

CONTRIBUTIONS TO THE KNOWLEDGE OF BRYOPHYTES OF THE FORESTS ALONG THE FEKETE-KÖRÖS, SE HUNGARY

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Recent studies revealed the presence of fifty-one bryophyte species (5 liverworts, 46 mosses) in the forests along the Fekete-Körös river, near Gyula, SE Hungary. Three species (*Bryum rubens*, *Campylium polygamum*, *Orthotrichum pallens*) are considered rare in Hungary, and 9 species (*Lophocolea heterophylla*, *Metzgeria furcata*, *Anomodon longifolius*, *Eurhynchium angustirete*, *Fissidens taxifolius*, *Homalia trichomanoides*, *Isoetecium alopecuroides*, *Leucodon sciuroides*, *Pseudoleskeella nervosa*) are rare in the Great Hungarian Plain.

Key words: bryophytes, Fekete-Körös, flora, statistical analyses

INTRODUCTION

Continuous riverine ash-elm-oak forests are located at the eastern part of the Great Hungarian Plain, along the rivers Fekete-Körös and Fehér-Körös. These are remnants of the once vast forests which occupied the broad valley systems of these rivers and their tributaries up to the mountains Erdélyi-szigethegység (Transylvania, Romania). In the past the forests at the eastern margin of the Great Hungarian Plain following the rivers stretched from the mountains towards the plains, where they became fragmented and mixed with marshlands and grasslands. By now these areas had been converted into agricultural land, but forest fragments along the river Körös survived here.

Presently, ca 70% of these forests is dominated by native tree species (e.g. *Quercus robur*, *Fraxinus angustifolia* ssp. *pannonica*, *F. excelsior* etc), 25% is occupied by adventive or introduced species, and 5% is clear-cut area or young plantation. Most of the stands consist of individuals of almost the same age, very often exclusively ash and oak, without any other woody species. In their shrub layer the number of species is very low. The herb layer is often dominated by nitrophilous weeds like *Urtica dioica*. It is interesting that the understorey is remarkably rich in submontane vascular plant species, although the precipitation is quite low (MOLNÁR *et al.* 1998).

In spite of the unsatisfactory present situation of the composition and silvicultural characteristics of these forests, they are essential for nature conserva-

tion, because continuous riverine oak-ash-elm forests of considerable extension can only be found here in the Great Hungarian Plain.

Compared to montane areas, riparian forests are usually relatively poor in cryptogamic plant species. The lack of particular substrates (i.e. basic or acidic rocks, acidic soil, etc.) definitely excludes the occurrence of species known for specific requirements toward such habitat conditions. However, the microclimatic conditions of some afforested areas along the Fekete-Körös, especially the Mályvád forest are suitable for a certain range of cryptogams, which usually live in montane forests. These places, as refugia, provide some chances for their survival.

A short history of the former bryological investigations

There are very few bryological records from the studied habitats along the Fekete-Körös. Ádám Boros visited the area only four times (1922, 1936, 1938 and 1957). The following species are listed in his field notes (BOROS 1922, 1936, 1938) from the forests around Gyula and Doboz: *Frullania dilatata*, *Radula complanata*, *Amblystegium varium*, *Anomodon viticulosus*, *Brachythecium rutabulum*, *B. velutinum*, *Leskea polycarpa*, *Leucodon sciurioides*, *Orthotrichum affine*, *O. obtusifolium*, *Pylaisia polyantha*. In addition, the presence of *Marchantia polymorpha* was recorded in one occasion from a well, and *Riccia crystallina* was mentioned from a dead arm of the Körös river. Two species were added to this list by the comprehensive papers of BOROS and TÍMÁR (1962, 1963), *Hypnum cupressiforme* from the Gyulavár forest, and *Porella platyphylla* from the forest between Békéscsaba and Doboz.

MATERIAL AND METHODS

The studied forest areas are located along the Fekete-Körös in the surroundings of the town of Gyula, SE Hungary. Namely, Sitka and Mályvád forest – north-east of Gyula town; Sebesfok forest – northwest of Doboz village; Sarkad-Remete forest – southwest of Sarkad village; and Gerla-Maró forest – southwest of Doboz village (Fig. 1). Most of our records came from the vast, continuous Mályvád forest (containing some older stands of native trees as well), and a smaller amount from the other forests listed. The forest stands of different forest management, of different age and tree species composition were visited several times in 1998.

Hierarchical cluster analysis (Jaccard's similarity, UPGMA fusion technique) and PCA was carried out to compare the corticolous bryophyte vegetation

of the forest stands of different age and of various tree species. For the computations, the program package SYN-TAX (PODANI 1993) was used.

RESULTS AND DISCUSSION

A total of 51 species (5 liverworts, 46 mosses) were found in these areas. Three species are considered rare in Hungary, *Bryum rubens*, *Campylium polygamum*, *Orthotrichum pallens* and nine are rare in the Great Hungarian Plain, i.e. *Lophocolea heterophylla*, *Metzgeria furcata*, *Anomodon longifolius*, *Eurhynchium angustirete*, *Fissidens taxifolius*, *Homalia trichomanoides*, *Isoetecium alopecuroides*, *Leucodon sciuroides*, *Pseudoleskeella nervosa* (cf. ORBÁN and VAJDA 1983). These species, being rare in the plain and characteristic to the Central Mountain Range, require shaded, humid microclimate. This is provided by the closed forest, hence their presence in the area studied may be attributed to the closed-canopy forest. The same situation can be observed in the territory of Nyírség, northeastern part of the Great Hungarian Plain, where also a remarkable part of the bryophyte flora is rare in the plains and their presence is connected to the closed forests ("closed forest" microclimate, JAKAB 1998).

Two types of bryophyte vegetation are present on soils here: 1) fugitive, colonist, annual and short-lived shuttle species appear in open areas, clear-cuttings,

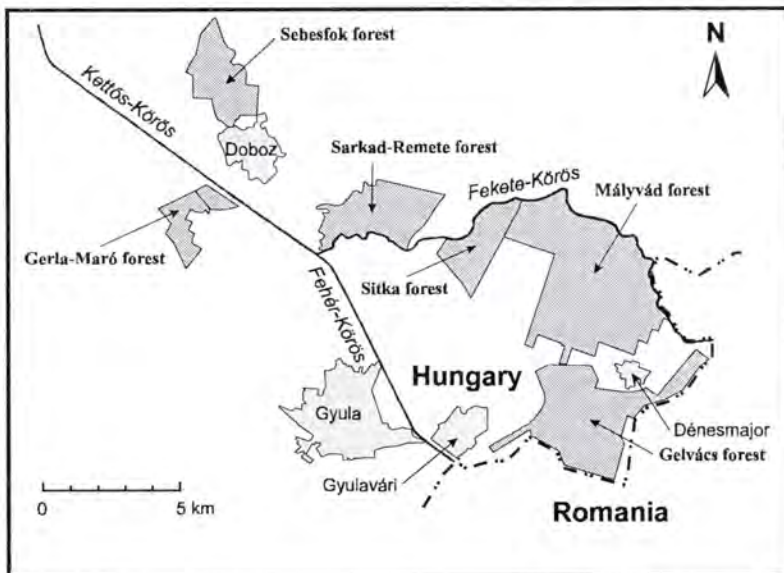


Fig. 1. Location of the study area.

clearings, young plantations, e.g. the always fertile, quick spore producing *Funaria hygrometrica*, *Physcomitrium pyriforme*, *Phascum cuspidatum*; or *Bryum rubens* with rhizoid gemmae, or *Bryum bicolor* quickly spreading by its axillary bulbils; 2) perennial and long-lived shuttle species (e.g. *Brachythecium rutabulum*, *Eurhynchium hians*, *Plagiomnium cuspidatum*, *Fissidens taxifolius*) live on wet soil in shaded forests, adapted to the more constant, undisturbed conditions. The bryophyte vegetation is quite poor in species in some forests because of the shading of the dense nitrophilous weeds or of some very dense and dark tree stands, where the soil is covered only by litter.

In inundation areas the main substrate for the bryophytes is the tree trunk. The species composition varies with the distance from the ground. At the base of the trees, up to ca 40 cm, *Brachythecium* species (*B. populeum*, *B. rutabulum*, *B. velutinum*, *B. salebrosum*), *Plagiomnium cuspidatum*, *Amblystegium serpens* and *Bryum laevifilum* are frequent, but rarely also *Eurhynchium angustirete*, *Lophocolea heterophylla* occur. Some of them are also frequent on soil (*Brachythecium rutabulum* or *Plagiomnium cuspidatum*). The very common *Hypnum cupressiforme* is also very abundant at the base, but may also be frequent even in the upper parts of the trees.

At higher zone of the tree trunks, between 40 and 70 cm, in the well structured, semi-natural forest stands *Anomodon* species (*A. attenuatus*, *A. viticulosus*), *Homalia trichomanoides*, *Isothecium alopecuroides* and *Porella platyphylla* appear. *Hypnum cupressiforme* is also predominant in this height in the more artificial stands.

At 70–120 cm *Pylaisia polyantha*, *Pseudoleskeella nervosa*, *Platygyrium repens* are frequent, *Homalothecium sericeum* is rare, and in good, semi-natural stands *Leucodon sciuroides* occurs as well.

At 120–150 cm *Orthotrichum* species, or rarely *Tortula papillosa* and *Ulota crispa* occur. Two liverwort species (*Frullania dilatata*, *Radula complanata*) are also very frequent and characteristic.

The borders of these zones are certainly not very sharp, the distribution of the species is often overlapping. The corticolous bryophyte cover in the semi-natural, old, mixed stands is often remarkable, it may be 70–80% near the base (up to ca 60 cm), and appr. 50% at higher parts (60–120 cm), and only 20–30% above 100–120 cm. In humid microclimatic conditions with satisfactory water regime mainly pleurocarpous mosses of mats, lax tufts, sometimes pendulous growing forms are typical. The small cushion forms (*Orthotrichum*, *Ulota* species), adapted to drier conditions, appear in the upper parts of the tree trunks.

ENUMERATION

The nomenclature of names follows DÜLL (1983, 1984, 1985). The Hungarian distribution of the bryophytes is characterised according to ORBÁN and VAJDA (1983).

Hepaticae

Frullania dilatata (L.) Dum. – Frequent on the upper part of the trees, occurring on various phorophyte species (oak, ash, elm, black locust). Widespread everywhere in Hungary.

Lophocolea heterophylla (Schrad.) Dum. – Some small patches only at the base of a felled oak tree at a clear-cut forest stand in the Gerla-Maró forest. In Hungary, common on decaying wood and soil in the Central Mountain Range, but rare in the Great Hungarian Plain.

Metzgeria furcata (L.) Dum. – One specimen from an ash tree at the Sebesfok forest. Also common in the montane, hilly areas, and rare in the plain, occurring on bark and rocks.

Porella platyphylla (L.) Pfeiff. – Mainly from ash trees (one record from an oak) in older mixed stands in the Mályvád, Sebesfok and Sarkad-Remete forests. Not frequent here, but wide-spread in Hungary on bark and rocks.

Radula complanata (L.) Dum. – Frequent everywhere on most phorophyte species, occurring mainly on the upper part of the trees together with *Frullania dilatata*. Common in the whole country.

Musci

Amblystegium riparium (Hedw.) B., S. et G. – On rotten wood in a black locust stand in the Mályvád forest. Frequent in the hilly, montane areas, mainly in the valleys. Not rare in the Great Hungarian Plain. It grows in fen-woods, and reed stands.

Amblystegium serpens (Hedw.) B., S. et G. – Frequent in all parts of the studied area on bark, soil and wood. Common in the whole country.

Amblystegium serpens (Hedw.) B., S. et G. var. *juratzkanum* (Schimp.) Rau et Herv. – Only two specimens found in the Sitka and Mályvád forests from rotten wood and soil. Common in the whole country. It usually grows in the same habitat as *A. serpens*.

Amblystegium varium (Hedw.) Lindb. – Not frequent in the studied area, only some specimens collected from ash bark and rotten wood in the Mályvád and Sarkad-Remete forests, from soil in the Gerla-Maró and Sebesfok forests, from black locust and rotten wood in the Gelvács forest. Common in the whole country in wet, shaded forests or stream banks.

Anomodon attenuatus (Hedw.) Hueb. – Some records from oak and ash trees in old, mixed stands of the Mályvád and Sarkad-Remete forests. Not frequent here. Frequent in the Central Mountain Range, but rarer in the forests of Great Hungarian Plain.

Anomodon longifolius (Brid.) Hartm. – Frequent in the forests of the Central Mountain Range, but rarer than *A. attenuatus*. Rare in the Great Hungarian Plain.

Anomodon viticulosus (Hedw.) Hook. et Tayl. – Occurs mainly in older, mixed stands; only a few specimens were found on ash trees and rotten wood in the Mályvád forest, on ash in the Sarkad-Remete and the Sebesfok forests, on oak tree in the Gerla-Maró forest. Common in the whole country on bark and rocks.

Atrichum undulatum (Hedw.) P. Beauv. – On soil from a low, dense, mid-aged oak stand of the Mályvád forest. Common in the whole country on soil in forests, and roadsides.

Barbula unguiculata Hedw. – Frequent on soil in clear-cut areas, young plantations and roadsides. Common in the whole country on sunny clayey and sandy soil.

Brachythecium mildeanum (Schimp.) Schimp. ex Milde – Two specimens from wet soil in the Mályvád and Sebesfok forests. Widespread in the whole country, but not very frequent. It grows in fen-woods and wet meadows.

Brachythecium populeum (Hedw.) B., S. et G. – From oak, ash, rotten wood and soil, but not frequent. Common in the whole country on bark, soil and rocks.

Brachythecium rutabulum (Hedw.) B., S. et G. – Frequent on bark, soil, as well as on rotten wood. Common in the whole country on bark, soil and rocks.

Brachythecium salebrosum (Web. et Mohr) B., S. et G. – Frequent on various phorophytes, soil and rotten wood. Common in the whole country on rotten wood and soil.

Brachythecium velutinum (Hedw.) B., S. et G. – Frequent on bark, soil and rotten wood. Common in the whole country on bark, soil and rocks.

Bryum argenteum Hedw. – On soil of clear-cut areas, young plantations or roadsides. Common in the whole country on rocks, sandy, clayey sunny soil.

Bryum bicolor Dicks. – On habitats similar to those of *B. argenteum*. Frequent in the whole country on sunny clayey soil.

Bryum laevifilum Syed – On various phorophytes, rotten wood and soil, but not very frequent. Common in the whole country on bark and soil.

Bryum rubens Mitt. – Frequent on soil of clear-cut areas and young plantations. So far only a few localities are known from Hungary: Nagy-erdő near Debrecen (JAKAB 1997), loess cliffs above Balatonkenese and along the Danube river at Dunaszekcső (VAN ZANTEN 1999). A plant of arable fields, mole-hills, earth banks, bare patches in turf or other temporary habitats (CRUNDWELL and NYHOLM 1964). It belongs to the *Bryum erythrocarpum* complex. Probably not rare in Hungary, but this *Bryum* group has been neglected or overlooked in the country. So the records available regarding this group are insufficient for a well founded judgement.

Campylium polygamum (B., S. et G.) J. Lange et C. Jens. – One record from rotten wood in an ash stand of the Mályvád forest. Not frequent in Hungary, it occurs in hilly or montane areas in meadows or on soil of wet forests.

Ceratodon purpureus (Hedw.) Brid. – On soil of clear-cut areas, young plantations or roadsides. Common in the whole country on sunny, dry places.

Dicranella varia (Hedw.) Schimp. – One record from wet soil in the Sebesfok forest. Common in the whole country on wet clayey and sandy soil.

Drepanocladus aduncus (Hedw.) Warnst. – One record from a black locust trunk in the Gelvács forest. Common in the whole country in inundation areas, wet places, ditches.

Eurhynchium angustirete (Broth.) T. Kop. – Not frequent; a few specimens from ash bark and soil in the Mályvád forest. Frequent in the whole country in hilly and montane areas, but rare in the Great Hungarian Plain.

Eurhynchium hians (Hedw.) Sande Lac. – Frequent on soil in forests and roadsides. Frequent in the whole country in shaded places on slightly wet soil.

Fissidens taxifolius Hedw. – Some occurrences on soil in forests, roadsides. Common in the whole country, but rare in the Great Hungarian Plain.

Funaria hygrometrica Hedw. – Mainly on soil of young plantations or roadsides. Common in the whole country, frequent on slightly wet soils rich in nitrogen.

Homalia trichomanoides (Hedw.) B., S. et G. – Some specimens from oak and ash bark in the Mályvád and Sarkad-Remete forests. Common corticolous species, frequent in the whole country, but rare in the Great Hungarian Plain.

Homalothecium sericeum (Hedw.) B., S. et G. – Some specimens from ash bark in the Mályvád and Sebesfok forests. Frequent on rocks and bark in montane areas, rarer in the Great Hungarian Plain.

Hypnum cupressiforme Hedw. – Very common everywhere on all kinds of phorophytes and soil. Widespread and common in the whole country on various substrates.

Isothecium alopecuroides (Dubois) Isov. – Some specimens from oak and ash bark in the Gerla-Maró, Sebesfok and Sarkad-Remete forests. Frequent on shaded, non-calcareous rocks and bark in the whole country, but rare in the Great Hungarian Plain.

Leucodon sciurioides (Hedw.) Schwaegr. – Some specimens from ash bark in old, mixed stands of the Mályvád, Sebesfok and Sarkad-Remete forests. Frequent in the whole country on various rocks and bark in forests, but rare in the Great Hungarian Plain.

Orthotrichum affine Brid. – Not rare in the forests along the Fekete-Körös, occurring on various phorophytes, like oak, black locust, ash. Common in the whole country in open forests.

Orthotrichum diaphanum Brid. – Not frequent in the studied stands. Two specimens from ash and elm bark in the Mályvád forest. Common corticolous species in the whole country, growing also on roadside trees.

Orthotrichum lyellii Hook. et Tayl. – Found on various phorophytes in the Mályvád and Sitka forests. Common in the whole country on bark of forest trees.

Orthotrichum pallens Bruch ex Brid. – Several specimens from ash, oak, black locust and elm bark in the Mályvád and Sarkad-Remete forests. Not frequent in Hungary.

Orthotrichum patens Bruch ex Brid. – Not rare in the forests along the Fekete-Körös, on various phorophytes. Common corticolous species in the whole country, but rarer in the Great Hungarian Plain.

Orthotrichum speciosum Nees ex Sturm – Found on oak and ash bark in the Mályvád forest. Common in the whole country in open forests.

Phascum cuspidatum Hedw. – Found on soil in young plantations, clear-cut areas, and roadsides. Common in the whole country on sunny clayey and sandy soils.

Physcomitrium pyriforme (Hedw.) Brid. – Collected from soil in a young plantation in the Mályvád forest. Common in the whole country on wet clayey or sandy soils.

Plagiomnium cuspidatum (Hedw.) T. Kop. – Not rare on soil and bark in the forests along the Körös. Common in the Central Mountain Range, but rarer in the Great Hungarian Plain.

Platygyrium repens (Brid.) B., S. et G. – Not rare in the studied area on various phorophytes. Common corticolous species, widespread in the whole country.

Pseudoleskeella nervosa (Brid.) Nyh. – Frequent on various phorophytes. Common on shaded rocks and bark in the hilly, montane areas, but rare in the Great Hungarian Plain.

Pylaisia polyantha (Hedw.) Schimp. – Frequent in the forests along the Fekete-Körös, occurring on various phorophytes. Common in the whole country on various phorophytes, rarely also on rocks.

Tortula papillosa Wils. – Not rare, mainly on bark of older oak and ash trees. Corticolous species, frequent in hilly, montane areas, especially in valleys, and also in the inundation areas of the plains.

Ulotia crispa (Hedw.) Brid. – Two specimens from ash and oak bark in the Mályvád forest. Corticolous species, widespread in the whole country.

Weisia brachycarpa (Nees et Hornsch.) Jur. – Collected on soil in a young plantation in the Mályvád forest. Common in the whole country on clayey soil.

COMPARISON OF THE BRYOPHYTE VEGETATION OF FOREST STANDS WITH DIFFERENT AGE AND SPECIES COMPOSITION BY STATISTICAL METHODS

The corticolous bryophyte flora is very rich in species in the forests along the Fekete-Körös river. During the field work it was convincing to observe that the bryophyte species composition and richness were very different in the forest stands of different age and of various tree species composition. There were bryophyte species, which were frequent in each stands, but several of them were connected to the well-structured, semi-natural, older, mixed forest stands.

Statistical analyses were used to explore distribution patterns and differences in the bryophyte flora of these forest stands and how the differences could be explained by the presence and absence of certain bryophyte species.

As shown by the dendrogram made on the basis of bryophyte vegetation of the forest stands, the semi-natural, old, mixed forests (oM1, oM2, oM3) are forming a cluster (Fig. 2, marked as Group I) together with a mid-aged ash stand (mF). Their bryophyte flora is rich in species (species number 17–24). In Group II mid-aged black locust and old oak forests can be found as well as a mid-aged oak

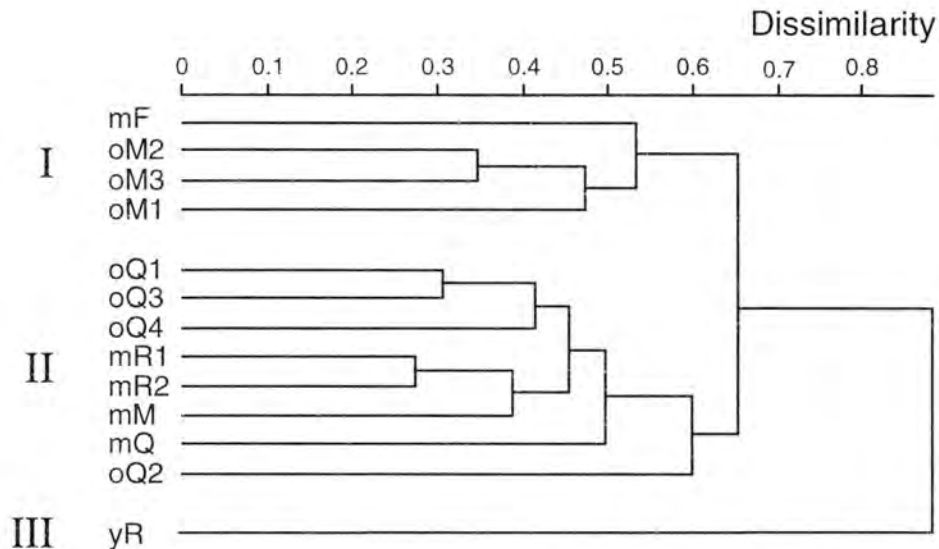


Fig. 2. Dendrogram of the stands with different age and species composition on the basis of their bryoflora (abbreviations of the stands: o – old, m – mid-aged, y – young forest stands; F – *Fraxinetum*, Q – *Quercetum*, R – *Robinietum*, M – mixed forest).

and a mid-aged mixed forest. Their bryophyte flora is poorer in species (usually around 11) than that of the old, mixed stands. A young black locust stand (yR) forms a third, highly separated cluster by itself (Group III). Its bryoflora consists of only 4 species.

The ordination (PCA) was made on the same dataset, i.e. the bryoflora of the studied forest stands (Fig. 3). The first three axes comprise 70.5% of the total variance. The first axis (51.2% of the total variance) does not really separate the forest stands, except the young black locust stand; it has the lowest eigenvalue on this axis, with no neighbours.

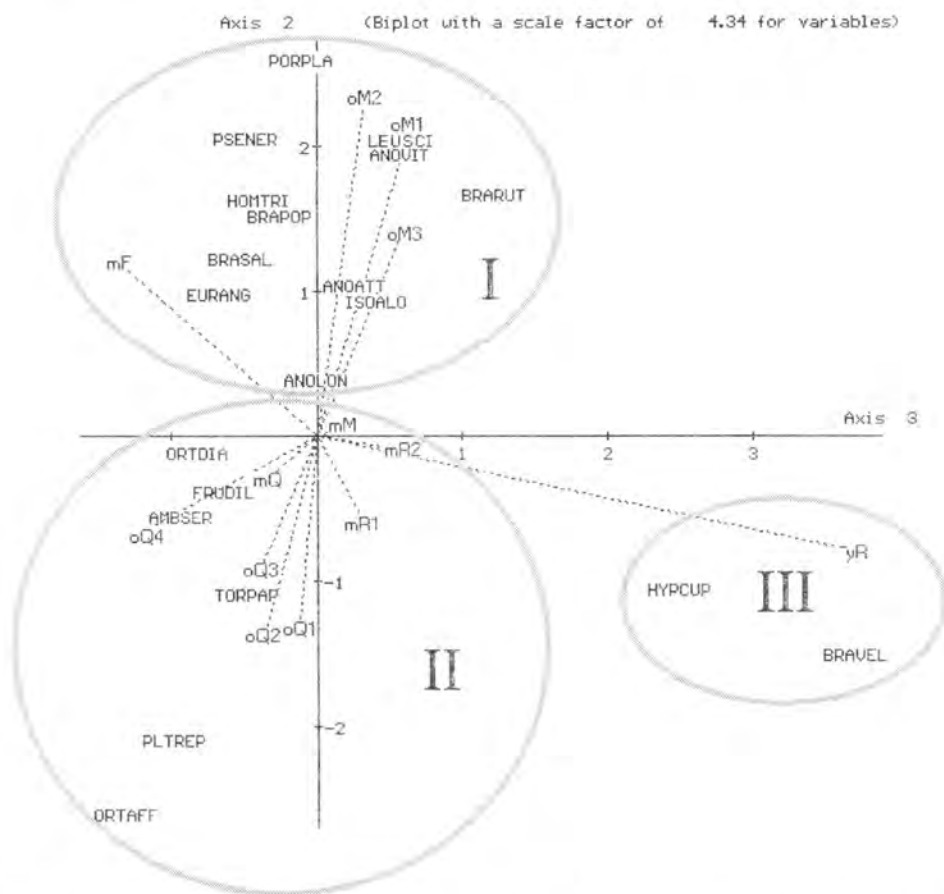


Fig. 3. Biplot of PCA analysis, the arrangement of the stands and some selected bryophyte species along the 2nd and 3rd axis. (abbreviations of the stands are the same as in Fig. 2, abbreviations of species are formed by the initial three letters of the genus and species names respectively).

The important differences can be observed along the second axis (10.9% of the total variance); all of the ash and mixed forest stands have positive eigenvalues. The eigenvalues of all black locust and oak stands are in the negative range of the second axis. The third axis (8.3% of the total variance) "draws apart" the stands very well. On the plot a good correlation with the results of the cluster analysis can be observed, the members of the three groups obtained there can be encircled here. The biplot offers a good opportunity to find out which species are responsible for the separation of the groups.

According to the biplot in the black locust stand some common bryophyte species (e.g. *Brachythecium velutinum*, *Hypnum cupressiforme*) can be found. The oak forests can be characterized mainly by *Orthotrichum* species, *Tortula papillosa*, *Frullania dilatata* occurring in the higher zone of trees and adapted to drier conditions and by pleurocarpous, mat forming, common species as *Amblystegium serpens*, *Platygyrium repens*. The corticolous bryophyte flora of the mixed forests is very diverse. Species adapted to higher humidity, with lax tufts or mat growing forms, as *Porella platyphylla*, *Anomodon* and *Brachythecium* species appear. Several species in these forests are rare in the Great Hungarian Plain, but frequent in montane forests; these are *Isothecium alopecuroides*, *Homalia trichomanoides*, *Eurhynchium angustirete*, *Anomodon longifolius*, *Pseudoleskeella nervosa*, *Leucodon sciuroides*.

The latter bryophyte species are indicators of semi-natural, well-structured forests, where humid microclimate and good light conditions are provided for them. They are not common in the oak and black locust forests in the study area, as these stands are almost monocultures, with almost no "alien" tree intermixing. As one conclusion, the presence of a "closed forest" is not enough to support a rich bryoflora. Besides the role of the age of the forest stand, its structure, the level of mixing and the age distribution of the different tree species has a key importance. It was observed in the study area that for example if ash trees are among the mixing species, the otherwise closed canopy of other species is broken in a way that produces better light conditions for bryophytes.

Consequently, we adorn the high importance of the establishment and maintenance of mixed forests; such forestry practices are desirable and beneficial for nature conservation.

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