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COMPARATIVE STUDY OF THE BRYOPHYTE EPIPHYTIC VEGETATION IN *QUERCUS PYRENAICA* AND *QUERCUS ROBUR* WOODLANDS FROM NORTHERN PORTUGAL

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Abstract: In the last few decades the remaining woodlands in the northern region of the Portuguese territory have been replaced by large extensions of artificial plantations. Nevertheless, some of these woodlands are still represented and included in the Natura 2000 Network Sites. Epiphytic bryophytes were studied on six sites selected according to its climacic vegetation: pure woodlands of *Quercus robur*, pure woodlands of *Q. pyrenaica* and mixed woodlands of *Q. robur* and *Q. pyrenaica*. Each trunk was divided into a basal, a middle and a top zone. Comparison of species composition for the three major biotypes is based on the use of the Index of Ecological Significance (Lara & Mazimpaka, 1998). Twenty-nine bryophytes (22 mosses and 7 liverworts) were registered but very few species show host specificity. Results helped to clarify some differences between the floristic composition of epiphytic communities in Portuguese temperate and mediterranean woodlands.

INTRODUCTION

Portuguese natural forests are nowadays reduced to small areas, frequently located in mountain areas or in closed valleys of difficult accessibility, in places not suited for agricultural purposes, as most natural woodlands are being destroyed by modern forestry and replaced by large extensions of artificial plantations dominated by *Pinus* and *Eucalyptus* species (Alves *et al.*, 1998). The establishment of epiphytic communities is restricted to those areas with well-structured natural woodlands, especially in the Mediterranean area (Fuertes *et al.*, 1996). Studies on the distribution pattern of epiphytic communities are still scarce in the northern part of the Portuguese territory but the recognition of the vulnerability of these communities to habitat disruption emphasises the importance of baseline studies in relatively undisturbed areas (Schmitt *et al.,* 1990). Correlations between epiphytes and their host trees have been studied by several authors in many types of forest, and those include variation in respect to many factors, such as climate, age of phorophyte, height on the tree, exposure, and geography (Slack, 1976). Recently, a study carried out in Galicia (Albertos *et al.*, 2001) provided an interesting analysis of the host specificity of epiphytic bryophytes growing on different *Quercus* species (*Q. robur* and *Q. pyrenaica*) in a mixed oak wood. Our work is focused in the epiphytic vegetation growing on *Q. robur* and *Q. pyrenaica* both in pure and mixed woodlands. Thus, it can be considered as a similar aproach to the portuguese extension of those woodlands. The following objectives were defined: (1) to analyse the differences between structure and floristic composition of epiphytic communities growing under different ecological conditions; (2) to evaluate the ecological importance of different taxa in these epiphytic habitats using the Index of Ecological Significance (IES) (Lara & Mazimpaka, 1998); and finally (3) to contribute to a more detailed knowledge of the ecology and conservation value of epiphytic vegetation from the main woodlands in the northern region of the Portuguese territory.

METHODS

The study sites

The six sites studied (Figure 1; Table 1) encompass three different provinces: Minho (Mi), Trás-os-Montes e Alto Douro (TM) and Douro Litoral (DL) and are located within areas of NATURA 2000 Network.

Figure 1: Study sites location. 1, Montesinho/Nogueira (pure *Quercus pyrenaica* woodlands); 2, Freita/Arada (pure *Q. robur* woodlands); 3, Corno do Bico (pure *Q. robur* woodlands); 4, Alvão-Marão (pure *Q. pyrenaica* woodlands); 5, Alvão-Marão (mixed woodlands); 6, Peneda-Gerês (mixed woodlands).

Site	Province	UTM Coordinate	Altitude (m)
1	TM	PG7724	1078
2	DL	PF6023	700
3	Mi	NG3736	650
4	TM	PF1091	880
5	TM	NF9885	900
6	Mi	NG8725	800

Table 1. Study sites location. TM: Trás-os-Montes e Alto Douro,DL: Douro Litoral, and Mi: Minho

In the selection of the study sites some factors were taken in consideration, namely age, size and conservation state of the woodland. Only preserved woodlands, remote from urban areas or industrial complexes were selected, so that they would be expected to show natural relationships for epiphytes in mature woodlands for each region. Three types of woodlands were studied: pure woodlands of *Quercus robur*, pure woodlands of *Q. pyrenaica* and mixed woodlands of *Q. robur* and *Q. pyrenaica*. Mixed woodlands are located in the transition between the Mediterranean and Eurosiberian regions of the Northern half of the Iberian Peninsula.

Sampling procedures

Sampling was performed in order to analyse three phorophytes from the same age class in each site. This study was restricted to relatively mature trees (defined by a trunk diameter of approximately 50 cm), and a distance of at least 10 meters was respected between individuals. The sampling was always performed in the centre of the selected woodlands to avoid ecotone effects. Each tree was divided into a basal zone (close to the ground), a middle zone (the central part of the trunk, between 40 cm and 120 cm from the ground), and a top zone (the part just below the first branches, between 120 and 180 cm from the ground) as described by Moe & Botnen (2000). Epiphytes from the branches were not included. In each tree, N, S, E and W exposures were analysed. The sample areas were defined by 20×20 cm quadrats which allowed the estimation of species percentage cover. Altitude (m), phorophyte species, exposure and species percentage cover were registered in each sample. Both bryophytes and lichen cover were registered on each tree in order to establish the relation between the ecological importance of different bryophyte species in these communities with the presence of certain lichenic communities. A total of 288 samples were analysed.

The nomenclature of species is according to Sérgio & Carvalho (2003) and the authors of species names as proposed by Brummit & Powell (1992).

TAXON	FAMILY
BRYOPSIDA	
Antitrichia curtipendula (Hedw.) Brid.	Leucodontaceae
Aulacomnium androgynum (Hedw.) Schwägr.	Aulacomniaceae
Aulacomnium palustre (Hedw.) Schwägr.	Aulacomniaceae
Dicranoweisia cirrata (Hedw.) Lindb. ex Milde	Dicranaceae
Dicranum scoparium Hedw.	Dicranaceae
*Eurhynchium praelongum (*Hedw.) Schimp. var. *stokesii* (Turner) Dixon	Brachytheciaceae
Grimmia decipiens (Schultz) Lindb.	Grimmiaceae
Hedwigia ciliata (Hedw.) P. Beauv.	Hedwigiaceae
Homalothecium sericeum (Hedw.) Schimp.	Brachytheciaceae
Hypnum andoi A. J. E. Smith	Hypnaceae
Hypnum cupressiforme Hedw. *s. l.*	Hypnaceae
Isothecium myosuroides Brid.	Brachytheciaceae
Leucodon sciuroides (Hedw.) Schwägr. var. *morensis* (Schwägr.) De Not.	Leucodontaceae
Leptodon smithii (Hedw.) F. Weber & D. Mohr	Neckeraceae
Neckera pumila Hedw. var. *pumila*	Neckeraceae
Orthotrichum lyellii Hook. & Taylor	Orthotrichaceae
Orthotrichum rupestre Schwägr. var. *rupestre*	Orthotrichaceae
Plagiothecium denticulatum (Hedw.) Schimp.	Plagiotheciaceae
Pterogonium gracile (Hedw.) Sm.	Leucodontaceae
Racomitrium heterostichum (Hedw.) Brid.	Grimmiaceae
Rhytidiadelphus triquetrus (Hedw.) Warnst.	Hypnaceae
Syntrichia laevipila (Brid.)	Pottiaceae
HEPATICOPSIDA	
Cololejeunea minutissima (Sm.) Schiffn.	Lejeuneaceae
Frullania dilatata (L.) Dumort.	Frullaniaceae
Frullania tamarisci (L.) Dumort.	Frullaniaceae
Metzgeria furcata (L.) Dumort.	Metzgeriaceae
Porella obtusata (Taylor) Trevis.	Porellaceae
Radula complanata (L.) Dumort.	Radulaceae
Radula lindenbergiana Gottsche ex C. Hartm.	Radulaceae

Table 2. List of bryophyte taxa found in the studied sites, arranged in alphabetical order, and their respective families.

Data analysis

As pointed by Slack (1976), the exposure factor does not seem to have as much effect in epiphyte distribution within a forest, as height on the tree does. After a careful analysis of the species richness and cover the results confirmed this conclusion (data not shown), therefore the data analysis was performed on the average of the percentage cover values registered for each species in the three levels of the trunk.

Additionally the original cover values were transformed in order to use the Index of Ecological Value or IES (Lara & Mazimpaka, 1998) which is based on the combination of the relative frequency and the mean cover of a species at a given site or habitat in the following way:

$$IES = F + FC$$

where F represents the relative frequency and C the mean cover of the species.

The range of index values is between 0 and 600, but in practice, and according to its authors, values over 400 are very rare, since they represent a consistent and almost absolute dominance of a taxon. In general, values over 50 reveal a significant ecological importance. The advantages of using this index are its simplicity, as it uses relative frequency values, and the fact that an over-evaluation of relative frequency avoids the distortion caused by the presence of occasional taxa with extensive cover, which can show much higher values than those more frequent, but with less extensive cover (Lara & Mazimpaka, 1998).

RESULTS

Twenty-nine bryophytes (22 mosses and 7 liverworts) were registered and are listed in Table 2.

Pure *Quercus robur* forests

Nineteen species were collected on *Quercus robur* trees in pure forests (Figure 2; Table 2). Epiphytic communities were persistently dominated by the pleurocarpous *Hypnum cupressiforme s.l.*, followed by *Pterogonium gracile*, *Neckera pumila*, *Isothecium myosuroides* and *Frullania tamarisci*.

Leptodon smithii, *Isothecium myosuroides*, *Hypnum andoi* and *Rhytidiadelphus triquetus* occurred exclusively on these trees, colonizing the middle part of trunks. Although sporadic, the two liverworts, *Cololejeunea minutissima* and *Metzgeria furcata*, were only found on top of the trunks. The middle part of the trunk is the richest in terms of species diversity.

Pure *Quercus pyrenaica* forests

Nineteen species were collected from *Quercus pyrenaica* trees (Figure 3; Table 2), the most frequent and abundant was again the pleurocarpous *Hypnum cupressiforme*, followed by *Orthotrichum* lyelli,i *Homalothecium sericeum*, *Aulacomnium androgynum* and *Pterogonium gracile*. *Frullania tamarisci* and *F. dilatata* were particularly abundant in the middle of the trunk. Species such as *Aulacomnium androgynum*, *Eurhynchium praelongum* var. *stokesii* and *Radula lindbergiana* occurred only in this type of woodlands, especially at the base of trees. In this case, the basal part of the trunk is the richest in terms of species diversity.

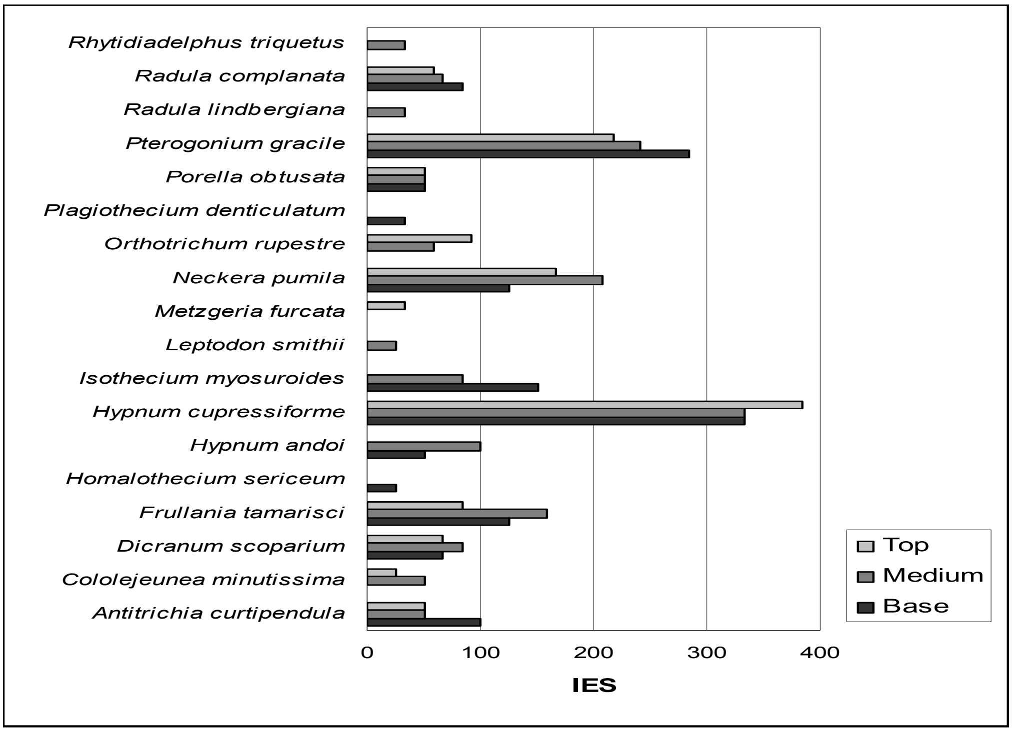

Figure 2: Index of Ecological Significance (IES) values of bryophytes species found on pure *Quercus robur* woodlands at different heights on the trunk.

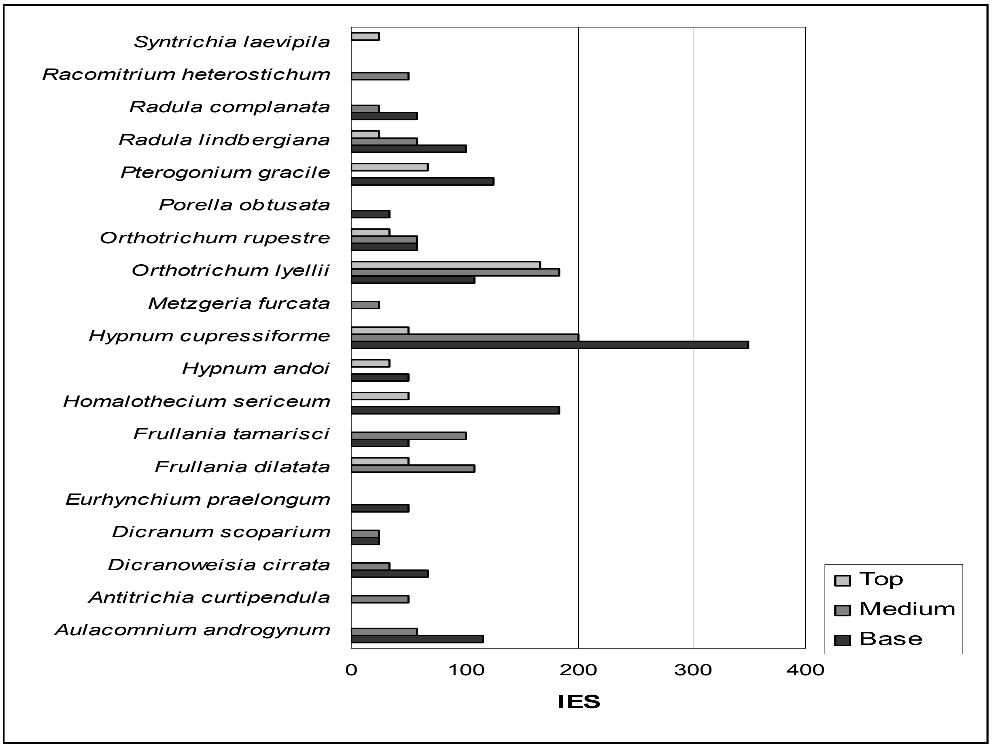

Figure 3. Index of Ecological Significance (IES) values of bryophytes species from pure *Quercus pyrenaica* woodlands at different heights on the trunk.

Mixed woodlands of *Q. robur* and *Q. pyrenaica*

In mixed stands dominated by *Q. robur* trees, the total number of species found decreases to eleven (Figure 4, A). *Hypnum cupressiforme* persists troughout the different parts of the trunk of *Q. robur*, even in mixed woodlands. Therefore, its IES value is very similar to the pure situation. However, a few species become less frequent and abundant, such as *Pterogonium gracile*, *Frullania tamarisci*, *Radula complanata* and *Dicranum scoparium*, or do not occur at all, as it happens with liverworts that occurred sporadically in pure forests, *Cololejeunea minutissima* and *Metzgeria furcata*. The difference between pure and mixed woodlands in terms of number of species is not significant, because species like *Orthotrichum lyellii* and *Dicranoweisia cirrata* occur, enriching the middle part of the trunk.

In mixed stands dominated by *Quercus pyrenaica*, taxa characterized by a large ecological amplitude such as *Hypnum cupressiforme* and *Homalothecium sericeum* find their dominance substantially reduced, and the majority of the mesophilic species identified in pure forests disappear (Figure 4, B). However, communities are enriched by species that occur exclusively associated with these trees, as the xerophytic *Leucodon sciuroides* var. *morensis* or with those normally associated to saxicolous habitats, such as *Grimmia decipiens* and *Hedwigia ciliata*. *Neckera pumila* and other mesophilic species are more frequent and abundant in these woodlands when compared to pure ones, while *Porella obtusata* disappears.

In mixed woodlands there is an overall loss of bryophytic diversity and change in species dominance, especially evident in *Quercus robur*, due to a much higher percentage cover of the lichenic component (Figure 5). *Frullania dilatata* was present in both pure and mixed woodlands but only occurred on *Q. pyrenaica* never on *Q. robur* trunks.

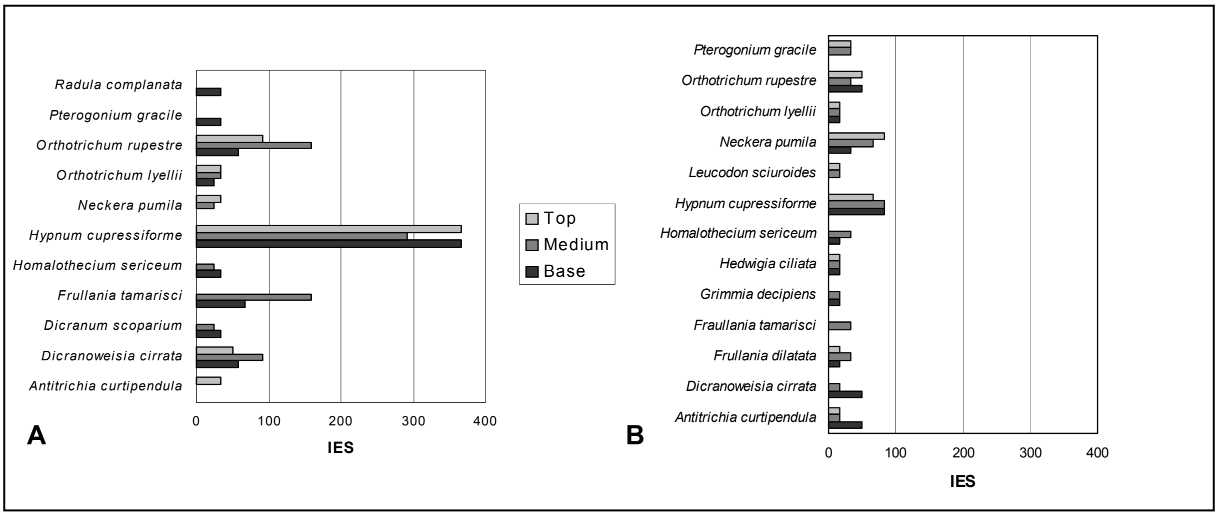

Figure 4: Index of Ecological Significance (IES) values of bryophytes species found in mixed woodlands at different heights on the trunk of *Quercus robur* (A) and *Q. pyrenaica* (B).

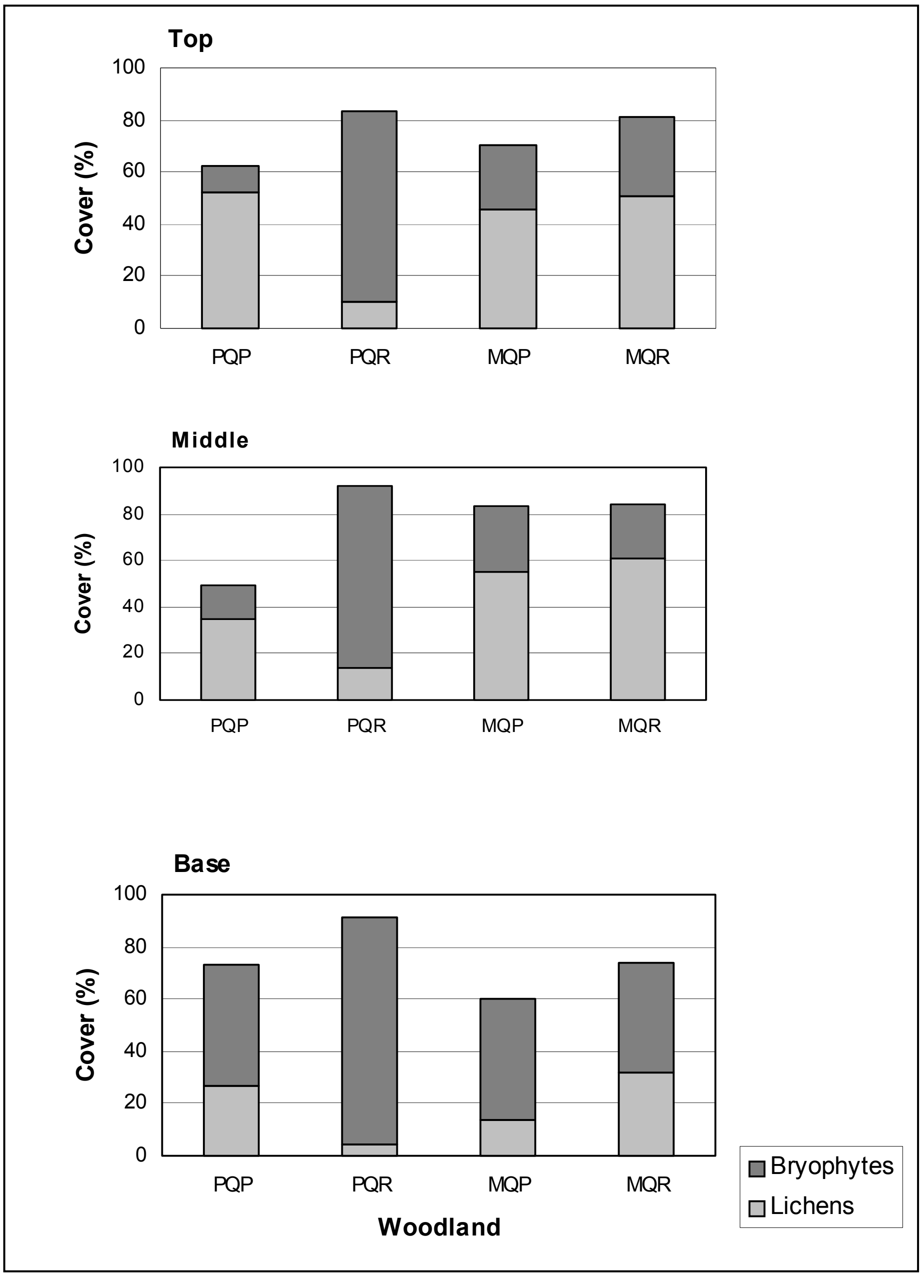

Figure 5. Percentage cover of epiphytic bryophytes found on studied woodlands at different heights in the trunk.

DISCUSSION

Epiphytic bryophytes are known to be sensitive to microclimatic variations (Moe *et al.,* 2000) and as it as been underlined by Fuertes *et al* (1996), the presence and distribution of bryophyte epiphytes in Portugal is directly related to air moisture and decreases following a north to south and west to east phytogeographical gradient.

In pure *Quercus pyrenaica* woodlands, the results indicate that the floristic composition of middle-aged trees closely resemble those described in detail by Lara & Mazimpaka (1994, 1998). These trees host bryophyte communities dominated by distinct *Orthotrichum* species – *O. rupestre* and *O. lyellii*– and by the xerophytic *Frullania dilatata*, and are frequently enriched by mesophilic species which ascend from the base of the trunks, such as the pleurocarpous *Hypnum cupressiforme* and *Homalothecium sericeum*. However, as pointed before, a great part of the species collected from trunks in pure *Q. pyrenaica* woodlands disappear or find their dominance substancially reduced in mixed woodlands of the Eurosiberian-Mediterranean border. The relatively regular occurrence of several saxicolous taxa can be associated to a mediterranean humid climate, with a markedly dry summer period (Lara & Mazimpaka, 1994).

The same reduction in species dominance occurs in *Quercus robur* trees in mixed woodlands, perhaps in a more obvious way. Regarding pure *Q. robur* woodlands, located in the western part of the studied area, the base is occupied by homogeneous communities of hygrophytic elements with great cover such as *Hypnum cupressiforme*, as well as *Isothecium myosuroides* and *Neckera pumila*. The presence of these oceanic species and of some liverworts reflects the climatic conditions of the Eurosiberian area. The microclimatic conditions of the top of the trunks are less favourable to the establishment of hygrophytic species. The absence of the photophilous and oceanic *Orthotrichum lyellii*, which thrives well even when the trunk is exposed to cold and dessicating winds (Moe & Botnen, 2000), did not colonize these trees, perhaps due to the sheltered locations of the woods studied.

There is a significantly lower number of species and percentage cover of bryophytes than of lichens as epiphytes in the different sites, particularly those situated in Mediterranean areas and at the Eurosiberian-Mediterranean border. The bryophytic component found on *Q. robur* trees from Eurosiberian areas is always higher than the lichenic component in terms of percentage cover, independently from the height in the trunk, and there is a dominance of the atlantic mat-type species, so that a vertical zonation is not very evident. This may reflect differences in the structure of the canopy, but is more likely to be correlated with the overall macroclimatic conditions (Burgaz *et al.,* 1994, Fuertes *et al.,* 1996). Bryophytes are more competitive in more humid habitats than lichens and disappear if the desiccation periods get too long, which are, on the other hand, tolerated by lichens (Frahm, 2003). The disappearence of liverworts with atlantic affinity from trunks of *Quercus robur* in mixed woodlands reflects increase in the length of dry periods during the year. In some cases differences may result from preferences for low altitudes as it happens with the presence of *Dicranoweisia cirrata*.

It is clear from the results that there are some remarkable similarities in the floristic composition and taxa richness of bryophytic epiphyte communites of the two phorophytes, while growing in the same ecological context, as shown by Albertos *et al.* (2001) for the mixed oak woods in Galicia. Nevertheless, the studied communities show both similarities and differences in their composition for the same phorophyte in two different areas. On the other hand only a few of the bryophyte species recorded are exclusive of the northern region. With few exceptions (*Frullania dilatata*), nearly all bryophyte species were present in the two phorophytes so, the results of this study show very little host specificity for individual bryophyte species.

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