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The impact of anthropogenic habitats on rare bryophyte species in Lithuania

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Abstract: Anthropogenic habitats support about one third of bryophytes known in Lithuania. Nearly half of them are rare in the country. 21 species occurring in anthropogenic habitats of Lithuania are of high conservation value. Possibility to conserve bryophyte species restricted to anthropogenic habitats is discussed.

Kokkuvõte: Haruldased sammaltaimed Leedu antropogeensetes kasvukohtades

Antropogeensetes kasvukohtades leidub umbes kolmandik Leedu sammaltaimedest. Neist peaaegu pooled on Leedus haruldased. Kaitse seisukohast on olulised 21 liiki. Käsitletakse antropogeensete kasvukohtade sammalde kaitse probleeme.

INTRODUCTION

Human activity directly and indirectly influences environmental conditions causing changes in landscapes. Agriculture, urbanization, recreation, roads and many other human impacts cause loss of natural habitats. Many plant species have declined as a result of habitat destruction, fragmentation and reduction. Lost natural habitats are replaced by artificial or seminatural habitats, or they become increasingly fragmented into more numerous, but smaller remnant patches. An inherent part of the current biodiversity are plant species restricted to anthropogenic habitats. Man-made habitats can be divided into arable land with weed vegetation and settlements, their surroundings, industrial areas harbouring ruderal vegetation (Lososova et al., 2006). In case of bryophytes, a number of species is mainly, or sometimes only, found in artificial habitats (ECCB, 1995). Recently a wide range of investigations on bryophyte distribution was performed in agricultural landscapes of Europe (Sauberer et al., 2004; Zechmeister et Moser, 2001; Zechmeister et al., 2002; Zechmeister et al., 2003a; Zechmeister et al., 2003b).

Lithuania (area 62.7 thousand km^2) is situated on the western edge of East European Plain. It is a part of the Baltic geomorphological province. Lithuania is the land of plains, variegated with hilly highlands: plains constitute 50%, hilly highlands 21%, plateus 29% (Basalykas, 1981) of the territory.

Anthropogenic habitats are significant components of Lithuanian landscape (Fig. 1). Farming land covers nearly 54% of the total area of Lithuania with arable land and grasslands accounting for 70.5%. Due to extraction of natural deposits, landscape of 0.5% of the territory was disturbed, mostly (75%) during peat extraction. At present gravel and sand pits are mainly concentrated in the hilly landscape and in the river valleys (Kavaliauskas & Baškytė, 2000). Dolomite and limestone quarries are restricted to the northern Lithuania. Areas of open rocks in abandoned quarries exceed sparing areas of natural outcrops occurring on the banks of the rivers Mūša and Nemunėlis (northern Lithuania). Ruderal vegetation is mosaically scattered throughout the country occurring in settlements and industrial areas, along roads and railways, on the banks of the ditches, etc. Artificial substrata (concrete constructions, bricks, tiles, etc.) are most common in urban territories, which cover about 3% of the territory.

Human activity influences structure of bryoflora by altering natural habitats. Up to the middle of the 20th century mires covered about 7.3% of the territory of Lithuania (Mierauskas et al, 2005), at present only 2.4%; part of them are modified by drainage and peat extraction. The majority of streams and rivers have been canalized (regulated channels make up to 82% of all water courses) (Kavaliauskas & Baškytė, 2000).

The major part of bryological investigations in Lithuania has been focused on bryophytes of natural ecosystems. The first bryological investigations of anthropogenic habitats, i.e. arable fields, (Andriušaitytė, 2001, 2002) proved them

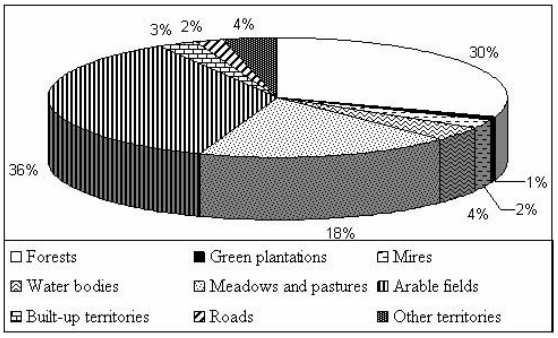

Fig. 1. Structure of Lithuanian territory according to land use (following Kavaliauskas & Baškytė, 2000).

to be rich in both common and rare species. This paper is focused on bryophytes occurring in wider range of anthropogenic habitats – arable land, bare ground in ruderal habitats, dolomite and limestone quarries, on artificial substrata (concrete constructions) and in artificial water bodies.

The aim of this study was to assess conservation value of anthropogenic habitats by ascertaining their role in Lithuanian bryoflora diversity and providing suitable habitats for rare bryophyte species. It is an attempt to look at anthropogenic habitats as an inherent part of the country and to answer questions: 1) what part of Lithuanian bryoflora is supported by anthropogenic habitats; 2) how many rare species are restricted to anthropogenic habitats and 3) is it necessary and possible to conserve rare bryophyte species in anthropogenic habitats.

METHODS AND MATERIALS

The analysis is based partly on the same data (herbaria BILAS and WI, literature references) which were used to compile Lithuanian bryofloras (Jukonienė, 2003, Naujalis et al., 1995) and the Red Data Book (Rašomavičius, 2007). Data of targeted investigations by the author in 6 dolomite and limestone quarries (still used and abandoned) in Northern Lithuania in 1996–1997 as well as the data of investigations by D. Andriušaitytė and the author in arable fields (186 study sites all over Lithuania) in 1998–2001 comprise the largest amount of the material concerning anthropogenic habitats. Data on bryophytes of concrete constructions (35 sites) and ruderal habitats (39 sites) were collected during general studies on bryoflora of particular territories throughout Lithuania in 1986–2006. The main sampling in arable lands was performed in autumn (between September and November) and in spring (between March and May). Sampling in other habitats took place in various time of the year. Specimen data are stored in BILAS Herbarium database using BRAHMS software. The specimens of anthropogenic habitats were selected using queries in the database (about 2500 specimens were selected: 1600 from arable land, 900 from other habitats). About 50 specimens of anthropogenic habitats collected by A. Minkevičius in 1926–1928 and E. Kerbelis in 2000 were found in WI Herbarium. Data on common species have been supported by field notes as well. Finally, the analysis was supplied with the data from phytocoenological references (Rašomavičius & Biveinis, 1996; Stancevičius, 1959).

Three types of anthropogenic habitats are analyzed: habitats with disturbed ground, epilithic habitats and artificial water bodies. The first group includes arable land (crop fields and fallow land ≤ 4 years) and first stages of ruderal habitats (banks of the ditches, roadsides, sand and gravel pits). Epilithic habitats include artificial substrata (concrete constructions) and open rock in dolomite and limestone quarries.

The numbers of species of natural habitats: forests, meadows, mires, bolders, sands (including coastal and continental dunes), are given according to floras (Jukonienė, 2003; Naujalis et al., 1995).

Categories of the species included into the Red Data Book of Lithuania follow the same classification used in the IUCN Red List (1976):

0 (Ex) – Extinct or possibly extinct species.
1 (E) – Endangered species on the verge of extinction yet can be saved but only with implementation of special conservation measures.
2 (V) – Vulnerable species whose population numbers and abundance is rapidly decreasing.
3 (R) – Rare species with a small number of populations due to their biological characteristics.
4 (I) – Indeterminate species, which can not be included in the other categories due to lack of data.
5 (Rs) – Restored species once included in the Red List whose abundance has since been restored.

According to frequency, species of anthropogenic habitats are divided into 5 groups: very rare species (1–3 localities), rare (4–9 localities), less frequent (10–20 localities), rather common (more than 20 localities, but in quite narrow range of habitats), common – widely distributed in various habitats).

The names of the species follow R. Grolle, D. G. Long (2000) (hepatics) and M. O. Hill et al. (2006) (mosses).

RESULTS

It was ascertained that anthropogenic habitats support 125 bryophyte species, representing about 27% (15% of hepatics and 30% of mosses) of total species number known in Lithuania (455 species). According to the colonized substrata, bryophytes of anthropogenic habitats are mainly terricolous and epilithic species. Anthropogenic habitats with disturbed ground are occupied by the largest number of species. The abundance of bryophyte species in arable land (about 22% of the country's bryoflora) is lower than in forests and is similar to that in mires (Fig. 2). Bryoflora in primary stages of ruderal habitats (banks of the ditches, roadsides, etc.) is similar in species composition but of lower diversity.

The abundance of bryophytes on open rock in quarries and on artificial epilithic substrata outnumbers their abundance on natural outcrops and stones (Fig. 3).

No particular bryophyte species strongly restricted to artificial water bodies were ascertained; however, 15 hydrophilous species use them as additional habitats.

About half of bryophyte species known from anthropogenic habitats are rare in Lithuania (found in less than 10 localities) and more than one third are found in 1–3 localities. The largest number of rare species was recorded on disturbed ground. However, the proportion of rare species on epilithic substrata is larger than the proportion of rare species on disturbed ground (Fig. 4).

About 45% of all species restricted to anthropogenic habitats have not been recorded in their natural habitat alternatives (Fig. 5), part of them are very rare species (Table 1). 25% of rare species are found both in anthropogenic and natural habitats, e.g. *Gyroweisia tenuis*, *Homomallium incurvatum*, *Lophozia badensis* and *Riccia canaliculata* (Fig. 6).

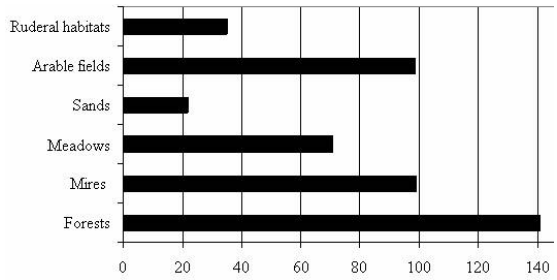

Fig. 2. Number of terricolous bryophyte species in various habitats.

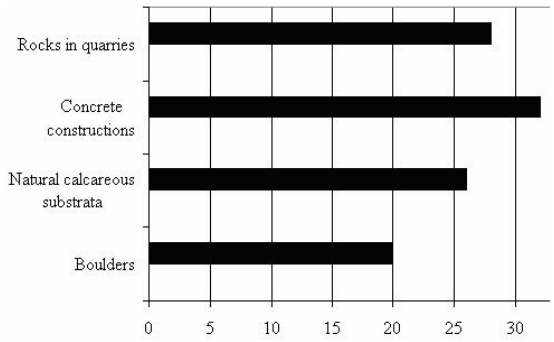

Fig. 3. Number of bryophyte species on various epilithic substrata. The data cover main quarries and natural outcrops of Northern Lithuania. Data on bryophytes of concrete constructions and boulders represent general investigations of particular territories throughout Lithuania.

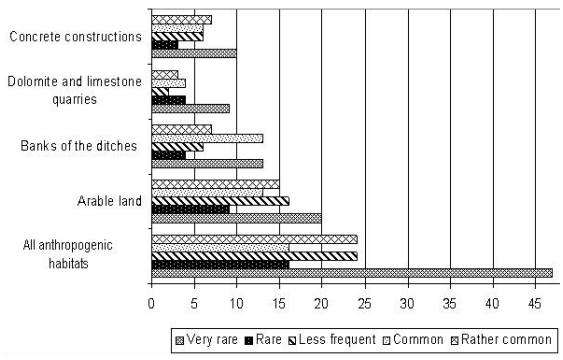

Fig. 4. Number of bryophyte species of different frequency categories in anthropogenic habitats of Lithuania.

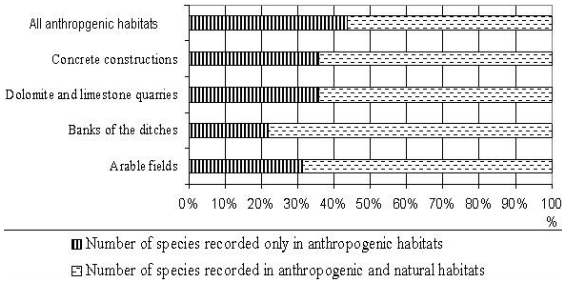

Fig. 5. Bryophyte species (%) recorded in anthropogenic habitats and in both anthropogenic and natural habitats.

21 species recorded in anthropogenic habitats of Lithuania are of high conservation value, they are included into the Red Data Book of Lithuania or Red Data Book of European Bryophytes (Table 2). The Red Data Book of Lithuania (Rašomavičius, 2007) includes 19 bryophyte species restricted to anthropogenic habitats, and it makes 20% of all redlisted species. It is somewhat lower comparing to the percentage (27%) of all species of anthropogenic habitats in Lithuanian bryoflora. Species included into the Red Data Book of Lithuania represent all main anthropogenic habitats: disturbed ground

Table 1. List of rare species recorded only in anthropogenic habitats of Lithuania (abbreviations: af – arable fields, bd – banks of the ditches, cc – concrete constructions, dlq – dolomite and limestone quarries)

Species	Number of localities			
	af	bd	dlq	cc
Acaulon muticum (Hedw.) Müll. Hal.	9			
Aloina aloides (Koch ex Schultz) Kindb.			1	
Aloina rigida (Hedw.) Limpr.			5	
Archidium alternifolium (Hedw.) Mitt.	1			
Atrichum angustatum (Brid.) Bruch et Schimp.		1		
Bryum bicolor Dicks.	3	1		
Bryum funckii Schwägr.			1	1
Bryum gemmilucens R. Wilczek et Demaret	2			
Bryum ruderale (Crundw.) Nyholm	1			
Ditrichum flexicaule (Schwägr.) Hampe			2	
Ditrichum pusilum (Hedw.) E. Britton ex Williams	5	1		
Fissidens dubius P. Beauv.				1
Microbryum floerkeanum (F. Weber & D. Mohr) Schimp.	3			
Pallaviccinia lyellii (Hook.) Carruth		1		
Philonotis caespitosa Jur.		2		
Pohlia camptotrachela (Renauld & Cardot) Broth.	7			
Pohlia lescuriana (Sull) Ochi	2			
Pohlia melanodon (Brid.) A.J.Shaw	4			
Protobryum bryoides (Dicks.) J. Guerra & M.J. Cano	4	1		
Pseudoleskeella catenulata (Brid. ex Schrad.) Kindb.				2
Pterygoneurum ovatum (Hedw.) Dixon	1		1	
Pterygoneurum subsessile (Brid.) Jur.	1			
Riccia huebeneriana Lindenb.	4			
Syntrichia papillosa (Wilson) Jur.				1
Tortula obtusifolia (Schwägr.) Mathieu				1
Trematodon ambiguus (Hedw.) Hornsch.		1		
Trichostomum crispulum Bruch		1	2	
Weissia squarrosa (Nees & Hornsch.) Müll. Hal.		1		

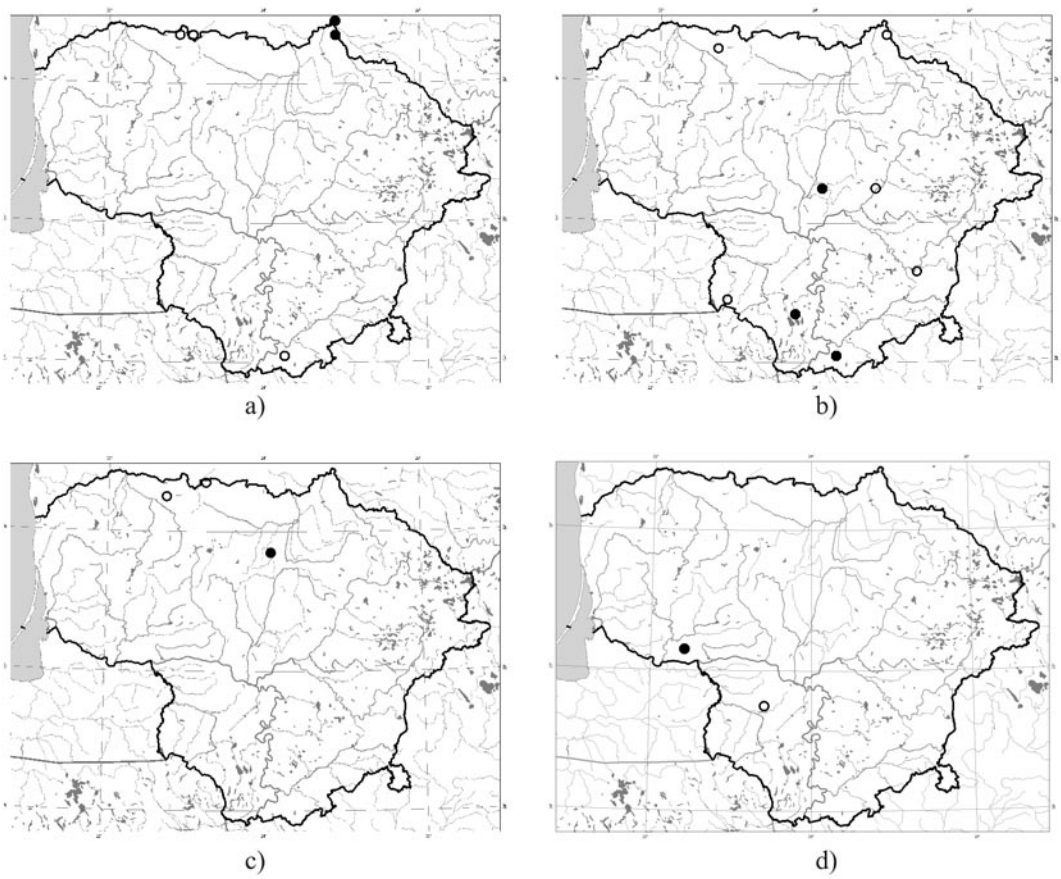

Fig. 6. Preliminary distribution of *Leiocolea badensis* (a), *Homomallium incurvatum* (b), *Gyroweisia tenuis* (c) and *Riccia canaliculata* (d) in Lithuania (• – natural habitats, o – anthropogenic habitats).

(arable fields, banks of the ditches, roadsides), dolomite and limestone quarries, concrete constructions, artificial water bodies (Table 2).

The majority of anthropogenic localities of the redlisted bryophyte species are outside the protected territories of Lithuania (Table 2).

DISCUSSIONS

Though anthropogenic habitats increase the importance of common species with ruderal strategy (Motiekaitytė, 2002; Kuwatz, Mac Donald, 2004), even in case of vascular plants anthropogenic habitats, especially arable fields, are rich in rare plant species (Hulina, 2005). Data from Lithuania support some of the published data about the importance of anthropogenic habitats for the richness of bryophyte species, especially those restricted to open environment and thus limited to areas with appropriate level of disturbance (Zechmeister et al., 2003; Vanderpoorten et al, 2004) and to artificial calcareous substrata (concrete constructions) (Ignatov, 1989; Rykovskij et al., 1989). Species of open ground form a significant proportion of many national Red Lists (ECCB, 1995). In Sweden about 20% of bryophytes occurring in agricultural land and urban habitats are redlisted (Gärdenfors, 2005).

Our analysis shows that man-made habitats are important for rare species of Lithuanian bryoflora in 2 aspects: they can ensure existence of the species in the territory and provide larger scale distribution for species occurring in similar natural habitats. All analysed anthropogenic habitats, except artificial water bodies, harbour rare bryophyte species that have not been recorded in their natural habitat alterna-

Table 2. Bryophyte species of high conservation value occurring in anthropogenic habitats. (Abbreviations: af – arable fields, awb – artificial water bodies, bd – banks of the ditches, cc – concrete constructions, dq – dolomite quarries, lq – limestone quarries, rs – roadsides; RDBL – Red Data Book of Lithuania; ERDB – Red Data Book of European bryophytes)

Species	RDBL	ERDB	Anthropogenic habitats	Number of localities in anthropogenic habitats	
				Total	In protected territories
Atrichum angustatum (Brid.) Bruch et Schimp.	R		bd	1	1
Bryum funckii Schwägr.	R		dq	1	1
Bryum neodamense Itzigs.		R	dq	1	1
Campylium protensum (Brid.) Kindb.	I		lq	1	0
Didymodon tophaceus (Brid.) Lisa	I		bd	2	0
Fissidens dubius P. Beauv.	R		cc	1	0
Fissidens exilis Hedw.	I		bd	1	1
Fossombronia wondraczekii (Corda) Dumort.	I		af	15	1
Gyroweisia tenuis (Hedw.) Schimp.	R		dq	2	1
Homomallium incurvatum Schrad. ex Brid.	R		cc	3	0
Microbryum floerkeanum (F. Weber & D. Mohr) Schimp.		K	af	3	0
Pallaviccinia lyellii (Hook.) Carruth	E	V	bd	1	1
Philonotis caespitosa Jur.	I		bd, af	2	1
Pogonatum nanum (Hedw.) P. Beauv.	R		af, rs	4	4
Protobryum bryoides (Dicks.) J. Guerra & M.J. Cano	R		af, gp	5	0
Pterygoneurum subsessile (Brid.) Jur.	R	RT	af	1	0
Riccia huebeneriana Lindenb.	I	R	af	2	0
Ricccia canaliculata Hoffm.	I		awb	1	0
Ricciocarpos natans (L.) Corda	I		awb	5	2
Trematodon ambiguus (Hedw.) Hornsch.	R		bd	1	1
Weissia squarrosa (Nees & Hornsch.) Müll. Hal.	R		bd	1	1

tives in Lithuania. Non occasional rarity of these species is proved by their distribution in neighbouring countries. The list presented in Table 1 includes 8 of 12 moss species ascertained as very rare for the Baltic countries that are known only from Lithuania and characterised by highest temperature indices (Vellak et al., 2007). The majority of other listed species are rare in Latvia (Abolina, 1994), Estonia (Ingerpuu et al., 1994) and Belarus (Rykovkij, Maslovskij, 2004). Species that inhabit arable ground or banks of the ditches constitute the majority of species recorded exceptionally in anthropogenic habitats; nevertheless, the chance of their occurrence in similar natural habitats should be taken into account, as bare soil appearing naturally provides similar habitats (ECCB, 1995). Rare bryophyte species of arable fields in Lithuania are known from the (*Nano)Cyperion flavescentis* Koch 1926 ex Libbert 1932, *Festuco-Brometea* Br.-Bl. & R. Tx. 1943, *Cratoneurion commutati* Koch 1928 etc. communities occupying both anthropogenic and natural habitats (sites kept open by disturbance or erosion, alluvial sand or gravel, loamy and silty soils in the flood zone of rivers, near springs and lakes, etc.) in Europe (Dierßen, 2001).

Anthropogenic habitats are especially significant for epilithic species of the country. It was ascertained that the shortage of habitats (rocks with high pH) determines high number of rare species with higher pH points in the Baltic countries (Vellak et al., 2006). The areas of natural calcareous rocks in Lithuania are the smallest comparing with the two neighbouring countries. Four times higher number of bryophyte species was registered on natural dolomite outcrops in Latvia (Ābolina, 1968, 1994) than in Lithuania. Some rare species (e.g. *Bryum funckii, Fissidens*

dubius), known to occur in natural habitats in Latvia or Estonia, are found in Lithuania only in anthropogenic habitats. In such situation (shortage of natural rocks) anthropogenic epilithic habitats are essential in providing larger scale distribution for the species occurring in similar natural habitats. Larger distribution scale of bryophytes is provided both by concrete constructions and limestone and dolomite quarries.

The majority of bryophytes of anthropogenic habitats, particularly those occupying bare ground, are often small-sized and short-living species. So the rarity of such bryophytes may depend on insufficient knowledge of their distribution due to their inconspicuousness. Nevertheless, the above-mentioned facts suggest the need to preserve bryophyte species found in anthropogenic habitats as part of plant diversity of the country. It is important for nature conservation in Europe to compile Red Data Lists of species (redlisting) and protect their habitats and sites (Hallingbäck, 1995).

Formally all redlisted species in Lithuania are protected by law because the Red Data Book of Lithuania serves as a legal document on which the protection of rare and endangered species is based (Rašomavičius, 2007). Protection of 19 bryophyte species known from anthropogenic habitats (Table 2) in the sites or protection of their habitats is more complicated. Management plans prepared for protected territories are aimed to restore and conserve natural habitats, and the measures sometimes do not coincide with the special requirements of bryophytes. Anthropogenic habitats are occupied by species that tolerate or even prefer human activities. So the continuation of particular management is more important than protection of the sites (ECCB, 1995; Jacquemart et al., 2003; Vanderpoorten et al., 2005). The best situation is with species of abandoned dolomite quarries, which, as natural calcareous outcrops, are habitats of European importance (Rašomavičius, 2000), thus management plans for maintaining favourable status for the habitat benefit the bryophyte species. The majority of localities of species occurring in arable fields, on concrete constructions, in artificial water bodies and in used quarries are outside the protected territories. They are exposed to various threats: from alteration of the habitat quality to its complete destruction. Species occurring in arable land are threatened by very intensive management (Zechmeister et Moser, 2001; Zechmeister et al., 2003) as well as by long-term abandonment as they can be outcompeted by vascular plant species (ECCB, 1995). The most unpredictable situation is for rare species occurring in still used quarries. So, conservation programs of the species occurring in anthropogenic habitats should include recommendations for arable land use at least in the sites with the highest concentration of rare species. Maintenance of open rock in dolomite and limestone quarries after their closing and of old concrete constructions as suitable substrata for rare bryophyte species is of high importance for such countries like Lithuania having small areas of natural calcareous outcrops.

CONCLUSIONS

During centuries anthropogenic habitats have become inherent part of Lithuanian landscape. Bryophytes occurring in habitats created by agriculture, urbanization and other human activities constitute about 27% of the country's bryoflora. About half of them are rare in Lithuania. For 25% of rare species anthropogenic habitats are additional for larger scale distribution as they are more abundant comparing with natural habitat alternatives; the others have not been recorded in natural habitats since now.

Although 20% of bryophyte species occurring in anthropogenic habitats of Lithuania are protected by law (Red Data Book of Lithuania), their protection in the sites is problematic. In protected territories they can not survive without human activity, i.e. special management that satisfies special requirements of bryophyte species. Special conservation measures, such as recommendations for management of the sites with high concentration of rare species and preservation of substrata suitable for bryophyte diversity in non protected territories, are needed.

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