

## Survey of the bryoflora on Monte Limbara (Northern Sardinia)

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**Abstract** – Given herein are the results of bryological explorations conducted on Monte Limbara (Northern Sardinia). The census includes 197 taxa (145 Musci and 52 Hepaticae). Eight Musci and 7 Hepaticae are reported in Sardinia for the first time. Some species of particular phythogeographic interest are reported on. An analysis of chorological elements is also given.

**Résumé** – Les exploration bryologiques effectuées dans le Monte Limbara (Sardaigne septentrionale) ont pour résultat une liste de 197 taxa (145 Musci et 52 Hepaticae) dont 8 Musci et 7 Hepaticae sont nouveaux pour la Sardaigne. Quelques espèces d'intérêt phytogéographique particulier sont mentionnées. Les éléments corologiques sont analysés.

**Riassunto** – Vengono riportati i risultati emersi dalle esplorazioni briologiche effettuate sul Monte Limbara (Sardegna settentrionale). Sono stati censiti 197 taxa (145 Musci e 52 Hepaticae). Sono stati reperiti 8 Musci e 7 Hepaticae nuovi per la Sardegna. Si riferisce su alcune specie di particolare interesse fitogeografico. Si riporta inoltre l'analisi degli elementi corologici.

**Bryophytes / Monte Limbara / Sardinia / ecology / chorology**

### INTRODUCTION

The state of knowledge on Sardinia's bryological flora was recently outlined in the work of synthesis by Cogoni *et al.* (1999) in which the author underscored the lack of research in this field, especially in areas above the altitude of 1000 metres above sea level, the level at which most bryological surveys performed up to now in Sardinia have stopped.

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It has been amply demonstrated that from the ecological viewpoint altitude strongly influences the distribution of bryophytes in relation to winter temperatures, humidity, rainfall and winds; one thus expects to find the species less thermophilous and more hygrophilous above this limit.

In the light of this consideration, an in-depth survey was performed on Monte Limbara, which has been the site of fragmentary explorations starting from the second half of the 19th century (Barbey, 1884; Massari, 1897; Bottini, 1907; Terracciano, 1909; Aleffi & Cortini Pedrotti, 1997), while the most recent bryological data is of Bischler & Jovet-Ast (1973) for liverworts and to Cortini Pedrotti & Troiano (1985) for mosses. Of great interest in this area is also the work by Raffaelli (1972) in which the only sites present in Sardinia of the genus *Sphagnum* are reported on.

## GEOGRAPHIC AND GEOMORPHOLOGICAL OVERVIEW

The Limbara horst, located in the northeastern part of Sardinia known as Gallura (Fig. 1), is composed of a series of peaks rising to over 1000 metres above sea level, the highest being Punta Balistrieri (1359 m); alternating with the peaks are outliers of erosion surfaces modelled into plateaus at different altitudes. The basic structure of the horst is composed of pink granites containing biotite, usually of medium grain, going back to the late Hercynian orogenesis. The steepest and most rugged peaks are composed of light-grey or whitish granites of small grain which are more resistant to agents of erosion. The land is scarred by a close-knit network of small streams formed by many springs fed by deep ground water flowing through fractured rock or thick layers of arenaceous granite (Barca & Di Gregorio, 1993). The soils, in the evolution of which climate plays an important role, go from shallow to deep, with reactions from subacid to acid (Aru *et al.*, 1991).

The study area is shown on the 1:25,000 IGM map, Sheets 443, Sections III (Bortigiadas) and II (Monti) and 461, Sections IV (Oschiri) and I (Berchidda) (UTM 32 NL01, 32 NL02, 32 NL11, 32 NL12).

## CLIMATE

The climate is of the *temperate-oceanic* type with a *submediterranean* variant characterized by cold winters with frequent snowfalls and hot summers. Temperature and rainfall data were taken at the Tempio station (558 metres) and Vallicciola (1000 metres) where mean annual temperatures of 14°C and 10.5°C and mean annual rainfall of 783 mm and 1235 mm respectively were reported. From the processing of bioclimatic indices it is found that there is a lower supratemperate thermotype horizon and a lower humid ombrotype (Rivas-Martínez *et al.*, 1999).



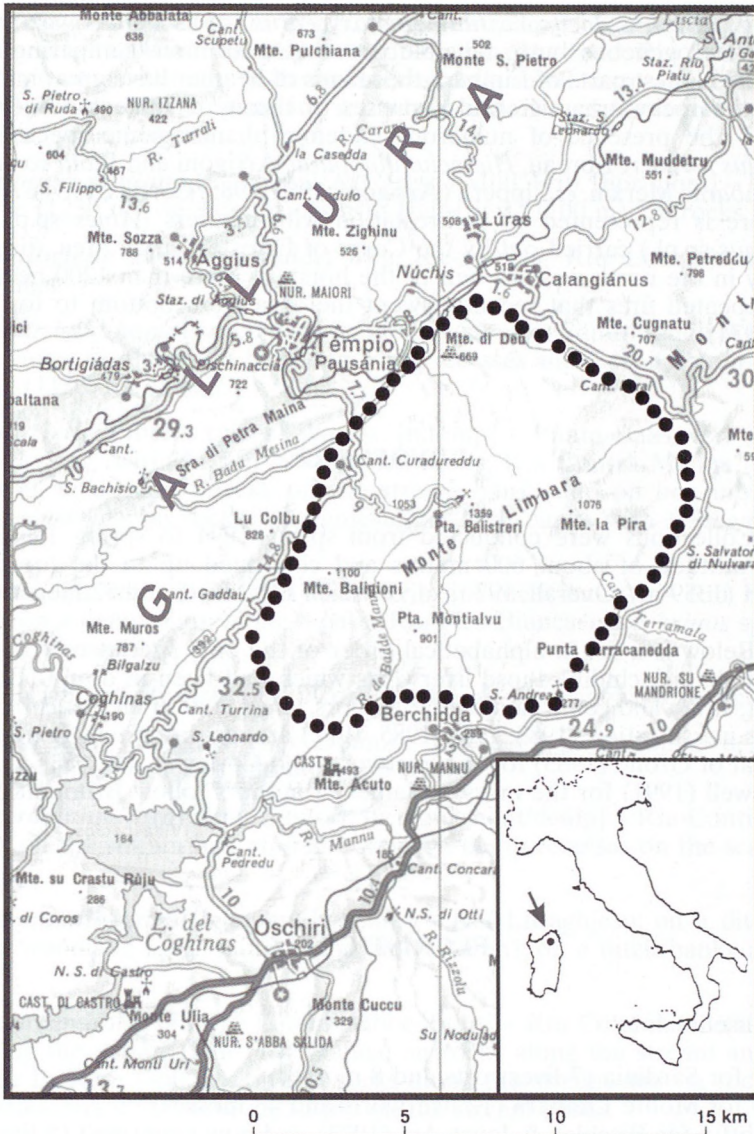


Fig. 1. Geographic position of the study area (Monte Limbara).

## VEGETATION

The main vegetation present on the Limbara horst are woods of *Quercus ilex* L. mixed with *Quercus suber* L. with sporadic specimens of *Quercus pubescens* s.l., *Ilex aquifolium* L. and *Taxus baccata* L. These aspects alternate with formations of thermophilous sclerophyllous evergreens (*Phyllirea latifolia* L., *Pistacia*

*lentiscus* L., *Arbutus unedo* L., *Juniperus oxycedrus* L.) as well as vast areas covered by heterogeneous bush, tangible proof of continuous tampering with the land. In the highest parts of Limbara the stands of heather have great importance, while in the rocky areas we find expanses of thorny chamaephytes. Of special interest is the presence of numerous endemic phanerogamic species such as *Ranunculus revelieri* Boreau, *Hieracium limbarae* Arrigoni and *Viola corsica* Nym. subsp. *limbarae* Merxm. et Lippert. (Arrigoni, 1983, 1985; Corrias, 1984). An imposing feature is represented by reforestation with conifers (*Abies* sp.pl., *Cedrus* sp.pl., *Pinus* sp.pl.) carried out by the Corps of Foresters in an area, that extends especially in the north-western belt of the horst, of more than 1200 hectares following repeated fires that recently swept the area from bottom to top (Veri & Bruno, 1974).

## BRYOFLORA

Collections were conducted from spring 1994 to spring 1999, starting from an altitude of about 600 metres and continued up to the top of Punta Balistrieri (1359 m). Overall, 197 taxa, of which 145 Musci and 52 Hepaticae were found.

Below is a list in alphabetical order of the only species new to Sardinia and to Limbara including those liverworts which had been in doubt (Bischler & Jovet-Ast, 1973) and confirmed by the authors. Chorological elements by employing Düll's classification (1983, 1984, 1985, 1992) are also reported. The nomenclature is that of Grolle (1983) for the liverworts and Corley *et al.* (1981) and Corley & Crundwell (1991) for the mosses. Names of authors follow Brummit & Powell (1992).

## FLORISTIC LIST

Symbols used:

- \*\* new for Sardinia (7 liverworts and 8 mosses)
- \* new for Monte Limbara (12 liverworts and 48 mosses)
- (+) doubtful for Bischler & Jovet-Ast (1973) and now confirmed (5 liverworts)

### Hepaticae

- (+) *Aneura pinguis* (L.) Dumort. [n.temp] – Punta Bandiera: bottom of a ditch.
- (+) *Calypogeia arguta* Nees & Mont. [oc-med] – Punta Bandiera: bog moss site; Riu Contra Manna: on bog moss.
- \* *Calypogeia fissa* (L.) Raddi [suboc-med] – Miriacheddu (990 m): on soil on a pool edge and on rocks; Riu Balistrieri (1100 m): on rocks along the stream; Madonna della Neve (1230-1250 m): on damp rocks along the stream; Riu Littaghjesu (900 m): on stream banks and on the bottom of a ditch along the



woodland road; Riu Fica Bianca: scarp along the stream; Li Fanghi (850 m): spring; Punta Bandiera (1300 m): bottom of the ditch along the road; Riu Contra Manna (1000 m): on sandy soil and in damp recesses on a small scarp along the stream; road to Vallicciola (850 m): dripping scarp by population of *Osmunda regalis*; Riu Fica Bianca: stream banks.

\*\* *Calypogeia neesiana* (C. Massal. & Carest.) Müll. Frib. [bor-mont] – Madonna della Neve (1230 m): on damp rocks; Riu Balistrieri (1100 m): on rocks.

(+) *Cephaloziella dentata* (Raddi) Mig. [oc-med] – Riu Littaghjesu: on the stream banks.

\*\* *Cephaloziella hampeana* (Nees) Schiffn. [n.suboc] – Punta Bandiera (1300 m): on rocks facing northeast, on humus in rocky recesses and on soil; Punta Bandiera Tableland (1120 m): on soil.

\* *Cephaloziella rubella* (Nees) Warnst. [n.temp] – Punta Balistrieri (1100 m): in rock crevices; Miriacheddu (990 m): on rocks; Riu Contra Manna (1000 m): on wet soil, in a damp recess, on the stream banks and on bog moss; Punta Bandiera (1200 m): on rocks; Littaghjesu: on ditch banks with *Sphagnum auriculatum*.

\* *Cephaloziella turneri* (Hook.) Müll. Frib. [oc-med(-mont)] – Riu Balistrieri (1100 m): on a damp scarp along a path; Riu Fica Bianca: on *Fraxinus* sp. and on scarp along the stream.

(+) *Chiloscyphus polyanthos* (L.) Corda [subbor] – Li Fanghi (850 m): spring.

\*\* *Diplophyllum albicans* (L.) Dumort. [n.suboc] – Madonna della Neve (1230 m): on dripping rocks and on damp rocks.

(+) *Jungermannia atrovirens* Dumort. [w.temp-mont/dealp] – Riu Contra Manna (1000 m): on the stream bed after the weir, on damp recesses on the scarp along the stream.

\*\* *Jungermannia gracillima* Sm. [w.temp] – Riu Littaghjesu: on a ditch banks along the woodland road; Punta Bandiera (1300 m): on a ditch banks along the road.

\* *Lejeunea cavifolia* (Ehrh.) Lindb. [suboc-mont] – Riu Columbanu (600 m): on rocks along the stream; Riu Fica Bianca: on rocks along the stream and on dry rocks; Riu Li Reni (860 m): on dry rocks along the stream and on rocks in the stream; Madonna della Neve (1230 m): on the stream banks.

\*\* *Lejeunea lamacerina* (Steph.) Schiffn. [euoc-mont] – Riu Fica Bianca (872 m): under the bridge along the road to Vallicciola.

\* *Lophocolea bidentata* (L.) Dumort. [w.temp] – Riu Balistrieri (1100 m): on rocks along the stream; Li Fanghi (850 m): spring; Riu Li Reni (860 m): on dry rocks along the stream; Riu Fica Bianca (800 m): on boulders; Punta Bandiera: on soil by the spring.

\*\* *Marchantia polymorpha* L. subsp. *polymorpha* [temp] – Riu Fica Bianca: on rocks along the stream.

\*\* *Pedinophyllum interruptum* (Nees) Kaal. [suboc-mont/dealp] – Riu Contra Manna: on soil along the stream banks.



- \* *Pellia endiviifolia* (Dicks.) Dumort. [s.temp] – Riu Columbanu (600 m): on marshy soil; Riu Littaghjesu: on stream banks; Cantoriera Gaddau, Spring of Ampulla (572 m): road to Berchidda.
- \* *Pellia epiphylla* (L.) Corda [w.temp] – Riu Balistrieri (1100 m): on rocks along the stream; Li Fanghi (850 m): spring; Punta Bandiera: bog moss site.
- \* *Plagiochila porelloides* (Torr. ex Nees) Lindenb. [subbor-mont] – Miriacheddu (990 m): on a damp scarp; Riu Columbanu (600 m): on rocks along the stream; Riu Fica Bianca: on dry rocks.
- \* *Radula complanata* (L.) Dumort. [w.temp] – Madonna della Neve (1230 m): stream; Riu Li Reni (m 860): on dry rocks along the stream; Riu Columbanu (600 m): on *Quercus ilex* and on rocks along the stream; Riu Fica Bianca: on *Fraxinus* sp. and on dry rocks; between Funtana Crispóli and Monte Nuddoni: on rocks; Monte Limbara (660 m): waterworks intakes of sa Soliana, on *Quercus ilex*.
- \* *Riccardia chamedryfolia* (With.) Grolle [n.suboc-mont] – Riu Columbanu (600 m): on marshy soil; Riu Fica Bianca: on periodically flooded rocks; Punta Bandiera: bog moss site.
- \* *Riccardia multifida* (L.) Gray [w.temp-mont] – Miriacheddu (990 m): on soil at the edge of a pool and on a damp scarp; Riu Columbanu (600 m): on rocks along the stream; Riu Balistrieri (1100 m): on rocks along the stream.
- \* *Scapania undulata* (L.) Dumort. [w.temp-mont] – Riu Columbanu (600 m): on rocks along the stream; Riu Balistrieri (1100 m): on rocks along the stream; Riu Littaghjesu: on stream banks; Riu Fica Bianca: on rocks and on stream banks; Madonna della Neve (1250 m): on boulders along the stream; Monte Nuddoni (1000 m): on rocks by a pool; Riu Contra Manna (1000 m): sandy places and on the wet soil of stream banks; Miriacheddu (990 m): on a damp scarp along the road.

### Musci

- \*\* *Amblystegium serpens* (Hedw.) Bruch & al. [temp] – Riu Balistrieri (1100 m): on rocks in the stream.
- \* *Archidium alternifolium* (Hedw.) Schimp. [suboc] – Riu Columbanu (600 m): on rocks along a stream.
- \* *Atrichum undulatum* (Hedw.) Beauvais [temp] – Punta Bandiera (1300 m): on damp soil along a drain and in a rocky recesses; Riu Contra Manna (1024 m): on the wet soil of the stream banks.
- \*\* *Aulacomium palustre* (Hedw.) Schwägr. var. *imbricatum* Bruch & Schimp. [subarc-subalp] – Punta Bandiera (1200 m): scarp along a path by the bog moss site.
- \* *Barbula convoluta* Hedw. var. *commutata* (Jur.) Husn. [submed(-mont)] – Riu Columbanu (600 m): on rocks at the waterfall sides.
- \* *Barbula unguiculata* Hedw. [temp] – Riu Columbanu (600 m): on rocks along the stream; Riu Balistrieri (1100 m): on rocks in the stream; Riu Fica Bianca (872 m): on soil in the lower part of the bank; Curadureddu: stream banks under the pinewood.
- \* *Bryum caespiticium* Hedw. [temp] – Riu Balistrieri (1100 m): scarp along the path.



- \* *Bryum capillare* Hedw. var. *capillare* [temp] – Cantoniera Curadureddu (575 m): on soil among rocks on a stream banks; Punta Balistrieri (1300 m): in rock crevices; Riu Balistrieri (1100 m): in the scarp along the stream; Li Fanghi: spring; Madonna della Neve (1250 m): on boulders along the stream; Punta Bandiera (1200 m): on a scarp along the path; Riu Contra Manna (1000 m): stream bed after the weir and on periodically flooded rocks; Miriacheddu (990 m): on a scarp; Fonte Silva: stream.
- \* *Bryum donianum* Grev. [oc-med] – Cantoniera Gaddau, spring of Ampulla (572 m): on rocks by the waterfall.
- \* *Bryum pseudotriquetrum* (Hedw.) P. Gaertn. & al. var. *bimum* (Schreb.) Lilj. [temp] – Curadureddu: along the banks of a little stream under the pinewood.
- \* *Bryum torquescens* Bruch & Schimp. [submed-suboc] – Miriacheddu (990 m): on a scarp.
- \* *Campylopus atrovirens* De Not. [oc-med] – Punta Bandiera (1120 m): on soil; Riu Contra Manna (1000 m): on damp recesses on a scarp along the stream.
- \* *Campylopus brevipilus* Bruch & al. [euoc] – Punta Bandiera (1300 m): on soil; Cantoniera Curadureddu (575 m): on soil among rocks on a stream banks; Riu Contra Manna: on the wet soil of banks.
- \*\* *Campylopus introflexus* (Hedw.) Brid. [suboc(i)] – Curadureddu (600 m): on a dry scarp along the woodland road.
- \* *Campylopus pilifer* Brid. [oc-submed] – Between Funtana Crispoli and Monte Nuddoni: on a damp rock by a well.
- \* *Didymodon spadiceus* (Mitt.) Limpr. [temp-mont] – Punta Balistrieri: on soil.
- \* *Distichium inclinatum* (Hedw.) Bruch & al. [bor-mont] – Punta Bandiera (1300 m): on soil.
- \* *Entosthodon fascicularis* (Hedw.) Müll. Hal. [suboc-submed] – Riu Balistrieri (1100 m): on a damp scarp along a path; Monte Baligioni (1000 m): on a damp scarp; Littaghjesu (900 m): bottom of a ditch along the road; Riu Contra Manna: on the wet soil of banks; Vallicciola (850 m): dripping scarp by a population of *Osmunda regalis*.
- \* *Ephemerum serratum* (Hedw.) Hampe var. *minutissimum* (Lindb.) Grout [suboc] – Riu Li Reni: on damp soil.
- \* *Eurhynchium praelongum* (Hedw.) Bruch & al. var. *praelongum* [temp] – Miriacheddu (990 m): on a scarp; Monte Baligioni (1000 m): on a damp scarp; Riu Columbanu (600 m): on rocks along the stream; Punta Balistrieri: on marshy soil; Punta Bandiera: on soil; Riu Fica Bianca: stream banks; Curadureddu: on a dry stream banks, under a pinewood.
- \* *Eurhynchium praelongum* (Hedw.) Bruch & al. var. *stockesii* (Turner) Dixon [suboc] – Riu Balistrieri (1100 m): on rocks in the stream; Riu Fica Bianca: on *Quercus ilex* and on rocks; Punta Bandiera (1300 m): on soil in the bottom of a ditch and on a scarp along the road; Madonna della Neve: in rock crevices.
- \* *Fabronia pusilla* Raddi [med] – Funtana Persico: on *Quercus ilex*; Berchidda (660 m): waterworks intakes of sa Soliana, su *Quercus ilex*.



- \* *Fissidens adianthoides* Hedw. [subbor] – Riu Lu Frassu: on wet soil.
- \* *Fissidens incurvus* Starke [submed] – Punta Bandiera (1300 m): in a rocky recess.
- \*\* *Fissidens serrulatus* Brid. [oc-submed] – Li Fanghi: spring; Miriacheddu (990 m): on a scarp; Riu Balistrieri (1100 m): on a scarp along the stream; Riu Columbanu (600 m): on a scarp along the stream.
- \* *Fissidens viridulus* (Sw.) Wahlenb. [submed] – Madonna della Neve (1270 m): on soil; Riu Balistrieri (1100 m): on a damp scarp along the path.
- \* *Grimmia caespiticia* (Brid.) Jur. [subarc-subalp] – Punta Bandiera (1300 m): on rocks.
- \* *Grimmia hartmanii* Schimp. [subbor-mont] – Riu Li Reni: on rocks at road edge.
- \* *Grimmia ovalis* (Hedw.) Lindb. [subbor-mont] – Punta Bandiera (1300 m): on rocks.
- \* *Gymnostomum calcareum* Nees & Hornsch. [submed-mont] – Funtana Persico: on a small wall with dripping.
- \* *Habrodon perpusillus* (De Not.) Lindb. [med-oc] – Curadureddu: on rocks by a trout breeding
- \* *Hedwigia ciliata* (Hedw.) Ehrh. ex P. Beauv. var. *ciliata* [subbor-mont] – Punta Bandiera (1300 m): on rocks and on humus in rock ravines.
- \* *Hedwigia ciliata* (Hedw.) Ehrh. ex P. Beauv. var. *leucophaea* Bruch & al. [subbor-mont] – Madonna della Neve (1270 m): on soil and on rocks.
- \* *Hedwigia stellata* Hedenäs [oc-med] – Miriacheddu (990 m): on rocks; Riu Li Reni: on rocks in a scarp along the road; between Funtana Crispoli and Monte Nuddoni: on rocks.
- \* *Neckera crispa* Hedw. [temp-mont] – Riu Columbanu (600 m): on rocks at waterfall sides; Riu Fica Bianca: on *Arbutus unedo*.
- \* *Orthotrichum affine* Brid. [temp] – Funtana Persico: on *Quercus ilex*; Cantoniera Curadureddu (575 m): on bark of *Ulmus* sp.; Berchidda (660 m): waterworks intakes of sa Soliana, on rocks.
- \* *Orthotrichum diaphanum* Brid. [temp] – Funtana Persico: on *Quercus ilex*; Cantoniera Curadureddu (575 m): on bark of *Ulmus* sp.
- \* *Phascum cuspidatum* Hedw. [temp] – Punta Balistrieri: on soil in a scarp along the road.
- \* *Philonotis arnellii* Husn. [n. suboc-mont] – Punta Bandiera (1300 m): on soil in a ditch along the path; Riu Fica Bianca: on the banks; Punta Balistrieri: on marshy soil.
- \*\* *Philonotis caespitosa* Jur. [bor] – Punta Bandiera (1200 m): on a scarp along the path.
- \*\* *Philonotis seriata* Mitt. [bor-mont] – Punta Bandiera (1300 m): on soil by a ditch along the road.



- \* *Philonotis tomentella* Molendo [bor-mont] – Punta Bandiera (1300 m): on soil; Riu Contra Manna: on the wet soil of banks; Fonte Silva: on the stream banks; Riu Fica Bianca: on the banks of a tributary.
- \* *Plagiomnium medium* (Bruch & Schimp.) T.J. Kop. [subarc-alp] – Riu Fica Bianca: on a scarp along the stream.
- \* *Plagiothecium denticulatum* (Hedw.) Bruch & al. [subbor] – Punta Bandiera (1300 m): on soil; Punta Balistrieri: on marshy soil.
- \* *Pogonatum aloides* (Hedw.) Beauvais [temp] – Miriacheddu (990 m): on a scarp along the road; Riu Balistrieri (1100 m): on a scarp along the path; Riu Fica Bianca: on a scarp along the stream; Punta Bandiera (1120 m): on soil; Curadureddu (600 m): on a dry scarp along a woodland road (on the basin); Riu Columbanu (600 m): on a scarp along the path.
- \* *Pogonatum nanum* (Hedw.) Beauvais [suboc-submed] – Punta Balistrieri (1300 m): on soil and in a meadow of *Juncus* sp.
- \*\* *Racomitrium elongatum* (Ehrh.) ex Frisvoll [bor] – Punta Bandiera (1120 m): on soil.
- \* *Racomitrium heterosticum* (Hedw.) Brid. [suboc-(mont)] – Punta Bandiera (1300 m): on rocks; between Funtana Crispoli and Monte Nuddoni: on a damp and porous rock; Punta Balistrieri (1300 m): on rocks.
- \*\* *Racomitrium sudeticum* (Funck) Bruch & Schimp. [subarc-subalp] – Punta Balistrieri: on soil.
- \* *Rhynchostegiella tenella* (Dicks.) Limpr. [submed-suboc] – Miriacheddu (990 m): on a scarp along the road; Riu Fica Bianca: on *Fraxinus* sp. and on *Quercus ilex*; Li Fanghi: spring; Riu Li Reni (860 m): on dry rocks in the stream; Cantoniera Curadureddu (575 m): on soil under the pinewood.
- \* *Rhynchostegium confertum* (Dicks.) Bruch & al. [submed-suboc] – Riu Columbanu (600 m): on marshy soil along the path; Riu Fica Bianca: on a scarp; Riu Contra Manna: on damp soil.
- \* *Schistidium confertum* (Funck) Bruch & Schimp. [subbor-mont] – Punta Bandiera: bog moss site.
- \* *Scorpiurium circinatum* (Brid.) M. Fleisch. & Loeske [oc-med] – Fanzoni (1000 m): on bark of *Quercus ilex*; Berchidda (660 m): waterworks intakes of sa Soliana, on *Quercus ilex* and on rocks.
- \* *Syntrichia laevipila* (Brid.) [submed-oc] – Cantoniera Curadureddu (575 m): on bark of *Ulmus* sp.
- \* *Tortella tortuosa* (Hedw.) Limpr. [bor-mont] – Funtana Persico: on a small wall with dripping.
- \* *Trichostomum crispulum* Bruch [temp-mont] – Punta Balistrieri (1300 m): on the soil of a scarp; Riu Balistrieri (1100 m): on a scarp along the path; Miriacheddu (990 m): on a scarp along the road; Riu Columbanu (600 m): on *Quercus ilex*; Cantoniera Curadureddu (575 m): among the rocks on the stream banks and on a scarp along the woodland road.



## FLORISTIC CONSIDERATIONS

The study yielded important qualitative and quantitative data not only for the area under examination, but also for the entire island; indeed, besides a 41% increase in the number of known taxa to Monte Limbara, the study also unveiled 7 Hepaticae and 8 Musci that are new to Sardinia.

Among the species that are new to Sardinia, those which have a special phytogeographical interest are reported below.

*Aulacomnium palustre* var. *imbricatum* is a subarctic-subalpine entity distributed in Europe, Siberia and North America, in Italy reported only in Lombardy, Trentino-Alto Adige and Friuli-Venezia Giulia. It develops in marshy habitats and on Limbara it was found on the northwestern slopes of Punta Bandiera (1200 m), on the edge of a scarp beside a dirt road. The area is rich in water, which percolates from the granite ridges of the crest; the surrounding vegetation is prevalently heather mixed with some specimens of *Salix atrocinerea* Brot., *Quercus ilex* and *Carex microcarpa* Bertol., *Hypericum tetrapterum* Fries., *Cephalanthera longifolia* (Hudson) Fritsch., *Blechnum spicant* (L.) Roth., all species typical of cool habitats with a certain gradient of humidity and soil acidity. Also found at the same site was *Philonotis caespitosa*, a boreal species with an extensive distribution in Europe, northern and central-western Asia, North Africa, in Macaronesia and North America; it is also fairly widespread in Italy. The characteristics of the site correspond to the species' typical habitat.

*Fissidens serrulatus* is instead an oceanic-submediterranean species present in Atlantic countries (Ireland, Great Britain, France, Spain and Portugal) and southern Europe (Corsica, Italy, ex Yugoslavia and Greece), in North Africa (Tunisia, Algeria) and Macaronesia (Canary Islands, Madeira and the Azores). On Limbara it was collected at the source of Li Fanghi, on the scarp of the Riu Balistrieri stream and at Miriacheddu, along the edges of a meteoric water drainage basin which is almost always full of water; all around the site is a thick reforestation area with *Pinus laricio* Poiret around which is *Erica arborea* L., *E. scoparia* L. and, among the hygrophytes *Salix atrocinerea*, *Juncus conglomeratus* L. and *Epilobium* sp.

*Racomitrium elongatum* is a boreal species, spread over Europe, the Caucasus, Asia Minor, Madeira, southern Greenland and North America. In Italy it is found in Trentino-Alto Adige, Tuscany, Abruzzo and Sicily; it lives on rocks, preferably siliceous, but sometimes even on basic soils, frequently in anthropic habitats, from the plain up to the snow line. On Limbara, it was found on soil near Punta Bandiera, at 1120 m, in a small flat valley that collects rain and spring water coming from the slopes above it. The place corresponds to one of the two sites at Punta Bandiera in which limited populations of bog moss have been found.

In the same environment *Philonotis seriata* was also found. This is a boreal species widespread in Europe, Asia, North Africa and North America; in Italy it has been reported in the northern regions down to Tuscany; it lives near springs, in damp environments and on marshy land.

On the plateau under Punta Bandiera, on marshy land sheltered from heather shrubs and in the humus in the rocky recesses along the path one finds *Cephaloziella hampeana*, a north suboceanic species distributed in Europe, the Balearic Islands, Macaronesia, Turkey, Iceland, Central and North America and Siberia; in Italy it has been reported in the central regions of the peninsula.

Of interest is the finding in Sardinia of *Campylopus introflexus*, an introduced suboceanic species; it presents an areal that includes northwestern Europe



and extends to the north of the Iberian peninsula and to a few regions in peninsular Italy (Liguria, Tuscany and Campania). It is also found in South Africa, Madagascar and the Mascarene Islands, Central and South America, southern Australia, Tasmania, New Zealand, New Guinea, Melanesia, Polynesia and Hawaii; it prefers peaty, sandy acid soils, humid sand dunes and sometimes rotting wood; on Limbara it was found at 600 m on land along the scarp of a woodland path in a place known as Curadureddu.

*Calypogeia neesiana*, a boreal mountain liverwort, is distributed in Europe, the Azores and Greenland; in Italy, before now, it had been reported only in the regions of the Alps (Valle d'Aosta, Piedmont, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia and Lombardy). On Limbara it grows on damp rocks starting from 1100 m, along the banks of Riu Balistrieri, up to 1230 m in the place known as Madonna della Neve.

*Lejeunea lamacerina*, an euoceanic-mountain species, is considered a European-Macaronesic endemism (Schumacker & Vána, 2000), in Italy it is reported only in Tuscany and Piedmont; on Limbara it grows on damp rocks along the Riu Fica Bianca (872 m) where *Marchantia polymorpha* ssp. *polymorpha*, a temperate species that grows in natural habitats and avoids places frequented by man, was also collected; its distribution is poorly defined and includes Europe, Iceland, North America, Japan and Siberia; it is scarcely found in Italy.

The presence of *Schistidium confertum*, a subboreal-mountain species that lives on dry, exposed rocks, prevalently granitic but more generally diabases, basalts, gneisses and schists, is also interesting. Previously reported in Sardinia on the Gennargentu range, according to the recent revision by Blom (1996), it is currently considered present only in Valle D'Aosta, Piedmont and Sicily at altitudes above 1000 m. On Limbara it was found at Punta Bandiera (1200 m).

Equally important is the finding of *Grimmia caespiticia*, a subarctic-sub-alpine species that grows on humid siliceous or schistose rocks at high altitudes. Greven (1995) gives this species as distributed in Europe (Corsica, Portugal, Pyrenees, Tatra), Caucasus, Greenland and Siberia; in Italy it has been reported in the alpine regions. In Sardinia it was Greven himself who found it in the Gennargentu mountains; on Limbara it was collected at Punta Bandiera (1300 m), on granitic rocks facing northeast.

## PHYTOGEOGRAPHICAL EVALUATION

The analysis of chorological elements is referred to the 197 taxa found on the Limbara horst. The nomenclature followed is that of Düll (1983, 1984, 1985, 1992) and the different types were subsequently brought together into the main chorological groups (Sérgio *et al.*, 1994) and their relative percentages were calculated.

From the analysis of the data shown in the Figure 2, we see among the mosses, and to a much lesser extent among the liverworts, the prevalence of the temperate element (30%, of which 20% for mosses and 10% for liverworts), followed by the oceanic-Mediterranean element (20%, of which 12% for mosses and 8% for liverworts). However, a significant presence of the boreal element (17%), represented almost entirely by mosses, is to be noted.

Such data is to be related most of all to the geographic position and phytoclimatic conditions of the Limbara horst, which make this land extremely interesting from the bryological standpoint owing to the presence of numerous species



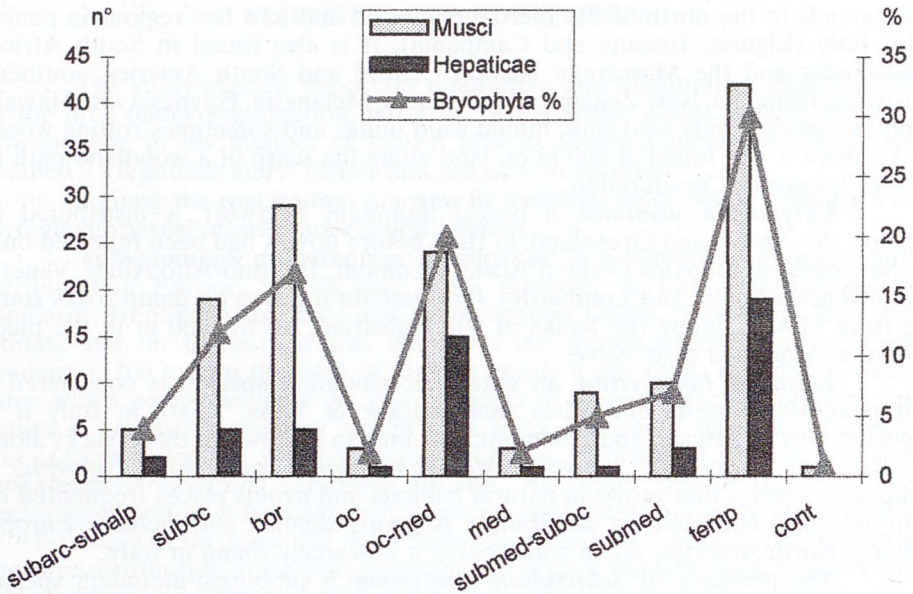


Fig. 2. Histogram of chorological elements.

of chorological and phytogeographic interest, both in Italy and the entire Mediterranean basin. On the Limbara factors that seem to most condition the presence and distribution of Bryophyta are altitude, which determines important microclimatic variations above all linked with humidity, the different types of phanerogamic vegetation and the nature of the granitic substrate which, more than others, favours greater biodiversity (Bischler & Jovet-Ast, 1973).

In particular, the Monte Limbara is characterized by cold winters, high humidity, thick fog and a prevalent north-western winds exposure that favours the presence of species less termophilous and more hygrophilous such as *Calypogeia fissa*, *Lophocolea heterophylla* (Schrad.) Dumort. and *Scapania compacta* (Roth) Dumort. among liverworts and *Aulacomnium palustre* var. *imbricatum*, *Distichium inclinatum*, *Philonotis tomentella* and *Racomitrium elongatum* among mosses.

Another quite important aspect, both from the chorological and phytogeographic viewpoints, is connected with the presence on the Limbara horst of the only Sardinian populations of the genus *Sphagnum*. A first, rather generic mention of the presence of the genus *Sphagnum* in Sardinia dates back to 1944, and was by Schmid; only twenty-eight years later, Raffaelli (1972) confirmed this presence and identified three species, giving a description of where they were found.

It is to be pointed out that in the past thirty years the land has undergone extensive works for the building of roads, water control and reforestation and these have brought about wide-reaching changes in the area's hydrogeographic profile and vegetation, so much so that the finding of such sites was fairly difficult (Cogoni & Ruggero, 1997). At present, following a series of careful surveys performed during this research work, it can be concluded that some of the sites men-



tioned by Raffaelli are to be considered lost; however, at the same time, some new, interesting sites have been discovered. In general, these are habitats represented either by the bottoms of ditches along dirt roads or small scarps above such ditches, in some cases ruined by the passage of wild boar; the only sites in a completely natural state are the one at Riu Contra Manna, along the banks of the stream, and the one on the plateau under Punta Bandiera, which was found to be the one most similar to Raffaelli's description (1972). He, about this same place name, speaks of a '...peaty meadow with stagnant water alternating with dry areas'.

In any case, all the populations of bog moss appear to be extremely fragmentary, reduced and highly vulnerable. Their survival thus depends on the performance of urgent works for their protection.

The species found are *Sphagnum auriculatum* Schimp, *Sphagnum capillifolium* (Ehrh.) Hedw. and *Sphagnum subnitens* Russow & Warnst., the distribution areals of which extend throughout the European continent; in Italy they are fairly widespread in the northern regions down to Tuscany and reappear here and there in a few central and southern regions representing their southernmost areal.

It is to be pointed out, especially in the light of the finding of the new sites, which are in zones sometimes quite distant from each other, the noteworthy ecological plasticity that the bog moss populations show on these lands and their adaptability even to environments intensively frequented by humans. On the other hand, it can be stated with certainty that the entire area of Monte Limbara is potentially capable of hosting such populations when environmental and ecological conditions allow. Thus we cannot exclude the presence of other sites with bog moss which have not been entirely explored because of the imperviousness and impenetrability of the area.

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