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## Isopods of the genus *Astacilla* (Valvifera, Arcturidae) from the LIFE + INDEMARES project off Alborán Island (S Spain), with the description of a rare species *A. carlosoteroi* (Reboreda, Wägele & Garmendia, 1994)

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### Abstract

Three species of the isopod genus *Astacilla* were collected off Alborán Island (SW Mediterranean Sea) within the LIFE + INDEMARES project. Twelve specimens of the rare species *Astacilla carlosoteroi* (Reboreda, Wägele & Garmendia, 1994) were found; this species is only known as a single incomplete female from Galicia (NW Spain, Atlantic). Males, reported for the first time, are described, as well as morphological details provided for two additional species, *A. dilatata* (G.O. Sars, 1883) and *A. mediterranea* Koehler, 1911.

**Keywords:** *Astacilla*; Isopoda; Alborán Island; SW Mediterranean; new record.

### Introduction

The systematics of the arcturid genera *Astacilla* Cordiner, 1793 and *Arcturella* Sars, 1897 have been problematic due to the difficulties to distinguish between both genera (Monod, 1925; Castelló, 1997; Rodríguez Sánchez & Junoy, 2002; King, 2003; Kensley *et al.*, 2007). Phylogenetic analysis do not differentiate them (King, 2001) and the genus *Arcturella* is currently considered a synonym of *Astacilla* (Kensley *et al.*, 2007). Therefore, the two species described from Alborán Sea as *Arcturella* are now considered *Astacilla*: *A. estherae* (Rodríguez-Sánchez & Junoy, 2002) and *A. poorei* (Castelló, 1997). Twelve additional species have been recorded from the Alborán Sea and Strait of Gibraltar (Castelló & Carballo, 2001; Junoy & Castelló 2003): *A. axeli* Castelló, 1992, *A. bocagei* Nobre, 1903, *A. bonnieri* Stephensen, 1915, *A. cingulata* Castelló & Carballo, 2000, *A. damnoniensis* (Stebbing, 1874), *A. depressa* Castelló & Poore, 1998, *A. dilatata* (G. O. Sars, 1883), *A. gorgonophila* Monod, 1925, *A. laevis* Castelló & Poore, 1998, *A. longicornis* (Sowerby, 1806), *A. mediterranea* Koehler, 1911, and *A. paucisaetosa* Castelló & Carballo, 2000. This species diversity represents nearly one third of *Astacilla* species worldwide, with a total of 48 species recognized (Schotte *et al.*, 2005; Poore & Schotte, 2009). In this paper the presence of one additional species is reported in the Alborán Sea, *A. carlosoteroi* (Reboreda, Wägele & Gar-

mendia, 1994), previously only known from a single, incomplete female from the Ferrol estuary (Galicia, NW Spain, Atlantic). This is the first report of the species from the Mediterranean Sea and constitutes the second worldwide record. A full description of the male and unknown morphological details of the female are provided in this work.

*Astacilla carlosoteroi* was collected during the LIFE + INDEMARES campaign in Alborán Island shelf, together with two other *Astacilla* species included in this paper, *A. dilatata* and *A. mediterranea*. A description of the males of *A. dilatata* showing a remarkable tubercle ornamentation not previously recorded and details of *A. mediterranea* are also provided.

### Materials and Methods

Two oceanographic surveys were carried out in the Alborán shelf within the LIFE + INDEMARES project during September 2011 and July 2012. Forty-four sites were sampled in the 25–290 m depth range, using a small beam trawl on soft bottoms and a benthic grab on hard bottoms (Gofas *et al.*, 2014). The samples were sieved through a 0.5 mm mesh screen and the collected specimens fixed in 4% formalin, subsequently transferred to 70 % ethanol. Some of the specimens were dissected in order to get microscopic details of small morphological parts by using DMHF (Dimethyl Hydantoin Formaldehyde).

Specimens are deposited in the Museo Nacional de Ciencias Naturales, Madrid, Spain (MNCN).

## Results

Subroder Valvifera Sars, 1882

Family Arcturidae Dana, 1849

Genus *Astacilla* Cordiner, 1793

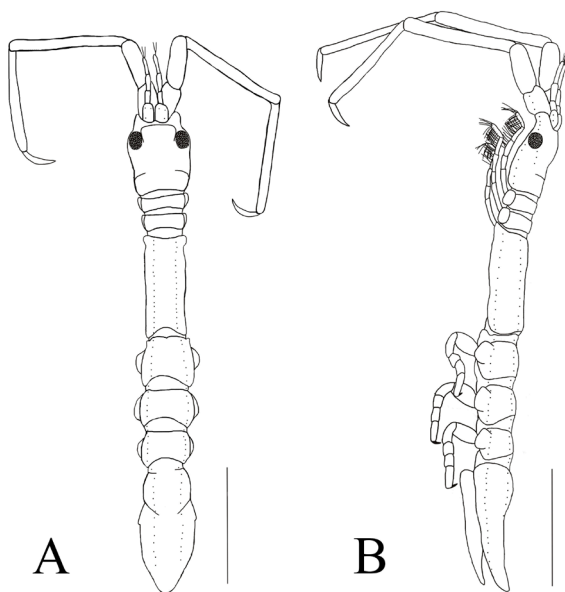
*Astacilla carlosoteroi* (Reboreda, Wägele & Garmendia, 1994)

**Material:** Station BV27: 25.09.2011, beam trawl, 35°50.40'N - 03°13.72' W to 35°50.41'N - 03°13.24' W, 100-109 m, on shell debris. Ten males, lengths 3.1 - 4.5 mm; two females, length 5.5 - 6 mm. Station DR25: 25.09.2011, benthic grab, 35°50.41' N - 03°13.39' W to 35°50.42' N - 03°13.49' W, 111-114 m, on shell debris. One male, 3 mm.

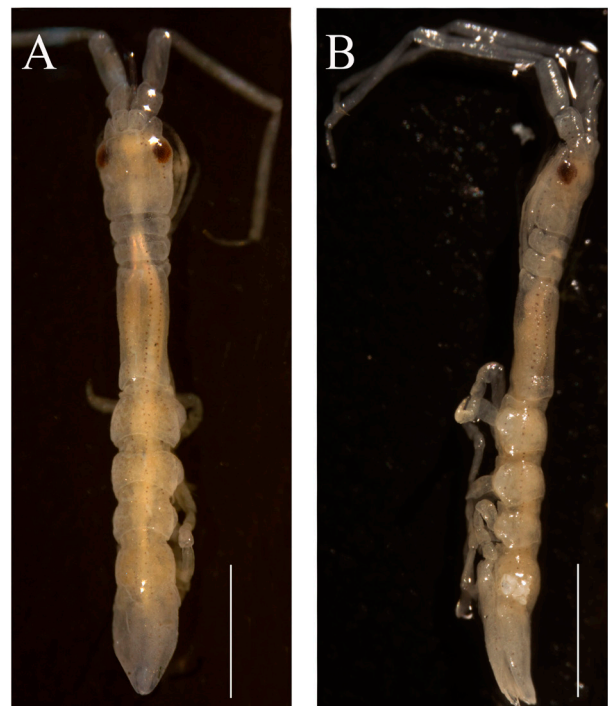
### Male description

Length (excluding antennae) 3.1 to 4.5 mm, shorter than females. Body elongated and cylindrical, 7.6 times longer than the greatest width; colouration pale orange, with two stripes of brown chromatophores longitudinally located on each side of the body, from antennae to pleotelson (Figs. 1, 2).

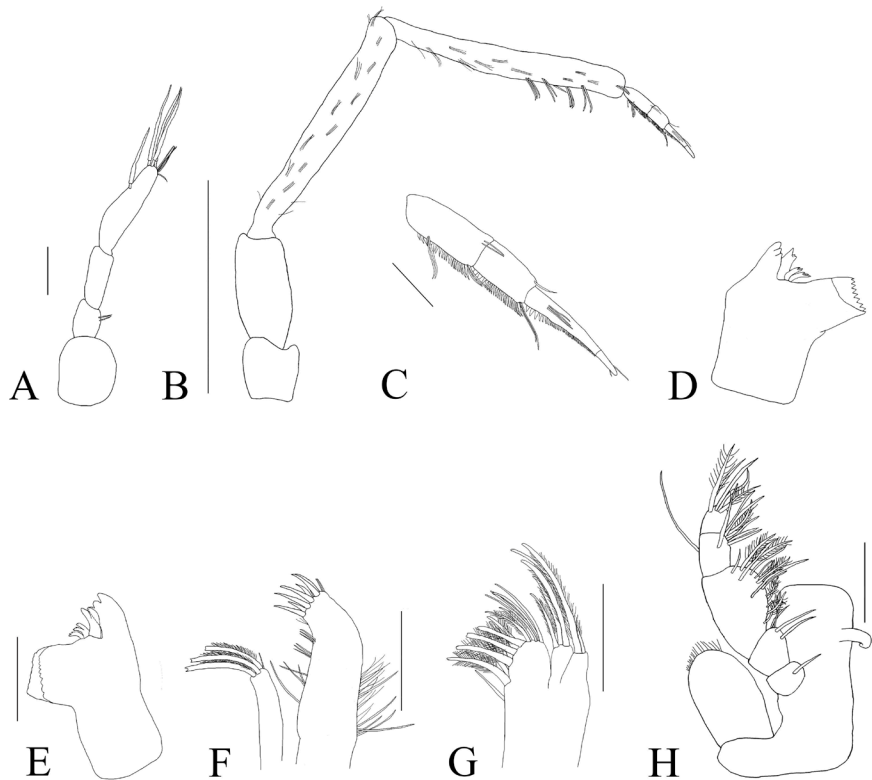
*Cephalon* (Figs. 1, 2) fused with pereonite 1. Anterior margin concave, with a small rostral point. Anterolateral lobes rounded. Eyes large. *Pereonites* (Figs. 1, 2). Pereonites 1-3 smooth. Unlike females, their width gradually decreasing. Pereonite 4 rectangular, 2.5 times longer than wide. Pereonites 5-7 gradually decreasing in size. Pereonite 5 anterior dorsal part with a medial incision. *Pleotelson* (Figs. 1, 2) similar than female; conical, tapering to a rounded tip. All pleonites fused, two transverse lateral incisions showing dorsally fusion lines between pleonites 1-3. *Antenna 1* (Fig. 3A) reaches two thirds of second peduncular article of antenna 2; peduncle article 1 wider than the other two. Flagellum of one article, with four non-segmented aesthetascs. *Antenna 2* (Fig. 3B, 3C) reaching posterior margin of pereonite 6 when pressed against the body, with spread simple setae and cluster of sensory setae. Tri-articulate flagellum, with simple setae and flattened scale-spines and apical claw. *Mandibles* (Fig. 3D, 3E) asymmetrical; right mandible, incisor and lacinia mobilis with three and two teeth respectively, spine row with two pectinate spines and slightly denticulate molar process. Left mandible, lacinia mobilis with a robust tridentate spine, molar process with sharper indentations. *Maxilla 1* (Fig. 3F) outer lobe with eight to ten stout apical setae in two rows, several short and medium simple setae on inner and outer margins; inner lobe with three terminal stout setae with denticulate apices. *Maxilla 2* (Fig. 3G) trilobate; exopod, outer and inner lobes with two and three setulated setae respectively; endopod with four long fine setae proximal to exopod and eight



**Fig. 1:** *Astacilla carlosoteroi*, male. A, dorsal view; B, lateral view. Scale bars: 1 mm.



**Fig. 2:** *Astacilla carlosoteroi*, male. A, dorsal view; B, lateral view. Scale bars: 1 mm.



**Fig. 3:** *Astacilla carlosoteroi*, male. A, antenna 1; B, antenna 2; C, detail of antenna 2; D, right mandible; E, left mandible; F, maxilla 1; G, maxilla 2; H, maxilliped. Scale bars: B = 1 mm, A, C-H = 0.1 mm.

denticulate setae in apical row. *Maxilliped* (Fig. 3H) palp 5-articulate, articles 3-5 with long plumose setae on mesial margins. Endite with one broad coupling hook on inner margin and without setae on upper margin. Epipodite ovate, shorter than endite, reaching one quarter of the third palp article. *Pereopods* (Fig. 4). Pereopods 1-4 with filter function. Pereopod 1 (Fig. 4A) more robust than pereopods 2-4, setation on posterior margin of ischium to dactylus consisting of simple and plumose setae, without unguis. Pereopods 2-4 (Fig. 4B, 4C, 4D) similar, slender and lacking dactylus. Two rows of long fine setae posteriorly. Pereopods 5-7 ambulatory (Fig. 4E, 4F, 4G) robust, with granulated dorsal part and scarce plumose setae on basis and propodus. Dactylus slightly curved, with robust unguis and a short secondary unguis. *Pleopods* (Fig. 5). Pleopod 1 (Fig. 5A) peduncle slender than pleopod 2, as long as rami. Exopod slightly longer than endopod, both with 8-10 elongated plumose setae on apex. Pleopod 2 (Fig. 5B) exopod shorter and broader than endopod, with 8 and 6 long plumose setae on apex, respectively. Appendix masculina straight, with wide base and slender bifid distal end. Pleopods 3-5 (Fig. 5C, 5D, 5E) wider and ovate, similar in shape. Exopod shorter than endopod, with a single plumose distolateral seta. *Uropods* (Fig. 5G, 5H) biramous; uropodal peduncle with four distolateral plumose setae. Endopod triangular, exopod half the size of endopod, ovate, with two apical setae.

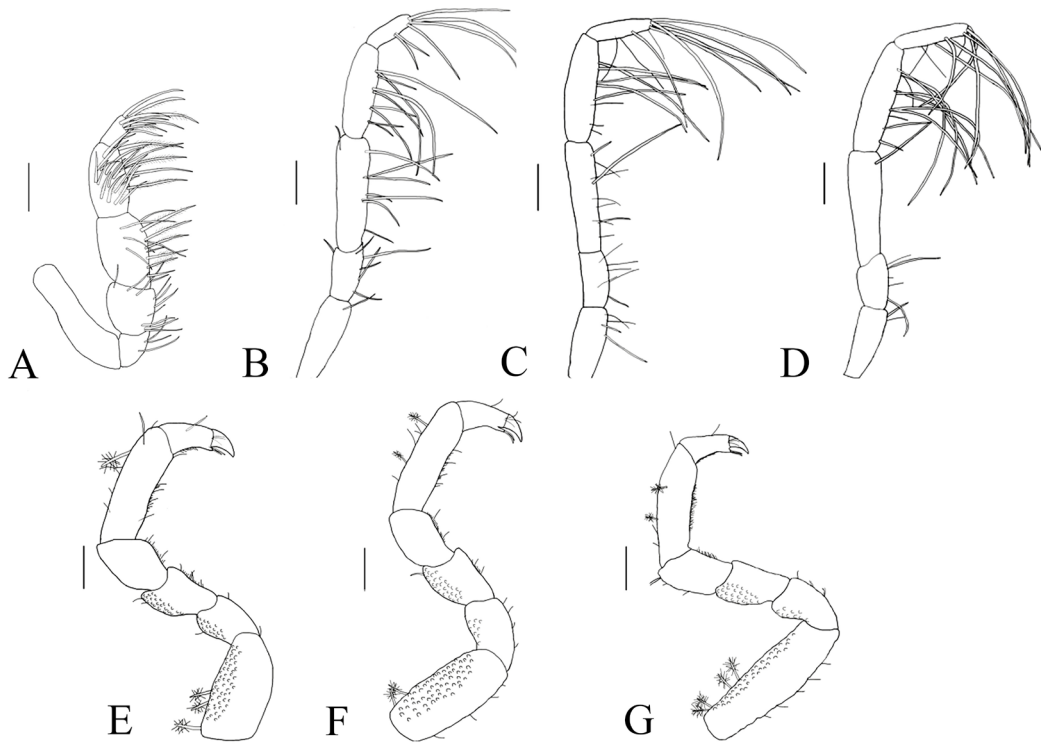
#### Female description

As the original species description (Reboreda *et al.*, 1994), the female shows a smooth cephalon without tubercles; pereonites 1-3 with five dorsal protuberances, pereonite 4, widest, smooth, with protruding rounded edges; pereonites 5-7 gradually decreasing in size. Pleotelson conical, curved dorsally. Antenna 2 is missing in the only specimen described by Reboreda *et al.* (1994). Females from Alborán Sea show an Antenna 2 reaching posterior margin of pereonite 4, a peduncle of five articles, the three basal ones stouter; tri-articulate flagellum, with simple setae, flattened scale-spines, and an apical claw (Fig. 6).

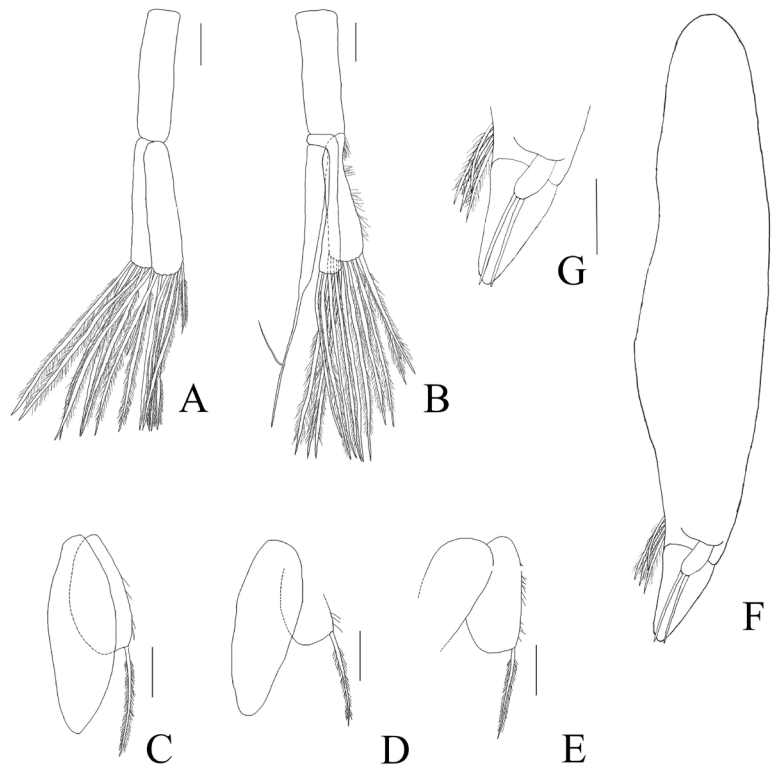
#### *Astacilla dilatata* (G.O. Sars, 1883)

**Material:** Station BV16: 23.09.2011, beam trawl, 35°53.10'N, 03°04.74'W to 35°53.26'N, 03°04.29'W, 82-92 m, on mærl. One male, 3.8 mm. Station BV27: 25.09.2011, beam trawl, 35°50.40'N - 03°13.72' W to 35°50.41'N - 03°13.24' W, 100-109 m, on shell debris. One male, 4.3 mm.

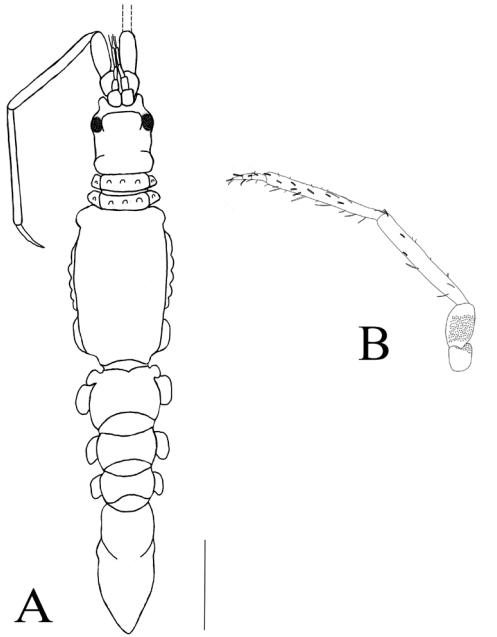
**Additional material.** Museo Nacional de Ciencias Naturales, Madrid, Spain (MNCN): Males MNCN 20.04/5541 and MNCN 20.04/5542 from Málaga, S Spain. Zoological Museum, University of Copenhagen,



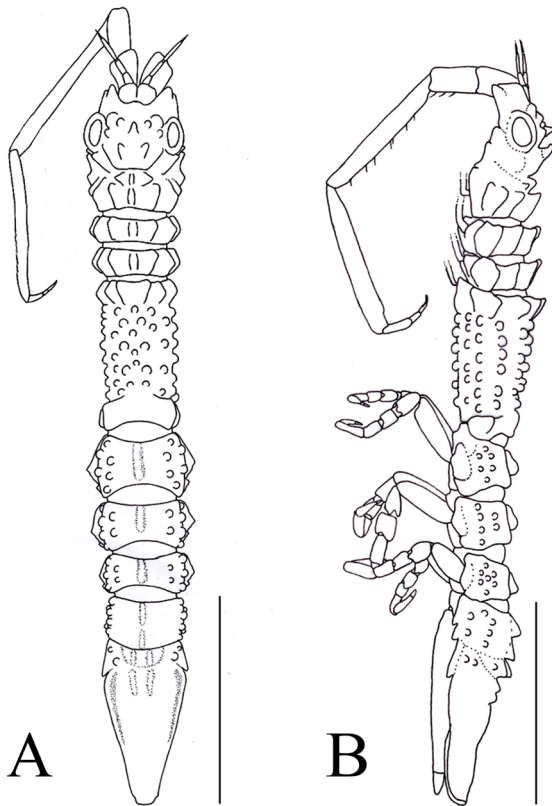
**Fig. 4:** *Astacilla carlosoteroi*, male. A, pereopod 1; B, pereopod 2; C, pereopod 3; D, pereopod 4; E, pereopod 5; F, pereopod 6; G, pereopod 7. Scale bars: 0.1 mm.



**Fig. 5:** *Astacilla carlosoteroi*, male. A, pleopod 1; B, pleopod 2; C, pleopod 3; D, pleopod 4; E, pleopod 5; F, uropod; G, detail of uropod. Scale bars: A-E: 0.1 mm, F: 0.5 mm, G: 0.1 mm.



**Fig. 6:** *Astacilla carlosoteroi*, female. A, dorsal view; B, antenna 2. Scale bars: 1 mm.



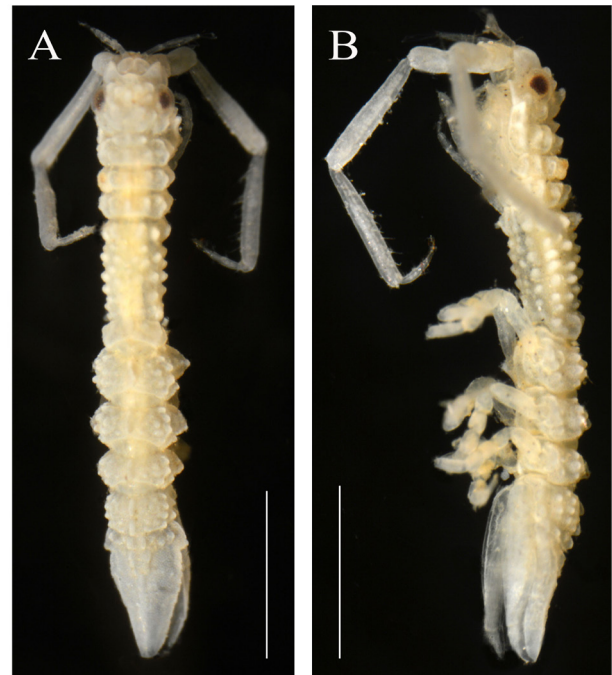
**Fig. 7:** *Astacilla dilatata*, male. A, dorsal view; B, lateral view. Scale bars: 1 mm.

Denmark (ZMUC): ZMUC 1-20/5 93 from Messina, Italy, numerous specimens; Hauch station 25, Sakegens Fyrskib, Denmark, several specimens.

#### Male description

Total length 3.8 to 4.3 mm. Body cylindrical and elongate, 6.8 times longer than the greatest width at pereonite 5, showing a remarkable tubercle ornamentation. Colouration pale yellow in alcohol, with sparse dark brown chromatophores spread all over the body and appendages (Figs. 7, 8).

*Cephalon* (Figs. 7, 8) fused with pereonite 1; anterior margin concave, with a small rostral point; anterolateral lobes rounded in lateral view, with a small distolateral spine; anterolateral margin subtruncate with a medial indentation. Eyes large and convex. Dorsal sculpture with one pyramidal tubercle medially, angled-forward in lateral view; two sets of three dorsolateral smaller tubercles between the eyes, and two big dorsolateral juxtaposed tubercles distally, somewhat procurved and angled forward. Three dorsal pyramidal tubercles between the head and pereonite 1, the central one biggest. *Pereonites 1-3* (Fig. 7, 8) with a transverse series of five ridges; coxal plates triangularly expanded, more prominent on pereonite 1. Pereonite 3 with a midventral process. *Pereonite 4* longest, wider at both ends. Sculpture formed by a complex longitudinal pattern: eight anterior ridges, 12 medial rows of rounded tubercles, and two posterior ridges. *Pereonites 5-7* successively narrower and constricted in the middle,



**Fig. 8:** *Astacilla dilatata*, male. A, dorsal view; B, lateral view. Scale bars: 1 mm.

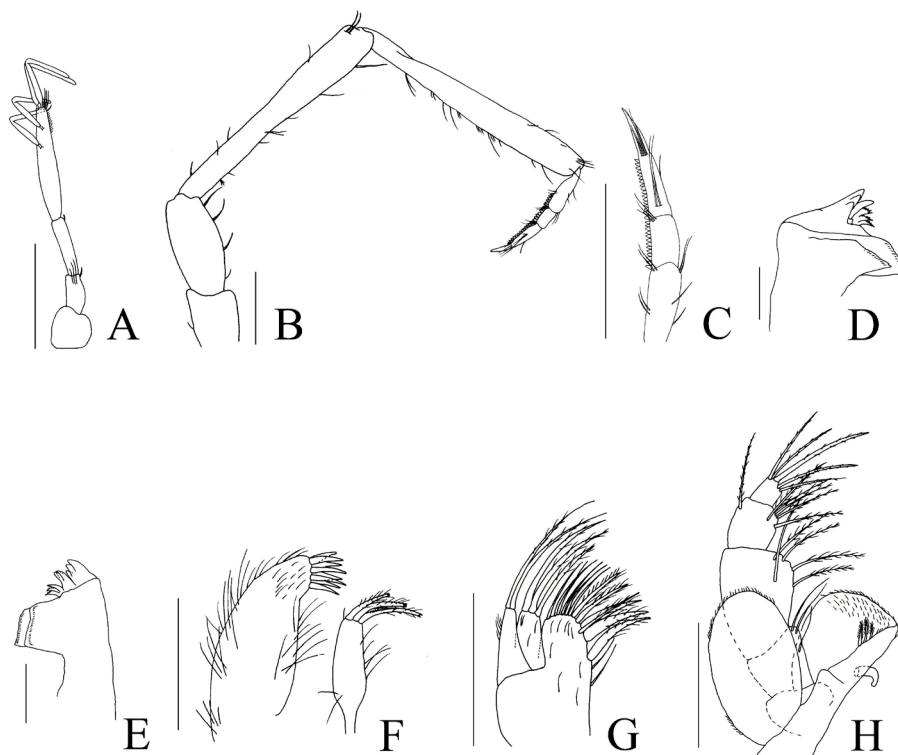
with a dorsal carina and four lateral rows of tubercles. Coxal plates laterally protruded, largest on pereonite 5. *Pleotelson* (Fig. 7) elongated and cone-shaped. Proximal part resembling the ornamentation of pereonites 5-7, distal part anteriorly bicarinated, with three dorsolateral tubercles on each side. Apex truncate, slightly curved dorsally. *Antenna 1* (Fig. 9A) reaches half the third article of antenna 2; flagellum with three to four non-segmented aesthetascs. *Antenna 2* (Fig. 9B, 9C) slender, flagellum tri-articulate with a distal claw. *Mandibles* (Fig. 9D, 9E) lacking palp, asymmetrical; right mandible incisor and lacinia mobilis with three teeth, spine row with three pectinate spines, molar process with a slightly toothed margin; left mandible similar, with acute molar process. *Maxilla 1* (Fig. 9F) outer lobe with eight stout apical setae; inner lobe with three terminal stout setae with denticulate apex. *Maxilla 2* (Fig. 9G) trilobate; exopod, outer lobe with two long setulated setae; inner lobe with three setulated setae; endopod with six fine setae and six denticulate setae on apical row. *Maxilliped* (Fig. 9H) palp 5-articulate, endite with one coupling hook and three plumose setae on inner margin. *Pereopod 1* (Fig. 10A) robust, posterior margin of merus-propodus with spinose setae with plumose tip, mesial margin with plumose and serrate setae; dactylus with six thick setulated setae, unguis pectinate. *Pereopods 2-4* (Fig. 10B, 10C, 10D) similar, filtering, slender; with two rows of long setae on posterior margin; dactylus absent. *Pereopods 5-7* (Fig. 10E, 10F, 10G) similar, ambulatory, robust and progressively shorter; dactylus

with a secondary unguis on posterior margin. *Pleopod 1* (Fig. 11A) with four coupling hooks on inner margin; exopod slightly longer than endopod, with proximal lateral notch and three plumose setae, nine elongated plumose setae on apex; endopod with seven long plumose setae on distal margin. *Pleopod 2* (Fig. 11B) peduncle with three coupling hooks on medial margin; exopod shorter than endopod, apex with eleven long plumose setae; endopod with five long plumose setae. Appendix masculina straight, reaching well beyond rami, narrowing at its medial length, distally bifid. *Pleopods 3-5* (Fig. 11C, 11D, 11E) similar, ovate; exopod shorter than endopod, pleopod 3 with two distolateral plumose setae. *Uropods* (Fig. 11F, 11G) biramous; uropodal peduncle with three distolateral plumose setae; endopod triangular, with two long simple setae, exopod with three long apical setae.

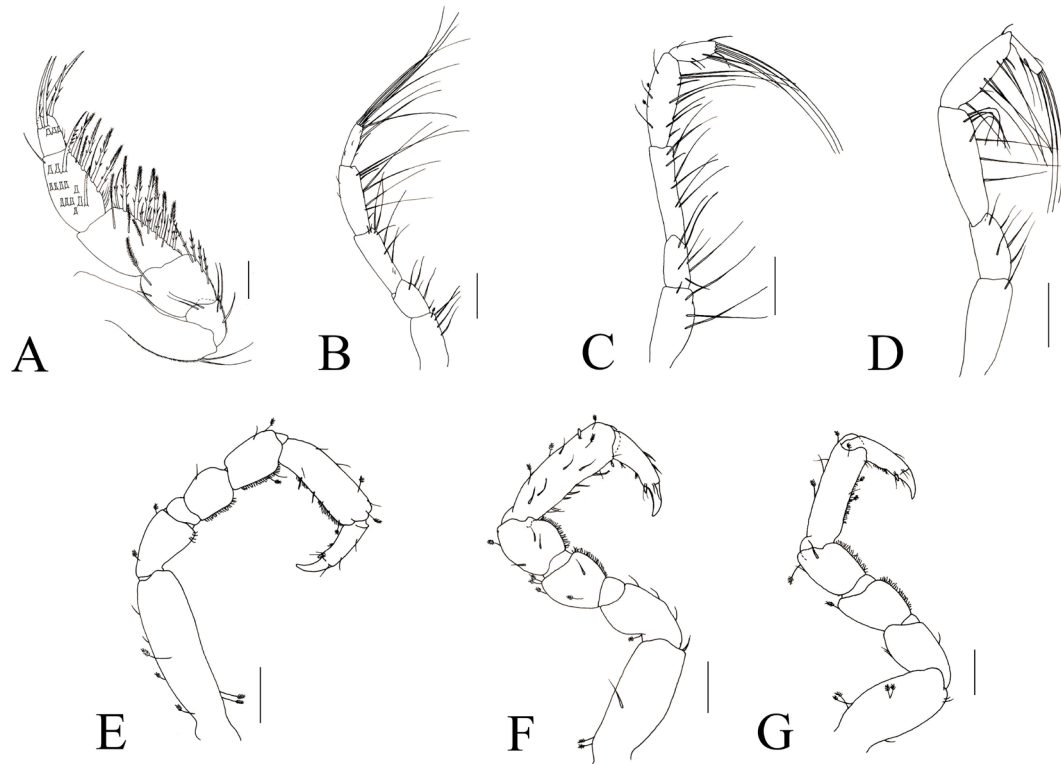
*Astacilla mediterranea* Koehler, 1911

**Material:** Station BV16: 23.09.2011, beam trawl, 35°53.10'N - 03°04.74'W to 35°53.26'N - 03°04.29'W, 82-92 m, on mäerl. One male, 4 mm and two females, 6.5 and 7 mm.

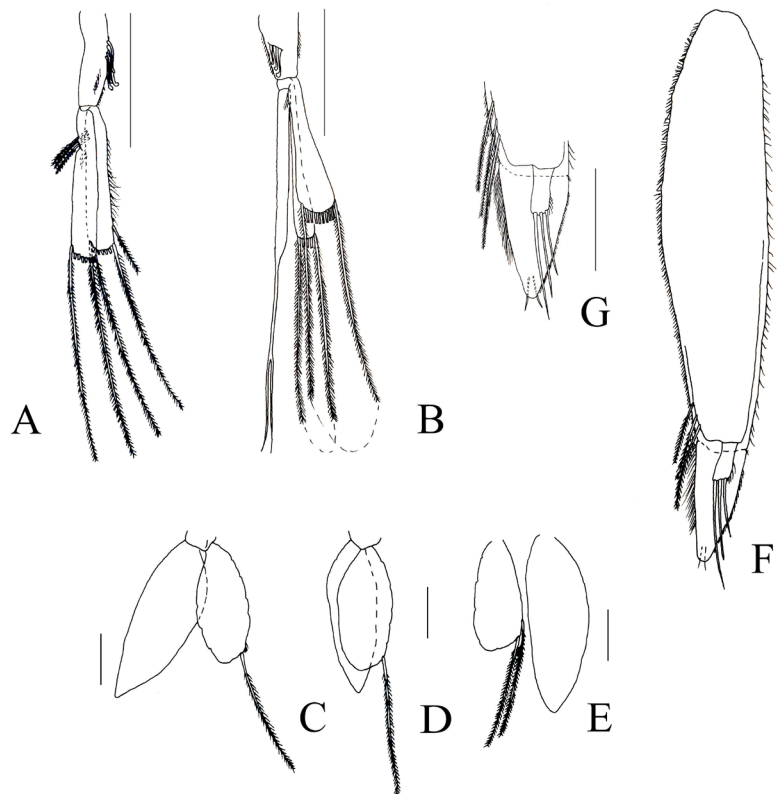
**Remarks:** The species is recognised by the body ornamentation and the specimens collected do not show morphological differences to the original description (Koehler, 1911). Females are longer than those described by Koehler (6.5-7 mm vs 5-5.5 mm). The only male collected is damaged.



**Fig. 9:** *Astacilla dilatata*, male. A, antenna 1; B, antenna 2; C, detail of antenna 2; D, right mandible; E, left mandible; F, maxilla 1; G, maxilla 2; H, maxilliped. Scale bars: A-C: 0.5 mm, D-H: 0.1 mm.



**Fig. 10:** *Astacilla dilatata*, male. A, pereopod 1; B, pereopod 2; C, pereopod 3; D, pereopod 4; E, pereopod 5; F, pereopod 6; G, pereopod 7. Scale bars: 0.1 mm.



**Fig. 11:** *Astacilla dilatata*, male. A, pleopod 1; B, pleopod 2; C, pleopod 3; D, pleopod 4; E, pleopod 5; F, uropod; G, detail of uropod. Scale bars: A, B: 0.5 mm, C-F: 0.1 mm.



## Discussion

One of the current problems of Isopoda taxonomy is the inadequate description of the species, especially those reported between the end of the 19<sup>th</sup> century and first decades of the following century. Most descriptions are vague and incomplete which make species redescrptions necessary, despite the difficulties to publish them.

Female morphology has been widely used for distinguishing *Astacilla* species, mainly focusing on shape and ornamentation of pereonite 4 (e.g., Sars, 1899; Koehler, 1911; Barnard, 1920; Kensley & Schotte, 1989; Castelló, 1997; Castelló & Poore, 1998, Castelló & Carballo, 2000). Males generally show less distinguishable characters, and frequently lack complete descriptions. A major reason for this absence is that males are commonly unknown. This is the case of some species from the Alborán Sea such as *A. cingulata*, *A. laevis*, *A. paucisetosa*, and the rare *A. carlosoteroi*, only known by a single female.

*Astacilla carlosoteroi* is easily distinguishable from other species of the area due to the absence of ornamentation on pereonite 4 and the conical shape of the distal pleotelson, two characters present in both sexes, as stated above. *Astacilla carlosoteroi* resembles closely *A. estherae* and *A. bonnierii*; however, they can be easily differentiated by the presence of a protuberance in the pereonite 4 in *A. estherae* and the lack of ornamentation of pereonites 1-3 in *A. bonnierii*. The collection from the Alborán Sea constitutes the first record of the species in the Mediterranean Sea, the first time that males are collected, and the second citation worldwide.

The only information regarding males of *A. dilatata* comes from Sars (1883, 1899), who provided inaccurate description and drawings, omitting several important characters. The same information is also repeated by Kussakin (1982). The males of *A. dilatata* here described show a remarkable sculpture, not observed in other descriptions or in the smaller preserved male specimens from the ZMUC and MNCN museums. The comparison between the museum material and the Alborán Sea specimens allowed us a proper identification as *A. dilatata*; no major differences in body or appendages morphologies were found among the three sets of specimens. The males from Alborán Sea show a noticeable ventral process in pereonite 3, less evident in the smaller specimens from the museums. A male midventral process is observed in other species of *Astacilla* but, as stated previously, male morphology of the genus is widely unknown. The taxonomic value of such a process was discussed by Barnard (1920) and was used by Koehler (1911) to differentiate the genus *Arcturopsis*. According to King & Poore (2001), copulatory males of *Arcturopsis* present a fully formed midventral appendage, which distinguishes this genus from *Arcturella*; they noted that males described by Monod (1925) as *Arcturella dollfusi* are probably juvenile specimens of *Arcturopsis giardi*, in which the midventral appendage is not fully formed. The presence of fully developed appendix masculina on the specimens of

*A. dilatata* from the Alborán Sea, together with the size of pereonite 4 indicated that they do not belong to *Arcturopsis*.

## Acknowledgements

The authors would like to thank the scientists and technicians participating in the cruises in the Oceanographic Campaigns off Alborán Island, supported by the European Project LIFE + INDEMARES. We thank Dr. Begoña Sánchez (MNCN) and Dr. Danny Eiby-Jacobsen (ZMUC) for essential loans of specimens, and Ismael Arranz for revising the final version in English.

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