ЦРНОГОРСКА АКАДЕМИЈА НАУКА И УМЈЕТНОСТИ
ГЛАСНИК ОДЈЕЉЕЊА ПРИРОДНИХ НАУКА, 26, 2023.

ЧЕРНОГОРСКАЯ АКАДЕМИЯ НАУК И ИСКУССТВ
ГЛАСНИК ОТДЕЛЕНИЯ ЕСТЕСТВЕННЫХ НАУК, 26, 2023

THE MONTENEGRIN ACADEMY OF SCIENCES AND ARTS
PROCEEDINGS OF THE SECTION OF NATURAL SCIENCES, 26, 2023

UDK 595.371(540)

Gordan S. Karaman[*]

ON DOUBTFUL SPECIES *RIVULOGAMMARUS STOLICZKAE* S. KARAMAN, 1934 (CRUSTACEA: FAM. GAMMARIDAE) FROM NORTHEASTERN INDIA (CONTRIBUTION TO THE KNOWLEDGE OF THE AMPHIPODA 329)

Abtract

Stanko L. Karaman described (1934) a new epigean species of freshwater amphipods *Rivulogammarus stoliczkae*, sp. nov. (Fam. Gammaridae) from the vicinity of Tso Moriri Lake (Himalayan Mts., northeastern India). Genus *Rivulogammarus* was later considered nom. preocc. (Homonym) of genus *Rivulogammarus* Dorogostaysky (1917) from Baikal Lake and synonymous with genus *Gammarus* Fabricius, 1775 by Stock (1969). *Gammarus stoliczkae* (S. Karaman, 1934) later was cited as probably synonym of *Gammarus lacustris* Sars, 1863 (Schelenberg, 1937); Barnard & Barnard, 1983), based on S. Karaman`s description only, but never redescribed.

As various new *Gammarus* species were described later from Europe, Asia and N. America, the syntypes of *G. stoliczkae* are studied to resolve real taxonomical position of this species. The full morphological similarity of this species with *G. lacustris* Sars, 1863 (sensu auctorum) is established.

Keywords: Amphipoda, Gammaridae, *Gammarus*, *stoliczkae*, *lacustris*, taxonomy, NE India

[*] Montenegrin Academy of sciences and arts, karaman@t-com.me

INTRODUCTION

The famous investigator and researcher Ferdinand Stoliczka (= Stolička) (1838-1874) Moravian paleontologist, who studied in India western Himalayas and Tibet paleontology, geology and zoology (ornithology, malacology, herpetology of India), during his first Himalayan trip in 1864 with F. R. Mallet of the Geological Survey of India under the British Government in India, collected the samples of *Gammarus* from NE India (N. Himalaya). Unfortunately, later he died in Murgo during an expedition across the Himalayas, of high altitude sickness.

Stanko Karaman have received this sample of Stoliczka of 1864 for study, and described it (1934) as a new species *Rivulogammarus stoliczkae* from NE India [vicinity of Tso Moriri Lake, Rupchu province, Ladakh, northern side of Himalaya, 15.000 feet a.s.l.] in his honor.

Genus *Rivulogammarus* S. Karaman, 1931 [typus generis: *Cancer pulex* L., selected by Gurjanova, 1951] has been later considered by J. Stock (1969) a homonym of genus *Rivulogammarus* Dorogostajskij, 1917 from Baikal Lake, and name *Rivulogammarus* was submerged as synonym of genus *Gammarus* Fabr.1775.

Schellenberg (1937) mentioned that *G. stoliczkae* represent "nichts anders als eine *lacustris* form", mentioning that remarkable characters of this species are not described. Barnard & Barnard (1983) cited *G. stoliczkae* as identical with *Gammarus lacustris* Sars without any explanation.

Later *G. stoliczkae* was never mentioned in literature, neither as a distinct taxon nor as synonym of *G. lacustris (*G. Karaman & Pinkster, 1977; World Amphipoda Database 2022; Wikipedia, the free encyclopedia 2022, etc.).

As in meantime various other new *Gammarus* species, often rather similar to *G. lacustris* and *G. stoliczkae,* were described from this region of Tibet Mts., China, Pamir Mts. etc., it was necessary, at least on the basis of morphological study of original specimens of *G. stoliczkae* (syntypes), to resolve the taxonomical status of *G. stoliczkae* based on external morphology.

MATERIAL AND METHODS

The collected specimens have been preserved in 5% formaldehyde and later removed to 70% ethanol. The specimens were dissected using a WILD M20 microscope and drawn using camera lucida attachment. All appendages were temporarily submersed in the mixture of glycerin and water for study and drawing. The appendages were transferred to Liquid of Faure on permanent slides. All illustrations were inked manually.

Some morphological terminology and setal formulae follow G. Karaman's terminology (Karaman, G., 1969) regarding the last mandibular palpus article

[A= A-setae on outer face; B= B-setae on inner face; D= lateral marginal D-setae; E= distal long E-setae]. Terms "setae" and "spines" are used based on its shape, not origin. The research in this work is based on the classic morphological, ecological and zoogeographical studies.

TAXONOMICAL PART

Family GAMMARIDAE Leach, 1814

Genus *GAMMARUS* Fabricius, 1775

"*GAMMARUS STOLICZKAE*" (S. Karaman, 1934)
Figures 1-5

Rivulogammarus stoliczkae S. Karaman, 1934: 127, fig. 1;
Gammarus (Rivulogammarus) lacustris Schellenberg 1937*:* 496*;*
Gammarus stoliczkae (=*G. lacustris*) Barnard & Barnard, 1983: 467.

MATERIAL EXAMINED:

F-2= Northeastern India: vicinity of Tso Moriri Lake, Rupchu province, Ladakh, northern side of Himalaya Mts., 15.000 feet (=3.000 m), 12 exp, males and females (leg. Stoliczka 1864), slides F1, F2. [syntypes of *G. stoliczkae*];

S-6620= High-water am Wiljuisker Tract near Jakutsk, (affluent of Lena River, Russia), shallow muddy bottom with plant roots, t° 24°C (leg. Pietrzeniuk), 12 exp. (*G. lacustris*);

S-3101= Lago Vivo Lake, Abruzzo, central Italy, 10.8.1873, 5 exp. (leg. A. Vigna-Taglianti (*G. lacustris);*

DESCRIPTION

The specimens from Tso Moriri Lake were with partially broken extremities. The holotype was lost, and we selected from the original sample, one lectotype male 12.5 mm, and paralectotype, female 9.0 mm [slides F2/1-F2/4], deposited in Karaman`s Collection in Podgorica, Montenegro.

The males based on its morphological characters agree with description and figures of S. Karaman (1934, fig. 1a-d), and we mentioned some additional description of some body-parts.

Male 12.5 mm (lectotype): Metasomal segments 1-3 with 4-5 dorsoposterior marginal short setae each (fig. 3C). Epimeral plate 1 obtusely quadrate, convex posterior margin with several short setae, ventroanterior margin with group of 7 setae. Epimeral plates 2 and 3 sharply pointed and produced, bearing several

ventral spines and setae each (fig. 4B), at posterior concave margin are sitting several short setae.

Urosome only slightly elevated, without carina (fig. 3 C), urosomal segments 1-3 with 1-2 dorsolateral spines, mixed often with single short setae; urosomal segments 1 and 2 with one dorsomedian group of 2 spines mixed sometimes with 1-2 short setae (fig. 3D), urosomal segment 3 without median group of elements. Urosomal segment 1 at ventroposterior corner with one seta near basis of uropod 1-peduncle and 3 single ventral setae (fig. 3C).

Head with short, obtusely angular lateral cephalic lobes and deep ventroanterior sinus; eyes oval, nearly as long as diameter of antenna 1 peduncle (fig. 1A).

Antenna 1: peduncular articles 1-3 progressively shorter (ratio: 41:30:26), scarcely setose, setae short (fig. 1A); main flagellum relatively slender, articles bearing short setae (distal articles broken); aesthetascs not observed. Accessory flagellum 3-articulate, first and third article shorter than second one (fig. 1A).

Antenna 2: peduncular articles 4 and 5 almost equal (ratio: 50:53), at ventral margin with 4-5 bunches of setae remarkably longer than diameter of articles themselves (fig. 1A), flagellum missing; calceola unknown.

Labrum with convex distal margin. Labium without inner lobes.

Mandible: molar, incisor and lacinia mobilis well developed, like these in *Gammarus lacustris*. Mandibular palpus article 1 naked, article 2 with several setae; article 3 falciform, with nearly 30 marginal D-setae and 5 distal E-setae, on inner face by 2 groups of 4 B-setae each, on outer face by one group of 4 A-setae (fig. 4A).

Maxilla 1 and maxilla 2 like these in *G. lacustris*.

Maxilliped: inner plate quadrate, with 3-4 distal spines, accompanied by numerous short setae (fig. 1C); outer plate not exceeding half of palpus article 2, with numerous mesial row of spines and row of distal setae; palpus article 2 along mesial margin with numerous long setae, at outer margin with 2 bunches of setae; article 3 at outer margin with 2 median and one distal group of setae, at mesial margin with numerous setae (fig. 1B); article 4 (dactylus) with bunch of 4 ventral setae near basis of the nail (fig.), at outer margin with one median seta, nail short (fig. 1D).

Coxae 1-4 moderately long. Coxa 1 longer than broad (ratio: 65:40), with nearly parallel lateral margins and convex ventral margin bearing single short setae (fig. 2A). Coxa 2 longer than broad (ratio: 75:40) with parallel lateral margins and broadly subrounded ventral margin bearing single short marginal setae (fig. 2D). Coxa 3 slightly longer than coxa 2, longer than broad (ratio: 89:43), ventral margin more subrounded in anterior part, scarcely setose (fig. 3A). Coxa 4 longer than broad (ratio: 91:67), with several marginal setae, ventroposterior lobe well developed (fig. 3B).

Coxa 5 much shorter than coxa 4, bilobed, broader than long (ratio: 56:36), anterior lobe smaller than posterior one, along posterior subangular lobe with 2 short setae (fig. 4C).

Coxa 6 broader than long (ratio: 40:30), posterior lobe subangular (fig. 4D), single short setae present.

Coxa 7 entire, unlobed (fig. 4E), broader than long (ratio: 41:25), with single short marginal setae.

Gnathopods 1 and 2 of subequal size, moderately setose. Gnathopod 1: article 3 with distoposterior bunch of setae. Article 5 shorter than propodus ((ratio: 46:54) anteriorly with several inner facial groups of setae, posterior margin with numerous setae (fig. 2A). Propodus egg-shaped; longer than broad (ratio: 112:70) at posterior margin with 6 groups of spines and setae; as well as with several facial submarginal spines (fig. 2B). Palm convex, inclined nearly half of propodus-length, with one median strong spine accompanied by 3-4 long setae (fig. 2C), and row of marginal short setae, defined by relatively short corner spine; dactylus with one median seta at outer margin.

Gnathopod 2: article 3 with distoposterior bunch of short setae; article 5 shorter than propodus (ratio: 44:59), at anterior margin with 1-2 median and one distal group of setae, posterior margin with 2-3 transverse rows of setae (fig. 2D). Propodus with parallel lateral margins, longer than broad (ratio: 118:67), posterior margin with 8 transverse rows of setae; inner face with several bunches of short setae, especially at anterior side (fig. 2E). Palm rather convex, inclined nearly ¼ of propodus-length, with row of short setae and one median strong spine accompanied by 3-long setae (fig. 2E), palm defined by relatively short corner spine accompanied by several facial and marginal spines (fig. 2F); dactylus with one median seta at outer margin.

Pereopods 3 and 4 slender. Pereopod 3 along posterior margin of articles 2, 4, 5 with numerous long, mainly straight setae longer than diameter of articles themselves (fig. 3A). Article 3 with distoposterior bunch of setae. Articles 4-5 of different length (ratio: 65:45); articles 6-7 missing.

Pereopod 4 is slightly shorter than pereopod 3. Article 3 with distoposterior bunch of setae. Articles 2,4,5,6, along posterior margin with numerous long straight setae, along anterior margin scarcely setose (fig. 3B). Articles 4-6 of different length (ratio: 55:40:38); dactylus moderately slender, much shorter than article 6 (ratio: 19:38) (fig. 3B), at inner margin with one slender spine-like seta, at outer margin with one median seta.

Pereopods 5-7 moderately slender. Pereopod 5: article 2 slightly longer than broad (ratio: 60:40), anterior margin with row of nearly 6 spine-like setae, posterior slightly concave margin with 11 short setae, ventroposterior corner

subacute (fig. 4C). Article 4 at anterior margin with 4 groups of spine-like setae, at posterior margin with 3 single spines; articles 5-7 missing.

Pereopod 6: article 2 longer than broad (ratio: 70:41), anterior almost straight margin with row of 6-7 slender spines, posterior margin concave in the middle, with 13 short setae, ventroposterior corner subacute (fig. 4D). Articles 4-6 of different length (ratio: 47:69:50), along both margins with short spines and setae; article 2 longer than article 6 (ratio: 70:50); dactylus moderately slender, much shorter than article 6 (ratio: 16:50), at inner margin with one spine-like seta near basis of the nail, one median seta appears at outer margin.

Pereopod 7: article 2 longer than broad (ratio: 77:46), along anterior rather convex margin with several slender spines, along posterior convex margin with 11 short setae, ventroposterior corner obtuse, not dilated (fig. 4E). Articles 4-6 of different length (ratio: 39:63:44), along both margins with single and groups of short spines. Article 2 longer than article 6 (ratio: 78:44). Dactylus slender, remarkably shorter than article 6 (ratio: 19:44), at inner margin with slender spine, at outer margin with one median seta (fig. 4F); nail shorter than pedestal (ratio: 17:45).

Pleopods 1-3 with 2 retinacula, peduncles scarcely setose.

Uropod 1: peduncle longer than rami, with one outer median lateral spine and single dorsoexternal spines; dorsointernal distal spine well developed; rami nearly of equal length (fig. 3C), with 5 unequal short distal spines, inner ramus with one median spine.

Uropod 2 inner ramus distinctly longer than outer one, with one median spine; both rami with 5 unequal short distal spines (fig. 3C).

Uropod 3 with relatively slender long rami; inner ramus slightly shorter than outer one (ratio: 110:135), both rami along outer and inner margin covered with numerous plumose setae; second article of outer ramus short (fig. 1E).

Telson nearly as long as broad, deeply incised; each lobe with 1-2 distal spines accompanied by 3-4 short and long setae; and with 0-1 facial seta; a pair of short plumose setae are attached near the middle of each lobe; poorly visible (fig. 3E).

Coxal gills moderately broad (fig. 2D).

Female 9.0 mm with setose oostegites:

Like male bur relatively smaller, urosomal segments 1-3 like these in male; urosomal segment 1 with 3 single setae at ventral margin. Epimeral plates similar to these in male, plates 2-3 sharply pointed.

Antenna 2: peduncular articles 4-5 of nearly equal length, provided along ventral margin with several bunches of setae remarkably longer than these in male; flagellar articles with short dorsal setae and very long ventral setae (fig. 5A); calceola not observed [distal part of flagellum missing]; conus excretorius longer than that in male, exceeding distal tip of peduncular article 3 (fig. 5A).

Coxae similar to these in male. Coxa 3 much longer than broad (ratio:80:38), ventral margin oblique convex, with 2 short setae (fig. 5D).

Coxa 4 longer than broad (ratio: 80:55), ventral margin straight in the middle, bearing single very short setae, ventroposterior lobe well developed (fig. 5E).

Gnathopods 1-2 rather smaller than these in males. Gnathopod 1: article 5 triangular, longer than broad (ratio: 70:41), rather shorter than propodus (ratio: 68:80), with 3 bunches anterior marginal setae and 4 posterior marginal bunches of setae (fig. 5B). Propodus longer than broad (ratio: 80:45), not egg-shaped, at posterior margin with 4 transverse rows of setae and single spines; palm inclined rather less than half of propodus-length, median palmar spine absent, but bunch of several long setae at this place is present; dactylus exceeding width of propodus, with one median seta at outer margin (fig. 5B).

Gnathopod 2 with articles 4 and 5 more narrow than these in gnathopod 1. Article 5 nearly as long as propodus, remarkably longer than broad (ratio: 75:33), at posterior margin with 7 transverse rows of setae, at anterior margin with 2 bunches of setae (fig. 5C). Propodus quadrate, much longer than broad (ratio: 75:32), with 6 posterior bunches of setae, and 2 bunches of anterior marginal setae (fig. 5C); palm only rather inclined, defined by short corner spine; median palmar spine absent; dactylus exceeding width of propodus, with one median seta at outer margin (fig. 5C).

Pereopods 3-4 relatively slender. Pereopod 3 with numerous long straight setae on all articles, although setae on article 6 are rather shorter (fig. 5D). Articles 4-6 of different length (ratio: 47:35:30). Dactylus moderately slender, much shorter than article 6 (ratio: 15:30), with one spine-like seta at inner margin.

Pereopod 4 similar to pereopod 3, all articles along posterior margin with long straight setae, rather shorter in article 6. Articles 4-6 of different length (ratio: 43:30:28); dactylus like that in pereopod 3 (fig. 5E).

Pereopods 5-7 like these in male; dactylus of pereopod 7 rather slender, with one spine-like seta at inner margin near basis of the nail (fig. 5F), nail shorter than pedestal.

Uropods 1–2 like these in male, uropod 3 like that in male but shorter, inner ramus reaching tip of outer ramus first article.

Telson as long as broad, lobes with 2 distal spines mixed with several setae, and with 0-1 facial seta (fig. 5G).

Coxal gills like these in male. Oostegites moderately narrow (fig. 5D).

VARIABILITY:

Mandibular palpus article 3 with rather various number of A and B-setae and D-setae. Metasomal segments 1-3 with 4-6 dorsoposterior marginal setae; articled 1-2 equally long, third article very short. Spines on urosomites 1-3 often

mixed with 1-2 short setae, urosomite 3 with 0-2 dorsomedian short setae. Ventral margin of urosomal segment 1 with various number of setae and short spine-like seta or spine near basis of uropod 1-peduncle. Telson with or without single facial setae, lobes with 1-2 distal short spines mixed with variable number of setae.

The specimens of *Gammarus lacustris* from northern Russia [High water in Wiljusker tract near Jakutsk): metasomal segments 1-3 with 6- 7 dorsoposterior marginal setae, urosomal segment 1 on ventral margin with median bunch of 4 setae and small spine near basis of uropod 1-peduncle; calceola developed in males, lobes of telson with 2-3 distal spines.

The specimens of *G. lacustris* from central Italy (Lago Vivo Lake, Abruzzi) with metasomal segments 1-3 with 6 very short dorsoposterior setae, calceola developed in males, accessory flagellum 3-articulated, articled 1-2 equally long, third article very short. Urosomal segment 1 with 2-3 single or bunches of ventral marginal setae and ventral short spine near basis of uropod 1-peduncle., lobes of telson with 2 distal spines with 3-4 setae, and 2 groups of facial setae on each lobe.

REMARKS AND AFFINITIES

Based on all these morphological characters, the specimens of *Gammarus stoliczkae* correspond to these of *Gammarus lacustris* Sars 1863 (sensu auct.). But it is necessary to make further molecular genetic studies of samples from the Tso Moriri Lake to verify this conclusion, because there are numerous questions regarding taxonomy of *Gammarus lacustris*.

Many authors underline the unique Holarctic distribution of *Gammarus lacustris* extended to North America also, as boreoalpine and circumpolar distribution, including distribution in numerous isolated mountain chains in central and southern Europe and Asia.

The species *Gammarus lacustris* has been discovered and described by Sars (1863) from Norway without precise locality, and Karaman & Pinkster (1977) established Selsvand, Vage in Norway as locus typicus, and selected lectotype from this locality (deposited in Oslo Museum, Norway).

Stanko Karaman (1931) without knowledge of this Sars`s description, described *Rivulogammarus scandinavicus*, sp. n. from Sweden [Hultsfred-Smaland, Frostviken-Jamtland, Qvickjock-Lappmark-Gänta Järvi] and Norway [Trondenes (Westeralen)], later considered identical with *G. lacustris* (Schellenberg, 1937; G. Karaman & Pinkster, 1977).

Later, various scientists mentioned *G. lacustris* from numerous localities from Europe (France, Italy, Balkan Peninsula, northern Europe, Russia, various

localities in Asia (Turkey, Pamir, China, India, etc.) till North America (Canada and USA) (Schellenberg 1937; Pinkster, 1972; G. Karaman 1993, etc).

Regarding the Tibet Mts. region, S. Karaman (1934, sub *stoliczkae*), Schellenberg, (1937) G. Karaman & Pinkster (1977), Barnard & Dai (1988), Hou & Li (2004) cited some locality of *G. lacustris* from this region.

During last 30 years, over 15 new species of genus *Gammarus* have been described of various authors from Tibet, Himalaya regions and China; among them some species very similar to *G. lacustris*.

Clewing, Wilke & Albreche (2016) mentioned that "All newly sequenced Tibetan Plateau samples most likely belong to the widespread Holarctic species-group *G. lacustris* and are therefore assigned to *G. lacustris"*, indicating that they are not endemic to the plateau. They mentioned " the actual zoogeographic affinity of the Tibetan Plateau gammarids remain uncertain due to the unresolved relationships within the *G. lacustris* clade".

Hou & Li (2018) describing the four new *Gammarus* species from this Plateau, composed key to the 15 known species of *Gammarus* from the Tibetan Plateau including in it *G. lacustris,* but without detailed localities.

It is very interesting conclusion of Clewing et al. (2016) that the plateau gammarid fauna (of Tibet) is probably the result of a single recent colonization event. The similar event was in central and southern Europe where *G. lacustris* settled various localities during the last Glacial period. After the end of glacial period, many populations remain isolated in various localities, especially mountain lakes (Bosnia and Herzegovina, Montenegro, N. Italy), sometimes nominated as a distinct taxa).

Hou et al. (2007) based on their molecular phylogenetic study of genus *Gammarus,* suggested the hypothesis of" monophyly of the genus *Gammarus*, paraphyly of the *Gammarus* from North America and Europe, and monophyly of *Gammarus* from Asia. They split the Asian clade into a southeastern group and a northwestern group, mentioning that climate change following the uplift of the Tibetan Plateau was probably the most important factor in process of the diversification of southeastern and northwestern groups. They moved *G. lacustris* in the northwestern group, with dispersion from Asia towards, Europe and North America. They concluded that based on phylogeny, *G. lacustris* have Asian phylogeny. The Asiatic origin of *G. lacustris* is confirmed based on allozyme study of the European specimens of *G. lacustris* (see Vainola & Vainola, 2003).

Matafonov (2007) studied *Gammarus lacustris* in transbaikalian fresh- and salt lakes: Lake Khalanda (salt), lake Bain-Tsagan, lake Arakhlei (weakly mineralized), lake Zun-Torei, lake Bain Bulak, but he don`t mention any morphological differences between populations living in various types of waters.

Østbye, K. et al. (2018) made comparative studies on population of *G. lacustris* in Norway from two ecologically different localities: subterranean Sandågrotta Cave system and epigean Lake Lille Lauarvann (southern Norway), establishing morphological and ecological differences between populations of these two localities: different length of antennae 1-2, number of ommatidia in eyes, some eco-physiological differences. This show that populations of *G. lacustris* (sensu auct.) can obtain some morphological and other differences in different living places, and eventually later to evolve into a distinct different species.

The presence of all these various suggestions and hypotheses show that we have not yet understand established decisive taxonomical characters (morphological, phylogenetic, molecular, etc.) for exact recognition of many single populations and taxa of genus *Gammarus*, including these similar to *G. lacustris.* It is rather questionable that *Gammarus lacustris,* despite its extreme circumpolar distribution (Europe, Asia, N. America), very adaptive species living in fresh and brackish waters, omnivore, but poorly competitive regarding other invasive species, remains considered a single taxon, based on present degree of morphological and molecular genetics investigations.

We need to adopt further new additional molecular genetics methods, more detailed and more complete morphological description of single body-parts, use additional characters (comparative anatomy, cytology, ontogeny, etc.) to recognize different taxonomical categories within populations of various localities, including the category of subspecies.

REFERENCES

[1] BARNARD, J. L. & BARNARD, C. M. 1983. Freshwater amphipods of the World. I. Evolutionary patterns. II. Handbook and bibliography. — Hayfield Associates: Mt. Vernon, Virginia, 1983, pp. XIX +849 pages, 50 figs., 7 graphs, 98 maps, 12 tables.

[2] BARNARD, J. L. & DAI AY 1988. Four species of *Gammarus* (Amphipoda) from China. — Sinozoologia, 6: 85–112.

[3] CLEWING, C, WILKE, T. & ALBRECHE, C. 2016. Phylogenetic patterns of freshwater amphipods inhabiting the Tibetan Plateau. Crustaceana 89: 239–249. https://doi.org/10.1163/15685403-

[4] DOROGOSTAISKII, V. Ch. 1917. O faune rakoobraznikh r. Angari. — Ezheg. Zoolog. Muz. A. N., 21 (4): 302–322, pl. 16 (1916).

[5] GURJANOVA, E. F. 1951. Bokoplavy morei SSSR i sopredelnikh vod (Amphipoda Gammaridea). — Akademiia Nauk SSSR., Zoolog. Institut Akademii Nauk, Opredeliteli po faune SSSR, 41: 1–1131, 705 figs.

[6] HOU, Z. & LI, S. 2004 *Gammarus* species from Tibet highland, China (Crustacea: Amphipoda: Gammaridae). — The Raffles Bulletin of Zoology 52: 147–170.

[7] HOU, Z, FU, J. & LI, S. 2007. A molecular phylogeny of the genus *Gammarus* (Crustacea: Amphipoda) based on mitochondrial and nuclear gene sequences.- Molecular

Phylogenetic and Evolution 45: 596–611. https://doi.org/10.1016/j.ympev.2007.06.006.
[8] HOU, Z. & LI, S. 2018. Four new *Gammarus* species from Tibetan Plateau with a key to Tibetan freshwater gammarids (Crustacea, Amphipoda, Gammaridae). — ZooKeys 747: 1–40 (2018) doi: 10.3897/zookeys.747.2199 http://zookeys.pensoft.net.
[9] KARAMAN, G. 1969. XXVII. Beitrag zur Kenntnis der Amphipoden. Arten der Genera *Echinogammarus* Stebb. und *Chaetogammarus* Mart. an der jugoslawischer Adriaküste. — Glasnik Republičkog zavoda za zaštitu prirode i Prirodnjačke zbirke u Titogradu, 2: 59–84, 51 figs.
[10] KARAMAN, G. & PINKSTER, S. 1977. Freshwater *Gammarus* Species from Europe, North Africa and adjacent regions of Asia (Crustacea- Amphipoda). Part. I. *Gammarus pulex*-group and related Species. — Bijdragen tot de Dierkunde, Amsterdam, 47 (1): 1–97, 38 figs.
[11] KARAMAN, G. 1993. Crustacea Amphipoda di acqua dolce. — Fauna d`Italia, vol. XXXI: 1–337, 154 figs, Edizione Calderini, Bologna, Italia.
[12] KARAMAN, S. 1931. 4. Beitrag zur Kenntnis der Süsswasser-Amphipoden. — Glasnik Skopskog Naučnog Društva, Odelenje Prirodnih Nauka, Skoplje, 9 (3): 93-107, figs. 1–6.
[13] KARAMAN, S. 1934. Über asiatische Süsswassergammariden. — Zoologischer Anzeiger, Leipzig, 106 (5/6): 127–134, figs. 1–4.
[14] MATAFONOV, D.V. 2007. Ecology of *Gammarus lacustris* Sars (Crustacea: Amphipoda) in Transbaikalian Water Bodies. — Izvestiia Akademii Nauk, Seriia Biologicheskaya 2: 188–196.
[15] ØSTBYE, K., ØSTBYE, E., LIEN, A.M, LEE, L.R, LAURITZEN, S-E, & CARLINI, D.B. 2018. Morphology and life history divergence in cave and surface populations of *Gammarus lacustris* (L.). PLoS ONE 13(10): e0205556. https://doi.org/10.1371/journal.pone.0205556.
[16] PINKSTER, S. 1972. On members of the *Gammarus pulex*-group (Crustacea Amphipoda) from western Europe. — Bijdragen tot de Dierkunde, 42 (2): 164–191.
[17] SARS, G.O. 1863. Beretning om en i Sommeren 1862 foretagen zoologisk Reise i Christianias og Trondhjems Stifter. — Nyt Magazin for Naturvidenskaberne, Christiania, 12 (3): 193–252.
[18] SCHELLENBERG, A. 1937. Kritische Bemerkungen zur Systematik der Süsswassergammariden. Zoologische Jahrbuecher, Abteilung fuer Systematik, 69: 469-516.
[19] STOCK, J.H. 1969. Notes and news. *Rivulogammarus*, an Amphipod name that must be reyected. — Crustaceana, 17 (1): 106–107.
[20] VAINIO, J.K. & VAINOLA, R., 2003. Refugial races and postglacial colonization history of the freshwater amphipod *Gammarus lacustris* in Northern Europe. — Biol. J. Linnean Soc. 79, 523–542.
[21] WIKIPEDIA, the free encyclopedia 2022.
[22] WORLD AMPHIPODA DATABASE 2022.

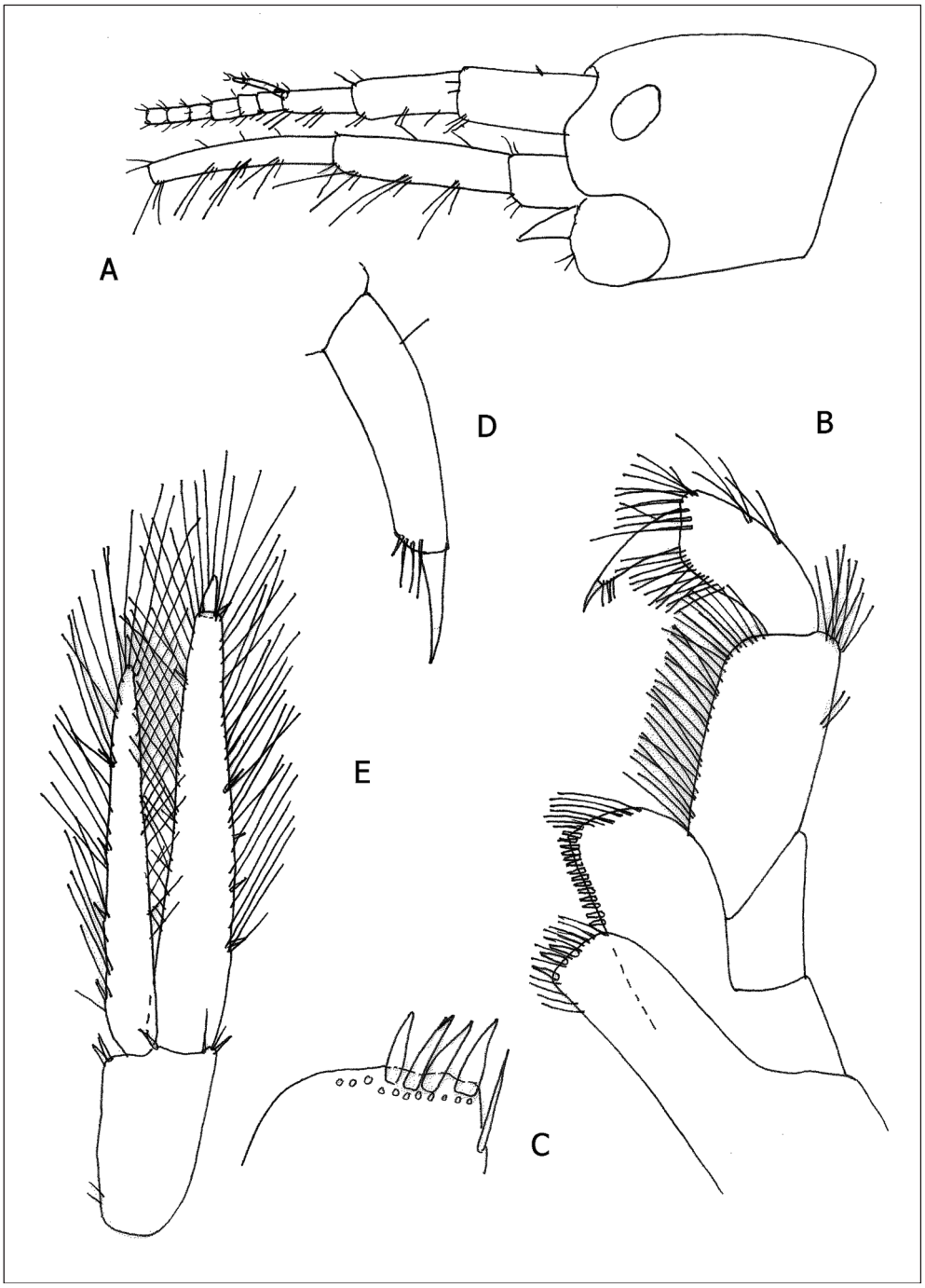

Fig. 1. "*Gammarus stoliczkae*" S. Karaman, 1934. Tso Moriri Lake, Rupchu province, Ladakh, NE India:. Male 12.5 mm: A= head wih antennae; B= maxilliped; C= inner plate of maxilliped; D= palpus article 4 of maxilliped; E= uropod 3.

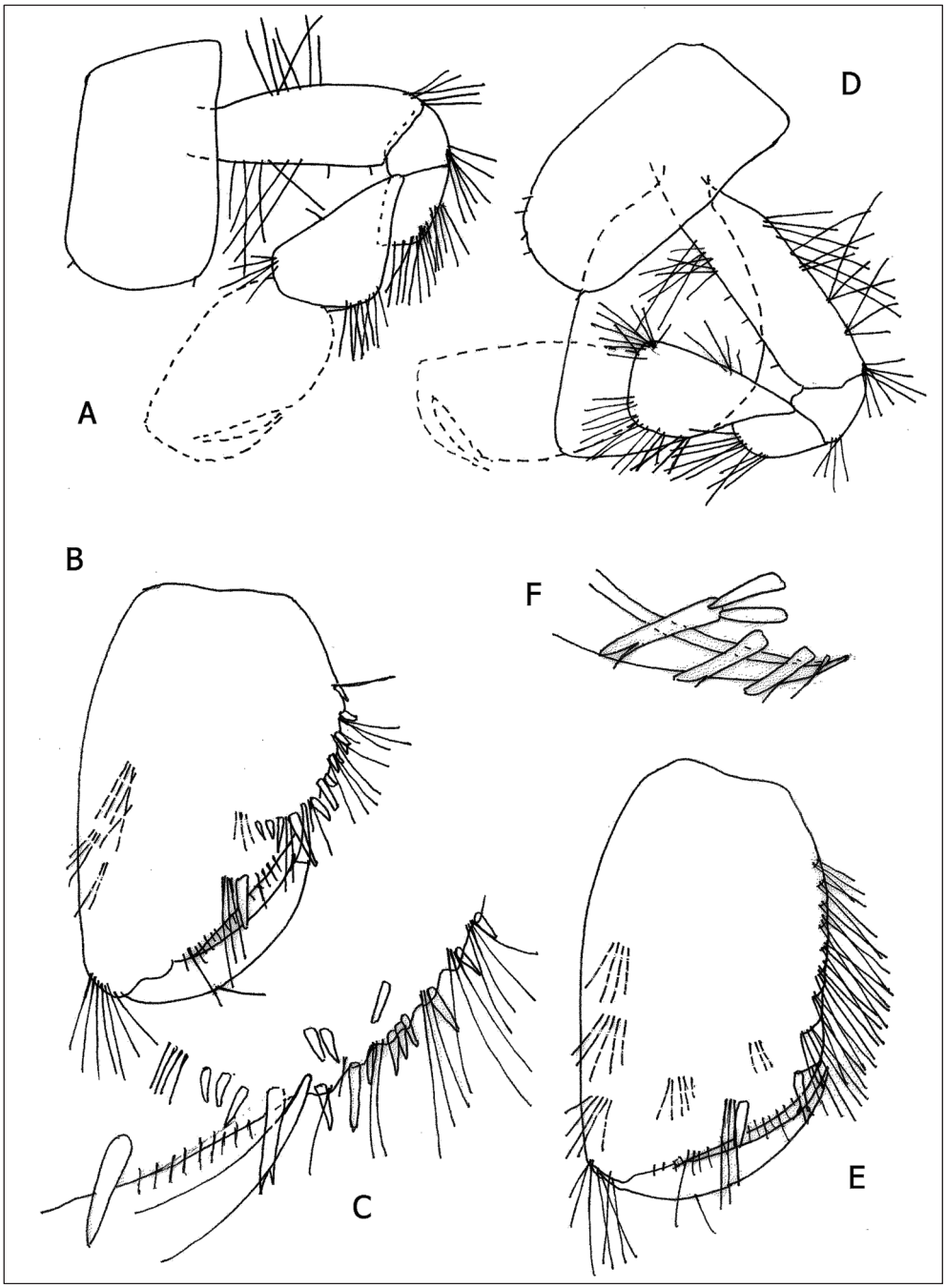

Fig. 2. "*Gammarus stoliczkae*" S. Karaman, 1934. Tso Moriri Lake, Rupchu province, Ladakh, NE India. Male 12.5 mm. : A=gnathopod 1; B= propodus of gnathopod 1; C= palm of gnathopod 1- propodus; D= gnathopod 2; E= propodus of gnathopod 2; F= palm of gnathopod 2-propodus.

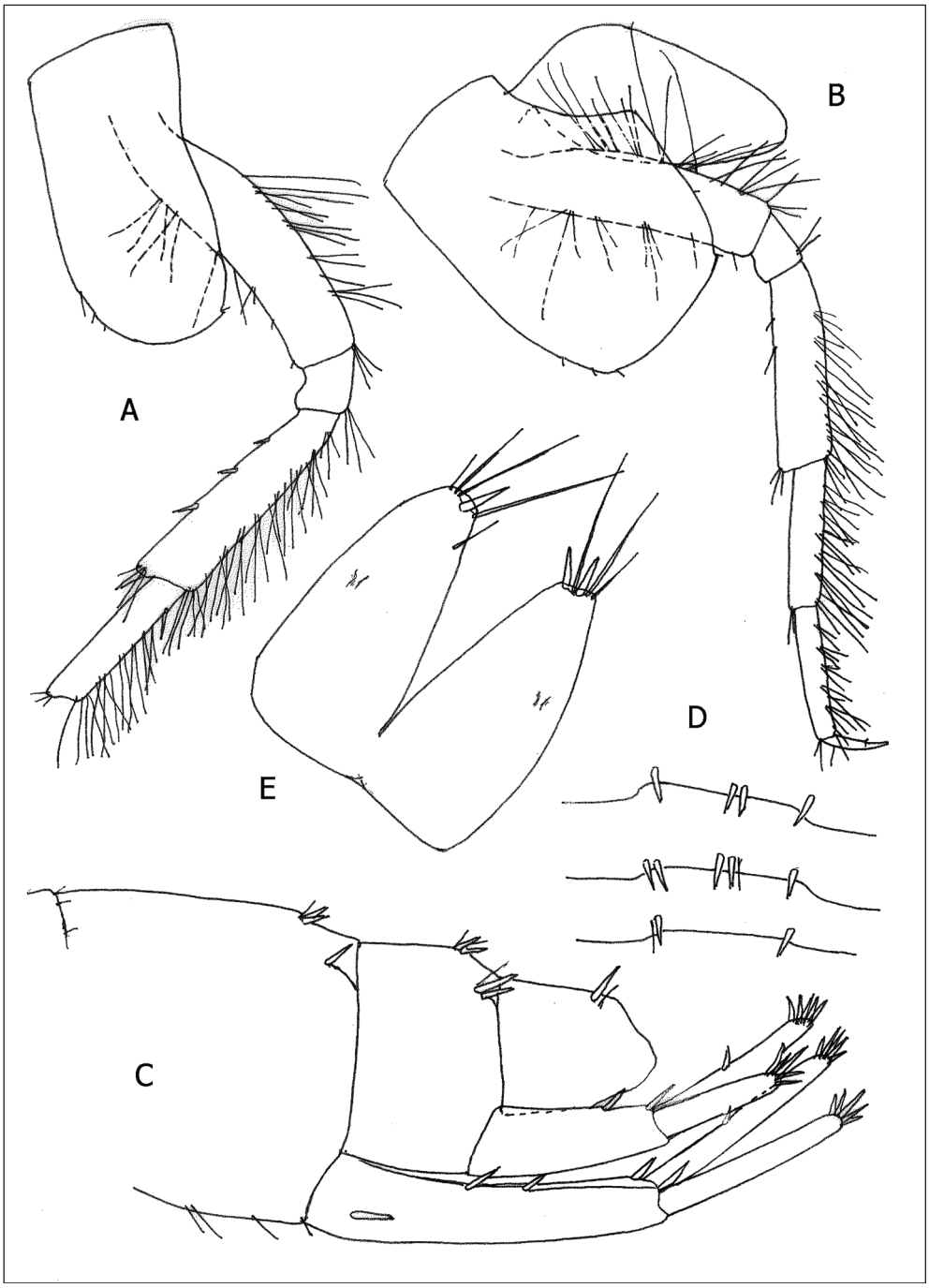

Fig. 3. "*Gammarus stoliczkae*" S. Karaman, 1934. Tso Moriri Lake, Rupchu province, Ladakh, NE India. Male 12.5 mm. A= pereopod 3; B= pereopod 4; C= urosome with uropods 1-2; D= urosome, dorsal view; E= telson.

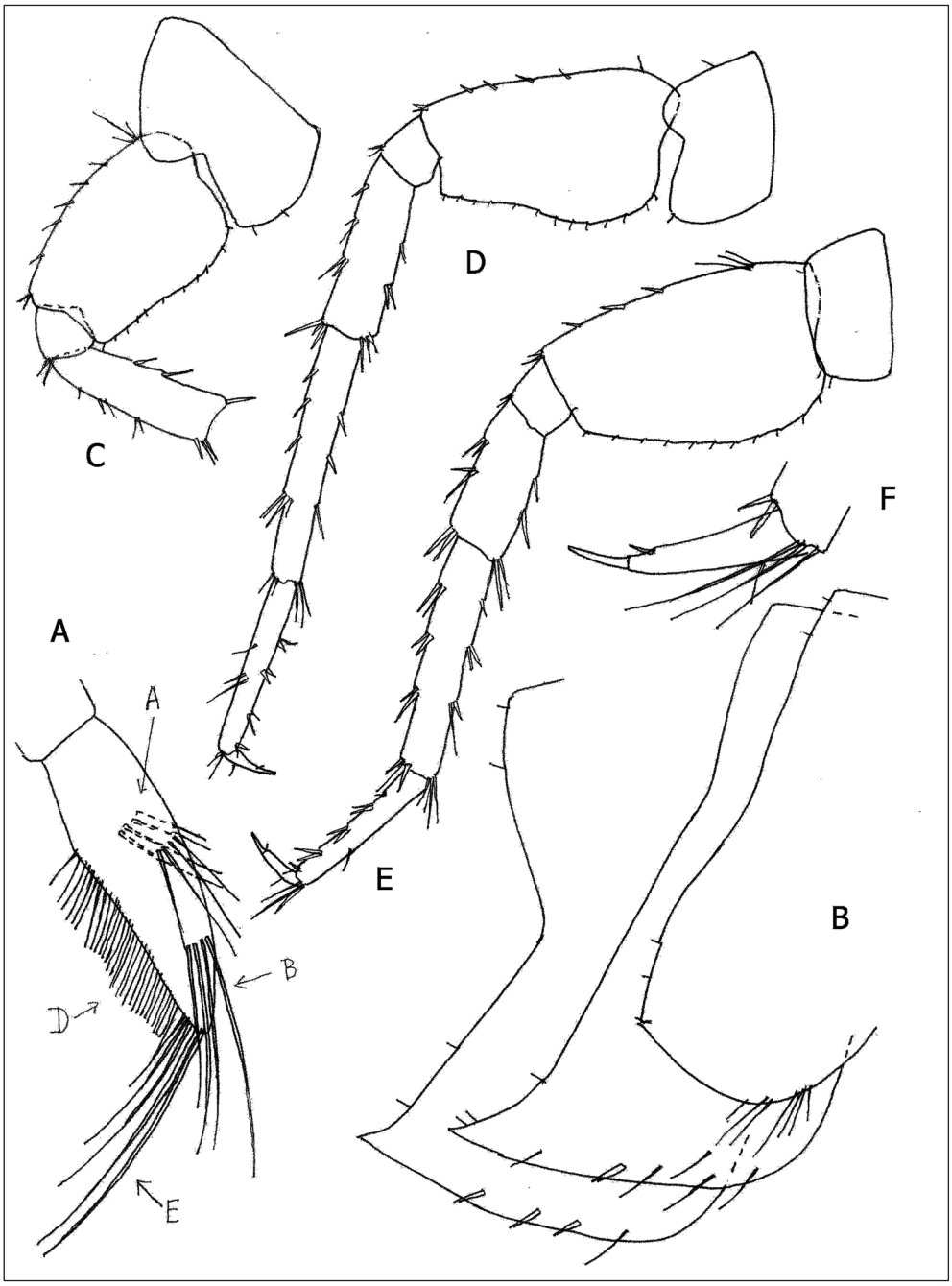

Fig. 4. "*Gammarus stoliczkae*" S. Karaman, 1934. Tso Moriri Lake, Rupchu province, Ladakh, NE India. Male 12.5 mm. A= mandible distal article (D= marginal D-setae; E= distal E-setae; A= outer facial A-setae; B= inner facial B-setae); B= epimeral plates 1-3; C= pereopod 5; D= pereopod 6; E-F= pereopod 7.

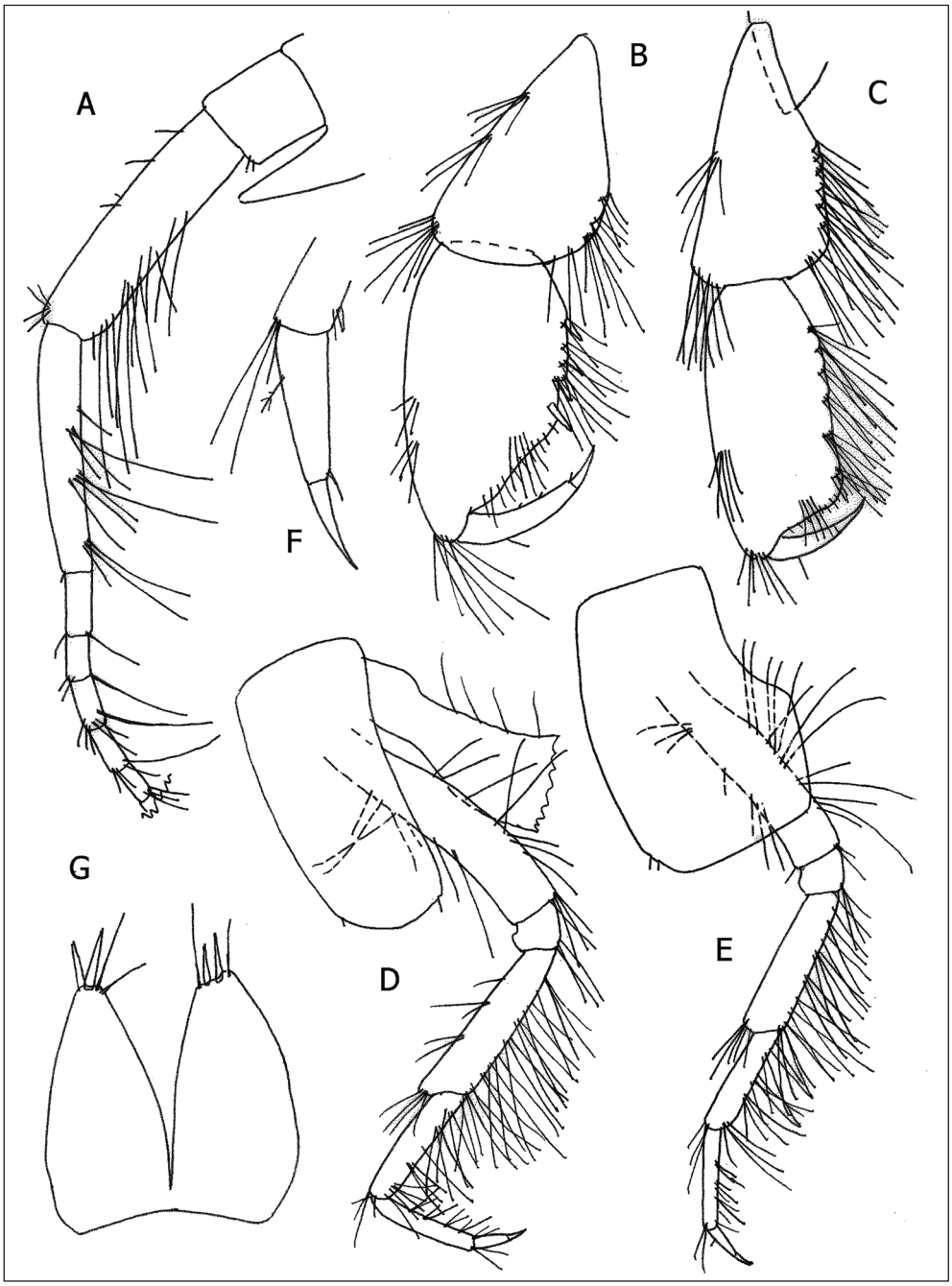

Fig. 5. "*Gammarus stoliczkae*" S. Karaman, 1934. Tso Moriri Lake, Rupchu province, Ladakh, NE India. Female, ovig. Female 9.5 mm: A= antenna 2; B= gnathopod 1 article 5 and propodus; C= gnathopod 2 article 5 and propodus; D= pereopod 3; E= pereopod 4; F= pereopod 7 dactylus; G= telson (one facial seta missing).