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DYNAMIC TENDENCIES IN THE BRYOFLORA OF THE NATURE RESERVE "BUKOWE ZDROJE" (PUSZCZA BUKOWA FOREST NEAR SZCZECIN) IN THE YEARS 1969-2006

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ABSTRACT. The aim of the research was to assess the changes in the bryophyte species composition of the forest nature reserve "Bukowe Zdroje" in the years 1969-2006. The reserve is situated in the Puszcza Bukowa forest near Szczecin and it occupies an area of 220.69 ha. It was established to preserve beech forest community *Galio odorati-Fagetum* (= *Melico-Fagetum*) and ash forest communities *Carici remotae-Fraxinetum* and *Ficario-Ulmetum* (Rutkowski et al. 2006). In the vicinity of the reserve there is a highway and two large housing estates. The site was bryologically explored several times: in 1969 (by Balcerkiewicz), in 1999 (by Fudali) and in summer of 2006 by the authors. Altogether 109 moss and nine liverwort species were noted. A list of species recorded in 2006 was compared to those previously gathered. During 37 years the species composition changed, but the general richness of the bryoflora did not decrease. The bryophytes have shown various types of response: 1) 39 species (35.8%) were present during the whole period of studies, 2) 24 species (22%) haven't been found in recent inventory, 3) 29 (26.6%) have been reported for the first time in 2006 – they probably colonize the reserve area, 4) 17 species (16.6%) noted for the first time in 1999 was confirmed in 2006. What is more, the number of their localities has increased, which may be interpreted as entering a phase of settlement. Ecologically the "newcomers" (groups 3 and 4) are differentiated. A large group is formed by epiphytes (11 species). It is striking that epiphytes and obligatory epixylic species which are constant element of bryoflora (group 1) have shown a tendency to increase the number of their localities. This led to the presumption that ecological variety of the reserve's bryoflora has become more similar to that of natural forests. The vicinity of housing-estates has not caused an increase of the number of ruderal bryophytes. Among species not found recently (group 2) there are bryophytes typical for initial habitats which in the past were recorded on a bare soil on the slopes along forest paths. It seems that their absence results from natural habitat dynamic.

KEY WORDS: changes in bryoflora, forest bryophytes, bryo-epiphytes, Puszcza Bukowa forest, Western Pomerania

INTRODUCTION

The theory of the synanthropization of vegetation assumes continual changes manifesting among others in decrease of the number of hemerophobous plant species and biodiversity and spread of hemerophilous ones (Kornaś 1982, Kowarik 1990, Kornaś and Medwecka-Kornaś 2003). However, that process, as it was pointed out by Faliński (1971) does not proceed on the whole area with the same intensity – in the same time particular biocoenoses can show various degree of anthropogenic deformations depending on the intensity of human pressure and habitat transformation.

In the contemporary dominating cultural landscape, nature reserves and other protected areas of various protection status play a role of environmental islands in which natural vegetation can survive (Pullin 2004). The law limits human activity in these areas, what should result in retardation of the synanthropization process. In Polish botanical literature from the last decades numerous papers document essential changes in plant species composition of the flora of nature reserves. These changes concern extinction of many specialized plant species and appearing of some new, often alien taxa (anthropophytes). Unfortunately only few works focused on the changes in the bryoflora of nature reserves (Bystrek and Karczmarz 1987). It is commonly known that European mosses are hardly affected by the process of anthropophytization (Ochyra 1983, Söderstrom 1992, Stieperaere 1994, Hill et al. 2006). That is why the authors have arisen a question whether the only bryophyte response to continual

but moderate human pressure (as it happens in protected areas) is the decrease of the biodiversity (as is evident from the so-far published data), or other tendencies appear.

To answer this question the authors have analysed changes of bryophyte species composition in the nature reserve "Bukowe Zdroje im. prof. Tadeusz Dominik" in the years 1969-2006.

MATERIALS AND METHODS

Changes in the nature reserve bryoflora have been defined comparing bryophyte list obtained as result of the authors' field studies with previously published data (Lisowski 1959, Celiński 1962, Balcerkiewicz 1969, Fudali 1999). Field works were conducted in July and August 2006 on 40 plots (each of 100 m²) established in all types of plant communities. In every plot bryophytes were noted from each type of substratum and some samples were picked up for identification. In total 544 records were gathered. Comparison allowed to distinguish groups of various response type. In the case of rare species noted earlier but not found in 2006 a revision of herbarium material was done to exclude misidentifications.

General dynamic tendencies of bryophytes flora in the studied reserve in the years 1969-2006 were assessed on the basis of presence – absence data, whereas for the period 1999-2006 more detailed evaluation was possible since there were quantitative data available.

AREA OF STUDY AND ITS ANTHROPOGENIC THREATS

The nature reserve is situated in north-western part of the Puszcza Bukowa forest, in the vicinity of highway A6 and two large housing-estates of the Szczecin town built in 1980's (Fig. 1). It is a part of the Szczecin Landscape Park and occupies an area of 220.69 ha. The reserve was established in 1959 and its current aim is "to preserve character and natural processes typical

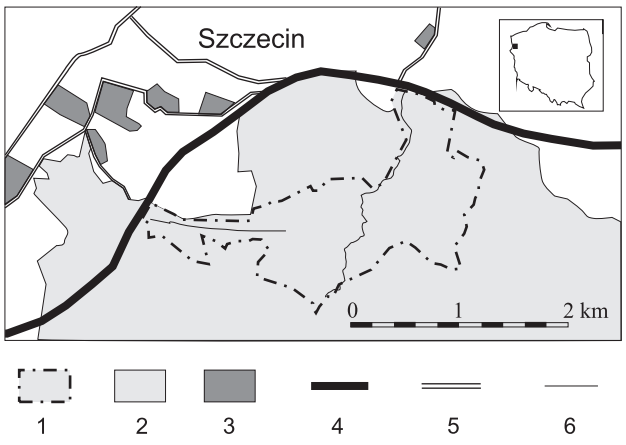

Fig. 1. Situation of the nature reserve "Bukowe Zdroje" in Poland and in the vicinity of Szczecin: 1 – the boundary of the reserve, 2 – forest area, 3 – settlements, 4 – A6 highway, 5 – roads, 6 – streams

for the beech forest community *Galio odorati-Fagetum* and ash and alder forest communities *Carici remotae-Fraxinetum*, *Fraxino-Alnetum* and *Ficario-Ulmetum* complex developing in a young-glacial landscape" (Rutkowski et al. 2006).

The Bukowe Hills, on which the nature reserve is situated, are remains of old hills formed by the large mesozoic and tertiary formations (xenoliths) brought by glaciers and covered with younger glacial forms (Musielak 1993). The characteristic feature of their morphology are deep valleys and ravines, mainly with dry bottoms, cut into moraine hills. The highest point reaches the altitude of 125 m a.s.l., the lowest is situated at the altitude of 40 m a.s.l.

Two streams: Jeziorna and Chojnówka with their tributaries originate in the nature reserve. In the 19th century Chojnówka was dammed and several ponds were formed. In the reserve there is no permanent level of shallow underground water and the main source of humidity is rainfall and snowfall.

The vicinity of Szczecin is characterised by mild and humid climate. Amount of rainfall and its annual distribution is typical for weakly oceanic areas (Woś 1999). Soils of Bukowe Zdroje reserve have developed on the clayey and sandy ground of tertiary origin (Musielak 1993). Most of them (near 80%) belong to various groups of brown soils (Gajewska and Gajewski 1999).

The forests covering the Bukowe Hills (acc. to Rutkowski et al. 2006) may be to some extent of anthropogenic origin. They were established probably in the 18th century on previously rural areas and have been subject of forest management for more than two centuries. According to the map of potential natural vegetation of Poland (Matuszkiewicz et al. 1995) in the nature reserve prevail habitats of beech forest communities: *Galio odorati-Fagetum* (86% of the area) and *Luzulo pillosae-Fagetum* (4%) with small patches of other forest communities: *Carici remotae-Fraxinetum* (3%), *Fraxino-Alnetum* (1%), *Stellario-Carpinetum* (2%), *Ficario-Ulmetum* (3%) and *Fago-Quercetum* (1.5%). The actual real vegetation resembles this pattern but the area covered with *Galio odorati-Fagetum* is much smaller (58%) and 30% is covered with forest communities of substitution, mainly beech plantations devoid any vegetation in the forest floor (Rutkowski et al. 2006).

The nature reserve "Bukowe Zdroje" is constantly influenced by human activity. According to Domian and Ziarnek (1996) and Rutkowski et al. (2006) the most important threats for vegetation are: 1) intensive penetration by inhabitants of neighbouring two large housing-estates, walking out dogs, trekkers, cyclists and motor-bikes tourists. Intensification of pedestrian traffic is observed in spring and autumn, 2) enlargement of adjacent highway A6, 3) air pollution from nearby Chemical Works "Wiskord", power station "Dolna Odra" and heat generating station "Pomorzany", 4) drop of ground water level as a result of a higher demand of inhabitants and agronomy.

RESULTS AND DISCUSSION

General remarks about the bryoflora

Total number of bryophyte species stated in the reserve amounts 109; including nine liverworts and 100 mosses species. Number of species found in 1969 amounts 54, in 1999 – 64 and in 2006 – 85. According to their habitat preferences the prevailing group comprises these occurring in forest, shrub and meadow communities (82%). Differentiation of bryoflora following the type of substrate shows dominance of epigeic species (62 taxa), quite numerous are epiphytes (19) and epixylics colonizing dead wood in various degree of decay (26, including four obligatory epixylics). In streams on stones five species were observed.

The highest richness in bryoflora was found in the patches of *Carici remotae-Fraxinetum*, *Fraxino-Alnetum*, *Ficario-Ulmetum* and *Stellario-Carpinetum* communities situated in the stream valleys. Some species, such as mesophilous: *Atrichum undulatum*, *Fissidens taxifolius*, *Oxyrrhynchium hians*, *Plagiothecium nemorale* and hygrophilous: *Brachythecium rivulare*, *Plagiomnium undulatum*, *Pellia endiviifolia*, *Rhizomnium punctatum* occurred there with higher frequency. The moss layer of beech forests was much poorer. The more frequent species in these phytocenoses were: *Dicranella heteromalla*, *Leucobryum glaucum*, *Plagiothecium nemorale*, *Polytrichum formosum* and *Pseudotaxiphyllum elegans*.

Most frequent in the nature reserve in 1999-2006 were eurytopic mosses, such as *Amblystegium serpens*, *Brachythecium rutabulum, Brachytheciastrum velutinum*, *Mnium hornum* and *Hypnum cupressiforme* colonizing various substrata (soil, bark of trees, decaying wood, protruding tree roots) in all types of forest communities.

Considering geographical elements in the nature reserve bryoflora it is worthy to point out a presence of the so-called montane species, i.e. these which localities are concentrated in the mountain regions of southern Poland. These are: occurring on stones in water *Platyhypnidium riparioides*, *Sciuro-hypnum plumosum*, *S. populeum* and *Thamnobryum alopecurum*, growing on soil: *Diphyscium foliosum*, *Mnium stellare*, *M. marginatum*, *Pogonatum aloides*, *Pseudotaxiphyllum elegans*, *Tortula subulata*. Among 15 species of suboceanic range only four occurred more frequently: *Leucobryum glaucum*, *Mnium hornum*, *Plagiomnium undulatum* and *Pseudotaxiphyllum elegans*.

In spite of a well-developed net of tourist trails the presence of hemerophilous species was negligible. Only in one site, on concrete ruins of old water-mill (Szwedzki Młyn) some epilithic species typical for built-up areas occurred abundantly.

The analysis of bryophyte species composition and changes in the years 1969-2006

A list of bryophyte species recorded in 2006 was compared to these from 1969 and 1999. During 37 years the bryophyte species composition changed considerably, but the number of species did not decrease. Only 39 species (that is 35.8% of total number) were noted in all lists, 29 taxa (26.6%) have been reported for the first time in 2006, while 24 (22.0%) have not been found in recent inventory. It should be mentioned that 14 species of the latter were still observed in 1999. The remaining 17 species (15.6%) are bryophytes noted for the first time in 1999 and confirmed in 2006 (Fig. 2).

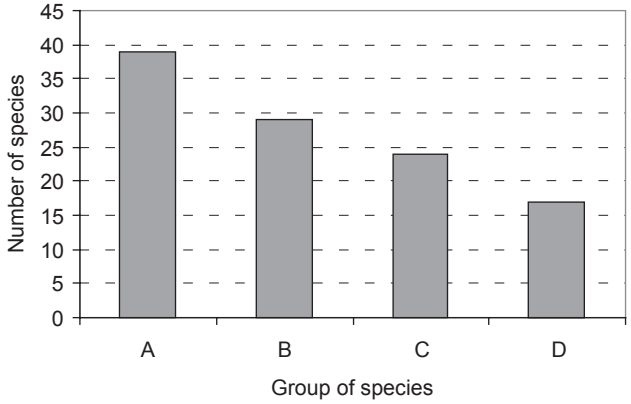

Fig. 2. Occurrence of bryophytes in the years 1969-2006
A – persistent species – reported in 1969, 1999, 2006,
B – "newcomers" – reported for the first time in 2006,
C – assumed vanishing species – not found in 2006,
D – entering the phase of settlement – noted for the first time in 1999 and confirmed in 2006.

The group of species which are a constant element of the nature reserve bryoflora consists mainly of forest and thickets (18) and forest and meadow (8) species. Regarding their life history strategy (sensu During 1992) a prevalence of perennials is visible (60%). The species show similar ecological demands in relation to humidity and reaction of substratum as well as to intensity of light: almost all of them are mesophytes or occur in a wide range of humidity from mesophytic to higrophytic sites. They are eurytopic in relation to site's reaction (from moderately acid to subneutral) and light intensity (from considerably shaded sites to moderately illuminated). Eight taxa are considered to be sciophytes. Most of persistent species show substratum specialization: among them there are three obligatory epixylics occurring on decayed logs and stumps, five epiphytes and 16 epigeic species. The latter group consists of 13 humicolous species preferring soil reach in humus. 15 species are polysubstrate bryophytes colonizing various substratum types (Fig. 3).

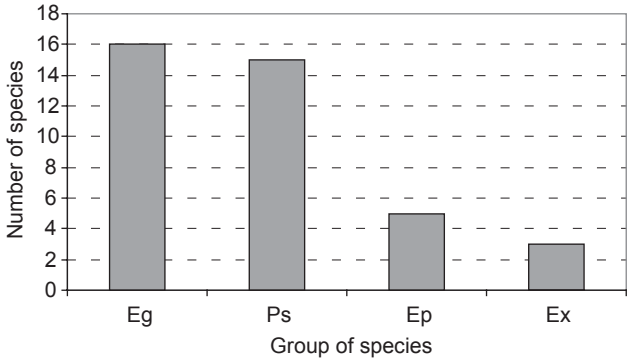

Fig. 3. Substrate requirements of persistent species (reported in 1969, 1999 and 2006)
Eg – epigeic species, Ps – polysubstrate species, Ep – epiphytes, Ex – epixylic.

Bryophyte species reported for the first time in 1999 and confirmed in 2006 reveal similar ecological character: 12 are forest perennials sensu During (1992).

Comparing bryophyte records made in 1999 and in 2006 (Table 1) one can notice that in case of 12 species the number of their localities has increased considerably (over twice). Such type of reaction was shown among others by large leafy epiphytes (*Homalia trichomanoides*, *Isothecium alopecuroides* and *Neckera complanata*) and specialized epixylics (*Herzogiella seligeri*, *Tetraphis pellucida* and *Rhizomnium punctatum*). Persistence and spreading of epixylics in forest ecosystems is related with increase of availability of decayed wood (Söderstrom 1987). In 1990's bigger amounts of dead wood were left in the nature reserve (pers. inf. from forester).

Five of six epiphytes reported for the first time in 1999 (*Dicranoweisia cirrata*, *Hypnum cupressiforme* var. *filiforme*, *Metzgeria furcata*, *Orthodicranum montanum*, *Plagiothecium laetum*) also occurred more abundantly and frequently in 2006, which may be interpreted as entering a phase of settlement. These species are considered to be resistant to air pollution (Dierssen 2001). Greven already in 1992 reported that some acidophilous epiphytes, such as *Dicranoweisia cirrata*, *Orthodicranum montanum*, *Herzogiella seligeri* have been spreading in the forests of Netherlands in the last decades of XX century. In the forests of the Beskidy Zachodnie range (Southern Poland) Stebel (2006) also noticed spreading of certain epiphytic species, such as *Dicranoweisia cirrata*, *Orthodicranum tauricum*, *Orthotrichum obtusifolium* and *Platygyrium repens*. Koperski (1998) observed in oak-beech forests of Lower Saxony that a number of localities of epiphitic species which preferred moderately acid to slightly basic substrate has increased but they colonized almost exclusively bark of old beeches. Three of the species listed by Koperski (1998) have been noted in the studied nature reserve (*Isothecium alopecuroides*, *Neckera complanata* and *Metzgeria furcata*); all showed a weak tendency to expansion.

Half of the bryophytes (15 taxa) within the group of "newcomers" (reported for the first time in 2006) are colonists sensu During (1992). In relation to their habitat preferences: seven species occurred on concrete, two – on granite boulder, five – on living trees bark, two – on decayed wood, five – on soil in forests along streams, eight – on the soil in the beech forests (two – on naked ground and six on humicolous soil) (Fig. 4).

Most of them are species naturally associated with forest or spring communities. Only nine among them were hemerophilous bryophytes, including seven epiliths growing on concrete ruins of old water-mill and bridge. Sporadically two epigeic species occurring often on ruderal habitats were found: *Bryum rubens* and *Ceratodon purpureus*. On decayed wood the neophytic invasive moss *Orthodontium lineare* was found once. The species was already noted within Puszcza Bukowa Forests (Fudali 1999), in another nature reserve. With exception of *Platygyrium repens* other new epiphytes were recorded only once what suggests a phase of colonization attempt. Three of them (*Orthotrichum affine*, *Pylaisia polyantha*, *Ulota crispa)* are considered to be sensitive to air pollution (Dierssen 2001) but show

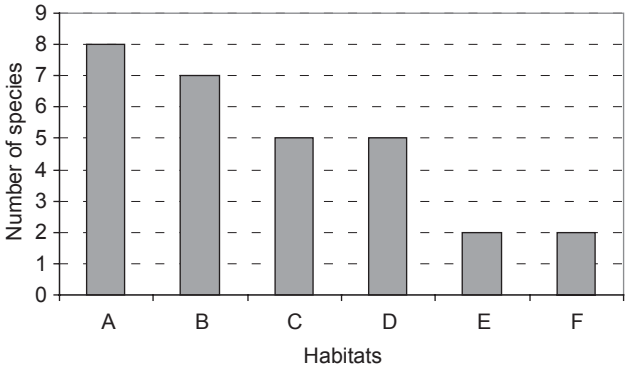

Fig. 4. Habitat preferences of the "newcomers" group (reported for the firs time in 2006)
A – soil in the beech forests, B – concrete, C – soil at the border of streams, D – bark of living trees, E – granitic boulders, F – decayed wood.

a wide ecological amplitude in relation to substratum reaction (from moderate acid to subneutral habitats). Stebel (2006) reported a decrease in the number of *Ulota crispa* localities in the montane region of the Beskidy Zachodnie (southern Poland) in last decades. The spring species recorded for the first time in 2006 had presumably occurred earlier but then their sites were not available to inventory because of high water level (the summer of 2006 was exceptionally dry in the region). It concerns especially such hydrophytic perennials as *Leptodictyum riparium*, *Platyhypnidium riparioides* and *Sciuro-hypnum plumosum*.

In the search of reasons of absence of 24 species their ecological demands were analysed (Table 1). Three of 10 species not confirmed since 1969, namely *Diphyscium foliosum*, *Pogonatum aloides* and *Hypnum lindbergii* are related to initial habitats. They were noted on eroded slopes along forest roads. It is highly probable that their current absence may result from habitats' natural changes. *Anomodon attenuatus* and *Thamnobryum alopecurum* are large epiphytic and epilitic mosses growing on protruding roots, tree stem bases and boulders. They show a clear preference to subneutral substrata. Decline of these species was observed earlier in Poland and other countries and has been interpreted as response to the environment acidification (Schaepae 1986, Fudali 1997, Hohenwallner 2000, Stebel 2006). Air pollution with SO_2 in Szczecin vicinity is considered to be one of the most important threats for the vegetation of nature reserve. *Bryum pseudotriquetrum* and *Polytrichum commune* are peat-bog species and their absence can be a result of drying out of a midforest swamp. Nine out of a group of 14 species not confirmed in 2006, were noted for the first time in 1999 and all occurred sporadically, on individual sites. Among them there are species typical for initial habitats (*Barbula convoluta*, *B. unguiculata*, *Polytrichum juniperinum*, *P. piliferum*) or fire-sites (*Funaria hygrometrica*). We can suppose that their absence is temporary and dependent on habitats dynamics.

Table 1. The bryophytes reported from the "Bukowe Zdroje" nature reserve in the years 1969-2006 and their ecological characteristics (after Dierssen 2001)

Name of species	Number of localities			Strategy	Substrate	Type of vegetation	Humidity	Reaction	Light
	since 1969	1999	2006						
1	2	3	4	5	6	7	8	9	10
I. Reported for the first time in 2006									
1. *Bryum rubens*	.	.	1	c	EG	R	*m*	*mac.-bs.*	
2. *Buclandiella heterosticha*	.	.	1	cp	EL	O	*h-x*	*ac.*	*ph.*
3. *Cephaloziella divaricata*	.	.	3	c	EGH	L	*m-x*	*sn.*	*ph.*
4. *Cirriphyllum piliferum*	.	.	5	pc	EG	L	*h-m*	*sn.-bs.*	*sc.-ph.*
5. *Didymodon rigidulus*	.	.	1	c	ELM	R, O	*x*	*sn.*	*sc.-ph.*
6. *Fissidens bryoides*	.	.	1	c	EG	L, M	*h-x*	*mac.-sn.*	*sc.-ph.*
7. *Leptodictyum riparium*	.	.	4	p	EG, EX	HL	*h*	*sn.*	*sc.-ph.*
8. *Mnium stellare*	.	.	1	l	EG	L	*h-m*	*sn.-bs.*	*sc.*
9. *Orthodicranum tauricum*	.	.	1	pc	EP	L	*m-x*	*cac.*	*sc.-ph.*
10. *Orthodontium lineare*	.	.	1	c	EP, EX	L	*m*	*cac.*	*sc.-ph.*
11. *Orthotheciella varia*	.	.	1	p	EP, EX	HL	*h-m*	*sn.*	*sc.-ph.*
12. *Orthotrichum affine*	.	.	1	c	EP	Z	*m-x*	*macn.-sn.*	*sc.-ph.*
13. *Orthotrichum anomalum*	.	.	1	c	ELM	R, O	*x*	*mac.-sn.*	*sc.-ph.*
14. *Orthotrichum diaphanum*	.	.	1	c	ELM	R, O	*x*	*sn.-bs.*	*ph.*
15. *Oxyrrhychium schleicheri*	.	.	1	p	EG	HL	*h-x*	*mac.-sn.*	*sc.*
16. *Paraleucobryum longifolium*	.	.	1	p	EL	O	*h-m*	*c-mac.*	*sc.*
17. *Pellia epiphylla*	.	.	4	c	EG	L	*h*	*mac.-sn.*	*ph.*
18. *Plagiochila asplenioides*	.	.	1	ps	EGH	L	*h-m*	*cac.-bs.*	*sc.*
19. *Platygyrium repens*	.	.	8	ps	EP	L	*h*	*mac.-sn.*	*ph.*
20. *Platyhypnidium riparioides*	.	.	4	p	EGW	HL	*h*	*mac.-bs.*	*sc.-ph.*
21. *Pohlia melanodon*	.	.	1	c	EGW	S	*h*	*sn.-bs.*	*sc.-ph.*
22. *Pylaisia polyantha*	.	.	1	ps	EP	L, Z	*h*	*cac.-sn.*	*sc.-ph.*
23. *Rhynchostegium murale*	.	.	1	p	ELM	R	*h-m*	*sn.-bs.*	*sc.-ph.*
24. *Schistidium apocarpum*	.	.	2	cp	ELM	O	*h-x*	*mac.-bs.*	*sc.-ph.*
25. *Sciuro-hypnum plumosum*	.	.	1	pc	ELW	HL	*h*	*mac.-sn.*	*sc.-ph.*
26. *Sciuro-hypnum populeum*	.	.	6	p	ELW, ELM	O	*m-x*	*cac.-sn.*	*sc.*
27. *Tortula subulata*	.	.	1	c	EG	Z, L, M	*m-x*	*sn.*	*sc.-ph.*
28. *Trichodon cylindricus*	.	.	1	c	EG	R, M	*h-m*	*mac.-sn.*	*sc.-ph.*
29. *Ulota crispa*	.	.	1	s	EP	L	*h*	*mac.-sn.*	*sc.-ph.*
II. Reported in 1969 and/or in 1999, not found in 2006									
1. *Anomodon attenuatus*	¤	.	.	p	EGH, EX	L	*m-x*	*sn.*	*sc.*
2. *Bryum pseudotriquetrum*	¤	.	.	pc	EG	HL, T	*h*	*cac.-sn.-bs.*	*sc.-ph.*
3. *Campylidium calcareum*	¤	.	.	p	EG	M	*x*	*bs.*	*sc.-ph.*
4. *Diphyscium foliosum*	¤	.	.	f	EG	L	*h-m*	*ac.*	*sc.-ph.*
5. *Hedwigia ciliata*	¤	.	.	l	EL	S	*x*	*ac.*	*ph.*
6. *Hylocomium splendens*	¤	.	.	pc	EG	L, M, W	*m*	*ac.-sn.*	*sc.-ph.*
7. *Hypnum lindbergii*	¤	.	.	pc	EG	L, T, M	*h*	*ac.-sn.*	*ph.*
8. *Pogonatum aloides*	¤	.	.	c	EG	M, W	*m*	*ac.*	*sc.*
9. *Polytrichum commune*	¤	.	.	pc	EGH	T, HL	*h-m*	*ac.*	*sc.-ph.*
10. *Thamnobryum alopecurum*	¤	.	.	p	EL	L, Z, M	*h-m*	*sn.*	*sc.*
11. *Bryoerythrophyllum recurvirostrum*	¤	1	.	c	EG, EL	L, M, S	*h-x*	*sn.-bs.*	*sc.-ph.*
12. *Dicranum majus*	¤	1	.	pc	EGH	L, M	*m*	*ac.*	*sc.-ph.*
13. *Funaria hygrometrica*	¤	2	.	f	EG	R	*h-m*	*ac.-sn.*	*sc.-ph.*
14. *Plagiomnium rostratum*	¤	2	.	pc	EGH	M, T, L	*h-m*	*sn.-bs.*	*sc.*
15. *Thuidium recognitum*	¤	1	.	ps	EG, EX	L, M	*m-x*	*ac.-sn.*	*sc.-ph.*

Table 1 – cont.

1	2	3	4	5	6	7	8	9	10
16. *Barbula convoluta*	.	1	.	c	EG	R, M	*m-x*	*sn.-bs.*	*ph.*
17. *Barbula unguiculata*	.	2	.	c	EG	R, M	*h-x*	*ac.-sn.*	*ph.*
18. *Conocephalum conicum*	.	4	.	l	EG, ELM	HL, Z	*h*	*sn.*	*sc.-ph.*
19. *Eurhynchiastrum pulchellum*	.	1	.	ps	EG	L, M	*m-x*	*ac.-sn.*	*sc.-ph.*
20. *Hypnum andoi*	.	1	.	p	EP	L	.	.	.
21. *Mnium marginatum*	.	1	.	l	EGH	L, M	*m*	*sn.*	*sc.-ph.*
22. *Polytrichum juniperinum*	.	1	.	ps	EG	M, W, L	*x*	*ac.-sn.*	*ph.*
23. *Polytrichum piliferum*	.	1	.	sp	EG	M, S, W	*x*	*ac.-sn.*	*ph.*
24. *Rosulabryum capillare*	.	2	.	c	EGH, EL	M, W, L	*m-x*	*sn.-bs.*	*sc.-ph.*
III. Reported in 1969, 1999 and 2006									
1. *Amblystegium juratzkanum*	¤	.	5	p	EP	L	*h-m*	*cac.*	*sc.-ph.*
2. *Amblystegium serpens*	¤	9	21	p	EGH, EP, EX, EL	L, M, R	*h-x*	*cac.-sn.*	*sc.-ph.*
3. *Atrichum undulatum*	¤	14	14	sp	EG	L	*h-m*	*mac.-sn.*	*sc.-ph.*
4. *Aulacomnium androgynum*	¤	6	5	s	EX	L	*h-m*	*hac.-ns.*	*sc.*
5. *Brachytheciastrum velutinum*	¤	13	15	p	EGH, EX	L, Z	*m-x*	*cac.-sn.*	*sc.-ph.*
6. *Brachythecium rutabulum*	¤	8	26	cp	EGH, EX, EP, EL	L, M, H	*h-m*	*cac.-sn.*	*sc.-ph.*
7. *Brachythecium salebrosum*	¤	7	7	cp	EGH, EX	L, HL, T	*h-m*	*mac.-sn.*	*sc.-ph.*
8. *Ceratodon purpureus*	¤	3	3	c	EG	M, R	*m-x*	*mac.-sn.*	*ph.*
9. *Cratoneuron filicinum*	¤	4	16	pc	EG, ELW	Zr	*h*	*bs.*	*ph.*
10. *Dicranella heteromalla*	¤	30	14	c	EGH	L	*m*	*h.-mac.*	*sc.-ph.*
11. *Dicranum scoparium*	¤	8	8	pc	EGH, EP, EX	L, M, W	*h-m*	*h.-mac.*	*sc.-ph.*
12. *Eurhynchium angustirete*	¤	2	1	p	EGH	L	*m-x*	*mac.-sn.*	*sc.-ph.*
13. *Eurhynchium striatum*	¤	3	2	p	EG	L	*h-m*	*cac.-sn.*	*sc.*
14. *Fissidens adianthoides*	¤	.	1	c	EG	L, T	*h*	*sn.*	*sc.-ph.*
15. *Fissidens taxifolius*	¤	10	11	c	EG	L	*m*	*mac.-sn.*	*sc.-ph.*
16. *Herzogiella seligeri*	¤	4	12	pc	EX	L	*h-m*	*cac.-sn.*	*sc.*
17. *Homalia trichomanoides*	¤	1	12	ps	EP	L	*m*	*mac.-sn.*	*sc.*
18. *Hypnum cupressiforme* var. *cupressiforme*	¤	19	30	p	EG, EP, EX	L, M, W, R	*m*	*hac.-sn.*	*sc.-ph.*
19. *Hypnum jutlandicum*	¤	.	2	p	EGH	L, T, W	*h-m*	*hac.*	*ph.*
20. *Isothecium alopecuroides*	¤	5	11	ps	EP	L, S	*m-x*	*cac.-sn.*	*sc.*
21. *Kindbergia praelonga*	¤	10	11	p	EGH, EX	L	*h*	*mac.-sn.*	*sc.*
22. *Leucobryum glaucum*	¤	9	7	p	EG	L, T	*h*	*c.-mac.*	*ind.*
23. *Mnium hornum*	¤	34	29	l	EGH, EX, EP	L, Zr	*h-m*	*c.-mac.*	*sc.-ph.*
24. *Neckera complanata*	¤	1	5	p	EP	L, S	*m-x*	*mac.-sn.*	*sc.-ph.*
25. *Plagiomnium affine*	¤	2	5	pc	EG	L, T	*h*	*mac.-sn.*	*sc.-ph.*
26. *Plagiomnium cuspidatum*	¤	3	6	pc	EG, EX	L, Z, R	*h-m*	*cac.-sn.*	*sc.*
27. *Plagiomnium undulatum*	¤	10	12	pc	EGH	L, T	*h*	*cac.-sn.*	*sc.*
28. *Plagiothecium cavifolium*	¤	7	2	ps	EGH	L	*h-m*	*cac.-sn.*	*ph.*
29. *Plagiothecium denticulatum*	¤	5	5	pc	EGH, EX	L	*h-m*	*c.-mac.*	*sc.-ph.*
30. *Plagiothecium nemorale*	¤	10	21	p	EG, EX	L	*h-m*	*cac.*	*sc.*
31. *Pohlia nutans*	¤	17	3	cp	EG, EX	L, W, T	*h-x*	*h.-mac.-sn.*	*sc.-ph.*
32. *Polytrichastrum formosum*	¤	17	13	pc	EGH	L	*m*	*h.-cac.*	*sc.-ph.*
33. *Pseudoscleropodium purum*	¤	.	1	p	EG	L, W, T	*m*	*cac.-bs.*	*sc.-ph.*
34. *Pseudotaxiphyllum elegans*	¤	20	11	cp	EG	L	*m*	*cac.-sn.*	*sc.*
35. *Rhizomnium punctatum*	¤	7	14	l	EG, EX, EL	HL, T, Zr	*h*	*cac.-sn.*	*sc.*
36. *Rosulabryum laevifilum*	¤	.	1	c	EP	L, Z	*h-m*	*mac.-sn.*	*sc.*
37. *Tetraphis pellucida*	¤	1	3	cp	EX	L, T	*h-m*	*cac.*	*sc.*

Table 1 – cont.

1	2	3	4	5	6	7	8	9	10
38. *Thuidium delicatulum*	¤	.	1	p	EG	L, T	*h-m*	*cac.-sn.*	*sc.-ph.*
39. *Thuidium tamariscinum*	¤	4	6	p	EG, EX	L	*m*	*mac.-sn.*	*sc.*
IV. Noted in 1999 and confirmed in 2006									
1. *Brachythecium rivulare*	.	3	9	pc	EG, ELW	HL, Z	*h*	*mac.-sn.*	*sc.-ph.*
2. *Calliergonella cuspidata*	.	2	2	pc	EG	T, HL	*h-m*	*cac.-sn.*	*sc.-ph.*
3. *Dicranoweisia cirrata*	.	1	3	cp	EP	L	*m-x*	*h ac.-sn.*	*ph.*
4. *Hypnum cupressiforme* var. *filiforme*	.	3	6	p	EP	L	*m*	*mac.-sn.*	*sc.-ph.*
5. *Lepidozia reptans*	.	3	2	cp	EX	L, W	*m*	*h-mac.*	*sc.-ph.*
6. *Lophocolea heterophylla*	.	7	21	cp	EP, EX	L	*h-m*	*cac.-sn.*	*sc.-ph.*
7. *Metzgeria furcata*	.	2	11	p	EP	L	*m-x*	*cac.-sn.*	*sc.-ph.*
8. *Orthodicranum montanum*	.	6	12	pc	EP, EX	L	*m-x*	*c-mac.*	*sc.*
9. *Oxyrrhynchium hians*	.	10	18	cp	EG	L, Z	*h-m*	*mac.-bs.*	*sc.-ph.*
10. *Oxyrrhynchium speciosum*	.	6	5	p	EGH	L	*h-m*	*mac.-sn.*	*sc.-ph.*
11. *Pellia endiviifolia*	.	1	5	c	EG	T, HL	*h*	*sn.-bs.*	*sc.-ph.*
12. *Plagiochila porelloides*	.	5	3	ps	EGH	L	*m-x*	*sn.-bs.*	*sc.-ph.*
13. *Plagiomnium elatum*	.	1	1	pc	EG	T, HL	*h*	*sn.*	*sc.-ph.*
14. *Plagiothecium curvifolium*	.	3	9	pc	EGH	L, W	*h-m*	*c-mac.*	*sc.-ph.*
15. *Plagiothecium laetum*	.	1	4	ps	EP, EGH	L	*m*	*c-mac.*	*sc.*
16. *Pleurozium schreberi*	.	1	2	pc	EGH	L, W, T	*m*	*cac.-sn.*	*sc.-ph.*
17. *Sciuro-hypnum oedipodium*	.	2	2	pc	EGH	L, M, Z	*m*	*mac.-sn.*	*sc.-ph.*
Totally	54	64	85						

Key to symbols and abbreviations: ¤ – species reported without quantitative data; life history strategy sensu During (1992): c – colonists, cp – pioneer colonists, f – fugitive, s – short lived shuttle, l – long lived shuttle, p – perennials, pc – competitive perennials, ps – stress tolerant perennials; substratum type: EG – soil, EGH – humus reach soil, EL – stones and boulders, ELM – concrete walls, ELW – boulders in water, EP – bark of living trees, EX – decayed wood; vegetation type: L – mesophilous deciduous forests, HL – hygrophilous forests, M – xerophilous grasslands, R – ruderal communities, S – epilithic communities, T – hygrophilous meadows and peatlands, W – heathlands, Z – shrubs communities, Zr – seepage phytocoenoses; water demands: *h* – hygrophyte, *m* – mesophyte, *x* – xerophyte; acidity and basicity demands: *ac.* – acidophyte, *cac.* – considerably acidophyte, *mac.* – moderately acidophyte, *sn.* – subneutrophyte, *bs.* – basophyte; light demands: *ph.* – photophilous, *sc.* – sciophytic, *sc.-ph.* – eurytopic in relation to light intensity.
Names of bryophytes were given after Ochyra et al. (2003) and Szweykowski (2006).

SUMMARY AND CONCLUSIONS

1. The bryophyte species composition changed during 37 years (1969 – 1999 – 2006), but the general richness of the bryoflora is comparable and the total number of species hasn't decreased. Various types of species response occurred: 1) persistence – 35.8% of the total number of recorded species were constant element of the bryoflora during the period studied, 2) assumed vanishing – 22.0%, 3) initial colonization – 26.6%, 4) entering a phase of settlement – 15.6% and 5) assumed expansion – some species constant for the nature reserve bryoflora occurred more frequently in 2006. These processes support certain stability in the bryoflora richness. None of them prevailed.

2. Species of initial habitats which colonized eroded slopes along forest paths has shown characteristic dynamics. They have periodically appeared and later vanished. Their presence in the nature reserve is closely related to dynamics of these specific habitats.

3. Epiphytes have shown the most significant changes, both qualitative and quantitative. Number of epiphytic species markedly increased: from six in 1969 to 14 in 2006. The number of localities of three epiphytes, constant in the nature reserve, also increased, but two subneutral terrestrial-epiphytic species reported in 1969 were not found either in 1999 or in 2006. All epiphytes occurring presently have wide amplitudes in relation to substratum reaction – from moderately acid to subneutral. Thus the dynamics of epiphytes seems to be promoted by human impact.

4. Specialized epixylics also showed a tendency for expansion (in 1999 – 14 localities, in 2006 – 22 localities). Most likely it resulted from increase of decayed wood availability. The increase of the epiphytes and epixylics species richness and number of localities lead to assumption that ecological variety of the reserve's bryoflora has became more similar to natural forests.

5. Pedestrian traffic has not caused an encroachment of ruderal bryophytes. Merely old concrete ruins created a habitat for hemerophilous epilitic species.

6. A neophytic invasive moss *Orthodontium lineare* was noted in 2006 for the first time.

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