

First record of the genus *Diarthrodella* Klie, 1949 (Copepoda, Harpacticoida, Paramesochridae) from the Mediterranean Sea, with description of a new species from Turkey

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Abstract: Both sexes of *Diarthrodella ergeneae* sp. nov. (Copepoda, Harpacticoida, Paramesochridae), which were collected from the intertidal zone of Kurtpınarı Beach along the Mediterranean coast of Turkey, are described in detail. The new species is morphologically most similar to *D. convexa* Kunz, 1981; *D. secunda secunda* Kunz, 1954; and *D. lancifera* Kunz, 1981 according to the setal formula of the swimming legs, but *D. ergeneae* sp. nov. can easily be differentiated from *D. convexa* by the ratio of P1 exopod/enp-1, by the lack of an inner seta on P2 enp-2, and by the shape and armature of P5; from *D. secunda* s. str. by having a seta on the proximal segment of A2 exopod, P3 enp-2 with inner seta, and P3 enp-3 with 2 setae and by the armature and shape of P5 and squarish caudal rami; and from *D. lancifera* by having 6 setae on P1 exp-2 and squarish caudal rami that bear filiform terminal setae. A key to the species of *Diarthrodella* is given. Investigation of the previous literature has revealed that the genus *Diarthrodella* has not been reported from the Mediterranean Sea so far; hence, this is the first record of the genus from the Mediterranean Sea.

Key words: Harpacticoida, taxonomy, new species, Mediterranean Sea, Diarthrodellinae

1. Introduction

Most species of the family Paramesochridae are cylindrical and small interstitial harpacticoids that inhabit the intertidal/subtidal (Boxshall and Halsey, 2004) and deep-sea marine sands (Back et al., 2011). However, some paramesochrids have cyclopoid (e.g., *Caligopsyllus* Kunz, 1975) or vermiform (e.g., *Apodopsyllus* Huys, 2009) body shapes (Amorri et al., 2010). Huys (1987) revised Paramesochridae and divided the family into 2 subfamilies, Paramesochrinae Lang, 1944 and Diarthrodellinae Huys, 1987, which includes the genera *Diarthrodella* Klie, 1949; *Tisbisoma* Bozic, 1964; and *Rossopsyllus* Soyer, 1975. The family is currently represented by 15 genera and 160 species/subspecies (Walter, 2014).

The genus *Diarthrodella* was established by Klie (1949) for a new species, *Diarthrodella orbiculata* Klie, 1949 from Helgoland in the North Sea, and placed into the family Thalestridae based on the structure of the maxilliped. Kunz (1954) then transferred the genus to the family Paramesochridae by considering its close similarities to *Paramesochra*. At present, the genus contains 12 valid species/subspecies (including *Diarthrodella ergeneae* sp. nov.), which are essentially mesopammic.

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Although Paramesochridae is one of the large families of the Harpacticoida, only 5 species have been recorded from Turkish marine waters so far (Karaytuğ and Sak, 2006; Alper et al., 2010). A new species of the genus *Diarthrodella* was discovered during a study of the harpacticoid copepod fauna of the Mediterranean coast of Turkey. Both sexes of *Diarthrodella ergeneae* sp. nov. are described and illustrated in detail.

2. Materials and methods

The specimens were collected using the Karaman-Chappuis method (Delamare Deboutteville, 1954). Illustrations of the habitus of the holotype and the paratype were drawn from whole specimens; the specimens were then dissected, and the dissected parts were mounted in lactophenol under an Olympus SZX-16 stereomicroscope. Broken glass fibers were used between the slide and the coverslip to prevent compression and assist rotation to allow observation of the material. Afterwards, preparations were sealed with Entellan (Merck) for permanent preservation. All drawings were made using a U-DA drawing tube attached to an Olympus BX-51 differential interference contrast microscope. An eyepiece micrometer was used for the measurement of the specimens.

Dissolved oxygen, temperature, conductivity, and salinity parameters of the sampled seawater were measured with a YSI 85 multiparameter probe (YSI Inc.), and pH was measured with an Orion 3-Star handheld pH meter (Thermo Fisher Scientific).

The work of Huys et al. (1996) was followed for the descriptive terminology. The following abbreviations have been used: P1–P6 for swimming legs 1 to 6; exp (enp)-1 (-2, -3) to refer to the proximal (middle, distal) segment of a ramus, and ae for aesthetasc. The holotype and other material were deposited in the collection of the Biology Department of Mersin University.

3. Results

Order Harpacticoida Sars, 1903

Family Paramesochridae Lang, 1944

Subfamily Diarthrodellinae Huys, 1987

Diarthrodella Klie, 1949

Diarthrodella ergeneae sp. nov. (Figures 1A and 1B, 2A–2D, 3A–3E, 4A–4D, and 5A–5D)

Type locality. Turkey, Mediterranean Sea coast, Hatay, Kurtpınarı municipality, sandy beach; 36°53.409'N, 35°56.775'E. pH = 6.59, O₂ = 4.6 mg/L, temperature = 32.1 °C, conductivity = 52.2 ms, salinity = 34.2 ppt.

Material examined. Holotype ♀ dissected on 3 slides. Paratype dissected on 3 slides; paratypes 18 ♀♀, 12 ♂♂ preserved in alcohol. Leg. S. Karaytuğ, S. Sak, A. Alper, S. Sönmez; 13 September 2008.

Additional material. 1 ♀ in alcohol. Turkey, Mersin, Mamure Beach, 15 September 2008; 36°05.167'N, 32°54.354'E. pH = 7.14, O₂ = 5.84 mg/L, temperature = 30.8 °C, conductivity = 54.5 ms, salinity = 35.9 ppt.

Description of the female.

Body (Figure 1). Total body length from tip of rostrum to posterior margin of caudal rami 272 µm (247–287 µm; mean = 266 µm; n = 10). Body cylindrical, slightly tapering posteriorly, with clear demarcation between urosome and prosoma. Largest width measured at the middle of cephalothorax 82 µm, anal somite narrowest. Genital double somite longest, without any trace of subdivision. P5-bearing somite shortest. Genital double somite and 2 succeeding somites bear smooth hyaline frills at posterior margin. Nauplius eye absent.

Rostrum (Figure 1). Well developed, triangular, about 1.35 times as long as basal width, distinct from cephalosome, furnished with a pair of sensillae and a pore apically. Cephalic shield subrectangular with anterior corners rounded, about 1.1 times as long as maximum width, occupying about 33% of total body length, furnished with fine sensillae, posterior margin smooth. Genital double somite nearly as long as wide armed with spinular rows laterally near proximal margin and furnished with several sensillae dorsally.

Anal somite (Figures 1A and 2A). With spinular rows either side of the midline near posterior margin. Anal operculum short and without ornamentation. Anal cleft furnished with fine spinules.

Caudal rami (Figures 2C and 2D). Parallel, squarish in dorsal aspect, posterior margin furnished with a spinular row ventrally and a tube pore laterally, bearing 6 setae; seta I reduced; seta II very short and naked, located dorsally; seta III short, thick, and plumose, located laterally; seta IV long and plumose, with fracture plane, located at inner terminal; seta V about 1.6 times as long as seta IV, plumose, with fracture plane, located at outer terminal; seta VI short, thick, and plumose; seta VII located dorsally, long, plumose, and triarticulated at base.

Antennule (Figure 3A). Eight-segmented; segment 1 furnished with a short spinular row ventrally, bears a long and plumose seta at inner distal corner; segment 2 longest, occupying 1/5 of total antennule length, with 8 setae, of which 4 are plumose and 4 naked; segment 3 bears 1 long slender seta, 3 naked setae, and 2 plumose setae; inner distal corner of segment 4 with an aesthetasc (length = 42 µm) fused basally to a naked slender seta and bearing 2 plumose setae; segment 5 bears a slender naked seta at outer distal corner; segment 6 and 7 with 3 naked setae; segment 8 with 4 setae, of which 1 is articulated at base, and an apical acrothek consisting of an aesthetasc (length = 42 µm) and 2 slender setae. Setal formula: 1-[1 plumose], 2-[4 + 4 plumose], 3-[4 + 2 plumose], 4-[2 plumose + (1 + ae)], 5-[1], 6-[3], 7-[3], 8-[4 + (acrothek)].

Antenna (Figures 5C and 5D). Coxa small, rectangular, and unornamented, about 1.6 times as long as maximum width; allobasis elongated, about 2.5 times as long as maximum width, bears a short bare seta at outer distal corner; exopod 2-segmented, exp-1 about 2 times as long as exp-2, with a long plumose seta at outer distal corner, exp-2 bears 2 closely set spinulose strong setae apically; endopod 2-segmented, enp-1 bears a short naked seta, enp-2 elongated, about 1.6 times as long as exp-1, bears a short strong spinulose seta on posterior surface, 4 long and geniculate setae apically, 2 relatively short and naked setae subapically, 2 long bare and 1 minute setae laterally.

Mandible (Figure 3B). Praecoxa elongate and narrow, cutting edge of gnathobase bears several teeth around distal margin; palp well developed. Coxa-basis elongate, about 3.85 times as long as maximum width, bears 2 bare and 1 plumose setae. Endopod and exopod unisegmented, endopod about 1.75 times as long as exopod and curved on the anterior surface of coxa-basis. Exopod rectangular, about 4 times as long as maximum width, bears 5 bare setae. Endopod rectangular, 5.2 times as long as maximum width, bears 3 bare setae laterally, 2 pairs of basally fused bare setae (1 of them with spatula-like tip), and 3 bare setae apically.

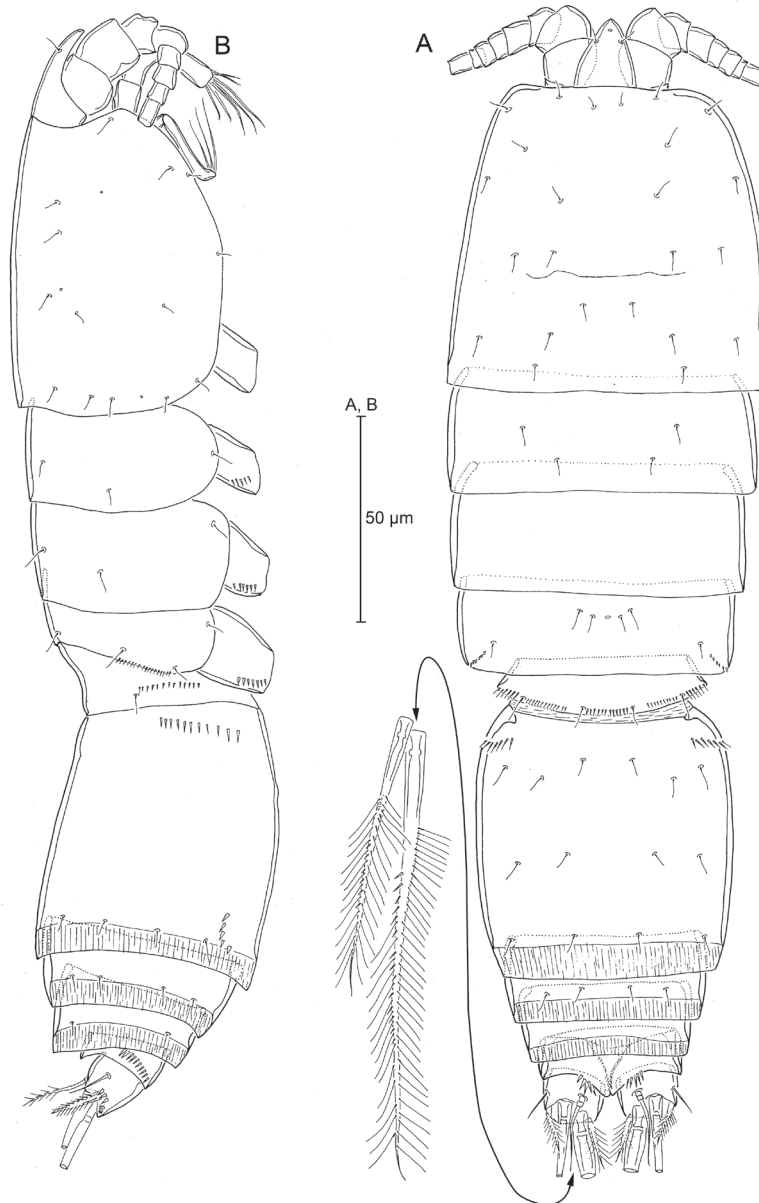


Figure 1. *Diarthrodella ergeneae* sp. nov. ♀, holotype. A: Habitus, dorsal; B: habitus, lateral.

Maxillule (Figure 3C). Praecoxa squarish and naked; coxal arthrite rectangular, about 1.5 times as long as maximum width, bears 1 bidentate and 1 bare setae laterally, 2 fine setae, 8 curved spines on apical edge. Coxal endite rectangular, about 3 times as long as greatest width, bears 1 pinnate and 5 slender bare setae at inner margin; endopod unisegmented, armed with 4 bare and 1 plumose setae apically; exopod unisegmented, short, bears 2 plumose and 3 bare setae.

Maxilla (Figure 3D). Syncoxa armed with 3 endites. Proximal endite bilobed; with 3 bare setae on the first lobe,

1 spinulose and 2 bare setae on the second lobe; middle endite armed with 1 spinulose and 2 bare setae; distal endite bears 1 minute and 2 relatively long bare setae. Basis widened, with 4 bare setae, endopod armed with 4 bare setae and 1 long, medially geniculate, strong seta.

Maxilliped (Figure 3E). Syncoxa well developed, rectangular, about 1.7 times as long as maximum width, armed with a minute bare seta. Basis elongated, about 2.5 times as long as maximum width; endopod 2-segmented, curved on the posterior edge of basis, enp-1 about 2.1 times as long as enp-2 and about 1.6 times as long as

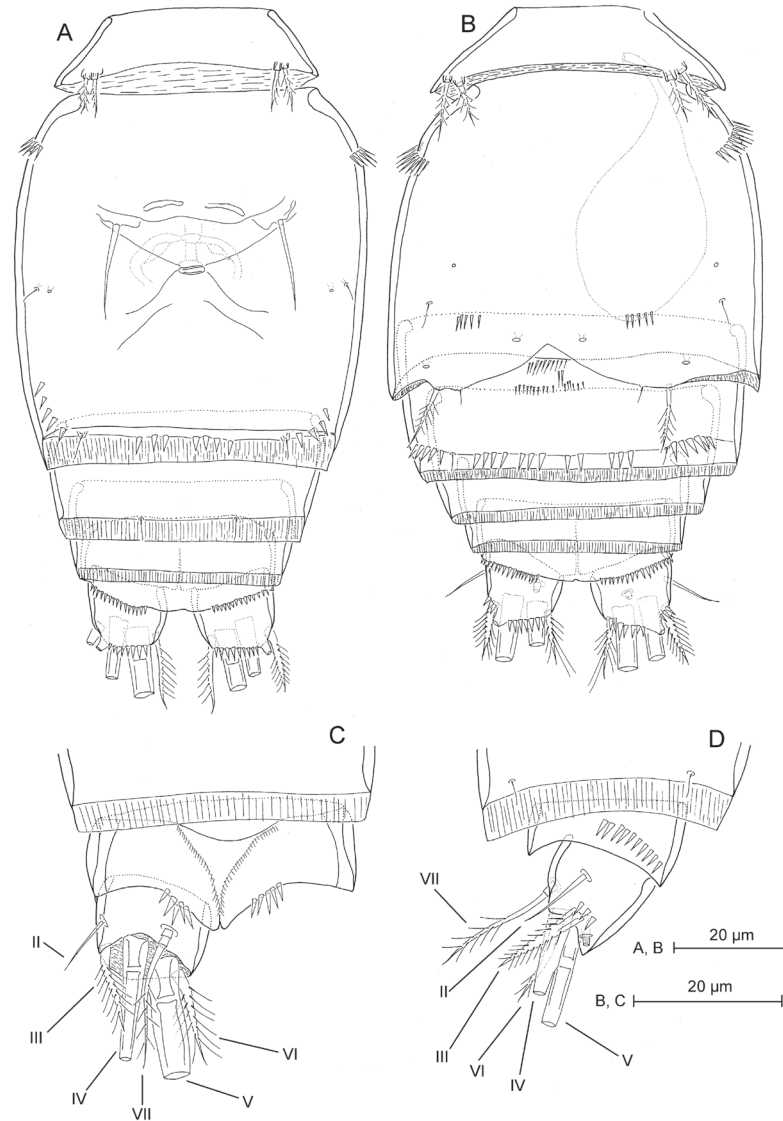


Figure 2. *Diarthrodella ergeneae* sp. nov. **A:** Urosome ♀, holotype, ventral; **B:** urosome ♂, paratype, ventral; **C:** anal somite and caudal ramus ♀, holotype, dorsal; **D:** anal somite and caudal ramus ♀, holotype, lateral.

maximum width, armed with a long bare seta on anterior surface and a long, strong, spinulose seta distally; enp-2 squarish, bears 2 closely set bare setae on apical edge.

Swimming legs (Figure 4). With 2- (P1) or 3- (P2–P4) segmented exopods and 3-segmented endopods. Except for P1, endopods always shorter than exopods. Intercoxal sclerite of P1 narrow, ornamented with a spinular row on either side; P2 and P3 squarish and ornamented with fine spinules on either side, P4 small and naked.

P1 (Figure 4A). Coxa well developed, about 3.5 times as wide as maximum length, unornamented. Basis rectangular, 2.8 times as wide as maximum length, outer

basal seta short, naked, and with long, fine spinules on inner proximal edge. Exopod 2-segmented, exp-1 furnished with a spinular row at outer margin and a bipinnate outer spine subdistally, inner margin naked; exp-2 about 1.5 times as long as exp-1, furnished with a spinular row and a bipinnate spine at outer proximal, 1 unipinnate seta subdistally, 2 unipinnate setae (1 of them geniculate) apically, and a naked inner seta subdistally. Endopod 3-segmented, enp-1 elongate, about 3 times as long as 2 succeeding segments, outer edge ornamented with spinule row, inner edge armed with a plumose seta and a spinule row; enp-2 squarish, armed with 3 closely

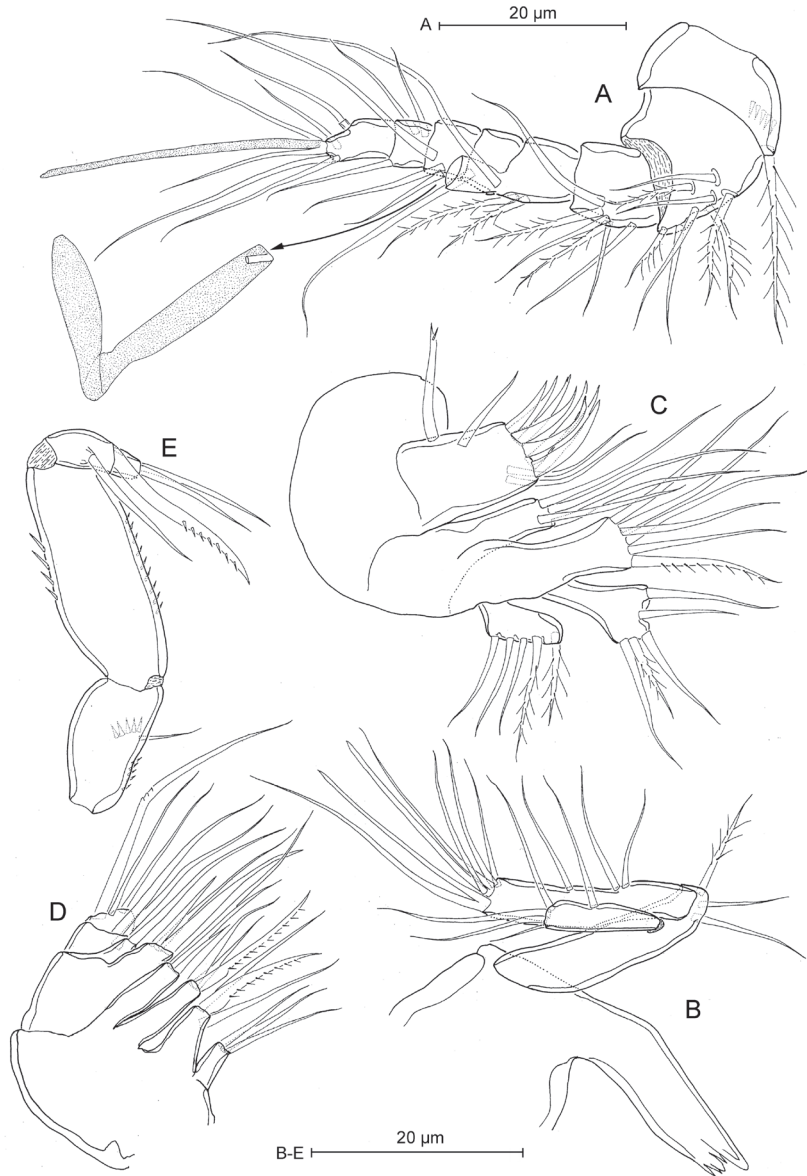


Figure 3. *Diarthrodella ergeneae* sp. nov. ♀, holotype. **A:** Antennule; **B:** mandible; **C:** maxillule; **D:** maxilla; **E:** maxilliped.

set fine spinules at outer distal corner, inner edge naked; enp-3 squarish, outer margin naked, apical edge with a long, geniculate, strong, spinulose seta and a minute seta at inner distal corner.

P2–P4 (Figures 4B–4D). Praecoxa well developed and naked at P2. Coxa well developed, about 2 times (P3, P4) or 2.6 times (P2) as wide as maximum length (at outer margin), furnished with a spinule row on outer margin. Basis widened, about 2.6 times as wide as maximum length, with a bare (P2) or plumose (P3, P4) seta at outer distal corner, a pore on anterior surface, and some fine spinules at inner distal edge. Exopod 3-segmented; exp-1

armed with a spinule row on outer edge and a pinnate spine and a pore on anterior surface (except P2) at outer distal corner, inner margin with a strong spinulose seta (P2) or a plumose seta (P3, P4), exp-2 furnished with a spinule row on outer edge, a strong pinnate spine, a pore on anterior surface at outer distal corner, and a fine plumose seta at inner distal corner; exp-3 armed with a spinule row on outer edge, a strong spine and a pore on anterior surface at outer distal corner, 2 setae (outer seta strong and bipinnate at P4) apically and 2 plumose setae subdistally. Endopod 3-segmented; enp-1 about 2 times as long as 2 succeeding segments (P2, P3), bears a spinular row on outer edge and

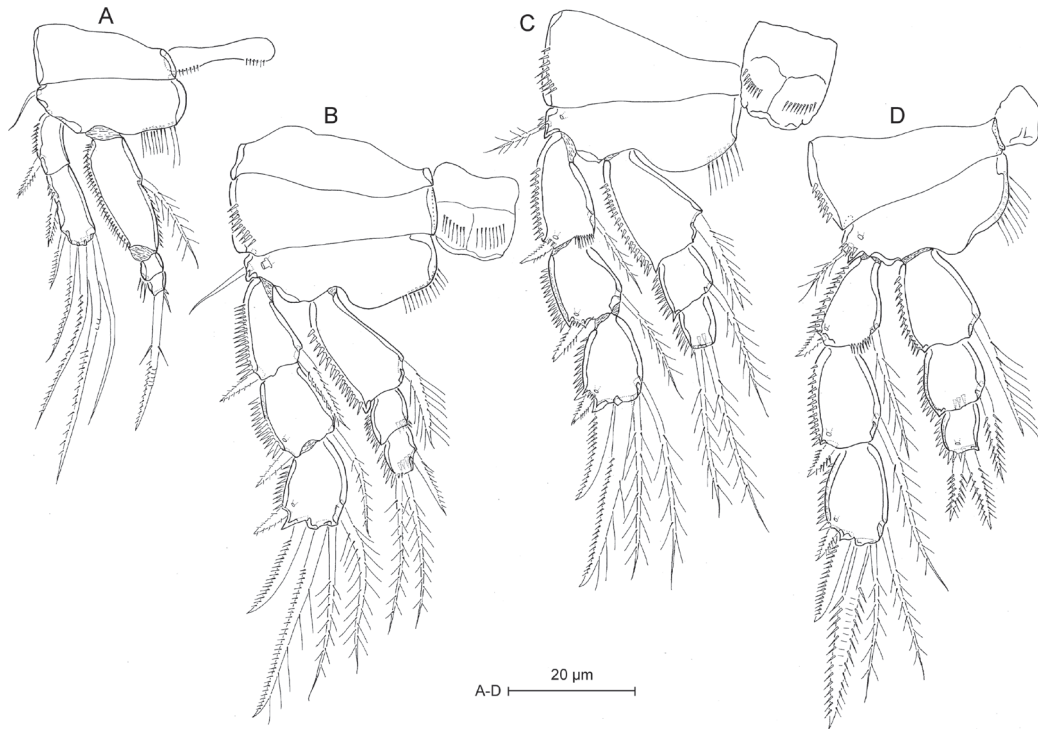


Figure 4. *Diarthrodella ergeneae* sp. nov. ♀, holotype, anterior. A: P1; B: P2; C: P3; D: P4.

a strong plumose seta at inner subdistal corner; enp-2 short and squarish, furnished with a spinule row on outer edge, with a spinule row on posterior surface as shown (P2, P4) or naked (P3). Enp-3, outer margin ornamented with a spinule row, bears 2 long plumose setae (P2–P3) or 2 short, strong, bipinnate setae (P4) apically, 1 unipinnate seta at inner subdistal (P2), a spinule row on posterior surface, and a pore on anterior surface (P4). Setal formula of the swimming legs:

P1		P2	
Exopod	Endopod	Exopod	Endopod
0.132	1.0.020	1.1.131	1.0.120
P3		P4	
Exopod	Endopod	Exopod	Endopod
1.1.131	1.1.020	1.1.131	1.1.020

P5 (Figure 2A). Baseoendopod and exopod reduced to 2 closely set chitinous projections; each projection armed with a short plumose seta.

P6 (Figure 2A). Baseoendopod and exopod fused to a short and wide plate, armed with a bare slender seta.

Description of the male.

Body (Figure 5A). Total body length from tip of rostrum to posterior margin of caudal rami 264 µm (241–284 µm; mean = 257 µm; n = 10). Body ornamentation

generally as in female. Sexual dimorphism in antennule, P6 and genital segmentation; last thoracic somite (P6 bearing somite) ornamented with a spinule row medially on dorsal surface, and 4 pores close to the posterior margin on ventral surface (Figure 2B).

Antennule (Figure 5B). Eight-segmented, haplocer; segment 1, inner margin as long as outer margin, bears a long plumose seta at inner distal corner; segment 2 with a slender bare seta at inner subdistal; segment 3 squarish, armed with a long plumose seta on anterior surface, short plumose seta at inner distal corner, a bare short seta at subdistal, and 5 bare setae on posterior surface; segment 4 triangular, with 2 plumose and 2 bare setae; segment 5 triangular, bears a plumose and 3 bare setae apically; segment 6 longest, occupying about 24% of total antennule length, armed with a short bare seta, a short spinulose spine, and 2 long setae at inner edge, and an aesthetasc (length = 38 µm) fused basally to a naked slender seta at inner distal corner; segment 7 rectangular, armed with a very short spinulose spine on inner margin and a long bare seta at inner distal corner; segment 8 rectangular, bears 6 bare setae and an apical acrothek consisting of an aesthetasc (length = 18 µm) and 2 slender bare setae. Setal formula: 1-[1 plumose], 2-[1], 3-[6 + 2 plumose], 4-[2 + 2 plumose], 5-[3 + 1 plumose], 6-[3 + 1 spinulose spine + (1 + ae)], 7-[1 + 1 spinulose spine], 8-[7 + acrothek].

P6 (Figure 2B). Baseoendopod and exopod fused with the posterior margin of somite forming a semicircular shape, armed with a minute seta and a plumose seta.

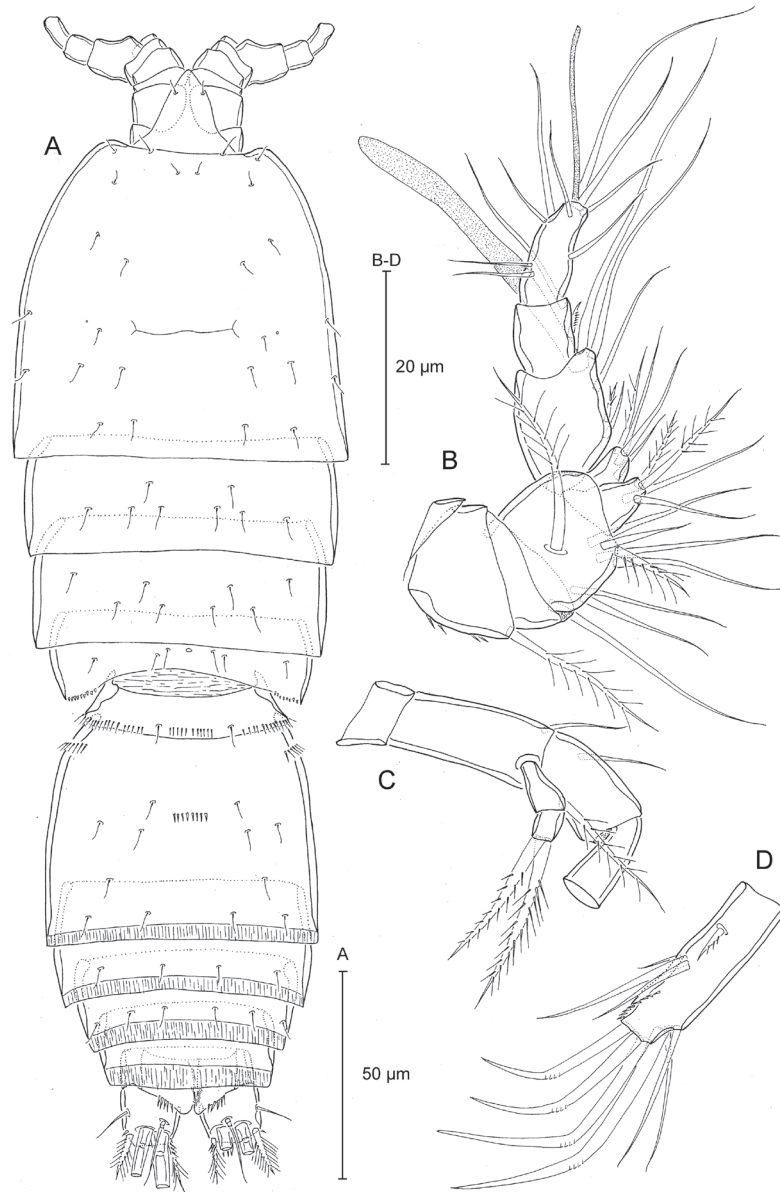


Figure 5. *Diarthrodella ergeneae* sp. nov. A: Habitus ♂, paratype, dorsal; B: antennule, ♂, paratype; C: antenna ♀, holotype, ventral; D: antenna ♀, holotype, terminal endopodal segment.

Variability. Except for the body length and the length/width ratio, no conspicuous variability observed.

Etymology. The species is dedicated to Prof Dr Serap Ergene, Mersin University, in recognition of her contribution to zoological studies in Turkey.

4. Discussion

The new species described herein shares the general body shape and 2-segmented exopodite of P1 with members of the genus *Diarthrodella*. Within the 11 species/subspecies (*D. orbiculata* Klie, 1949; *D. secunda secunda* Kunz, 1954;

D. secunda pacifica Kunz, 1981; *D. psammophila* Bocquet & Bozic, 1955; *D. parorbiculata parorbiculata* Wells, 1963; *D. parorbiculata pacifica* Mielke, 1984; *D. convexa* Kunz, 1981; *D. lancifera* Kunz, 1981; *D. neotropica* Mielke, 1984; *D. galapagoensis* Mielke, 1984; and *D. chilensis* Mielke, 1985) of the genus, *Diarthrodella ergeneae* sp. nov. is morphologically most similar to *D. convexa* Kunz, 1983; *D. secunda* s. str. Kunz, 1954; and *D. lancifera* Kunz, 1981 according to the setal formula of the swimming legs, but can easily be differentiated from *D. convexa* by the lack of an inner seta on P2 enp-2, having P5 reduced to 2 closely

set chitinous projections that are armed with a seta in both sexes, and P1 exopod /enp-1 ratio (1 for *D. ergeneae* sp. nov.; 0.7 for *D. convexa*); from *D. secunda* s. str. by having a seta on the proximal segment of A2 exopod, a squarish caudal ramus, P3 enp-2 with inner seta, P3 enp-3 with 2 setae, and P5 as described above; and finally from *D. lancifera* by having 6 setae on P1 exp-2 and a squarish caudal ramus that bears filiform terminal setae.

A dichotomous key to species/subspecies of the genus *Diarthrodella* is given below.

1. P5 well developed, baseoendopod and exopod not fused, exopod bears 4 elements 2
- P5 weakly developed or reduced, baseoendopod and exopod fused or weakly separated 5
2. P1 enp-1 without an inner seta, P4 endopod 2-segmented *D. psammophila*
- P1 enp-1 with an inner seta, P4 endopod 3-segmented 3
3. P2 endopod 2-segmented *D. orbiculata*
- P2 endopod 3-segmented 4
4. A2 exopod 3-segmented *D. parorbiculata* s. str.
- A2 exopod 2-segmented *D. parorbiculata pacifica*
5. P3 enp-2 with an inner seta 6
- P3 enp-2 without an inner seta 9

6. P2 endopod 2-segmented, P1 exp-3 bears 7 elements *D. chilensis*
 - P2 endopod 3-segmented 7
 7. P1 endopod 2-segmented *D. galapagoensis*
 - P1 endopod 3-segmented 8
 8. P2 enp-2 with an inner seta *D. convexa*
 - P2 enp-2 without an inner seta *D. ergeneae* sp. n.
 9. P1 exp-3 bears 5 elements *D. lancifera*
 - P1 exp-3 bears 6 elements 10
 10. P3 enp-3 with 2 elements *D. neotropica*
 - P3 enp-3 with 3 elements 11
 11. P1 and P4 enp-3 with 2 setae *D. secunda* s. str.
 - P1 and P4 enp-3 with 1 seta *D. secunda pacifica*
- Members of the genus *Diarthrodella* have been recorded from the Atlantic Ocean, Pacific Ocean, and North Sea (Plum and George, 2009), but have not been recorded from the Mediterranean Sea yet. Therefore, the new species is the first record of the genus from the Mediterranean Sea.

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