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## ***Zenkevitchia karamani*, a distinct new species of *admirabilis*-group (Crustacea: Amphipoda: Typhlogammaridae) from Abkhazia**

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### **Abstract**

New species of the family Typhlogammaridae (Amphipoda, Gammaridea), *Zenkevitchia karamani*, sp. n. from the subterranean waters of Novy Afon cave in Abkhazia is described and illustrated. The affinity of the new species to concerned taxa is discussed. New records of *Zenkevitchia yakovi* are provided as well.

**Key words:** taxonomy, Amphipoda, Typhlogammaridae, stygobiont, Caucasus.

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### **Introduction**

The stygobiont fauna of underground biotopes of Caucasus is still poorly known as well as taxonomic composition of amphipod crustaceans in most areas of Abkhazian caves remains relatively unknown.

The endemial cavernicolous genus *Zenkevitchia* was established by Birstein (1940), based primarily on morphology of the outer plate of maxilla 1, which was described as ‘filtrative’ with numerous multi-toothed spines. To date four species of *Zenkevitchia* have been reported from the Abkhazian caves, which are preliminarily attributed in two unranked categories ‘*admirabilis*’ and ‘*sandroruffoi*’ groups (Sidorov et al., 2015).

In the present paper, I describe a fifth species of the genus, *Z. karamani*, sp. n., which was collected in cave-lakes of Novy Afon cave. The Novy Afon cave (Novoafonskaya cave or Anakopia abyss) is one of the largest karst cavities in Caucasus from where several troglobiont species are reported (Marin, Sokolova, 2014; Vinarski et al., 2014).

### **Material and Methods**

Seven specimens of Typhlogammaridae were collected from Novy Afon cave localized in the Abkhazian region of the western Caucasus (fig. 1). All specimens were collected directly by tweezers and preserved with 80% ethanol per site. Body length of the amphipods was recorded by holding the specimen straight and measuring the distance along the dorsal side of the body from the base of the first antenna to the base of the telson using a micrometer eye piece in a Lomo MBS-9 dissecting microscope. Permanent preparations were made by using polyvinyl lactophenol (PVL) and a methylene blue staining solution was used as mounting medium. Appendages were drawn using a Carl Zeiss NU-2 compound microscope equipped with a drawing

device as described in Gorodkov (1961). The nomenclature for setal patterns on article 3 of the mandibular palp follows the standard introduced by Karaman (1970) and Stock (1974).

The description is based on the type series, deposited in the Zoological Museum of the Far East Federal University, Vladivostok (FEFU) and in the research collection of D.A. Sidorov in the Institute of Biology and Soil Science, Vladivostok (IBSS).



**Figure 1.** Map showing the position of sampling site and distribution of Typhlogammaridae species in Balkans (red dots) and Caucasus (blue dots). Inset shows habitus of *Z. karamani*, sp. n., holotype (photo by D. A. Sidorov).

## Species description

Family Typhlogammaridae

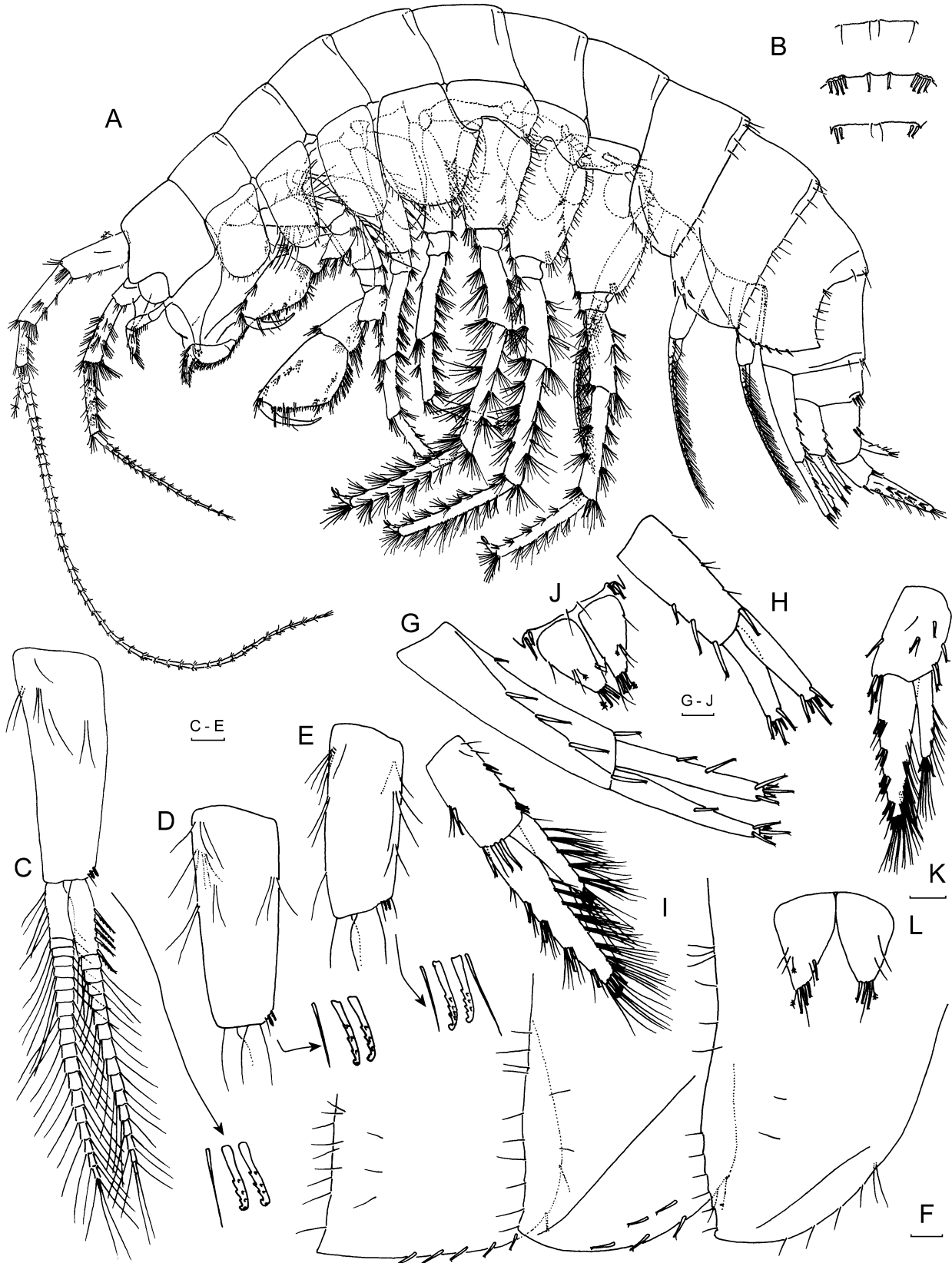
### *Zenkevitchia karamani*, sp. n.

Figures 1-5

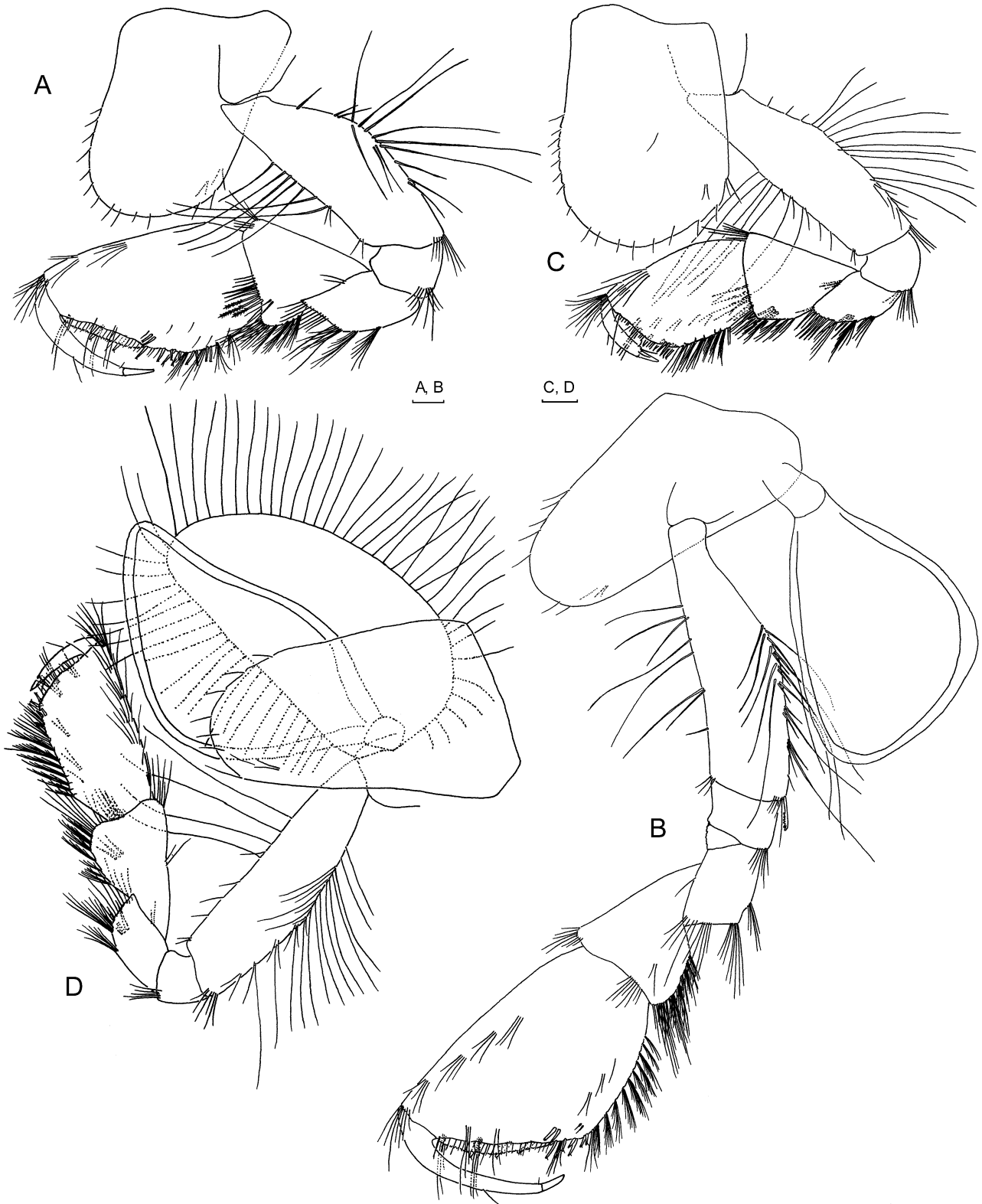
syn.: *Zenkevitchia admirabilis* Birstein, 1940: Birstein, Ljovuschkin, 1970, p. 1474, fig. 1. —*Anopogammarus* sp. Vinarsky et al., 2014, p. 2248.

**Material examined:** Holotype specimen (X45055/Cr-1824-FEFU): adult male, 16.0 mm, from (type locality) Novy Afon cave, 43.09065, 40.810008, Anatolia lake, Gudauta District of Abkhazia, Western Caucasus, 05.Feb.2015, coll. M. Bizin, V. Marinsky; 3 paratype specimens (X45055/Cr-1825-27-FEFU): 14.0 mm, female (carrying 6 eggs), 10.5 mm, female (oostegites undeveloped), 10.0 mm, female (oostegites weakly developed, non-setose); paratypes with same data as holotype.

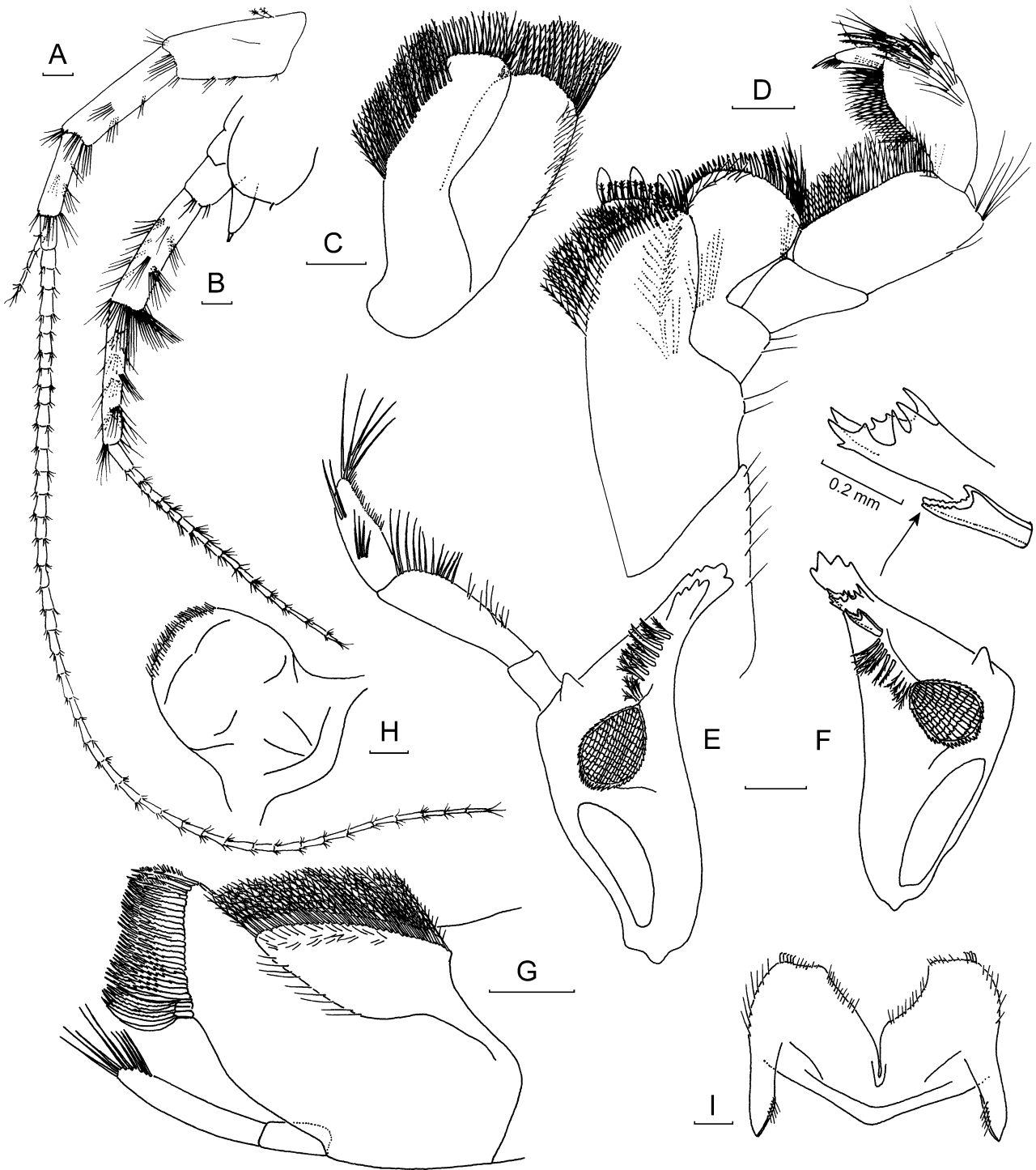
**Other specimens examined from the same cave locality** (not included in the type series): 11.0 mm, male in Bezimjnnoe lake, 05.Feb.2015, coll. M. Bizin, V. Marinsky; 9.0 mm, female (oostegites weakly developed, non-setose), 12.0 mm, male in Goluboe lake, 06.Feb.2015, coll. R. Borisov. Deposited in the research collection of D.A. Sidorov in the Institute of Biology and Soil Science, Vladivostok (1-11/sd03-IBSS), Russia.



**Figure 2.** *Zenkevitchia karamani*, sp. n., male, 16.0 mm, holotype X45055/Cr-1824-FEFU: (A) habitus, lateral view; (B) urosome, dorsal view; (C) pleopod 1; (D) pleopod 2, part; (E) pleopod 3, part; (F) epimeral plates 1–3; (G) uropod 1; (H) uropod 2; (I) uropod 3; (J) telson. Female, 14.0 mm, paratype X45055/Cr-1825-27-FEFU: (K) uropod 3; (L) telson. Scale bars 0.4 mm.



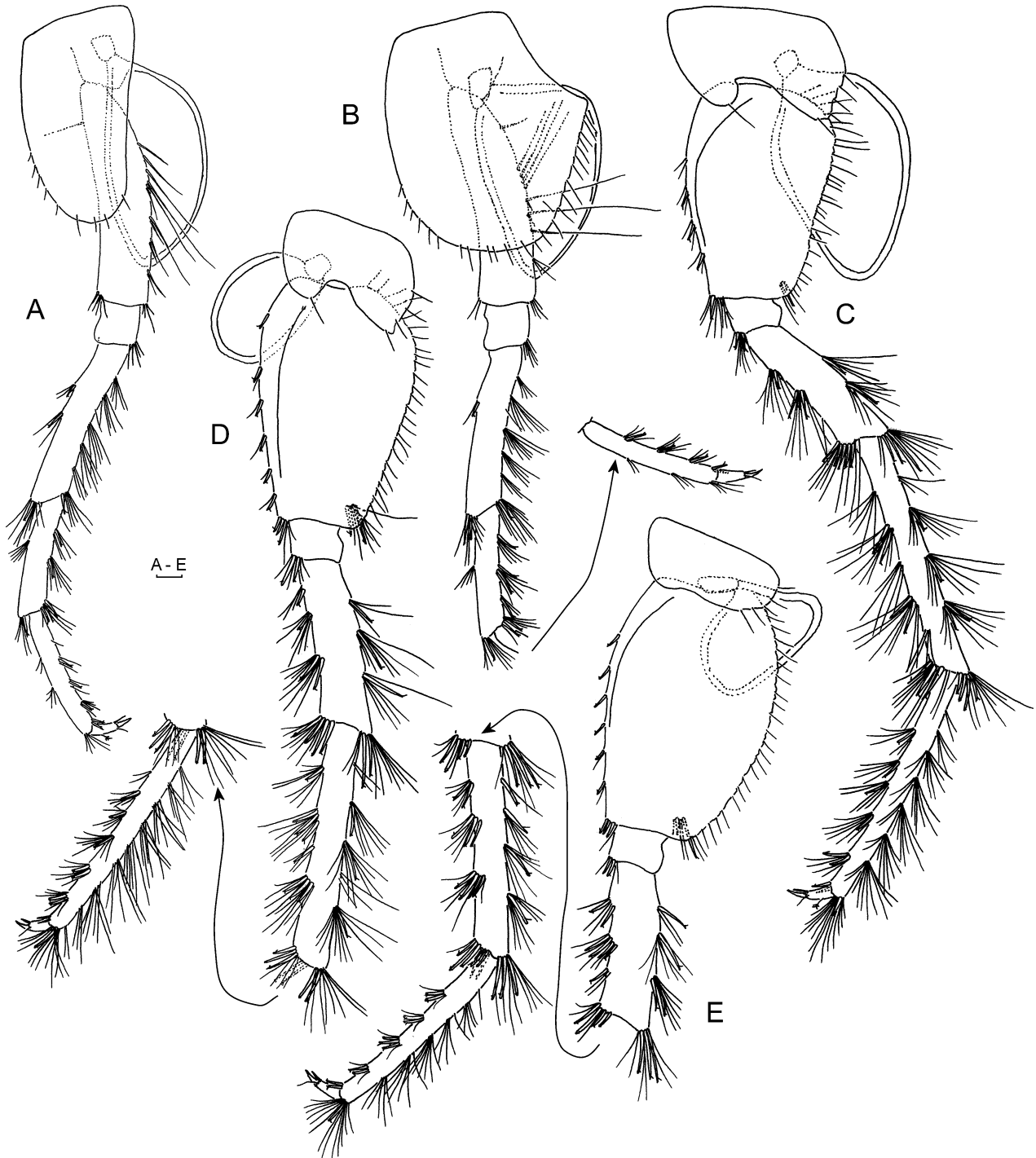
**Figure 3.** *Zenkevitchia karamani*, sp. n., male, 16.0 mm, holotype X45055/Cr-1824-FEFU: (A) gnathopod 1; (B) gnathopod 2. Female, 14.0 mm, paratype X45055/Cr-1825-27-FEFU: (C) gnathopod 1; (D) gnathopod 2. Scale bars 0.4 mm.



**Figure 4.** *Zenkevitchia karamani*, sp. n., male, 16.0 mm, holotype X45055/Cr-1824-FEFU: (A) antenna 1; (B) antenna 2; (C) maxilla 2; (D) maxilliped; (E) mandible, left. (F) mandible, right; (G) maxilla 1; (H) upper lip; (I) lower lip. Scale bars 0.4 mm, if not indicated otherwise.

**Diagnosis** (both sexes): Robust and stout, large-sized species of gammarid-like habitus. Sexual dimorphism weakly pronounced, i.e., males usually larger than females, both gnathopods and uropod 3 sexually dimorphic. Antenna 1 long, reaching 55–60% length of body; antenna 2 reaching about 60% length of antenna 1, gland cone relatively long. Maxilla 1 inner plate triangular, with 35–37 plumose setae, outer plate of filtration-type with about 200 multi-toothed sickle-shaped comb-like spines; palps symmetrical and reduced. Mandibular palp article 3 with 2 A-groups of setae. Gnathopods 1–2 small, with propodus not larger

than corresponding coxa; palmar angle of male gnathopod 2 well-defined (with 2 mid-palmar spines in the place where tip of nail close); dactyli with 1 seta each along outer margin, nails short. Urosomite 2 with medial group of spines. Pleopods 1–3 with 2 coupling setae (retinacula). Male uropod 3 long, 0.17× longer than uropod 2, endopodite small, 0.5× shorter than exopodite, both rami densely setose with bundles of long setae. Telson with 2 or 3 distal spines per lobe. Coxal gill 7 smallest, stalk relatively long. Body length 9.0–14.0 mm (♀♀), 11.0–16.0 (♂♂).



**Figure 5.** *Zenkevitchia karamani*, sp. n., male, 16.0 mm, holotype X45055/Cr-1824-FEFU: (A) pereopod 3; (B) pereopod 4; (C) pereopod 5; (D) pereopod 6; (E) pereopod 7. Scale bar 0.4 mm.

**Description.** Holotype (X45055/Cr-1824-FEFU): male, body length 16.0 mm. **General body morphology** (figs 2A, B, F, J). Body smooth, lacking dorsal cuticular elements (keel or tubercles). *Head* as long as first pereon segment; lack rostrum; inferior antennal sinus shallow, sub-rounded. Eyes absent. Pleonites 1–3 and urosomite 1 with median and lateral groups of thin setae. Urosomites 2 and 3 on dorsal surface with lateral groups of spines. *Epimeral plate 1*: postero-ventral corner acuminate; posterior and ventral margins convex; 6 thin setae along ventral margin, 6 setae along posterior margin. *Epimeral plate 2*: postero-ventral corner acuminate; posterior margin concave; ventral margin convex; 5 notched spines along ventral margin in two rows, 6 setae along posterior margin. *Epimeral plate 3*: postero-ventral corner acuminate; posterior margin slightly concave; ventral margin convex; 6 notched spines along ventral margin, 9 setae along posterior margin. *Telson* width : length ratio is 1 : 0.83; cleft 0.9 of length; 2 sub-apical spines per lobe present, these are 0.30× telson length, each accompanied by 2 setae. **Antennae** (figs 2A, 4A, B). *Antenna 1* 0.60× of body length; flagellum with up to 42 articles; each article with 3–6 short setae; peduncular articles in ratio 1 : 0.9 : 0.6; proximal article of peduncle distally with 2 medial sets of short setae; accessory flagellum 5-articulated. Length ratio antenna 1 : 2 as 1 : 0.6; flagellum of *antenna 2* with 16 articles, each article densely setose; peduncle article 4 as long as article 5; flagellum slightly longer than peduncle (articles 4+5); peduncular article 4 with dense cluster of long stiff setae distally; gland cone moderately long, reaching peduncle segment 4. **Mouth parts**, typical gammarid, except for unusual filtration-type maxilla 1 and right mandible (figs 4C–D). *Labrum* rounded, clypeus detached, rounded. Inner lobes of *labium* absent, outer lobes broad with stiff curved setae marginally, mandibular process distinct (narrow). *Left mandible*: incisor with 5 teeth, lacinia mobilis with 4 teeth; between lacinia and molar row of 6 serrate spines. *Right mandible*: incisor process with 4 teeth, lacinia mobilis bifurcate with several long denticles, between lacinia and molar a row of 6 serrate spines, one of them modified; triturative molar process without seta. *Mandibular palp* article 2 0.35× longer than article 3 (distal); proximal palp article without setae; the second article with two groups of 9 short setae in proximal part and 12 long setae distally; distal article narrowed, with 1 A group of 4 setae, 2 B setae, 21 D setae, 5 E setae. *Maxilla 1* palp reduced, distal article with 9 apical and sub-apical long naked setae (both palps symmetrical); outer plate with 185 multi-toothed sickle-shaped spines; inner plate triangular with 35 plumose setae. *Maxilla 2* inner plate slightly smaller than outer one with oblique row of 28 plumose setae; both of them apically with about 150 stiff setae in two rows. *Maxilliped* palp article 2 with about 80 setae along inner margin; article 4 (distal) with dorsal seta, bearing 5 setae at the nail base, nail twice shorter than pedestal; outer plate with 16 flattened spines, a group of 3 long plumose and 8 naked setae on apex; inner plate with 3 strong peg-spines, 11 stiff serrate and 3 naked setae on apex, 33 plumose setae on ventral face. **Coxal plates, gills** (figs 2A, 3A–D, 5A–E). *Coxal plate 1* of rectangular shape, antero-ventral margin slightly narrowed with 13 setae along edge. *Coxal plate 2* of rectangular shape, antero-ventral margin narrowed with 7 setae along edge. *Coxal plate 3* width : depth is 0.5 : 1; along antero-ventral margin 9 setae. *Coxal plate 4* of sub-quadrangle shape, width : depth is 0.8 : 1; posteriorly with prominent excavation; along ventral margin 25 setae. *Coxal plates 5–7* progressively smaller towards the posterior; coxal plates 5–6: anterior lobe well-developed bearing 1 seta each on ventral margin; posterior margin serrate with 4 or 5 setae. *Coxal plate 7* semicircular with anterior lobe indistinct, along posterior margin 5 setae in shallow serration. *Coxal gills 2–7* stalked, large but progressively smaller towards the posterior; gills 2–4 sub-triangular; gills 5–7 saccular or irregularly ovoid; gill 7 smallest, stalk relatively long. **Gnathopods 1 and 2** (figs 3A, B). *Gnathopod 1*, ischium with 4 postero-distal sets of setae. Carpus 0.4× length of propodus; anterior margin of carpus without setae; carpus posteriorly with transverse row of lateral and sub-marginal setae. Propodus almond-shaped, palm as long as posterior margin, slightly convex with cutting margin acanthaceous; along posterior margin 8 notched spines and 4 sets of simple setae; anterior margin with 2 pairs of setae, antero-distal group with 7 setae; palmar margin with short, notched setae along outer and inner faces and armed with row of 4 distally-notched, robust spines on outside (1 strong spine in the middle), palmar angle with 2 corner spines on inner face; nail 0.2× total length of dactylus, 1 seta along anterior margin, 1 short stiff seta at hinge. *Gnathopod 2*, basis width : length is 0.27 : 1, bearing 1 serrate spine distally. Ischium with 3 sets of postero-distal setae. Carpus 0.37× length of basis and 0.42× length of propodus; anterior margin of carpus with 1 distal set of setae; carpus posteriorly with 7 lateral sets of setae. Propodus small (compared to the body) and 1.2× larger than propodus of gnathopod 1; propodus sub-triangular, palm as long as posterior margin, beveled, slightly convex with cutting margin acanthaceous; posterior margin with 10 sets of simple setae; anterior margin with 4 sets of setae; antero-distal group with 7 setae; palmar margin with short, notched setae along outer and inner faces and armed with row of 9 distally-notched robust spines on outside (1 strong spine in the middle), palmar angle with 2 corner spine on inner

face; dactylus similar to that of gnathopod 1. **Pereopods 3–7** (figs 2A, 5A–E). Lengths of pereopods 3–4 sub-equal. Dactylus 4  $0.32 \times$  propodus 4; nail length  $0.37 \times$  total dactylus length. Dactyli 3–4 with dorsal plumose seta; inner margin with 1 stiff seta and 1 thin seta at hinge. Lengths of pereopods 5 : 6 : 7 is 1 : 1.01 : 0.95. *Pereopod 7* length  $0.48 \times$  body length. Bases 5–7 narrowed distally, length : width is 1 : 0.58–0.68; posterior margins straight (in basis 5) or convex (distinctly in basis 7), without postero-distal lobes; posterior marginal serration with short setae; anteriorly 3–6 notched spines accompanied with short setae. Dactylus 7 length  $0.2 \times$  propodus 7 length. Dactyli 5–7 with dorsal plumose seta; inner margin with 1 stiff seta and 1 thin seta at hinge. **Pleopods and uropods** (figs 2A, C–E, G–I). *Pleopods 1–3* sub-equal, each with 2 coupling setae accompanied with 1–2 stiff setae; peduncular articles fringed with long, thin setae; proximal article of inner rami fringed with 4–5 plumose setae. Pleopods 1–3 rami with 16–20 articles each. *Uropod 1* protopodite without basofacial spine, 4 dorso-lateral and 2 dorso-medial spines; exopodite as long as endopodite; rami straight with 1 or 2 spines along outer margins; both with 5 strong notched spines apically and sub-apically. *Uropod 2* protopodite with 4 setae and 1 strong spine along dorso-medial margin; exopodite as long as endopodite. *Uropod 3* protopodite with 3 strong notched spines on apex; endopodite  $0.8 \times$  protopodite length, 5 sets of long simple setae along inner margin, 2 spines and 7 long setae apically; exopodite  $1.8 \times$  longer than protopodite, with 4 groups of lateral spines accompanied with long setae, 8 sets of long simple setae along inner margin, 4 spines and 7 long setae apically.

**Sexual dimorphism:** Comparison based on 14.0 mm female, X45055/Cr-1825-FEFU, sexually dimorphic characters (figs 2K, L, 3C, D). Body smaller and slender. Antenna 1 60% of total body length; antenna 2 short reaching 30% length of antenna 1. Gnathopod 1 smaller than gnathopod 2, propodi sub-rectangular; palmar margins sub-transverse, short and weakly armed with spines. Carpus of gnathopod 2 flexible, shorter than propodus. Pereopods 5–7: bases broader than those of male. Uropod 3 exopodite  $1.5 \times$  longer than protopodite. Oostegites 2–5 on gnathopod 2 and pereopods 3–5.

**Variability:** The number of sickle-shaped spines on the outer plate of maxilla 1 varies from 180 to 198; other mouth parts and appendages have minor differences or quite indistinguishable.

**Distribution and ecology:** The amphipods *Zenkevitchia karamani*, sp. n. inhabits sandy and muddy bottoms with water temperature + 12–13 °C in cave-lakes Anatolia, Bezimjnnoe and Goluboe in Novy Afon cave; known only from type locality (fig. 1). Stygobiont crustacean *Synurella* sp. were collected from this same locality.

**Etymology:** Species named in honor of famous zoologist Acad. Gordan S. Karaman (Montenegrin Academy of Sciences and Arts, Podgorica) for his outstanding contribution to the amphipod systematics.

**Taxonomic comments:** Within the genus *Zenkevitchia*, *Z. karamani* sp. n. is clearly related to the *admirabilis*-group with ‘filtrative’ outer plate of maxilla 1. The new species differs from other species of the group in the following characters: antenna 1 longer and reach  $0.6 \times$  of body length; maxilla 1 outer plate with up to 200 spines; molar process without a seta; both gnathopods 1–2 in males with broadened and bevelled palmar margin (especially in gnathopod 2); a more detailed comparison of *Z. karamani* sp. n. is given in Table 1.

*Zenkevitchia karamani*, sp. n. is an unique taxon that shares the features of several groups. Among the seven subterranean species of gammarid Amphipoda of the Caucasian region (*Anopogammarus birsteini* Derzhavin, 1945, *Kruberia abchasica* Sidorov, Samokhin, in press) in Gammaridae and (*Adaugammarus pilosus* Sidorov et al., 2015, *Zenkevitchia admirabilis*, *Zenkevitchia sandroruffoi* Sidorov et al., 2015, *Zenkevitchia revazi* Birstein et Ljovuschkin, 1970, *Zenkevitchia yakovi* Sidorov, 2015) in Typhlogammaridae, *Z. karamani* has a some distinct features: (1) palmar angle of gnathopods with small corner spines on inner face (this feature is also inherent to the following species *A. birsteini*, *K. abchasica* and *A. pilosus*); (2) modified spine between lacinia and molar process (this feature is also inherent to *K. abchasica*) (Sidorov, Samokhin, in press).



**Table 1.** Comparison of morphological and ecological characteristics and their variability between species of *admirabilis*-group.

Character	Character states		
	<i>Z. karamani</i> , sp. n.	<i>Z. yakovi</i> Sidorov, 2015	<i>Z. admirabilis</i> Birstein, 1940 (probably complex of species)
Body length, mm	9.0-14. mm (♀♀) 11.0-16.0 (♂♂)	8.0-9.75 (♀♀) 5.0-10.0 (♂♂)	4.0 (♀♀) 14.0 (♂♂)
Antenna 1 / Body length ratio (males)	0.55-0.60	0.50	- ? -
Antenna 1 / Antenna 2 length ratio (males)	0.60	0.60	- ? -
Antenna 1, primary flagellum	40-43 articles (♂♂) 35 articles (♀♀)	27 articles (♂♂) 19-20 articles (♀♀)	19-31 articles (sex not specified)
Antenna 2, primary flagellum	16 articles (♂♂) 15 articles (♀♀)	11 articles (♂♂) 9 articles (♀♀)	8-16 articles (sex not specified)
Maxilla 1, palp	8-9 spines	5-8 spines	5-10 spines
Maxilla 1, inner plate	35-37 setae	20-24 setae	15-17 setae
Maxilla 1, outer plate	~ 200 spines	105-114 spines	23 spines
Gnathopod 1, male p.m. <sup>1</sup>	14 spines	9 spines	6-7 spines
Gnathopod 1, female p.m.	6-7 spines	7 spines	4 spines
Gnathopod 2, male p.m.	12 spines	6 spines	6-7 spines
Gnathopod 2, female p.m.	6-7 spines	5 spines	4 spines
Pereopod 7 / Body length ratio	0.48	0.45	- ? -
Ecology	Gudauta: Novy Afon cave, in cave-lakes	Gulripshi: "Istočnik Tcebel'da", Sredne-Shakuranskaya, Abrskila and Golova Otapa caves, in cave rivulets and cave-well	Sukhumi: small cave near Andreevka (Apra) and other localities

Note : <sup>1</sup>p.m. – palmar margin.

### *Zenkevitchia yakovi* Sidorov, 2015

syn.: *Zenkevitchia yakovi* Sidorov, 2015: Sidorov et al., 2015, p. 42, figs. 2-7.

**Material examined:** Abkhazia: all specimens measured, partially dissected and stored in different vials (1-11/sd04-IBSS), 2 females (oostegites undeveloped), Abrskila cave, 42.920472, 41.554450, near Otapi village, Ochamchira District of Abkhazia, Western Caucasus, cave rivulet, water temperature +15 °C, numerous *Troglocaris*, 31.Jun.2015, coll. M. Bizin, V. Marinsky; 2 females (oostegites undeveloped), 5 males, Golova Otapa cave, 42.922019, 41.538787, about 1.2 km NW from Abrskila cave, cave-well, depth - 5 m, 02.Feb.2015, coll. R. Borisov. Deposited in the research collection of D.A. Sidorov in the Institute of Biology and Soil Science, Vladivostok, Russia.

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