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The phytogeography of Mediterranean bryophytes: progress and problems

Abstract

Geissler, P.: The phytogeography of Mediterranean bryophytes: progress and problems. – Bocconea 13: 81-88. 2001. – ISSN 1120-4060.

A survey on the state of bryofloristic knowledge of the area around the Mediterranean Sea includes very approximative species numbers of the related countries, a review of bryogeographical terms used for this area and some delimitations to be considered for a program to establish a checklist of bryophytes in the Mediterranean area.

Introduction

Mediterranean-type vegetation can be succinctly characterized by dominant sclerophyll forest, a growth-form adapted to the semiarid climate, hot and dry in summer and mild in winter receiving then two thirds of the annual rainfall. These particular conditions are also found in California, Chili, Cape and Southern and Southwestern Australia, belonging to four different phytogeographic areas, the Holarctis, Neotropis, Cape and Australia (see e.g. the map (fig. 1) in Castri & Mooney (1973)). The dominant vegetation in each of these areas is taxonomically unique. With respect to seed plant diversity the region around the Mediterranean Sea is by far the richest among them and probably also the best known (Quézel 1985).

Bryophytes rather play a secondary role in these vegetation types. The climatic conditions hamper the evolution towards bogs, fens or snow beds, rich in bryophytes in boreal zones. Inside the evergreen oak forest survival conditions are less extreme, sometimes even comparable to more thermophilous temperate deciduous forests, only perhaps with less bryophytes covering the soil. However, human disturbance led to degradation towards a dense maquis (Garrigue, Phrygana). The only habitats where bryophytes are found in typical mediterranean growing conditions, and where they might compete with seed plants, are rocks and rock-crevices as well as open areas, bare soils or slopes, patchily distributed within the degraded low scrub and grassland. Groups that are particularly resistant to prolongated periods of drought are the Marchantiales among the liverworts and the moss family *Pottiaceae*.

Since the beginning of modern botany in the 16th century the richness of flowering plant diversity of the region around the Mediterranean Sea, particularly with its endemisms

has been an attraction to naturalists. To bryophytes, however, not the same attention was paid, although several typical Mediterranean Marchantialean genera have already been recognized by Micheli (1729), at a time when the quality of microscopes hardly allowed to distinguish cellular structures.

Today, our knowledge on the ecological importance of bryophytes in mediterranean habitats is scarce. How do these organisms manage reproductive efforts? What are their particular life strategies? How did the mediterranean bryoflora evolve? Are they genetically distinct from their relatives, mostly considered as conspecific, in mediterranean regions of other continents?

These questions can only be answered by thorough studies of the Mediterranean bryophytes. The organisation of an international project, as already operational for lichens (Nimis 1996) would be helpful. Two conditions have to be fulfilled as a working base with the aim to receive comparable results: Intensive field exploration, particularly of the floristically less known parts, and a common application of a sound taxonomic concept.

Present state of floristics in mediterranean countries.

No modern bryophyte flora is available for any mediterranean country. Projects for Israel, Spain and Italy are in progress, at various levels of achievement. Check-lists were published for Spain (Casas 1981, Sérgio & al. 1994), Italy (Aleffi & Schumacker 1995, Cortini Pedrotti 1992), Greece (Düll 1995), Turkey (Çetin 1988); the North African regions are under work (Ros & al. 1998). For the European part Düll (1983, 1984, 1985, 1992) published an extensive list of species indicating their presence in each country, delimited by the political border. Unfortunately he gives no clear information on its source, whether it is based on literature or field record, and where the corresponding herbarium specimen is housed. For the purpose of this presentation a draft "bryomedchecklist" was produced (T. 1), putting the data from Düll (1983, 1992) in a table, completed for North Africa and the Near East with available indications from Bilewsky (1965), El Oqlah & al. (1988), El-Saadawi & Badawi (1977), Gattefossé & Werner (1932), Herrnstadt & al. (1982), Jelenc (1950), Jovet-Ast & Bischler (1966, 1971), Pampanini (1930), Townsend (1964), citing the most recent publication for each country. In contrast to Düll (1983, 1992) and Greuter & al. (1984), the area considered was deliberately restricted to the biogeographical Mediterranean zone, thus excluding Macaronesia and the oceanic, temperate and alpine regions of the European countries (but including the oromediterranean level). Only taxa recognized at species level were considered. The approximate numbers listed in T. 1, completed to the higher fifty, might be somewhat lower than in the corresponding checklists. No verifications or other critical assessments were done. The intention of that list is only to give a rough idea on current knowledge. In some cases low numbers indicate low habitat diversity indeed, as e.g. in Egypt, but also lack of bryological activities. For some countries, as e.g. Algeria, Libya, Albania, few recent field data are available.

Bryogeographical and taxonomic considerations

Traditional plant geography deals with the analysis of distribution patterns. Chorological investigations start with putting dots or hatching areas on geographical maps.

These limits could be explained with correlations between climatological and ecological factors determining the environment within this area and the autecology of the plant considered, at least for species of the dominant vegetation layer. Distribution areas may depend on latitudinal (arctic, boreal, temperate, meridional), longitudinal (oceanic, continental) or altitudinal (lowland, montane, subalpine, alpine) gradients. Meusel & al. (1965) define as floral element the center of the distribution area in strict geographical terms. Thus they describe within the Holarctis 11 floral regions, within the Macaronesian-Mediterranean region the macaronesian, mediterranean, submediterranean and caucasian subregion, each with several provinces with a characteristic combination of floral elements and often endemic species.

For bryophytes the situation is more complex. Generally, the distribution area of most species extends over several continents, endemisms are much rarer and species disjunctions more frequent. Herzog (1926), the author of the reference manual on bryogeography, followed mainly the classical approach. The first part if his book deals with ecology, dispersal and anatomical adaptations, and presents then the chorological particularities of the larger families. The second part is devoted to floristic bryogeography, with the analysis of disjunctions and endemisms according to phytogeographic regions (Florenreich) and provinces already delimited in the last century. He too recognized the presence of Mediterranean taxa in the southern part of Pacific North America as well as in the mediterranean vegetation types of South Africa. He already noted on the coincidence of the areas of the moss genus *Gigaspermum* and the conifer *Callitris* (including *Callitris* = *Tetraclinis articulata* (Vahl) Masters) in the West Mediterranean area, South Africa, and Australia. The extensive description of the "European" Mediterranean region (however, he explicitly includes also North Africa and Near East) gives long lists of endemic species.

Today, most of them are considered as microspecies of commoner holarctic taxa, or they have now been discovered also outside the strict Mediterranean area. Hardly any endemic Mediterranean liverwort is known (Bischler-Causse 1994). However, the Mediterranean-North African area appears to be the center of dispersal if not a center of origin of the genus *Riella,* occuring also in California, Argentina, South Africa, Australia and Turkestan (Schuster 1992). *Riella bialata* Trab. and *R. numidica* Trab. from Algeria as well as *R. cyrenaica* Maire from Libya are still considered to be good species (Jelenc 1957). This seems true also for two members of another typical Mediterrean genus, *Riccia melitensis* Mass. from Gozo and *Riccia mamillata* Trab. from Algeria, both only reported from the type specimens collected in 1906 and 1942 and never seen since, whereas Jovet-Ast (1986) considers the Algerian *Riccia zachariae* K. Müll., still recognized by Grolle (1983), as a synonym of *R. gougetiana* Dur. & Mont. Also *Riccia sommieri* Levier and *Athalamia spathysii* (Lindenb.) Hatt. has up till now not yet been discovered outside the area, *Mannia androgyna* (L.) Evans occurs also in the Caucasus.

Among the "endemic" mosses *Sematophyllum bottini* (Breidl.) Podp. and *Weissia tyrrhena* Fleisch. described from Viareggio and Portofino respectively, were recently rediscovered on Ischia (Thyssen 1965; Düll 1992), however without questioning its taxonomic status. *Barbella strongylensis* Bott. and *Thamnobryum cossyrense* (Bott.) A. J. E. Sm. are currently investigated. Among the more frequent species only the range of *Homalia lusitanica* Schimp. (He 1997), *Weissia triumphans* (De Not.) M. Hill and *Pottia pallida* Lindb. seems to be restricted to the Mediterranean environment. All other taxa mentionned by

Herzog (1926) are also dwelling in other continents or in temperate zones. However, thorough field work in the Iberian peninsula revealed the existence of several endemic species, mostly new to science, among others:

Acaulon casasianum Brugués & Crum
Acaulon dertosense Casas, Sérgio, Cros & Brugués
Anomobryum lusitanicum (Luis.) Thér.
Didymodon bistratosum Hébrard & Pierrot
Didymodon sicculus Cano. Ros, Garcia-Zamora & Guerra
Gymnostomum lanceolatum Cano, Ros & Guerra
Orthotrichum macrocephalum Lara, Garilleti & Mazimpaka
Phascum cuynetii M. Biz. & Pierrot
Phascum longipes Guerra, Martinez & Ros
Pterygoneurum compactum Cano, Guerra & Ros

Some of them have now already been discovered in adjacent countries.

Fissidens mnevidis Amann, *Grimmia nutans* Bruch, *Enthostodon durieui* Mont., *Gymnostomum mosis* (Lor.) Jur. & Milde and *Tortula rigescens* Broth. & Geh. were earlier believed to be eastern-mediterranean endemics, but the latter three are now also reported from the western part. The high bryodiversity of the Iberian peninsula is not otherwise surprising because also with respect to seed plants this region is particularly rich in endemics.

Recent discoveries or range extensions of *Crossidium seriatum* Crum & Steere (Pottiaceae), *Didymodon trivialis* (C. Müll.) J. Guerra (Pottiaceae), *Gigaspermum mourettii* Corb. (Gigaspermaceae), *Goniomitrium seroi* Casas (Funariaceae), *Tortula bolanderi* (Lesq. & James) M. A. Howe (Pottiaceae), and *Triquetrella arapilensis* Luis. (Pottiaceae) demonstrate close relationship at species or genus level to other mediterranean areas of the world.

Calymperes erosum C. Müll. (Calymperaceae), *Didymodon australasiae* (Hook. & Grev.) Zand. (Pottiaceae), *Didymodon umbrosus* (C. Müll.) Zand. (Pottiaceae), *Helicodontium italicum* (Schimp.) Fleisch. (Myriniaceae), *Racomitrium lamprocarpum* (C. Müll.) Jaeg. (Grimmiaceae), *Rhamphidium purpuratum* Mitt. (Ditrichaceae), *Trematodon longicollis* Michx. (Bruchiaceae), and *Vesicularia galerulata* (Duby) Broth. (Hypnaceae) have tropical affinities. They might have been introduced, some of them are growing on hot, even active volcanic soil or rock.

Many bryophytes which are frequent in mediterranean environments, are also found as rarities on xero-thermophilous sites in Central and Western Europe. The richness of the Mediterranean bryoflora is also due to the presence of some "oceanic" microhabitats, narrow ravines or other protected places sheltered from the summer drought. Thus several leafy liverworts, members of tropical genera, are sporadically encountered in the western Mediterranean basin, whereas they are more frequent from Macaronesia along the Atlantic coast up to the British Isles. Salanon & al. (1990) studied in the "Vallon des Serres" near Nice the survival conditions of the unique French Mediterranean population of *Marchesinia mackaii* (Hook.) S. Gray., the only extratropical species of an African-Neotropical genus. It is known from 12 stations along the Mediterranean coast from Spain to Italy and Croatia. The microclimate inside the Vallon des Serres is characterized by a constant high atmospheric humidity. The accompanying species on the shaded rocks are frequently found in Western and Central Europe. Only *Tortella inflexa* (Bruch) Broth. or

Homalia lusitanica Schimp. are more typical Mediterranean species. The vascular plant vegetation at the bottom of these narrow, deep incisions where the large top areas are colonized by sclerophyllous scrub, is even more dominated by temperate elements. Surprisingly, *Marchesinia* was only found on a single place within this system of "vallons obscurs" of more than 100 km length with comparable growing conditions.

Düll (1983, 1984, 1985) attributes chorological indications ("primary centers of distribution") for the species listed. They are neither clearly defined, nor is a reference work cited, nor is an explanation given on how these attributions were established (Schumacker 1988). Some as carp[atic], pont[ic] or s[outhern] etc. refer to geographical definitions, others as mediterranean-oceanic and oceanic-mediterranean include ecological aspects. It is quite obvious that "mediterranean" means here also meridional and thermo(xero-)philous, as some of these species occur also in Central Europe in appropriate habitats. Most times Düll uses combinations of formulas, thus expressing the difficulties of assigning bryogeographic characters due to the still incomplete knowledge on distribution and ecology of bryophytes. Nevertheless, the analysis of the chorological types of the species accepted for Table 1 (a draft "MedCheckList"), presented in Fig. 1, shows that, according to Düll, for the whole mediterranean flora only 16 liverworts and 38 mosses are strictly mediterranean. Among these are 7 hepatics and 25 mosses , rather rare "endemic species", known only from few sites and belonging to the groups discussed above. Most taxa from the Mediterranean area are considered by Düll to be oceanic elements, either oceanic-mediterranean, oceanic-montane, or suboceanic, among the mosses submediterranean preferences are also important. The mosses of the boreal and temperate zone are probably most frequent in mesic habitats inside forests and in montane regions. This table suggests only qualitative indications on the mediterranean bryodiversity. The relative richness of oceanic-mediterranean liverworts is probably restricted to very few sites as the one near Nice described above.

The authors of check-lists have to apply a consistent species concept. They are rarely specialists for all groups. Modern revisions are available only for some families and genera. Ideally these should deal with the variability within the entire distribution range to be able to evaluate the relationships to other biogeographic regions in the world, to discover disjunctions or recent introductions from other continents. It is important to include also detailed study of the sporophytic characters in all revisory efforts. Most of the taxa described as endemic for the

Table 1. Approximate number of species occuring in the mediterranean part of the circum-Mediterranean countries (abbreviations according Greuter & al. 1984)

Country	Hepaticae	Musci
Lu Hs Ba	250	700
Ga Co	250	700
It	250	700
Sa	100	400
Si	150	350
Yu	200	600
Al	50	100
Bu	150	450
Gr Cr AE	150	500
Tu An	150	500
Cy	50	200
LS	50	100
I J Sn	50	200
Eg	<50	50
Li	<50	100
Tn	100	100
Ag	100	300
Ma	100	300

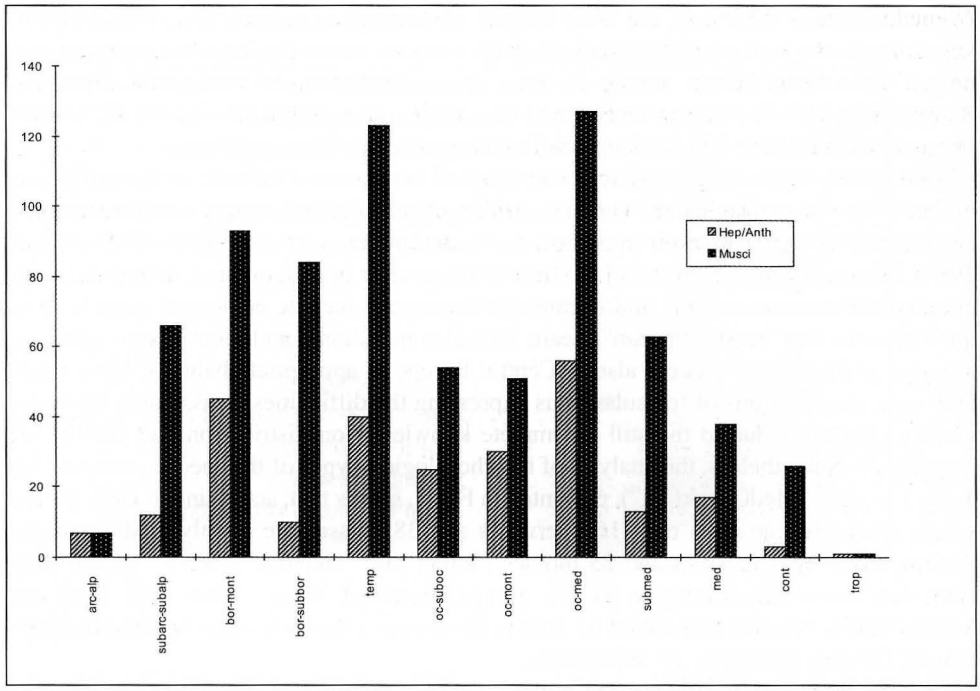

Fig. 1. Distribution of chorological types in the bryoflora of the Mediterranean region (Abbreviations: see Düll (1983)

Mediterranean region turned out to be conspecific with already described species after thorough revision, or they were found outside the Mediterranean area. If this way the number of recognized good species could be considerably reduced, another tendency to give a taxonomic rank to particular ecological expressions can presently be observed. This view is mainly followed now by Scandinavian bryologists with intensive field experience (e.g. Blom 1986). However, up till now, this concept has not yet been proven by molecular data. Good taxonomic knowledge is also indispensable for correct determination of the specimens collected. It is a well known fact that all important herbaria house large quantities of badly identified specimens. Once the incorrect reports published, they often are repeated in subsequent lists without any attempt of verification.

Concluding remarks

Bryophytes are much less known in Mediterranean areas than tracheophytes. Even if they are quantitatively less important in this environment, a more intensive bryological exploration is urgently needed because of the habitat diversity and the biogeographic position at the southern limit of the Holarctis. OPTIMA could be a promising platform to organize the collaboration among Mediterranean bryologists, and to standardize transfer of data. The "Mediterranean Region" could be delimited as proposed in Nimis (1996). National mapping projects should then be extracted according to mapping units situated in

the mediterranean region. At this moment mapping programs exist only for the Iberian Peninsula (Casas & al. 1985, 1996). But the first task to be accomplished is the establishment of a checklist.. For taxonomic decisions international cooperation including specialists outside the Mediterranean area is needed. But it is also important to have local specialists in each country. For this purpose it is necessary to offer a good university training in bryology as well as to give amateurs the possibility to collaborate. With joint efforts it is hoped to get new insights of Mediterranean bryology, a better understanding of ecological and evolutionary processes in bryophytes growing around the Mediterranean Sea and perhaps also to find an answer to the question: What is a Mediterranean element among bryophytes?

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