

First record of *Armadilloniscus candidus* Budde-Lund, 1885 in the coastal areas of the Iberian Peninsula (Crustacea: Oniscidea: Detonidae)

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Armadilloniscus Uljanin, 1875 is a genus of halophilic woodlice that strictly occurs in coastal habitats. Two species are known in the coastal areas of the western Mediterranean and only one species, *A. ellipticus*, was previously recorded in the Iberian Peninsula and the Balearic Islands. Another species, *A. candidus*, is reported for the first time in Asturias and the Iberian Peninsula. This species could have arrived to the Atlantic coast attached to floating objects, like logs, trunks or plants. The record shows the capability of *A. candidus* to adapt to coastal areas of the Atlantic. Until now, this species was only documented in the Atlantic by two single records from the French coast and the Azores islands. Ecological data are provided of this species in the Iberian Peninsula. Finally, figures of the habitus and of the morphological characteristics are provided, that allow the identification of the two species of *Armadilloniscus* present in the Iberian coastal areas.

Keywords: *Armadilloniscus*, *Oniscidea*, *halophilic terrestrial isopods*, *Iberian Peninsula*, *Atlantic coasts*.

PRIMERA CITA D'*Armadilloniscus candidus* BUDE-LUND, 1885 A AMBIENTS COSTANERS DE LA PENÍNSULA IBÈRICA (CRUSTACEA: ONISCIDEA: DETONIDAE). *Armadilloniscus* Uljanin, 1875 és un gènere d'isòpodes terrestres halòfils que ocupen hàbitats estrictament litorals. A les costes de la Mediterrània occidental es coneixen dues espècies d'aquest gènere i sols una d'elles ha estat enregistrada a la península Ibèrica i a les Balears: *A. ellipticus*. L'altra espècie, *A. candidus*, se cita per primera vegada a les costes d'Astúries i de la península Ibèrica. Aquesta espècie pot arribar fins a les costes atlàntiques adherida a objectes flotants com fustes, troncs o plantes. Aquest registre demostra la capacitat d'*A. candidus* per colonitzar el litoral atlàntic, que fins ara sols estava documentada per dos únics registres a la costa atlàntica francesa i a les illes Açores. Es proporcionen dades ecològiques addicionals d'aquesta espècie a la península Ibèrica. Finalment, es proporcionen figures de l'hàbitus i de les característiques morfològiques que permeten identificar les dues espècies d'*Armadilloniscus* presents a les costes ibèriques.

Paraules clau: *Armadilloniscus*, *Oniscidea*, *isòpodes terrestres halòfils*, *península Ibèrica*, *costes atlàntiques*.

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Introduction

Armadilloniscus Uljanin, 1875 is a woodlouse genus belonging to the family Detonidae Bude-Lund, 1904 that includes 31 species well distributed worldwide (Boyko *et al.*, 2008). All species are strictly coastal and have halophilic habits (Taiti & Ferrara, 1989; Schmalzfuss, 2003). *Armadilloniscus* species live closely to the sea, on sandy or rocky beaches using both stones and plant remains as a refuge (Vandel, 1962; Taiti & Ferrara, 1989). Their flattened body shape and clinger ability (Schmalzfuss, 1984) are a strategy to adapt to the unstable environment in which they live. It allows them to cling tightly to the substrate, either on the lower surface of stones, wood or other remains deposited by the waves (Vandel, 1962). In this way they can resist the battering of the waves, submersion and periods of marine transport on floating objects to which they adhere. Only two species of *Armadilloniscus* occur in coastal areas of the western European Mediterranean: *Armadilloniscus ellipticus* (Harger, 1878) and *Armadilloniscus candidus* Budde-Lund, 1885. Other Mediterranean species such as *Armadilloniscus aegaeus* Schmalzfuss, 1981, *Armadilloniscus aestuarii* Verhoeff, 1930, *Armadilloniscus bulgaricus* Frankenberger, 1941 and *Armadilloniscus letourneuxi* Simon, 1885 seem confined to the coasts of the central and eastern Mediterranean Sea and the Black Sea. Nevertheless, the last two species are probably synonymous of *A. ellipticus* (Taiti & Ferrara, 1989; Schmalzfuss, 2003), the most common species in the Mediterranean. The identity of another Mediterranean species, *Armadilloniscus minutus* Uljanin, 1875, remains undefined (Schmalzfuss, 2003).

A. ellipticus has been reported in the Mediterranean coasts of France, Italy, Greece, the former Yugoslavia, Slovenia, Croatia, Morocco, Tunisia, Spain (including the Balearic Islands) and the islands of Corsica and Malta (Vandel, 1962; Schmalzfuss, 2003; Khemaissia *et al.*, 2013; Séchet & Noël, 2015; Noël, 2016; Noël & Séchet, 2017). In addition, it was found in the Ukrainian, Romanian, Bulgarian and Russian coastal areas of the Black Sea (Giurginca & Čurčić, 2003; Gongalsky *et al.*, 2011; Linetskii *et al.*, 2020). It seems to be an expansive species because, although it has a Mediterranean origin (Vandel, 1962; Noël, 2016), it has also been found in Hawaiian Islands, Malaysia, Japan, Korea, China, Madagascar and the Atlantic coast of North America (Vandel, 1962; Schmalzfuss, 2003). It was also reported from the Azores and Madeira (Vandel, 1956; 1960; 1962; Schmalzfuss, 2003) and the French Atlantic Island of Île-d'Aix (Noël, 2016). In the Iberian Peninsula and neighbouring islands, this species has been previously registered as *Armadilloniscus litoralis* Budde-Lund, 1885, in Girona and Eivissa island (Cruz, 1991), Mallorca (Garcia and Cruz, 1996), the Chafarinas Islands (Pons *et al.*, 1999) and as *A. ellipticus* in Mallorca and sa Dragonera islands (Garcia, 2008, 2009) and Cádiz (Cifuentes, 2021). The synonymy between *A. litoralis* and *A. ellipticus* has been established by Garthwait *et al.*, (1992). The other species, *A. candidus*, was only known from the Mediterranean coastal areas of France, Italy, Algeria, Tunisia, Malta (Vandel, 1962; Taiti & Ferrara, 1996; Schmalzfuss, 2003; Messina *et al.*, 2012; Séchet & Noël, 2015; de Matthaëis *et al.*, 2019) and the Azores in the Atlantic (Vandel, 1956). The record from the Azores (Vandel, 1956; 1962) was the only record in the Atlantic until recently, when *A.*

candidus was found on the Atlantic coast of France (Cherpitel *et al.*, 2019).

The main goal of this work is to provide the first record of *Armadilloniscus candidus* for the Iberian Peninsula, specifically in Asturias. Additionally, morphological and ecological data are provided and its presence on the European Atlantic coasts is discussed.

Material and methods

Surveys were carried out in the northern Iberian Peninsula (Asturias, Spain) (Fig. 1A) in 2020. Several coastal localities were visited to collect specimens under stones, dead wood, and deposits of plants (Fig. 1B). Specimens (Fig. 1C-1D) were hand collected and then fixed and preserved in 75% ethanol. Specimens are kept in the first author's collection. *Armadilloniscus candidus* specimens were photographed in situ with a Xiaomi Redmi Note 7 mobile device with a macro-lens.

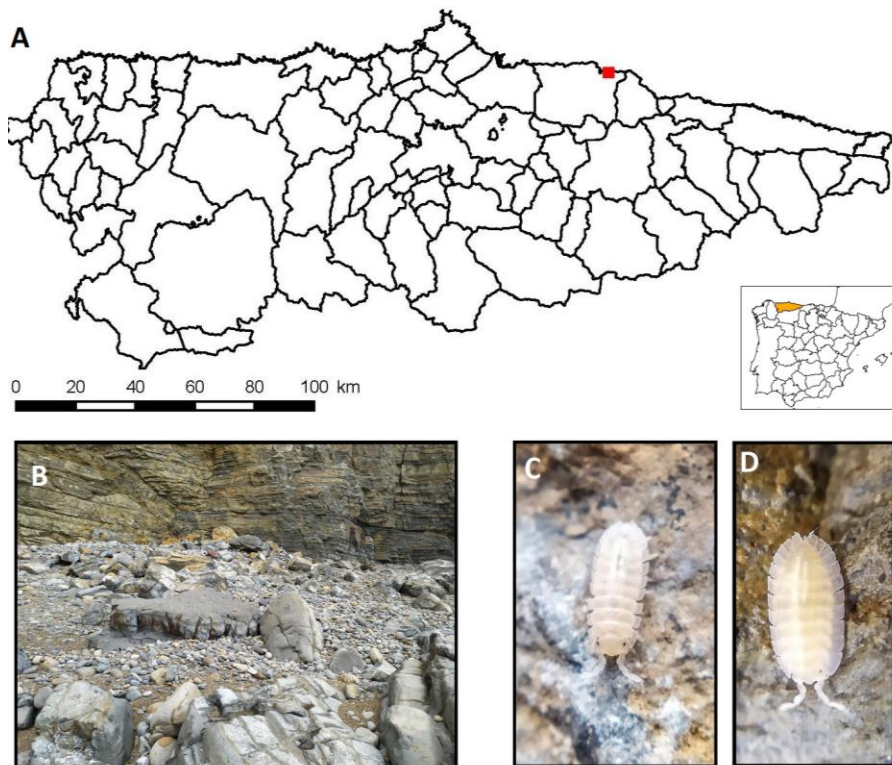


Fig. 1. A. Geographical situation of the *Armadilloniscus candidus* population detected in Asturias. B. Rocky shore with algae of Conejera beach (Selorio, Villaviciosa). C. Typical layout of an immature *Armadilloniscus candidus* in its habitat. D. Same for an adult.

Fig. 1. A. Situació geogràfica de les poblacions detectades a Astúries d'*Armadilloniscus candidus*. B. Costa rocosa amb algues de la platja de Conejera (Selorio, Villaviciosa). C. Aspecte típic d'un immadur d'*Armadilloniscus candidus* al seu hàbitat. D. El mateix per a un adult.

Photographs of preserved specimens of *A. candidus* and *A. ellipticus* were taken with a digital microscope (Dino-Lite). First pleopods and genital papilla of males were dissected and mounted on glass slides using Faure's liquid. Photographs of the dissected appendices were taken with a digital camera (Nikon Coolpix) connected to an optical microscope. Drawings were prepared using a camera lucida connected to an Olympus CH-30 microscope. Photographs were edited with GIMP 2.10.12. Maps were generated with ArcGis Desktop 10.8.1.

Results

Armadilloniscus candidus Budde-Lund, 1885

Material examined. Spain - Asturias: Conejera beach, Selorio (Villaviciosa): 4♂ + 6♀ + 3 immature, 3-IX-2020, 3masl. Conejera beach, Selorio (Villaviciosa): 1♀ + 1 immature, 19-IX-2020, 3 masl. Conejera beach, Selorio (Villaviciosa): 1♂ + 1♀ + 1 immature, 24-IX-2020, 3masl. (30T 308988 4822659).

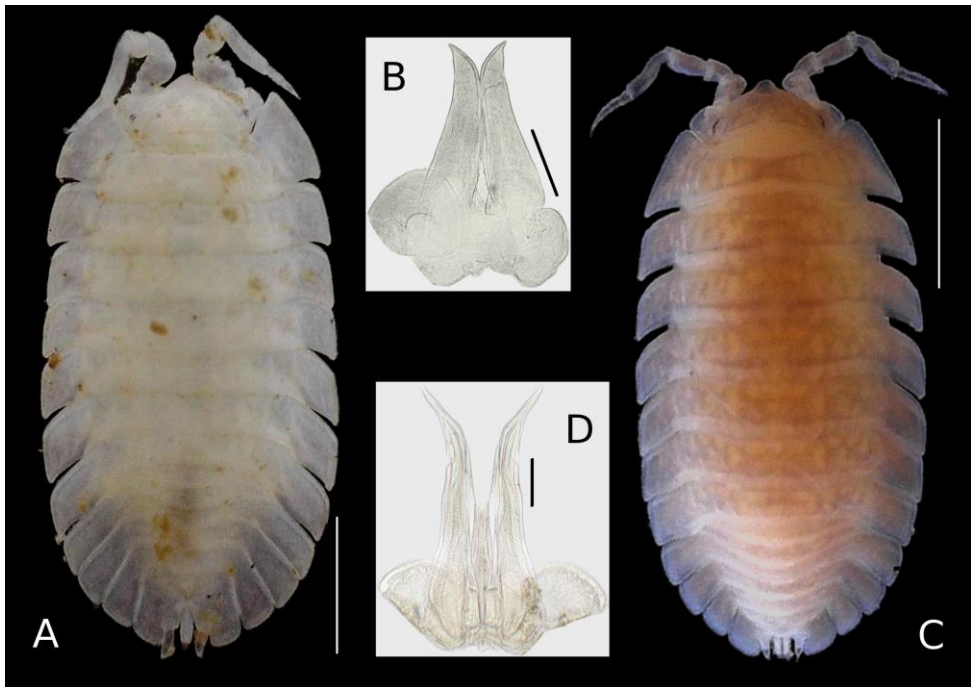


Fig. 2. A. *Armadilloniscus candidus*, female from Asturias (scale: 1 mm). B. First male pleopods of *A. candidus* from Asturias (scale: 0.1 mm). C. *Armadilloniscus ellipticus*, female from Balearic Islands (scale: 1 mm). D. First male pleopods of *A. ellipticus* from Balearic Islands (scale: 0.1 mm).

Fig. 2. A. *Armadilloniscus candidus*, femella d'Astúries (escala: 1 mm). B. Primers pleopodis d'un mascle d'*A. candidus* d'Astúries (escala: 0.1 mm). C. *Armadilloniscus ellipticus*, femella de les Illes Balears (escala: 1 mm). D. Primers pleopodis d'un mascle d'*A. ellipticus* de les Illes Balears (escala: 0.1 mm).

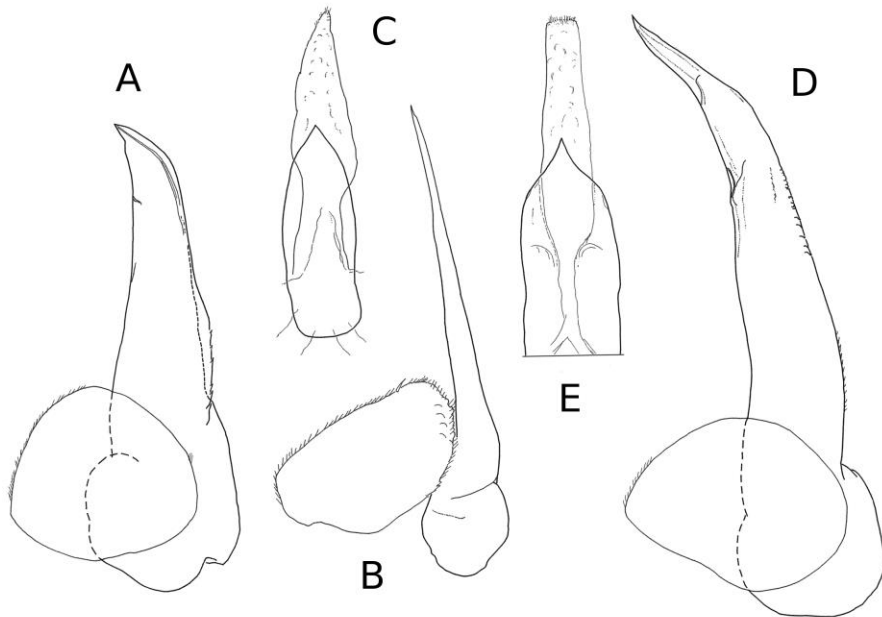


Fig. 3. A-C. *Armadilloniscus candidus*: A. First male pleopod. B. Second male pleopod. C. Genital papilla. D-E. *Armadilloniscus ellipticus*: D. First male pleopod. E. Genital papilla.

Fig. 3. A-C. *Armadilloniscus candidus*: A. Primer pleopodi del mascle. B. Segon pleopodi del mascle. C. Apòfisi genital. D-E. *Armadilloniscus ellipticus*: D. Primer pleopodi del mascle. E. Apòfisi genital.

Morphological remarks. According to Vandel (1962) and Taiti & Ferrara (1989), the identification of *Armadilloniscus* species is mainly based on morphology and tergal sculpture. Contrary to most terrestrial isopoda, *Armadilloniscus* species have, with exceptions, homogeneous sexual characteristics. Diagnostic characters mentioned by Vandel (1962) to distinguish both species lead to a certain confusion in the Asturian specimens. The main somatic difference between the two *Armadilloniscus* species is the shape of the uropods basipodites, semicircular in *A. ellipticus* and quadrangular in *A. candidus*. In the studied specimens this difference is not so clear (Fig. 2A-2C). On the contrary, the examination of the first male pleopods of

both species (Fig. 2B-2D and 3A-3D), especially the shape of the endopodite of the first pleopod (Taiti & Ferrara, 1996) and the genital papilla (Fig. 3C-3E), allows an easy identification. The most useful characteristics to identify and differentiate both species have been illustrated to facilitate future reviews (Figs. 2 and 3). Live specimens appear completely white (Fig. 1C-D) but under magnification darker due to a slightly pigmented epimera (Fig. 2A). The pigmentation of *A. ellipticus* is darker both in vivo and preserved specimens (Fig. 2C).

Ecological remarks. All specimens were found in a coastal area adhered to the lower surface of large stones which were covered

sporadically with water during high tide, resulting in a very humid microhabitat. In the study area, accumulations of algae (mainly *Codium* spp. and *Gelidium* spp.) were present, but no logs, trunks or deposits of seagrass species (*Zostera* spp.) (Fig. 1B). It is interesting to remark that although several consecutive surveys were made, some days no specimens of *A. candidus* were found.

Discussion

Woodlice are a group of isopods highly adaptable to a diversity of habitats. Vandel (1962) created some categories that allowed to include terrestrial isopods in groups according to their different ecological characteristics. One of the least diverse groups are coastal and halophilic woodlouse species, those exclusive to the supralittoral area (Vandel, 1962). Most of them feed on organic matter accumulations from plants and wood (Vandel, 1962; Taiti & Ferrara, 1989). Due to sampling difficulties and the little interest in coastal environments, the distribution of many of the coastal woodlouse species is patched, making it difficult to establish their real range. *Armadilloniscus* is a good example. *A. ellipticus* is a species widely distributed along the Mediterranean, but Iberian records are still scarce. *A. candidus* is an even less known species, recorded from fewer countries and had not yet been found in the Iberian Peninsula until this study. This report expands the catalogues of terrestrial isopoda species of Asturias and the Iberian Peninsula.

A. candidus, like *A. ellipticus*, is a Mediterranean species with only two previous records for Atlantic coastal areas and islands (Vandel, 1968; Cherpitel *et al.*, 2019). Even less is known about its biology. Most data agree on its coastal

habitats, living under large stones, wood, logs and particularly, deposits of marine seagrass species of the genus *Zostera* spp. and *Posidonia* (Vandel, 1962; Taiti & Ferrara, 1989; Garcia, 2008; Noël & Séchet, 2017). *A. candidus* specimens have been collected in Asturias under large stones among accumulations of Atlantic algae (*Codium* spp. and *Gelidium* spp. among others). No seagrass species, present in most Mediterranean areas, were found. However, the study area is part of the Villaviciosa estuary, one of the few areas of distribution of the two Asturian *Zostera* species (Diaz, 2003). The findings reflect the ability of *A. candidus* to adapt to Atlantic environments. In addition, Vandel (1962) commented that coastal and halophile woodlice are highly expansive. Attached to logs, fragments of wood and plants, these species can travel across the ocean and colonize new shores (Vandel, 1962). By this means, *A. ellipticus* is supposed to have spread throughout the world. Something similar could be applied to *A. candidus*. Direct arrival from the Mediterranean or the Azores is unlikely due to ocean currents. The Asturian population may have arisen from other unknown populations along the European Atlantic coast. Thus, the Mediterranean origin of this species should be reviewed in the future, perhaps with the support of molecular data. More surveys and studies are needed to clarify the origin of these populations, means of dispersal and the distribution of this species. *A. candidus* was not found on every sampling day in the study area. Variations in the abundance and detectability of this species could probably be explained by fluctuations in temperature and precipitation, which have shown to have influence on isopod populations from coastal areas (Messina *et al.*, 2016).

In summary, *Armadilloniscus candidus* is reported for the first time in the Iberian Peninsula, specifically in Asturias, thus expanding its known distribution in southwestern Europe. In addition, the report confirms the capability of *A. candidus* to adapt to Atlantic conditions and improves the ecological and morphological knowledge of this species in the Iberian Peninsula.

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