

## New data on *Niphargus boskovici* S. Karaman, 1952 and some other Gammaridean amphipods from the western Balkans (Contribution to the knowledge of the Amphipoda 279)

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**Summary.** Several species of amphipods of the suborder Gammaridea (Amphipoda) from the western Balkans are treated in this work. The subterranean amphipod *Niphargus boskovici* S. Karaman, 1952 (fam. Niphargidae) is redescribed and figured from new localities of the Metković region (Croatia), and its relationships with some other members of this genus are discussed. The species *Niphargus salonitanus* S. Karaman, 1950, known from various subterranean localities in Dalmatia, was discovered on Korčula Island (Adriatic Sea, Croatia) and some of its taxonomical characters are presented. The subterranean species *Typhlogammarus mrazeki* Schäferna, 1906 (fam. Typhlogammaridae), known from various subterranean waters in Montenegro, Bosnia and Herzegovina and western Croatia, was discovered near Dubrovnik in the cave Špilja za Gromačkom vlakom. The epigeal species *Gammarus roeselii* Gervais, 1835 (fam. Gammaridae), widely distributed over Europe and Asia Minor, was discovered in a spring near Pecka (Croatia) and the distribution of this species in Croatia is discussed. The epigeal species *Gammarus fossarum* Koch, in Panzer, 1836, distributed in Europe and some parts of Asia Minor, was discovered in numerous new localities in Croatia and Bosnia & Herzegovina, and some remarks on this species in Croatia and Bosnia and Herzegovina are presented.

**Keywords:** Amphipoda, distribution, *Gammarus*, *Niphargus*, taxonomy, *Typhlogammarus*, western Balkan.

### INTRODUCTION

The fauna of freshwater subterranean and epigeal Amphipoda is of great interest for various scientists involved in a wide range of studies on the ecology, zoogeography, origin and biodiversity of certain regions and water streams.

Amphipoda are indicators of phylogenetic and zoogeographic events which have occurred in the past or are occurring today. In addition they serve as markers of water pollution and changes to the settlement areas of various taxa during various geological periods up until the present day.

However, the highly expressed variability of amphipod morphological characters within a single population (*Gammarus fossarum* [Karaman G and Pinkster 1977a]) or within populations along an entire river (*G. balcanicus* [Karaman G 1977]), as well as between populations from distant locali-

ties occasionally connected by seasonal changes (*Echinogammarus tibaldii* f. *roco* G. Karaman, 1970 [Karaman G 1993]) makes recognition of valid taxa very difficult. This is evident within taxa of the genera *Gammarus* (fam. Gammaridae) and *Niphargus* (fam. Niphargidae), where the settlement of single species from various areas was realized in different geological periods, and accumulated species represent a combination of ancient and recent taxonomical characters. An additional difficulty is that both of the above mentioned genera are today in the process of maximal diversification into species and subspecies, including transitive populations still in the process of morphological and genetic isolation.

During recent investigations conducted as part of the international speleo-diving expedition "Abyss Kovači – Spring of Ričina 2014", and previous expeditions conducted since 2006 and organized by the Speleological Society "Mi-

jatovi Dvori” Tomislavgrad (Bosnia and Herzegovina); numerous epigeal and subterranean amphipod materials have been collected. Thanks to speleologist Mr. Sci. R. Ozimec (Zagreb), we obtained this material for study. A portion of this material is analyzed here, along with material from other sources.

The species *Niphargus boskovici* S. Kar. 1952 was only partially described (Karaman S 1952, 1953) and many taxonomical characters of this species remain unknown. For this reason, we re-described this species based on new localities. New localities for the species *Niphargus salonitanus* S. Kar., 1950, *Typhlogammarus mrazeki* Schäf., 1906, *Gammarus roeselii* Gerv., 1835 and *G. fossarum* Koch, 1836 are mentioned.

## MATERIAL AND METHODS

The material used in this study was collected by numerous biologists and speleologists from Zagreb (Croatia), from the Zasavica Natural Reserve (Serbia), from Bosnia and Herzegovina, from S. KARAMAN's Collection and by our personal investigations.

The studied material was preserved in 70% ethanol. Studied specimens were dissected using a WILD M20 microscope and drawn using a camera lucida. All appendages were temporarily submerged in a mixture of glycerine and water for study and drawing. The body-length of examined specimens was measured from the tip of head to the end of the telson using a camera lucida. All illustrations were manually drawn in ink. After the end of the study, dissected body-parts were submerged in Liquid of Faure and covered by thin cover glass.

Some morphological terminology and seta formulae follow Karaman's terminology (Karaman G 1969, 1993, 2012b): for the last mandibular palp [A= setae on outer face; B= setae on inner face; C= additional setae on outer face; D= lateral marginal setae; E= distal long setae] and for propodus serrate spines; M= facial setae; R= subcorner spine on inner face]. Terms “setae” and “spines” are used based on shape, not origin.

## RESULTS

### Family Niphargidae

#### *Niphargus boskovici* S. Karaman, 1952

(Figs 1-7)

*Niphargus (Orniphargus) boskovici* Karaman S. 1952: 45, Figs 1-10;

*Niphargus boskovici boskovici* Karaman S 1960: 81; Karaman G 1974: 16; Barnard JL and Barnard CM 1983: 690; Karaman G and Ruffo 1986: 523;

*Niphargus boskovici* Karaman S 1953: 145 (9), Figs 5-11; Karaman G 2014a: 211.

Loc. typ.: Vjetrenica cave near Zavala in Popovo polje, Bosnia and Herzegovina.

### Material examined

Bosnia and Heregovina:

Sp. 483= Vjetrenica Cave in Popovo polje, 6 spec., 1951 (leg. Zora Karaman); P.133= ibid., 4 spec. (data?), (leg. S. Karaman);

S-6667= Bjelušica Cave, W. of Vjetrenica Cave, Zavala, Popovo Polje, 2 spec., 16.08.2004 (leg. G. Karaman & B. Karaman);

R-64= ibid., 3 spec., 23.08.2006 (leg. M. Pavlek);

R-72= ibid., 3 spec., 24.08.2006 (leg. H. Bilandžija);

Croatia:

OR-221= Vištica Jama Cave, Dukat, Metković, 6 spec., 24.09.2014 (leg. G. Rnjak);

OR-227= ibid., 1 juv. spec., 24.09.2014 (leg. A. Kovačević);

OR-230= ibid. 2 juv. spec., 24.09.2014 (leg. G. Polović);

OR-238= ibid., 5 spec., 24.09.2014 (leg. R. Ozimec);

OR-239= Kornjatuša Jama Cave, Vidanje, Metković, Croatia, 2 spec., 24.09.2014 (leg. P. Rade).

### Description

**Male** 10.0 mm (Vištica Jama Cave). Body moderately slender, metasomal segments 1-3 at dorsoposterior margin with row of 8-10 longer setae each (Fig. 3E). Epimeral plates 1-2 nearly angular, with well-marked ventroposterior corner, along posterior margin with several short setae each; epimeral plate 3 distinctly pointed, with concave posterior margin bearing a row of several short setae (Fig. 3E). Epimeral plates 2 and 3 with 2 subventral spines each (Fig. 3E).

Urosomal segment 1 on each dorsolateral side with 1 seta; urosomal segment 2 on each dorsolateral side with 1-2 setae or 1 spine and 1 seta, urosomal segment 3 naked (Fig. 3F). Urosomal segment 1 with one ventroposterior spine near basis of uropod 1 peduncle (Fig. 3F).

Head with weakly convex dorsal margin and with short sub-rounded lateral cephalic lobes, ventroanterior sinus well-developed (Fig. 1A), eyes absent.

Antenna 1 shorter than half of body (41:100); peduncular articles 1-3 progressively shorter (ratio 70:48:20), very scarcely setose (Fig. 1B), distal article short; main flagellum consisting of 15-16 articles, proximal articles bearing one short aesthetasc each, distal articles missing (Fig. 1B). Accessory flagellum 2-articulated, short (Fig. 1B).

Antenna 2: peduncular article 3 short, with 2 distoventral setae; peduncular article 4 poorly longer than article 5 (ratio 76:72), article 4 along dorsal margin with single short setae and short spines (Fig. 1C), along ventral margin with several long simple setae; article 5 at dorsal margin with 3-4 bunches of short setae, at ventral margin with 3 bunches

of longer setae (the longest setae are much longer than the width of article itself; flagellum moderately slender, only slightly longer than the last peduncular article (ratio 90:72) and consisting of 8 articles scarcely setose (Fig. 1C). Antennal gland cone short.

Mouthparts: Labrum broader than long, slightly concave distally (Fig. 4G). Labium broader than long, with entire outer lobes and well-developed inner lobes (Fig. 4H)

Mandibles with triturative molar. Left mandible: incisor with 4 teeth, lacinia mobilis with 5 teeth; right mandible: incisor with 4 teeth, lacinia mobilis bifurcate, with several teeth (Fig. 1D). Mandible palpus 3-articulated: first article naked, second article with 8 strong lateral setae (Fig. 1E). Third palpus article slightly longer than second one (ratio 70:65), falciform, along the ventral margin with nearly 17 D-setae and 5 distal E-setae, on outer face appears a row of 5 A-setae (Fig. 1F), on the inner face appear 3 bunches of B-setae (1-2-2) (Fig. 1E).

Maxilla 1: inner plate with 2 setae, outer plate with 7 spines (5 spines with 1 lateral tooth, 1 spine with 2 teeth, inner spine with several very small teeth), palpus 2 -articulated, not reaching distal tip of outer plate- spines and with 7 distal setae (Fig. 1G).

Maxilla 2: both plates with marginal setae only (Fig. 1M).

Maxilliped: inner plate short, with 5 distal spines, outer plate with row of distolateral spines (Fig. 2G), palpus article 3 at outer margin with one median seta and a bunch of distal setae; palpus article 4 (dactylus) at inner margin with 1-2 short setae near the basis of the nail and with one median seta at outer margin (Fig. 2G).

Coxae relatively short. Coxa 1 broader than long (=high) (ratio 51:39), with subrounded ventroanterior corner and bearing 8 marginal setae (Fig. 2A); coxa 2 hardly longer than broad (ratio 53:50) with 9 longer marginal setae (Fig. 2D). Coxa 3 hardly longer than broad (ratio 58:56), with nearly 8 marginal setae (Fig. 3A); coxa 4 slightly broader than long (ratio 59:55) with subrounded corners and slightly concave posterior margin, at margin appear 7-8 setae (Fig. 3C).

Coxae 5-7 progressively smaller. Coxa 5 much broader than long (ratio 71:40), anterior lobe subrounded, posterior lobe subangular (Fig. 4A). Coxa 6 short, broader than long (ratio 60:32) (Fig. 4C). Coxa 7 subrounded ventrally, broader than long (ratio 56:23) (Fig. 4E).

Gnathopods 1-2 of moderate size, with propodus almost as long as the corresponding coxae. Gnathopod 1: article 2 with long setae along both margins; article 3 with one median bunch of setae at the posterior margin (Fig. 2B); article 5 shorter than article 6 (ratio 36:47), at anterior margin with distal bunch of setae. Propodus trapezoid, slightly longer than broad (ratio 80:70), at the posterior margin with 7 transverse rows of setae (Fig. 2B); palm inclined nearly half of propodus length, defined on outer face by 1 strong corner S-spine accompanied laterally by 3 slender serrate L-spines (Fig. 2C) and 3 long facial M-setae, at inner face by

one subcorner R-spine (Fig. 2C); dactylus reaching posterior margin of propodus, bearing 5 single setae along outer margin (Fig. 2B).

Gnathopod 2 distinctly larger than gnathopod 1, with article 2 bearing long setae along both margins (Fig. 2D); article 3 at posterior margin with one median group of setae; article 5 shorter than 6 (ratio 45:55), with one distal bunch of setae at anterior margin (Fig. 2D). Propodus trapezoid, almost as long as broad (ratio 90:87), along posterior margin with 10 transverse rows of setae; palm slightly convex, inclined nearly half of the propodus-length, defined on the outer face by a strong corner S-spine accompanied laterally by 2 slender serrate L-spines and 3 long facial M-setae (Fig. 2E), on the inner face by one short subcorner R-spine (Fig. 2F). Dactylus reaching posterior margin of propodus, along the outer margin with a row of 5 single setae (Fig. 2E).

Pereopods 3 and 4 of subequal size, moderately slender.

Pereopod 3: article 2 along the posterior margin with numerous long setae, at the anterior margin with shorter setae in the distal part and longer setae in the proximal part of the article itself. Articles 4-6 of unequal length (ratio 54:35:45), scarcely setose, posterior margin of articles 5 and 6 provided with single short spines and setae (Fig. 3A). Dactylus short and strong, much shorter than article 6 (ratio 19:45), at the inner margin with one spine accompanied by short seta near the basis of the nail (Fig. 3B), along the outer margin with one median plumose seta; nail is shorter than pedestal (ratio 28:35).

Pereopod 4 with setae and spines like these in pereopod 3. Articles 4-6 of unequal length (ratio 50:36:44). Dactylus short and strong, much shorter than article 6 (ratio 18:44), at the inner margin near the basis of the nail with the spine accompanied by short seta, at the outer margin with one median plumose seta; nail is slightly shorter than pedestal (ratio 29:32).

Pereopods 5-7 of moderate length, pereopod 5 is remarkably shorter than pereopods 6 and 7 (Fig. 4A, C, E).

Pereopod 5: article 2 longer than broad (ratio 80:52), anterior slightly convex margin with a row of 5-6 single spine-like setae, along the convex posterior margin with nearly 13 short setae, ventroposterior lobe not developed (Fig. 4A). Articles 4-6 of unequal length (ratio 47:52:55), at both margins with scarce number of short setae and slender spines. Article 6 shorter than article 2 (ratio 55:80), along the anterior margin with 5 bunches of short spines. Dactylus short and strong, much shorter than article 6 (ratio 19:55), along the inner margin with one spine and short seta near the basis of the nail, at the outer margin with one median plumose seta (Fig. 4B); nail shorter than pedestal (ratio 28:38).

Pereopod 6: dilated, longer than broad (ratio 92:55), along the anterior margin with 7-9 single strong spine-like setae, along the posterior margin with 11-12 short setae, ventroposterior lobe not developed (Fig. 4C). Articles 4-6 of

unequal length (ratio 56:72:85), bearing bunches of spines and single short setae along both margins. Article 6 slightly shorter than article 2 (ratio 92:85). Dactylus much shorter than article 6 (ratio 28:85), at the inner margin with one spine and short seta near the basis of the nail (Fig. 4D), at the outer margin with one median plumose seta; nail shorter than pedestal ratio 33:56).

Pereopod 7: article 2 longer than broad (ratio 93:54), along anterior margin with a row of 6 spine-like setae, along the posterior margin with 10-11 setae, ventroposterior lobe absent (Fig. 4E). Articles 4-6 of unequal length (ratio 55:68:93), along both margins with bunches of spines and single setae (Fig. 4E); article 6 as long as article 2. Dactylus much shorter than article 6 (ratio 31:93), at the inner margin with one spine and short seta near the basis of the nail, at the outer margin with one median plumose seta (Fig. 4F); nail shorter than pedestal (ratio 33:58).

Pleopods 1-3 with 2 retinacula each. Peduncle of pleopod 1 naked (Fig. 1I); peduncle of pleopod 2 with one dis-toanterior seta (Fig. 1J); peduncle of pleopod 3 along the posterior margin with 3 strong setae (Fig. 1K).

Uropod 1: peduncle longer than rami, with a dorsoexternal row of spines and dorsointernal row of setae (except distal spine) (Fig. 3F); rami of equal length, bearing several lateral and 5 distal short spines, on the outer ramus appears 2 lateral bunches of short simple setae (Fig. 3F).

Uropod 2: rami of equal length or inner ramus hardly longer, with lateral and distal short spines, setae absent (Fig. 3F).

Uropod 3 very long; peduncle short, longer than broad (ratio 34:18), with 2-3 distal short spines (Fig. 1H); inner ramus short scale-like, shorter than peduncle and bearing several short spines; outer ramus 2-articulated: first article with several bunches of simple setae, along inner margin with several single spines accompanied by single short plumose setae (Fig. 1H); second article poorly longer than first article (ratio 148:143), along both margins with bunches of short simple setae, tip is subrounded, with simple short setae (Fig. 1H).

Telson nearly as long as broad, incised nearly 2/3 of telson-length (Fig. 1L); each lobe with 5 distal narrow short spines, right lobe bearing one additional outer marginal median spine; a pair of short unequal plumose setae appears near the middle of each lobe (Fig. 1L).

Coxal gills 1-6 of moderate size, not reaching ventral tip of corresponding article 2 (Figs 2A, D, 3A, C, 4A, C).

**Female** 6.5 mm with oostegites bearing very short setae (Kornjatuša Jama Cave). Body slightly stouter than in males; metasomal segments 1-3 with 7-8 moderately long setae at the dorsoposterior margin (Fig. 7E). Epimeral plates 1-2 distinctly angular, with a slightly convex posterior margin bearing a row of short setae (Fig. 7E). Epimeral plate 3 distinctly pointed, with concave posterior margin bearing a

row of short setae; Epimeral plate 2 with 1 subventral spine, epimeral plate 3 with 2 subventral spines (Fig. 7E).

Urosomal segment 1 on each dorsolateral side with one seta, urosomal segment 2 on each dorsolateral side with 1 spine and 0-1 seta, urosomal segment 3 naked (Fig. 6G). Urosomal segment 1 at the ventroposterior corner with one spine near the basis of the uropod 1 peduncle.

Antenna 1 reaching nearly 2/5 of the body-length (ratio 28:65), peduncle like that in males, main flagellum consisting of 16 articles.

Flagellum of antenna 2 consisting of 8 articles.

Mouthparts like these in males. Inner plate of maxilla 1 with 2 setae, inner plate of maxilliped with 3-4 spines.

Coxa 1 slightly broader than long (ratio 40:37), with subrounded ventroanterior corner and bearing several longer marginal setae (Fig. 5A). Coxa 2 slightly longer than broad (ratio 49:44), with longer marginal setae (Fig. 5D). Coxa 3 slightly longer than broad (ratio 56:49), with 6-7 distal setae (Fig. 7A). Coxa 4 almost as long as broad (ratio 55:53), bearing short marginal setae, ventroposterior lobe not distinctly developed (Fig. 7B).

Coxa 5 broader than long (ratio 63:39), anterior lobe subrounded, posterior lobe subquadrate (Fig. 6A). Coxa 6 smaller than 5, broader than long (ratio 50:32) (Fig. 6C); coxa 7 entire, convex, broader, than long (ratio 45:22) (Fig. 6E).

Gnathopods 1-2 slightly smaller than these in males.

Gnathopod 1 is rather smaller than gnathopod 2 (Fig. 5A, D); article 3 at posterior margin with one median bunch of setae; article 5 shorter than article 6 (ratio 33:43), with anterior distal bunch of setae (Fig. 5A). Propodus trapezoid, longer than broad (ratio 80:70), along the posterior margin with 6 transverse rows of setae (Fig. 5B); palm slightly convex, inclined nearly half of the propodus-length, defined on the outer face by one corner S-spine accompanied laterally by 2 serrate L-spines and 3 long facial M-setae, on the inner face by one subcorner R-spine (Fig. 5C). Dactylus reaching the posterior margin of the propodus, along the outer margin with 4 median setae (Fig. 5B).

Gnathopod 2: article 3 at the posterior margin with one bunch of setae (Fig. 5D); article 5 shorter than article 6 (ratio 40:47), along anterior margin with distal bunch of setae. Propodus trapezoid, slightly longer than broad (ratio 90:80), along posterior margin with 6 transverse rows of setae (Fig. 5E). Palm inclined nearly to half of the propodus-length, defined on the outer face by 1 corner S-spine accompanied laterally by 2 serrate L-spines and 3 long facial M-setae (Fig. 5E, F), on the inner face by one subcorner R-spine (Fig. 5F). Dactylus reaching the posterior margin of the propodus, with 6 median setae along the outer margin (Fig. 5E).

Pereopods 3-4 similar to each other, not elongated, poorly setose and with a scarce number of short spines (Fig. 7A, C).

Pereopod 3: articles 4-6 of unequal length (ratio

46:30:37) (Fig. 7A); dactylus strong and much shorter than article 6 (ratio 16:37), at the inner margin with one slender spine and short seta near the basis of the nail, at the outer margin with one median plumose seta; nail shorter than pedestal (ratio 18:28) (Fig. 7B).

Pereopod 4: articles 4-6 of unequal length (ratio 41:30:35) (Fig. 7C), dactylus much shorter than article 6 (ratio 15:35), at the inner margin with one slender spine and seta near the basis of the nail, at the outer margin with one median plumose seta (Fig. 7E); nail shorter than pedestal (ratio 19:29).

Pereopod 5 remarkably shorter than pereopods 6 and 7 (Fig. 6A, C, E), with article 2 longer than broad (ratio 67:43), along the anterior margin with 6 groups of short setae, along the posterior convex margin with nearly 12 short setae, ventroposterior lobe absent (Fig. 6A). Articles 4-6 of unequal length (ratio 38:42:47) with a scarce number of short setae and spines (Fig. 6A); article 2 is longer than article 6 (ratio 67:47). Dactylus is much shorter than article 6 (ratio 14:47), strong, at the inner margin with one spine and short seta near the basis of the nail, at the outer margin with one median plumose seta (Fig. 6B), nail shorter than pedestal (ratio 21:26).

Pereopod 6: article 2 longer than broad (ratio 79:48), along the anterior margin with 6 bunches of short spine-like setae, at the posterior margin with nearly 11 short setae, lobus absent (Fig. 6C); articles 4-6 of unequal length (ratio 46:65:72), at both margins covered by several bunches of short spines and simple setae (Fig. 6C); article 2 is slightly longer than article 6 (ratio 79:72). Dactylus much shorter than article 6 (ratio 26:72), at the inner margin with one spine and seta near the basis of the nail, along the outer margin with one median plumose seta (Fig. 7F), nail shorter than pedestal (ratio 53:27).

Pleopods like these in males.

Uropod 1: peduncle longer than rami, with a dorsoexternal row of spines and dorsointernal row of setae (except distal spine) (Fig. 6G); rami of equal length (when both rami are removed in the same direction), with some lateral and 5 distal spines; one bunch of 2 simple setae is attached on the outer ramus) (Fig. 6G).

Uropod 2: both rami of equal length (Fig. 6G).

Uropod 3: much shorter and broader than that in males. Peduncle short but longer than broad (ratio 43:24), with several distal spines (Fig. 5G); inner ramus scale-like, shorter than peduncle, bearing 2 distal spines and 1 lateral seta; outer ramus 2-articulated: first article at the outer margin with 4 bunches of spines, at the inner margin with 4 bunches of spines accompanied by single long plumose setae (Fig. 5G); second article slightly elongated, but remarkably shorter than the first article (ratio 45:136), short simple setae along both margins and tip (Fig. 5G).

Telson nearly as long as broad, each lobe with 3 strong distal spines, one short spine is attached at the outer margin

(Fig. 5H); a pair of short plumose setae appears near the middle of each lobe.

Coxal gills of moderate size, not reaching the ventral tip of corresponding article 2 (Figs 5D, 6A, B, 7A, C).

Oostegites broad, with very short marginal setae (probably not adult) (figs 5D, 6A, 7A, C).

## Variability

**The female 5.0 mm of Vištičina Jama Cave** is similar to that of Kornjatuša Jama Cave, including the presence of 2 subdistal short setae on the outer ramus of uropod 1, pointed epimeral plate 3 and the presence of 6-7 moderate setae at the dorsoposterior margin of metasomal segments 1-3. Antenna 1 not reaching half of the body.

Telson nearly as long as broad, with 3-4 distal strong spines, lateral spines absent. Spines on the telson in females are stronger than those in males.

Urosomal segment 1 in females always found with 1 seta on each dorsolateral side, urosomal segment 2 on each dorsolateral side with 1-2 spines.

Often rami of uropods 1-2 at first glance seem to be of unequal length, but usually rami are of equal length when extended horizontally; rarely the inner ramus of both uropods can be barely longer than the outer one.

Juvenile specimens have article 2 of pereopods 5-7 broader than that in adult specimens.

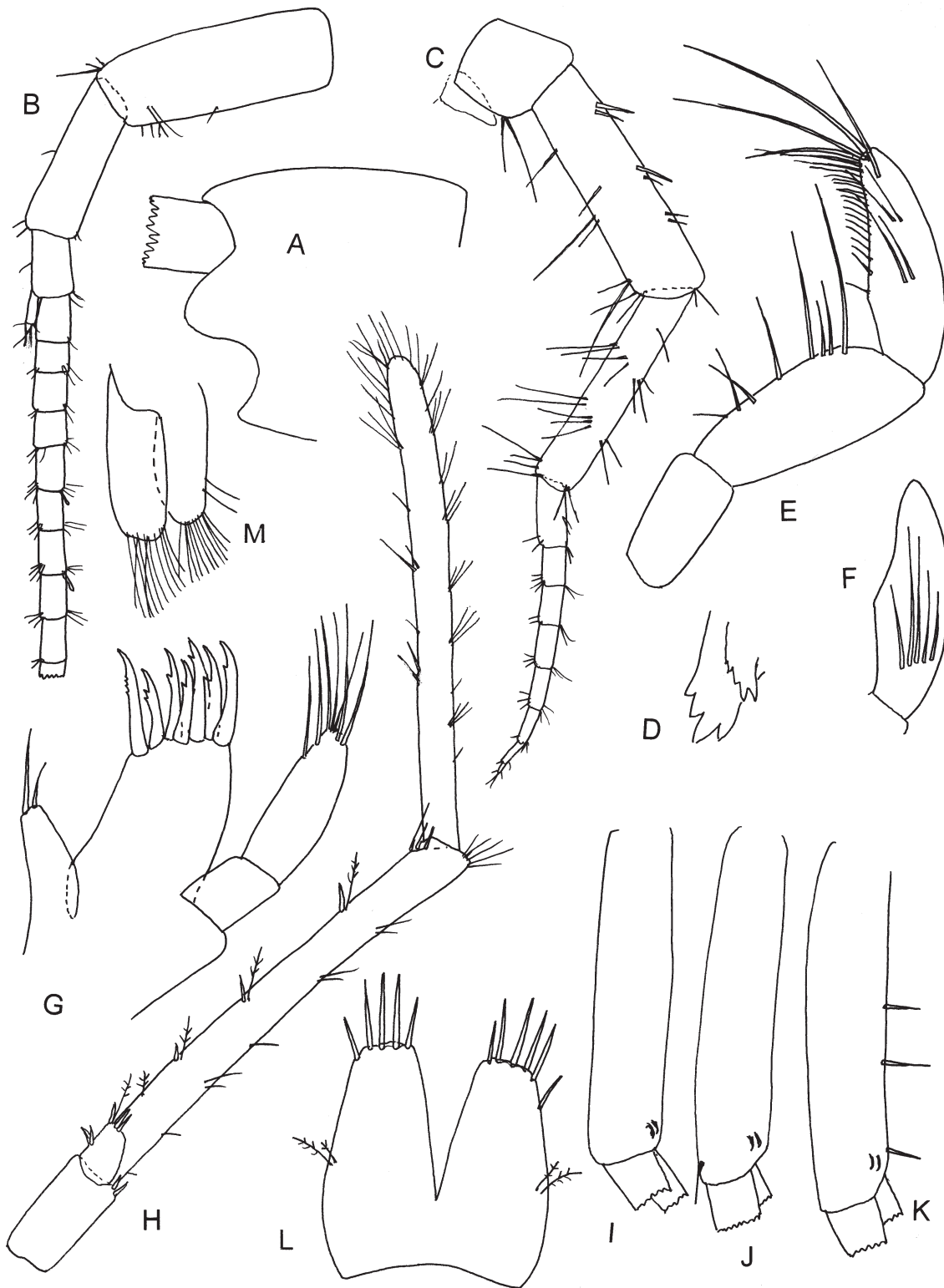
**Male 8.3 mm of Vištičina Jama Cave.** Urosomal segment 1 on each dorsolateral side with 1 seta, urosomal segment 2 on each dorsolateral side with 2 setae or 1 spine. Epimeral plate 3 only slightly pointed, with a slightly inclined posterior margin. Telson deeply incised, each lobe with 3 distal spines and 1 outer marginal spine attached just under the distal spines.

**Male 10.3 mm of Vištičina Jama Cave.** Lobes of telson with 4 distal slender spines only, lateral and facial spines absent.

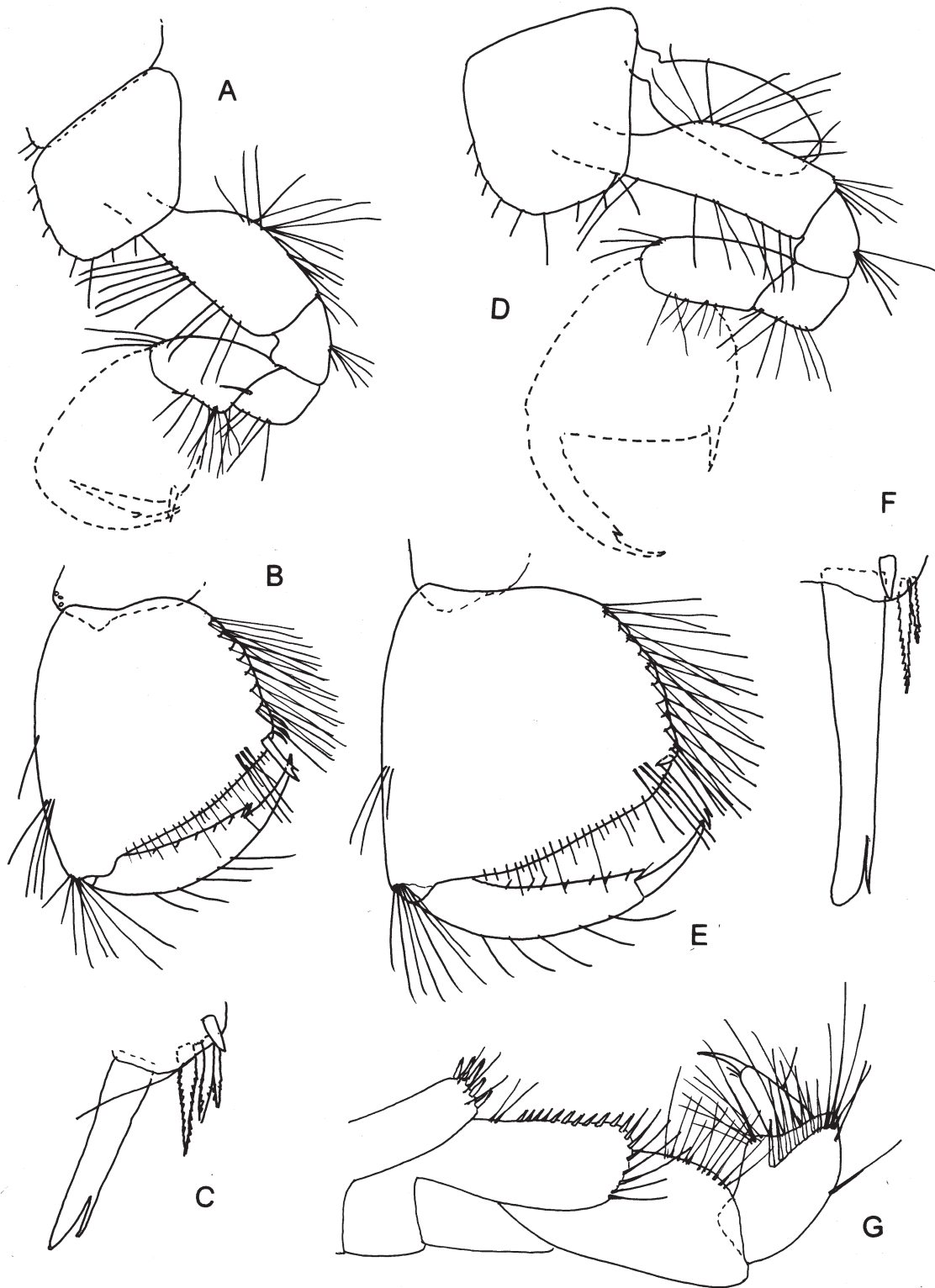
**The males 6-9 mm from Bjelušica Cave** are in agreement with type specimens from Vjetrenica cave: presence of 5-6 very short dorsolateral setae on metasomal segments 1-3, short antenna 1 reaching nearly 2/5 to 1/2 of the body-length, presence of one seta on each dorsolateral side of urosomal segments 1 and 2 in males; telson with very short distal spines; inner ramus of uropods 1 and 2 scarcely longer than outer one or rami are of equal length; second article of outer ramus in uropod 3 as long as or longer than the first article; epimeral plate 3 distinctly angular or poorly acute.

## Remarks and affinity

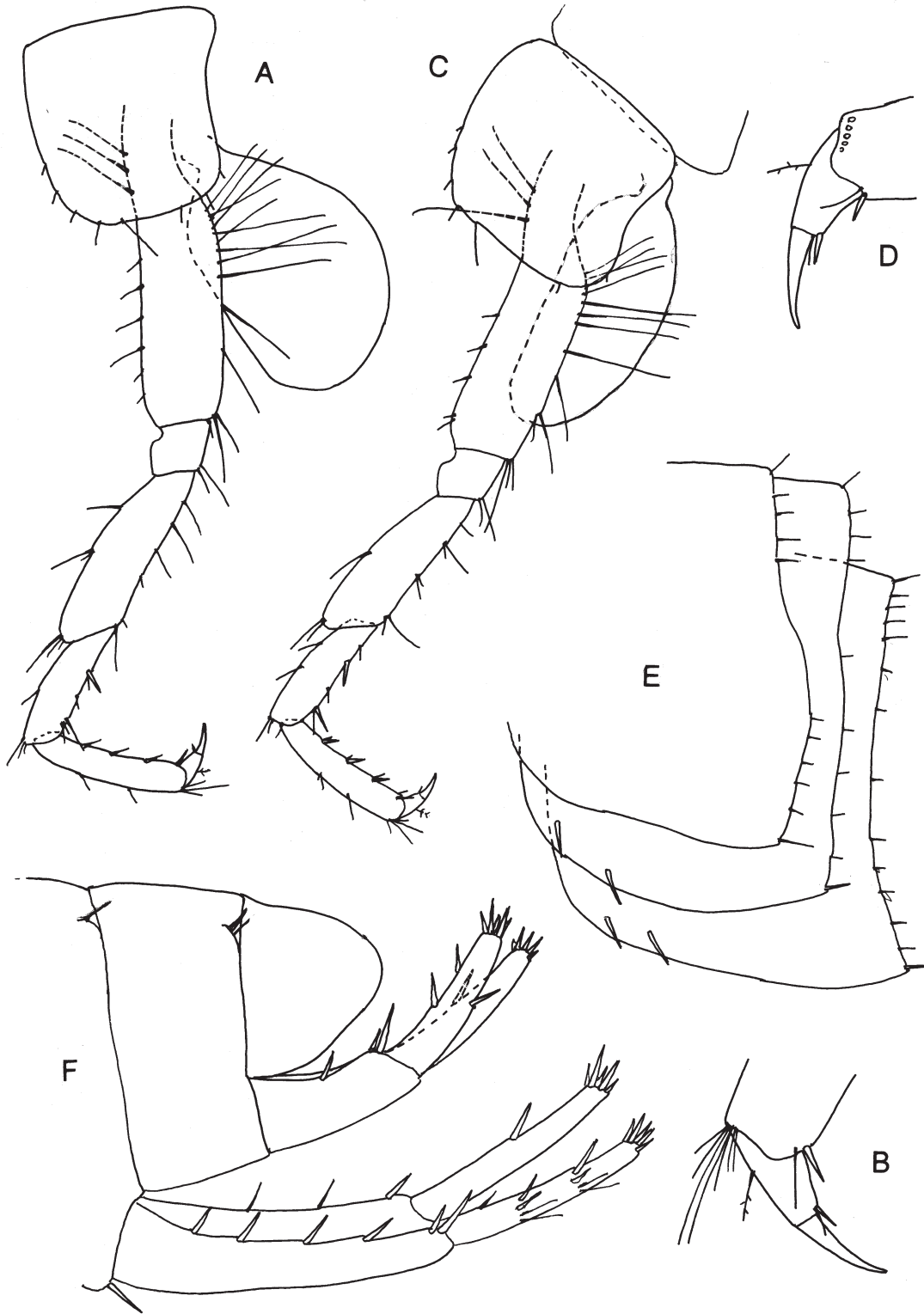
The specimens collected from Neretva region, Croatia (Vištičina Jama Cave and Kornjatuša Jama Cave) are almost identical with specimens of *N. boskovici* S. Karaman, 1952 from Vjetrenica Cave and Bjelušica Cave in Popovo Polje



**Fig. 1.** *Niphargus boskovici* S. Karaman, 1952, Vištičina Jama Cave, male 10.0 mm. **A**, head; **B**, antenna 1 (distal part missing); **C**, antenna 2; **D**, incisor and lacinia mobilis of right mandible; **E**, mandible palpus, inner face; **F**, distal article of mandible palpus, outer face; **G**, maxilla 1; **H**, uropod 3; **I-K**, peduncle of pleopods 1-3, lateral projection; **L**, telson.

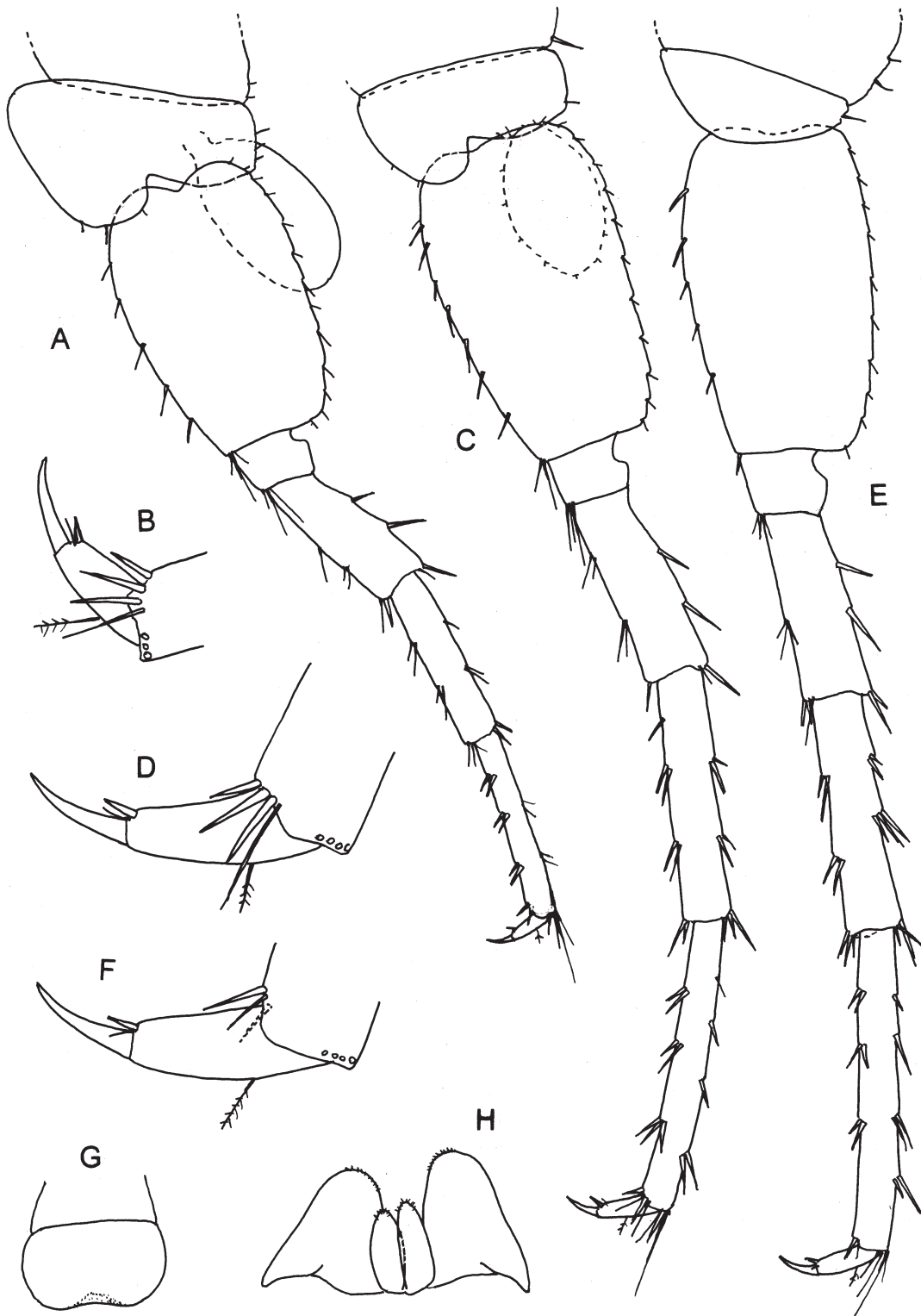


**Fig. 2.** *Niphargus boskovici* S. Karaman, 1952, Vištica Jama Cave, male 10.0 mm. **A-B**, gnathopod 1, outer face; **C**, distal corner of gnathopod 1 propodus, inner face; **D-E**, gnathopod 2, outer face; **F**, distal corner of gnathopod 2 propodus, inner face; **G**, maxilliped.

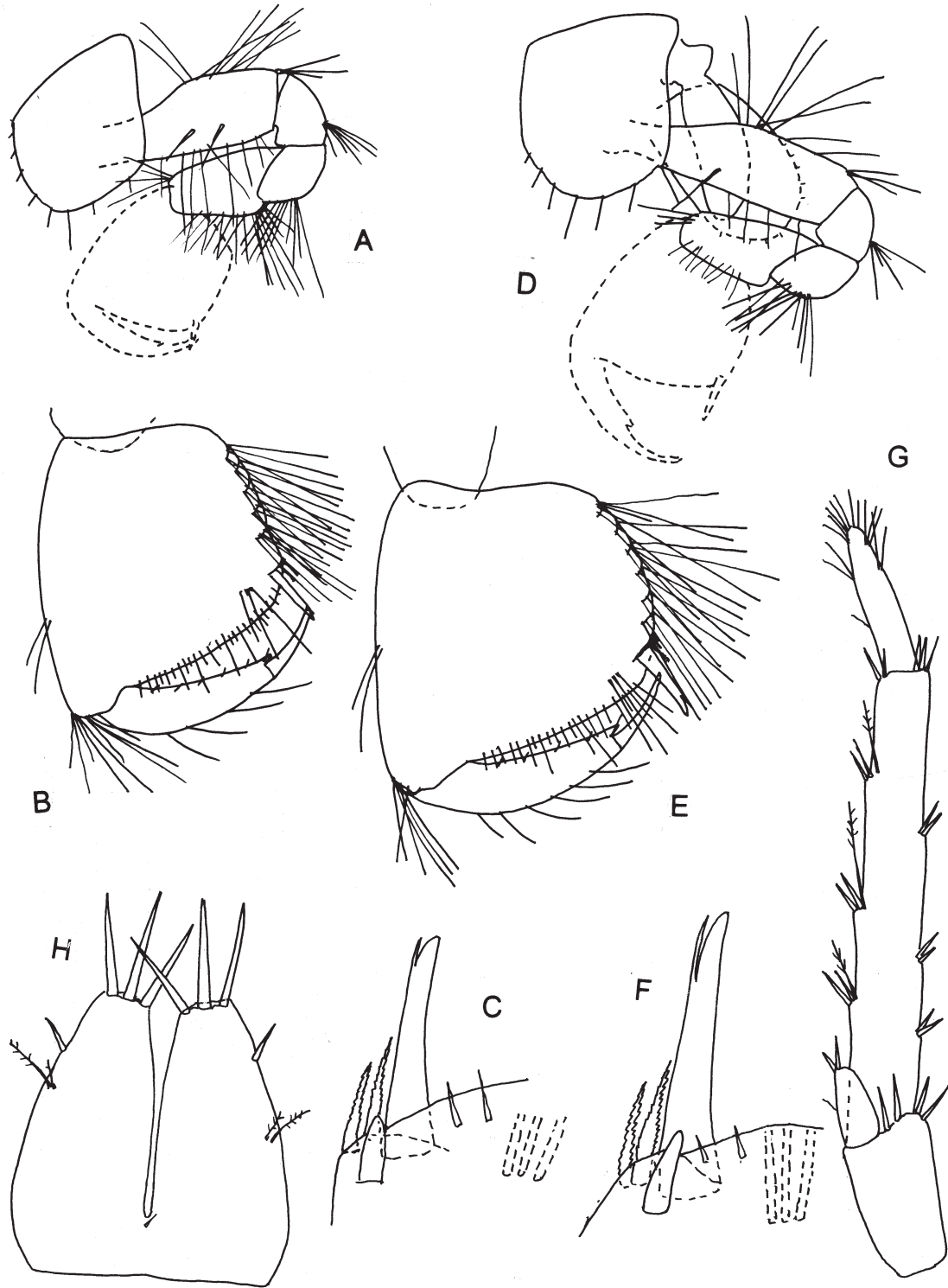


**Fig. 3.** *Niphargus boskovici* S. Karaman, 1952, Vištičina Jama Cave, male 10.0 mm. **A-B**, pereopod 3; **C-D**, pereopod 4; **E**, epimeral plates 1-3; **F**, urosome with uropods 1-3.

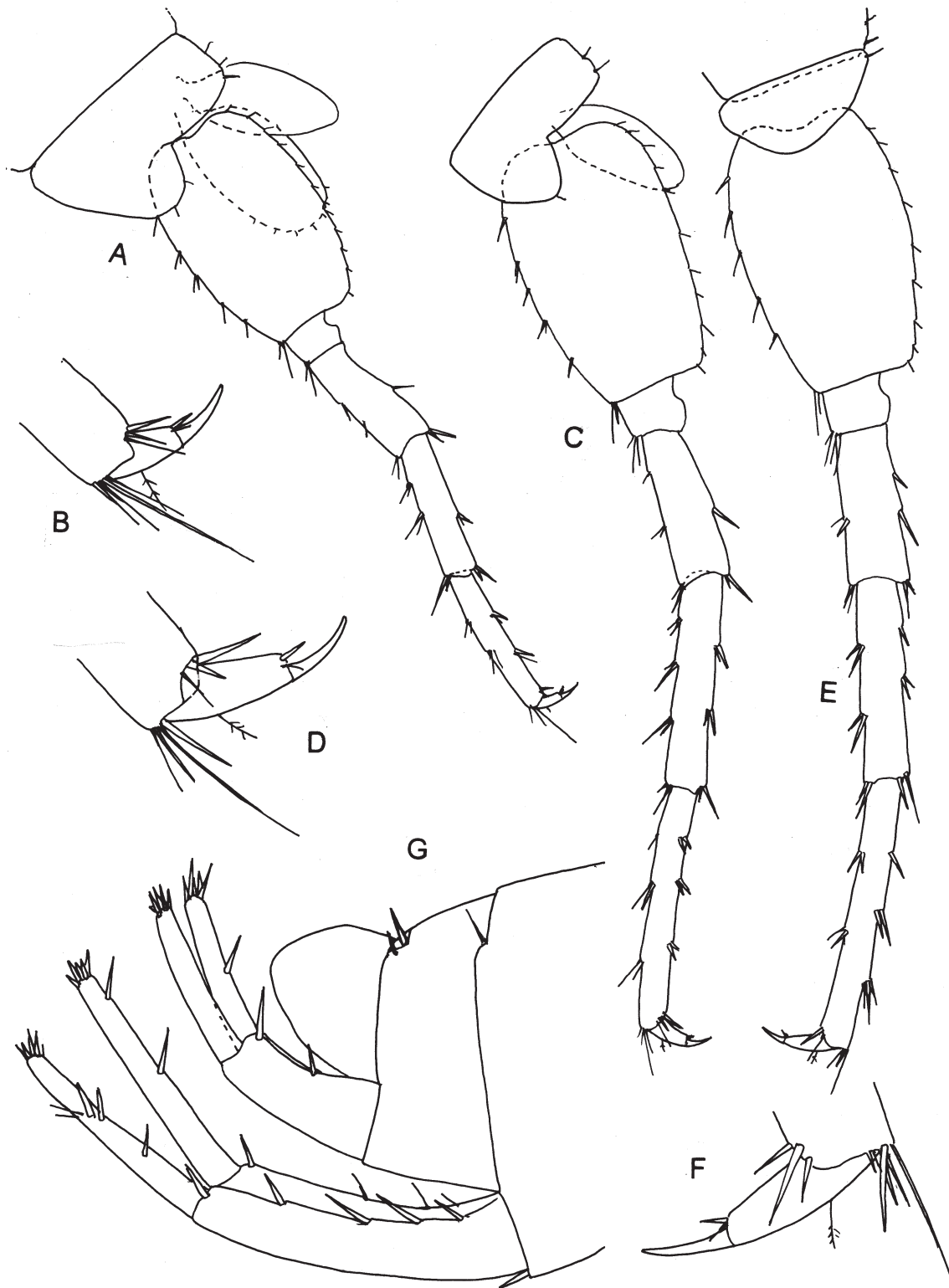




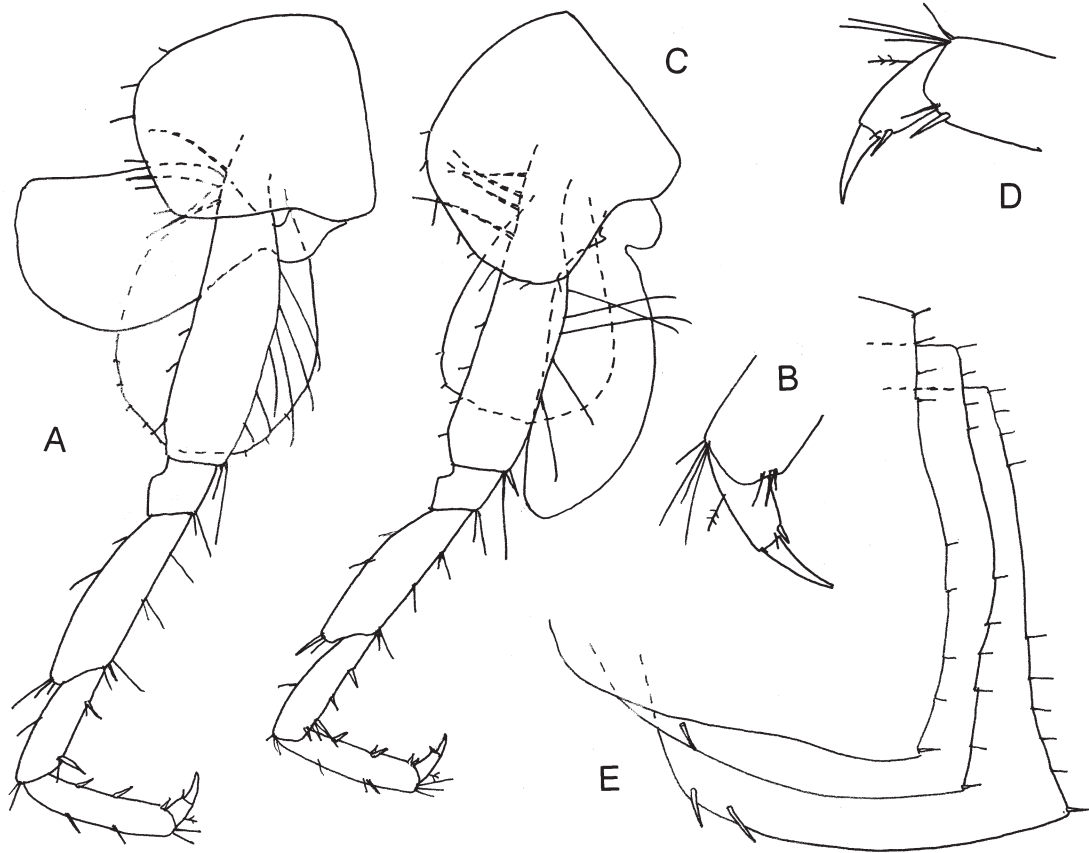
**Fig. 4.** *Niphargus boskovici* S. Karaman, 1952, Vištičina Jama Cave, male 10.0 mm. **A-B**, pereopod 5; **C-D**, pereopod 6; **E-F**, pereopod 7; **G**, labrum; **H**, labium.



**Fig. 5.** *Niphargus boskovici* S. Karaman, 1952, Kornjatuša Jama Cave, female 6.5 mm. **A-B**, gnathopod 1, outer face; **C**, distal corner of gnathopod 1 propodus, inner face; **D-E**, gnathopod 2, outer face; **F**, distal corner of gnathopod 2 propodus, inner face; **G**, uropod 3; **H**, telson.



**Fig. 6.** *Niphargus boskovici* S. Karaman, 1952, Kornjatuša Jama Cave, female 6.5 mm. **A-B**, pereopod 5; **C-D**, pereopod 6; **E-F**, pereopod 7; **G**, urosome with uropods 1-2



**Fig. 7.** *Niphargus boskovici* S. Karaman, 1952, Kornjatuša Jama Cave, female 6.5 mm. **A-B**, pereopod 3; **C-D**, pereopod 4; **E**, epimeral plates 1-3.

{Bosnia and Herzegovina) in most taxonomical characters (gnathopods, coxae, very elongated uropod 3 in males, mouthparts, pereopods, presence of 1-2 bunches of median setae on rami of uropod 1, etc.), but differ from Vjetrenica Cave by the presence of slightly shorter antenna 1, slightly longer dorsoposterior marginal setae on metasomal segments 1-3 and by a smaller number of simple setae on the rami of uropod 1.

Many specimens (males and females) have epimeral plate 3 slightly more pointed than that in specimens from Vjetrenica, but some males from Vištičina Jama Cave have an angular epimeral plate 3 similar to those from Vjetrenica cave.

Therefore, despite the small morphological differences observed between both localities (Popovo Polje and Metković), there is no reason to separate Metković populations from Popovo polje populations as different taxa, and we consider, based on morphological and ecological characters, that specimens of Metković region belong to the same species, *N. boskovici* S. Karaman, 1952.

## Distribution

*Niphargus boskovici* settled the subterranean waters of Popovo polje (Vjetrenica Cave and Bjelušica Cave) and Metković region, Dalmatia (Vištičina Jama Cave and Kornjatuša Jama Cave).

In upper region of Neretva drainage system appears another similar species, *N. borkanus* S. Karaman, 1960 described from Boračko jezero Lake, Bosnia and Herzegovina), known recently also from the spring at torrent Pješčar, village Kostajnica near Konjic Bosnia and Herzegovina) (Karaman G 2014b), but this species differs distinctly from *N. boskovici* by the presence of a more spiniferous telson and uropods 1-2, by maxilla 1, etc.

*Niphargus alatus* G. Karaman, 1973b (loc. typ.: spring in Veruša, NE. of Podgorica, Prokletije Mt.) is known from the upper part of Tara River in Crna Gora. It is similar to *N. boskovici* in many characters (epimeral plates, uropods 1-2, urosomal segments 1-3, etc.), but *N. alatus* differs from *boskovici* by the presence of a more inclined palm of gnathopods 1-2 propodus, different armature of telson, etc.

Evidently the subterranean waters in Popovo polje in Herzegovina are connected with this region of the Neretva River, because many species known from Popovo polje have also been discovered in the subterranean waters of Neretva river (*N. salonitanus* S. Karaman, 1950, *N. steueri kolombatovici* S. Karaman, 1950, *N. boskovici* S. Karaman, 1952, etc.) (Karaman S 1950).

*Niphargus boskovici* is rather close to *N. cerjanensis* G. Karaman, 2014c, known from Cerjanska Jama Cave, Kleonovnik, Ravna Gora, Varaždin reg., but *N. cerjanensis* differs by larger body size, more subrounded epimeral plates in males, more setose inner plate of maxilla 1, the presence of numerous setae on the rami of uropod 1, and rather more spinose telson, etc.

### *Niphargus salonitanus* S. Karaman, 1950

*Niphargus (Orniphargus) salonitanus* S. Karaman, 1950: 137, figs. 62-72;

*Niphargus salonitanus* G. Karaman 2014b: 215 (other synonyms omitted).

#### Material examined

Croatia:

OR-211= Cavern in the tunnel Blato, Blato, Korčula island, 21.11.2013, 4 spec. (leg. D. Basara & P. Rade);

OR-213= Ibid., 17.11.2013, 3 spec. (leg. R. Ozimec);

OR-205= Šipun Cave, Cavtat, 07.05.2012, 1 spec. (leg. J. Bedek & P. Rade), mixed with *Salentinella angelieri* Del. Deb. & Ruffo, 1952.

#### Remarks

This species is characterized by elongated peduncular articles 1-3 of antenna 1, slender peduncular articles and the flagellum of antenna 2 and short accessory flagellum.

At the inner margin of maxilliped palp article 4 of the observed single specimen from Šipun Cave (male 14.5 mm) appear 2 distal seta only, median seta absent (Karaman G 2012a).

The specimens from Korčula Island agree with those of Vjetrenica Cave and Vilina špilja Cave in Rijeka Dubrovačka, Croatia (Karaman G 2014a).

**Male 16.2 mm from Korčula Island.** Metasomal segments with dorsoposterior marginal spines, antenna 1 reaching nearly 2/3 of body (ratio 162:110), urosomal segments 1 and 2 at each dorsolateral side with 3 spines, urosomal segment 3 naked; coxa 1 rhomboid, with obtuse ventroanterior corner. Propodus of gnathopods 1-2 large, with palm inclined over half of the propodus-length; palm of gnathopod 2 propodus with serrate L-spines sitting distinctly behind the corner S-spine. Telson narrowed, bearing 3 distal spines, lateral and facial spines absent.

#### Distribution

*Niphargus salonitanus* settled the subterranean waters of middle and southern Dalmatia till Cavtat, Herzegovina and Korčula island (present work). Sket (1977) mentioned it for Lošinj island.

### Family Typhlogammaridae *Typhlogammarus mrazeki* Schäferna, 1906

*Gammarus (Typhlogammarus) mrazeki* Schäferna 1906: 1-4, Fig. I, pl. 1, Figs 1-35;

*Typhlogammarus mrazeki* Schäferna 1922: 89 (other synonyms omitted).

#### Material examined

OR-219= Špilja za Gromačkom vlakom Cave, Gromača, Dubrovnik region, Croatia), 2 exp. 28.08.2014 (leg. A. Čukušić);

OR-223= ibid., 25.09.2014, 2 spec. (leg. T. Dražina);

OR-224= ibid., 28.08.2014, 2 spec. (leg. P. Rade & G. Rnjak).

#### Remarks

The specimens agree completely with typical specimens from Lipska pečina Cave.

Previous specimens collected from Špilja za Gromačkom vlakom Cave (Karaman G 1988) belong to *Acubogammarus albor* (Karaman G 1973a).

#### Distribution

*Typhlogammarus mrazeki* is a Tertiary relict of the western Dinarid region, known from various localities of Crna Gora (Schäferna 1906; Karaman S 1932; Sket 1958; Karaman G 1972, 1988, etc.), Bosnia & Herzegovina (Spandl 1926; Karaman S 1932; 1953, etc.) and Croatia (Spandl 1926; Karaman G 1972, 2014b, etc.). This represents a new locality for this species.

### Family Gammaridae *Gammarus roeselii* Gervais, 1835

*Gammarus Roeselii* Gervais, 1835: 127;

*Carinogammarus roeselii* Spandl, 1924: 455;

*Carinogammarus triacanthus* Schäferna, 1922: 35, pl. I, Fig. 1; text Figs 14, 15;

*Gammarus roeseli* G. Karaman & Pinkster, 1977b: 170, Figs 1-3;

*Gammarus roeselii* f. *triacanthus* G. Karaman, 1978: 2581;

? *Gammarus fluviatilis* Rös., Jurinac, 1887a: 23. [other synonyms omitted]

## Material examined

Croatia:

R-74= Spring towards Bajičke, Pecka, Perna, Topusko, Banovina, 07.03.2009, 14 spec. mixed with *G. fossarum* Koch (leg. R. Ozimec).

## Remarks

The specimens possess a moderately large dorsal tooth on metasomal segments 1-3 and belong to the forma *triacanthus* (Schäferna, 1922). Otherwise, because of the large morphological variety of this species, numerous subspecies and varieties have been described, although most of these were later included into *G. roeselii* as synonyms (Karaman G and Pinkster 1977b), although new studies on this species (in progress) indicate the presence of several different taxa within this species (sensu auctorum).

## Distribution

*Gammarus roeselii* settled almost the entire region of central and southern Europe and Asia Minor (Karaman G and Pinkster 1977b), and is a relatively aggressive species still in the process of invading streams of western Europe and the Balkans, pushing native species such as *Gammarus balcanicus* Schäferna, 1922, *G. ochridensis* Schäferna, 1926, etc. (Karaman G 2013), and recently penetrating into Italy as well (Karaman G 1993).

With respect to Croatia, there are a relatively small number of citations for this species (Karaman G and Pinkster 1977b; Gjeparić 1999; Gottstein et al. 2000; Žganec 2001), and these refer mainly to localities along Mura River, Drava River, torrent Stiper, Moždenec, Kalnik, Varaždinske toplice and Una River. However, the first confirmed citation of *G. roeselii* in Croatia was for Plitvice Lakes, cited by Spandl (1924), although Jurinac (1887) cited for the torrents in the vicinity of Oriovac, Croatia, *Gammarus fluviatilis* Rös. (= ?*G. roeselii*) and *G. pulex* L. (= *G. fossarum*). Žganec et al. (2010) mentioned this species from Una River on the Croatian-Bosnian border (Hrvatska Kostajnica and Bosanska Otoka).

### *Gammarus fossarum* Koch, in Panzer, 1836

*Gammarus fossarum* Koch, in Panzer, 1836: 2;

*Gammarus fossarum* Karaman G & Pinkster 1977: 50, Figs 19, 20;

*Gammarus pulex* Fabr., Jurinac, 1887a: 23; Jurinac, 1887b: 95. [other synonyms omitted].

## Material examined

Croatia:

OR-17= spring from Pećina Cave, Malinci, Žumberak,

2 spec. accompanied by *Niphargus* sp., 20.09.2002 (leg. R. Ozimec & T. Rubinić);

OR-26= spring Senovac, Žumberak, 4 spec., 09.05.2003 (leg. R. Ozimec);

OR-37= spring near cave by Šiljak, Šiljci, Žumberak, 2 spec., 26.04.2003 (leg. R. Ozimec);

R-59, 69= spring W of Crveni Križ, Ponikve, Medvednica, 4 spec., 21.05.2005 (leg. H. Bilandžija & M. Pavlek);

R-61= spring in Križevščak, quarry, Bizek, Medvednica, 5 spec., 28.05.2005 (leg. J. Bedek);

R-66= torrent Kamenica near cave Dobra Voda, Ravna Gora, Varaždin, 2 spec., 16.05.2006 (leg. H. Cvitanović);

R-70= spring near Ivanščica, 10 spec., 12.05.2009 (leg. A. Komerički);

R-73= spring Križevščak, Dolje, Medvednica, 11 spec., 28.05.2005 (leg. R. Ozimec);

R-74= spring towards Bajičke, Pecka, Perna, Topusko, Banovina, 4 spec. intermixed with *G. roeselii*, 07.03.2009 (leg. R. Ozimec);

R-76= spring of Velika Radetina, Papuk, 8 spec., 18.07.2004 (leg. M. Lukić);

R-77= captive springs in Podgora Krapinska, Strahinšćic, 1 spec., 18.05.2009 (leg. A. Komerički);

R-78, 82= spring below Jambrišak Vrelo, Ponikve, Medvednica, 10 spec., 21.05.2005 (leg. R. Ozimec & H. Bilandžija);

R-79, 81= spring of Crveni Križ, Ponikve, Medvednica, 8 spec., 21.05.2005 (leg. M. Pavlek & H. Bilandžija);

R-80= spring near Njivice, quarry Dolje, Medvednica, 2 spec., 28.05.2005 (leg. J. Bedek);

R-83= abyss/ spring near Njivice, Medvednica, 5 spec. accompanied by *Niphargus* sp. and *Synurella ambulans* (G. Muller, 1846), 28.05.2005 (leg. R. Ozimec);

R-84= spring below Skalovka, Lobar, Ivanščica, 5 spec., 18.05.2009 (leg. A. Komerički);

R-85= Jambrišak Vrelo-spring, Ponikve, Medvednica, 3 spec., 21.05.2005 (leg. R. Ozimec);

R-109= spring Ksenovac, Žumberak, 1 spec. intermixed with *Niphargus* sp., 23.06.2003 (leg. J. Bedek);

R-133= spring Sitnik, Stiči, Žumberak, 3 spec., 09.03.2003 (leg. J. Bedek);

R-137= spring Ksenovac, Žumberak, 1 spec., 26.04.2003 (leg. F. Karla).

Bosnia and Herzegovina:

S-241= cave-spring Grozničkvica, Bosanska Bijela, 10 spec., 12.07.2004 (leg. J. Mulaomerović);

S-7200= spring Brezovac, Gola Mt., National Park Kozara, 20 spec., 18.08.2013 (leg. M. Stanković);

S-7152= torrent near Podrašnica, Zelenkovac, (Mrkonjić Grad reg.), many spec., 22.08.2011 (leg. M. Stanković);

S-7046= torrent in Zelenkovac, Mrkonjić Grad, 1 spec. intermixed with *Gammarus balcanicus* and *Echinogammarus acarinatus* S. Kar. 1931 (leg. M. Stanković);

S-7048= spring near Podgreda village, Glamočko polje field, many spec. intermixed with *Gammarus balcanicus* Schäferna, 1922, 27.08.2008 (leg. M. Stanković).

## Remarks

Very variable species, still in the process of diversification. The male specimens from Ivanščica have an inner ramus of uropod 3 reaching nearly 2/5 of the outer ramus, stronger setose urosomal segments 1-3 and uropod 3, eyes ovoid, epimeral plates 1-3 along the ventral margin without setae, basipodit of pereopods 5-7 without facial setae at the inner face.

Male specimens from Pecka have remarkably setiferous pereopod 3, with the inner ramus of uropod 3 reaching 3/5 of the outer ramus, all setae along the outer margin of the outer ramus first article are simple, setae along the outer margin are plumose.

The specimens from R-79 and R-81 have smaller eyes and females of 6.2 mm were with 2 eggs in the marsupium.

## Distribution

*Gammarus fossarum* is a Tertiary species settling central, southern and eastern Europe, the Balkan peninsula and Asia Minor.

In Croatia this species is broadly distributed, mostly cited in its northern and eastern range, and cited by various authors in over 30 localities (Jurinac, 1887; Karaman S 1931; Meštrov et al. 1978, 1983, 1984; Garašić and Meštrov 1983; Lattinger 1988; Sket 1988; Gjerapić 1999; Gottstein et al. 2000; Žganec 2001; Žganec et al. 2013a).

The first citation of *G. fossarum* in Croatia was made by Jurinac (1887a for Mrežnica River near Oštarije and Zagorje, Dobra and Vitunjčica).

In Bosnia and Herzegovina, only a limited number of localities of this species are known, mostly near Bosnian-Croatian border (Karaman G 1974, 2011; Žganec et al. 2010; 2013b).

## CONCLUSIONS

Due to recent intensive research into the subterranean fauna of the western Dinarid area by various expeditions and single investigations, numerous samples of subterranean Amphipoda were collected from various localities. During our study of a fraction of these samples, new localities of several taxa of the family Gammaridae Niphargidae and Typhlogammaridae have been established and are presented here. These new localities will help to improve our understanding of the distribution of these species in the western Balkan region.

In addition, the species *Niphargus boskovici* S. Karaman, 1952 is redescribed and figures based on specimens

from new localities in the Metković region (Croatia). Based on these results, the variability of taxonomical characters of this species has been established.

The discovery of various new localities for the studied species extends our knowledge of the distributional area of these taxa.

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