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Article

A New Species of Freshwater Amphipods *Echinogammarus* (Amphipoda, Gammaridae) from Algeria

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Abstract: Several samples of amphipods were obtained from six stations in the upper reach of the Youkous Stream, near Hammamet. This study describes a new species, *Echinogammarus monodi* n.sp., differing from other *Echinogammarus* species in the length of the first antenna, the setation of the third article of the mandibular palp (bearing three rows of A-setae and two rows of B-setae), the merus and carpus of pereopods 5 with long setae only, and the exopodite of uropod 3 with numerous groups of long simple setae. A full description of the new species and information about its distribution is given in this paper.

Keywords: crustacea; Northern Africa; fresh water; stream

1. Introduction

The Mediterranean area is one of the most important hotspots of gammarid diversity in the Palearctic inland surface waters [1]. However, for most of the species known in the European coast of the basin, knowledge about their diversity in the North African part of the basin remains limited [2–4]. The number of described species slightly increased since the description of *Echinogammarus simoni* (Chevreux 1894) in Algeria and Tunisia. The total number of species known in this part of the world is now 22 [3,5], out of which eight were described since 2001.

In Algeria, six freshwater species of the genus *Echinogammarus* are known, with most of them being restricted to a very small area [6]. Contrary to adjacent countries, Algeria is the only country harboring representatives of all three “morphological” groups of *Echinogammarus* species of the Mediterranean Basin [6]. The first group is the *Echinogammarus berilloni* group, represented only by *Echinogammarus annandalei* (Monod, 1924), while the second group is the *Echinogammarus pungens* group for which two species *Echinogammarus reductus* Pinkster, 1993, and *Echinogammarus valedictus* Pinkster and Platvoet, 1990, are known. The last group is the *Echinogammarus simoni* group which has three species: *Echinogammarus simoni* (Chevreux, 1894), *Echinogammarus tacapensis* (Chevreux and Gauthier, 1924) and *Echinogammarus haraktis* Piscart, Merzoug and Hafid 2013. The *Echinogammarus simoni* group is the most widespread group in this basin with *E. simoni* being the only species widely distributed in North Africa and in the Iberian Peninsula [6]. Most of the other species are restricted to a small territory around the type locality. However, recent works in Algeria [7] and in Tunisia [5] highlighted the presence of several species closely related to *E. simoni*. These works suggested that several species might have been misidentified as *Echinogammarus simoni* in the past.

To clarify the distribution and the diversity of freshwater amphipods in Algeria, several sampling campaigns were made in the last 5 years (2013–2018). During surveys in northeastern Algeria, a new species of *Echinogammarus* was found in the upper pristine reach of the Youkous Stream, near the city of Tebessa.

2. Material and Methods

2.1. Study Sites

Amphipod samples were collected in October 2017 from six stations in the spring area of the Youkous Stream near the city of Hammamet (22 km at the west of Tebessa) (Figure 1). This stream is a small tributary of the Medjerda River flowing from Algeria to the Mediterranean estuary in Tunisia near Tunis. The mineral stream flows over around 20 km from the Youkous spring (35°25'2" N, 7°57'47" E) located at 1100 m a.s.l. in a natural karst area in the south of the city Hammamet. This stream is well known for both the quality of its highly mineralized water and the naturalness of the surrounding environment.

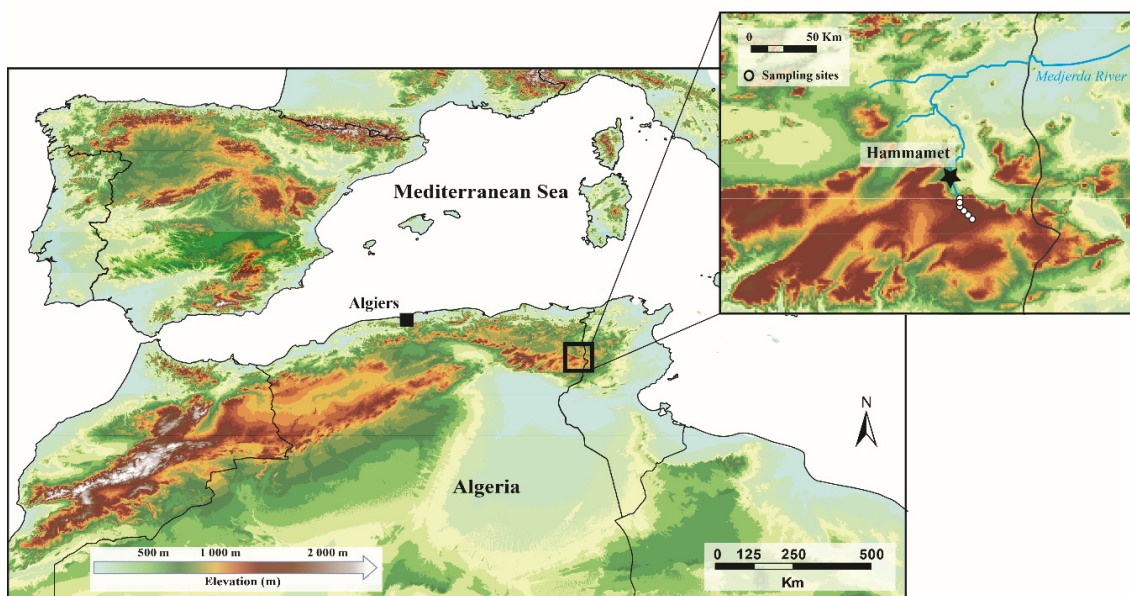


Figure 1. Location of sampling sites in Algeria.

2.2. Animal Sampling and Preparation

Animals were collected with a hand net sampler and fixed in 96% ethanol in the field. The identification was based on the key of *Echinogammarus* [6], which has been updated with new descriptions of species from the genera *Echinogammarus* [5,7]. Amphipod slides were prepared using Faure's permanent mounting medium after the maceration of material in lactic acid and coloration with pink lignin. Body parts were digitally drawn using a Pen tablet and the Illustrator software package (Adobe™) [8].

3. Results

3.1. Systematic Part

Order Amphipoda Latreille, 1816
 Family Gammaridae Leach, 1814
 Genus *Echinogammarus* Stebbing, 1899
Echinogammarus monodi sp. nov
 Figures 2–8

3.2. Material Examined

We examined 35 specimens collected from Youkous spring, Hamamet town near Tebessa, 30.IX.2017. The holotype male (σ 10 mm) was deposited in the Museum National d'Histoire Naturelle, Paris (France), under the references MNHN- IU- 2019-2279. Five male paratypes and five female paratypes were also deposited under the references MNHN- IU- 2019-2280 and MNHN- IU- 2019-2281, respectively.

3.3. Type Locality

The Source Youkous ($35^{\circ}25'2''$ N, $7^{\circ}57'47''$ E) is a natural spring near the city Hamamet, Algeria, North Africa.

3.4. Etymology

The name monodi refers to Theodore Monod, a famous carcinologist, savant and humanist who dedicated his life to the study of fauna and people from the Sahara desert.



Figure 2. *Echinogammarus monodi* n.sp., (σ paratype 9 mm; D, ♀ paratype 7 mm).

3.5. Description

A rather small species, maximum length observed 10 mm. Head with a rounded lateral cephalic lobe, eyes relatively small, twice as long as wide and weakly separated from the mid-dorsal line (Figures 2 and 3A). The first antenna is much longer than half the body length (Figure 3B), the peduncle articles are short and poorly setose, the flagellum has 31–32 articles, and the accessory flagellum is

3-articulated and armed with a few setae. The second antenna (Figure 3C) is long and robust but shorter than first antenna and is as long as a half of the body length, the gland cone is well developed, almost reaching the third article of the peduncle, peduncle articles 4 and 5 are of similar size and armed with many groups of setae on all sides, the flagellum has 14 articles, armed with transverse rows of setae that are longer than the diameter of the segment and decreasing in length distally, and calceoli are always absent.

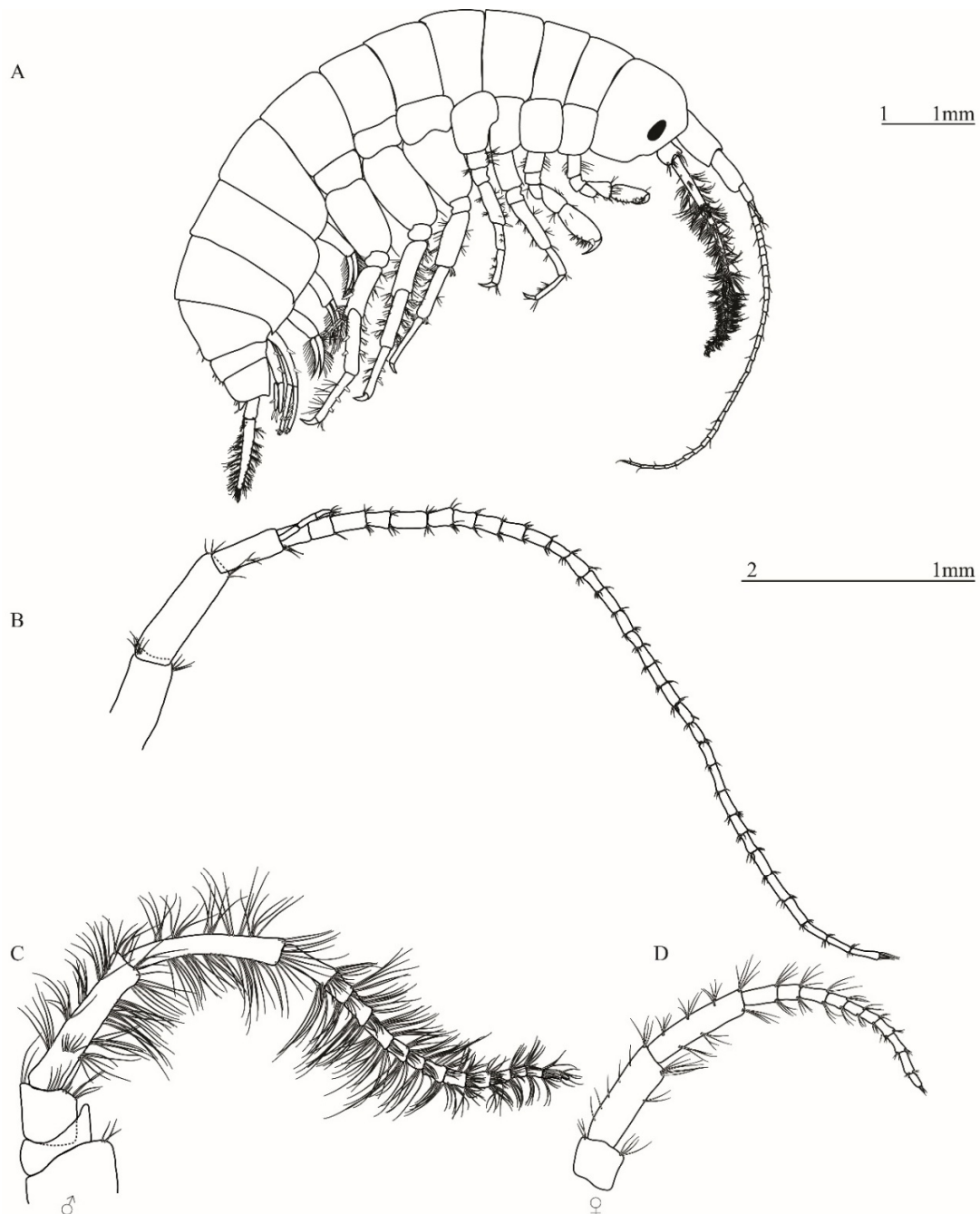


Figure 3. *Echinogammarus monodi* n.sp., ((A–C), ♂ holotype 10 mm; (D), ♀ paratype 7 mm): (A), habitus (scale 1); (B), first antenna (scale 2); (C), second antenna (scale 2); (D), second antenna (scale 2).

The mouthparts are similar to those of other species of the genus *Echinogammarus* (Figure 4). The mandibular incisor is 5-toothed, *lacinia mobilis* is 4-toothed, followed by a tuft of plumose setae, and the proximal molar process is robust with a brush of plumose setae. The maxilliped is similar

to those of other species of the genus (Figure 4A). The inner plate of maxilla 1 bears 16–18 plumose setae and the outer lobe bears eight pectinate setae (Figure 4C), palp 2-articulated, with 7–9 apical and antero-distal setules. Maxilla 2, inner and outer lobes, has one row of apical and sub-apical simple setae (Figure 4B). The three articles of the mandibular palp are normally developed (Figure 4D). The first article is unarmed, the second article is armed with long inferior setae, and third article bears three rows of A-setae, 2 rows of B-setae, an irregular row of 30–32 D-setae and 5–6 relatively short apical E-setae (i.e., around an half of the article length).

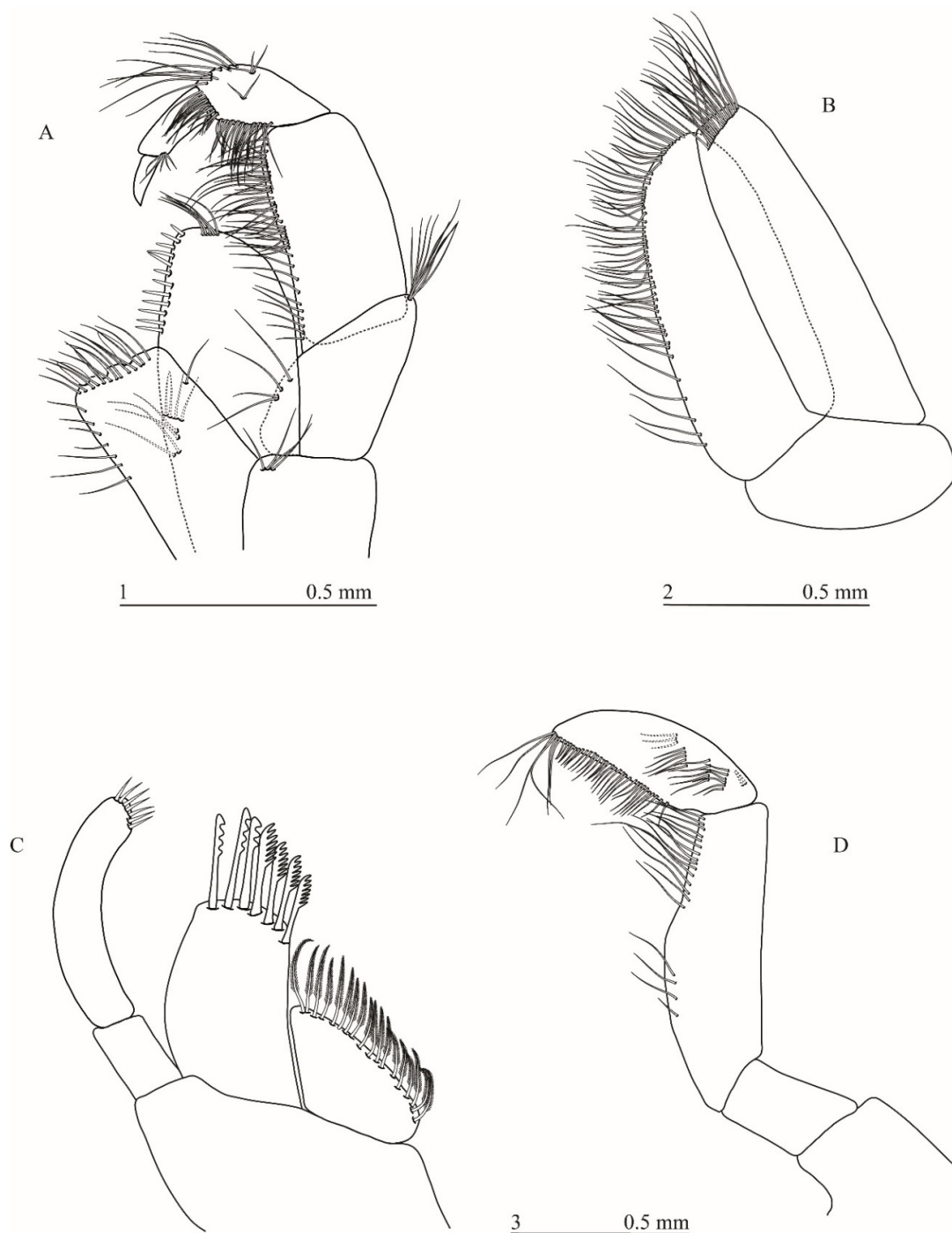


Figure 4. *Echinogammarus monodi* n.sp., ((A–D), ♂ holotype 10 mm): (A), maxilliped palp (scale 1); (B), maxilla 2 (scale 2); (C), maxilla 1 (scale 3); (D), mandibular palp (scale 3).

Coxal plates 1 to 4 have rounded ventral corners, set with a few short setules. Gnathopod 2 propodus is 1.3× longer than in gnathopod 1 and is different in shape. Gnathopod 1 propodus pyriform is about twice as long as it is wide (Figure 5A), palm oblique, and armed with strong and acute medial palmar spine and two spines in palmar angle and groups of long dorsal and ventral setae. Gnathopod 2 propodus (Figure 5C) is a more transverse palm, bearing more groups of longer setae on both superior and inferior margins, a rounded medial palmar spine and two smaller spines toward the palmar angle.

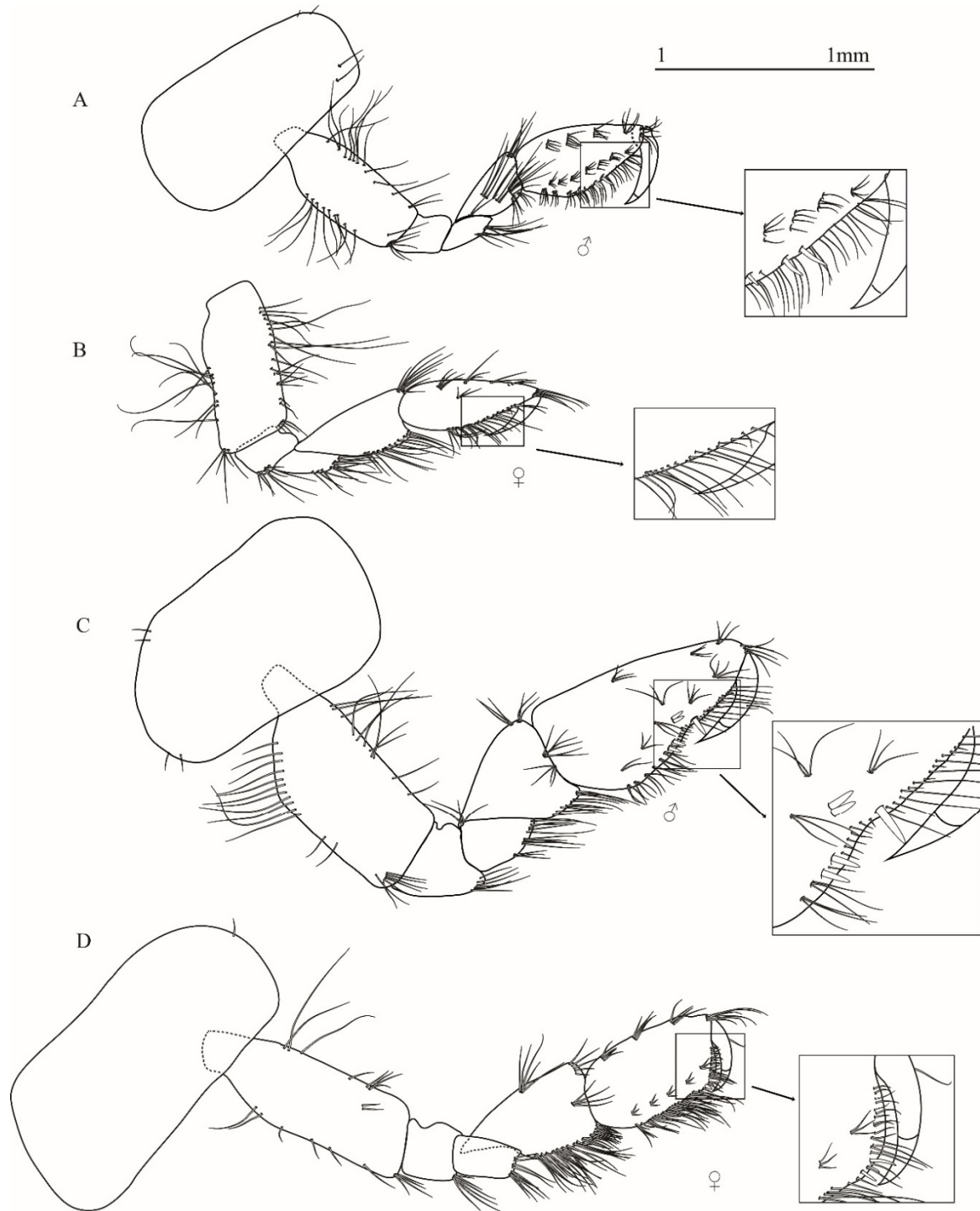


Figure 5. *Echinogammarus monodi* n.sp., ((A,C), ♂ holotype 10 mm; (B) and (D), ♀ paratype 7 mm): (A), gnathopods 1 ♂; (B), gnathopods 1 ♀; (C), gnathopods 2 ♂; (D), gnathopods 2 ♀.

Pereopods 3 and 4 (Figure 5A,C) have groups of long setae in both margins, and the propodi are armed with groups of spines and also long setae.

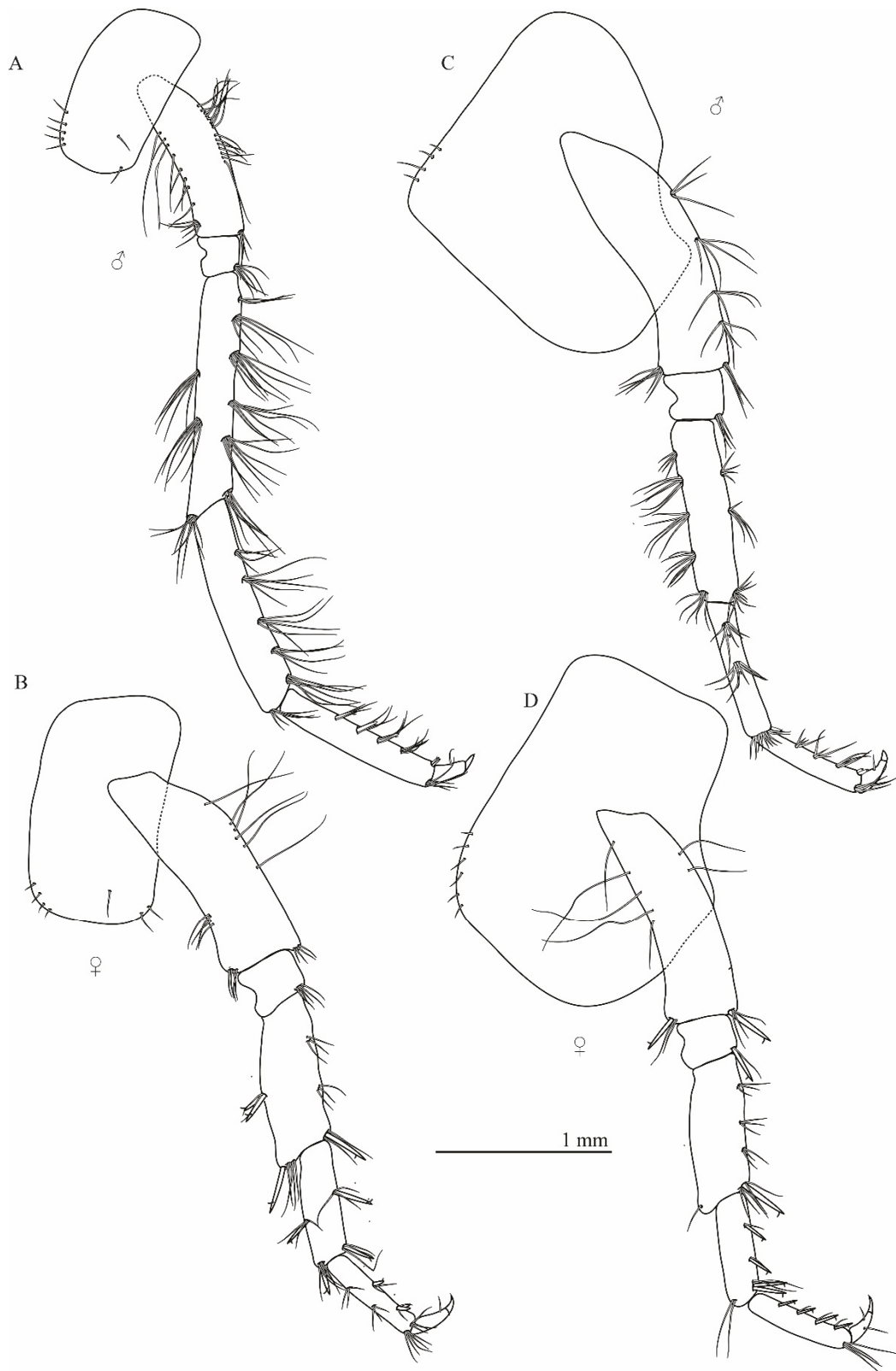


Figure 6. *Echinogammarus monodi* n.sp., ((A,C), ♂holotype 10 mm; (B) and (D), ♀paratype 7 mm): (A), pereopod 3; (B), pereopod 3; (C), pereopod 4; (D), pereopod 4.

Pereopods 5–7 have a rectangular basis (Figure 7), two times as long as they are wide, and pereopods 6–7 basis are longer compared to pereopod 5. Pereopods 5 carpus without spines and other articles is armed with spines and setae longer than spines. The bases of pereopods 6 and 7 have a spine on the distal posterior margin (Figure 7), merus, carpus and propodus with many long setae especially in pereopod 7 and few spines shorter than setae.

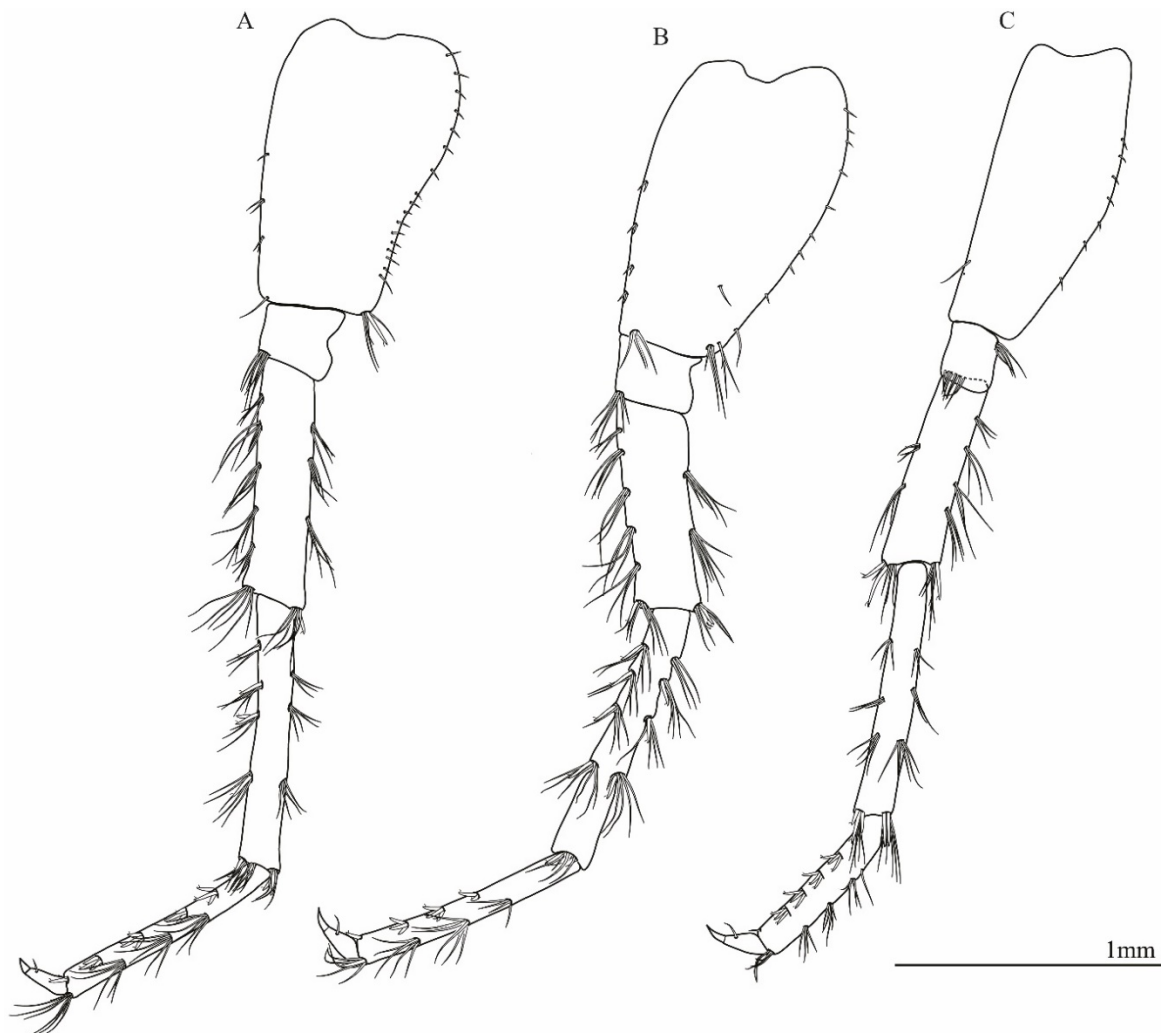


Figure 7. *Echinogammarus monodi* n.sp., ((A–C), ♂ holotype 10 mm): (A), pereopod 5; (B), pereopod 6; (C), pereopod 7.

Uropod 1 (Figure 8A) is well developed and longer than uropod 2 (Figure 8B), but as long as uropod 3. Uropod 3 has a base with three long distal spines (Figure 8C), the endopodite is very short with one distal spine, the first exopodite article is weakly armed with spines but with numerous groups of long simple setae along the inner and outer margins, and the second exopodite article is short but slightly longer than terminal spines of the first article.

The dorsal surface of metasome is unarmed (Figure 8F). The urosomites are flat. The first urosomite is armed with one dorsal group of setae. Urosomites 2 and 3 are armed with one dorsal group of spines and setae. Epimeron 2 to 3 are postero-ventral corner pointed and armed with two or three marginal ventral spines (Figure 8G). Telson lobes are twice as long as they are wide, usually armed with three terminal spines and a few simple setae in the lateral and dorsal margins (Figure 8E).

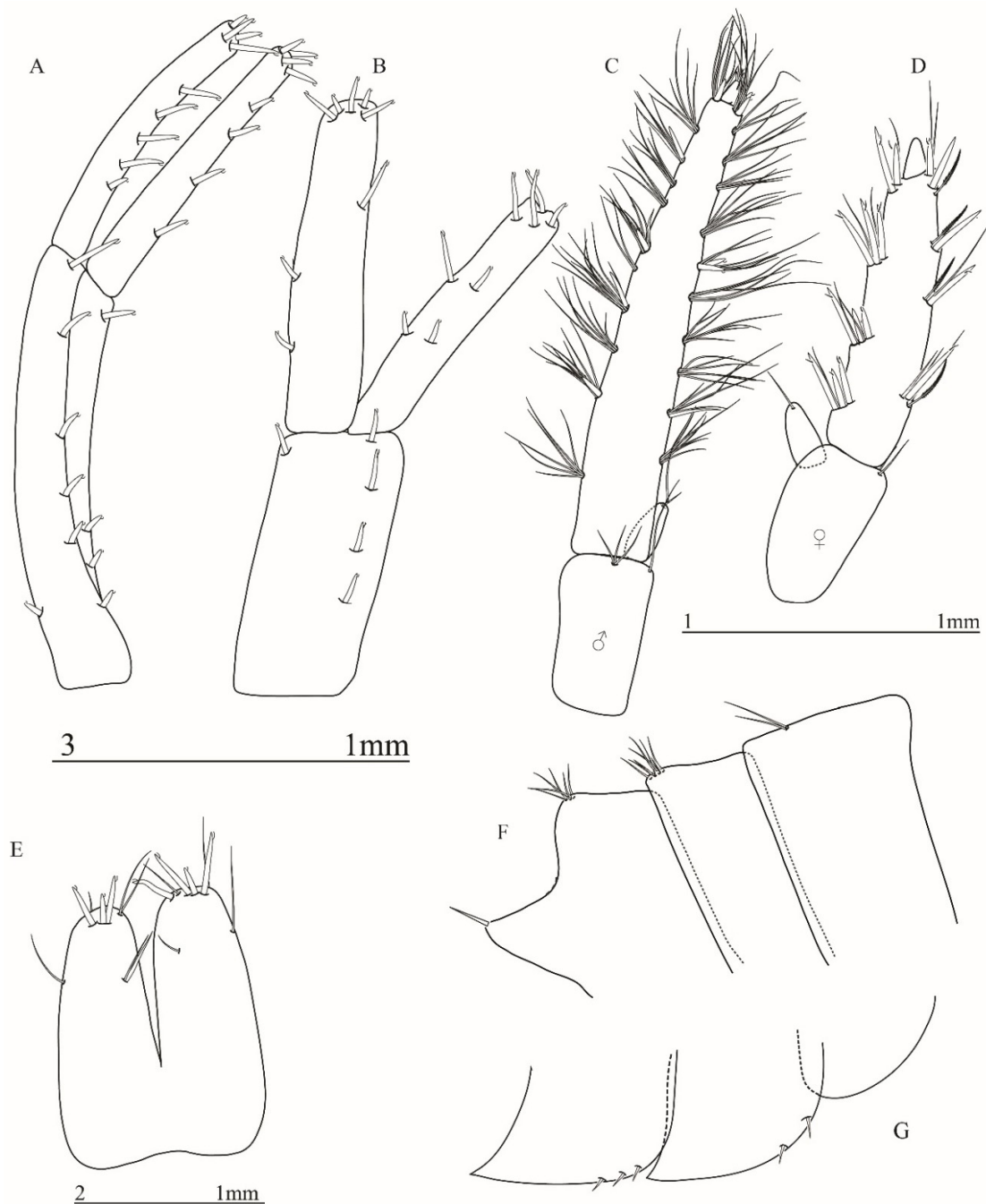


Figure 8. *Echinogammarus monodi* n.sp., ((A–C,E,F), ♂holotype 10 mm; (D) and (G), ♀paratype 7 mm): (A), uropod 1 (scale 1); (B), uropod 2 (scale 1); (C), uropod 3 (scale 1); (D), uropod 3 (scale 1); (E), telson (scale 2); (F), urosome (scale 3); (G), eprimeron 1–3 (scale 3).

3.6. Sexual Dimorphism

The setation of the second antenna is much less dense in females than in males with shorter setae (Figures 2 and 3D). Gnathopods 1 and 2 are shorter and the medial palmar spines are lacking in females (Figure 5B,D). The setation of pereopods 3 and 4 (Figure 6B,D) is more developed and the exopodite of uropod 3 is shorter than in males (Figure 8B).

3.7. Remarks and Affinity

Echinogammarus monodi is characterized by propodi of gnathopods 1 and 2 similar in size, the setation of pereopods 5–7 and the shape of the eyes and hence closely resemble the species of the *Echinogammarus simoni* group (Table 1). By the setation of antenna 2, *E. monodi* is close to *E. simoni* and *E. haraktis* but it differs from these species by the length of the first antenna which is longer than half of the body length; a gland cone is almost as long as the third article of peduncle; the third article of mandibular palp bears three rows of A-setae and two rows of B-setae; pereopods 5–7 has long setae, longer than spines; pereopod 5 with an elongated basis is two times as long as it is wide; the merus and carpus of pereopod 7 are without spines; the exopodite of uropod 3 has numerous groups of long simple setae and is without plumose setae. By setation of pereopods and uropod 3, *E. monodi* looks similar to *Echinogammarus dactylus*, but differs by many other morphological traits (a normally developed dactyli on pereopod 5 to 7, the number of article of the accessory flagellum of first antenna, the shape of the basis of pereopod 7 and the lack on setae on epimeron). By the setation on pereopods, *E. monodi* also resembles species of the *Echinogammarus pungens* group, but it differs by the lack of setae on basis of pereopods and on epimeron 1 to 3.

Table 1. Morphological criteria for *Echinogammarus monodi* and freshwater groups of species in the genus *Echinogammarus* according to Stock (1968) [9], Pinkster (1969) [10], and Pinkster and Stock (1972) [9] and updated by Pinkster (1993) [6]. X indicates the presence of the morphological traits.

Morphological Characteristics	<i>E. monodi</i>	<i>E. berilloni</i> Group	<i>E. pungens</i> Group	<i>E. simoni</i> Group
- Eyes large, elongated		X	X	
- Eyes small, rounded	X			X
- Gnathopod 2 propod larger than those of gnathopod 1		X		
- Gnathopod 2 carpus elongated	X			X
- Pereopods 5–7 with groups of long setae	X	X		
- Metasome with teethlike projections		X		
- Metasome with dense spinulation		X		
- The presence of compressed dorsal elevations on the urosome			X	
- Epimeron with long setae in ventral margin		X	X	

3.8. Distribution and Ecology

The new species *Echinogammarus monodi* was collected in all sampled sites along the Youkous Stream in the regions of Hammamet (altitude above 1000 m a.s.l.), near the city of Tebessa. It co-occurred with *E. simoni*. The water had a good quality, relatively low temperatures, and low nutrient contents (Table 2).

Table 2. Mean (min–max) values of physico-chemical parameters of sites where *E. monodi* occurred along the Youkous Stream.

	Mean Values (Min–Max)
Temperature (°C)	15.5 (15.3–15.8)
pH	7.5 (7.4–7.6)
Electrical conductivity ($\mu\text{Sm}\cdot\text{cm}^{-1}$)	389 (359–445)
NH_4^+ ($\text{mg}\cdot\text{L}^{-1}$)	0.2 (0.2–0.3)
NO_3^- ($\text{mg}\cdot\text{L}^{-1}$)	3.3 (2–4)
NO_2^- ($\text{mg}\cdot\text{L}^{-1}$)	0.1 (0.1–0.2)
PO_4^{2-} ($\text{mg}\cdot\text{L}^{-1}$)	0.8 (0.7–1)
$\text{H}_2\text{SiO}_4^{2-}$ ($\text{mg}\cdot\text{L}^{-1}$)	23.7 (18.5–28)
Ca^{2+} ($\text{mg}\cdot\text{L}^{-1}$)	69.6 (67–73.6)
Mg^{2+} ($\text{mg}\cdot\text{L}^{-1}$)	15.4 (13.9–16.9)
Cl^- ($\text{mg}\cdot\text{L}^{-1}$)	115 (109–134)

4. Discussion

Over the last 50 years, the genus *Echinogammarus* was divided into three main groups of species sharing many morphological characteristics (Table 1), which led to taxonomic confusion [6]. The first group, the *Echinogammarus pungens* group, was proposed by Stock [11] who included nine species, but further description increased this number to 25 species [6,12,13]. Later, the *Echinogammarus berilloni* group was defined by Pinkster [10] and constituted by 18 species [6,14]. Finally, Pinkster and Stock [9] introduced the *Echinogammarus simoni* group, widely distributed in the Iberian Peninsula and North Africa, with 10 known species [5–7]. Until now, the taxonomic position of species from these groups has been a subject of debate [10,15,16], but without consensus concerning the position of the *Echinogammarus pungens* and *simoni* groups. Based on molecular studies [15,16], Hou and Sket proposed the genus *Homoeogammarus* Schellenberg, 1937, as a valid name and have been considered species of the *Echinogammarus simoni* group as members of this genus [15]. However, Hou and Sket failed to provide a clear diagnosis of the genus based on its morphology. The fact that there is a lack of clear morphological diagnosis of the genus *Homoeogammarus*, acknowledged by the authors themselves, [16] and that only one species from Northern Africa has been taken into account in these studies means that there is not sufficient evidence to solve this issue. Moreover, in the study of Sket and Hou [15], it seems that the genus *Homoeogammarus* is polyphyletic and could be constituted by several genera.

5. Conclusions

From a morphological point of view, *E. monodi* share the morphological characteristics of several groups. Considering the shape of the eyes and the shape of the carpus of gnathopod 2, it could be considered a member of the *Echinogammarus simoni* group. However, with the setation of pereopods 5–7, it is closer to the *Echinogammarus berilloni* group, considered as the genus *Echinogammarus* sensu stricto by Hou and Sket [15], than to the *Echinogammarus simoni* group. Hence, *E. monodi* could be considered an intermediate form between the two groups. This result is congruent with molecular analyses considering that the two groups are polyphyletic [15]. Further ongoing molecular studies on a larger number of species among these groups, especially in Northern Africa should clarify the taxonomical position of members of the *Echinogammarus/Homoeogammarus* species.

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Conflicts of Interest: The authors declare no conflict of interest.

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