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Selection of Important Bryophyte Areas in Hungary

Beáta Papp
Botanical Department, Hungarian Natural History Museum, Budapest, Pf. 222. H-1476, Hungary
E-mail: pappbea@bot.nhmus.hu

Abstract: Until now 99 sites could be selected as important bryophyte areas on the basis of 125 populations of 26 European red-listed species and an additional three species protected by law in Hungary. Most of the species with confirmed recent occurrences have few existing populations. The most important habitats from the point of view of the conservation of European red-listed bryophytes are places with shaded rocks or rocks in streams in forest-covered mountainous areas, which maintain 30% of the existing Hungarian populations of European red-listed species. Saline-alkali and dry rocky grasslands and loess cliffs are also very important habitats in the preservation of submediterranean, continental, and subcontinental elements. Wet grasslands nowadays are of minor importance in the preservation of rarities as they are in very bad conditions mainly due to dry climatic periods of the last decades. Similarly, the number of populations of species living on decaying wood and tree bark is not high either.

Kokkuvõte: Tähtsate Samblaalade valik Ungaris.

Praeguseks on välja valitud 99 tähtsat samblaala toetudes 26 Euroopa Punasesse Raamatusese kuuluva ning lisaks 3 Ungaris seadusega kaitstava liigi, kokku 125 populatsiooni, andmetele. Enamikul kaasaegseid kindlaid leiukohti omavatel liikidel Ungaris on väikesed populatsioonid. Euroopa Punasesse Raamatusse kuuluvate liikide kaitse seisukohast kõige tähtsamateks kasvukohtadeks on varjuliste paikade kaljud ning ojades asuvad kivid metsaga kaetud mägipiirkondades. Nimetatud kasvukohtades esineb kolmandik (30%) Euroopa Punase raamatu liikide Ungari populatsioonidest. Submediterraansetesse ja subkontinentaalsetesse elementidesse kuuluvate liikide kaitse seisukohalt on tähtsad ka sooldunud aluselised ning kuivad kivised rohumaad ja lössikaljud. Märjad rohumaad omavad tänapäeval haruldaste liikide kasvukohana vähemat tähtsust, kuna nad on viimaste aastakümnete kuivaperioodide tõttu väga halvas seisukorras. Ka kõdupuidul ning puutüvedel kasvavate liikide populatsioonide arv ei ole suur.

INTRODUCTION

The Important Bryophyte Area project can be connected with the Important Plant Area (IPA) project. In 2002, the Conference of the Parties to the Convention of Biological Diversity adopted the Global Strategy for Plant Conservation including several global targets for 2010. The targets are concentrated under 5 main groups: Understanding and Documenting Plant Diversity; Conserving Plant Diversity; Using Plant Diversity Sustainably; Promoting Education and Awareness about Plant Diversity; Building Capacity for the Conservation of Plant Diversity. Target 5 has set as an aim to protect 50% of the important areas for plant diversity by 2010. Identification of Important Plant Areas (IPAs) meets with this target. This project is lead by the Plantlife International and IUCN with other partners like Planta Europa. An IPA exhibits exceptional botanical richness and /or supports an outstanding assemblage of rare, threatened and/or endemic plant species and/or vegetation of high botanical value. The IPA program considers the lowers plants and fungi as well. These plants are underrepresented in existing European conservation legislation. The IPA network is one possibility to protect and properly manage those sites, which are identified as important for the preservation of lower plants. Bryophytes were taken into consideration in the selection of IPAs in the Czech Republic, Estonia, Poland, Romania, Slovakia and Slovenia (Anderson, 2002). The Important Bryophyte Area (IBrA) project aims at identifying areas, which are important from a bryological point of view. An IBrA holds existing, viable populations of bryophyte species included in either World Red List, European Red List, or supports endemics/near endemics. The site may also represent an exceptionally rich bryophyte flora in relation to its biogeographic zone and habitat types. The IBrA project can be regarded as a part of the IPA program, but it can also be treated as separate project especially in our case, because Hungary has not participated in the IPA program.

Hungary has initiated a Natura 2000 project instead of the IPA program. In the selection of

Natura 2000 sites only the data of 5 bryophytes included in the Bern Convention and EU Habitats Directive (*Buxbaumia viridis, Dicranum viride, Hamatocaulis vernicosus, Mannia triandra, Orthotrichum rogeri*) and all *Sphagnum* species (listed in Annex V.) occuring in Hungary were taken into consideration (Demeter, 2000). According to our recent knowledge *Hamatocaulis vernicosus* has disappeared from the earlier known localities and *Orthotrichum rogeri* has not been refound within the last 50 years in Hungary.

Hungary is situated in the Carpathian basin and the whole territory of the country belongs to the Pannonian biogeographic region, which is one of the biodiversity hotspots in Europe. Several areas in the Carpathian basin have served as refugia during the last glacial periods. The mountains around the basin act as barriers but could also play a role as a mediator. The transitional character of the climate in the basin made it possible that this region became the contact zone of flora and fauna elements of different origin: boreal-montane from the Carpathians and Alps, submediterranean from the Balkans and continental from the eastern steppes. The coexistence of different elements is also supported by the highly mosaic natural landscape structure (Forró, 2007).

The aim of this paper is to present the preliminary results of IBrA project, which is not financed officially. The results derived from earlier projects for database establishment and a recently ongoing project of National Biodiversity monitoring System supported by the Environmental Ministry and several national parks of Hungary.

MATERIAL AND METHODS

The IPA site selection is based on three criteria. A.) sites of significant populations of one or more species that are of global or European conservation concern. B.) sites with an exceptionally rich flora in a European context in relation to its biogeographic range. C.) sites, which are outstanding examples of a habitat type of global or European plant conservation and botanical importance.

For the selection of IBrAs the first criterion can be applied easily. The species list of the Red Data Book of European Bryophytes (ECCB, 1995) can be used according to the suggestions of the IPA project (Anderson, 2002). The selection in Hungary has been started with the recently known Hungarian localities of the European red-listed species. The work is based on the locality database of rare bryophytes of the Hungarian Natural History Museum. This database includes the earlier and presently known localities of European and national rarities. The Hungarian bryophyte flora is well explored due to the outstanding activity of earlier bryologists, Ádám Boros and László Vajda, but their data are now 50–60 years old. After their period there was a gap in bryological activity in Hungary. Our work began 10 years ago with the search for rarities in the earlier known localities and in potential new sites. This is an ongoing task and the list of the IBrAs can be extended year by year according to newly found localities of existing populations of European rarities.

Although the number of sites selected is a national decision there is a recommendation of the IPA project. For the highly threatened species with fewer than 10 sites within the country all sites with viable population can be selected. For species with up to 20 sites the largest (5% or more of the national population) can be selected. Nomenclature of the species follows Grolle and Long (2000) and Hill et al. (2006). European distribution of the species is given according to Düll (1983, 1984, 1985).

For the selection of sites presented in this paper only the first criterion ("A") was used and the data obtained last 10 years were taken into consideration, as the IPA project requires recent knowledge about the populations.

RESULTS

According to the Red Data Book of European Bryophytes 47 European red-listed species have been reported from Hungary (ECCB, 1995 – p. 177). *Hamatocaulis vernicosus* was erroneously lacking from this list. Later on two species (*Aloina bifrons, Grimmia sessitana*) were excluded from our bryophyte flora (Erzberger & Papp, 2004), but three red-listed species (*Ephemerum sessile, Orthotrichum sprucei, Tortula brevissima*) were discovered in Hungary (Erzberger, 1998, Erzberger & Papp, 2000, 2004, Papp et al., 2000). According to the European checklist of Hill et al. (2006) *Fissidens exiguus* can be also excluded, because European specimens identified as *Fissidens exiguus* are poorly limbate forms of either

F. pusillus or F. viridulus. Hence the number of European red-listed species occuring in Hungary in the present or past is 48.

Until now 99 sites could be selected on the base of 125 populations of 26 European red-listed species and an additional three species protected by law in Hungary (Papp et al., 2002) and included in the regionally threatened (RT) category in the Red Data Book of European Bryophytes (ECCB, 1995). The other 22 European red-listed species occurring in Hungary have been not refound within the last 10 years. Most of the species with confirmed recent occurrences have very few existing populations. Only three species have more than 10 known localities. Hence all the known localities could be selected as IBrA. The number of existing populations can be seen in Table 1.

Forest-covered mountainous areas

The region richest in European red-listed species is the Bükk Mts. In this mountain area 12 localities could be selected on the base of 16 populations of 9 European red-listed species (Table 2, 3, 5). The Bükk Mts are one of the foothills of the Carpathian mountain range and part of the North Hungarian mountain range. On the plateaus and northern slopes and gorges the flora has Carpathian (montane-alpine) features,

Table 1. The number of existing populations of European red-listed species in Hungary

species of Bern Convention, EU Habitats Directive & Red Data Book of European Bryophytes	category in RDB	number of populations
Buxbaumia viridis (Moug. ex Lam. & DC.) Brid. ex Moug. & Nestl.	V	1
Dicranum viride (Sull. & Lesq.) Lindb.	V	7
Mannia triandra (Scop.) Grolle	R	1
Pyramidula tetragona (Brid.) Brid.	V	4
species of Red Data Book of European Bryophytes		
Amblystegium radicale (P.Beauv.) Schimp.	R	1
Anacamptodon splachnoides (Froel. ex Brid.) Brid.	E	1
Anomodon rostratus (Hedw.) Schimp.	R	12
Asterella saccata (Wahlenb.) A.Evans	V	11
Brachydontium trichodes (F.Weber) Milde	R	1
Campyliadelphus elodes (Lindb.) Kanda	RT	1
Campylostelium saxicola (F.Weber & D.Mohr) Bruch & Schimp.	R	1
Didymodon glaucus Ryan	V	1
Drepanocladus sendtneri (Schimp. ex H.Müll.) Warnst.	RT	2
Entosthodon hungaricus (Boros) Loeske	R	11
Fissidens arnoldii R.Ruthe	R	5
Frullania inflata Gottsche	V	3
Grimmia plagiopodia Hedw.	R	3
Hilpertia velenovskyi (Schiffn.) R.H.Zander	R	16
Lophozia ascendens (Warnst.) R.M. Schust.	R	2
Microbryum floerkeanum (F.Weber & D.Mohr) Schimp.	K	13
Neckera pennata Hedw.	V	2
Orthotrichum sprucei Mont.	R	1
Pseudocalliergon lycopodioides (Brid.) Hedenäs	RT	2
Pterygoneurum lamellatum (Lindb.) Jur.	V	5
Rhychostegium rotundifolium (Scop. ex Brid.) Schimp.	R	7
Rhynchostegiella teneriffae (Mont.) Dirkse & Bouman	R	3
Taxiphyllum densifolium (Lindb. ex Broth.) Reimers	R	4
Tortula brevissima Schiffn.	R	3
Tortula cernua (Huebener) Lindb.	R	1

Table 2. IBrAs sites characterized by shaded limestone rock habitats and occurrence of European red-listed species. A – *Anomodon rostratus,* D – *Didymodon glaucus,* M – *Mannia triandra,* R – *Rhynchostegium rotundifolium,* T – *Taxiphyllum densifolium*

locality	A	D	M	R	T
Aggteleki karst, Lófej-valley					+
Aggteleki karst, Ménes-valley	+				
Bakony Mts, Ördög-valley at Gézaháza	+				
Bükk Mts, Ablakoskő-valley	+			+	
Bükk Mts, Háromkút-valley	+				
Bükk Mts, Hór valley	+				
Bükk Mts, Kerek hill at Lillafüred			+		
Bükk Mts, Leány-valley				+	
Bükk Mts, Szalajka-valley				+	
Bükk Mts, Szeleta cave		+			
Bükk Mts, Vöröskő hill at Ómassa	+				
Pilis Mts, Fekete-hill at Pilisszentkereszt	+				
Pilis Mts, Kétbükkfa-nyereg	+				
Pilis Mts, Vaskapu	+			+	
Vértes Mts, Meszes valley at Vérteskozma	+				
Vértes Mts, Vár-valley at Csókakő	+				
Vértes Mts, Ugró-valley at Csákberény	+				

Table 3. IBrAs sites characterized by shaded volcanic rock habitats and occurrence of European red-listed species. B – *Brachydontium trichodes,* C – *Campylostelium saxicola,* F – *Frullania inflata,* R – *Rhynchostegium rotundifolium,* T – *Taxiphyllum densifolium*

locality	B	C	F	R	T
Balaton Upland, Szent György hill				+	
Börzsöny Mts, Kopolya-kövek rocks	+	+			
Bükk Mts, Szarvaskő hill			+		
Keszthelyi Mts, Tátika hill			+		
Mátra Mts, Saskő rocks					+
Mátra Mts, Sombokor rocks					+
Visegrádi Mts, Apátkúti-valley				+	
Visegrád Mts, Szerkövek rocks				+	+
Zemplén Mts, Kis-szikla rocks at Kéked			+		

Table 4. IBrAs sites characterized by shaded rocky habitats in streams of limestone and volcanic bedrock and occurrence of European red-listed species. Fisarn – *Fissidens arnoldii,* Rhyten – *Rhynchostegiella teneriffae*

locality	Fisarn limestone	Rhyten volcanic
Bakony Mts, Ördög-valley at Gézaháza	+	
Balaton Upland, Szakadék valley at Pécsely	+	
Cserhát Mts, Cserkúti-stream	+	
Visegrádi Mts, Apátkúti-valley		+
Visegrádi Mts, Nyír-valley at Pilismarót		+
Visegrádi Mts, Rám-szakadék gorge, Lukács-árok valley		+

while the lower regions and southern slopes are covered by thermophilous vegetation. The most important vegetation types are the closed oak and at higher elevation the beech forests. The bedrock of this mountain area is mainly limestone, but some volcanic outcrops can also be found. The elevation ranges up to 900–950 m a.s.l. The annual rainfall is 700–800 mm and the average temperatures ranging from -3 to -4 °C in January and 19–20 °C in July. This mountain area is one of the coldest regions in Hungary. Almost all area of the mountain is protected belonging to the Bükk National Park. This mountain is one of the biodiversity hotspots of Hungary according to the distribution map of Annex I habitats and Annex II species of Habitats Directive (Horváth et al., 2003).

Most of the populations of red-listed bryophyte species found in this mountain area live on shaded limestone rocks in humid gorges e. g. *Anomodon rostratus* and *Rhynchostegium rotundifolium* (Papp et al., 2000; Papp & Erzberger, 2003). *Didymodon glaucus* has a population in a cave entrance, which is the only locality of the species in Hungary, while the only existing population of *Mannia triandra* in the country can be found at the base of a large limestone rock wall. There are also decaying wood inhabiting bryophytes as *Buxbaumia viridis* and *Lophozia ascendens* (Papp et al., 2000). These species can be found in the same valley in Bükk Mts, in Leány-valley. This locality is supporting the

Table 5. IBrAs sites of forest habitats and occurrence of European red-listed species inhabiting decaying wood or bark of trees. B – *Buxbaumia viridis,* L – *Lophozia ascendens,* A – *Anacamptodon splachnoides,* D – *Dicranum viride,* N – *Neckera pennata*

locality	B	L	A	D	N
	decaying wood		bark of tree		
Bátorliget swamp forest			+		
Bereg region, Téb-forest at Tarpa					+
Budai Mts, Páty			+		
Bükk Mts, Hór-valley				+	
Bükk Mts, Leány-valley	+	+			
Bükk Mts, Old Forest				+	
Bükk Mts, Vár hill at Felsőtárkány				+	
Mátra Mts, Kékes forest reserve		+			
Vend region, Lujza hill at Felsőszölnök					+
Zala region, Vétyem				+	
Zemplén Mts, Piszkés-tető at Hollóháza				+	
Zemplén Mts, Vadász-tető, Vajda-valley				+	

only known population of *Buxbaumia viridis* in Hungary (Papp et al., 2002). Three larger populations of *Dicranum viride* can be found in the Bükk Mts; one in a beech forest called Old Forest, while two in oak forests (Papp et al., 2000; 2002; Papp & Erzberger, 2003). *Frullania inflata* has a small population on a volcanic outcrop at the southern part of the mountain range (Papp & Erzberger, 2003), while *Tortula brevissima* was discovered some years ago on a rhyolite tuff outcrop at the southern border of the mountains (Erzberger, 1998; Papp et al., 2000). Some parts of the mountains provide suitable conditions for more than one European red-listed species e. g. Leány-valley, Hór-valley, Ablakoskő-valley. The sizes of the selected sites are small (1–10 km^2) and they are scattered all over the mountains. The population sizes are also usually small, but most of them are stable.

Several other IBrAs can be selected in the forest belt of mountainous areas of Hungary in the North Hungarian (Aggteleki karst, Börzsöny Mts, Cserhát Mts, Mátra Mts, Zemplén Mts) and Transdanubian mountain ranges (Bakony Mts, Balaton Upland, Gerecse Mts, Keszthelyi Mts, Pilis-Visegrádi Mts, Vértes Mts). In these mountainous regions species with different habitat requirements (shaded rock walls; rocks in streams; tree barks; decaying wood in humid forests) occur. Out of the sites of Bükk Mts 8 shaded limestone rocky places can be designated to the populations of *Anomodon rostratus* (Papp et al., 2000, Papp & Erzberger, 2003). At two sites *Rhynchostegium rotundifolium* can also be found (Papp & Erzberger, 2003) (Table 2). Several sites with volcanic rocks can be selected on the basis of the populations of *Frullania inflata*, *Rhynchostegium rotundifolium*, *Taxiphyllum densifolium* and one site with the small populations of *Campylostelium saxicola* and *Brachydontium trichodes* (Papp et al., 2000; 2002; Papp & Erzberger, 2003) (Table 3). Streams with limestone rocks can be selected to protect *Fissidens arnoldii* and streams with volcanic rocks for the preservation of *Rhynchostegiella teneriffae* (Erzberger, 2002; Papp et al., 2000; Papp & Erzberger, 2003) (Table 4.). Very few sites can be selected, which maintain rarities living on decaying wood or tree barks in humid forests. Apart from the Leány-valley in Bükk Mts, there is only one more site with *Lophozia ascendens*, a liverwort inhabiting decaying wood (Papp et al., 2000, 2002). Apart from the 3 sites of *Dicranum viride* in the Bükk Mts, 4 more sites can be selected for the protection of this species (Papp et al., 2002; Papp & Erzberger, 2003). On the basis of the populations of other species living on tree barks only 3 sites can be selected; *Neckera pennata* and *Anacamptodon splachnoides* (Papp et al., 2000; Papp & Erzberger, 2003) (Table 5). These latter species in 1950–60 had several localities in Hungary (20–25 sites). The drastic reduction of the distribution of these species reflects the effects of intensive forestry activity in our country. Almost no intact forest exists nowadays in Hungary. The shaded rocky habitats are also threatened by forestry, since cutting of the overshadowing forest around the rock walls creates drier and more exposed environmental conditions. Fortunately most of the rocky places are situated in quite steep slopes which make forestry activities difficult.

Dry rocky grasslands

Dry rocky grasslands are important habitat types from a conservation point of view at a European level and are listed on Annex I of the EU Habitats Directive (Horváth et al., 2003).

11 limestone grassland sites can be selected on the base of the existing populations of *Asterella saccata*. These are situated mainly in the Transdanubian mountain range in Vértes, Gerecse, Budai and Pilis Mts (Papp & Erzberger, 2003). On the site of the Remete-hill in Budai Mts *Pyramidula tetragona* can also be found (Papp & Erzberger, 2003). One isolated, but quite large population of *A. saccata* can be found in the southern part of Hungary on Szársomlyó-hill in the Villányi Mts (Papp et al., 2000; Papp & Erzberger, 2000). In another site in the Villányi Mts, a small population of *Microbryum floerkeanum* was discovered (Papp & Erzberger, 2000). 3 basaltic grasslands were selected in the Balaton Upland region as the other localities of *Pyramidula tetragona* (Papp et al., 2000, 2002), and another basaltic grassland area in Visegrádi Mts as the locality of *Grimmia plagiopodia*. Altogether 16 grasslands were selected (Fig. 1). Dry rocky grasslands can be found in mosaics in thermophilous oak forests mostly on the southern slopes of mountains. Most of the limestone grasslands are situated in the Transdanubian mountain range. Grasslands formed on volcanic bedrock can be found mainly in the Northern Hungarian mountain range. On the basis of the occurrence of European red-listed species from the latter region IBrA sites can not be selected and in the Transdanubian range there are also more valuable sites from bryological point of view, hence in the case of dry rocky grasslands further selection on the basis of indicator species is very important.

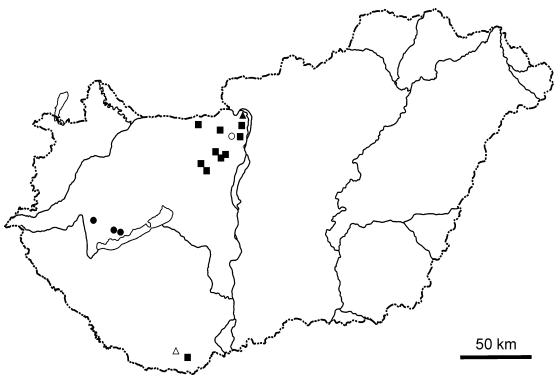

Fig. 1. IBrA sites of dry grassland habitat type.
■ – locality of *Asterella saccata* (Budai Mts: Kecske hill; Gerecse Mts: Kecske-kő at Gyermely; Lóingató hill at Óbarok; Nagy-Teke at Süttő; Turul at Tatabánya, Zuppa at Szár, Pilis Mts: Csúcs hill at Csobánka, Vértes Mts: Szólókő at Csákvár; Tábor hill at Vérteskozma, Villányi Mts: Szársomlyó), ● – loc. of *Pyramidula tetragona* (Balaton Upland: Gulács hill; Szent György hill, Keszthelyi Mts: Tátika hill); ○ – loc. of *Asterella saccata* and *Pyramidula tetragona* (Budai Mts: Remete hill); △ – loc. of *Microbryum floerkeanum* (Villányi Mts: Kövesmáj at Máriagyüd); ▲ – loc. of *Grimmia plagiopodia* (Visegrádi Mts: Kő-hegy hill at Pomáz).

Most of the dry grasslands are parts of the mountain ranges, which belong to national parks or nature protection areas. Many of them are threatened by grazing and mechanical disturbance of wild animals. Large population of deer, wild pig, moufflon are maintained, fed by hunting societies as hunting is a rewarding business in our country. Due to the thin, not stable soil layer trampling, grubbing cause great damage in rocky grasslands.

Saline-alkali grasslands

Continental salt meadows and steppes are rare habitat types and are listed on Annex I of the EU Habitats Directive (Horváth et al., 2003). A characteristic species of the Hungarian saline-alkali areas is *Enthosthodon hungaricus* (Boros, 1924; 1943; 1945), which is also red-listed in Europe. 11 sites could be selected as the known localities of this species. It is frequently accompanied by *Microbryum floerkeanum*. There are 8 saline-alkali sites, where they occur together (Papp & Rajczy, 1999). The latter species can be found in 2 other saline-alkali areas, but it has other localities, as well, where its habitats are roadsides or arable fields (Balaton Upland: Koloska-valley at Balatonfüred; Dunakeszi) and a limestone grassland mentioned before (Papp & Erzberger, 2003). At one site of *Enthosthodon hungaricus* another European red-listed species, *Tortula cernua* was found, too (Papp et al., 2000). This is the only recently existing population of this species in Hungary. In the preservation of these species Hungary has a great responsibility, as the main habitats of these species are the saline-alkaline areas, which are rare in Europe, but can be found in large extension in our country. Altogether 13 sites could be selected (Fig. 2). Most of the sites are situated on the Danube-Tisza Interfluve region, where the

elevation ranges between 90–120 m a.s.l. This region has a moderately continental climate with characteristically a high number of sunny hours, high daily and yearly temperature fluctuations as well as relatively low air humidity. The mean yearly sum of the sunny hours is ca. 2000–2100. The mean yearly temperature 10–11 °C. The coldest month is January (-1.5 to -2 °C), the warmest month is July (21–22 °C). The mean yearly temperature fluctuation is considerable, 23–24 °C. The Danube-Tisza Interfluve is one of the driest areas in Hungary (500–600 mm/year). Drought is frequent in summer (Tóth, 1979). Due to the insufficient water regime and high salt-content, alkali areas are covered mainly by halo- and xerophilous vegetation (Tölgyesi, 1979). Plant communities are arranged characteristically in levels in close relation with micro relief, water regime and soil properties. Arable fields and anthropogenic grasslands occupy the highest, sandy or loess areas. At lower elevations wormwood-dominated alkali grasslands (*Artemisio-Festucetum*) appear. The deepest places are covered by the association most heavily affected by salt, *Lepidio-Camphorosmetum annuae* or *Camphorosmetum annuae*. At the littoral zone of alkali lakes the less heavily salt-affected *Lepidio-Puccinellietum limosae* association is found. The above mentioned three European red-listed species appear mainly on bare soil in the transitional zone of *Artemisio-Festucetum* and *Lepidio-Puccinellietum* communities in spring. Grazing plays an important role to preserve the composition and structure of the grasslands, but both overgrazing and lack of management cause considerable changes in the vegetation, which might affect the appearance of bryophytes. Agricultural activity is also a threat in the saline-alkali areas. The cultivated fields are often situated very close to the saline lakes or salt meadows altering the structure of the soil (causing changes in the aeration and water regime), which has drastic effects on the natural habitats (Papp & Rajczy, 2000). In the last years, the agricultural activity and animal keeping has decreased in Hungary. The first could favourable affect the distribution and population size of the red-listed species, but the lack of grazing could cause the reduction of suitable habitats. Although almost all saline-alkali areas are protected and belong to national parks in Hungary, more attention should be paid to adequate treatment for the protection of the unique bryophyte assemblages living here.

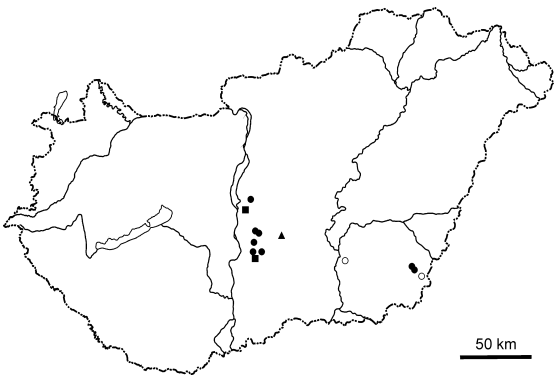

Fig. 2. IBrA sites of saline-alkali grassland habitat type.
○ – locality of *Entosthodon hungaricus* (Békés county: Szikmező at Elek; Csongrád county: Lápis lake at Szentes), ■ – loc. of *Microbryum floerkeanum* (Duna-Tisza Interfluve: Bak-ér at Dömsöd; Miklapuszta), ● – loc. of *Entosthodon hungaricus* and *Microbryum floerkeanum* (Békés county: Peres and Törökhalom at Kétegyháza; Duna-Tisza Interfluve: Apajpuszta; Böddi-szék at Dunatetétlen; Kelemen-szék and Zabszék at Fülöpszállás; Büdös-szék and Kis-rét at Szabadszállás); ▲ – loc. of *Entosthodon hungaricus* and *Tortula cernua* (Duna-Tisza Interfluve: Szappanszék at Fülöpháza).

Loess habitats

Loess habitats are also listed on Annex I of the EU Habitats Directive (Horváth et al., 2003). A characteristic European red-listed moss species of loess cliffs in Hungary is *Hilpertia velenovskyi*. 16 loess cliffs could be designated for the existing populations of this species (Pócs, 1999 and T. Pócs pers. com.). *Pterygoneurum lamellatum* can be found on 5 sites (T. Pócs pers. com.). At one site they live together. On 2 sites of *Hilpertia velenovskyi Tortula brevissima* also occurs (Kürschner & Pócs, 2002). Altogether 20 sites can be selected (Table 6).

In the Pannonian basin loess cliffs are situated mainly along rivers (e.g. Danube, Tisza, Zagyva, Hernád, Bodrog). Due to the erosion of the loess deposits steep vertical cliffs are formed. Additionally huge gorges and cliffs can develop due to secondary erosion at roads, highways,

vineyard terraces, vine cellars. The establishment of cryptogamic vegetation on cliffs is highly dependent on the structure and chemical composition of the loess. Aeolian, pale yellow loess deposited during the glacial periods and preserved among semiarid conditions are the best for the formation of well-developed cryptogam assemblages. The near vertical cliffs show desertic character, because of the orography, edaphic and microclimatic conditions. It means at least 7 dry months per year, high insolation and a total rainfall that is less than 150 mm per year (Pócs, 1999; Kürschner & Pócs, 2002).

Naturally, from time to time parts of the vertical loess walls can fall down. This is a natural disturbance and cryptogam communities are adapted to it, they can establish their assemblages again very quickly on the new surfaces. But several walls are situated near houses, cellars, where the anthropogenic influence is high. Pollution, construction with concrete to prevent the walls from collapsing can destroy the suitable habitats for the rare bryophytes.

Wetlands

Wetlands are very threatened habitats in Hungary and they are listed on Annex I of the EU Habitats Directive (Horváth et al., 2003). The extension of these habitat types has been reduced last decades and their water supply has changed unfavourable mainly due to the drier climate of last years. Eutrophication is also a threat factor for these habitats in our country. The European red-listed species have disappeared from our wetlands. For example *Hamatocaulis vernicosus,* a species listed in the Bern Convention and EU Habitats Directive, had 10 large populations in Hungary around 1950–1960, but nowadays not any existing population can be found (Papp et al., 2002). On the basis of the recent populations of European red-listed species only one site could be selected; *Amblystegium radicale* occurs in small quantity in Szőce meadow in the western part of Hungary (Papp & Erzberger, 2003). Hence in the selection of wetland IBrA sites three species protected by law in Hungary and included in the regionally threatened (RT) category of the Red Data Book of European Bryophytes were taken into consideration. *Campyliadelphus elodes* has a small population in the Danube-Tisza Interfluve, while *Pseudocalliergon lycopodioides* and *Drepanocladus sendtneri* live together in two wet meadows in the western part of Hungary (Papp & Erzberger, 2003). Altogether 4 wetland sites could be selected (Fig. 3). The population sizes are very small; it is very doubtful that these species can survive under the recent environmental conditions for a long time in these localities.

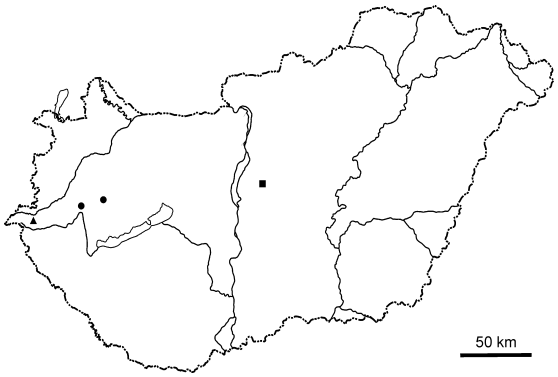

Fig. 3. IBrA sites of wet grassland habitat type.
▲ – locality of *Amblystegium radicale* (Szőce); ● – loc. of *Pseudocalliergon lycopodioides* and *Drepanocladus sendtneri* (Türje, Gyepükaján); ■ – loc. of *Campyliadelphus elodes* (Dabas).

Special habitats

Most of the above mentioned IBrA sites are situated in protected areas, belonging to national parks or nature reserves, but there are some special, not protected habitats, which are also important from a bryological point of view. For example, the recently discovered, only population of *Orthotrichum sprucei* was found on wood attached to the concrete of the inside wall of a sluice chamber along a channel in the Danube-Tisza Interfluve (Erzberger & Papp, 2000). Two populations of *Grimmia plagiopodia* occur on andesite rocks of castle hills. The exposed walls of the Visegrád castle at the Danube river maintain quite a large population (more than 1000 patches, which are ca. 1 cm^2 dense turf of shoots probably growing from the same prothallium) of the species. Two small populations of *Fissidens arnoldii* can be found in millraces of watermills along a stream of the Transdanubian mountain range (Papp et al., 2000). In these cases it is very important to draw attention to the bryophyte rarities living in such special habitats and reconcile the interests of the protection of monuments, historical buildings and the nature

conservation to preserve these species. The sites can be seen on Fig. 4.

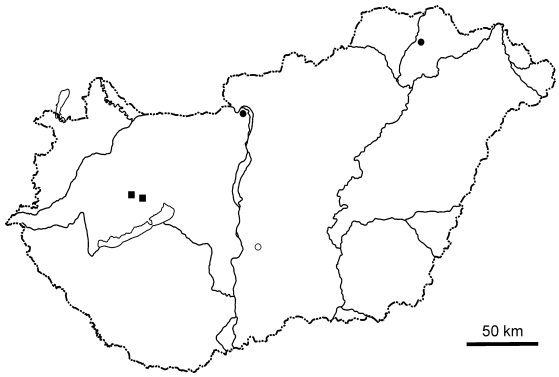

Fig. 4. IBrA sites of special habitats.
■ – watermill with *Fissidens arnoldii* (Bakony Mts: Bánd, Kislőd); ● – castle hill with *Grimmia plagiopodia* (Visegrádi Mts: Visegrád; Zemplén Mts: Boldogkőváralja); ○ – loc. of *Orthotrichum sprucei* (Danube-Tisza Interfluve: Kelemen-szék at Fülöpszállás).

Table 6. IBrAs sites of loess habitats and occurrence of European red-listed species. H – *Hilpertia velenovskyi,* P – *Pterygoneurum lamellatum,* T – *Tortula brevissima.*

	H	P	T
Alsónána, cellars		+	
Bajót	+		
Basaharc	+		
Báta, Csóka-hill	+		
Bölcske		+	
Dunaföldvár, Alsó Öreg-hill	+		
Dunaföldvár, Kálvária-hill	+		
Dunakömlőd, Sánc-hill	+	+	
Kecel, Császártöltés		+	
Kisapostag-Dunaújváros	+		+
Mórágy		+	
Nagyszékely, cellars	+		
Neszmély, Vár hill	+		
Pécel, Vár-hill	+		
Ravazd, Likas Horog	+		
Süttő, Diós-árok gorge	+		
Szekszárd, Szarvas Szurdik gorge	+		
Tokaj, N edge of the town	+		
Tokaj, Nagykopasz hill	+		+
Vértesacsa and Váli gorge	+		

CONCLUSIONS

In Hungary the most important habitats from the point of view of the conservation of European red-listed bryophytes are places with shaded rocks or rocks in streams on forest-covered mountainous areas, which support almost 30% of the existing populations (Table 7). A submediterranean element, *Anomodon rostratus* has the highest number of populations in these habitats. Other species with submediterranean character have also several populations e. g. *Rhynchostegium rotundifolium, Rhynchostegiella teneriffae, Frullania inflata.* A pontic (Caucasian) element, *Taxiphyllum densifolium* can also be found at 4 sites (Table 1). Saline-alkali and dry rocky grasslands and loess cliffs are also very important habitats in the preservation of the European red-listed submediterranean (e .g. *Microbryum floerkeanum, Pyramidula tetragona*) and continental, subcontinental elements (e .g. *Asterella saccata, Entosthodon hungaricus, Hilpertia velenovskyi*). These habitats provide suitable conditions for half of the existing populations of the European red-listed species (Table 7). Wet grasslands are of minor importance nowadays in the preservation of rarities as they are in very bad conditions mainly due to dry climatic periods of last decades. The number of populations of species living on decaying wood and tree barks is also not high. Most of our forests are managed, forestry is a high pressure in these habitats.

Table 7. Quantity of Hungarian populations of European red-listed species in different habitat types.

habitats	number of populations	% of populations
Forest (species on shaded rocks or in streams)	36	29
Saline-alkali grasslands	22	18
loess cliffs	23	18
dry rocky grasslands	17	14
Forest (species on decaying wood or bark of trees)	13	10
wet grasslands	6	5

Hungary has a high responsibility in the preservation of the European red-listed submediterranean and continental, subcontinental elements. These species still can be found in several

localities in our country; 80% of the existing populations belong to these groups (Table 8). In the protection of boreal and subboreal elements, on the other hand, Hungary cannot play an important part. Probably due to change of climate, these species have disappeared except some small, isolated populations, which have very doubtful survival chances. However, the existing populations are very valuable, because these species live here at the border of their distributional range.

Table 8. Quantity of Hungarian populations of the different European red-listed flora elements.

European distribution	number of populations	% of populations
submediterranean and/or subatlantic and/or atlantic	51	41
continental, subcontinental, pontic	49	39
temperate zones of Europe	14	11
boreal, subboreal, subarctic-subalpine	11	9

The selection of IBrAs on the basis of the existing localities of European red-listed species is going on. Visiting the earlier known localities and searching for populations of rarities is continuing. For further selection it is inevitable to obtain up-to-date knowledge on the old sites, since the earlier data are usually 50–60 years old. The search for European red listed species in potentially suitable habitats may also increase the number of IBrAs.

The other part of the proposed areas using criterion B would be the localities with high number of indicator species. The identification of indicator species for each habitat type is also an ongoing task. Especially for dry grasslands and wetlands, where the areas selected on the basis of criterion A are not sufficient and do not represent the richness and variety of these habitats in our country, selection according to criterion B is very important. In some habitats the European red-listed species can be regarded as indicators, too (e. g. *Entosthodon hungaricus, Mniobryum floerkeanum* in saline-alkali areas; *Hilpertia velenovskyi* in loess cliffs).

From nature conservation point of view it can be mentioned that most of the recently presented, selected sites are situated in protected areas (national parks, nature reserves), but there are few localities, which are not protected. We would like to draw the attention of nature conservation to these sites, but we also would like to express our opinion that even in protected areas it is necessary to pay more attention to the requirements of bryophyte conservation.

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