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Couverture / *Cover* :
Dorsal view of male adult specimens of all six polydesmid species collected.

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Polydesmid millipedes in the MSS of the northern Iberian Peninsula (Diplopoda, Polydesmida, Polydesmidae)

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ABSTRACT
The Superficial Subterranean Environment, known as the MSS (*Milieu Souterrain Superficiel*), was sampled at 15 localities of three main mountain systems in the northern Iberian Peninsula, at different time intervals from 2012 to 2021. A total of 2673 polydesmid individuals (Diplopoda: Polydesmida) were captured, of which 1970 could be identified with certainty as belonging to six species. The new records of these six species provide important new information about their distribution. *Polydesmus angustus* Latzel, 1884 is confirmed to inhabit the Atlantic region of the Iberian Peninsula. *Archipolydesmus osellai* Ceuca, 1968 is found for the third time since its description, but in the Iberian System far from its type locality in the Pyrenees. We provide new records of the rare millipede *Polydesmus asturiensis* Djursvoll, 2019 and slightly expand its known range. The known distribution of the *Polydesmus racovitzai* Brölemann, 1910 previously known from the Pyrenees and the Basque Mountains, is also extended to the Iberian System. The common and widely distributed in western Europe *Polydesmus coriaceus* Porat, 1870 and *Propolydesmus dismilus* (Berlese, 1891) are also recorded, but only the first one was abundant in the MSS. We also include photographs of the habitus and gonopods of the species found, as well as illustrations of the sampling methodology and habitats. The results highlight the importance of surveying the MSS in different mountain regions in order to increase knowledge about the biology and distribution of species.

KEY WORDS
Myriapoda,
subterranean biology,
scree habitats,
species distribution,
superficial subterranean habitats,
rare species,
new records.

RÉSUMÉ
Les mille-pattes polydesmides du MSS du nord de la péninsule ibérique (Diplopoda, Polydesmida, Polydesmidae).
Le milieu souterrain superficiel, connu sous le nom de MSS (Milieu souterrain superficiel), a été échantillonné dans 15 localités de trois principaux systèmes montagneux du nord de la péninsule ibérique, à différents intervalles de temps de 2012 à 2021. Un total de 2 673 individus polydesmides (Diplopoda, Polydesmida) ont été capturés, dont 1 970 ont pu être identifiés avec certitude comme appartenant à six espèces. Les nouvelles signalisations de ces six espèces fournissent des informations originales pertinentes sur leur distribution. Il est confirmé que *Polydesmus angustus* Latzel, 1884 habite la région atlantique de la péninsule ibérique. *Archipolydesmus osellai* Ceuca, 1968 est trouvé pour la troisième fois depuis sa description, mais dans le système ibérique, loin de sa localité type dans les Pyrénées. Nous fournissons de nouvelles données sur le rare mille-pattes *Polydesmus asturiensis* Djursvoll, 2019 et étendons sa distribution connue. La distribution du *Polydesmus racovitzai* Brölemann, 1910, précédemment connue des Pyrénées et des Montagnes basques, est également étendue au système ibérique. Les espèces communes et largement distribuées en Europe occidentale *Polydesmus coriaceus* Porat, 1870 et *Propolydesmus dismilus* (Berlese, 1891) sont également signalées, mais seule la première était abondante dans le MSS. Nous incluons également des photographies, tant de la morphologie externe que des gonopodes des espèces trouvées, ainsi que des illustrations de la méthodologie d'échantillonnage et des habitats échantillonnés. Les résultats soulignent à quel point l'étude des MSS de différentes régions montagneuses est importante pour accroître les connaissances sur la biologie et la distribution des espèces.

MOTS CLÉS
Myriapoda,
biologie souterraine,
habitats d'éboulis,
répartition des espèces,
habitats souterrains
superficiels,
espèces rares,
signalisations nouvelles.

INTRODUCTION

Millipedes (Class Diplopoda) constitute a highly diverse class of arthropods, but understudied compared to insects and arachnids (Brewer *et al.* 2012). The diversity of millipedes in Europe is relatively well known, but some regions, such as the Iberian Peninsula, have not yet been deeply studied (Kime & Enghoff 2011, 2017, 2021). Polydesmida Leach, 1815 is the millipede order with the highest number of species worldwide (Shear 2011), but it is represented in the Iberian Peninsula by only 45 valid species (Djursvoll 2008, 2019; Mauriès 2013, 2014; Reboleira & Enghoff 2013; Djursvoll & Melic 2015; Gilgado *et al.* 2015). In the Iberian Peninsula, the order Polydesmida includes mainly epigean and edaphic species, but also subterranean species. Seven of these species are considered troglobionts, which have been found only in caves (Kime & Enghoff 2011; Reboleira & Enghoff 2017; Gilgado 2023): *Archipolydesmus cordubaensis* Mauriès, 2013, *Archipolydesmus giennensis* Mauriès, 2014, *Boreviulisoma barrocalense* Reboleira & Enghoff, 2013, *Cantabrodesmus lorioli* Mauriès, 1971, *Cottodesmus breuili* Mauriès & Vicente, 1977, *Mastigonodesmus destefanii* Silvestri, 1898 and *Tonodesmus bolivari* Silvestri, 1925. A possible eighth troglobiont species is *Stosatea capolongoi* Strasser, 1970, which has been found in caves and superficial subterranean habitats (Strasser 1971; Ortuño *et al.* 2013; Jiménez-Valverde *et al.* 2015), but could also be a troglophile (Gilgado 2023). Some other species have been found mainly, but not exclusively, in caves, such as *Polydesmus asturiensis* Djursvoll 2019 or *Polydesmus biscayensis* Djursvoll 2019 (Djursvoll 2019), and other mostly epigean species, considered troglophiles, often occur in caves, such as *Propolydesmus dismilus* (Berlese, 1891) or *Polydesmus coriaceus* Porat, 1870 (Kime & Enghoff 2011). Apart from caves, there are also records of polydesmid millipedes in superficial subterranean habitats, namely the MSS (see below). Some of these species have been found both on the surface and in the MSS (Gilgado *et al.* 2015), such as *Archipolydesmus bedeli* (Brölemann, 1902) and *Archipolydesmus foliatus* Gilgado & Enghoff *in* Gilgado *et al.*, 2015, but others have been exclusively found in the MSS, such as *Archipolydesmus altibaeticus* Gilgado & Enghoff *in* Gilgado *et al.*, 2015.

The MSS, after *Milieu Souterrain Superficiel* (often translated as Mesovoid Shallow Substratum), is a subterranean environment formed by a network of voids created by rocky debris (Juberthie *et al.* 1980, 1981; Mammola *et al.* 2016). This environment can have different origins and consist of rocks of different lithology (Ortuño *et al.* 2013). It harbours a particular faunal composition containing epigean, edaphic and troglobiont species (Ortuño *et al.* 2013; Jiménez-Valverde *et al.* 2015; Gilgado *et al.* 2015; Mammola *et al.* 2016). The MSS was firstly studied in the Pyrenees, the Canary Islands and Central Europe (see for example Juberthie *et al.* 1980, 1981; Oromí *et al.* 1986; Pipan *et al.* 2011; López & Oromí 2010; Nitzu *et al.* 2010, 2014; Rendoš *et al.* 2012; Růžička & Dolanský 2016; Mammola *et al.* 2016), but recently it has been systematically studied in some regions of the Iberian Peninsula (see for example Ortuño *et al.* 2013, 2014; Gilgado *et al.* 2015; Jiménez-Valverde *et al.* 2015; Ledesma *et al.* 2020; Eusébio *et al.* 2021). Some of these studies focus on or include information about millipedes, but there is no published information on the millipedes of the MSS in the northern part of the Iberian Peninsula.

Recent sampling of the MSS in different mountain ranges in northern Iberian Peninsula have resulted in the collection of a large number of millipede individuals. In the present work, we provide an overview of the polydesmid millipedes (Order Polydesmida) that inhabit the MSS in northern Ibe-

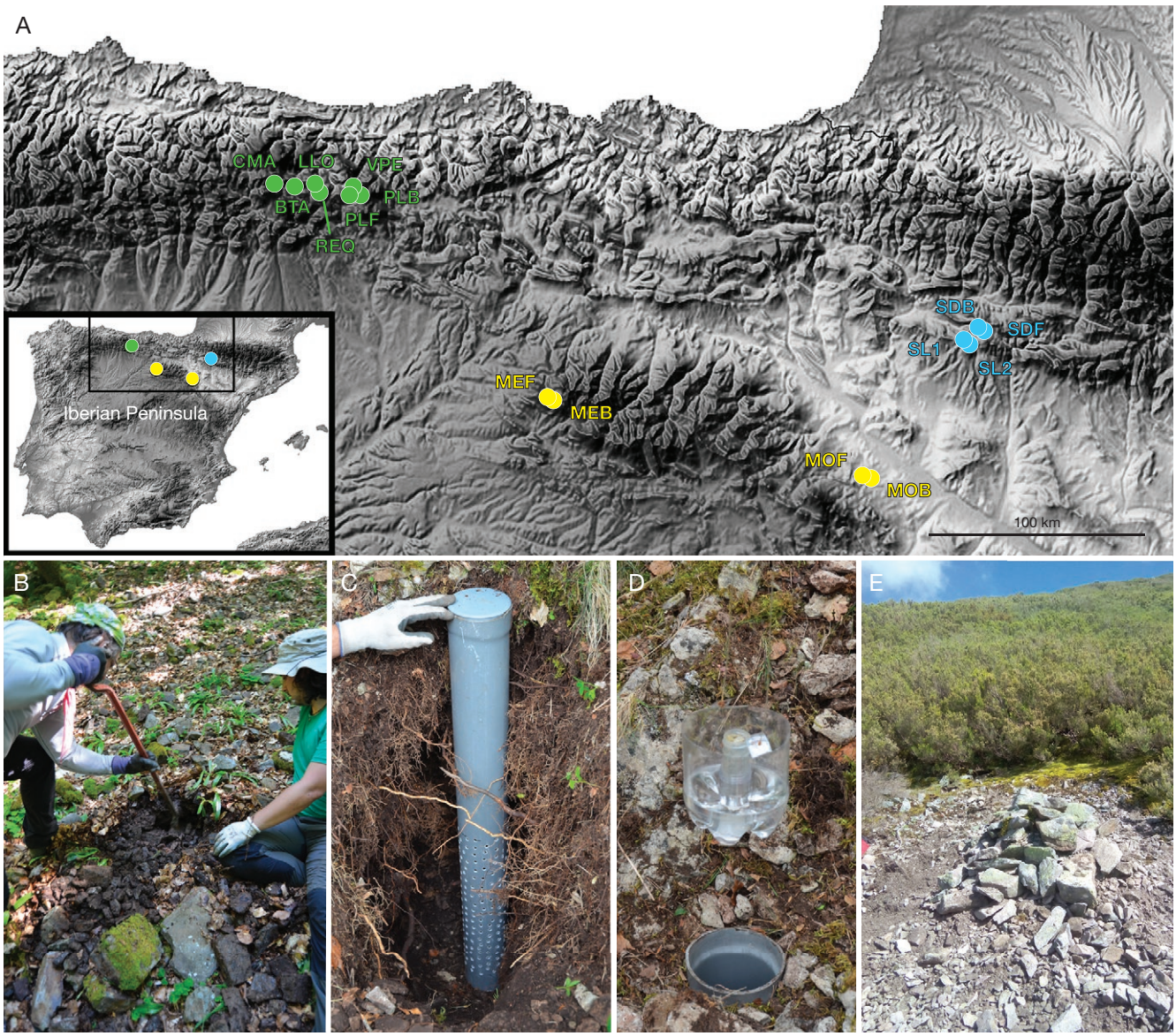

FIG. 1. — Location of sampling sites and installation of subterranean sampling devices (SSDs): **A**, physical map of the northern Iberian Peninsula with sampling points marked in **green** (Cantabrian Range), **yellow** (Iberian System) and **blue** (Pyrenees); codes as in Table 1; **B**, hole digging in a scree; **C**, multiperforated tube (1 m) placed in the hole; **D**, buried tube with open top and pitfall trap about to be installed inside; **E**, fully installed SSD and covered with stones.

rian Peninsula. These are the first records in the MSS for most of the species, which provide novel information about their microhabitat use. Moreover, these records extend the known distribution ranges of three of the species. The remaining millipede orders will be treated in future works.

MATERIAL AND METHODS

We sampled the MSS at 15 sites in three of the main Spanish mountain systems (Figs 1; 2): the Cantabrian Range (seven sampling points); the Iberian System, namely the Mencilla range (two sampling points) and the Moncayo massif (two sampling points); and the Pyrenees, namely the Sierra de Santo Domingo and the Sierra de Luesia in the Pre-Pyrenees (4 sampling points), with the number of traps at each sampling point varying from 1 to 4 (Table 1). The MSS was sampled using subterranean sampling devices (SSDs) which consist of subterranean pitfall traps placed at the bottom of buried multiperforated tubes (Fig. 1), as described in Baquero *et al.* (2017) and Gilgado *et al.* (2017). The traps contained propylene glycol as a preservative and blue cheese as bait. The tubes were 1 m long and perforated only in the lower half assuring that the fauna captured was moving at a minimum depth of 50 cm below the surface. The SSDs operated at each site during different time periods between 2012 and 2021 (Table 1), and they were recovered at different frequencies, from three months to one year. The samples were sorted in the laboratory and the millipedes were observed under a Nikon SMZ800 stereomicroscope. They were identified using recent

TABLE 1. — Location, characteristics, and sampling dates of sampling localities.

Code	Mountain System	Mountain or Range	Location	Coordinates	Elevation (m a.s.l.)	Number of SSDs	Sampling dates (Installation to last recovery)
SDB	Pyrenees	Sierra de Santo Domingo (Pre-Pyrenees)	Bare scree, Portillo de Longás, Longás, Huesca	42°26'45"N, 00°55'60"W	1200	4	15.V.2015-25.VII.2016
SDF	Pyrenees	Sierra de Santo Domingo (Pre-Pyrenees)	Forested scree, Portillo de Longás, Longás, Huesca	42°26'55"N, 00°56'11"W	1220	4	15.V.2015-25.VII.2016
SL1	Pyrenees	Sierra de Luesia (Pre-Pyrenees)	Alluvial debris, Galapatizos gully, Luesia, Zaragoza	42°24'48"N, 01°00'36"W	790	1	15.V.2015-25.VII.2016
SL2	Pyrenees	Sierra de Luesia (Pre-Pyrenees)	Alluvial debris, Arba de Luesia River, Luesia, Zaragoza	42°24'21"N, 01°01'10"W	770	1	15.V.2015-25.VII.2016
MEF	Iberian System	Sierra de Mencilla in Sierra de la Demanda	Beech Forest, Pineda de la Sierra, Burgos	42°11'55"N, 03°18'41"W	1460	2	26.VI.2017-3.08.2020
MEB	Iberian System	Sierra de Mencilla in Sierra de la Demanda	Bare Scree in Glaciar Circus, Pineda de la Sierra, Burgos	42°11'21"N, 03°18'37"W	1750	3	26.VI.2017-3.08.2020
MOB	Iberian System	Sierra del Moncayo	Bare Scree, Collado Bellido, Añón de Moncayo, Zaragoza	41°46'1"N, 01°47'01"W	1540	4	5.VI.2012-2.VII.2014
MOF	Iberian System	Sierra del Moncayo	Beech Forest, Barranco de Castilla, Tarazona, Zaragoza	41°48'18"N, 01°50'37"W	1420	4	5.VI.2012-2.VII.2014
PLB	Cantabrian Range	Sierra de Peña Labra	Bare Scree, Piedras Luengas, Palencia	43°02'21"N, 04°26'55"W	1520	2	16.XI.2015-21.VI.2018
PLF	Cantabrian Range	Hoyo de los Lobos	Forest, Las Lombas, Piedras Luengas, Palencia	43°02'42"N, 04°28'16"W	1300	1	16.XI.2015-25.VI.2019
PES	Cantabrian Range	Sierra Mediana	Forest, Collado de la Cruz de las Cabezuelas, Pesaguero, Cantabria	43°04'19"N, 04°28'18"W	1050	4	20.VI.2016-1.9.2021
REQ	Cantabrian Range	Pico Palanca	Scree with trees beside river Requejada, Cucayo, Dobres, Vega de Liébana, Cantabria	43°02'55"N, 04°38'08"W	1150	2	21.VI.2016-23.VI.2019
LLO	Cantabrian Range	Monte Casanzo	Forested Scree, Llobango, Barrio, Cantabria	43°03'40"N, 04°39'42"W	1290	2	21.VI.2016-23.VI.2019
BTA	Cantabrian Range	Boquerón de Tarna	Scree, near San Glorio Mountain Pass, Llánaves de la Reina, Boca de Huérgano, León	43°03'23"N, 04°46'03"W	1710	4	17.XI.2015-20.VI.2018
CMA	Cantabrian Range	Calar de San Martino	Forested Scree, Portilla de la Reina, Boca de Huérgano, León	43°04'60"N, 04°51'31"W	1410	3	22.VI.2016-20.VI.2018

literature (see for example Gilgado *et al.* 2015; Djursvoll 2019) and checking against the original or a subsequent description (see for example Demange 1981; Vicente 1982; Blower 1985). Adult males and females, and most juveniles, could be identified to species level. However, in the localities where more than one Polydesmidae species was present, juveniles (which are similar among species) were not ascribed to any of them to avoid possible misidentifications, and thus they are not reflected in the present work. Some poorly preserved and broken specimens could not be identified either. Specimens for Scanning Electron Microscopy (SEM) were dehydrated in several baths of absolute ethanol and acetone, and coated with platinum/palladium. SEM photographs were taken in the microscopy service of the University of Alcala, with a JEOL JSM-IT500, and Optic Microscopy (OM) photographs were taken with a Nikon D5100 attached to a Nikon SMZ800 stereo microscope (habitus) and a Leica DM 2500 microscope (gonopods). The habitus and gonopods photographs were stacked with Helicon Focus, and all the images, including maps were elaborated with Photoshop CS and Photopea (www.photopea.com). The majority of the studied material is stored in the collection of the GIBSES group at the University of Alcala (UAH), Madrid, Spain, but voucher specimens are stored in the collection of the Muséum national d'Histoire naturelle (MNHN), Paris, France.

RESULTS

REMARK

A total of 2673 polydesmid individuals were captured, but only 1970 could be assigned with certainty to six species. Detailed information on each species can be found below.

Family POLYDESMIDAE Pocock, 1887
Genus *Archipolydesmus* Attems, 1898

Archipolydesmus osellai Ceuca, 1968
(Figs 3A; 4A)

Archipolydesmus osellai Ceuca, 1968: 137.

MATERIAL EXAMINED. — **Spain** • 1 ♂, 3 ♀; Burgos, Pineda de la Sierra, Sierra de Mencilla in Sierra de la Demanda, beech forest; 42°11'55"N, 03°18'41"W; 1460 m a.s.l.; 22.VI.2019; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 1 ♂; same data; MNHN • 1 ♂; same data; 18.VI.2018; UAH.

REMARKS

This species was previously known only from two records in the Balneario de Panticosa (Ceuca 1968) and a mixed forest

FIG. 2. — Examples of sampled landscapes: **A**, scree in the glacier circus of Mencilla (MEB); **B**, beech forest over scree in Moncayo mountain (MOF); **C**, forested scree in the Sierra de Santo Domingo (SDF); **D**, alluvial debris in the Arba de Luesia river (SL2); **E**, scree in the Piedras Luengas Pass (PLB); **F**, scree in Calar de San Martino (CMA).

near San Juan de la Peña, both in Huesca (Serra *et al.* 1996; Gilgado *et al.* 2015). Both localities are in the Pyrenean region, and the present record extends the range of the species to the north of the Iberian System. The species could therefore also occur in other nearby mountains such as the Basque Mountains, or the Cantabrian Range.

Genus *Polydesmus* Latreille, 1803

Polydesmus angustus Latzel, 1884
(Figs 3B; 4B)

Polydesmus angustus Latzel, 1884: 262.

MATERIAL EXAMINED. — **Spain** • 1 ♀; Palencia, Piedras Luengas, Hoyo de los Lobos, Las Lombas, Forest; 43°02'42"N, 04°28'16"W; 1300 m a.s.l.; 20.VI.2016; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 1 ♂; same data; 25.VI.2019; UAH • 1 ♂; Palencia, Sierra de Peña Labra, Piedras Luengas, bare scree; 43°02'21"N, 04°26'55"W; 1520 m a.s.l.; 21.VI.2018; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 3 ♂; Cantabria, Pesaguero, Sierra Mediana, Collado de la Cruz de las Cabezuelas, forest; 43°04'19"N, 04°28'18"W; 1050 m a.s.l.; 27.VI.2017; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg; MSS; UAH • 1 ♂, 1 ♀; same data; MNHN • 5 ♂, 3 ♀; same data; 31.X.2018; UAH • 33 ♂, 7 ♀; same data; 21.VI.2018; UAH • 9 ♂, 6 ♀; same data; 22.VI.2019; UAH • 121 ♂, 20 ♀; same data; 1.IX.2021; UAH.

REMARKS
The species has a wide distribution in western Europe, namely in Germany, Switzerland, the United Kingdom and France, including the northern part of the Pyrenees, and several other countries (Kime & Enghoff 2011). This species was reported in Spain for the first time by Mauriès (1971), in the province of Lerida, in the Catalonian Pyrenees, and according to Kime & Enghoff (2011) the species had not been recorded in the Atlantic zone of Spain. Djusrvoll (2019) states that this species occurs in the Atlantic zone, in the provinces of Alava and Asturias, but he provides no capture information or bibliographic references. The present record from Pesaguero confirms the occurence of the species in the Atlantic region of Spain. However, it is not clear whether this region was part of its native distribution range, whether it has been recently colonized due to natural dispersal of the species (Hauser & Voigtländer 2009) or whether it is the result of anthropogenic introduction events (it has been introduced in North America, see for example Shelley (2002) or Kime & Enghoff (2011)). Interestingly, *Polydesmus angustus* was found in syntopy with *P. coriaceus*, the most common polydesmid in the present study.

Polydesmus asturiensis Djursvoll, 2019
(Figs 3C; 5A-C)

Polydesmus asturiensis Djursvoll, 2019: 57.

MATERIAL EXAMINED. — **Spain** • 2 ♂; Cantabria, Barrio, monte Casanzo, Llobango, forested scree; 43°03'40"N, 04°39'42"W; 1300 m a.s.l.; 23.VI.2019; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 1 ♂; same data; MNHN • 2 ♂; same data; 27.VI.2017; UAH.

REMARKS
This species was recently described from nine specimens collected in a cave in Teverga, and in Vega de Enol, both in Asturias Province (Djursvoll 2019). The present record in Cantabria province is 35 km southeast from the closest locality, so it only slightly extends the known range of the species. The presence of *Polydesmus asturiensis* in a cave and the MSS, indicate at least a partially subterranean lifestyle. The morphology of the gonopod of the captured specimens corresponds to the original description (Djursvoll 2019), but the exomere seems to be slightly longer and more twisted. However, observation with different angles of tilt may cause different impressions (Fig. 5A-C).

Polydesmus coriaceus Porat, 1870
(Figs 3D; 4C)

Polydesmus coriaceus Porat, 1870: 819.

MATERIAL EXAMINED. — **Spain** • 8 ♂, 8 ♀, 9 juv; León, Boca de Huérgano, Portilla de la Reina, Calar de San Martino, Forested scree; 43°04'60"N, 04°51'31"W; 1410 m a.s.l., 28.VI.2017.; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 2 ♂, 2 ♀, 51 juv.; same data; 20.VI.2018; UAH • 2 ♀, 1 juv.; Cantabria, Barrio, monte Casanzo, Llobango, forested scree; 43°03'40"N, 04°39'42"W; 1300 m a.s.l.; 19.VI.2018; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 2 ♂, 1 ♀; same data; 23.VI.2019; UAH • 5 ♂, 1 ♀; Palencia, Piedras Luengas, Hoyo de los Lobos, Las Lombas, forest; 43°02'42"N, 04°28'16"W; 1300 m a.s.l.; 16.XI.2015; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; UAH • 1 ♂, 2 ♀; Palencia, Piedras Luengas, Sierra de Peña Labra, bare scree; 43°02'21"N, 04°26'55"W; 1520 m a.s.l.; 27.VI.2017; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 3 ♂, 6 ♀; same data; 21.VI.2018; UAH • 2 ♀; Cantabria, Vega de Liébana, Dobres, Cucayo, below Pico Palanca, scree with trees beside river Requejada; 43°02'55"N, 04°38'08"W; 1150 m a.s.l.; 27.VI.2017; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS • 2 ♂, 3 ♀, 7 juv.; same data; 19.VI.2018; UAH • 3 ♂, 2 ♀, 3 juv.; same data; 23.VI.2019; UAH • 1 ♀, 1 juv.; León, Boca de Huérgano, Llánaves de la Reina, Boquerón de Tarna, scree; 43°03'23"N, 04°46'03"W; 1710 m a.s.l., 28.VI.2017; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 1 ♂, 2 ♀; 1 juv; same data; 20.VI.2018; UAH • 1 ♂; Cantabria, Pesaguero, Sierra Mediana, Collado de la Cruz de las Cabezuelas, forest; 43°04'19"N, 04°28'18"W; 1050 m a.s.l.; 22.VI.2019; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS, UAH • 4 ♀; same data; 1.IX.2021; UAH • 21 ♂, 69 ♀, 96 juv.; Huesca, Longás, Sierra de Santo Domingo, Portillo de Longás, bare scree; 42°26'45"N, 00°55'60"W; 1200 m a.s.l.; 2.IX.2015; V. M. Ortuño, J. D. Gilgado, E. Ledesma & E. Cuesta leg.; MSS; UAH • 8 ♂, 5 ♀, 8 juv.; same data; 21.XII.2015; UAH • 8 ♂, 4 ♀, 1 juv; same data; 13.IV.2016; UAH • 9 ♂, 18 ♀, 2 juv.; same data; 25.VII.2016; UAH • 118 ♂, 101 ♀, 337 juv.; Huesca, Longás, Sierra de Santo Domingo, Portillo de Longás, forested scree; 42°26'55"N, 00°56'11"W; 1220 m a.s.l.; 2.IX.2015; V. M. Ortuño, J. D. Gilgado, E. Ledesma & E. Cuesta leg.; MSS; UAH • 18 ♂, 5 ♀, 3 juv.; same data; 21.XII.2015; UAH • 6 ♂, 2 juv.; same data; 13.IV.2016; UAH • 59 ♂, 59 ♀, 49 juv.; same data; 25.VII.2016; UAH • 4 ♂, 3 ♀, 2 juv.; Burgos, Pineda de la Sierra, Sierra de Mencilla in Sierra de la Demanda, bare scree in Glaciar Circus; 42°11'21"N, 03°18'37"W; 1750 m a.s.l.; 22.VI.2019; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 1 ♀; Burgos, Pineda de la Sierra, Sierra de Mencilla in Sierra de la Demanda, beech forest; 42°11'55"N, 03°18'41"W; 1460 m a.s.l.; 18.VI.2018; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 92 ♂, 62 ♀; same data; 22.VI.2019; UAH • 18 ♂, 16 ♀; same data; 3.VIII.2020; UAH • 10 ♂, 15 ♀, 2 juv.; Zaragoza, Añón de Moncayo, Sierra del Moncayo, Collado Bellido, bare scree; 41°46'1"N, 01°47'01"W; 1540 m a.s.l.;12.III.2014; V. M. Ortuño, J. D. Gilgado, E. Ledesma & E. Cuesta leg.; MSS; UAH • 41 ♂, 31 ♀, 36 juv.; same data; 2.VII.2014; UAH • 3 ♂, 2 ♀; same data; MNHN • 2 ♂; Zaragoza, Tarazona, Sierra del Moncayo, Barranco de Castilla, beech forest; 41°48'18"N, 01°50'37"W; 1420 m a.s.l.;

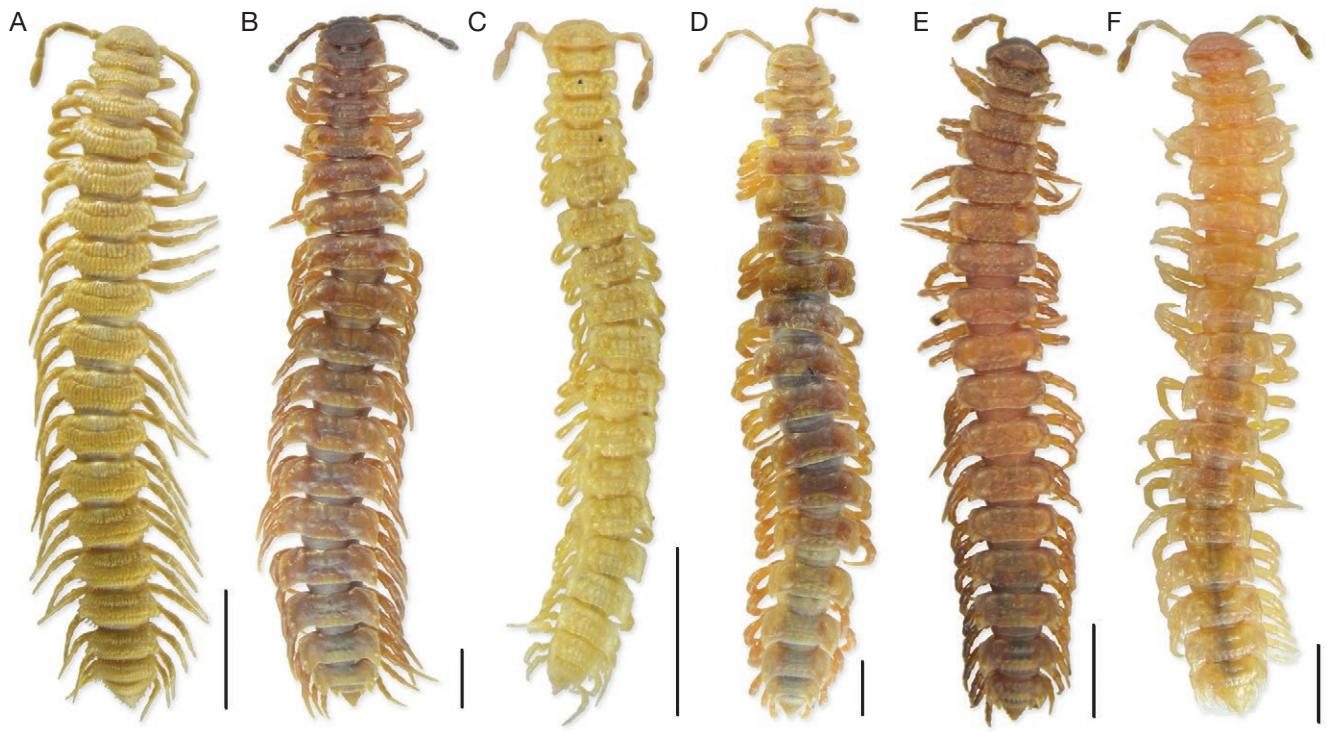

Fig. 3. — Dorsal view of male adult specimens of all six polydesmid species collected: **A**, *Archipolydesmus osellai* Ceuca, 1968 from the Sierra de Mencilla (MEF); **B**, *Polydesmus angustus* Latzel, 1884 from the Sierra Mediana (PES); **C**, *Polydesmus asturiensis* Djursvoll, 2019 from Llobango (LLO); **D**, *Polydesmus coriaceus* Porat, 1870 from the Sierra de Santo Domingo (SDF); **E**, *Polydesmus racovitzai* Brölemann, 1910 from the Sierra del Mencilla (MEF); **F**, *Propolydesmus dismilus* (Berlese, 1891) from the Sierra de Luesia (SL1). Scale bars: 2 mm.

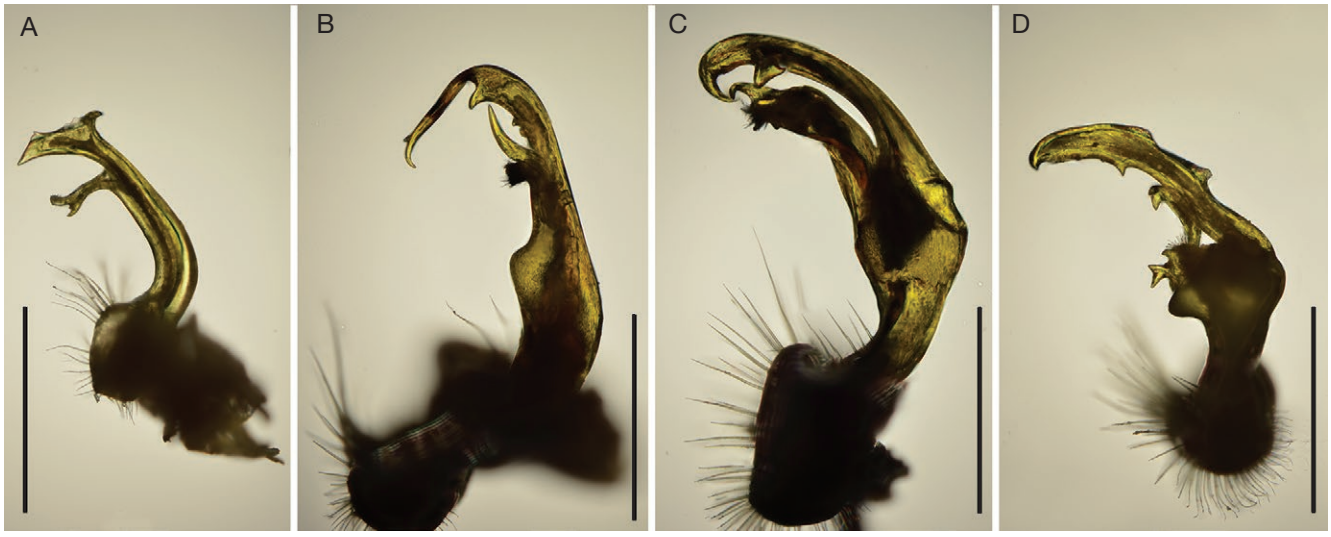

Fig. 4. — Gonopods of four of the six species collected: **A**, left gonopod of *Archipolydesmus osellai* Ceuca, 1968 from the Sierra de Mencilla (MEF) in lateral view; **B**, right gonopod of *Polydesmus angustus* Latzel, 1884 from the Sierra Mediana (PES) in mesal view; **C**, left gonopod of *Polydesmus coriaceus* Porat, 1870 from the Sierra de Santo Domingo (SDF) in lateral view; **D**, left gonopod of *Propolydesmus dismilus* (Berlese, 1891) from the Sierra de Luesia (SL1) in lateral view. Scale bars: 0.5 mm.

V. M. Ortuño, J. D. Gilgado, E. Ledesma & E. Cuesta leg.; MSS; UAH • 9 ♂, 2 ♀, 6 juv.; same data; 2.VII.2014; UAH.

Remarks

This species is very common in the northern Iberian Peninsula, and in some Atlantic regions of Europe such as France, Belgium and the United Kingdom. It occurs in different habitat types and is not rare in caves, probably due to its preference for humid places (Kime & Enghoff 2011). This also agrees with its presence in the MSS in forested screes, as shown in the present study and in Eusébio *et al.* (2021).

Polydesmus racovitzai Brölemann, 1910
(Figs 3E; 5D-F)

Polydesmus racovitzai Brölemann, 1910: 352.

MATERIAL EXAMINED. — **Spain** • 2 ♂, 1 ♀; Burgos, Pineda de la Sierra, Sierra de Mencilla in Sierra de la Demanda, beech forest; 42°11'55"N, 03°18'41"W; 1460 m a.s.l.; 18.VI.2018; V. M. Ortuño, J. D. Gilgado & E. Ledesma leg.; MSS; UAH • 39 ♂, 1 ♀; same data; 22.VI.2019 • 3 ♂; same data; 3.VIII.2020; UAH • 2 ♂, 1 ♀; same data; MNHN.

REMARKS
This species is known from the French Pyrenees and northern Spain (provinces of Biscay, Navarre and Gipuzkoa) (Kime & Enghoff 2011; Djursvoll 2019). The present record extends the known distribution of the species to the south and east. It also occurs at a higher altitude than previous records, according to Kime & Enghoff (2011) up to 1300 m a.s.l. As Djursvoll (2019) points out, the gonopod morphology of *P. racovitzai* may resemble that of *Polydesmus inconstans* Latzel, 1884, as drawn by Demange (1981). The drawing in the original description of *P. racovitzai* (Brölemann 1910: plate V, figs 32, 33) shows a shorter and softly curved tip of exomerite, while it is longer and almost describing a straight angle after the lateral tooth in the drawing of Demange (1981: 125, figs 170-171). Our specimens agree with the gonopod morphology of *P. racovitzai* in Demange (1981), and we are including three images of it (Fig. 5D-F).

Genus *Propolydesmus* Verhoeff, 1895

Propolydesmus dismilus (Berlese, 1891)
(Figs 3F; 4D)

Polydesmus dismilus Berlese, 1891: 348.

MATERIAL EXAMINED. — **Spain** • 1 ♂, 1 ♀; Huesca, Longás, Sierra de Santo Domingo, Portillo de Longás, bare scree; 42°26'45"N, 00°55'60"W; 1200 m a.s.l.; 2.IX.2015; V. M. Ortuño, J. D. Gilgado, E. Ledesma & E. Cuesta leg.; MSS; UAH • 2 ♀; same data; 25.VII.2016; UAH • 7 ♂, 2 ♀, 16 juv.; Zaragoza, Luesia, Sierra de Luesia, Galapatizos gully, alluvial debris; 42°24'48"N, 01°00'36"W; 790 m a.s.l.; 2.IX.2015; V. M. Ortuño, J. D. Gilgado, E. Ledesma & E. Cuesta leg.; MSS; UAH • 4 ♂, 6 ♀, 26 juv.; same data; 27.VI.2016; UAH • 3 ♂, 3 juv.; Zaragoza, Luesia, Arba de Luesia river, alluvial debris; 42°24'21"N, 01°01'10"W; 770 m a.s.l.; 2.IX.2015; V. M. Ortuño, J. D. Gilgado, E. Ledesma & E. Cuesta leg.; MSS; UAH • 2 ♂; same data; 21.XII.2015; UAH • 2 ♂, 2 ♀; same data; MNHN • 1 ♂, 1 ♀, 2 juv.; same data; 25.VII.2016; UAH.

REMARKS
This species is considered as troglophile. It has been recorded in Italy, Spain, including the Balearic and Canary Islands, and Algeria. Its range is wide in continental Spain, but there are few records, probably due to lack of sampling (Kime & Enghoff 2011).

DISCUSSION

The six species found represent about 13% of the Iberian polydesmid species. This is a high diversity, considering that we only sampled 15 localities in the north part of the Iberian Peninsula. However, the sampled scree habitats showed different features (mountain scree or alluvial plain, with dense forest cover, with few or no trees, and different elevations) (Table 1; Fig. 2), which may have increased this diversity. We found differences in species composition between regions and localities, but one species, *Polydesmus coriaceus* was present at almost all sampling points. The remaining species appeared in one or a few localities in one mountain system each. Two of these species, *Polydesmus angustus* and *Propolydesmus dismilus* have a large known ranges, which contrasts with the small number of sampling points where they were found in the present study (3 and 2 respectively). *Polydesmus angustus* (Figs 3B; 4B) may be rare in the Iberian Peninsula (Kime & Enghoff 2011; Djursvoll 2019), but its low presence in the MSS may be due to a preference for epigean habitats. On the other hand, *Propolydesmus dismilus* (Figs 3F; 4D) is known to be common in subterranean habitats in southern regions (Kime & Enghoff 2011). The scarcity of *Propolydesmus dismilus* may be due to several, non-mutually exclusive, reasons: either it does not prefer scree habitats (note that it was mostly captured in an alluvial plain), or it is less abundant overall, or it only needs to go deeper in subterranean habitats in search of moisture in drier regions. Another species, *Polydesmus racovitzai* (Figs 3E; 5D-F), is also known to have a relatively wide distribution range in the Pyrenees and Basque mountains (Kime & Enghoff 2011; Djursvoll 2019). Thus, its present record outside its known distribution area, while being absent in the sampled Pyrenean localities, draws attention. The remaining two species, *Archipolydesmus osellai* (Figs 3A; 4A) and *Polydesmus asturiensis* (Figs 3C; 5A-C) are rare species with few records (Gilgado *et al.* 2015; Kime & Enghoff 2011; Serra *et al.* 1996; Djursvoll 2019), and in both cases the present data extend their known distribution range.

Knowledge about the distribution ranges of millipedes in the Iberian Peninsula is very patchy (Kime & Enghoff 2011, 2017, 2021), and therefore any study in poorly known areas will result in new records. This is especially the case when a poorly known habitat is also sampled, such as the MSS. The present work shows how the sampling of the MSS has provided both new information on the habitat preferences of the species, and new records that have expanded the known distribution of several species. Some of these species are even rare and only known from a few records, such as *Archipolydesmus osellai* or *Polydesmus asturiensis*. In previous studies, other previously considered rare millipede species, such as *Archipolydesmus bedeli*, were found even in large numbers in the MSS (Gilgado *et al.* 2015), but also other rare arthropod species such as the beetle *Dima assoi* Pérez Arcas, 1872 (Gilgado *et al.* 2014). *Archipolydesmus osellai* was not captured in large numbers, but was only known from a few specimens at two localities in the Pyrenees, in Huesca province (Ceuca 1968; Serra *et al.* 1996). The present record is 220 km from

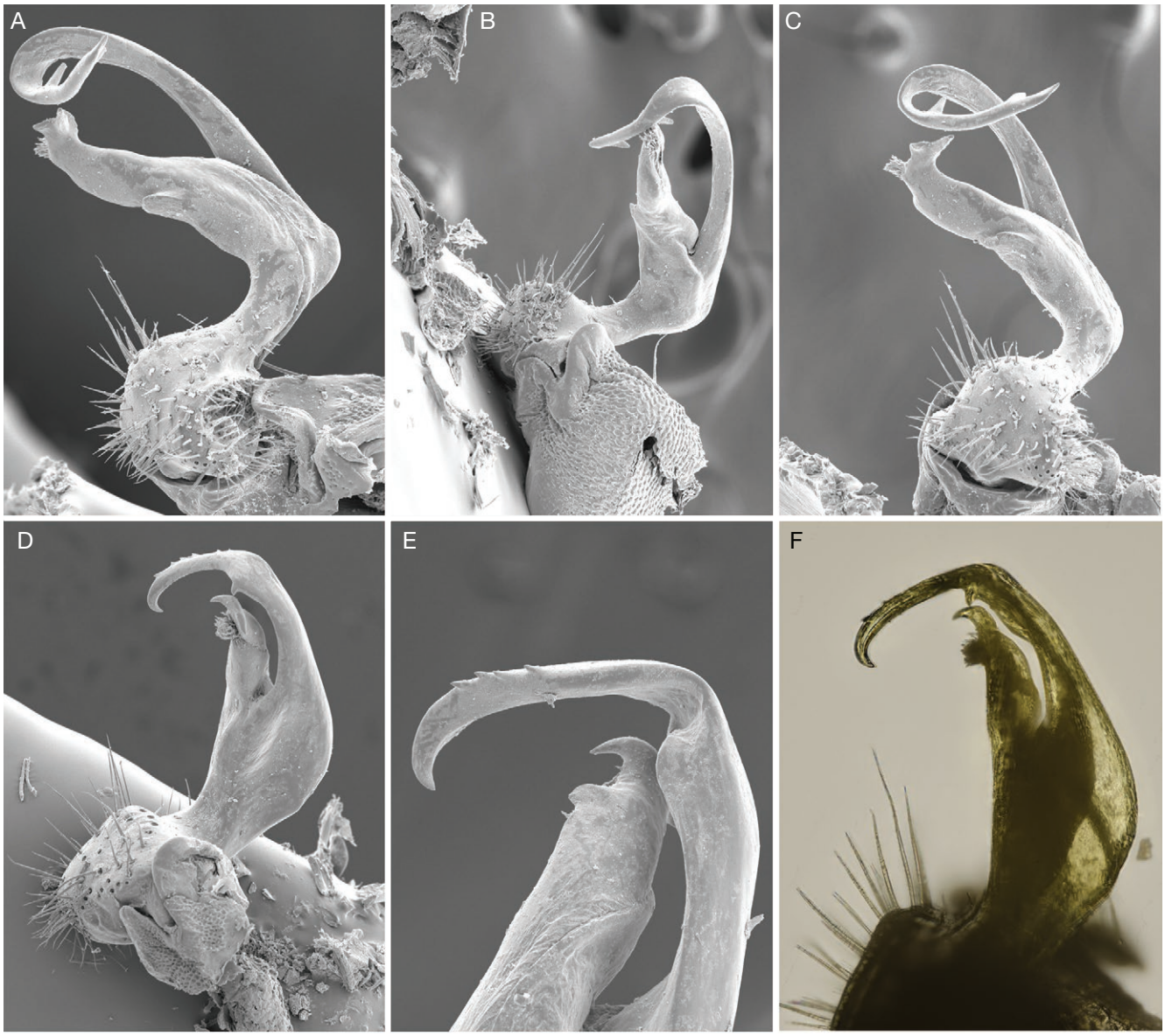

Fig. 5. — Gonopods of two of the six species collected: **A**-**C**, right (**A**, **C**) and left (**B**) gonopods of *Polydesmus asturiensis* Djursvoll, 2019 from Llobango (LLO) in mesal (**A**), lateral (**B**) and ventro-anteromesal (**C**) view; **D**-**F**, left (**D**) and right (**E**-**F**) gonopods of *Polydesmus racovitzai* Brölemann, 1910 from Sierra del Mencilla (MEF) in lateral (**D**) and mesal (**E**-**F**) view. Scale bars: A-C, 0.1 mm; D, 0.2 mm; E, 0.1 mm; F, 0.2 mm.

the nearest known locality, in a different mountain system separated by the natural barrier of the Ebro basin. Interestingly, the species was not captured in the Pyrenean sampling points of the Sierra de Santo Domingo, which is only 22 km from the nearest known locality. The situation is similar with *Polydesmus racovitzai*, although this species is much more frequent in its distribution range (Kime & Enghoff 2011; Djursvoll 2019). As with the previous species, this is also a Pyrenean species found for the first time in the Iberian System. The present records in the MSS of the Sierra de Mencilla are the southern and eastern limits of its distribution range, in a different mountain system and around 100 km from the nearest known locality, which is separated from the previous records by the Ebro basin. It is noteworthy to point at the fact that the drawing of the gonopod in the original description (Brölemann 1910) is different from a drawing in Demange (1981), the latter resembling more that of Polydesmus inconstans, as pointed out by Djursvoll (2019). Our specimens fit this second drawing of *P. racovitzai* (Fig. 5D-F). In the case of *Polydesmus asturiensis*, the distance of the present record to the nearest previously known locality is only 35 km, and is in the same mountain system. This species was recently described based on specimens collected in 1934 and 1969 (Djursvoll 2019). Finally, it is worth mentioning the presence of *Polydesmus angustus* in Cantabrian mountains based on precise records for the first time (see "Remarks" on *Polydesmus angustus* in the Results section). The present record confirms the presence of the species in the Atlantic zone of Spain and extends its known distribution area to the province of Cantabria.

In conclusion, the study of the MSS in mountain regions provides new records of rare species, increasing their known distribution area, and it shows that several epigean, or troglophile species are abundant in superficial subterranean areas. The present results have increased the known distribution area of three out of the six species, and while some common polydesmid species such as *Polydesmus coriaceus* seem to be widespread in superficial subterranean habitats of the Iberian Peninsula, several other common or less common species also occasionally inhabit this environment.

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