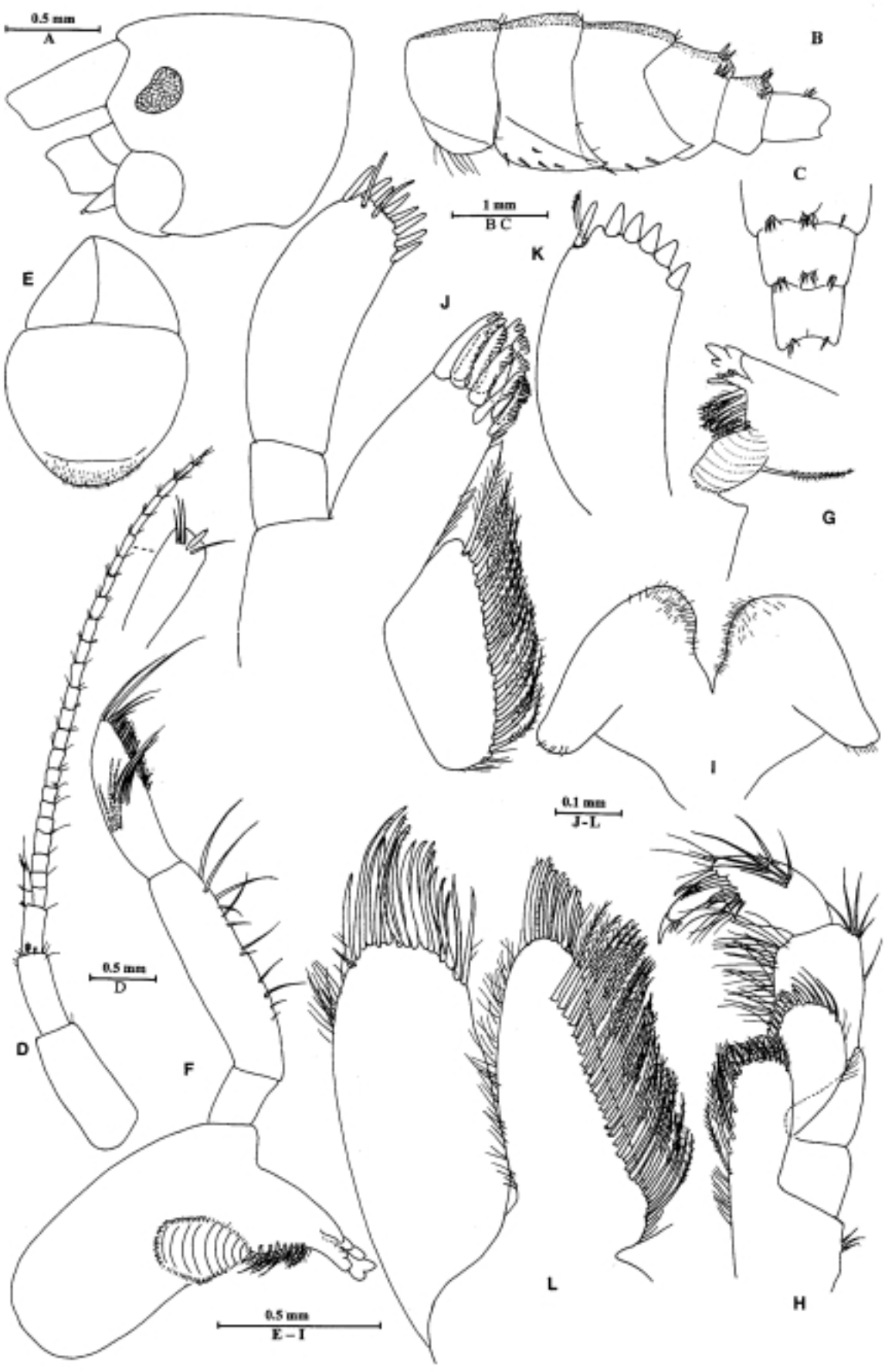


Fig. 6. *Gammarus jaspidus*, new species, male, holotype. A. head, B. pleonites and urosomites (lateral view), C. urosomites (dorsal view), D. antenna 1, E. upper lip, F. left mandible, G. incisor of right mandible, H. maxilliped, I. lower lip, J. left maxilla 1, K. palp of right maxilla 1, L. maxilla 2.

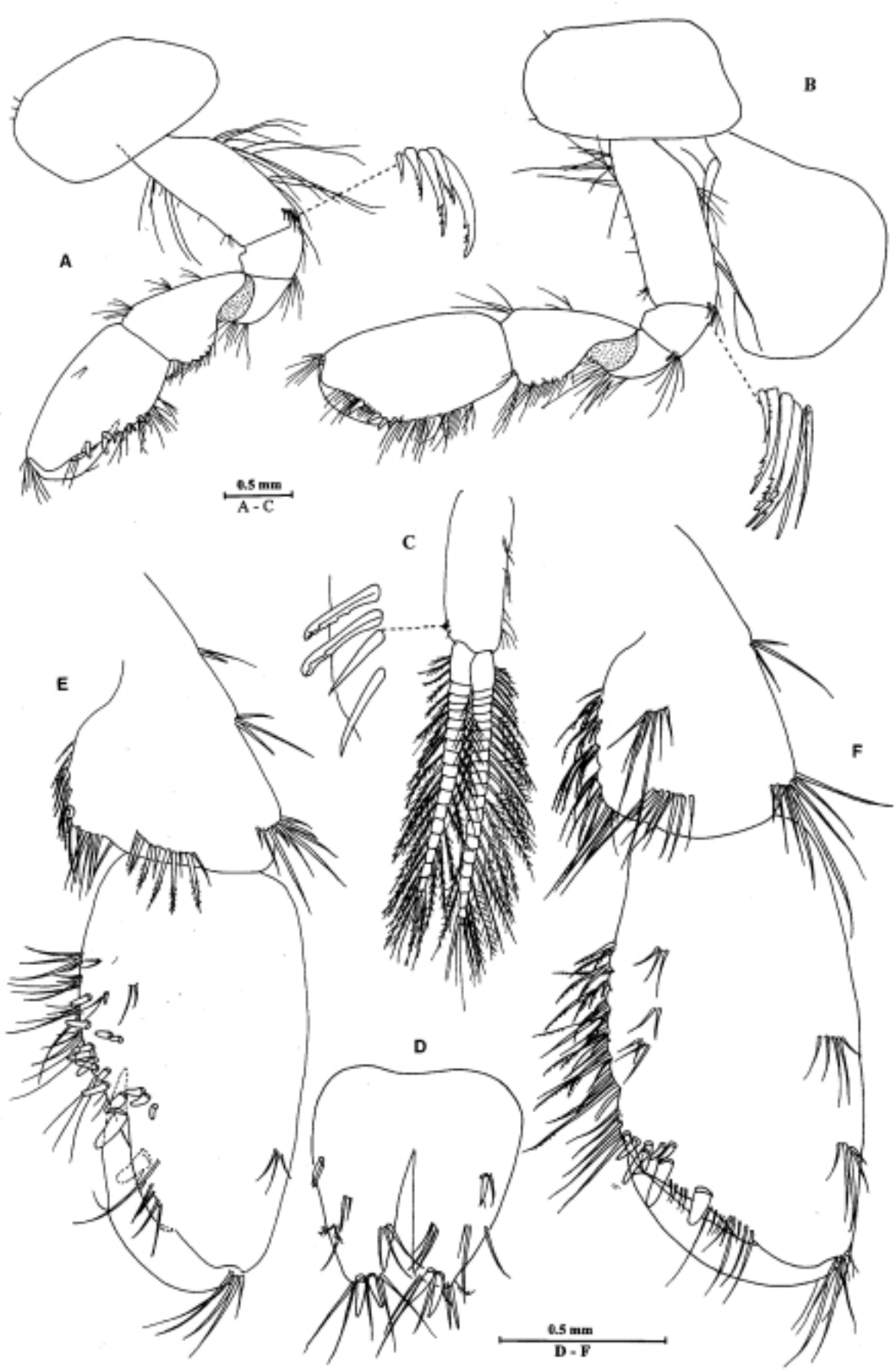


Fig. 7. *Gammarus jaspidus*, new species, male, holotype. A. gnathopod 1, B. gnathopod 2, C. pleopod 1, D. telson, E. propodus of gnathopod 1, F. propodus of gnathopod 2.

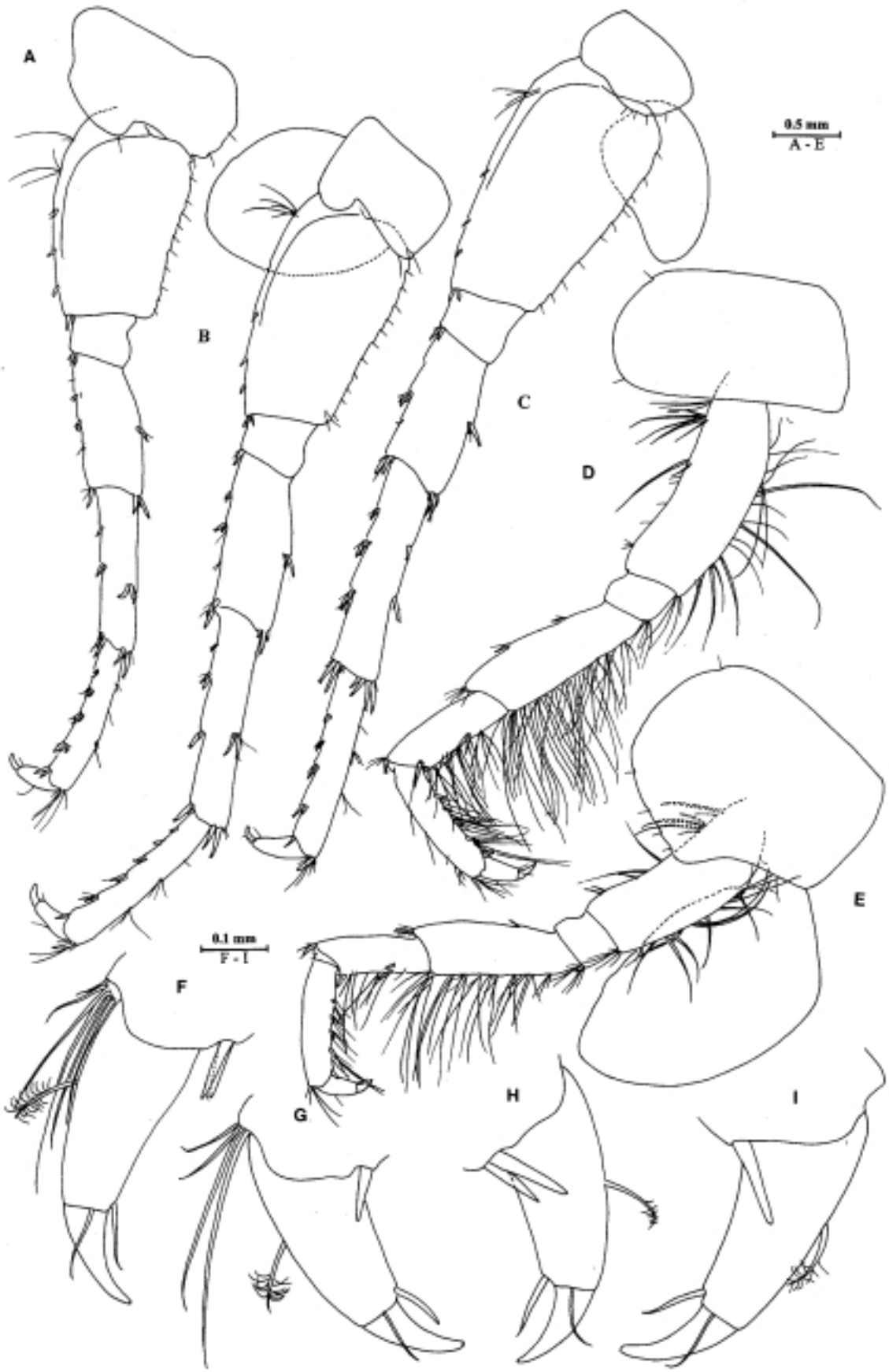


Fig. 8. *Gammarus jaspidus*, new species, male, holotype. A. pereopod 5, B. pereopod 6, C. pereopod 7, D. pereopod 3, E. pereopod 4, F. dactylus of pereopod 3, G. dactylus of pereopod 4, H. dactylus of pereopod 5, I. dactylus of pereopod 6.

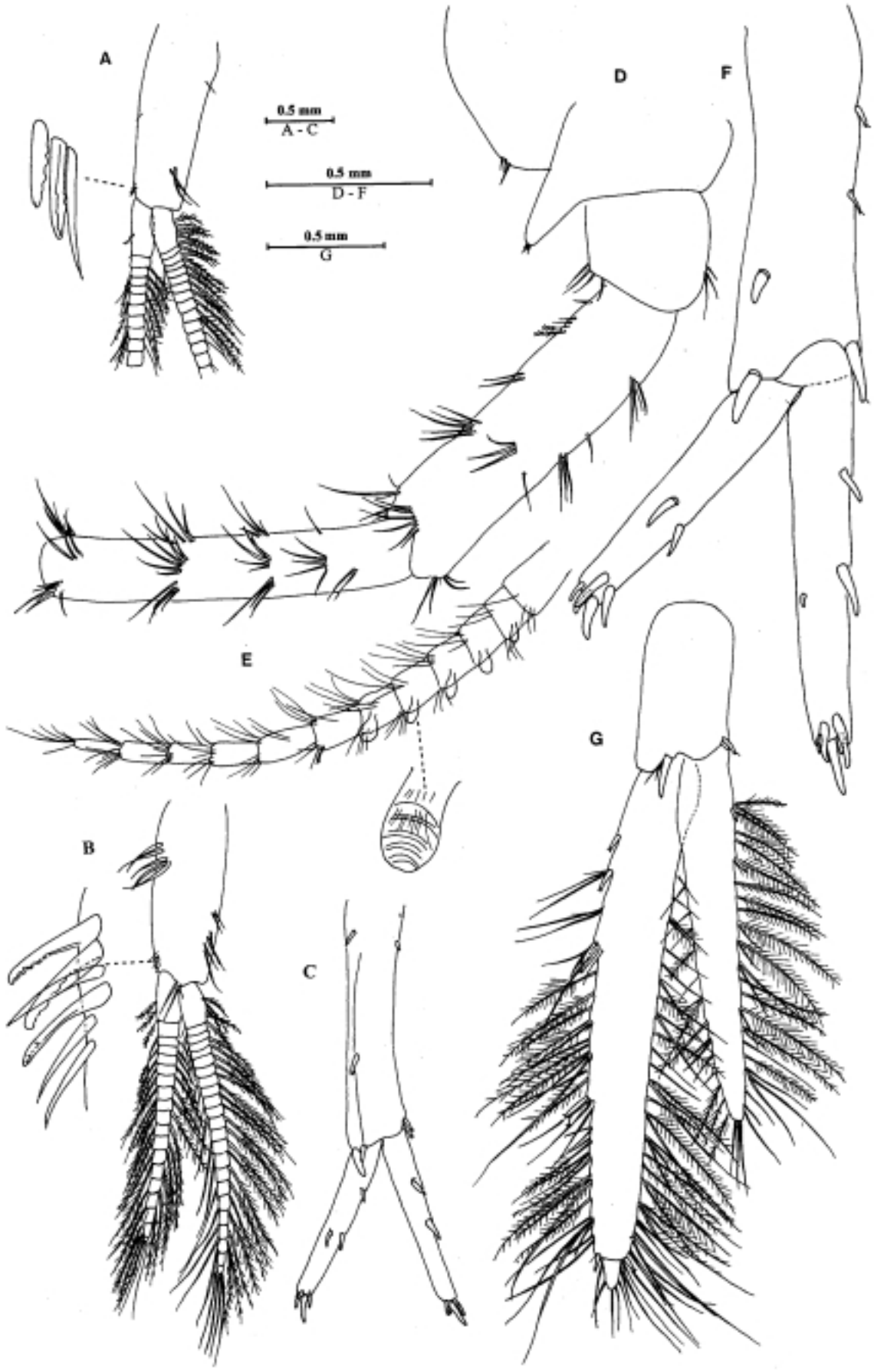


Fig. 9. *Gammarus jaspidus*, new species, male, holotype. A. pleopod 3, B. pleopod 2, C. uropod 1, D. peduncle of antenna 2, E. flagellum of antenna 2, F. uropod 2; G, uropod 3.

Fig. 10. *Gammarus jaspidus*, new species, female. A. gnathopod 2, B. gnathopod 1, C. oostegite of gnathopod 2, D. propodus of gnathopod 1, E. propodus of gnathopod 2.

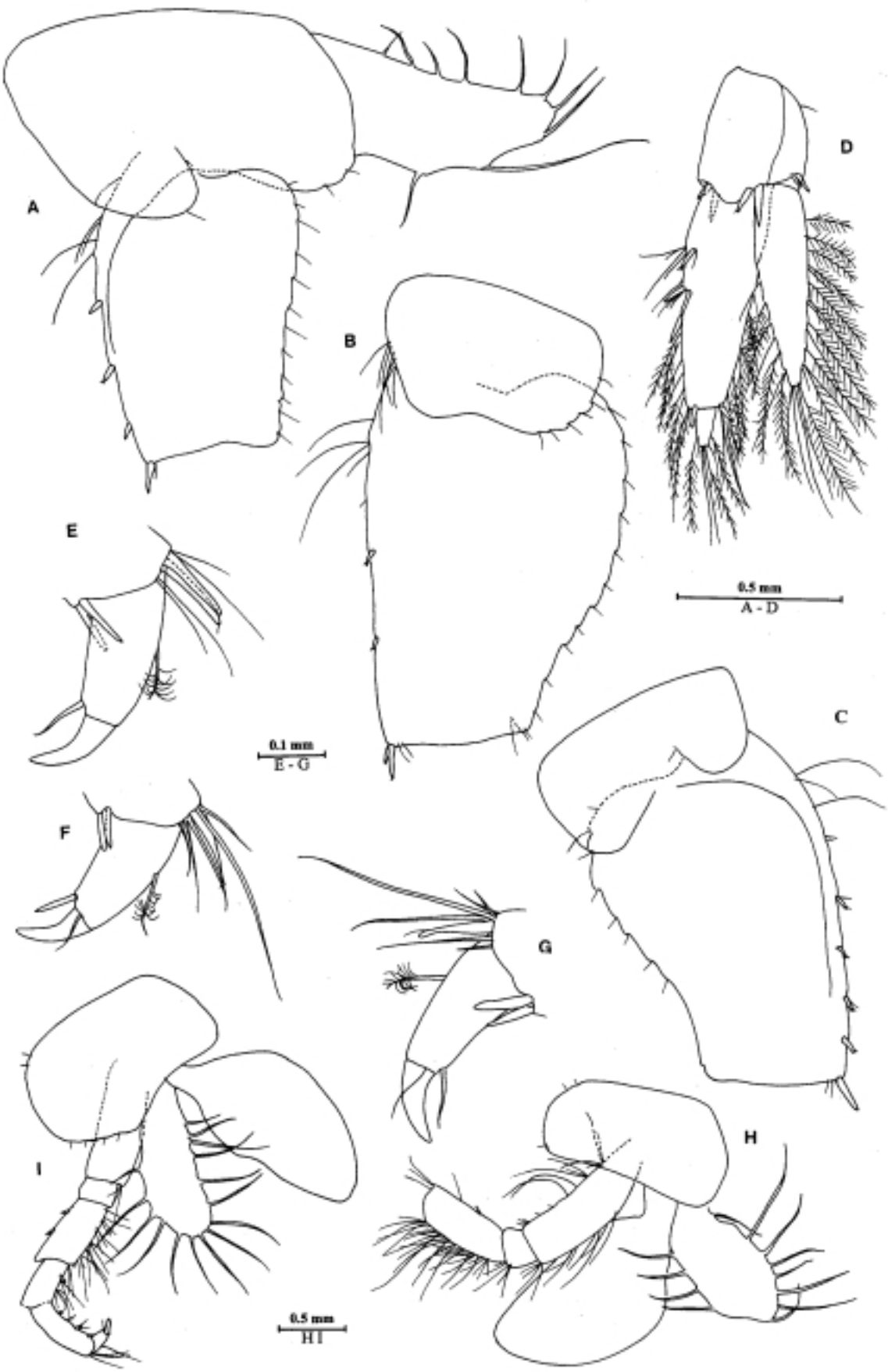


Fig. 11. *Gammarus jaspidus*, new species, female. A. basis of pereopod 5, B. basis of pereopod 7, C, basis of pereopod 6, D. uropod 3, E. dactylus of pereopod 7, F. dactylus of pereopod 5, G. dactylus of pereopod 6, H. pereopod 3, I. pereopod 4.

propodus with 1 median spine and 6 spines on posterior corner; dactylus fitting with palm margin of propodus.

Pereopod 3 (Figs. 8D, F): pereopod 3 with long straight setae on posterior margin; articles 5 and 6 accompanied by several spines on posterior margin; dactylus slender, with 1 seta on outer margin and 2 setae at joint of nail. Pereopod 4 (Figs. 8E, G): shorter than pereopod 3, posterior margin with long straight setae.

Pereopods 5-7 (Figs. 8A-C, H, I): pereopods 6 and 7 longer than pereopod 5, anterior margin of bases of pereopods 5-7 slightly convex, with 5 short spines and several setae proximally, posterior margin nearly straight in pereopod 5, weakly sinusoid in pereopods 6 and 7, with a row of 12 short setae, inner face of bases of pereopods 6 and 7 with a few short setae; articles 4-6 with groups of spines on anterior margin, without long setae; dactylus slender, with 1 seta on outer margin and 2 setae at joint of nail.

Coxal gills (Figs. 7B, 8B, C, E): coxal gills of pereopods 2-7 ovate.

Pleonites (Fig. 6B): weakly elevated, with several short setae on dorsal margins. Epimeral plates: epimeral plates 1-3 with progressively acuminate posterior corners, with a few short setae on posterior margin; epimeral plate 1 ventrally rounded, with 6 setae on anterior corner; epimeral plate 2 with 5 spines on ventral margin; epimeral plate 3 with 3 spines on ventral margin. Pleopods (Figs. 7C, 9A, B): subequal in length, peduncle with some long setae, 2-3 retinacula accompanied by 1-3 setae; rami with about 22 articles, fringed with plumose setae.

Urosomites (Figs. 6B, C): urosomites 1 and 2 with laterally compressed, dorsal elevations, bearing 3-3-1 and 2-2-2 spines on dorsal margin, respectively; urosomite 3 with 2 spines on dorsal margin. Uropod 1 (Fig. 9C): both rami subequal. Uropod 2 (Fig. 9F): peduncle with 1-1 and 1-1-1 spines on outer and inner margins, respectively; outer ramus a little shorter than inner ramus. Uropod 3 (Fig. 9G): peduncle with 3 distal spines; rami slender; length of inner ramus about 70% of article 1 of outer ramus, with 1 lateral spine; article 1 of outer ramus with 1-1-2-2 lateral spines and 2 distal spines, article 2 stout; both rami armed with plumose setae.

Telson cleft (Fig. 7D), each lobe with 2 distal spines accompanied by 5 setae, 1 basolateral spine and 2-3 clusters of facial setae.

Female. **–** Body length 8.5 mm, ovigerous, with more than 20 eggs. Gnathopod 1 (Figs. 10B, D): with long setae on posterior margin, carpus a little shorter than propodus, propodus not as oblique as in male, with 8 spines on posterior margin, dactylus with 1 seta on outer margin. Gnathopod 2 (Figs. 10A, C, E): larger than gnathopod 1, propodus subrectangular, with 3 spines on posterior corner. Uropod 3 (Figs. 11D): stout, length of inner ramus about 90% of article 1 of outer ramus, both rami ornamented with plumose setae. Oostegites: oostegites in pereopods 2-5 broad or elongate (Figs. 10C, 11H, I, A), with many marginal setae.

Etymology. **–** From the Tibetan language, "YamzhoYumco" meaning jade-colored and changing into Latin "jaspidus".

Remarks. **–** *Gammarus jaspidus* belongs to *G. pulex*-group. *Gammarus jaspidus* is similar to *G. lacustris* Sars, 1863 in (1) the shape of the gnathopods, (2) the armature of the pereopods 3 and 4, (3) the ratio of the inner and outer ramus of uropod 3. *Gammarus jaspidus* differs from *G. lacustris* in (1) the urosomites 1 and 2, which laterally compressed and dorsally elevated, (2) the epimeral plates 2 and 3 not very acute, and (3) the telson with 1 basolateral spine and 3 groups of facial setae.

Gammarus jaspidus differs from *G. lasaensis* in the relatively slender body (stout in *G. lasaensis*) and the palm of propodus of gnathopods 1 and 2 without extra spines except for a main middle spine (*G. lasaensis* with 2 and 3 median palmar spines on the gnathopods 1 and 2, relatively).

Distribution. **–** Nagarze, Tibet, China (present study).

Gammarus sinuolatus, new species

(Figs. 12-17)

Material examined. **–** Holotype - male, 10.1 mm (IZCAS-I-A0071), altitude 3400 m, tributary of Lancang River, near Qamdo Town (31.1°N, 97.1°E), 15 Aug.2001.

Paratypes - 8 males, 7 females (IZCAS), 2 males, 2 females (ZRC), same data as holotype.

Diagnosis. **–** (1) Gnathopod 2: carpus and propodus with long setae on dorsal margins. (2) Pereopods 6 and 7: bases elongate and concave posteriorly, setae on posterior margin relatively long; articles 4 and 5 with 2 groups of spines accompanied by setae along anterior margins. (3) Uropod 3: inner ramus about one-third of outer ramus, both rami armed with long simple setae. (4) Epimeral plates: bearing long setae on ventral margins. (5) Urosomites: urosomites 1-3 armed with groups of long setae on dorsal margins. (6) Telson with long setae on dorsal face.

Description. **–** Holotype - male, 10.1 mm (IZCAS-I-A0071). Body: slender. Head (Fig. 12A): lateral cephalic lobe of head truncate, inferior antennal sinus distinct, eyes ovate. Antenna 1 (Fig. 14A): peduncular articles 1-3 in length ratio 1 : 0.75 : 0.45, with some distal setae; primary flagellum with 22 articles, most with aesthetascs; accessory flagellum with 4 articles. Antenna 2 (Fig. 15H): peduncular articles 4 and 5 subequal in length, both with 2-3 clusters of setae along anterior and posterior margins; flagellum with 10 articles, most articles with calceoli.

Upper lip (Fig. 12E) convex, with minute setae. Mandibles (Figs. 12L, J): left incisor 5-dentate; lacinia mobilis with 4 weak dentitions, molar triturative, article 2 of palp with 10 stiff setae, article 3 a little shorter than article 2, with 5 A-setae on outer face, 3 B-setae on inner face, about 20 D-setae and 4 E-setae; right incisor 4-dentate, lacinia mobilis bifurcate. Lower lip (Fig. 12F): inner lobe absent. Maxilla 1

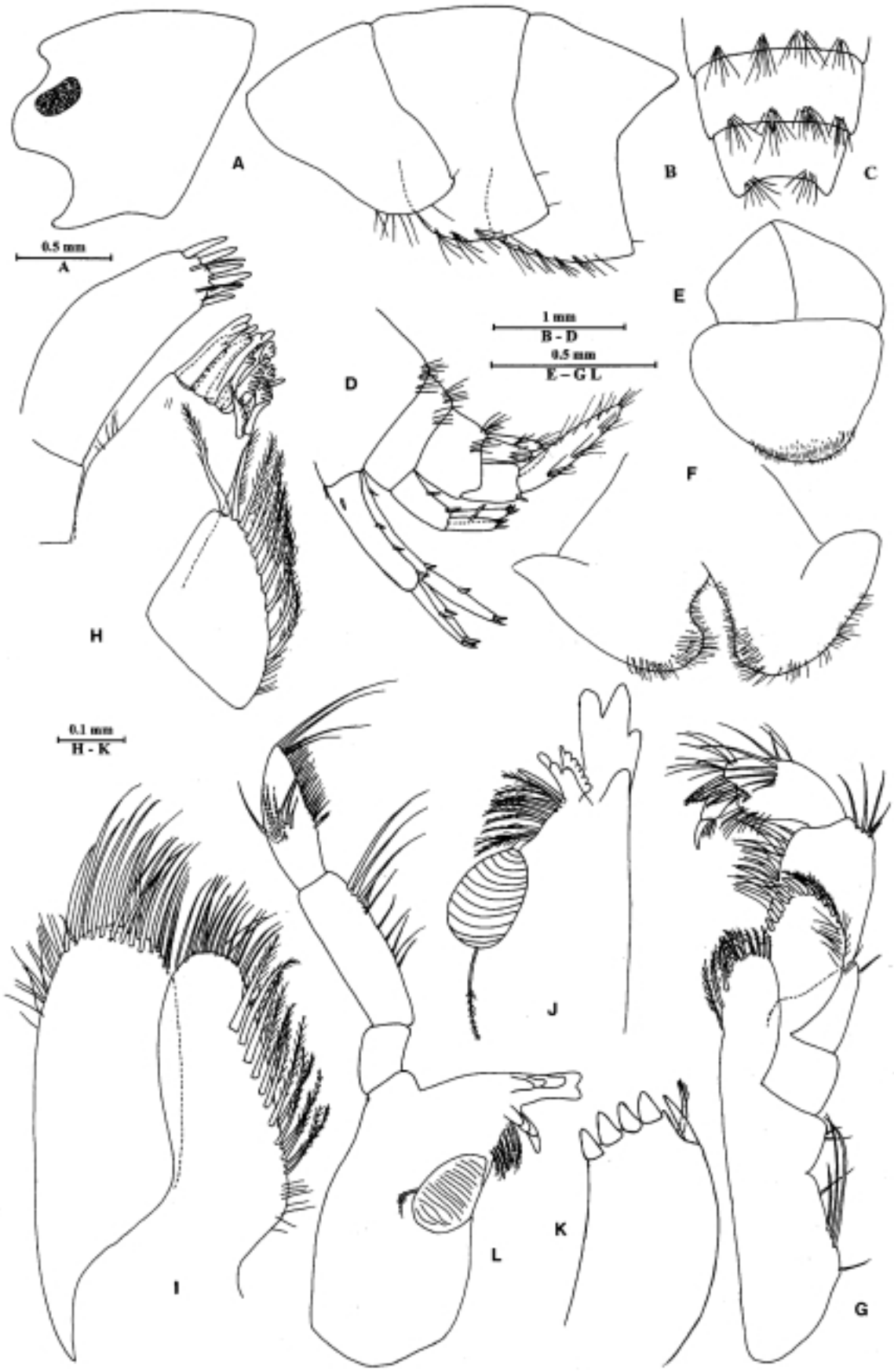


Fig. 12. *Gammarus sinuolatus*, new species, male, holotype. A. head, B. epimeral plates, C. urosomites (dorsal view), D. urosomites (lateral view), E. upper lip, F. lower lip, G. maxilliped, H. left maxilla 1, I. maxilla 2, J. incisor of right mandible, K. palp of right maxilla 1, L. left mandible.

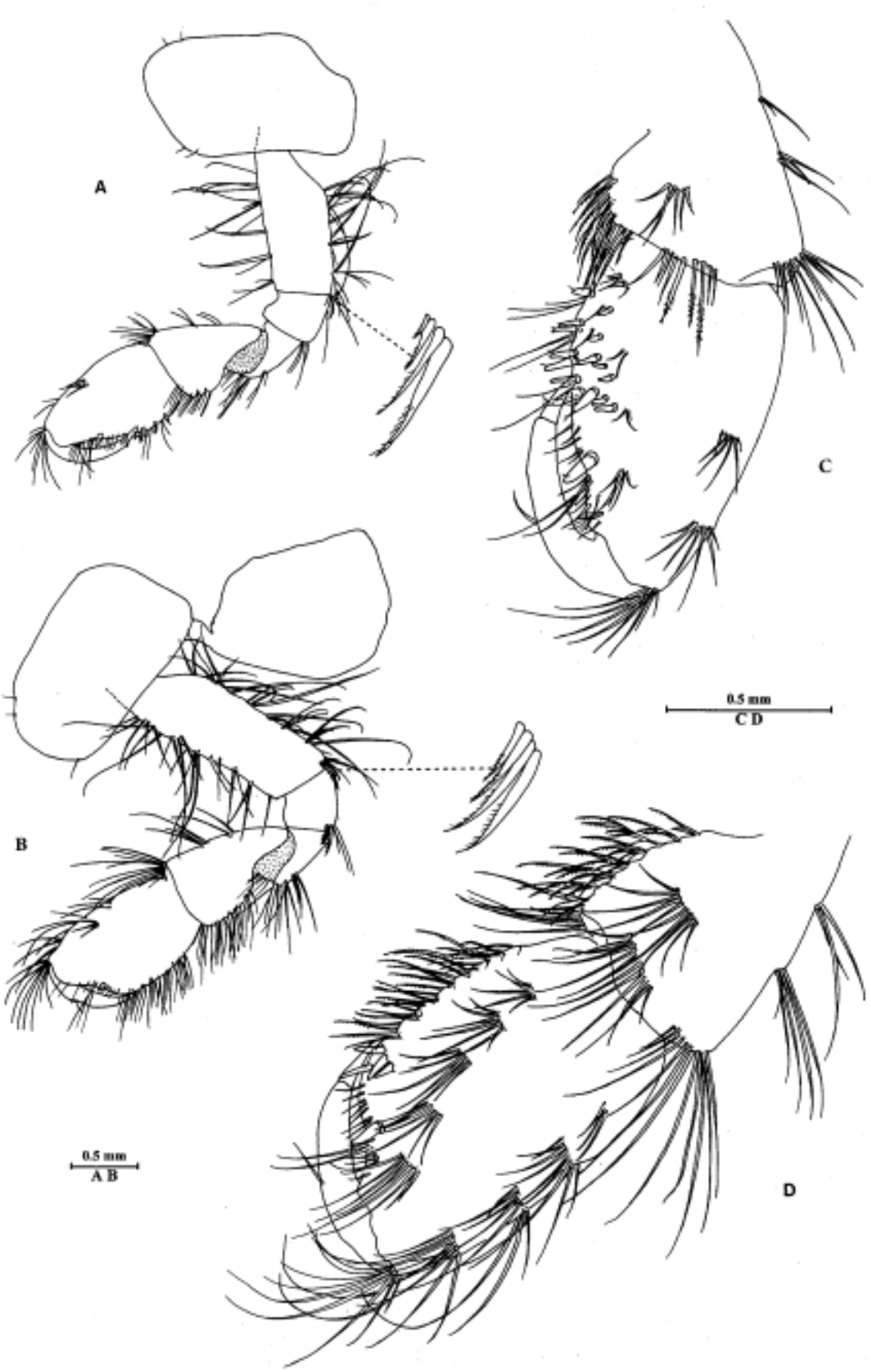


Fig. 13. *Gammarus sinuolatus*, new species, male, holotype. A. gnathopod 1, B. gnathopod 2, C. propodus of gnathopod 1, D. propodus of gnathopod 2.

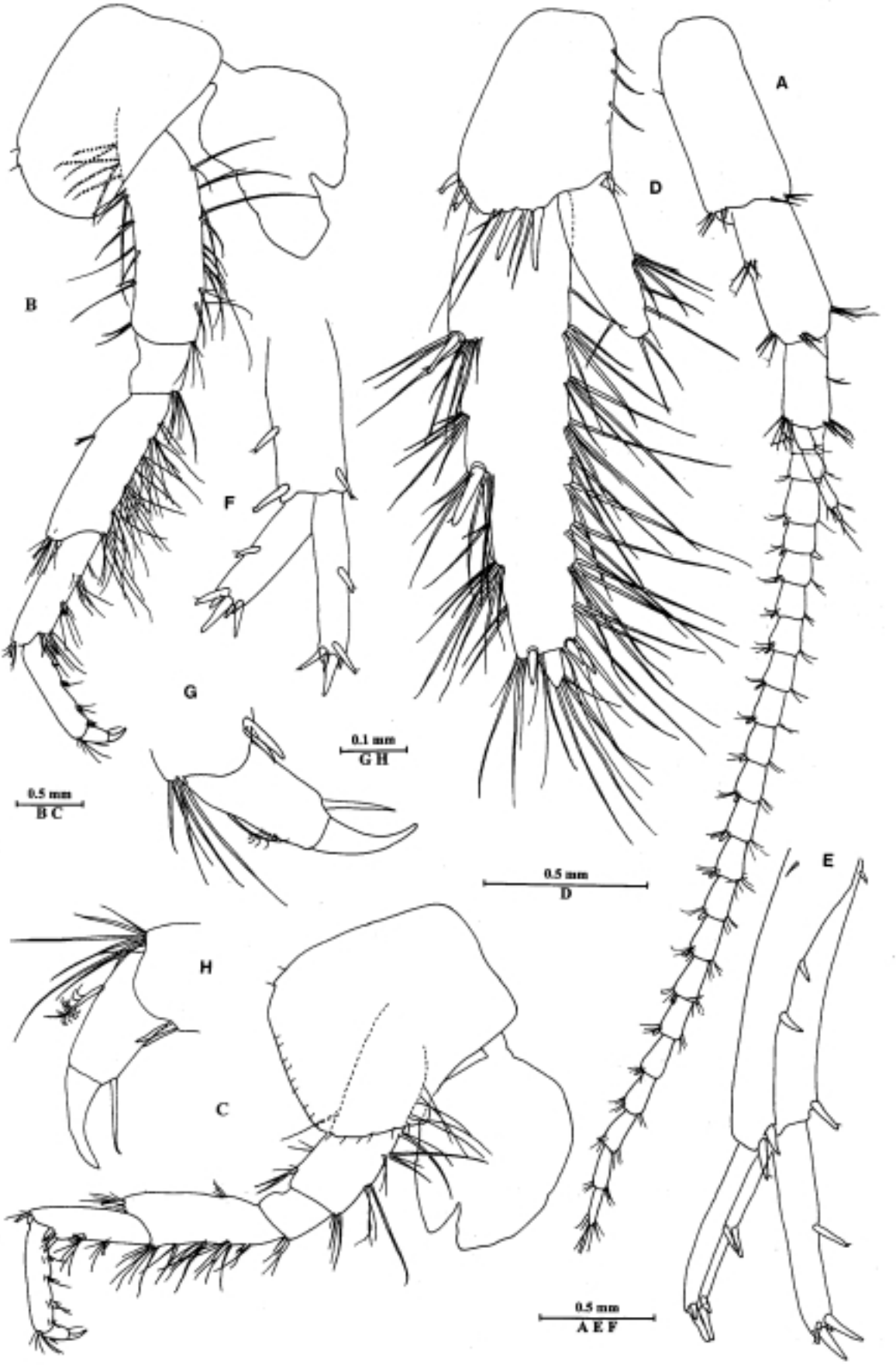


Fig. 14. *Gammarus sinuolatus*, new species, male, holotype. A. antenna 1, B. pereopod 3, C. pereopod 4, D. uropod 3, E. uropod 1, F. uropod 2, G. dactylus of pereopod 3, H. dactylus of pereopod 4.

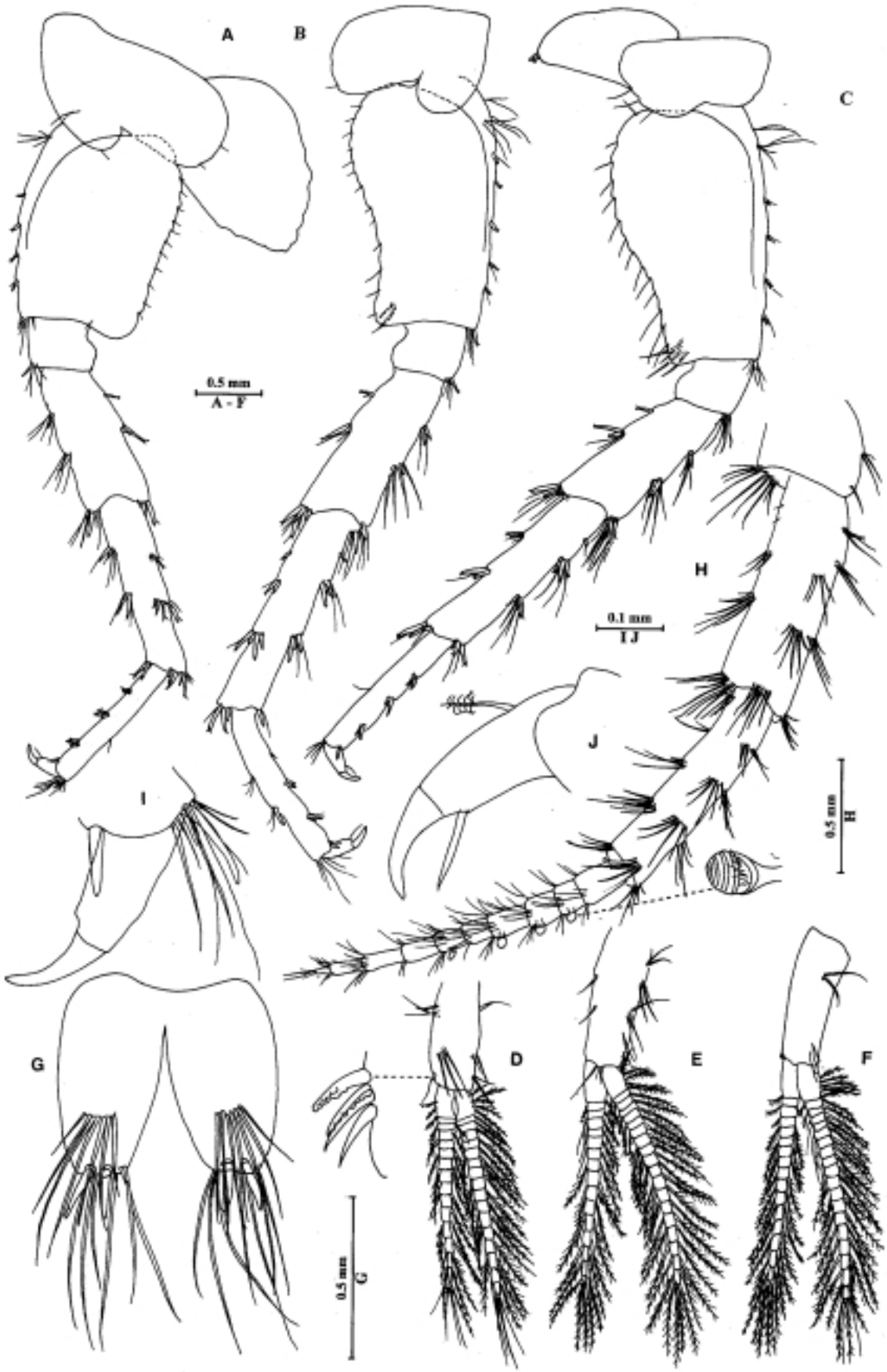


Fig. 15. *Gammarus sinuolatus*, new species, male, holotype. A. pereopod 5, B. pereopod 6, C. pereopod 7, D. pleopod 3, E. pleopod 2, F. pleopod 1, G. telson, H. antenna 2, I. dactylus of pereopod 5, J. dactylus of pereopod 6.

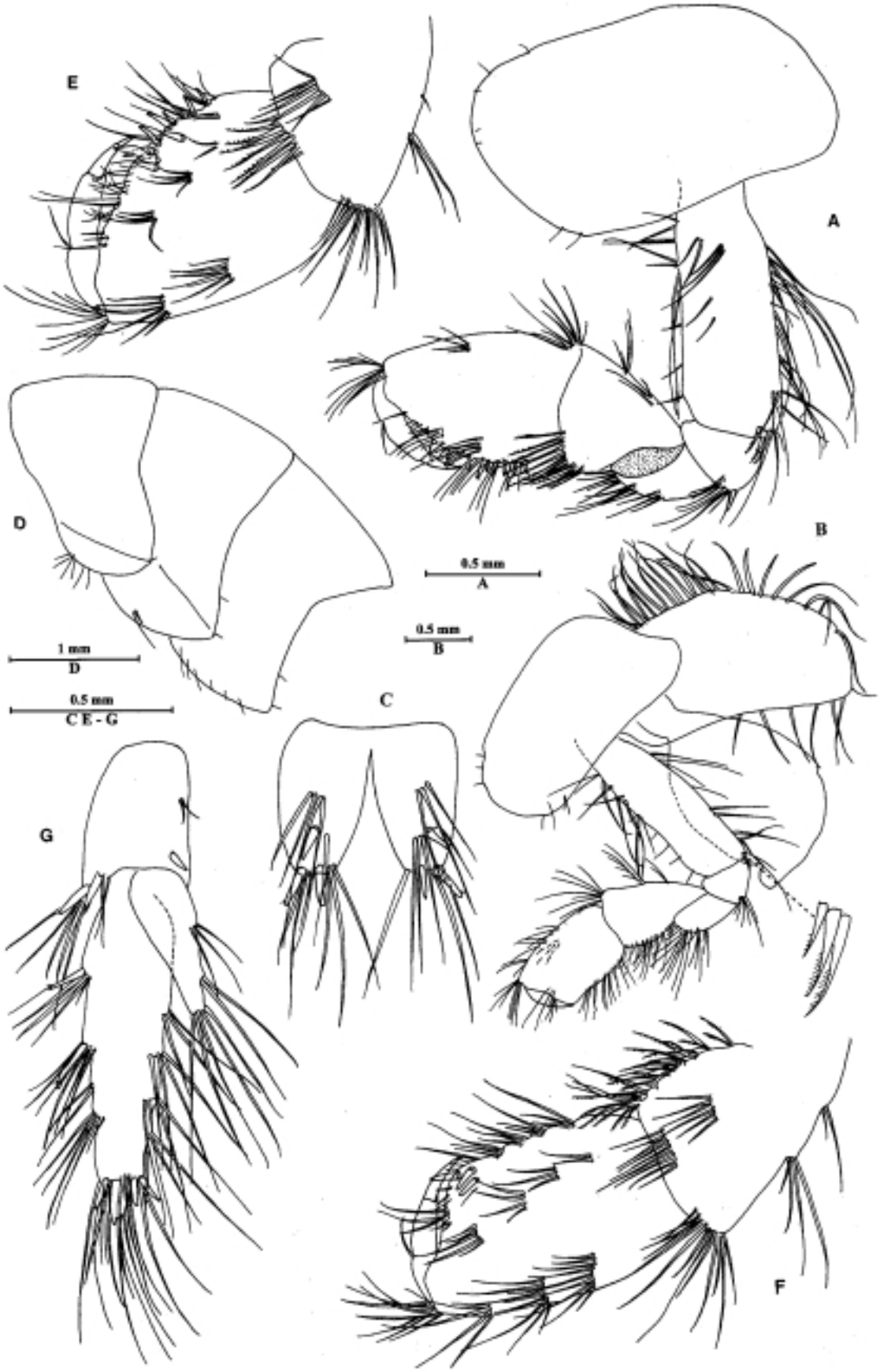


Fig. 16. *Gammarus sinuolatus*, new species, female. A. gnathopod 1, B. gnathopod 2, C. telson, D. epimeral plates, E. propodus of gnathopod 1, F. propodus of gnathopod 2, G. uropod 3.

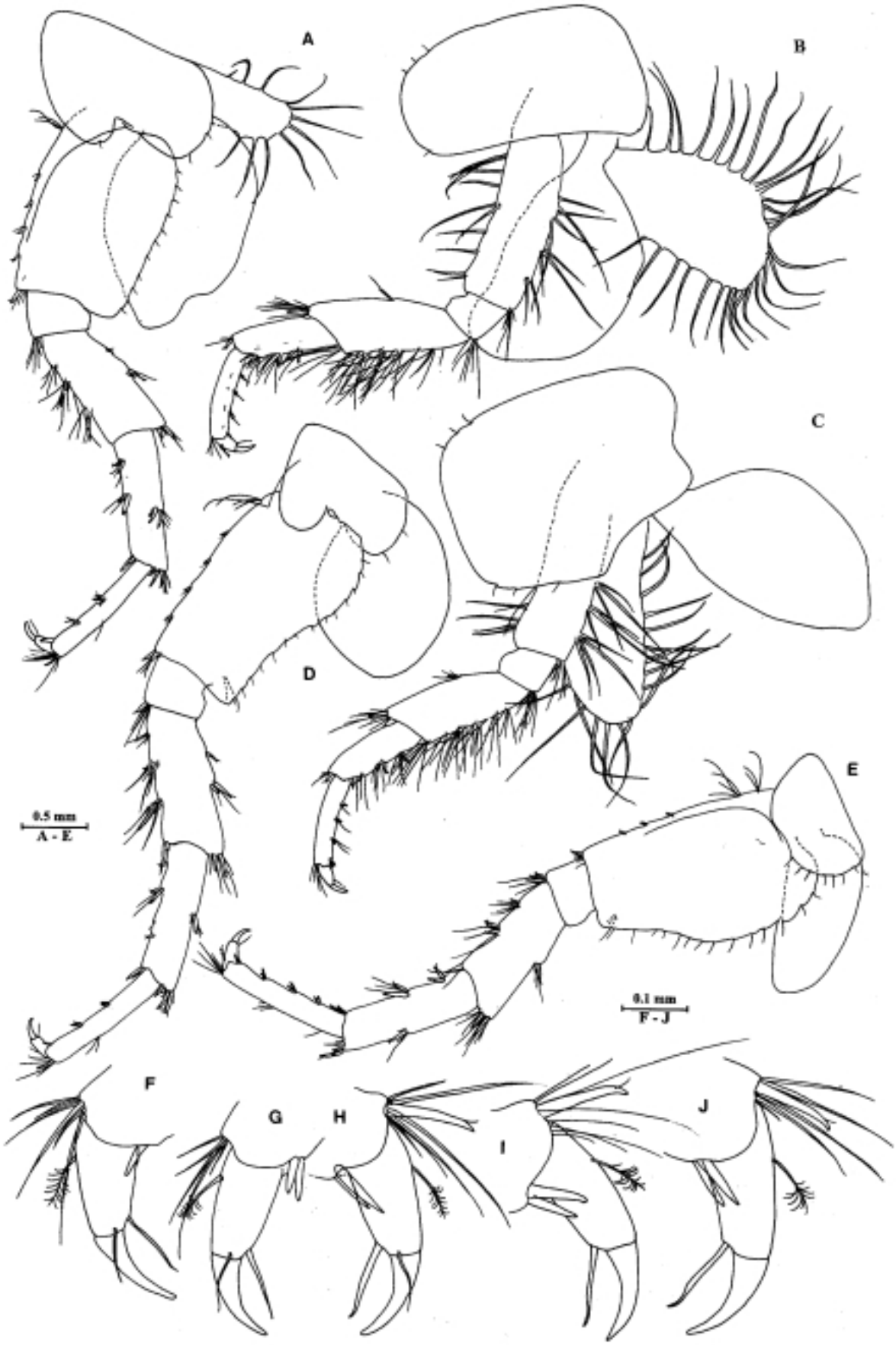


Fig. 17. *Gammarus sinuolatus*, new species, female. A. pereopod 5, B. pereopod 3, C. pereopod 4, D. pereopod 6, E. pereopod 7, F. dactylus of pereopod 3, G. dactylus of pereopod 4, H. dactylus of pereopod 5, I. dactylus of pereopod 6, J. dactylus of pereopod 7.

(Figs. 12H, K): inner plate with 10 plumose setae, article 2 of left plap with 6 sharp spines and 2 stiff setae; article 2 of right palp broad, with 5 blunt spines and 1 stiff seta. Maxilla 2 (Fig. 12I): inner plate with 10 diagonal plumose setae on inner face, outer plate with long apical setae. Maxilliped (Fig. 12G): inner plate with 3 apical spines and 1 subapical spine, outer plate with 9 slender spines on medial margin and 5 pectinate setae apically, palp with 4 articles.

Coxal plates: coxal plates 1-3 subrectangular (Figs. 13A, B, 14B), with 2 setae on anterior corner and 1 seta on posterior corner; coxal plate 4 excavated (Fig. 14C), with 2 setae on anterior corner and 7 setae on posterior margin; coxal plates 5 and 6 (Figs. 15A, B), anterior lobe small, with 1-2 setae on posterior corner; coxal plate 7 (Fig. 15C) with 3 setae on posterior margin.

Gnathopod 1 (Figs. 13A, C): basis with long setae along anterior and posterior margins; carpus and propodus in length ratio 1 : 1.33, carpus triangular; propodus pyriform, palm oblique, bearing 1 median palmar spine, 8 spines on posterior margin and 10 spines on inner face; dactylus about half the length of the propodus margin, with 1 seta on outer margin. Gnathopod 2 (Figs. 13B, D), basis similar to that of gnathopod 1; carpus a little shorter than propodus, both with long setae (some weakly curled) on dorsal margin; palm of propodus transverse, bearing 1 median palmar spine and 3 spines on posterior corner; dactylus fitting with propodus margin, with 1 seta on outer margin.

Pereopod 3 slender (Figs. 14B, G), posterior margin with long straight setae; articles 5 and 6 with 3 groups of spines on posterior margin; dactylus with 1 seta on outer margin and 1 stiff seta at joint of nail. Pereopod 4 (Figs. 14C, H) shorter than pereopod 3, armature reduced.

Pereopods 5-7 (Figs. 15A-C, I, J): pereopods 6 and 7 longer than pereopod 5; anterior margin of bases with 5 short spines and several long setae proximally, posterior margin nearly straight in pereopod 5, concaved in pereopods 6 and 7, with a row of about 12 setae, inner face of bases of pereopods 6 and 7 with 2-4 setae; articles 4 and 5 with 2 groups of spines accompanied by setae along anterior and posterior margins, setae longer than spines; article 6 with 3 clusters of spines on anterior margin and a few setae on posterior margin; dactylus slender, with 1 seta on outer margin and 1 seta at hinge of nail.

Coxal gills (Figs. 13B, 14B, C, 15A, C): coxal gills of pereopods 2-7 sac-like.

Epimeral plates (Fig. 12B): epimeral plates 1-3 not acute on posterior corners, with 1-2 short setae on posterior margin, and many long setae on ventral margins. Pleopods (Figs. 15D-F) subequal in length, peduncle with dorsal setae, 2 retinacula accompanied by 2 setae; rami with about 20 articles, all fringed with plumose setae.

Urosomites (Figs. 12C, D): urosomites 1-2 dorsally flat, with 4 groups of long setae accompanied by few spines; urosomite 3 with 2 groups of setae. Uropod 1 (Fig. 14E): peduncle longer than rami, with 1-1-2 and 1-1 spines on outer and inner margins, respectively; inner ramus with 1 mid-lateral and 5 distal spines; outer ramus with 1 spine on each side and 4 distal spines. Uropod 2 (Fig. 14F): peduncle with 3 spines, both rami with 1 lateral spine on outer margin. Uropod 3 (Fig. 14D): peduncle with 3 setae on dorsal margin and 5 spines accompanied by several long setae on distal margin; inner ramus about 35% of outer ramus; outer ramus with 2 articles, article 1 with 2 lateral spines and 3 distal spines, article 2 small, 8% of article 1; both rami armed with long simple setae.

Telson deeply cleft (Fig. 15G), wider than long, with 2 distal spines accompanied by 5-7 long setae, and a cluster of 7 long setae on dorsal face.

***Female.* –** Body length 11.5 mm. Antenna 2: calceoli absent. Gnathopod 1 (Figs. 16A, E): basis with long setae on posterior margin, and 7 facial setae; propodus not as oblique as that of male, with 9 spines on posterior margin. Gnathopod 2 (Figs. 16B, F): setae of carpus and propodus fewer than those of male, palm of propodus truncate, with 3 spines on posterior corner. Pereopods 3-7 (Figs. 17A-J): pereopods 3-7 similar to those of male, but relatively short, with fewer setae. Uropod 3 (Fig. 16G): stout, inner ramus about 40% of outer ramus, both rami fringed with simple setae. Telson cleft (Fig. 16C), with 2 distal spines accompanied by long setae, 1 facial spine accompanied by long setae, and a clusters of 3-4 long setae on dorsal face. Epimeral plates (Fig. 16D): epimeral plates 1-3 with fewer long setae on ventral margin than those of male.

Oostegites (Figs. 16B, 17A-C): oostegites of pereopods 2-5 progressively increasing, bearing many long setae.

***Etymology.* –** This specific name comes from its slim and bowed body shape.

***Remarks.* –** *Gammarus sinuolatus* belongs to the *G. pulex*-group. *Gammarus sinuolatus* resembles *G. gregoryi* Tattersall, 1924, from Yunnan. Both species have a short inner ramus of uropod 3 (about one-third of outer ramus), and both rami of uropod 3 are densely set with simple setae. *Gammarus sinuolatus* can be distinguished from *G. gregoryi* by the urosomite 1 with 4 groups of long setae on the dorsal margin, while *G. gregoryi* has few setae on the dorsal margin of urosomite 1.

This taxon is similar to *G. parucispinus* Hou & Li, 2002b, and *G. electrus* Hou & Li, 2003c, in the uropod 3 with long simple setae and the telson with long setae on dorsal face. *Gammarus sinuolatus* differs from *G. parucispinus* in the antenna 2 with calceoli, inner ramus of uropod 3 shorter than half of outer ramus, urosomites and epimeral plates with long setae on dorsal and ventral margins, respectively. *Gammarus sinuolatus* differs from *G. electrus* in propodus of gnathopods 1-2 and posterior margin of pereopod 3 with straight setae, while *G. electrus* with long curled setae on propodus of gnathopods 2 and posterior margin of pereopod 3.

Table 1. Differences among *G. sinuolatus*, new species, *G. jaspidus*, new species, *G. frigidus*, new species and the related species.

Character (male)	Setae number of maxilla 2	Propodus palm of gnathopod 1	Palmar median spine gnathopod 2	Pleonites and urosomites	Ratio of inner and outer rami of uropod 3	Setae of both rami of uropod 3	Posterodistal corners of epimeral plates 2 and 3	Dorsal armature of telson
G. sinuolatus	8-15	Oblique	1	Dorsally flat	30%-45%	Simple	Blunt	With some long setae
*G. lacustris**	20-35	Oblique	1	Dorsally flat	75%-90%	Plumose	Deeply acute	With few setae
*G. lasaensis**	20-35	Oblique	3	Dorsally flat	70%-90%	Plumose	Acute	With few setae
G. jaspidus	20-35	Oblique	1	Weakly elevated	60%-80%	Plumose	Acute	With 1 basolateral spine and some long setae
G. frigidus	25-40	Ovate	1	Dorsally flat	80%-95%	Plumose	Acute	With few setae

*Data based on Barnard & Dai (1988).

Gammarus sinuolatus, new species, is also similar to *G. frigidus*, new species, and, *G. jaspidus* new species. The differences among these three new species and the related species are given in Table 1.

***Distribution.* –** Qamdo, Tibet, China (present study).

ACKNOWLEDGEMENTS

The authors would like to express their thanks to Dr. Dirk Platvoet (University of Amsterdam, the Netherlands) for providing advice in the course of this study and for critically reading the manuscript.

The present study was supported by the National Natural Sciences Foundation of China (NSFC-30270183, 30370263, 30310464), and by the National Science Fund for Fostering Talents in Basic Research (NSFC-J0030092). Additional support was received from the Knowledge Innovation Program of the Chinese Academy of Science (KSCX2-1-06A, KSCX3-IOZ-01) and from the Life Science Special Fund of the Chinese Academy of Science under the authority of the Ministry of Finance (STZ-00-19).

LITERATURE CITED

Barnard, J. L. & C. M. Barnard, 1983. *Freshwater Amphipoda of the World I, II*. Hayfield Associates, Mt. Vernon, Virgina. Pp. 1-830.

Barnard, J. L. & A. Y. Dai, 1988. Four species of *Gammarus* (Amphipoda) from China. *Sinozoologia*, **6**: 85-112.

China Society of the Qinghai-Tibetan Plateau Research, 1995. *Qinghai-Tibetan Plateau and global variations: Proceedings of symposia (1993 and 1994) sponsored by China Society of the Qinghai-Tibetan Plateau Research*. Beijing, China Meteorological Press: 1-285.

Fabricius, J. C., 1775. *Systema Entomologiae, Sistens Insectorum Classes, Ordines, Genera Species Adiectis Synonymis, Locis, Descritionibus, Observationibus.* Flensbergi et Lipsiae. 832 pp.

Hou, Z. E. & S. Q. Li, 2002a. A new species of the genus *Gammarus* from Yunnan, China (Crustacea: Amphipoda: Gammaridae). *Acta Zootaxonomica Sinica*, **27**(1): 65-73.

Hou, Z. E. & S. Q. Li, 2002b. Descriptions of two new species of Genus *Gammarus* (Crustacea: Amphipoda: Gammaridae) from Yunnan, China. *The Raffles Bulletin of Zoology*, **50**(1)*:* 37-52.

Hou, Z. E., S. Q. Li & S. Koenemann, 2002. *Gammarus emeiensis*, a new species of amphipod crustacean from Sichuan Province, China. *Beaufortia*, **52**(4): 37-43.

Hou, Z. E., S. Q. Li & H. Morino, 2002. Three new species of the genus *Gammarus* (Crustacea: Amphipoda: Gammaridae) from Yunnan, China. *Zoological Sciences*, **19**: 939-960.

Hou, Z. E., S. Q. Li & M. Q. Zheng, 2002. A new species of freshwater Amphipoda from China (Crustacea: Amphipoda: Gammaridae). *Acta Zootaxonomica Sinica*, **27**(3): 456-465.

Hou, Z. E. & S. Q. Li, 2003a. *Gammarus glabratus*, A new cave Amphipoda from Guizhou, China (Amphipoda: Gammaridae). *Crustaceana*, **76**(4): 433-442.

Hou, Z. E. & S. Q. Li, 2003b. Two new freshwater gammarids (Crustacea: Amphipoda: Gammaridae) from Lake Lugu, China. *Revue Suisse de Zoologie*, **110**(3): 1-18.

Hou, Z. E. & S. Q. Li, 2003c. *Gammarus electrus*, a new species of Amphipoda from Beijing, China (Crustacea: Amphipoda: Gammaridae). *Acta Zootaxonomica Sinica*, **28**(2): 241-248.

Hou, Z. E. & S. Q. Li, 2003d. A new species of blind Amphipoda from China (Crustacea: Amphipoda). *Acta Zootaxonomica Sinica*, **28**(3): 448-454.

Karaman, G. S. & S. Pinkster, 1977. Freshwater *Gammarus* species from Europe, North Africa and adjacent regions of Asia (Crustacea-Amphipoda) Part I *Gammarus pulex*-group and related species. *Bijragen tot de Dierkunde*, **47**(1): 1-97.

Karaman, G. S. & S. Pinkster, 1987. Freshwater *Gammarus* species from Europe, North Africa and adjacent regions of Asia (Crustacea-Amphipoda) Part III *Gammarus balcanicus*-group and related species. *Bijragen tot de Dierkunde*, **57**(2): 207-260.

Morino, H. & N. Whitman, 1995. A new species of the genus *Gammarus* (Crustacea: Amphipoda) from fresh waters of Russian Far East. *Publications of Itako Hydrobiological Station*, **8**: 27-36.

Schellenberg, A., 1937. Kritische Bemerkungen zur Systematik der Suesswassergammariden. *Zoologische Jahrbuecher, Abteilung fuer Systematik*, **69**: 469-516.

Stock, J. H., A. R. Mirzajani, R. Vonk, S. Naderi & B. H. Kiabi, 1998. Limnic and brackish water Amphipoda (Crustacea) from Iran. *Beaufortia*, **48**(9): 173-234.

Tattersall, W. M., 1914. Notes on some amphipods collected on the Pamirs at an altitude of 15600 feet. *Records of the Indian Museum*, **10**: 213-215.

Tattersall, W. M., 1924. Zoological results of the Percy Sladen Trust expedition to Yunnan, under the leadership of professor J. W. Gregory, F. R. S. (1922). *Journal and proceedings, Asiatic Society of Bengal (New series)*, **19**(9): 429-435.

Uéno, M., 1934. Report on the amphipod Crustacea of the genus *Gammarus*. *Memoirs of the Connecticut Academy of Science*, **10**: 63-75.