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## Chorological and ecological analysis of the bryophyte flora in Sicily\*

### Abstract

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A chorological and ecological analysis of the Sicilian bryoflora is presented, based on the published inventories and on additional published plus some yet unpublished records. Numbers of families, genera and species are given and compared with similar numbers available for other Mediterranean areas. A grouping of the Sicilian species into four broadly defined chorological elements reveals a slight predominance of the circumboreal (42 %) over the Mediterranean element (41 %), and of the (sub-) cosmopolitan (9 %) over the Atlantic element (8 %). Ecological groups were defined with respect to four significant parameters: water (mesophilous species prevail, with 42 %); pH of the substratum (acidophilous species, with 42 %, form the largest group); type of the substratum (one half of the species are terricolous); and light (most species — 43 % — are indifferent). Finally, the same kind of ecological analysis has been carried out separately for each of the four major chorological elements. The results are presented in tabular form and are visualized by graphs. [Editors' abstract.]

### Introduction

Due to its geographic position and to the diversity of its environment Sicily hosts a very rich and varied flora. Whereas the vascular flora of the island is comparatively well known thanks to investigations starting in the 17th century and much intensified during the past few decades — which have resulted in a considerable number of additions and taxonomic reassessments (Raimondo 1988) — so that a thorough analysis of its chorology and biology has been possible (Di Martino & Raimondo 1979), the bryophytes have been much less exhaustively studied. Most of the papers concerning Sicilian bryology were published at the end of the 19th or at the beginning of the 20th century, and bryological research has been fully resumed only in the last decade. Quite recently, checklists of Sicilian liverworts (Dia & al. 1985) and mosses (Dia & al. 1987) have been prepared, providing a first overall picture of the state of our knowledge of the bryoflora of the island. A survey of the present state of the bryological investigation of Sicily (Raimondo & al. 1988) has also been produced, which concluded that the bryophytes are now reasonably well known for most of the island, but that some areas have not been fully investigated as yet.

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The present paper aims at giving a first analysis of the Sicilian bryoflora with respect to its chorological affinities and main ecological features, by analogy to what has already been done for the vascular flora of the island (Di Martino & Raimondo 1979). As in the published check-lists (Dia & al. 1985, 1987) Sicily is here defined in a wide sense, to include not only the small islands surrounding Sicily proper but also the Maltese islands. The nomenclature follows Düll (1983, 1984-1985), where the full authors citations of names quoted in the present paper can also be found.

### **Geoclimatic features.**

Detailed data on Sicilian geomorphology can be found in works such as Pecora (1968), Vittorini (1973), Gullotti & al. (1980), and Fierotti (1988). In the present context, only a few aspects that are particularly relevant for the distribution of bryophytes need be mentioned.

The climate of Sicily is, generally speaking, of a Mediterranean type, but it widely varies depending on altitude and on the orientation of slopes. One can observe a gradual change from the thermophilous, arid, typically Mediterranean climate of the lowlands to the cooler and more humid conditions of the hillsides and mountains, where habitats become progressively more suited to host boreal and montane species, and in some cases even genuinely alpine taxa (Raimondo & Dia 1978, 1981b, Privitera & Lo Giudice 1980, 1986a). Also, on the northern slopes of the mountain massifs the climatic conditions are of a more oceanic type, due to the predominance of moist, northerly winds coming from the Tyrrhenian Sea. Fog formation is a frequent phenomenon in some north-facing localities, in which the conditions are favourable to the survival of species belonging to the hygrothermic atlantic geoclimatic element (Raimondo & Dia 1981a).

Microclimates combining warm and moist conditions, which are very rarely associated elsewhere in the Mediterranean area, are locally found around fumaroles on some of the small volcanic islets. In such peculiar niches atlantic and subtropical species are found (Bottini 1907, Raimondo & al. 1981, Dia 1987).

Different substrata, such as limestones, siliceous rocks, gypsum and lava, contribute to the habitat diversity of Sicily. Another diversifying element is the solute content of water, varying from oligomineral to strongly mineralized. In the former case, the formation of peatland may occur, whereas in the latter case calcicolous communities spread (Raimondo & Dia 1978, Raimondo & al. 1980, 1980-1981a-b, Privitera & Lo Giudice 1986b).

Corticicolous species strongly depend, in their distribution, on the occurrence of the tree species that serve as their support, which in turn is profoundly affected by the influence of man on Sicilian forest communities.

### **Species diversity of the Sicilian bryoflora**

The numbers of species, genera and families of bryophytes that are present in Sicily are set out in Table 1, and the species numbers of the major genera of the Sicilian bryoflora are given in Table 2. All these figures are essentially based on the two published check-lists (Dia & al. 1985, 1987) which were, however, up-dated for the present purpose. Data by Gulia (1858-1859) and Le Gallo (1951), not taken into account when compiling the check-lists, have been added. Reports of more recent discoveries (Privitera & Puglisi 1989, Privitera 1990, Dia 1991) have also been taken into account, as well as some still unpublished findings made during the 3rd *Iter Mediterraneum* in Sicily in 1990 and kindly

Table 1. Numbers of species and genera of the bryophyte families represented in Sicily.

Mosses			Liverworts		
family	genera	species	family	genera	species
<i>Pottiaceae</i>	23	83	<i>Ricciaceae</i>	1	17
<i>Bryaceae</i>	6	44	<i>Jungermanniaceae</i>	2	9
<i>Brachytheciaceae</i>	9	43	<i>Scapaniaceae</i>	2	7
<i>Dicranaceae</i>	12	23	<i>Cephaloziellaceae</i>	1	7
<i>Grimmiaceae</i>	5	23	<i>Codoniaceae</i>	2	6
<i>Orthotrichaceae</i>	4	19	<i>Lophoziaceae</i>	2	5
<i>Amblystegiaceae</i>	8	12	<i>Geocalycaceae</i>	2	5
<i>Funariaceae</i>	4	12	<i>Porellaceae</i>	1	5
<i>Fissidentaceae</i>	1	12	<i>Anthocerotaceae</i>	2	4
<i>Hypnaceae</i>	6	11	<i>Calypogeiaceae</i>	1	4
<i>Polytrichaceae</i>	3	11	<i>Frullaniaceae</i>	1	4
<i>Bartramiaceae</i>	3	10	<i>Aytoniaceae</i>	3	3
<i>Leskeaceae</i>	5	8	<i>Marchantiaceae</i>	2	3
<i>Mniaceae</i>	3	8	<i>Aneuraceae</i>	2	3
<i>Neckeraceae</i>	4	7	<i>Arnelliaceae</i>	2	3
<i>Plagiotheciaceae</i>	3	7	<i>Plagiochilaceae</i>	2	3
<i>Leucodontaceae</i>	4	5	<i>Lejeuneaceae</i>	2	3
<i>Encalyptaceae</i>	1	5	<i>Metzgeriaceae</i>	2	2
<i>Sphagnaceae</i>	1	4	<i>Targioniaceae</i>	1	2
<i>Fontinalaceae</i>	2	3	<i>Pelliaceae</i>	1	2
<i>Ephemeraceae</i>	1	2	<i>Radulaceae</i>	1	2
<i>Aulacomniaceae</i>	1	2	<i>Sphaerocarpaceae</i>	1	1
<i>Thamniaceae</i>	1	2	<i>Conocephalaceae</i>	1	1
<i>Buxbaumiaceae</i>	1	1	<i>Lunulariaceae</i>	1	1
<i>Archidiaceae</i>	1	1	<i>Cleveaceae</i>	1	1
<i>Calymperaceae</i>	1	1	<i>Exormothecaceae</i>	1	1
<i>Ptychomitriaceae</i>	1	1	<i>Corsiniaceae</i>	1	1
<i>Timmiaceae</i>	1	1	<i>Oxymitriaceae</i>	1	1
<i>Hedwigiaceae</i>	1	1	<i>Blasiaceae</i>	1	1
<i>Meteoriaceae</i>	1	1	<i>Gymnomitriaceae</i>	1	1
<i>Fabroniaceae</i>	1	1	<i>Cephaloziaceae</i>	1	1
<i>Thuidiaceae</i>	1	1	<i>Lepidoziaceae</i>	1	1
<i>Entodontaceae</i>	1	1	<i>Trichocoleaceae</i>	1	1
<i>Sematophyllaceae</i>	1	1			
Total: 34	121	367	Total: 33	47	111

reported by Prof. Düll (in litt.). Intraspecific taxa have been excluded from the analysis since their taxonomy and distribution is still imperfectly known. Similarly, critical taxa and those whose occurrence in Sicily is uncertain, have been omitted.

Table 3 provides a comparison of the numbers of taxa of the Sicilian bryoflora with those of other Mediterranean areas for which recent inventories of bryophytes exist. The figures for Crete were kindly communicated by Prof. Düll (in litt.) and are based on his published inventory (Düll 1979) to which recent records of *Riccia* (Jovet-Ast 1986) have been added, as well as some of his own unpublished new records. The other figures in Table 3 are based on works of Cetin (1988a-b) for Turkey, Jovet-Ast & Bischler (1971) for Tunisia, Bischler & Jovet-Ast (1971-72), Cortini Pedrotti (1980), and Cortini Pedrotti & Troiano (1985) for Sardinia, Bischler & Jovet-Ast (1973) for Corsica, Jovet-Ast & Bischler (1978) for Libya, Bilewsky (1965, 1977) and Jovet-Ast & Bischler (1966) for Israel. Although the data for most of these areas, perhaps excluding Crete, are incomplete and heterogeneous, it is still obvious from the figures in Table 3 that the Sicilian bryoflora is comparatively rich. The only area from which a greater number of bryophyte species is known is Turkey, which has however a surface that is several times as large as that of Sicily.

Table 2. Species numbers of the most important genera of the Sicilian bryoflora.

Mosses		Liverworts	
genus	species	genus	species
<i>Bryum</i>	32	<i>Riccia</i>	17
<i>Tortula</i>	17	<i>Jungermannia</i>	7
<i>Orthotrichum</i>	15	<i>Cephaloziella</i>	7
<i>Fissidens</i>	12	<i>Scapania</i>	6
<i>Pottia</i>	12	<i>Fossombronia</i>	5
<i>Grimmia</i>	12	<i>Porella</i>	5

Table 3. A numerical comparison of the bryoflora of Sicily with that of a selection of other Mediterranean areas.

Area	Mosses			Liverworts		
	families	genera	species	families	genera	species
Turkey	38	154	549	35	56	135
<b>Sicily</b>	<b>34</b>	<b>121</b>	<b>367</b>	<b>33</b>	<b>47</b>	<b>111</b>
Sardinia	30	105	336	26	33	62
Crete	22	79	284	28	34	72
Israel	20	71	202	16	16	33
Corsica	—	—	—	30	49	109
Tunisia	—	—	—	29	37	79
Libya	—	—	—	12	12	24

### Chorological analysis of the Sicilian bryoflora

In spite of the fact that the bryophytes, like other cryptogams, have wider distributional areas on average than flowering plants, a chorological analysis of the Sicilian bryoflora shows that it is remarkably heterogeneous, just as the vascular flora (Di Martino & Raimondo 1979).

When species are classified in geographical elements, mainly following Düll (1983, 1984-1985) and Lecointe (1979, 1981a, 1981b, 1988), one finds that a large number of chorological groups exist in the bryoflora of Sicily. A synthesis has therefore been necessary to reduce this large quantity of choro-types to 4 broadly defined groups: the circumboreal, Mediterranean, cosmopolitan and Atlantic elements (Tab. 4, Fig. 1).

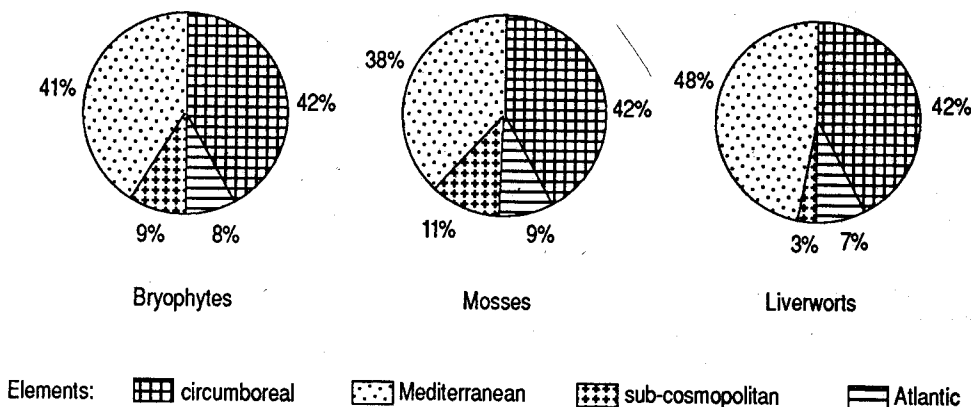


Fig. 1. Chorological spectra of the Sicilian bryoflora.

The circumboreal and Mediterranean elements are by far best represented. The slight overall prevalence of the former (42 % as compared to 41 %) is due to the mosses, whereas in liverworts the Mediterranean element is clearly dominant.

The circumboreal element consists of boreal species (8 %, e.g. *Nardia geoscyphus*, *Bryum weigelii*, *Dicranella humilis*, *Dicranum bonjeanii*, *Philonotis caespitosa*), boreal-montane species (18 %, e.g. *Apometzgeria pubescens*, *Blasia pusilla*, *Jungermannia obovata*, *Bartramia ithyphylla*, *Dichodontium pellucidum*, *Isopterygium pulchellum*, *Pseudoleskeella nervosa*), boreal-montane-dealpine species (1 %, e.g. *Lophozia collaris*, *Preissia quadrata*), subboreal species (6 %, e.g. *Chiloscyphus pallescens*, *C. polyanthos*, *Brachythecium rivulare*, *B. salebrosum*, *Plagiothecium denticulatum*), subboreal-montane species (6 %, e.g. *Conocephalum conicum*, *Porella porelloides*, *Scapania curta*, *Eurhynchium pulchellum*, *Grimmia ovalis*), subcontinental species (2 %, e.g. *Brachythecium campestre*, *Orthotrichum speciosum*), subcontinental-montane species (2 %, e.g. *Cirriphyllum reichenbachianum*, *Platydicta subtilis*), temperate species (34 %, e.g. *Cephaloziella divaricata*, *Fossombronia wondraczekii*, *Lophocolea heterophylla*, *Amblystegium humile*, *Anomodon viticulosus*, *Bryum comense*, *B. kunzei*, *Dicranella varia*, *Homalothecium lutescens*, *Isothecium alopecuroides*, *Orthotrichum affine*), S temperate species (1 %, e.g. *Anthoceros agrestis*, *Pellia endiviifolia*), W temperate species (3 %, e.g. *Jungermannia gracillima*, *Lophocolea bidentata*, *Metzgeria furcata*, *Pellia epiphylla*, *Plagiochila asplenioides*, *Porella platyphylla*, *Radula complanata*), temperate-

montane species (6 %, e.g. *Jungermannia hyalina*, *Didymodon spadiceus*, *Fissidens cristatus*, *F. pusillus*, *Neckera crista*, *Pohlia cruda*), W temperate-montane species (5 %, e.g. *Frullania tamarisci*, *Marsupella emarginata*, *Scapania nemorea*, *S. undulata*), artic-alpine species (2 %, e.g. *Cirriphyllum ornellanum*, *Pohlia atropurpurea*), subartic-subalpine species (4 %, e.g. *Lescurea saxicola*, *Mielichhoferia mielichhoferiana*, *Polytrichum alpinum*, *Weissia wimmeriana*), subartic-alpine species (2 %, e.g. *Grimmia holleri*, *Lescurea radicata*, *Plagiomnium medium*).

Table 4. Numbers and percent ratios of species by major chorological groups in the Sicilian bryoflora.

Geographical elements (broadly defined)	Bryophytes (478 species)		Mosses (367 species)		Liverworts (111 species)	
	species	%	species	%	species	%
Circumboreal	202	42	155	42	47	42
Mediterranean	193	41	140	38	53	48
Cosmopolitan + subcosmopolitan	43	9	40	11	3	3
Atlantic	40	8	32	9	8	7

The Mediterranean element consists of Mediterranean species proper (7 %, e.g. *Mannia androgyna*, *Phaeoceros bulbiculosus*, *Riccia lamellosa*, *Antitrichia californica*, *Entosthodon curvisetus*, *E. pallescens*, *Funaria convexa*, *Homalothecium aureum*, *Timmia anomala*, *T. barbuloidea*), Mediterranean-oceanic species (2 %, e.g. *Riccia atromarginata*, *R. melitensis*, *Habrodon perpusillus*), Mediterranean-suboceanic species (2 %, e.g. *Riccia bicarinata*, *Targionia lorbeeriana*, *Fissidens ovatifolius*), submediterranean species (17 %, e.g. *Oxymitra paleacea*, *Riccia glauca*, *R. gougetiana*, *Aloina aloides*, *A. ambigua*, *Bryum barnesii*, *Cinclidotus riparius*, *Pleurochaete squarrosa*, *Pottia bryoides*), E submediterranean species (1 %, e.g. *Mannia fragrans*, *Riccia ciliata*), submediterranean-montane species (6 %, e.g. *Cinclidotus aquaticus*, *Gymnostomum calcareum*, *Schistidium pulvinatum*, *Tortula intermedia*) W submediterranean-montane species (2 %, e.g. *Porella arboris-vitae*), submediterranean-oceanic species (1 %, e.g. *Entosthodon attenuatus*, *Rhynchostegium confertum*), submediterranean-suboceanic species (7 %, e.g. *Bryum torquescens*, *Cinclidotus mucronatus*, *Eurhynchium schleicheri*, *Leptobarbula berica*, *Orthotrichum scanicum*, *O. tenellum*), submediterranean-suboceanic-montane species (6 %, e.g. *Reboulia hemisphaerica*, *Funaria muhlenbergii*, *Grimmia laevigata*, *G. tergestina*, *Pottia caespitosa*), oceanic-Mediterranean species (18 %, e.g. *Cephaloziella baumgartneri*, *C. dentata*, *Cololejeunea minutissima*, *Fossombronia angulosa*, *Petalophyllum ralfsii*, *Bryum canariense*, *B. donianum*, *Pottia commutata*, *P. crinita*, *P. pallida*, *Tortella nitida*), S oceanic-Mediterranean species (2 %, e.g. *Athalamia spathysii*, *Sematophyllum substrumulosum*) oceanic-Mediterranean-montane species (2 %, e.g. *Cephaloziella turneri*,

*Anacolia webbii*, *Anomobryum julaceum*), oceanic-Mediterranean-tropical species (2 %, e.g. *Marchantia palacea*, *Bryum cellulare*, *Calymperes erosum*), oceanic-submediterranean species (6 %, e.g. *Anthoceros punctatus*, *Riccia beyrichiana*, *Bryum dunense*, *Campylopus pilifer*, *Pseudocrossidium revolutum*), suboceanic-Mediterranean species (6 %, e.g. *Calypogeia arguta*, *Corsinia coriandrina*, *Riccia macrocarpa*, *Bryum radiculosum*, *Cryphaea heteromalla*, *Eurhynchium meridionale*), suboceanic-submediterranean species (10 %, e.g. *Fossombronia pusilla*, *Bryum gemmiparum*, *Didymodon sinuosus*, *Entosthodon fascicularis*, *E. obtusus*, *Pogonatum nanum*), subtropical species (1 %, e.g. *Trematodon longicollis*), and endemic species (2 %, e.g. *Riccia melitensis*, *Barbella strongylensis*, *Thamnobryum cossyrense*). Endemism in the bryophytes, as in most other cryptogamic groups, is a rarer phenomenon than in flowering plants. Therefore the presence, even in small numbers, of endemics is important from a phytogeographical point of view.

The (sub-)cosmopolitan element is poorly represented (9 %). Among the species belonging to it are *Metzgeria furcata*, *Brachythecium rutabulum*, *B. plumosum*, *B. rivulare*, *Caliergonella cuspidata*, *Grimmia pulvinata*, *G. trichophylla*, and *Leucodon sciuroides*.

Lastly, the Atlantic element has a low incidence (8 %), but one should bear in mind that those species having a combined Mediterranean and Atlantic distribution have been attributed to the Mediterranean element. As here defined, the Atlantic element includes oceanic species (4 %, e.g. *Zygodon viridissimus*), N oceanic species (6 %, e.g. *Orthotrichum pulchellum*, *Racomitrium ericoides*), suboceanic species (33 %, e.g. *Riccia warnstorffii*, *Antitrichia curtispindula*, *Bryum mildeanum*, *Eurhynchium striatum*, *Hypnum jutlandicum*, *Orthotrichum striatum*), N suboceanic species (13 %, e.g. *Diplophyllum albicans*, *Brachythecium plumosum*, *Mnium hornum*, *Neckera pumila*), suboceanic-montane species (35 %, e.g. *Frullania fragilifolia*, *Lejeunea cavifolia*, *Amphidium mougeotii*, *Cynodontium bruntonii*, *Grimmia decipiens*, *G. montana*), and N suboceanic-montane species (9 %, e.g. *Riccardia chamaedryfolia*, *Scapania aspera*, *Orthotrichum rupestre*).

### Ecological analysis of the Sicilian bryoflora

The Sicilian bryophytes have been attributed to ecological groups on the basis of some of the main factors limiting their occurrence: water, pH of the substratum, type of substratum and light. The ecological preferences of the taxa have been mainly taken from Lecoq (1979, 1981a, 1981b, 1988) and Amann & Meylan (1912). Failing these, other specific contributions have been consulted.

Our own experience, based on the requirements of Sicilian bryophytes as observed in the field, has also been used, especially in those cases in which the published data were incomplete or were conflicting.

Tab. 5 and Fig. 2, which summarize the data related to the above-mentioned classification, reveal the overall prevalence of the mesophytes (42 %) over the hygrophytes (34 %) and of the latter over the xerophytes (24 %). Among the mosses the xerophytes (29 %) are equal to the hygrophytes (29 %) in number, while among the liverworts the hygrophytes (50 %) are dominant and the xerophytes are reduced to 7 %.

Concerning the pH of the substratum the acidophilous species prevail (40 %) followed by the indifferent ones (34 %). The neutrophilous species amount to 26 %, a percentage which considerably declines (15 %) when one considers the liverworts alone.

As regards the type of substratum, the terricolous species (50 %) are largely prevalent, followed by the saxicolous ones (29 %), whereas the percentage of corticolous (9 %) and

humicolous and turficolous species (11 %) is relatively low. The occurrence of the latter is however of relevance since they are the chief constituents of small acid peat-mosses, extremely rare in the Mediterranean region. Besides the *Sphagnum* species (*Sphagnum contortum*, *S. lescurii*, *S. subsecundum*) the main turficolous bryophytes are: *Aneura pinguis*, *Bazzania trilobata*, *Calypogeia arguta*, *Riccardia chamaedryfolia*, *R. multifida*, *Aulacomnium palustre*, and *Polytrichum commune*.

Table 5. Numbers and percent ratios of species by major ecological groups in the Sicilian bryoflora.

Ecological factors	Ecological preferences	Bryophytes 478 species		Mosses 367 species		Liverworts 111 species	
		species	%	species	%	species	%
Water	mesophilous	204	42	156	42	48	43
	hygrophilous <sup>1</sup>	161	34	106	29	55	50
	xerophilous	113	24	105	29	8	7
pH of substratum	acidophilous	188	40	124	34	64	58
	neutrophilous	126	26	109	30	17	15
	indifferent	164	34	134	36	30	27
Substratum type	terricolous	241	50	174	48	67	60
	saxicolous	139	29	114	31	25	22
	humicolous <sup>2</sup>	52	11	38	10	14	13
	corticicolous	42	9	37	10	5	5
	indifferent	4	1	4	1	—	—
Light	sciaphilous	144	30	103	28	41	37
	photophilous	127	27	105	29	22	20
	indifferent	207	43	159	43	48	43

<sup>1</sup> incl. hydrophilous

<sup>2</sup> incl. turficolous

For 43 % of the Sicilian bryophyte species light is not a limiting factor. The remaining 57 % are divided into photophilous (27 %) and sciaphilous species (30 %). The proportion of the latter is higher (37 %), and that of the photophilous species is lower (20 %) among the liverworts.

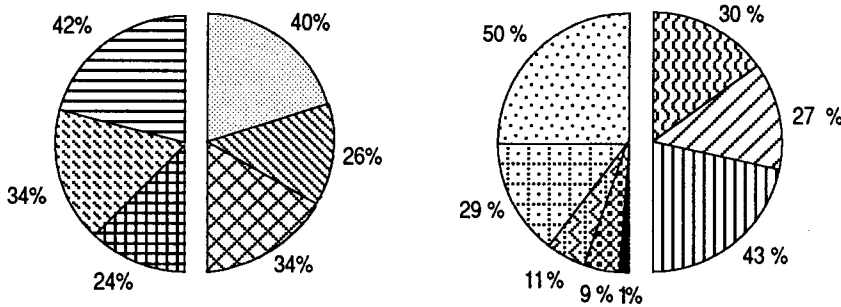
Lecoite (1988), in his phytogeographical analysis of the bryoflora of Normandy, states that knowing the ecology of a flora is extremely important if one wants to understand its chorological characters.

We agree that an ecological grouping of the species within each major chorological element is an important complement to the chorological analysis of the bryoflora. The results of such a more detailed analysis are shown in Fig. 3.

The circumboreal element is mainly represented by mesophytes (47 %, e.g. *Plagiochila*



*porelloides*, *Porella cordaeana*, *Anomodon viticulosus*, *Atrichum undulatum*, *Brachythecium glareosum*, *B. populeum*, *B. velutinum*, *Ctenidium molluscum*, *Didymodon rigidulus*, *Eurhynchium hians*, *Fissidens bryoides*, *Neckera complanata*, *Orthotrichum affine*, *Pylaisia polyantha*, *Rhytidiadelphus triquetrus*, *Ulota crispa*); by acidophilous species (43 %, e.g. *Brachythecium albicans*, *B. campestre*, *Bryum inclinatum*, *B. pallens*, *B. pallescens*, *Dicranella heteromalla*, *Hygroamblystegium tenax*, *Polytrichum formosum*); by terricolous species (46 %); and by sciaphilous species (40 %)



Ecological preferences:

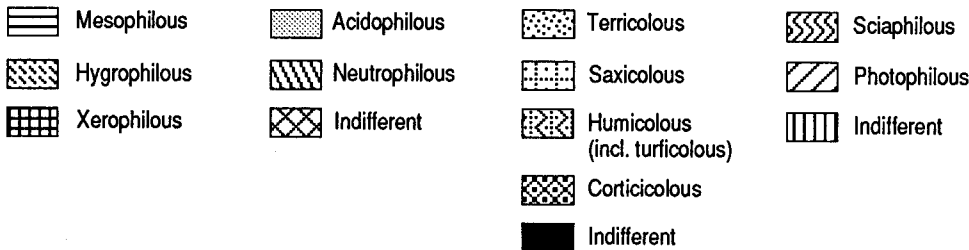


Fig. 2. Ecological spectra of the Sicilian bryoflora.

The Mediterranean element is characterized by a high percentage of both mesophilous (40 %) and xerophilous species (38 %, as compared to 24 % for the whole bryoflora). The incidence of neutrophilous species (32 %) is remarkably high as well. The mesophytes include: *Petalophyllum ralfsii*, *Porella obtusata*, *Southbya tophacea*, *Anacolia webbii*, *Antitrichia californica*, *Bryum donianum*, *Eurhynchium pumilum*, *E. schleicheri*, *Fissidens limbatus*, *F. ovatifolius*, *Isothecium striatulum*, *Metaneckera menziesii*, *Orthotrichum scanicum*, *Rhynchostegiella tenella*. Among the xerophytes are: *Plagiochasma rupestre*, *Acaulon triquetrum*, *Aloina aloides*, *A. ambigua*, *Crossidium crassinerve*, *C. squamiferum*, *Didymodon acutus*, *D. vinealis*, *Encalypta vulgaris*, *Grimmia crinita*, *Orthotrichum diaphanum*, *Phascum curvicolle*, *Pottia bryoides*, *P. davalliana*, *Rhynchostegium megapolitanum*. Examples of neutrophilous species are: *Cephaloziella baumgartneri*, *Lophozia turbinata*, *Southbya nigrella*, *Bryum canariense*, *Cinclidotus mucronatus*, *Dicranella varia*, *Didymodon luridus*, *D. sinuosus*, *Eucladium verticillatum*, *Fissidens taxifolius*, *Gymnostomum calcareum*, *Gyroweisia tenuis*,

*Philonotis calcarea*, *Pleurochaete squarrosa*, *Tortula atrovirens*, *T. ruraliformis*. As regards the other ecological preferences the prevalent groups are terricolous species (60 %), and those that are indifferent to light condition (57 %). Furthermore, one observes a relatively low proportion of hygrophytes (22 %) and the absence of humicolous and turficolous elements.

The (sub-) cosmopolitan element consists mostly of species that are indifferent to the pH of the substratum (65 %) and to light (79 %), such as: *Brachythecium rutabulum*, *B. salebrosum*, *Bryum argenteum*, *B. capillare*, *Eurynchium praelongum*, *Funaria hygrometrica*, *Grimmia pulvinata*, *Leucodon sciuroides* and *Tortula muralis*. The species are more equally distributed on different types of substratum as compared to the whole bryoflora; moreover 9 % of them are ubiquitous.

In the Atlantic element, as compared to the average of the bryoflora, one finds a high percentage of hygrophytes (50 %, e.g. *Diplophyllum albicans*, *Riccardia chamaedryfolia*, *Cynodontium bruntonii*, *Isopterygium elegans*, *Mnium hornum*, *Philonotis arnellii* and *Sphagnum lescurii*) and of sciaphytes (50 %, e.g. *Frullania fragilifolia*, *Antitrichia curtipendula*, *Cirriphyllum crassinervium*, *Diphyscium foliosum*, *Neckera pumila*, *Plagiothecium undulatum*, and *Racomitrium aciculare*). This element also presents a very high proportion of acidophilous (77 %) such as *Lejeunea cavifolia*, *Archidium alternifolium*, *Ephemerum sessile*, *Grimmia montana*, and *Hypnum jutlandicum*. As regards the type of substratum, the terricolous species (35 %) are far less numerous than in the other elements, whereas both the corticolous (15 %) and humicolous and turficolous (25 %) species are particularly well represented here.

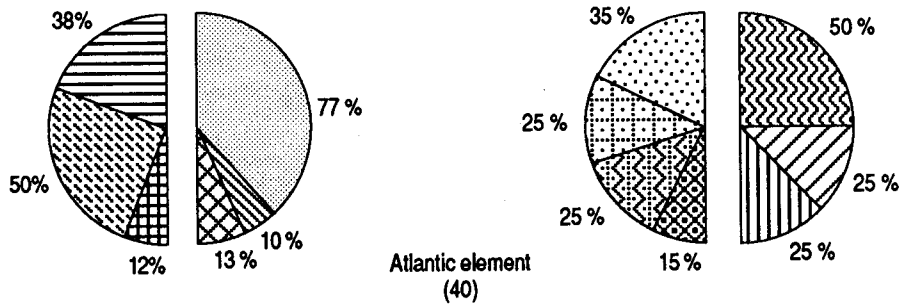
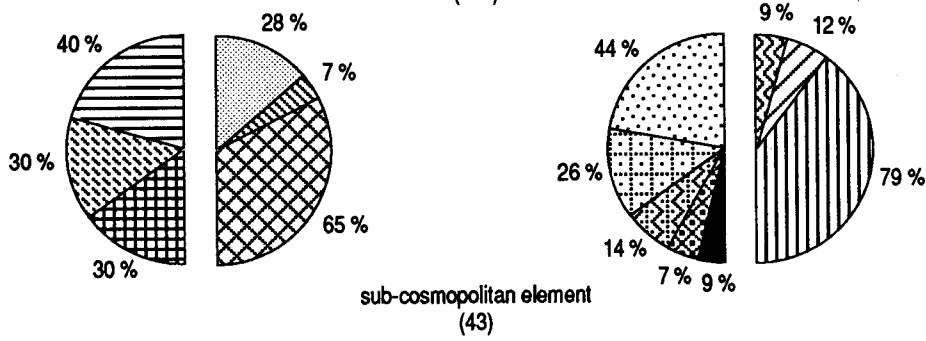
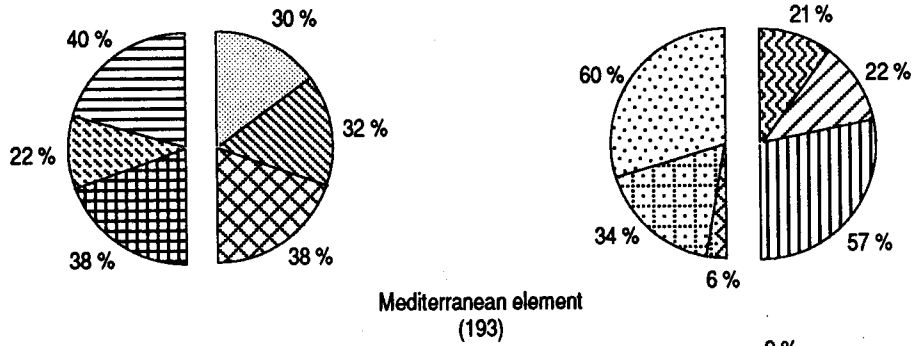
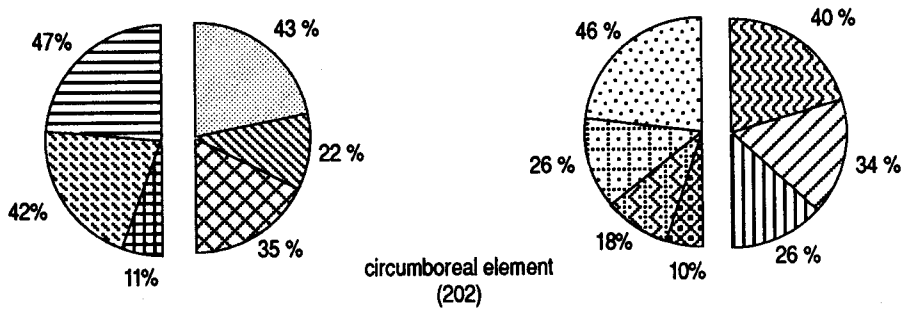
## Discussion

As has already been stated, the Sicilian bryoflora is characterized by the prevalence of the circumboreal element (42 %). The incidence of the Mediterranean element is almost as strong (41 %), which reflects the geographical position and microclimatic characteristics of the island.

It is difficult to compare the chorological features of the Sicilian bryoflora with those of neighbouring areas, due to the lack of suitable data. A notable exception is the moss flora of Sardinia, with which the Sicilian moss flora shows a considerable affinity, and for which Cortini Pedrotti (1980) has published an analysis of the chorological components, taking into account besides specific taxa some infraspecific taxa. According to her data, the (widely defined) circumboreal element is most prominent (c. 48 % of the taxa), followed by the Mediterranean element, again broadly defined, which comprises c. 39 % of the taxa. These figures are in remarkably good agreement with those for Sicily, 42 % and 38 %, respectively. The Atlantic element is poorly represented in both floras, but is slightly more pronounced in Sicily (9 %) than in Sardinia (5.6 %).

Outside the Mediterranean area, the bryoflora of Normandy (Lecointe 1988) is available for a comparison with the Sicilian bryoflora in its entirety. It is characterized by a slightly higher incidence of circumboreal species (48 %, just as for Sardinia), but chiefly by a considerably lower proportion of Mediterranean (20 %) and correspondingly higher rate of Atlantic species (22 %).

Fig. 3. Ecological spectra within the major chorological elements of the Sicilian bryoflora. The figures in parenthesis are species numbers. See Fig. 2 for further explanations.



At a higher level of sophistication, the chorological analysis of the Sicilian bryoflora reveals the presence of a pronounced mountain element, corresponding to 38 % of the circumboreal element, to 16 % of the Mediterranean element, and to 44 % of the Atlantic element. Even some artic-alpine species are present (8 % of the circumboreal element). We interpret the presence of the latter, and of the boreal and boreal-montane element as well, which are characteristic for some high-altitude habitats of the major Sicilian mountain ranges, as witnessing past geoclimatic conditions of the Quaternary era. We assume that they have immigrated during cold, glacial phases of the Pleistocene, and that today they represent relicts confined to peculiar microthermic habitats. The alleged occurrence of some such species at low altitudes and even on the small islands surrounding Sicily is more difficult to explain, and confirmation of these data would indeed be welcome.

Concerning the ecological groupings, the spectra for the entire bryoflora are matched fairly well by those for the circumboreal element alone, which is partly explained by the numerical predominance of the latter. The overall dominance of mesophilous and acidophilous species also holds true for the circumboreal element. The incidence of xerophilous and neutrophilous species is, on the contrary, disproportionately high due to the high occurrence of the Mediterranean element. In all major chorological elements terricolous species predominate, although the percentages show significant differences. Indifference to light is heavily prevailing in the Mediterranean element, and even more so in the cosmopolitan element, which accounts for its overall predominance in the Sicilian bryoflora.

The ecological spectra within the major chorological elements of the Sicilian bryoflora are in good general agreement with Lecoq's (1988) observations on the bryoflora of Normandy. The main difference is in a higher overall percentage of hygrophilous and acidophilous species, which reflects the higher proportion of the circumboreal and Atlantic elements in Normandy.

The results of the chorological and ecological analysis presented here will certainly have to be somewhat modified as the bryological exploration of Sicily progresses and as the taxonomy of Sicilian bryophytes becomes better known.

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#### References

- Amann, J. & Meylan, C. 1912: Flore des Mousses de la Suisse, 2. — Lausanne.  
 Bilewsky, F. 1965: Moss-Flora of Israel. — Weinheim. pp. 434.  
 — 1977: New records of mosses in Israel. — Israel I. Bot. 26: 93-97.  
 Bischler, H. & Jovet-Ast, S. 1971-1972: Les hépatiques de Sardaigne. Enumération, notes écologiques et biogéographiques. — Rev. Bryol. Lichénol. 38: 325-419.  
 — & — 1973: Les hépatiques de Corse. Enumération, notes écologiques et biogéographiques. — Rev. Bryol. Lichénol. 39: 43-153.  
 Bottini, A. 1907: Sulla briologia delle isole italiane. — Webbia 2: 345-402.  
 Cetin, B. 1988a: Checklist of the liverworts and hornworts of Turkey. — Lindbergia 14: 12-14.  
 — 1988b: Checklist of the mosses of Turkey. — Lindbergia 14: 15-23.  
 Cortini Pedrotti, C. 1980: Prodomo dei muschi della Sardegna. — Lav. Soc. Ital. Biogeogr. 8:

- 139-169.
- & Troiano, R. 1985: Contributo alla conoscenza dei muschi della Sardegna. — *Boll. Soc. Sarda Sci. Nat.* **24**: 123-147.
- Dia, M. G. 1987: Note briogeografiche. V. Distribuzione ed ecologia di *Ulota crispa* (Hedw.) Brid. in Italia. — *Cryptog. Bryol. Lichénol.* **8**: 241-250.
- 1991: Reperti nuovi o interessanti per la brioflora sicula. — *Naturalista sicil.*, ser. 4, **15**(1-2): 65-68.
- , Miceli, G. & Not, R. 1985: Check-list delle epatiche note in Sicilia. — *Webbia* **39**: 163-177.
- , — & Raimondo, F. M. 1987: Check-list dei muschi noti in Sicilia. — *Webbia* **41**: 61-123.
- Di Martino, A. & Raimondo, F. M. 1979: Biological and chorological survey of the Sicilian flora. — *Webbia* **34**: 309-335.
- Düll, R. 1979: Neue Übersicht zur Moosflora der Insel Kreta. — *J. Bryol.* **10**: 491-509.
- 1983: Distribution of the European and Macaronesian liverworts (Hepaticophytina). — *Bryol. Beitr.* **2**: 1-115.
- 1984-1985: Distribution of the European and Macaronesian mosses (Bryophytina). — *Bryol. Beitr.* **4-5**: 1-232.
- Fierotti, G. 1988: Carta dei suoli della Sicilia. — Palermo.
- Gulia, G. 1858-1859: Repertorio di storia naturale. — Valletta.
- Gullotti, A., Alterio, G. & Barbaro, S. 1980: Individuazione nel territorio siciliano delle zone climatiche attraverso metodologie di analisi globale in rapporto con il confort ambientale. — Palermo.
- Jovet-Ast, S. 1986: Les *Riccia* de la région méditerranéenne. — *Cryptog. Bryol. Lichénol.* **7**: 287-431.
- & Bischler, H. 1966: Les Hépatiques d'Israel: Enumeration, notes écologiques et biogéographiques. — *Rev. Bryol. Lichénol.* **34**(1-2): 91-126.
- & — 1968: Les hépatiques de Libye. Enumeration, notes écologiques et biogéographiques. — *Rev. Bryol. Lichénol.* **36**: 245-291.
- & — 1971: Les hépatiques de Tunisie. Enumération, notes écologiques et biogéographiques. — *Rev. Bryol. Lichénol.* **38**: 1-125.
- Lecoq, A. 1979 : Intérêts phytogéographiques de la bryoflore normande: 1 — Les cortèges cosmopolite et méditerranéen s.l. — *Bull. Soc. Linn. Normandie* **107**: 61-70.
- 1981a: Intérêts phytogéographiques de la bryoflore normande: 2 — Le cortège atlantique s.l. — *Bull. Soc. Linn. Normandie* **108**: 51-60.
- 1981b: Intérêts phytogéographiques de la bryoflore normande: 3 — Le cortège circumboréal s.l. — *Bull. Soc. Linn. Normandie* **109**: 55-66.
- 1988: Intérêts phytogéographiques de la bryoflore normande: 4 — Additions, corrections, spectres biogéographiques et écologiques. — *Bull. Soc. Linn. Normandie* **110-111**: 23-40.
- Le Gallo, P. C. 1951: Florule bryologique des îles Siant-Pierre et Miquelon. — *Rev. Bryol. Lichénol.* **20**: 43-93.
- Pecora, A. 1968: Sicilia. [In : *Le Regioni d'Italia*, **16**]. — Torino.
- Privitera, M. 1990: Sulla presenza di *Entosthodon pallescens* Jur. var. *mitratus* Cas. Gil, nuovo reperto per l'Italia. — *Giorn. Bot. Ital.* **124**: 110.
- & Lo Giudice, R. 1980: Segnalazione di alcuni muschi nuovi per la Sicilia. — *Boll. Accad. Gioenia Sci. Nat. Catania*, ser. 4, **14**(1): 15-18.
- & — 1986a: *Grimmia montana* Bruch et Schimp.: primo rinvenimento per la Sicilia. — *Webbia* **39**: 275-280.
- & — 1986b: Sulla briovegetazione dei tufi calcarei dell'Ennese (Sicilia). — *Cryptog. Bryol. Lichénol.* **7**: 129-139.
- & — 1989: *Tortula revolvens* (Schimp.) G. Roth (*Pottiaceae*), nuovo reperto per la brioflora sicula. — *Giorn. Bot. Ital.* **123**, Suppl. **1**: 51.
- Raimondo, F. M. 1988: Stato delle conoscenze floristiche della Sicilia al 1987. — Pp. 637-665 in: 100 anni di ricerche botaniche in Italia 1888-1988. — Firenze.
- & Dia, M.G. 1978: Note briogeografiche. I. Il genere *Sphagnum* L. in Sicilia. — *Naturalista*

- Sicil., ser. 4, 2(3-4): 109-126.
- & — 1981a: Note briogeografiche. II. *Cryphaea heteromalla* (Hedw.) Mohr in Sicilia. — Atti Accad. Sci. Palermo, ser. 4, 38(1): 153-171 (1981).
- & — 1981b: Ricerche sulla brioflora delle Madonie. 1. — *Webbia* 35: 87-131.
- , — & Cortini Pedrotti, C. 1988: Stato dell'esplorazione briogeografica in Sicilia. — *Giorn. Bot. Ital.* 122, Suppl. 1: 220.
- , — & Rossitto, M. 1980-1981a: L'Eucladio-Adiantetum Br.-Bl. 1931 in Sicilia. — Atti Accad. Sci. Palermo, ser. 4, 40(1), Estratto pp. 12.
- , — & Villari, R. 1981: *Cryphaea heteromalla* (Hedw.) Mohr, nuovo reperto per la brioflora dell'Isola di Pantelleria. — *Giorn. Bot. Ital.* 115: 413-414.
- , Mazzola, P. & Rossitto, M. 1980-1981b: Note briogeografiche. IV. Distribuzione ed ecologia di *Polytrichum commune* L. ex Hedw. in Sicilia. — Atti Accad. Sci. Palermo, ser. 4, 40(1), Estratto pp. 15.
- , Scialabba, A. & Dia, M.G. 1980: Note briogeografiche. III. Distribuzione in Italia di *Aulacomnium palustre* (Hedw.) Schwaegr. ed ecologia della specie nelle stazioni siciliane. — *Naturalista Sicil.*, ser. 4, 4(3-4): 79-99.
- Vittorini, S. 1973: Il bilancio idrico secondo Thornthwaite nelle isole di Stromboli, Ustica, Pantelleria e Lampedusa. — *Lav. Soc. Ital. Biogeogr.* 3: 13-20.

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