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AMUROCRANGONYX, A NEW GENUS OF SUBTERRANEAN AMPHIPOD (CRANGONYCTIDAE) FROM THE RUSSIAN FAR EAST, WITH A REDESCRIPTION OF THE POORLY KNOWN *CRANGONYX ARSENJEVI* AND COMMENTS ON BIOGEOGRAPHIC RELATIONSHIPS

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ABSTRACT

Amurocrangonyx n. gen. is described on the basis of recently collected specimens of *Crangonyx arsenjevi* (Derzhavin, 1927), a very poorly known subterranean amphipod crustacean originally described from springs in the Khor River basin of the Ussury River drainage in the Russian Far East. The species is redescribed from specimens obtained from the type-locality, Orekhovy spring, and a neotype is designated. A careful examination of the newly acquired material, although closely similar morphologically to *Crangonyx*, suggests that it represents a new genus in Crangonyctidae. However, determination of the precise phylogeographic relationship of *Amurocrangonyx* to *Crangonyx* or to other crangonyctoid genera in East Asia is unclear and must await molecular analyses.

INTRODUCTION

Recent biological exploration of subterranean groundwater outlets near the Khor River, approximately 60 km south of Khabarovsk in the Amur River drainage basin, by one of us (DAS) resulted in the collection of amphipods in the family Crangonyctidae from Orekhovy Spring. The specimens, of moderate stygomorphic facies, are light reddish in color and eyeless except for yellowish pigment masses in their place. The material was found at the type-locality of the poorly known *Crangonyx arsenjevi*, which was described by A. N. Derzhavin in 1927 and originally placed in the now defunct genus *Eucrangonyx*. The species was later reassigned to the genus *Crangonyx* by Borutzky (1928). Type material of *C. arsenjevi* was either lost or not deposited, and the original description of the species by Derzhavin (1927) was so lacking in detail that the correct generic assignment and taxonomic status have remained problematic until now (Holsinger, 1977, 1986; Zhang and Holsinger, 2003). Careful study of the recently collected specimens leaves no doubt about the identity of this species, its placement in Crangonyctidae, and its close morphological affinity with other species in the genus *Crangonyx*. However, despite the many similarities with *Crangonyx* sensu stricto, this species differs significantly from all other members of the genus by the structure of uropod 3 and is herein designated the type-species of the new genus *Amurocrangonyx* described below.

The lack of a holotype or other type-specimens for *Crangonyx arsenjevi* (Derzhavin) necessitated the designation of a neotype for the species. A search for collections of A. N. Derzhavin in the Zoological Institute of the Russian Academy of Sciences (ZINRAS) in St. Petersburg and in Moscow State University was futile. Moreover, we were informed by Dr. G. M. Pjatakova (personal communication), who worked with Derzhavin in the last years of his life, that all of his collections except for several types of Caspian amphipods had been destroyed.

Preparation of specimens, measurements, and illustrations were made utilizing the standard techniques described by Zhang and Holsinger (2003). Nomenclature for setal patterns on segment 3 of the mandibular palp follows the widely accepted standard introduced by Stock (1974). The material examined in this study is deposited in the Zoological Institute of the Russian Academy of Sciences (ZINRAS), St. Petersburg; research collection of the Institute of Biology and Soil Science, Vladivostok; and research collection of J. R. Holsinger (JRH) at Old Dominion University, Norfolk.

SYSTEMATICS

Crangonyctidae Bousfield, 1973 (emended 1977)
Armurocrangonyx, new genus

Diagnosis.—Closely allied morphologically and ecologically with *Crangonyx* but differing from that genus primarily in the distinctive outer ramus of uropod 3, which tapers only slightly distally and bears 2 lateral and 1 median spines and 5 or 6 prominent spines on the apex. Lateral lobe of head broadly rounded. Antenna 1 longer than antenna 2; accessory flagellum 2-segmented; peduncular segments 4 and 5 subequal in length. Incisor, lacinia mobilis, and molar of both mandibles well developed; segment 2 of palp longer than segment 3, bearing row of setae medially, segment 3 with complete setal pattern. Inner lobes of lower lip present. Inner plate of maxilla 1 with strong, plumose apical setae; outer plate with 7 apical, serrate and bifid spines. Inner and outer plates of maxilla 2 subequal in size, inner with oblique row of plumose setae on medial margin and inner face. Inner plate of maxilliped bearing 3 apical spines and row of plumose setae; outer plate extending well beyond inner plate, medial margin with row of small, non-plumose setae and 4 slender spines; segment 2 of palp nearly as long as entire palp, with row of long, non-plumose setae on inner margin; dactyl with prominent nail.

Gnathopods: propodi robust and coxae relatively deep; propodus of gnathopod 2 approximately 25% larger than propodus of gnathopod 1; both propodi distinguished by relatively long, oblique palmar margins bearing complex double rows of distally notched (bifid) spine teeth. Pereiopods 3 and 4 subequal in length, bases rather long and narrow, and bearing long setae on posterior margins; coxa of 3 more than twice as deep as wide; coxa of 4 deep and greatly expanded distally, with prominent posterior excavation. Pereiopod 6 longer than pereiopods 5 and 7; basis of 7 longer than bases of pereiopods 5 and 6; dactyli relatively short, 1/4 to 1/3 length of corresponding propodi. Coxal gills on pereiopods 2-6, absent from 7. Single, median sternal gills/processes present on pereionites 2 and 3; paired, simple, lateral sternal gills on pereionites 6 and 7 and pleonite 1. Brood plates (oöstegites) rather broad, with long marginal setae. Pleonal plates 1-3: distoposterior corners produced and acute in plates 2 and 3, receded and subacute in plate 1; posterior margins with few setules, ventral margins with tiny spines. Pleopods 1-3 subequal in length, peduncles with 4 retinaculae, outer margin of peduncular segment of inner rami bearing bifid spines, all rami with plumose setae.

Uropods 1 and 2 moderately spinose: rami subequal in length, peduncles equal to or little longer than rami. Uropod 3: inner ramus vestigial, scale-like, with 2 short apical spines; outer ramus little longer than peduncle, bearing 3 spines toward distal end; apex blunt and bearing 5 or 6 relatively prominent spines but lacking setae. Telson broader than long, apical margin incised from 40 to 50% of length to base; apical lobes each bearing 3 to 4 prominent spines.

Type Species.—*Crangonyx arsenjevi* (Derzhavin) (by monotypy). Gender masculine.

Etymology.—The generic name is a derived by a combination of *Amur*, the name of a great river in East Asia, with *Crangonyx*, a closely similar genus.

Amurocrangonyx arsenjevi (Derzhavin, 1927)
Figs. 1-5

Eucrangonyx arsenjevi Derzhavin, 1927: 176 (figs. 1, 2, 3, 4).

Crangonyx arsenjevi (Derzhavin).— Borutzky 1928: 254.— Schellenberg, 1936:35.— Birstein, 1969:32.— Holsinger, 1977:254.— Holsinger, 1986:536.— Zhang and Holsinger, 2003: 2.

Material Examined.—RUSSIA. Khabarovsk territory, Perejaslavsky region: Orekhovy spring (47° 54.097′ N; 135° 20.370′ E) 4 km east of Georgievka village in Khor River basin, ♀ neotype (12.3 mm), 4 ♀♀ paraneotypes (8.0-11.0 mm) and 1 ♂ paraneotype (9.0 mm), D. Sidorov, M. Tiunov and T. Tiunova, 15 July 2005. Orekhovy spring and seeps on the bank of Privalovskaya channel (47° 54.025′ N; 135° 21.273′ E), 24 ♀♀, D. Sidorov and K. Semenchenko, 8 Aug. 2005.

The neotype ♀ is deposited in the Zoological Institute of Russian Academy of Sciences (1/88417-ZINRAS), along with 4 paraneotype ♀♀ (2/88418, 3/88419, 4/88420, 5/288421). Additional paraneotypes (29 ♀♀ and 1 and ♂) are deposited in research collections of the Institute of Biology and Soil Science Vladivostok, Russia and J. R. Holsinger (H-4406), Old Dominion University.

Diagnosis.—A medium-sized species of moderate stygomorphic facies, lightly reddish in color when alive but completely colorless in preservation; eyes absent but with yellowish pigment masses in their place. Body smooth, not carinate; lateral lobe of head broadly rounded, without inferior sinus (Fig. 1H). Antenna 2 of male lacking calceoli (in the single specimen at hand). Propodus of gnathopod 2 larger than propodus of gnathopod 1, palmar margins of both gnathopod propodi bearing complex double rows of distally bifid spines. Pereiopod 6 little longer than pereiopod 6. Uropod 2 of male apparently not sexually dimorphic; uropod 3 differing from that of the closely related genus *Crangonyx* as noted in generic diagnosis. Telson broader than long, with prominent apical notch. Largest females, 12.3 mm; largest and only known male, 9.0 mm.

Female.—Lateral lobe of head broadly rounded (Fig. 1H). Antenna 1 (Fig. 1B) 65 to 80% length of body, approximately twice length of antenna 2; peduncular segments 1 and 2 subequal in length; flagellum with 30 segments, each bearing 1 or sometimes 2 aesthetascs on medial margin; accessory flagellum two-articulate, shorter than accompanying flagellar segment. Antenna 2 (Fig. 1A): peduncular segment 4 little longer than peduncular segment 5; flagellum with 10 segments. Upper lip subrounded, with setules on apex. Right mandible (Fig. 1D): incisor 5-dendate; lacinia mobilis bifurcate, both parts with serrations; molar strong, with plumose seta; spine row with approximately 19 small, plumose spines; palp segment 2 longer than segment 3, bearing row of about 11 rather long setae on inner margin; palp segment 3 with 3 A setae, 3 B setae, 2 C setae, 4 E setae and row of about 18 D setae. Left mandible (Fig. 1C) similar to right mandible except is 5-dendate and not bifurcate. Lower lip (Fig. 1F) with cone-shaped inner lobes. Maxilla 1 (Fig. 1G): inner plate with 6-9 long, plumose setae; outer plate with 7 apically spines, 5 distally serrate, 2 bifid; palp with a mixture of 13 slender spines and spine-like setae. Maxilla 2 (Fig. 2A): inner plate little broader than outer plate, with oblique row of 8 rather long, plumose setae extending from medial margin onto inner face; both plates with numerous apically setae, some lightly plumose. Lateralia (Fig. 1E) (structure in anterior part of stomach) subrectangular, with 10-13 strong pectinate spines and group of slender setae on distal margin.

Gnathopod 1 (Fig. 3A): propodus nearly twice length of carpus, palm (Fig. 3C) nearly straight, subequal in length to posterior margin, armed with row of 22 distally-notched (bifid) spine teeth on inside and 19 on outside, defining angle bearing 2 large, distally notched spines and 2 smaller, serrate spines on inside and 4 comparatively much smaller serrate spines on outside, superior medial setae singly inserted but in groups of 3, posterior margin with 5 sets of setae; dactylus with row of 6 setules on inner margin, nail short with 2-3 setules at hinge; basis bearing long, thread-like setae on anterior, posterior and medial margins; coxa subrectangular, deeper than broad, with about 8 setules on ventral margin. Gnathopod 2 (Fig. 3B): propodus about 30% longer than propodus of gnathopod 1, palm (Fig. 3D)

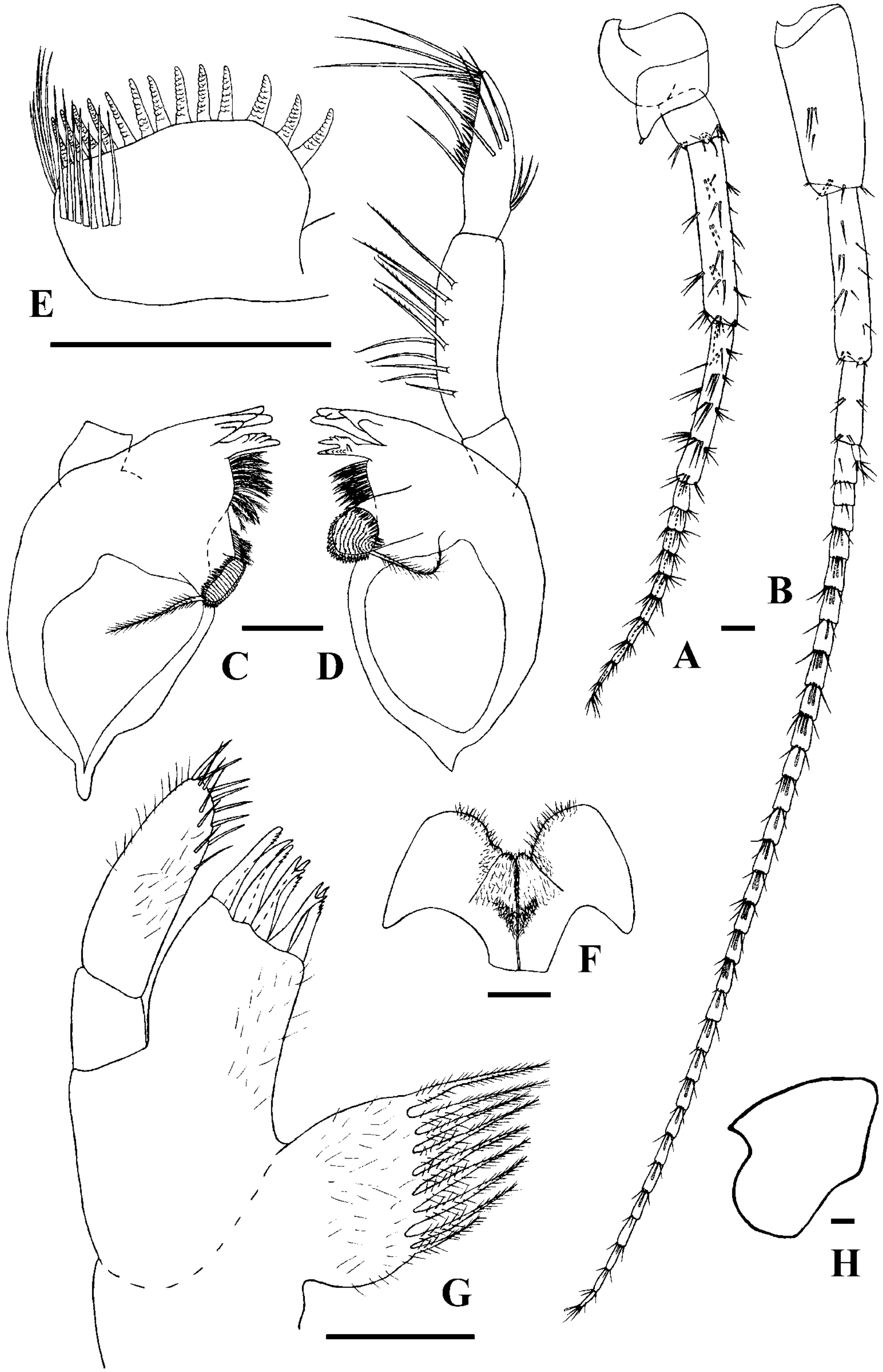

Fig. 1. *Amurocrangonyx arsenjevi* (Derzhavin), neotype female (12.3 mm), Orekhovy spring: A, antenna 2; B, antenna 1; C, left mandible; D, right mandible; E, lateralia; F, lower lip; G, maxilla 1; H, head. Scale bar 0.2 mm.

weakly convex, longer than posterior margin, armed with double row of 32 distally notched spine teeth on inside and 19 on outside, defining angle with 2 notched spine teeth on inside and 3 notched spine teeth of unequal lengths on outside, superior medial setae in groups of 2 and 3, posterior margin weakly convex, bearing 5 clusters of setae; dactylus with 6 setules on inner margin, nail short with 2 or 3 setules at hinge; basis with row of 5 long, thread-like setae on

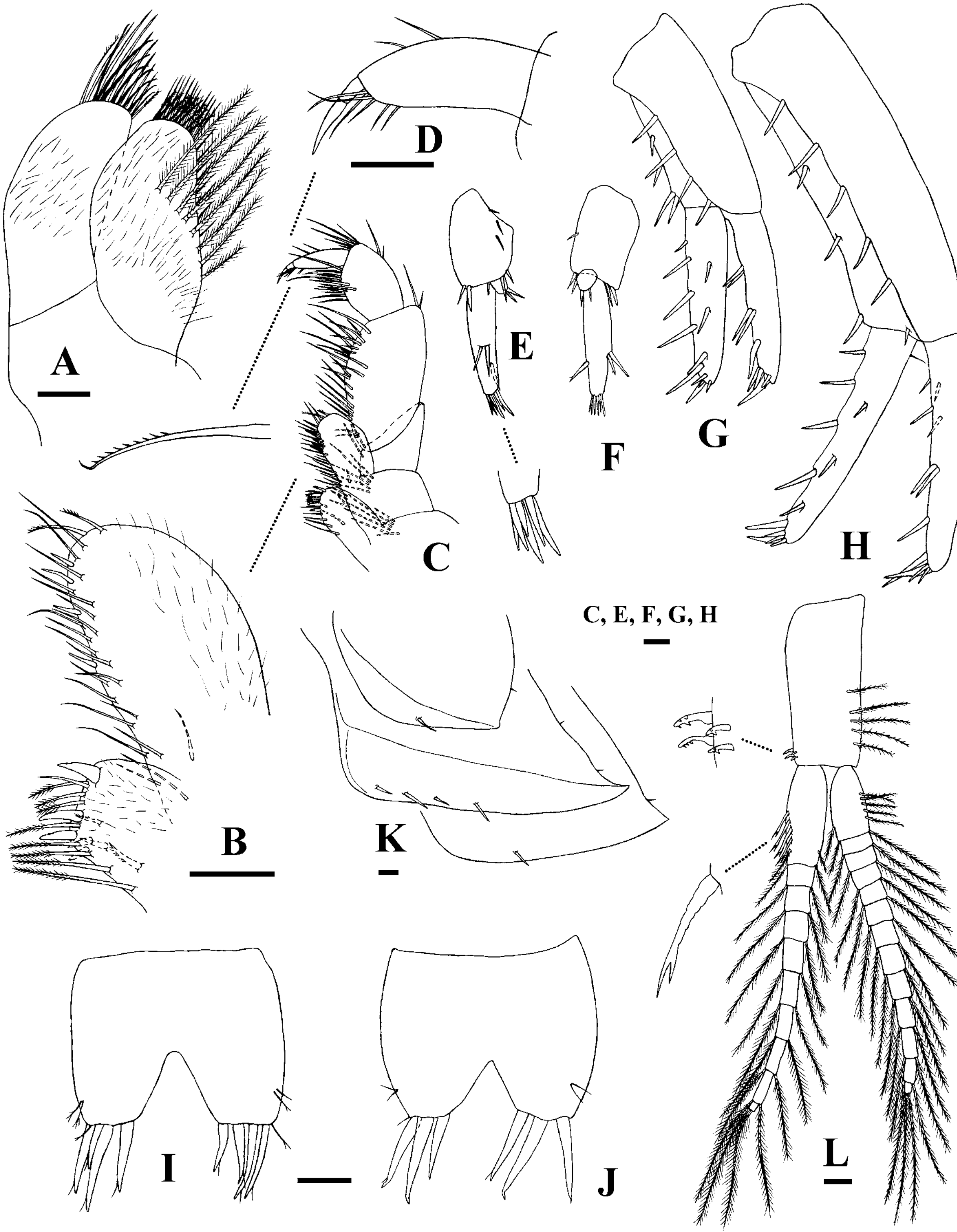

Fig. 2. *Amurocrangonyx arsenjevi* (Derzhavin), neotype female (12.3 mm), Orekhovy spring: A, maxilla 2; B, inner and outer plates of maxilliped; C, inner face of maxilliped; D, palp dactylus of maxilliped; E, uropod 3; G, uropod 2; H, uropod 1; I, telson; K, pleonal plates; L pleopod 1. Paraneotype female (11.0 mm), Orekhovy spring: F, uropod 3; J, telson. Scale bar 0.1mm.

posterior margin and 3 such setae on anterior margin just beyond coxa; coxa subrectangular, deeper than broad, with about 8 setules on ventral margin. Pereiopods 3 and 4 (Fig. 4A, B) subequal in length; coxae 50% deeper than broad; distal margin of coxa 3 narrowly rounded, with 9 or 10 setules; coxa of pereiopod 4 greatly expanded distally, posterior margin with prominent excavation, distal margin broadly convex, with 12-18 setules; bases bearing long,

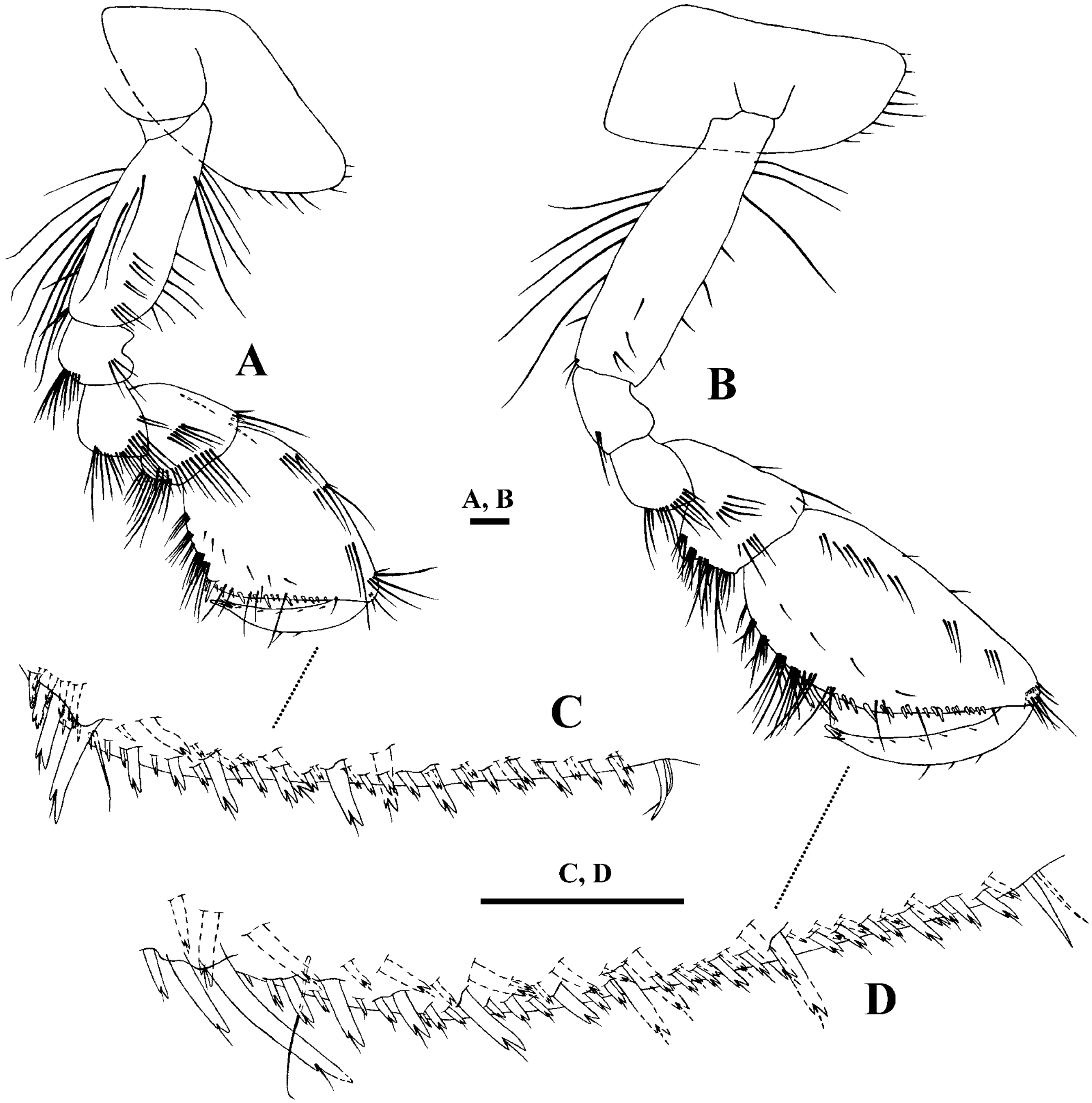

Fig. 3. *Amurocrangonyx arsenjevi* (Derzhavin), neotype female (12.3 mm), Orekhovy spring: A, gnathopod 1; B, gnathopod 2; C, palmar region of gnathopod 1; D, palmar region of gnathopod 2. Scale bar 0.2 mm.

thread-like setae on posterior margins; dactyls (Fig. 4F) short, only about 25% length of corresponding propodi. Pereiopods 5-7 (Fig. 4C, D, E): coxae of 5 and 6 with relatively broad posterior lobes bearing few tiny spines, coxa of 7 much smaller, cap-like; pereopod 6 (Fig. 4D) approximately 75% length of body, pereiopod 5 (Fig. 4C) subequal in length to pereopod 7 (Fig. 4E) but basis longer; pereiopod 6 (Fig. 4D) longer than pereiopods 5 and 7, but basis comparable in length to that of 7; bases of pereiopod 5-7 broader proximally that distally, margins with setules, distoposterior lobes poorly developed; dactyls (Fig. 4G) relatively short, only about 25-30% length of corresponding propodi. Stalked coxal gills present on pereiopods 2-6; single median sternal gills (processes) present on pereionites 2 and 3; simple, paired, lateral sternal gills present on pereionites 6 and 7, and pleonite 1. Brood plates (oöstegites) saccular, expanded distally, with long marginal setae.

Pleonal plates 1-3 (Fig. 2K): posterior margin of plate 1 slightly convex, not produced, with 1 setule, distoposterior corner small, recessed, subacute, ventral margin with

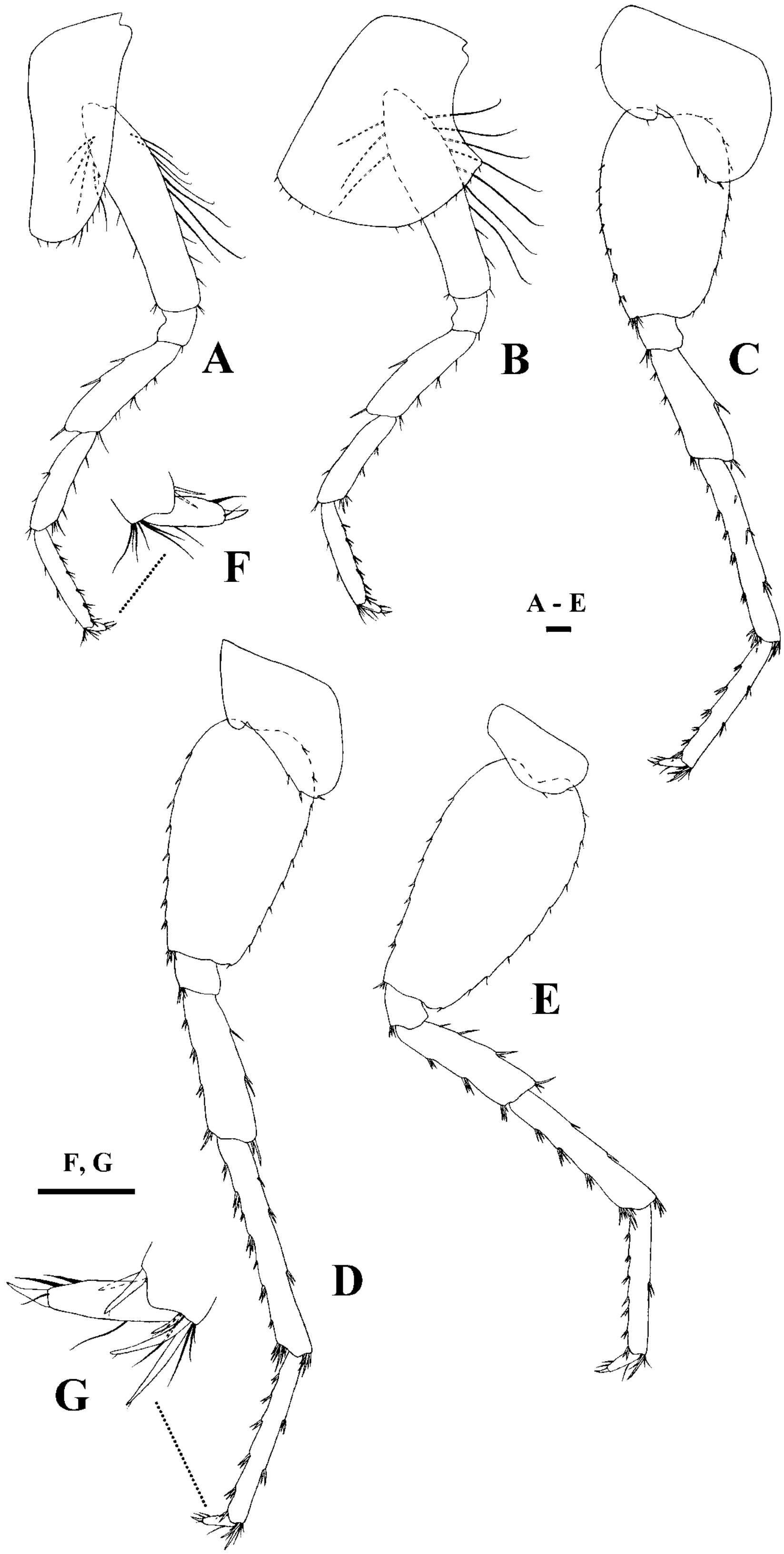

Fig. 4. *Amurocrangonyx arsenjevi* (Derzhavin), neotype female (12.3 mm), Orekhovy spring: A, pereiopod 3; B, pereiopod 4; C, pereiopod 5; D, pereiopod 6; E, pereiopod 7; F, dactylus of pereiopod 3; G, dactylus of pereiopod 4. Scale bar 0.2 mm.

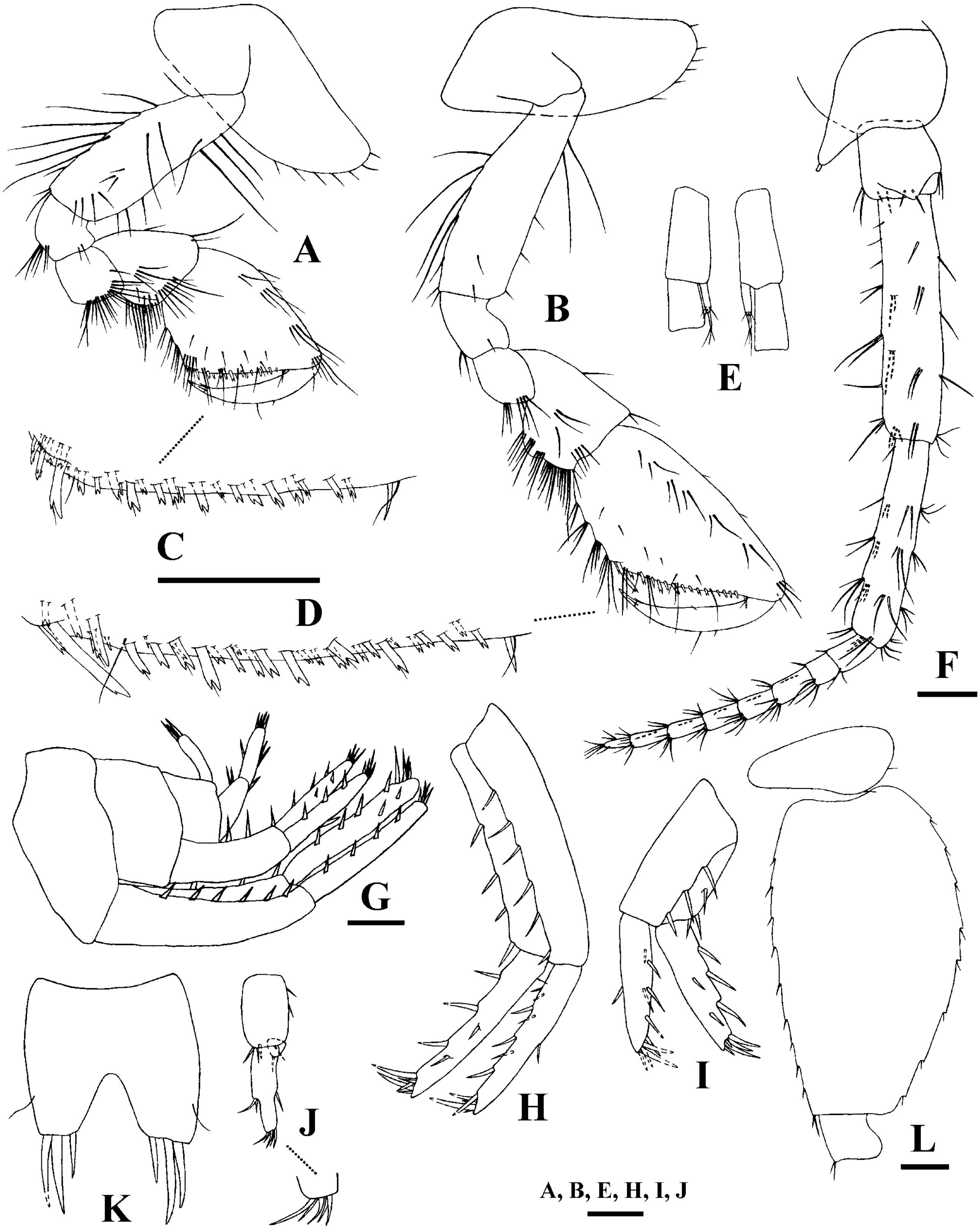

Fig. 5. *Amurocrangonyx arsenjevi* (Derzhavin), paraneotype male (9.0 mm), Orekhovy spring: A, gnathopod 1; B, gnathopod 2; C, palmar margin of gnathopod 1; D, palmar margin of gnathopod 2; E, length variation in accessory flagella of antenna 1; F, antenna 1; G, urosome with attached appendages; H, uropod 1; I, uropod 2; J, uropod 3; K, telson; L, pereiopod 7 (in part). Scale bar 0.2 mm.

1 spine; posterior margins of plates 2 and 3 strongly produced, with 1 or 2 setules each, distoposterior corners relatively large, acute; ventral margin of plate 2 with 4 spines, that of 3 with 1 spine. Pleopods 1-3 (Fig. 2L) subequal, peduncles each with 4 coupling spines (retinaculae) on inner margin distally and 5 lightly plumose setae on outer margin; segment 1 of inner ramus bearing 4 slender bifid and 1 plumose setae on inner margin; segment 1 of outer ramus bearing 5 plumose setae on outer margin; all segments of rami with pairs of rather long plumose setae. Uropod 1 (Fig. 2H): inner ramus subequal in length to outer ramus and peduncle, armed with 7 or 8 marginal and 5 apical spines; outer ramus with 7 or 8 marginal spines and 4 apical spines; peduncle with 6 outer and 3 inner spines. Uropod 2 (Fig. 2G): inner ramus subequal in length to outer ramus and peduncle; armed with 6 or 7 marginal and 5 apical spines; outer ramus with 5 upper marginal and 5 apical spines; peduncle with 4 outer and 4 inner spines. Uropod 3 (Fig. 2E, 2F): inner ramus rudimentary, reduced to a scale with 2 short spines; peduncle with 4 or 5 small spines apically and 1 to 3 very small spines medially; outer ramus little longer than peduncle, tapering slightly toward distal end, armed on lateral margin with 2 spines and on medial margin with 1 spine, all inserted more distally than proximally; apex blunt or very slightly convex, armed with 5 or 6 naked spines but no setae. Telson (Fig. 2I, J) broader than long, with slightly convex outer margins; apical margin incised from 40 to 50% of length to base; apical lobes each bearing 3 to 4 prominent spines.

Male (apparently submature).—Differing from female as follows. Smaller with more slender body. Primary flagellum of antenna 1 with 24 to 28 segments, accessory flagellum (Fig. 5E) variable in length with respect to accompanying primary flagellar segment (cf., Derzhavin, 1927). Flagellum of antenna 2 (Fig. 5F) with 8 segments. Right mandible: spine row with 8 spines; palp segment 3 with 2 A setae, 2 B setae, 2 C setae, 3 E, and row of about 14 D setae. Palmar margin of propodus of gnathopod 1 (Fig. 5A, C) armed with row of 8 distally notched spine teeth on inside and 9 on outside, defining angle with 3 serrate spines and 1 large, distally notched spine tooth on inside and 4 serrate spine teeth on outside; posterior margin with 3 or 4 sets of setae; ventral margin of coxa with 7 short setae. Palmar margin of propodus of gnathopod 2 (Fig. 5B, D) armed with row of 14 distally-notched spine teeth on inside and 14 on outside; defining angle with 1 small and 1 large distally notched spine tooth on inside and 2 notched spine teeth on outside; superior medial setae in sets of mostly 2; posterior margin with 4 sets of setae; ventral margin of coxa with 6 short setae. Basis of pereiopod 7 (Fig. 5L) broader, with 8 weak serrations on posterior margin, 9 very short spines in groups on anterior margin. Uropods 1 (Fig. 5H) and 2 (Fig. 5I) with few less spines overall; outer ramus of uropod 2 not modified or sexually dimorphic in single specimen at hand. Outer ramus of uropod 3 subequal in length to peduncle, apex with 5 weakly curved spines.

Variation.—Some of the females have 7-9 spines on the outer margin of uropod 1.

Type Locality.—Orekhovy spring (Figure. 6), 4 km east of Georgievka village in the Perejaslavsky region of Khabarovsk territory, Russia. As shown on the map in Fig. 6 (lower right panel), Orekhovy spring is one of several groundwater discharge points in this part of the drainage basin complex of the Khor River.

Distribution and Ecology.—At Orekhovy Spring specimens of *Amurocrangonyx arsenjevi* were collected from small, subsidiary groundwater outlets at a depth of 5-20 cm in substrate consisting of a mixture of variously sized sand grains beneath stones and pebbles. Specimens were not found in the main outflow of the spring. Physical and chemical parameters of the water at the collecting sites included: temperature 5°C, hardness 1.2-1.6°, pH 6.7-6.9, dissolved oxygen 2.5-5 mg/l (20-40% saturation), and CO_2, 17-25 mg/l. At the second locality, specimens were collected from subterranean groundwater seeps on the bank of the Privalovskaya channel. Females displayed different levels of brood plate development; some were brooding eggs, while others were carrying newly emerging young, 2.8-3.0 mm in length.

Amurocrangonyx arsenjevi has been collected in company with the stygobitic amphipod *Pseudocrangonyx levanidovi* Birstein (1955) (Pseudocrangonyctidae), an epigean amphipod *Gammarus* sp., the stygobitic isopod *Sibirasellus dentifer* (Birstein and Levanidov, 1952), oligochaetes *Haplotaxis gordioides* (Hartman), *Gordius* sp., various amphibiotic insect larvae representing the orders Ephemeroptera, Plecoptera, Trichoptera, Chironomidae, and several species of water mites (Hydrachnellae).

Discussion

Apparently the only significant morphological difference between *Amurocrangonyx* and the closely similar sister genus *Crangonyx* is in the structure of uropod 3. However, the absence to date of a fully mature male of *Amurocrangonyx* prevents the recognition of what may be two other differences between these genera. Sexually mature males of all species of *Crangonyx* have a structurally modified outer ramus of uropod 2 and, excepting two species, have calceoli on antenna 2 (Zhang and Holsinger, 2003). Neither of these characters is present in the single, presumably submature, male specimen examined. Whether or not they exist in sexually mature males of *A. arsenjevi* must await further collection.

The freshwater amphipod family Crangonyctidae is composed of six extant genera and over 200 described species and is widespread throughout the Holarctic region. More than three-fourths of the species are stygobites restricted to subterranean groundwater habitats. The majority of species are recorded from North America and only a few are known from Eurasia (Holsinger, 1977, 1986). Only three species of *Synurella*, two of *Stygobromus*, and *Amurocrangonyx arsenjevi* are presently reported from areas east of the Ural Mountains. However, species of *Synurella* occur far north of the Amur basin in northeastern Siberia, whereas species of *Stygobromus* occur far west of the basin in mountainous regions of central Asia (Holsinger, 1977, 1987). In contrast, Pseudocrangonyctidae, morphologically closely related to Crangonyctidae, is well represented in the Amur region by *Pseudocrangonyx* and *Procrangonyx*, both of which are endemic to subterranean

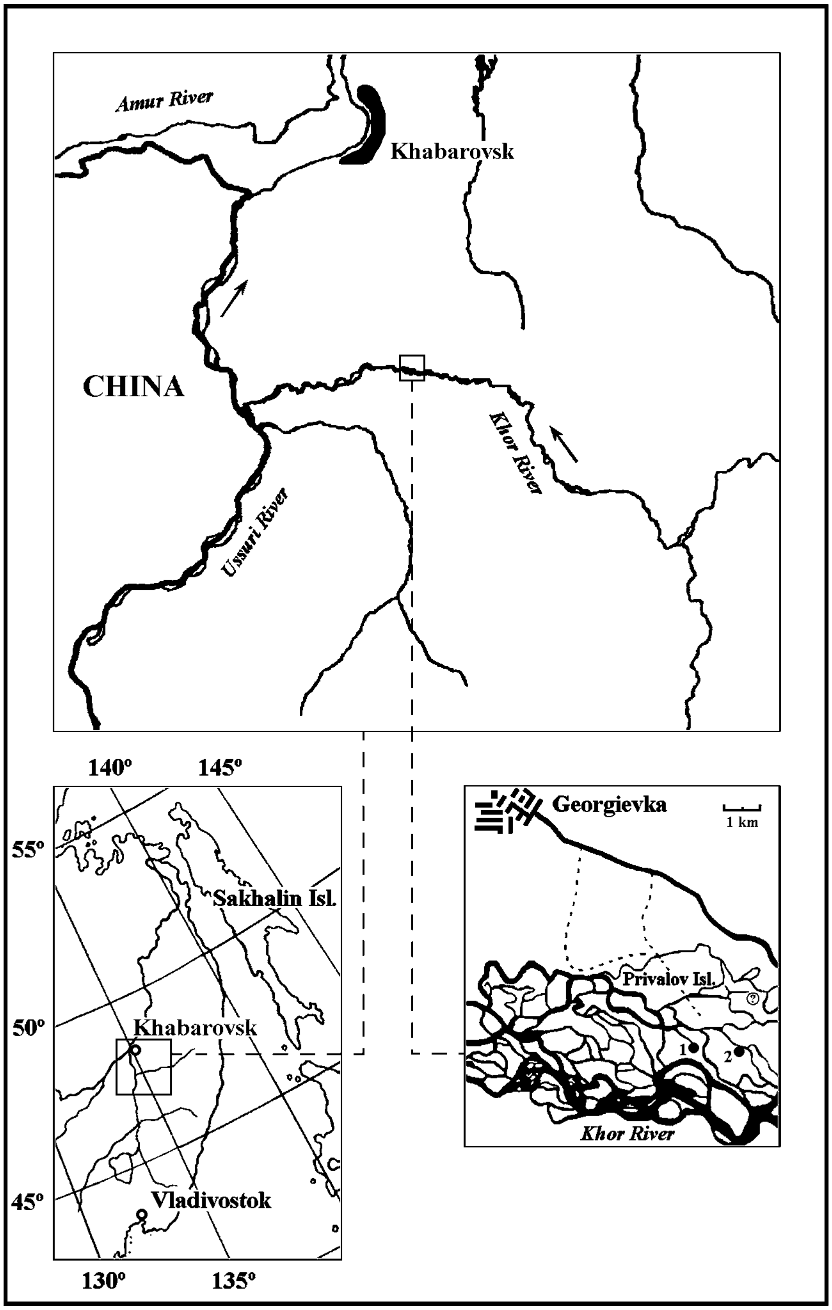

Fig. 6. Distribution of *Amurocrangonyx arsenjevi* (Derzhavin) in the Khor River basin of eastern Russia. Lower left panel: overview of the Russian Far East. Upper (large) panel: overview of Khabarovsk region showing principal drainage. Lower right panel: collecting sites for *A. arsenjevi* indicated by closed circles. 1, type-locality (Orekhovy spring); 2, seeps on the bank of the Privalovskaya channel. Open circle with question mark is the second locality (Privalovsky spring) mentioned by Derzhavin (1927).

freshwaters in far eastern Asia (Holsinger, 1989; Labay, 2001; Sidorov, 2006; Sidorov and Holsinger, 2007). As pointed out above, *Pseudocrangonyx levanidovi* is sympatric with *A. arsenjevi* in Orekhovy Spring, and both amphipods co-occur with the stygobitic asellid isopod *Siberasellus dentifer* (see Henry and Magniez, 1993; Sidorov, 2005).

The precise phylogeographic relationship between *Amurocrangonyx* and *Crangonyx* or, for that matter, between the crangonyctids and pseudocrangonyctids is still unclear but could probably be resolved with a molecular analysis. In an earlier cladistic analysis of the Holarctic crangonyctoids based on morphological characters, the pseudocrangonyctid genera *Procrangonyx* and *Pseudocrangonyx* form a sister group to the crangonyctid genera and apparently represent a more primitive group (Holsinger, 1994). The addition of *Amurocrangonyx* to this analysis suggests that this genus is more closely related phylogenetically to *Crangonyx* than to other genera in the family Crangonyctidae or Pseudocrangonyctidae. Within Crangonyctidae, the analysis suggests that *Crangonyx* and *Amurocrangonyx* are closely related phylogenetically and share an immediate common ancestor. It is conceivable that *Amurocrangonyx* has arisen from an earlier, more widely distributed *Crangonyx*-like ancestor that became isolated in the Amur drainage in the Russian Far East. However, pending further study, a general time frame for the origin and subsequent divergence of *Amurocrangonyx* cannot be determined.

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