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A survey of the epiphytic bryophyte flora in the northwest of the Iberian Peninsula

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Abstract – The epiphytic bryoflora growing on trunks of *Quercus pyrenaica* Willd. and *Q. robur* L. has been surveyed throughout an extended area in the northwest of the Iberian Peninsula. Seventy four species are catalogued (14 liverworts and 60 mosses) with an indication of their distribution in the area. Knowledge of the regional flora is supplemented with a total of 44 novelties for 7 of the 8 provinces considered. Substrate affinity for several facultative epiphytes is discussed on the basis of their frequency on bark. The distribution of regionally rare species such as *Harpalejeunea molleri*, *Metzgeria fruticulosa*, *M. temperata*, *Orthotrichum consimile, O. scanicum*, *O. shawii, Ulota coarctata* and *Zygodon viridissimus* is used in conjunction with overall species richness and the degree to which they are representative of the regional flora to assess the local significance of the different localities and to select a list of hotspots for conservation.

bryophytes / chorology / ecology / diversity / rarity / hotspots / conservation / Spain / Portugal

INTRODUCTION

The northwestern part of the Iberian Peninsula comprises several provinces in both Spain and Portugal. It has been frequently visited by bryologists and the number of publications concerning the area exceeds one hundred. Many interesting reports were published during the first half of 20th Century, including *Splachnum ampullaceum* Hedw. (Luisier, 1918), *Kurzia pauciflora* (Dicks.) Grolle (Casares Gil, 1919), *Sphagnum pylaesii* Bridel (Dismier, 1927) and *Heterocladium wulfsbergii* I. Hagen (Buch, 1942), and many others have been reported more recently: *Cyclodictyon laete-virens* (Hook. & Tayl.) Mitt. (Vigón, 1975), *Adelanthus decipiens* (Hook.) Mitt. (Simó & Vigón, 1975), *Dicranum crassifolium* Sérgio, Ochyra & Séneca (Sérgio *et al*., 1995). Hyper-Atlantic areas such as Fraga de Caaveiro (Eume river, La Coruña, Spain) have attracted special attention (Casas & Reinoso, 1984; Reinoso, 1982 and 1985) because liverworts like *Lepidozia cupressina* (Sw.) Lindenb., *Cephalozia hibernica* Spruce ex Pearson, *Lophocolea*

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fragrans (Moris & De Not.) Gottsche, Lindenb. & Nees, *Telaranea nematodes* (Gottsche ex Aust.) Howe and the fern *Hymenophyllum tunbrigense* (L.) Sm. take refuge in a nearly subtropical humid environment.

The singularity of the area can be explained by its climate and geomorphological diversity. The Atlantic influence is very strong because the region faces the sea on two fronts (north and west) but at the same time the influence of the Mediterranean, penetrating from the southeast, can be felt in most of the territory. As a result, the area is conformed as a patch of Atlantic, transitional and submediterranean 'islands' scattered across the territory.

Despite its evident floristic interest, the area lacks a regional flora. Contributions about relevant species have been published, but no complete survey has been undertaken, except for especially interesting small areas such as the Cuiña Valley (Casas *et al.*, 1987) in León (Spain), the above mentioned Fraga de Caaveiro, and the Serra do Gerês National Park (Sérgio & Schumacker, 1992) in Minho (Portugal). Consequently, quite common bryophytes are still unreported from the innermost provinces. Information concerning epiphytes is even more scarce, since their habitat has been traditionally less well explored until recent times.

The aim of this paper is, firstly, to fill some of the gaps in systematic recording, especially in the under explored provinces, through an extensive survey of the epiphytic bryophyte flora growing in deciduous oak woods, the commonest type of forest in the area. Secondly, it aims to evaluate the interest of that flora and to select the most significant localities in terms of their conservation value and the degree to which they are representative of the regional flora.

STUDIED AREA

The studied area comprises in Spain the Region of Galicia (the provinces of La Coruña, Lugo, Orense and Pontevedra), together with the western part of the provinces of Zamora, León and Asturias, and in Portugal the northern part of Minho province (Fig. 1). The maximum altitude in the study area is reached in the Cantabrian Range (2.185 m). These mountains cross the northern part of Spain in a E-W direction, but in the western part of the province of Asturias the range is oriented NE-SW and divides into two lesser branches enclosing between them the depression of El Bierzo. The sierras forming these branches are Ancares, Caurel, Queija and San Mamed on one side, and the León Mountains and La Cabrera on the other. These sierras are separated one from another by several valleys and small depressions. To the SW, across the broad valley of the Limia river, the Peneda and Gerês Mountains continue the main NE-SW axis. In the province of Lugo, west of the Ancares and Caurel Sierras, there is a large plain at 600-800 m with a gentle relief (the Lugo plain). To the SE of this area, another raised plain, called Sanabria, is subject to the Mediterranean influence from the Spanish northern meseta (the high and flat Duero basin), although mollified by the altitude effect (1000 m). In addition to the sierras of the Cantabrian Range, several lower ranges are found in the north and west, giving the landscape a quite mountainous character which has a major influence on the climate of the region.

Climatic conditions are affected by the influence of the Atlantic in the north and west, and of the Mediterranean from the northern meseta in the southeast. As a result of this, the main climatic gradient is NW-SE, that is, orthogonal to most of the mountains, including the Cantabrian Range. For that reason, the

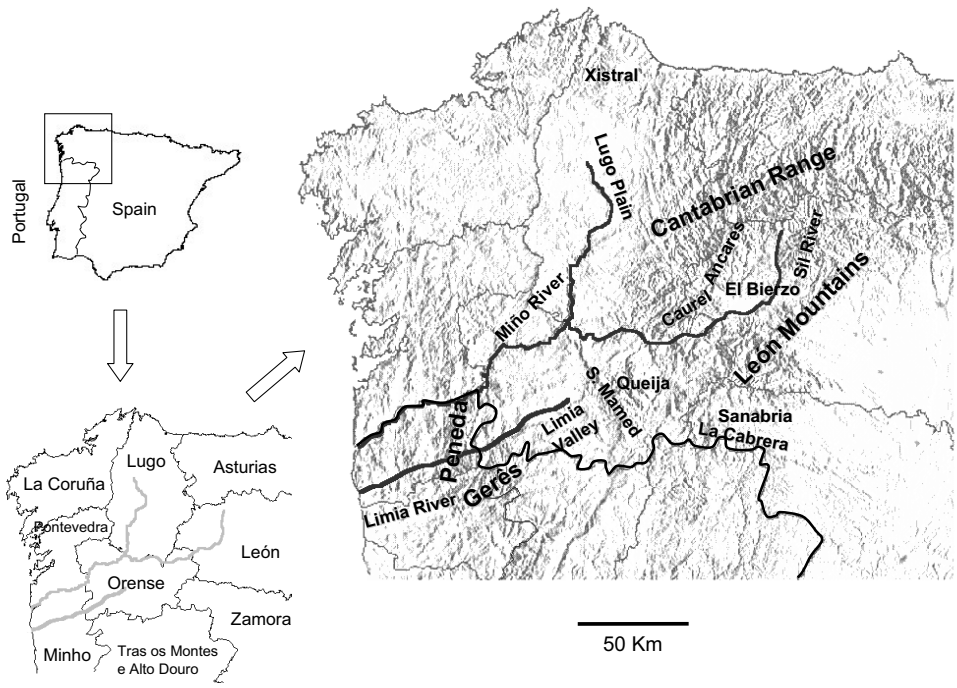

Fig. 1. Location of the studied area and principal geographic elements.

rainfall is typically orographic and abundant (higher than 3000 mm on mountains near the coast), although average sunshine is similar to that of the Mediterranean region and summer drought (more or less severe) is common. Gaps between the sierras are frequent and the two climatic influences penetrate through the mountains and create a complex transition where two neighbouring localities can be affected by rather different types of weather.

Deciduous oak woods of *Quercus robur* L. and *Q. pyrenaica* Willd. are the commonest natural forests in the region and they have therefore been the target of our sampling. Evergreen oak woods (green oaks and cork oaks) are found in the warmest localities, under clearly Mediterranean conditions; beech woods are scarce and located in the northeast; and finally, the highest areas are colonized by birch (*Betula alba* L.).

FIELD WORK

The sampling has been more intensive in the area delimited by the 41º 50' and 43º 0' N parallels and the 6º 30' and 7º 50' W meridians (Fig. 2). A hundred sampling sites were located inside this area, and 11 in the peripheral Atlantic areas to the north and west.

In well preserved *Quercus robur* and *Q. pyrenaica* woods (also mixed woods of both species), samples were taken from tree trunks of 15 to 45 cm in

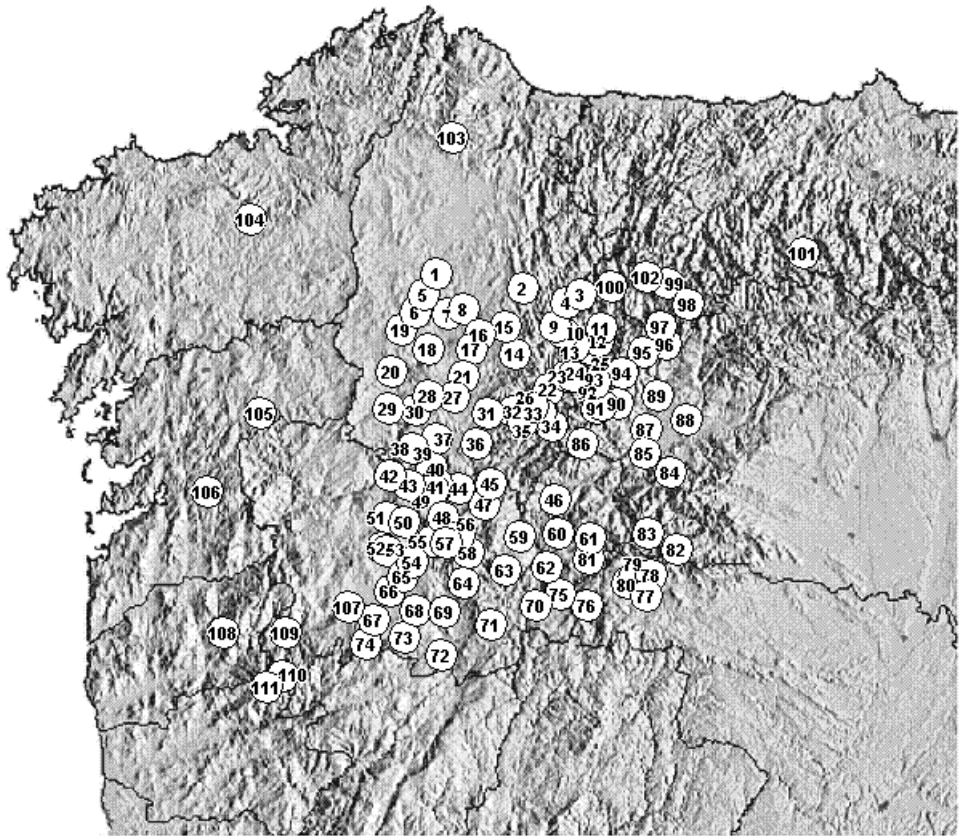

Fig. 2. Situation of the sampling sites. Numbers correspond to those on appendix 1.

diameter, at 150-180 cm above ground level. In each forest, 20 samples of 20×20 cm in size were collected. Bryophytic cover in the quadrat was noted before removal of the sample so that species cover estimated in the laboratory could be related to that in the field.

Samples were identified in the laboratory, and for every species an abundance value was assigned using IES (Lara & Mazimpaka, 1998; Albertos *et al.*, 2002). This index combines an estimate of cover with relative frequency of occurrence of each species in the forest.

Details of the localities are given in appendix 1 and the locations are mapped in figure 2. Specimens are kept in the authors' herbarium (Departamento de Biología, Universidad Autónoma de Madrid).

RESULTS

Seventy-four bryophytes (14 liverworts and 60 mosses) have been recorded in the study area. These are listed alphabetically below. Chorological

novelties are marked with an asterisk. The numbers after each taxon refer to the locality (appendix 1). For each taxon, distribution and reproductive state of the taxon throughout the area is summarised. The comments on species abundance refer to classes of IES values[1]. Nomenclature and classification follow Grolle & Long (2000) for liverworts and Casas (1991, 1993, 1995, 1996, and 1999) for mosses, except for the genera *Hypnum* (Smith, 1997) and *Syntrichia* (Gallego, 2002). Authors of plant names are standardised according to Brummit & Powell (1992) following the nomenclatural on line data base of the Missouri Botanical Garden TROPICOS.

HEPATICS

***Frullania dilatata* (L.) Dumort.** – 1-20, 22-60, 62-77, 79-81, 83-111. Generally with sporophytes. Quantitatively, it is the most important epiphyte. Its highest abundance is found in inland localities and decreases towards the coast and in the southeast.

***Frullania fragilifolia* (Taylor) Gottsche, Lindenb. & Nees** – 5, 11-12, 14, 28, 31, 33-34, 57-58, 102, 105, 107-108, 110-111. With sporophytes only in the westernmost localities (and fertile in the mountains). In the studied area it is restricted as an epiphyte to the north and west of the Cantabrian Range. Especially abundant in the Sierra Gerês (Portugal). In the Iberian Peninsula it is found as an epiphyte in the north and west, and its area comprises also some interior mountains where it grows on rocks.

***Frullania microphylla* (Gottsche) Pearson** – 57, 102, 105, 110. With sporophytes in Pontevedra. Found in Atlantic sites in Asturias, Pontevedra and Minho provinces and humid mountains in an inland locality in Orense province. In the Iberian Peninsula it is known from Atlantic areas (mainly in the north and west) but as an epiphyte it has only been reported from Galicia[2].

***Frullania tamarisci* (L.) Dumort.** – 3-7, 9-11, 13-15, 17-18, 20, 25-26, 28-33, 35, 38-40, 47-50, 54-55, 98-108, 110-111. Restricted to the north and west of the Cantabrian Range. Very abundant and fertile in the northeast of the studied area, on the Lugo plain and Gerês.

***Harpalejeunea molleri* (Stephani) Grolle** – 110. Moderately abundant in the Sierra Gerês (Portugal, Fig. 3A). In the Iberian Peninsula it grows on rocks and trees in coastal and sub coastal areas in the north (Spain: Navarra, Vizcaya, Guipuzcoa, Asturias, La Coruña and Pontevedra) and west (Portugal: Minho, Beira Alta, Beira Litoral, Estremadura), as well as on rocks in Gerona (NE Spain) and Cádiz (southern Spain).

***Lejeunea lamacerina* (Stephani) Schiffner** – 102, 110. Very scarce but fertile in the northeastern and southwestern extremities of the study area. In the north and northwest of the Iberian Peninsula it is rather frequent on rocks and soil.

***Microlejeunea ulicina* (Taylor) A. Evans** – 5, 15, 18-19, 25, 100, 103-106, 110. Fertile in the north of Lugo province. In inland localities it is only found northwards (relatively abundant in the Lugo plain). It reaches maximum abundance in the NW.

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1. IES value ≤20: very scarce; 20<IES≤60: scarce; 60<IES≤150: moderately abundant; 150<IES≤300: abundant; IES>300: very abundant.
2. La Coruña (Reinoso & Álvarez, 1984; Reinoso,1985; Reinoso & Viera, 1991b), Lugo (Reinoso & Viera, 1994), Orense (Reinoso & Viera, 1992b).

***Metzgeria fruticulosa* (Dicks.) A. Evans** – 101. Found very scarcely at the northeastern extremity (Fig. 3A). In the Iberian Peninsula it grows on trees all along the Cantabrian Range from sea level to 1100 m (Infante, 2000).

***Metzgeria furcata* (L.) Dumort.** – 1-11, 13,-21, 25-32, 34-35, 37-45, 47-48, 50-54, 57, 63, 68, 70-73, 91-93, 96-97, 99, 101-111. Throughout the territory except in the southeastern extremity. It reaches maximum abundance and occurs with sporophytes in the western half of the study area.

****Metzgeria furcata* var. *ulvula* Nees** – 1, 23, 29, 31, 53, 54, 55. Always propaguliferous. It occurs in the Lugo plain and on the northern slopes of the interior mountains. It usually grows with *M. furcata*, although less abundant.

***Metzgeria temperata* Kuwah.** – 103. Found scarcely in the north of Lugo province (Fig. 3A). Its Iberian distribution is similar to *M. fruticulosa* but it seldom grows higher than 600 m altitude (Infante, 2000).

****Porella obtusata* (Taylor) Trevis** – 20, 29, 35, 47, 80, 101, 110. Scarce and scattered in the area. It reaches maximum abundance in the southwest, in the Sierra Gerês.

***Radula complanata* (L.) Dumort.** – 1, 3-4, 7-11, 13, 15-17, 20-21, 25-27, 29, 31-32, 35-37, 39-42, 44-48, 51-55, 60-61, 64-66, 68-69, 72, 74, 76, 78, 85-88, 90-94, 96-102, 104, 108, 109-110. Generally propaguliferous and with sporophytes. Especially frequent in the north and west of the area. It reaches maximum abundance on mountains and the Lugo plain.

***Radula lindenbergiana* Gottsche ex C. Hartm.** – 3, 110. Always propaguliferous and with sporophytes. Found only in the northeast of the study area in Lugo province and in the southwest in Sierra Gerês.

MOSSES

****Antitrichia curtipendula* (Hedw.) Brid.** – 4, 5, 11-13, 22, 24-26, 31-36, 39, 45, 48, 56-58, 61, 68, 70, 75, 82, 87, 90, 92-95, 98-99, 102, 110-111. With sporophytes in the south of the studied area. Moderately abundant on mountains.

***Aulacomnium androgynum* (Timm ex Hedw.) Brid.** – 89, 90, 107. Generally propaguliferous. Found in the Sierra Ancares and the Limia valley, generally scarce.

***Brachythecium velutinum* (Hedw.) Schimp.** – 15, 20-21, 23-24, 26, 31-32, 35-37, 39-40, 44-45, 50, 54-55, 62, 66-68, 71-72, 74, 77-78, 80, 82, 85, 87-91, 93, 97-98, 107. Generally sterile. Common in inland localities and generally scarce. Only moderately abundant in some sites in the Sierra Ancares.

***Bryum argenteum* Hedw.** – 21. Found very scarcely in the Lugo plain.

***Bryum capillare* Hedw.** – 8, 17, 21, 26-27, 29, 49-50, 62, 70, 73, 87-88, 92, 94-95. Generally scarce. Scattered throughout the territory.

***Ceratodon purpureus* (Hedw.) Brid.** – 26, 50, 87, 95, 100. Occasionally with sporophytes. Found scarcely in inland localities between 450 m and 850 m in altitude.

****Cryphaea heteromalla* (Hedw.) D. Mohr** – 15, 17, 21, 26, 44, 54. Always with sporophytes and moderately abundant. Found in localities between 500 and 700 m in altitude in the north of the interior mountains. These reports from Lugo and Orense provinces are the innermost localities in the northwest, as it was previously reported from coastal or subcoastal areas in La Coruña, Pontevedra (Spain) and Minho (Portugal)[3].

3. Spain: Santiago, La Coruña (Reinoso & Smyth, 1985); Porreiro Mountain, Pontevedra (Casas *et al*., 1992). Portugal: Minho province (Casas *et al*., 1992).

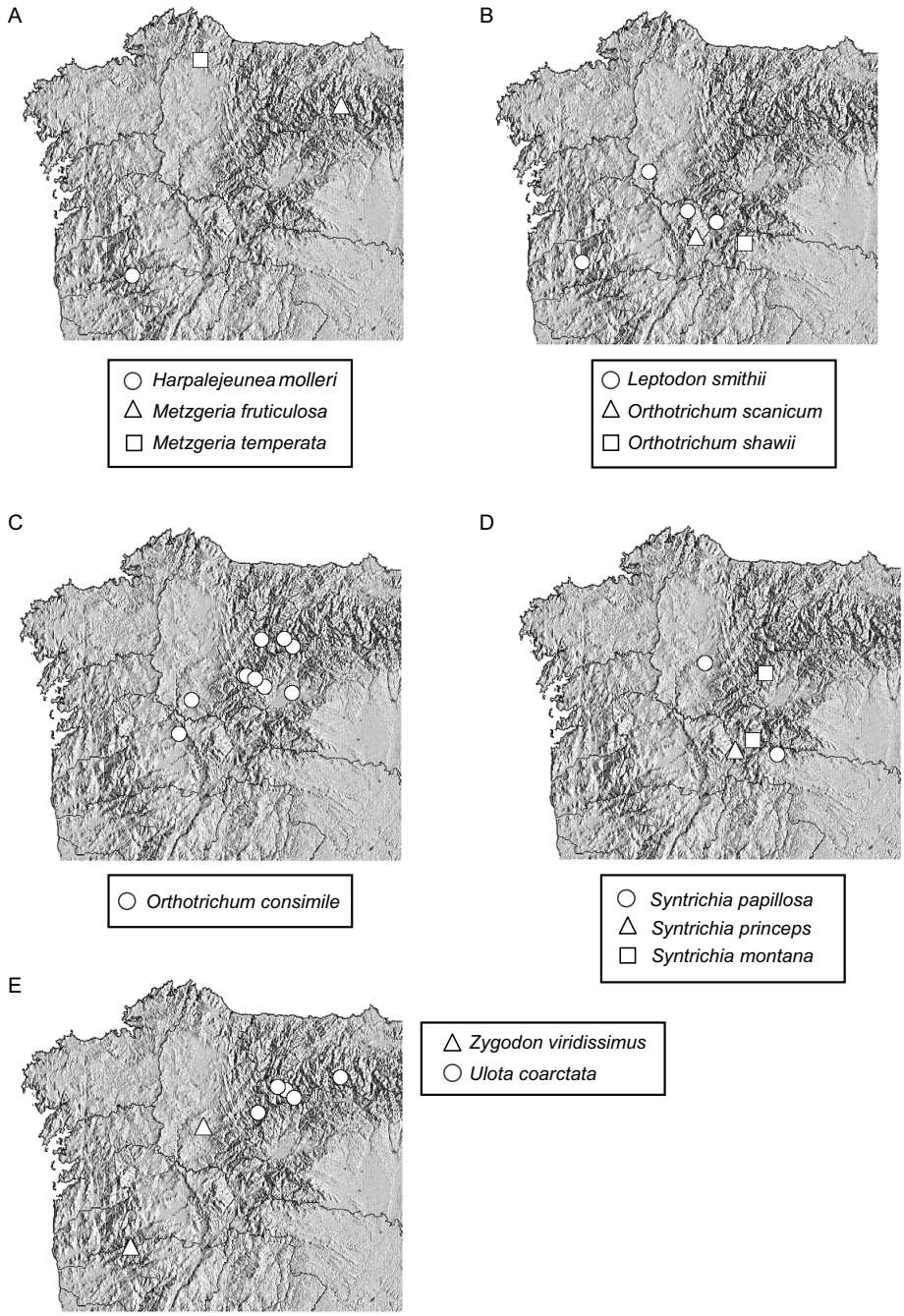

Fig. 3. Distribution of A) *Harpalejeunea molleri*, *Metzgeria fruticulosa* and *M. temperata*; B) *Leptodon smithii*, *Orthotrichum scanicum* and *O. shawii*; C) *Orthotrichum consimile*; D) *Syntrichia papillosa*, *S. princeps* and *S. montana*; E) *Ulota coarctata* and *Zygodon viridissimus* in the studied localities.

***Cynodontium bruntonii* (Sm.) Bruch & Schimp.** – 24, 72, 87. Generally with sporophytes and always scarce. Found in the south of Orense province and in the Sierra Ancares.

****Dicranoweisia cirrata* (Hedw.) Lindb.** – 1, 5-6, 9, 18, 22, 24, 28-30, 34, 39-40, 43, 45, 47-50, 54, 57, 62-63, 65, 68, 70-73, 75, 84, 86-93, 96, 98-100, 107, 111. Generally with sporophytes and moderately abundant. Its distribution is rather homogeneous but it is absent on the Lugo plain, in Sanabria and the coastal forests. It reaches maximum abundance in Lugo province (El Bierzo and Ancares).

***Dicranum scoparium* Hedw.** – 3, 4-6, 11, 14, 16, 18-19, 22, 24, 31, 33-35, 39, 43, 45, 47, 49, 50, 52-55, 57, 60, 64-65, 67-68, 72, 74, 75, 82, 84, 88-90, 96, 98-103, 106-111. It is moderately abundant in the interior mountains and it becomes rarer in the depressions and tablelands.

****Dicranum tauricum* Sapjegin.** – 1-3, 5-6, 14-15, 18-19, 22, 28-31, 34, 56, 59, 68, 74, 82, 89, 93, 96, 107, 110. Only once with sporophytes (locality 18). Occasionally abundant. Found in inland localities although seldom south of the interior mountains.

***Didymodon insulanus* (De Not.) M.O. Hill** – 31, 89. Very scarce in El Bierzo and Lugo plain.

***Eurhynchium crassinervium* (Taylor) Schimp.** – 71. Found once at the south of Orense province, very scarce.

***Eurhynchium praelongum* (Hedw.) Schimp.** – 38, 104. Found in the southwest of Lugo and in La Coruña provinces.

***Grimmia decipiens* (Schultz) Lindb.** – 72, 75, 80, 88-89, 100. With sporophytes in Orense province. Found scarcely in Sanabria, El Bierzo and the south of Orense province.

***Grimmia pulvinata* (Hedw.) Sm.** – 29, 49, 82, 87, 92. Generally scarce but with sporophytes. Found below 600 m altitude except in the León Mountains, near Sanabria, where subject to marked Mediterranean influence.

***Grimmia trichophylla* Grev.** – 6, 34, 48, 50, 54, 57, 62, 67, 76, 78, 80, 86-88, 90, 92, 108. Occasionally with sporophytes and always very scarce. Its frequency increases on the south faces of the interior mountains.

****Habrodon perpusillus* (De Not.) Lindb.** – 15, 46, 54, 68, 78, 85, 94. Occasionally propaguliferous. Found in depressions and tablelands, always scarce.

***Hedwigia ciliata* (Hedw.) P. Beauv.** – 77. Found very scarcely only in the Sanabria region.

***Hedwigia stellata* Hedenäs** – 3, 25, 34, 45, 50, 56-58, 62, 70, 72, 84, 86-89, 92, 100. Scarce or moderately abundant from the inland mountains to the southeast of the study area.

***Homalothecium sericeum* (Hedw.) Schimp.** – 1, 3-4, 6-13, 15-18, 20-32, 34-40, 42-54, 60-62, 65-74, 78, 80-81, 84-88, 90-102, 104, 106-110. Frequently with sporophytes and very abundant. Only absent in the San Mamed and Queija mountains. It frequently dominates epiphytic communities.

***Hypnum andoi* A.J.E. Sm.** – 1-10, 12-35, 37-62, 64-76, 78, 80-82, 84-85, 87-111. Generally with sporophytes. Found in almost all forest but its abundance decreases from northwest to southeast of the study area. In Sanabria it is very scarce and sterile.

***Hypnum cupressiforme* Hedw.** – 1-6, 8-14, 16-19, 22-24, 26-45, 47-57, 59, 61-64, 66-76, 78, 82, 84, 86-109, 111. Rarely with sporophytes. Very frequent although less abundant than the preceding species. Its abundance and distribution are similar but it is rarer than *H. andoi* in the southwest.

****Hypnum resupinatum* Hook. & Taylor** – 25, 27-28, 34, 38, 43, 48, 57, 86, 108. Always sterile and generally scarce. Present on the mountains and the Lugo plain.

****Isothecium alopecuroides* (Lam. ex Dubois) Isov.** – 11, 102. Found at the northeastern extremity of the study area. In the Iberian Peninsula it grows throughout the territory except the south and east. As an epiphyte (generally on tree bases), it is found mainly in the northern half of the Peninsula.

***Isothecium myosuroides* Brid.** – 1-7, 10-11, 13, 16-22, 24-27, 29, 31-32, 35, 38-42, 45, 48, 50, 54, 87, 90, 98, 100, 102-111. Seldom with sporophytes, moderately abundant. Almost restricted to the north and west of the Cantabrian Range. Its abundance increases towards the northwest extremity.

****Leptodon smithii* (Hedw.) F. Weber & D. Mohr** – 29, 47, 60, 108. Restricted to the southwest and always scarce (Fig. 3B).

****Leucodon sciuroides* (Hedw.) Schwägr.** – 3, 4, 8-9, 11-13, 17, 21, 25-26, 29, 36, 44-46, 59-62, 69-70, 75, 78, 85-86, 89-90, 92, 94-96, 101, 110. Frequently propaguliferous and occasionally with sporophytes. Despite its frequency, it is generally scarce. Present in inland localities, preferentially in the easternmost ones. Very abundant in the Sierra Ancares.

***Neckera complanata* (Hedw.) Hübener** – 5, 11, 19-20, 25-26, 33, 35, 46, 102. Frequently propaguliferous and occasionally with sporophytes. Moderately abundant near Lugo city and scarce in the interior mountains.

****Neckera pumila* Hedw.** – 2-4, 10-15, 17, 19, 21, 26-27, 30-32, 35, 42-44, 54-56, 75, 98-106, 108-111. With sporophytes on the Cantabrian Range from the Ancares to Gerês Sierras. Generally propaguliferous. Almost restricted to the north and west of the Cantabrian Range. Abundant in mountain areas.

***Orthotrichum affine* Schrad. ex Brid.** – 1-4, 7-11, 13, 15-19, 21, 23-32, 35-54, 56, 58, 59-96, 98-101, 106-107, 109. Always with sporophytes. It grows in almost every studied locality and dominates epiphytic communities in the southeast. Its abundance decreases towards the north and west.

***Orthotrichum consimile* Mitt.** – 23-24, 37, 50, 88, 90, 93, 98-100. Always with sporophytes. Found in the northeast and in the south of the Lugo plain, generally scarce (Fig. 3C). In the Iberian Peninsula it is only known in Spain. it occurs in sub-coastal ranges in the north of the country from 600 to 1200 m.

***Orthotrichum diaphanum* Schrad. ex Brid.** – 21, 46, 51, 60, 87, 89. Always with sporophytes. It occurs in inland localities outside the mountains. Very scarce in general although moderately abundant in the Lugo plain.

***Orthotrichum lyellii* W. J. Hook. & Taylor** – 1-102, 105-111. Always propaguliferous. Present in nearly all the studied forests and frequently with sporophytes. It is sterile in areas where its abundance is lower, namely depressions and tablelands. Especially abundant in mountainous areas. In coastal localities it is absent in the north and sterile in the northeast.

****Orthotrichum pumilum* Sw.** – 60, 62, 72, 78, 83, 85, 92. Always with sporophytes. Scarce in the south and east of the study area.

****Orthotrichum rupestre* Schleich. ex Schwägr.** – 1, 4, 6, 17, 22-24, 26-27, 29, 31-35, 38, 40, 43-46, 48-50, 53-54, 56-58, 60-65, 67-82, 84, 86-95, 97-98, 100, 107-108. Always with sporophytes. Frequent and abundant south of the interior mountains and scarce in the Lugo plain.

***Orthotrichum scanicum* Grönvall** – 63. Found in the Sierra Queija with sporophytes and very scarce (Fig. 3B). The discovery of this moss in the province of Orense and the Central Pyrenees (Garilleti *et al.,* 1999) was the first report of its presence in the Iberian Peninsula. It is abundant in the Pyrenees (provinces of Huesca and Lérida) and it has also been reported from Portugal (Lara *et al.*, 2001). There are also unpublished collections from the eastern Betic Range (Albacete province).

***Orthotrichum shawii* Wilson** – 80. Found once in Sanabria very scarcely and with sporophytes. In Spain it has been reported from Orense (Mazimpaka *et al.*, 2000; Fig. 3B) and recently from the Pyrenees (Navarra province, Ederra *et al.*, 2003).

***Orthotrichum speciosum* Nees** – 10, 12, 22, 24, 27, 37, 39, 47, 56-58, 61, 63-64, 75, 80, 84, 86-88, 90, 93, 96, 98-100. Always with sporophytes. Common in the territory although absent in the northwestern and southwestern extremities. Maximum abundance in the San Mamed and Queija Sierras.

****Orthotrichum stramineum* Hornsch.** – 3, 10, 23, 26-27, 29, 31-32, 37, 44, 46-47, 49-51, 54, 59, 61-63, 67-68, 72, 74, 76-78, 80-83, 85, 91-92, 95-96, 98-102. Always with sporophytes and generally scarce. Absent in the northwestern extremity. Its abundance increases southwards.

****Orthotrichum striatum* Hedw.** – 1-4, 6-10, 12-15, 18, 23-26, 29-32, 35-54, 56-65, 67-69, 71-102, 105-109. Always with sporophytes. Very common but absent in the northernmost localities, the Sierra Gerês and some forests in the Lugo plain. Its abundance increases south of the interior mountains and reaches maximum values in the Ancares and Sanabria Sierras.

***Orthotrichum tenellum* Bruch ex Brid.** – 4, 8-9, 29, 37, 39, 44, 46, 51, 54, 57, 60, 62, 69, 72, 74, 77, 83, 85, 87, 89, 92, 95, 108. Always with sporophytes. Found in inland localities. It becomes rarer northwards and is absent from northernmost and westernmost localities. Moderately abundant in Sanabria, the León Mountains and Lugo plain. This species is not very frequent in the north of the Iberian Peninsula with the exception of the transitional ranges situated south of the Pyrenees (known as the pre-Pyrenean mountains); the number of reports (24 localities) is evidence of the Mediterranean influence in the northwest, as compared with areas at similar latitude elsewhere in Spain.

***Pseudotaxiphyllum elegans* (Brid.) Z. Iwats.** – 24. Found once with propagules in the Sierra Ancares.

***Pterigynandrum filiforme* Hedw.** – 11-13, 24-25, 32, 56-58, 61, 63, 70-71, 76, 82, 85-86, 91-93, 96, 98-99, 101-102, 107. Occasionally with sporophytes or propagules. It grows south of the Cantabrian Range and is moderately abundant in the mountains.

****Pterogonium gracile* (Hedw.) Sm.** – 3, 5-8, 10-11, 14, 16-18, 20-21, 26-30, 32, 35-37, 39-41, 44, 46-47, 49-54, 59, 62, 66, 68-73, 82, 91-92, 94, 102, 106-111. Preferentially distributed in the western half of the territory occasionally with sporophytes. It reaches maximum abundance in the Sierra Caurel and the Lugo plain.

***Racomitrium heterostichum* (Hedw.) Brid.** – 45, 75, 88-89, 100. Very scarce and preferentially in the eastern half of the territory.

****Rhynchostegium confertum* (Dicks.) Schimp.** – 87, 89. Very scarce. Found in el Bierzo region.

***Scleropodium purum* (Wilson ex Müll. Hal.) L.F. Koch** – 108. Very scarce in the Portuguese Sierra Peneda.

***Syntrichia laevipila* Brid.** – 1, 7-8, 16-17, 21, 27, 29, 35-36, 40, 44, 46, 59-63, 68, 70-73, 77-78, 80, 82, 89, 92, 94-95. Generally with sporophytes and moderately abundant. Absent in the westernmost forests and the northeastern extremity.

***Syntrichia montana* Nees** – 61, 91. Found very scarcely in Ancares and in the east of Orense province, near the León Mountains (Fig. 3D).

***Syntrichia papillosa* (Wilson) Jur.** - 17-78. Scarce in the Lugo plain and Sanabria (Fig. 3D).

***Syntrichia princeps* (De Not.) Mitt.** – 62. Found once in a depression in the west of Orense province (Fig. 3D).

***Syntrichia ruralis* var. *ruraliformis* (Besch.) Delogne** – 83. Scarce on the northern slopes of the León Mountains.

***Syntrichia virescens* (De Not.) Ochyra** – 17, 46, 61-62, 78, 82. Generally with sporophytes. Very rare in the Lugo plain and more frequent in the south-eastern sector (W Orense, Sanabria and León Mountains).

***Ulota bruchii* Hornsch.** – 1-5, 7, 9-16, 18-19, 22-26, 28-35, 37-45, 48-52, 54-57, 61, 67, 76, 91, 93, 95-106, 109-111. Always with sporophytes. Almost restricted to the north and west of the Cantabrian Range. Generally scarce but abundant in the mountains.

***Ulota coarctata* (P. Beauv.) Hammar** – 12, 98-99, 101-102. Always with sporophytes. Found scarcely in Ancares and the province of Asturias (Fig. 3E).

***Ulota crispa* (Hedw.) Brid.** – 2-4, 7-10, 12-19, 22, 24-26, 28-33, 35, 37-40, 42-45, 48-51, 53-57, 66-67, 72, 74, 84, 91, 93, 98-102, 104-106, 108-111. Always with sporophytes. Distribution similar to that of *U. bruchii* and also abundant in the Ancares and Caurel Sierras, but more abundant towards the coast.

***Zygodon conoideus* (Dicks.) Hook. & Taylor** – 1, 4, 8-9, 13, 19, 21, 31, 39, 54, 100, 108-111. Always propaguliferous and scarce. Only once with sporophytes in the Lugo plain. Found in the north and west of the interior mountains.

***Zygodon rupestris* Schimp. ex Lorentz** – 1, 3-4, 7-9, 11-12, 16-18, 20- 21, 25-27, 29, 32, 34-36, 40, 44-47, 49-50, 52-54, 59-62, 66-74, 78, 82, 89, 92, 94-95, 102, 104, 107, 110. Always propaguliferous. Especially abundant and with sporophytes in the Lugo plain where it is one of the dominant species in the epiphytic communities.

***Zygodon viridissimus* (Dicks.) Brid.** – 21, 110. Always propaguliferous and scarce. Found in the Lugo plain and the Sierra Gerês (Fig. 3E). In the northwest it has also been reported from La Coruña (Reinoso, 1984 and Reinoso & Smyth, 1985) and León (Fuertes, 1988).

DISCUSSION

The 74 catalogued species (14 hepatics and 60 mosses) belong to 22 different families. Among the 4 liverwort families, the Frullaniaceae and Metzgeriaceae are the most diverse, with 4 species each. *Frullania dilatata* is the commonest hepatic and the most abundant species of the catalogue (it appears in 107 sites and its IES value averages 197). Among the 17 families of mosses, the Orthotrichaceae are represented by 20 species and *Orthotrichum lyellii* is the most frequent species in the catalogue and the second in abundance (it appears in 109 sites and its mean IES value is 180). *Orthotrichum affine*, *O. striatum* and *O. rupestre* are also very frequent and abundant taxa.

Table 1. Chorological novelties.

Species	*Spain*						*Portugal*		*Iberian NW*
	Lugo	*Orense*	*Pontevedra*	*León*	*Zamora*	*Asturias*	*Galicia's region*	*Minho*	
Frullania microphylla						X		X	
Metzgeria furcata var. *ulvula*	X	X							
Porella obtusata					X				
Antitrichia curtipendula					X				
Cryphaea heteromalla	X	X							
Dicranoweisia cirrata		X							
Dicranum tauricum	X	X					X		
Habrodon perpusillus	X	X			X		X		
Hypnum resupinatum		X		X					
Isothecium alopecuroides	X								
Leptodon smithii		X							
Leucodon sciuroides	X	X							
Neckera pumila					X				
Orthotrichum pumilum		X		X	X		X		X
Orthotrichum rupestre	X								
Orthotrichum stramineum		X			X				
Orthotrichum striatum		X	X						
Pterogonium gracile						X			
Rhybchostegium confertum				X					
Syntrichia montana		X							
Syntrichia laevipila		X			X				
Syntrichia papillosa	X				X				
Syntrichia virescens	X	X		X	X		X		X
Ulota coarctata	X						X		
Zygodon conoideus	X	X							
Zygodon rupestris		X			X				

This catalogue increases our knowledge of the northwestern Iberian region with 44 novelties (Tab. 1) for 7 of the 8 provinces included in this work. Two of these novelties are new for the Galicia region (*Dicranum tauricum* and *Habrodon perpusillus*) and two for the whole northwestern region (*Orthotrichum pumilum* and *Syntrichia virescens*). The increase is especially significant for the provinces of Orense, Lugo and Zamora, with 16, 11 and 10 additions respectively. Other interesting discoveries are *Orthotrichum scanicum* (Garilleti *et al.*, 1999) and *O. shawii* (Mazimpaka *et al.*, 2000), each representing the first report in the Iberian Peninsula. Similarly, the records of *O. consimile* (Mazimpaka *et al.,* 1997), *Ulota bruchi* and *U. coarctata* (Albertos *et al.,* 2000) in the northwest have been very useful in establishing the actual range of these species regionally.

SUBSTRATE AFFINITY

Frequency on bark in the Iberian Peninsula varies greatly among the species listed in the catalogue. Some of them are preferentially terricolous or saxicolous plants which are able to colonise tree trunks only under especially favourable conditions. This situation is sometimes due to the mildness of the climate, reducing the rigour of the epiphytic habitat; in other cases the dryness of the Mediterranean climate makes trunks and rocks ecologically similar, as has been found in other xeric environments (Vitt, 1981). In the first case, hygrophytic plants, growing on rocks or soil, find trunks a suitable habitat. In the second case, environmental dryness leads to the enrichment of the bryophyte communities with some xerophytes occurring on both rocks and trunks, although abundance is generally lower on trees. For that reason, to define the substrate affinity of species accurately requires extensive and systematic sampling in different areas (Barrière *et al.*, 1978). Table 2 shows previous records on bark in the Iberian Peninsula of some facultative epiphytes present in this catalogue. Some comments on their affinity for epiphytic substrates are therefore included here, following Mazimpaka & Lara (1995).

Generally saxicolous plants – namely some *Grimmia* species and the genus *Hedwigia* – can be found regularly on trunks, although they are rarely reported from this habitat (Tab. 2). *Grimmia trichophylla* is the most habitual epiphytic species in the genus and it appeared in 15% of the studied sites, always with low cover values. *Grimmia decipiens* and *G. pulvinata* have also been found on trunks during this study and all of them with sporophytes, indicating successful adaptation to the habitat. *Hedwigia* species, especially *H. stellata*, are regular epiphytes in the Iberian Peninsula (Albertos *et al.*, 1997b). The abundance of *H. stellata* is constantly low but, in the northwest, it is even more frequent than *G. trichophylla*. All these species grow on trunks in areas where the Mediterranean influence is more pronounced, to the south and east of the Cantabrian Range, although *Hedwigia* frequently reaches into the mountain zone. They can be considered cortico-saxicolous plants, preferentially saxicolous.

Some species, considered to be saxi-terricolous plants, can colonize not only tree bases but also trunks if humidity is high enough. *Eurhynchium praelongum* has been found on bark in the Pyrenees and Galicia, and it was found during this study on tree trunks in La Coruña and Lugo provinces. *Pseudotaxiphyllum elegans* was previously found on bark in a hyper Atlantic locality (Fraga de Caaveiro, La Coruña province, Reinoso, 1984) and in the Sierra Ancares in this study (2000 mm of annual rainfall). The data demonstrate that the substrate affinity of these species is indifferent, preferentially saxi-terricolous. *Racomitrium heterostichum* although commoner on rock, also grows on soil. It was found five times in the study area and it is also present as an epiphyte in Portugal (Iberian Central Range, Serra da Estrela, Albertos, 2001). We do not know of any other report of its occurence as an epiphyte in the Iberian Peninsula (nor of any other species of the genus *Racomitrium*) but in the light of our data, it is better considered as an indifferent, preferentially saxicolous plant.

The same applies to some preferentially saxicolous plants, growing on trunks under a degree of oceanic influence as happens in the area. *Cynodontium bruntonii* has been previously reported on trees from Lugo, and the western Spanish Central Range. In this study it was found on three occasions, on two of them with capsules, and so it should be considered a cortico-saxicolous, preferentially saxicolous plant.

Table 2. Occurrence of facultative epiphytes in the Iberian Peninsula and the study area.

Species	*References as epiphyte in the Iberian Peninsula*	*% of localities in the study area*
Aulacomnium androgynum	NW Cantabrian Range: León and Zamora provinces (Allorge, 1928; Garilleti *et al.*, 1994; Bermejo *et al.*, 1989) Iberian Central Range: Ávila and Madrid provinces (Lara & Mazimpaka, 1994; Lara *et al.*, 1997) Iberian Range: Logroño and Teruel provinces (Casas *et al.,* 1977, 1987) Portugal: Alto Alentejo province (Sérgio *et al.,* 1997)	2,7% (Bierzo and SW Orense)
Bryum argenteum	Portugal: Estremadura province (Reis de Barros, 1942)	0,9% (Lugo plain)
Bryum capillare	Usual as epiphyte but not reported south of the Iberian Central Range.	14,4% (Lugo, Orense and León)
Cynodontium bruntonii	Galicia: Lugo province (Reinoso & Viera, 1991a) Iberian Central Range: Cáceres province (Casas *et al.,* 1988)	2,7% (Ancares and S Orense)
Ceratodon purpureus	Cantabrian Range: Cantabria and León provinces (Fernández & Simó, 1977; Muñoz *et al.,* 1995) Iberian Central Rage: Ávila, Guadalajara and Madrid provinces (Lara & Mazimpaka, 1994; Lara *et al.*, 1997) Pyrenees: Navarra provinces (Urdíroz & Ederra, 1996)	4,5% (Lugo, Orense plain, Bierzo, Ancares and Asturias)
Dicranoweisia cirrata	Usual on wood but towards the south is commoner on dead trunks than as an epiphyte except in oceanic areas	40,5% (present in all provinces in the study area)
Dicranum scoparium	Usual as an epiphyte but not reported from the southernmost provinces.	47,7% (present in all provinces in the study area)
Dicranum tauricum	Betic Range: Albacete province (Jiménez *et al.*, 1986) Cantabrian Range: León province (Allorge, 1928; Fernández & Simó, 1977) Iberian Central Range: Cáceres province (Casas *et al.*, 1988) Portugal: Alto Alentejo province (Sérgio *et al.*, 1997)	22,5% (Lugo, León, Orense and Minho)
Didymodon insulanus	Iberian Central Range: Ávila, Madrid and Segovia provinces (López *et al.*, 1993; Lara & Mazimpaka, 1994; Lara *et al.*, 1997) Iberian Range: La Rioja province (Martínez-Abaigar & Ederra, 1992)	1,8% (Lugo plain and Bierzo)
Eurhynchium praelongum	W Pyrenees: Navarra province (Fuertes & López, 1975) Galicia (Reinoso, 1984; Reinoso & Viera, 1991a and 1992)	1,8% (SW Lugo and La Coruña)
Eurhynchium crassinervium	Iberian Central Range: Ávila province (Albertos *et al.*, 1997a)	0,9% (S Orense)
Grimmia trichophylla	La Coruña (Reinoso & Viera, 1991c) Iberian Central Range: Ávila and Segovia provinces (Lara & Mazimpaka, 1994; Lara *et al.*, 1997)	15,3% (Lugo, Orense, Zamora, León and Minho)
Grimmia decipiens	Iberian Central Range: Ávila and Madrid provinces (Elías, 1987; Lara & Mazimpaka, 1994; Lara *et al.*, 1997)	5,4% (Sanabria, N Ancares, Bierzo and Orense)

Table 2. Occurrence of facultative epiphytes in the Iberian Peninsula and the study area *(following).*

Species	*References as epiphyte in the Iberian Peninsula*	*% of localities in the study area*
Grimmia pulvinata	S Andalucía Mountains: Almería province (García-Zamora *et al.*, 1998) W Pyrenees: Navarra province (Toledo & Ederra, 1990; Urdíroz *et al.*, 1997) Iberian Central Range: Ávila and Madrid provinces (López *et al.*, 1993; Lara & Mazimpaka, 1994; Lara *et al.*, 1997)	4,5% (Lugo plain, Orense, Sanabria, Bierzo and Ancares)
Hedwigia ciliata	Cantabrian Range: León province (Fernández-Ordóñez & Simó, 1977*) Iberian Central Range: Ávila and Madrid provices (López *et al.*, 1993*; Lara & Mazimpaka, 1994; Albertos *et al.*, 1997b)	0,9% (Sanabria)
Hedwigia stellata	Iberian Central Range: Ávila and Madrid provinces (Albertos *et al.*, 1997b)	16,2% (S and E of the study area)
Pseudotaxiphyllum elegans	Galicia (Reinoso & Álvarez, 1984; Reinoso, 1984)	0,9% (Ancares)
Racomitrium heterostichum	Iberian Central Range: Portugal (Albertos, 2001)	4,5% (N Ancares, Orense Mountains, Sanabria and Bierzo)
Rhynchostegium confertum	Galicia: La Coruña province (Reinoso, 1984) Iberian Central Range: Ávila and Madrid provinces (Lara & Mazimpaka, 1994; Vicente & Ron, 1989) S Andalucía Mountains: Cádiz province (Allorge, 1946) Catalan Coastal Range: Barcelona province (Casas, 1959) Portugal: Minho province (Barros de Sá Nogueira, 1950)	1,8% (Bierzo)
Scleropodium purum	Iberian Central Range: Ávila, Madrid and Segovia provinces (Lara & Mazimpaka, 1994; Lara *et al.*, 1997)	0,9% (Peneda)

* Citations prior to the description of *Hedwigia stellata* Hedenäs, 1994.

As for indifferent species, *i. e*. those occurring on various substrates, some of them have been found frequently on tree bases, but they are little known as epiphytes on trunks. Examples found on tree trunks during this study are *Aulacomnium androgynum*, *Didymodon insulanus*, *Ceratodon purpureus*, *Scleropodium purum* and *Rhynchostegium confertum*. Deserving special mention is *Dicranum scoparium*, widely known as epiphyte but in fact absent from trees in the south of Spain and Portugal. *Bryum capillare* behaves similarly, although its frequency is lower.

In the Iberian Peninsula, *Dicranum tauricum* has rarely been cited as an epiphyte because it is more usually found on dead wood than on living trunks. It has been reported, as a true epiphyte, from the Cantabrian Range, the easternmost mountains of the Betic Range, the westernmost ones of the Iberian Central Range and central Portugal. In the study area, it was found in 22% of the sites. It seems to prefer a degree of oceanic influence to colonise living trees. This is also the case of *Dicranoweisia cirrata*, which although commonly reported on trunks, becomes rarer towards the south and east in the Iberian Peninsula. In the Central Range

and southwards it is quite unusual on living trees but frequent on logs. In the study area it appeared in 40% of the sampling sites.

Finally, some species have been collected very rarely on trunks and additional information is needed to assess their ecological behaviour. Among them are *Eurhynchium crassinervium* and *Bryum argenteum*. The first was reported as an epiphyte in the Iberian Peninsula in a *Prunus lusitanica* L. grove in the Central Range and also appeared in the SW of Orense. The second was found in 1942 on a tree base, and in the present survey on tree trunk in the Lugo plain.

HOTSPOTS

Conservation policies are increasingly demanding the selection of sites of special biological interest in order to plan the location, extent and management of protected areas. The degree of scientific knowledge determines the accuracy of this selection and, with regard to the cryptogams, this knowledge is highly insufficient in most cases. Our aim is to use the systematic information obtained in this work to contribute to the analysis of the potential interest of the studied sites on the basis of their epiphytic bryophytes.

In the following paragraphs we analyse both richness and rarity in the studied localities and discuss the distribution of this parameters. A third factor usually considered in selecting sites of interest is the representative nature of the flora in a local context, and we have added a few comments on this topic. Finally, we discuss a selection of the most interesting sites.

Species richness – The richness of the studied communities is rather high considering that only the trunks of two phorophyte types have been sampled, but it is not consistent throughout the territory. The number of species found on trunks in each locality (Fig. 4) varies from 5 to 27 (mean value 17, mode 15). In general, diversity values above the median occur mostly in the mountains. On the basis of the mean and mode values for richness, we have considered that sites with 25 or more species can be regarded as specially diverse, that is, a hotspots for epiphytic richness. These sites are mostly located in the Cantabrian Range (Fig. 4) and they are the following ones: site 26, Seoane (25 species), site 29, Lamamarín (27 species), site 54, Vilar de Barrio (27 species), site 100, Santa Comba (25 species), site 102, Muniellos (25 species) and site 110, Portela do Homem (26 species). It seems that the combination of high rainfall and relatively low temperatures favours richness in the epiphytic communities. Nevertheless, the most diverse sites (sites 29 and 54, with 27 species) are located outside the Cantabrian Range, within the area of biogeographical transition. In both sites communities are dominated by *Frullania dilatata*, *Hypnum andoi*, *H. cupressiforme*, *Orthotrichum lyellii*, *O. affine*, and *Metzgeria furcata* and Mediterranean species like *Habrodon perpusillus* and *Orthotrichum tenellum* grow together with more Atlantic species like *Ulota bruchii*, *U. crispa* and *Neckera pumila*.

Rarity – The presence of uncommon species, growing on the boundaries of their ecological range, gives special interest to some of the localities. We have considered locally rare species those whose principal area of distribution is outside the study area, those having appeared with low frequency in the study (if they are not facultative epiphytes), and those included in red-lists. They are commented upon below and their distribution is shown in figure 3.

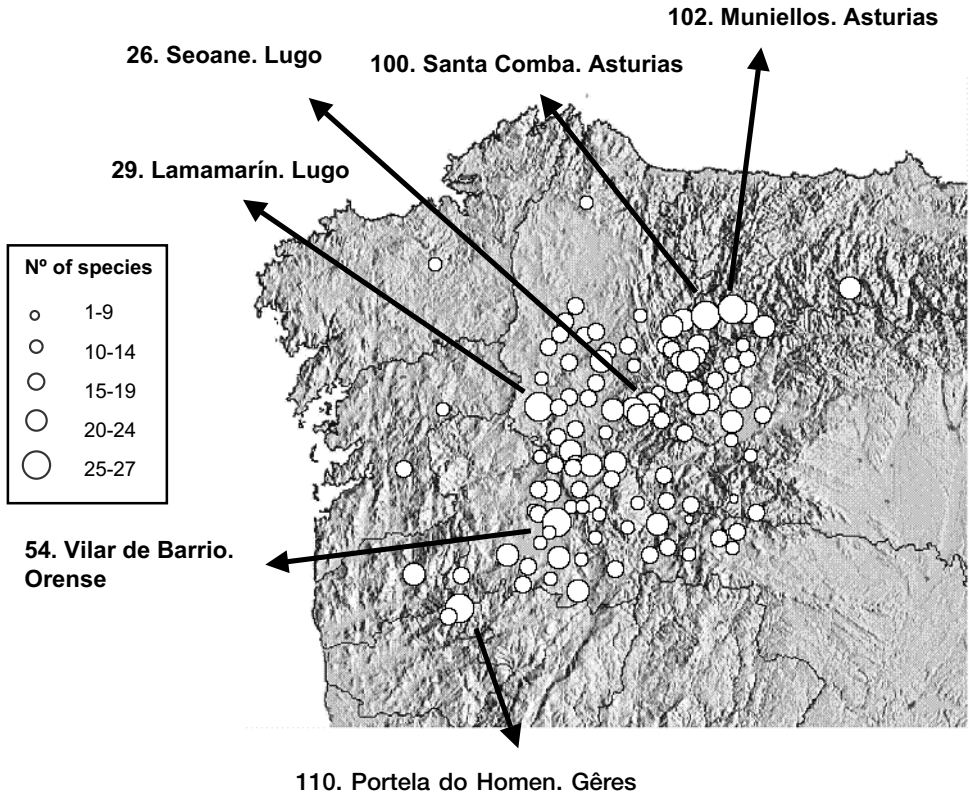

Fig. 4. Distribution of species richness in the area. Labelled sites are those with 25 spp. or more.

Harpalejeunea molleri – Atlantic species uncommon in inland areas such as those preferentially sampled in this study. Found in Gerês, one of the most Oceanic localities (Fig. 3A).

Metzgeria fruticulosa and *M. temperata* – Atlantic epiphytes found only once in the studied area, at the northeastern extremity in the province of Asturias, and north of Lugo province respectively (Fig. 3A).

Leptodon smithii – A Mediterranean-oceanic species common in the south and west of the Iberian Peninsula. It becomes rarer towards the north of Spain. Within the study area, where a certain oceanity can be felt even in the driest parts, it grows in areas subject to Mediterranean influence (Fig. 3B).

Orthotrichum consimile – It is not so infrequent in the studied area (Fig. 3C) having appeared in 11 sites, but we include this species in the category of rare because of its European status: it was at one time regarded as extinct (Schumacker and Düll, 1992) and subsequently as endangered in Europe (Lewinsky-Haapasaari *et al.*, 1995).

Orthotrichum scanicum – Included in the IUCN Red List of threatened species (Bryophyte specialist Group, 2000). Abundant in the Pyrenees but rare elsewhere in the Iberian Peninsula (Fig. 3B).

Orthotrichum shawii – Specially abundant in humid Mediterranean areas, but rare in the Iberian Peninsula (Fig. 3B). Originally reported from Scotland,

Corsica, France and Germany its distribution is now known to include Italy, Portugal, northern Morocco and it is specially abundant in Greece and Sicily.

Syntrichia montana, *S. papillosa*, *S. princeps* – All these *Syntrichia* species are not rare in the Iberian Peninsula, but in the northwest they are at the limits of their range as epiphytes and only grow in areas under Mediterranean influence (Fig. 3D).

Ulota coarctata – In the Iberian Peninsula it is only known from the Cantabrian Range and the records from the northwest do not extend its area of distribution (Albertos *et al.*, 2000), but they confirm the western limits of its range in the Iberian Peninsula. Considering the density of our findings (5 localities in 1500 Km^2, Fig. 3E), this species could be more frequent within its range than previous data suggested.

Zygodon viridissimus – This species is in need of a revision of the herbarium material collected prior to the widespread use of propagule morphology for the identification of *Zygodon* species, as has been proved in regional revisions (Cros, 1983). After the publication of Smith's British and Irish Flora (1978), this species has been reported mainly from the north and west of the Iberian Peninsula, but it seems to be quite rare in the northwest (Fig. 3E).

The number of localities containing at least one of these rare species in the studied area is 23, but only 4 sites have a maximum of two (sites 98, 99, 101 and 110, Fig. 2). Their distribution is more or less scattered but the density of hotspots is higher in the northeastern corner of the study area (the SW of Asturias province and the Sierra Ancares). Sites with 2 rare species, which we have considered to be hotspots of rarity, occur only at the NE and SW extremities of the Cantabrian Range: sites 98 (Cerredo) and 99 (Larón) in Asturias province with *Orthotrichum consimile* and *Ulota coarctata*; site 101 (Fresnedo) in Asturias province with *U. coarctata* and *Metzgeria fruticulosa*; and site 110 (Portela do Homem) in the Portuguese Sierra Gerês with *Harpalejeunea molleri* and *Zygodon viridissimus*.

Representation – It has been already explained how this area is a boundary between two main biogeographical zones, the Atlantic and the Mediterranean ones. Because of the resulting ecotony, the characteristics of the forests vary from clearly Atlantic communities to sub-Mediterranean ones. The ecological interest of some of the studied localities consists of being representative of one of those biogeographical regions. The most evident feature in the comparison between these extremes is that Atlantic communities are dominated by pleurocarpous mosses, mainly *Hypnum andoi*, while Mediterranean communities are dominated by *Orthotrichum* species. Remarkable differences are also found in the abundance of other species with clear affinity for one of the two biogeographical regions, such as *Frullania fragilifolia*, *Neckera* and *Ulota* species in the Atlantic environments, and *Syntrichia* and *Grimmia* species in the area of Mediterranean influence. In order to complete the selection of areas of interest, we have identified some sites whose epiphytic bryophyte flora best illustrates, in our opinion, the extremes of floristic composition in the studied communities and their characteristics are commented upon below.

Localities 33 (Devesa da Rogueira) and 103 (Montouto) in Lugo; 55 (A Teixeira) and 57 (Las Garbias) in Orense; 98 (Cerredo), 99 (Larón), 101 (Fresnedo) and 102 (Muniellos) in Asturias, have epiphytic communities that are widespread in the north of Spain under Atlantic conditions. In addition, site 33 is the westernmost locality of *Fagus sylvatica*. In these localities, bryophyte

communities on *Quercus* are clearly dominated by *Hypnum andoi* and, to a lesser degree, by *Antitrichia curtipendula*, *Isothecium myosuroides*, *Frullania fragilifolia* and *Neckera* species. Both *Ulota bruchii* and *U. crispa* are abundant and frequent and in some of the mentioned localities *Ulota coarctata*, *Metzgeria temperata* and *M. fruticulosa* are found.

Site 110 (Portela do Homen, Minho province) is similar to those mentioned above, although with an even more significant Atlantic influence. Communities are extremely rich and dominated by *Hypnum andoi*, *Frullania tamarisci*, *F. fragilifolia* (*F. dilatata* and *F. microphylla* also present), *Neckera pumila*, *Pterogonium gracile*, and *Antitrichia curtipendula*. Other Atlantic species are *Radula lindenbergiana*, *Lejeunea lamacerina*, *Microlejeunea ulicina* and *Harpalejeunea molleri*.

Forests 62 (San Agustín) and 63 (Pradoalbar) in Orense, 78 (Rábano de Sanabria) and 80 (Ribadelago) in Zamora, and 87 (Camponaraya) in León, are good examples of Mediterranean communities in the studied area. They all have in common the group of dominant species such as O*rthotrichum lyellii*, *O. rupestre*, *O. affine*, *O. stramineum* and *O. striatum*. The abundance of *Frullania dilatata*, co-dominating the communities in some of them (sites 62 and 63), indicates oceanic influence within the Mediterranean area. Other preferentially Mediterranean species that can be found in some of these forests are *Syntrichia virescens*, *O. pumilum*, *O. tenellum* and *O. diaphanum*.

Selected hotspots – Table 3 and figure 5 summarise the qualification of the sites considered as hotspots regarding any of the three criteria explained above. The three criteria do not necessarily coincide at the same site. All of them represent different aspects of the biological interest of a territory and only occasionally do they all point to the same direction. This coincidence occurs in site 110 (Portela do Homem), in the Portuguese Sierra **Gerês,** which can be regarded as a hotspot of rarity with the presence of *Harpalejeunea molleri* and *Zygodon viridissimus*, a hotspot of diversity because of the 26 species catalogued on trunks, and a typical example of an Atlantic bryophyte community.

A second group of forests stand out from the rest with regard to two of the three criteria. For instance, the truly Atlantic forest of site 26 (Seoane), in Sierra **Caurel** is also a hotspot of diversity with 25 species. Besides, four of the localities studied in the **SW of Asturias** (sites 98, Cerredo; 99, Larón; 101, Fresnedo; and 102, Muniellos) qualifies for two criteria, and another one in the same area (site 100, Santa Comba) qualifies for one criterion. They are all interesting in terms of rarity (*Ulota coarctata*, *Orthotrichum consimile* and *Metzgeria fruticulosa* occur in one or more of this localities), their diversity varies between 20 and 25 species, and most of them are good examples of Cantabrian forests.

A third group of sites qualify for one criterion although they also have one rare species. Site 100 has already been mentioned and site 103 (Montouto), in Sierra **Xistral** is also a typical Atlantic forest and the only place where *Metzgeria temperata* was found. Within the area subject to Mediterranean influence, specific diversity generally decreases when compared with Atlantic forests. For that reason site 62 (San Agustín), in **W Orense** must be regarded as an unusually rich area with 22 species representing a distinct Mediterranean-oceanic community. In the same area and also under Mediterranean conditions, *Orthotrichum scanicum*, a rare epiphyte in the Peninsula, was found in site 63 (Pradoalbar). Forests in the **Sanabria** plain (sites 78, Rábano de Sanabria; and 80, Ribadelago) are also representative of the Mediterranean environment and *Orthotrichum shawii* – one of the rarest species in the Iberian Peninsula – occurs at site 80.

Table 3. Summary of criteria used in selection of hotspots.

Site	*Name*	*Province*	*Rarity*	*Nº sp.*	*Representation*	*Nº of fulfilled criteria*
110	Portela do Homem. Serra do Gerês	Minho	*Zygodon viridissimus* *Harpalejeunea molleri*	26	Atlantic	3
26	Seoane	Lugo	-	25	Atlantic	2
98	Cerredo	Asturias	*Ulota coarctata* *Orthotrichum consimile*	23	Atlantic	2
99	Larón	Asturias	*Ulota coarctata* *Orthotrichum consimile*	21	Atlantic	2
101	Fresnedo	Asturias	*Ulota coarctata* *Metzgeria fruticulosa*	20	Atlantic	2
102	Muniellos	Asturias	*Ulota coarctata*	25	Atlantic	2
100	Santa Comba	Asturias	*Orthotrichum consimile*	25	-	1
103	Montouto	Lugo	*Metzgeria temperata*	11	Atlantic	1
62	San Agustín	Orense	*Syntrichia princeps*	22	Mediterranean	1
63	Pradoalbar	Orense	*Orthotrichum scanicum*	13	Mediterranean	1
78	Rábano de Sanabria	Zamora	*Syntrichia papillosa*	18	Mediterranean	1
80	Ribadelago	Zamora	*Orthotrichum shawii*	15	Mediterranean	1
87	Camponaraya	León	-	23	Mediterranean	1
33	Devesa da Rogueira	Lugo	-	12	Atlantic	1
55	A Teixeira	Orense	-	12	Atlantic	1
57	S. Mamede	Orense	-	14	Atlantic	1
29	Lamamarín	Lugo	-	27	-	1
54	Vilar de Barrio	Orense	-	27	-	1

Finally, some areas are also remarkable in terms of conservation because of their representative character or diversity alone. Site 87 (Camponaraya) in **El Bierzo** region is a good example of a Mediterranean community and, with 23 species, is the richest found in Mediterranean environments in this study. Atlantic forests, although not so oceanic as those of Gerês or Asturias, can still be found in Sierra **Caurel** (Lugo and Orense), even though this mountain vegetation has been in general greatly modified. The most representative is site 33 (Devesa da Rogueira) – named after an old man-managed chestnut grove – that has a well preserved oak wood and the westernmost beech forest. Sites 55 (A Teixeira) and 57 (Las Garbias) in Sierra **San Mamed**, are also well preserved forests in a similar environment to those in Caurel Sierra, despite its vicinity to the area subject to Mediterranean influence. Lastly, site 29 (Lamamarín) in the **Lugo plain** and site 54 (Vilar de Barrio) in the **Limia valley** represent the maximum species richness in the studied area. The reason seems to be the combination of influences in

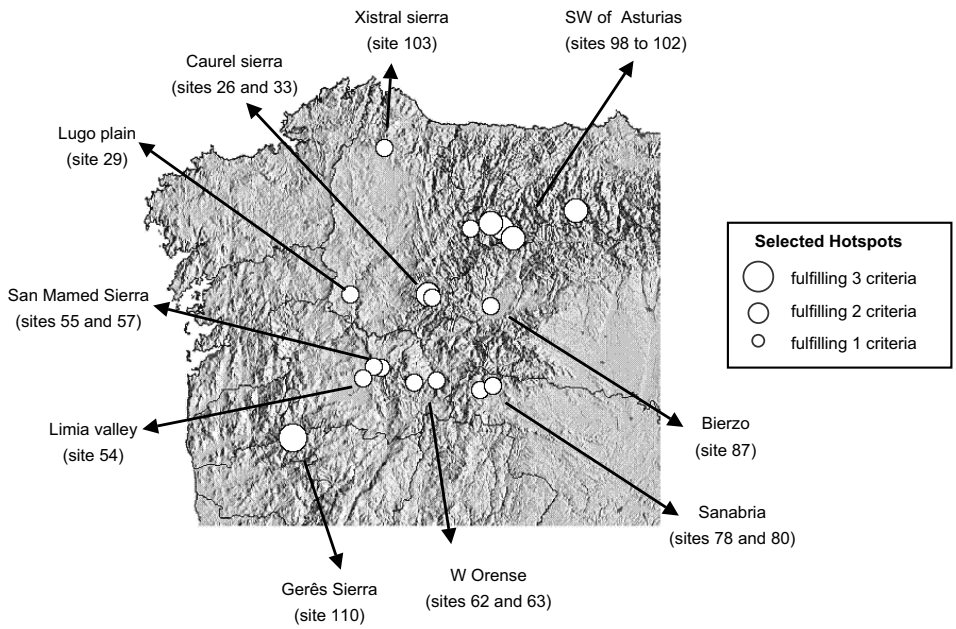

Fig. 5. Sites considered hotspot regarding any of the criteria of species richness, rarity and representation of the epiphytic bryoflora.

the territory favouring the presence of typical species from two biogeographical regions.

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Appendix 1. Sampled localities.

SPAIN

Lugo province: **1**. Lugo, Miño valley (Lugo), 400 m, UTM 29TPH1563. **2**. Quintá (Baleira), 700 m, UTM 29TPH4560. **3**. Muñís, Casa de Fontela (Navia de Suarna), 425 m, UTM 29TPH6559. **4**. Penamil, P.K. 24,5, right riverside of Navia river (Navia de Suarna), 425 m, UTM 29TPH6056. **5**. Calde (Lugo), 700 m, UTM 29TPH1156. **6**. Pradeda (Guntín), 500 m, UTM 29TPH0950. **7**. Ferroy (Guntín), 400 m, UTM 29TPH2050. **8**. Hostal Alborada, Km 6, Nal. 546 (Corgo), 420 m, UTM 29TPH2552. **9**. S. Román (Cervantes), 450 m, UTM 29TPH5748. **10**. Castelo, San Pedro (Cervantes), 600 m, UTM 29TPH6046. **11**. Canto da Cabeza, Pasadas stream (Cervantes), 950 m, UTM 29TPH7348. **12**. Ponte de Vales, 1000 m (Cervantes), UTM 29TPH7244. **13**. Vilanova, P.K. 26 (Cervantes), 620 m, UTM 29TPH6442. **14**. Sta. Mª do Monte (Triacastela), 800 m, UTM 29TPH4438. **15**. Riba de Neira (Baralla), 500 m, UTM 29TPH4047. **16**. Céltigos (Sarria), 425 m, UTM 29TPH3144. **17**. Sarria, near the village (Sarria), 500 m, UTM 29TPH2939. **18**. Higón (Paradela), 400 m, UTM 29TPH1438. **19**. Hospital (Portomarín), 700 m, UTM 29TPH0444. **20**. Taboada, near the village (Taboada), 600 m, UTM 29TPH0230. **21**. Oural (Sarria), 650 m, UTM 29TPH2730. **22**. Veiga de Forcas (Pedrafita), 1130 m, UTM 29TPH5627. **23**. Pedrafita do Cebreiro, near the village on the track to O Portelo (Pedrafita do Cebreiro), 1175 m, UTM 29TPH6232. **24**. To O Portelo, Valdepereos, Curisco river (Pedrafita do Cebreiro), 1200 m, UTM 29TPH6432. **25**. Cales river, near Cela (Cervantes), 1150 m, UTM 29TPH6941. **26**. Seoane, Lor valley (Folgoso do Caurel), 600 m, UTM 29TPH5121. **27**. Between Bóveda and Rubián (Bóveda), 510 m, UTM 29TPH2423. **28**. Between Brozas and Agroxo, near Agroxo (Saviñao), 700 m, UTM 29TPH1523. **29**. Lamamarín (Chantada), 500 m, UTM 29TPH0218. **30**. Villarreme (Saviñao), 600 m, UTM 29TPH1118. **31**. Covadelas (Puebla de Brollón), 700 m, UTM 29TPH3618. **32**. Folgoso-Seceda, Bolsiños, near the waterfall (Folgoso do Caurel), 700 m, UTM 29TPH4519. **33**. Devesa da Rogueira (Folgoso do Caurel), 1115 m, UTM 29TPH5419. **34**. Vieiros (Folgoso do Caurel), 1000 m, UTM 29TPH5815. **35**. Folgoso do Caurel, P.K. 21,5, Salgueiro slopes, Carballido stream (Folgoso do Caurel), 700 m, UTM 29TPH4816. **36**. Los Valles (Monforte de Lemos), 500 m, UTM 29TPH3308. **37**. A Vide (Monforte de Lemos), 260 m, UTM 29TPH1909. **38**. Arribadas-Sernande (Pantón), 590 m, UTM 29TPH1105. **39**. Liñares (Sober), 430 m, UTM 29TPG1899. **40**. Sampil (Sober), 470 m, UTM 29TPG2094. **41**. Portabrosmos (Sober), 210 m, UTM 29TPG2093. **103**. Montouto, Serra do Xistral (Abadín), 850 m, UTM 29TPJ1708.

Orense province: 42. Luintra (Nogueira de Ramuín), 630 m, UTM 29TPG0496. **43**. Alberguería-Parada (Nogueira de Ramuín), 630 m, UTM 29TPG1193. **44**. Castrocaldelas, near the village (Castrocaldelas), 495 m, UTM 29TPG2893. **45**. Ribadas (Río), 960 m, UTM 29TPG3995. **46**. San Fiz (A Veiga), 850 m, UTM 29TPG6191. **47**. Cerdeira, road to Saltos de S. Cristobal (Chandrexa de Queixa), 850 m, UTM 29TPG3788. **48**. Nogueira (Montederramo), 920 m, UTM 29TPG2383. **49**. Parada de Sil, near the village (Parada de Sil), 480 m, UTM 29TPG1992. **50**. Maceda, near the village (Maceda), 640 m, UTM 29TPG1081. **51**. Hermide (Paderne de Allariz), 470 m, UTM 29TPG0482. **52**. Junquera de Ambía, Paciños (Allariz), 500 m, UTM 29TPG0372. **53**. Cima de Vila (Junquera de Ambía), 700 m, UTM 29TPG0571. **54**. Vilar de Barrio, near the village (Vilar de Barrio), 700 m, UTM 29TPG1468. **55**. A Teixeira (Maceda), 900 m, UTM 29TPG2075. **56**. Queixa (Chandrexa de Queixa), 950 m, UTM 29TPG2977. **57**. Las Garbias, La Ferrería, Sierra de S. Mamed (Montederramo), 1200 m, UTM

29TPG2575. **58**. Seixo (Chandrexa de Queixa), 1340 m, UTM 29TPG3372. **59**. Raigada (Manzaneda), 800 m, UTM 29TPG5078. **60**. A Veiga, near the village (A Veiga), 960 m, UTM 29TPG6380. **61**. O Ponte (A Veiga), 1125 m, UTM 29TPG7479. **62**. San Agustín (Viana do Bolo), 800 m, UTM 29TPG6069. **63**. Pradoalbar (Villarino de Conso), 960 m, UTM 29TPG4667. **64**. Camba (Laza), 1100 m, UTM 29TPG3262. **65**. Folgoso (Sarreaus), 680 m, UTM 29TPG1163. **66**. In the way to Vilar de Barrio (Xinzo de Limia), 650 m, UTM 29TPG0758. **67**. Pejeiros (Blancos), 800 m, UTM 29TPG0248. **68**. Between Vila de Rey and Estivadas (Vila de Rey), 680 m, UTM 29TPG1652. **69**. Arcuelos (Laza), 520 m, UTM 29TPG2652. **70**. O Cañizo (A Gudiña), 1060 m, UTM 29TPG5756. **71**. Riós, near the village (Riós), 820 m, UTM 29TPG4249. **72**. Oimbra, near the village (Oimbra), 400 m, UTM 29TPG2638. **73**. Saceda (Cualedro), 740 m, UTM 29TPG1343. **74**. San Pelayo (Baltar), 1000 m, UTM 29TPG0040. **107**. Paradela de Abeleda (A Porqueira), 750 m, UTM 29TNG9352. **109**. Between Entrimo and Illa (Entrimo), 490 m, UTM 29TNG7242.

La Coruña province: 104. Mesón do Vento (Órdenes), 350 m, UTM 29TNH5077.

Pontevedra province: 105. Millerada (Forcarey), 800 m, UTM 29TNH5814. **106**. Moscoso (Fornelos de Montes), 350 m, UTM 29TNG4287.

Zamora province: 75. Pías, near the village (Pías), 1200 m, UTM 29TPG6560. **76**. Hedroso (Lubián), 1105 m, UTM 29TPG7557. **77**. El Puente (Robleda-Cervantes), 980 m, UTM 29TPG9561. **78**. Rábano de Sanabria (Galende), 1100 m, UTM 29TPG9668. **79**. S. Martín de Castañeda (Galende), 1135 m, UTM 29TPG9067. **80**. Ribadelago de Franco (Galende), 1000 m, UTM 29TPG8865. **81**. Porto, near the village (Porto), 1600 m, UTM 29TPG7472.

León province: 82. Truchillas (Truchas), 1465 m, UTM 29TQG0477. **83**. La Baña (Encinedo), 1045 m, UTM 29TPG9482. **84**. Montes de Valdueza (Ponferrada), 925 m, UTM 29TQH0002. **85**. Between Priaranza del Bierzo and Borrenes (Priaranza del Bierzo), 660 m, UTM 29TPH9108. **86**. Castropetre (Oencia), 750 m, UTM 29TPH6910. **87**. Camponaraya, near the village (Camponaraya), 500 m, UTM 29TPH9116. **88**. Congosto, near the village (Congosto), 620 m, UTM 29TQH0420. **89**. Sancedo, near the village (Sancedo), 700 m, UTM 29TPH9427. **90**. Paradaseca (Villafranca del Bierzo), 800 m, UTM 29TPH8024. **91**. Sotoparada (Trabadelo), 650 m, UTM 29TPH7322. **92**. Trabadelo, N-VI road and Trabadelo road crossing (Trabadelo), 625 m, UTM 29TPH72. **93**. From Balboa to Pumarín (Balboa), 850 m, UTM 29TPH7230. **94**. Vilar de Acero (Villafranca del Bierzo), 800 m, UTM 29TPH8134. **95**. Sorbeira (Candín), 850 m, UTM 29TPH8841. **96**. San Pedro de Paradela (Fabero), 800 m, UTM 29TPH9544. **97**. Peranzanes, near the village (Peranzanes), 950 m, UTM 29TPH9350.

Asturias province: 98. Cerredo (Degaña), 950 m, UTM 29TQH0258. **99**. Larón (Cangas de Narcea), 950 m, UTM 29TPH9464. **100**. Santa Comba (Ibias), 450 m, UTM 29TPH7562. **101**. Fresnedo near Páramo (Teverga), 800 m, UTM 29TQH4077. **102**. Muniellos Natural Park (Allande), 700 m, UTM 29TPH8766.

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Minho province: 108. Avelar, Serra Peneda (Viana do Castelo), 625 m, UTM 29TNG5141. **110**. Portela do Homem, Mata de Albergaria (Braga), 770 m, UTM 29TNG7228. **111**. Campo do Gerês to Albergaria (Braga), 740 m, UTM 29TNG6724.