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Diagnostic potential of epiphytic bryophytes in forest vegetation classification

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Abstract. The article reveals that epiphytic and epixylic bryophytes could be successfully used as differentials in classification of forest communities together with vascular plants and epigeic cryptogams, the fact proved for broadleaved forests in European Russia.

Introduction, materials and methods

Epiphytic and epixylic species of bryophytes and lichens are likely to serve as differentials not only of their synusiae [1] but also at the level of forest communities where they grow forming integrated diagnostic groups together with vascular plant and epigeic bryophytes. This publication is aimed at tracing the role of the epiphytic/epixylic bryophytes in floristic differentiation of broadleaved forests where the role of the epiphytic bryosynusia is maximal.

The study is based upon 112 relevés of broadleaved forests made in the Mordovian and Kaluzhskie Zaseki Nature Reserves (European Russia) by I. Kucherov in 2015–2016. Projective cover (%) of each species was estimated for each community layer together with soil texture and topographical location in plots not less than 400 m^2 in area. Epigeic, epiphytic (growing up to 0.6–1 m high from the trunk base) and epixylic bryophytes, totally not less than 600 multispecies moss and over 100 hepatic specimens were sampled for further studies by bryologists. Species composition of samples was identified by G. Grishutkina for the Mordovian Reserve and by V. Teleganova (mosses) and A. Potemkin (hepatics) for the Kaluzhskie Zaseki Reserve. The classification of vegetation was accomplished using the combined dominant-floristic approach which implies distinguishing the syntaxa according to dominants with further adjustment of their volume by determinant groups of ecologically close species. Epiphytes and epixyles were considered together with vasculars and epigeic bryophytes. The differentiation is represented in Tables 1 and 2 for each of the reserves separately; only determinants and prominent constants are shown in the tables.

Results and discussion

In the Kaluzhskie Zaseki Reserve (54°N, 36°E) (see Table 1), oak (*Quercus robur*) forests dominated by *Carex pilosa* in the field layer, developed on loamy sands of hilly watershed

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terrain and upper parts of slopes, are adjoint to those of the *Matteuccia struthiopteris* and *Galeobdolon luteum* variant of the *Aegopodium podagraria*- and *Allium ursinum*-dominated oak forests on even placor surfaces with heavy soil texture by a determinant group led by ash *Fraxinus excelsior*. Epiphytes and epixyles included in this group are *Cladonia coniocraea*, *Sciuro-hypnum populeum,* and rare *Pylaisia polyantha*. No one of these species is associated with ash directly. The group of non-inundated oak forest syntaxa also includes the variant of *Lunaria rediviva* and *Mercurialis perennis* of the *Aegopodium*-dominated forests in watershed depressions and bottom parts of slopes. The set of determinants of this group is headed by *Acer platanoides* in the tree layer and *A. campestre* in the undergrowth. Nemoral mesophytic herbs *Galium odoratum* and *Dentaria bulbifera* also join the group together with several nemoral (*Neckera pennata, Serpoleskea subtilis*) and multizonal (*Pseudoleskeella nervosa*) basiphilous epiphytic moss species. The ecologically and chorologically similar *Anomodon longifolius, A. viticulosus,* and *Leucodon sciuroides* occur only in the *Aegopodium*-dominated oak forests of the two mentioned variants in line with *Ulmus glabra* and *Acer campestre* in the tree layer. Maximal abundance of old trees of *A. platanoides* inhabited by the *Anomodon* species is observed in the same communities. Both the non-inundated and the inundated (floodplain) *Aegopodium*-dominated oak forests, the latter co-dominated by *Impatiens noli-tangere* and *Filipendula ulmaria* s.l. in their field layer, are united by a set of the multizonal (*Urtica dioica*), boreal-nemoral (*Matteuccia struthiopteris, Stellaria nemorum, Impatiens noli-tangere*), and nemoral (*Allium ursinum, Lamium maculatum*) mesophytes and hygromesophytes. *Homalia trichomanoides,* also a hygromesophyte, is a representative of basiphilous epiphytic mosses in this set. This species is absent in the less moist *Carex pilosa*-dominated oak forests.

A system of the uneven-aged Quaternary terraces is well-expressed in the Mordovian Reserve area (55°N, 43°E) (see Table 2). The first of them is a living floodplain of the Moksha River with a soil cover of heavy or medium loam. Oak groves with a species-poor field layer dominated by *Urtica dioica* and *Glechoma hederacea* are typical for this terrace. Their determinants are *Ulmus laevis* in the tree and the regrowth layers, *Rubus caesius,* also several boreal-nemoral hygromesophytic (*Filipendula ulmaria* s.l., *Scrophularia nodosa*) and mesohygrophytic (*Solanum dulcamara*) herbs. The multizonal epiphytic *Leskea polycarpa,* common in the floodplain, also joins the determinant group. The second and the third accumulative terraces of the Valdai (Würm) age are composed of deep sand underlain by limestone and covered by linden (*Tilia cordata*) forests with *Corylus avellana* and the field layer dominated by either *Aegopodium podagraria* (the typical variant), or *Carex pilosa*, often with the admixture of *Quercus robur* in the tree layer. Nitrophilous mesophytes with maxima of their abundance and cover on the first terrace (*Urtica dioica, Glechoma hederacea, Alliaria petiolata*) adjoin the oak groves of the latter with *Aegopodium*-dominated linden forests of the upper two terraces in contrast to *Carex pilosa*-dominated ones. *Cardamine impatiens, Adoxa moschatellina, Matteuccia struthiopteris* are also included into this group together with the epiphytic *Homalia trichomanoides* and *Pylaisia polyantha.* The first of these moss species mainly occurs on the lower two terraces whereas the last one inhabits all three. The residual fourth terrace of the Dnieper (Riss) age, composed of sand underlain by moraine loam, is covered by hemiboreal pine (*Pinus sylvestris*) forests with *Tilia cordata* and *Corylus avellana* in combination with *Carex pilosa*-dominated linden forests. Such boreal and boreal-nemoral mesotrophic mesophytes as *Betula pendula, Carex digitata, Maianthemum bifolium,* and *Rubus saxatilis* are common only in the forests of these types. The epiphytes which are in the same group are close to the vascular species mentioned in their ecology and zonal distribution. These are *Plagiothecium laetum* s.l. (the companion of *Picea abies*) and *Pleurozium schreberi* growing as an epiphyte only on this terrace.

Table 1. Floristic differentiation of broadleaved forests in Kaluzhskie Zaseki Nature Reserve

Species	Layer	Syntaxa			
		I	II		
			A	B	C
Tilia cordata	b_2	76^{4}	27^{+}	25^{+}	11^{+}
Carex pilosa	c	$\mathbf{100^{33}}$	14^{2}	38^{1}	11^{1}
Lathyrus vernus	c	82^{1}	14^{+}		11^{+}
Dicranum scoparium	z	47^{+}	14^{+}	13^{+}	22^{+}
Fraxinus excelsior	a_1	53^{6}	50^{8}	25^{3}	
Acer platanoides	a_2	82^{8}	$\mathbf{55^{11}}$	38^{8}	33^{5}
Tilia cordata	a_2	$\mathbf{71^{12}}$	41^{3}	25^{7}	33^{4}
Paris quadrifolia	c	65^{+}	73^{+}	25^{+}	33^{+}
Cladonia coniocraea	z	76^{+}	45^{+}	25^{+}	22^{+}
Sciuro-hypnum populeum	z	18^{+}	27^{+}		
Pylaisia polyantha	z	6^{+}	14^{+}		
Acer platanoides	a_1	53^{5}	$\mathbf{68^{13}}$	$\mathbf{88^{21}}$	33^{8}
A. campestre	a_3	29^{1}	41^{3}	38^{1}	
A. campestre	b_2	53^{+}	73^{1}	88^{2}	
A. platanoides	b_3	88^{2}	50^{+}	63^{+}	
Galium odoratum	c	59^{2}	73^{5}	75^{3}	33^{1}
Dentaria bulbifera	c	53^{1}	5^{+}	38^{+}	
Brachythecium salebrosum	z	59^{+}	73^{+}	50^{+}	22^{+}
Serpoleskea subtilis	z	35^{+}	64^{+}	38^{+}	
Neckera pennata	z	29^{+}	5^{+}	38^{+}	
Pseudoleskeella nervosa	z	6^{+}	18^{+}	13^{+}	
Ulmus glabra	a_1	18^{1}	45^{5}	63^{7}	11^{8}
Acer campestre	a_2		32^{3}	50^{4}	
Anomodon longifolius	z	29^{+}	64^{+}	88^{+}	33^{+}
A. viticulosus	z		14^{+}	38^{+}	
Leucodon sciuroides	z		14^{+}	38^{+}	
Ulmus glabra	b_1	29^{2}	68^{7}	63^{4}	56^{6}
Urtica dioica	c		91^{3}	88^{3}	89^{3}
Allium ursinum	c	18^{+}	$\mathbf{50^{12}}$	$\mathbf{100^{11}}$	$\mathbf{89^{10}}$
Impatiens noli-tangere	c	24^{+}	73^{1}	50^{4}	$\mathbf{67^{21}}$
Lamium maculatum	c	24^{+}	45^{1}	75^{1}	67^{1}
Stellaria nemorum	c	12^{+}	45^{1}	63^{3}	67^{3}
Matteuccia struthiopteris	c		$\mathbf{64^{12}}$	38^{1}	67^{4}
Homalia trichomanoides	z	29^{+}	82^{+}	88^{+}	67^{+}
Lunaria rediviva	c			$\mathbf{88^{19}}$	33^{1}
Athyrium filix-femina	c	6^{+}	5^{+}	38^{1}	56^{3}
Filipendula ulmaria s.l.	c		27^{+}	50^{+}	89^{5}
Oxyrrhynchium hians	d		9^{1}	13^{1}	44^{5}
Quercus robur	a_1	$\mathbf{94^{25}}$	$\mathbf{95^{28}}$	$\mathbf{75^{14}}$	$\mathbf{78^{17}}$
Aegopodium podagraria	c	94^{5}	$\mathbf{100^{17}}$	$\mathbf{100^{17}}$	$\mathbf{100^{14}}$
Galeobdolon luteum	c	100^{6}	$\mathbf{100^{13}}$	88^{8}	78^{6}
Mercurialis perennis	c	76^{4}	77^{8}	$\mathbf{88^{15}}$	89^{6}
Plagiomnium cuspidatum	z	82^{+}	91^{+}	88^{+}	78^{+}
Callicladium haldanianum	z	65^{+}	68^{+}	63^{+}	89^{+}
Dicranum montanum	z	82^{+}	64^{+}	50^{+}	56^{+}
Number of relevés		17	22	8	9

Notes. Syntaxa: I – *Quercetum pilosae-caricosum*, II – *Q. ursini-allioso-aegopodiosum* with variants: A – of *Matteuccia struthiopteris*, B – of *Lunaria rediviva*, C – of *Filipendula ulmaria*. Layers: a_1, a_2, a_3 – dominant and subordinate tree layers; b – regrowth and shrubs: b_1 – tall (> 3–4 m high), b_2 – medium, b_3 – low (≤ 1 m high); c – field layer; d – ground layer; z – epiphytes. Constancy (%) and average cover (%) (in superscripts) are given for species. Diagnostic groups are marked with bold margins, z species also with shading. Species within the groups are sorted first by layer, then by descending occurrence in the whole table relevé set. Cover and constancy values are shown in bold for dominants. Average cover under 0.5% is given as "+".

The *Aegopodium*-dominated lime forests of the *Mercurialis perennis* variant with the abundant *Acer platanoides* in the 2nd canopy layer occur on heavy soil in depressions of all the three non-inundated terraces, also at the upland fringe of the Satis River (the Moksha River tributary). Such nemoral species as *Lunaria rediviva* and *Brachythecium rutabulum*, the latter growing on trunk basements, are typical for these forests only. Amongst the species with more extended zonal ranges, *Chiloscyphus profundus* is also found only in the forests of this variant. But it occurs on all the terraces except the lowest one, and *Brachythecium rutabulum* inhabits only the upper two. Forests of this variant have a common determinant group with floodplain oak groves: it comprises *Padus avium*, *Oxyrrhynchium hians*, and the epiphytic *Anomodon attenuatus*, already known for its affiliation to floodplain habitats. This species almost exclusively occurs on the lower two terraces as well as *Homalia trichomanoides*, *Leskea polycarpa* and rare *Myrinia pulvinata*. All the non-inundated broadleaved-forest types are united by the presence of *Picea abies* and *Pinus sylvestris* as admixtures in the tree layer, also by *Acer platanoides* in the undergrowth and many nemoral mesophytic herbs like *Aegopodium podagraria*, *Pulmonaria obscura*, *Mercurialis perennis*, and *Asarum europaeum*. The same group of determinants also includes both *Carex pilosa* and *Lamium maculatum* together with *Galium odoratum*, also such boreal-nemoral herbs as *Lathyrus vernus*, *Milium effusum*, *Dryopteris carthusiana*, and *Stellaria holostea*. The epiphytic and epixylic bryophytes and lichens of this group are mainly represented by multizonal species with extensive ranges (*Brachythecium salebrosum*, *Brachytheciastrum velutinum*, *Stereodon pallescens*, *Cladonia coniocraea*), but the nemoral basiphilous *Anomodon longifolius*, the companion of *Acer platanoides*, is distributed in the same way in this area.

It follows from the above that all the recognized broadleaved-forest syntaxa are subject to distinct floristic differentiation with the help of not only vascular but also epiphytic bryophyte species under ecologically contrasting habitat conditions. The integrated diagnostic groups including both vasculars and epiphytic bryophytes are being formed due to the action of ecological factors which uniformly influence both groups of species [2]. The ecological and phytocoenotical association of these species presumably originates due to the climatic and especially the microclimatic factors. The air humidity and temperature ranges near the ground may be of the main importance among the latter [3]. The edaphic factors do not influence the association of vasculars and epiphytic bryophytes within the integrated diagnostic groups directly, but their indirect influence may be essential. The increased soil moisture should facilitate an air moisture increase, important for the effectiveness of bryophyte reproduction. Most nemoral species of epiphytic mosses also grow on tree bark with a basic reaction [4], typical for the broadleaved tree species. Many of the latter, in their turn, are dependent on soil with increased fertility and facilitate the genesis of such soil themselves by their litter.

The detailed results of this study have been recently published in Russian [5]. The work of I. Kucherov and A. Potemkin has been carried out in accordance with the current official planning tasks of the Komarov Botanical Institute RAS, projects 121032500047-1 "Vegetation of European Russia and Northern Asia: Diversity, dynamics, and principles of organization" and 121021600184-6 "Flora and taxonomy of algae, lichens and bryophytes of Russia and florologically significant regions of the World", respectively.

Table 2. Floristic differentiation of broadleaved forests in Mordovian Nature Reserve

Species	Layer	Syntaxa			
		1	2		3
			A	B	
Betula pendula	a_1	68^{4}	36^{1}	30^{3}	15^{1}
Carex digitata	c	42^{+}	14^{+}	10^{+}	
Rubus saxatilis	c	42^{1}	7^{+}	10^{+}	
Maianthemum bifolium	c	37^{+}	7^{+}		
Plagiothecium laetum s.l.	z	21^{+}	7^{+}		
Pleurozium schreberi	z	26^{+}			
Picea abies	a_1	37^{2}	64^{2}	70^{3}	
Pinus sylvestris	a_1	53^{6}	43^{3}	40^{6}	
Acer platanoides	a_2	**63^{11}**	50^{4}	**70^{23}**	23^{8}
A. platanoides	b_1	**79^{15}**	**86^{14}**	**80^{14}**	15^{1}
Aegopodium podagraria	c	95^{7}	**100^{39}**	**100^{15}**	23^{4}
Lathyrus vernus	c	100^{3}	100^{2}	50^{1}	15^{+}
Pulmonaria obscura	c	63^{1}	100^{4}	90^{2}	23^{+}
Mercurialis perennis	c	58^{3}	100^{8}	**100^{22}**	8^{+}
Lamium maculatum	c	58^{1}	50^{1}	80^{4}	15^{+}
Milium effusum	c	42^{+}	57^{4}	50^{+}	15^{2}
Dryopteris carthusiana	c	53^{+}	21^{+}	50^{+}	8^{+}
Galium odoratum	c	37^{2}	29^{2}	30^{3}	8^{+}
Asarum europaeum	c	100^{4}	93^{4}	80^{3}	
Carex pilosa	c	**100^{43}**	79^{8}	50^{3}	
Stellaria holostea	c	95^{2}	50^{+}	60^{1}	
Brachythecium salebrosum	z	63^{+}	57^{+}	40^{+}	15^{+}
Stereodon pallescens	z	42^{+}	36^{+}	60^{+}	15^{+}
Brachytheciastrum velutinum	z	47^{+}	43^{+}	20^{+}	15^{+}
Anomodon longifolius	z	21^{+}	14^{+}	30^{+}	
Cladonia coniocraea	z	21^{+}	14^{+}	20^{+}	
Urtica dioica	c	16^{+}	71^{2}	60^{3}	**100^{25}**
Glechoma hederacea	c	21^{+}	50^{1}	30^{+}	**100^{33}**
Adoxa moschatellina	c		36^{+}	30^{+}	15^{+}
Cardamine impatiens	c		21^{+}	20^{+}	31^{+}
Matteuccia struthiopteris	c		7^{+}	10^{1}	23^{1}
Homalia trichomanoides	z	5^{+}	36^{+}	30^{+}	46^{+}
Pylaisia polyantha	z	5^{+}	29^{+}	20^{+}	23^{+}
Lunaria rediviva	c			**40^{17}**	
Chiloscyphus profundus	z	11^{+}	7^{+}	40^{+}	
Brachythecium rutabulum	z	11^{+}		50^{+}	8^{+}
Padus avium	b_2	16^{+}	14^{+}	40^{+}	46^{3}
Oxyrrhynchium hians	d			10^{5}	8^{+}
Anomodon attenuatus	z	5^{+}		10^{+}	23^{+}
Ulmus laevis	a_2		7^{+}		54^{5}
Rubus caesius	b_3				46^{5}
Scrophularia nodosa	c	5^{+}	29^{+}	20^{+}	77^{+}
Filipendula ulmaria s.l.	c				54^{1}
Solanum dulcamara	c				38^{+}
Leskea polycarpa	z	11^{+}	21^{+}	10^{+}	85^{+}
Tilia cordata	a_1	**63^{26}**	**93^{42}**	**90^{40}**	**62^{21}**
Quercus robur	a_1	32^{4}	43^{9}	20^{3}	**77^{30}**
Corylus avellana	b_1	26^{2}	21^{5}	20^{1}	31^{3}
Plagiomnium cuspidatum	z	89^{+}	71^{+}	60^{+}	38^{+}
Serpoleskea subtilis	z	58^{+}	64^{+}	50^{+}	31^{+}
Platygyrium repens	z	32^{+}	57^{+}	20^{+}	77^{+}
Pseudoleskeella nervosa	z	42^{+}	57^{+}	40^{+}	23^{+}
Number of relevés		19	14	10	13

Notes. Syntaxa: I – *Tilietum pilosae-caricosum*, II – *T. aegopodiosum* with variants: A – *typica*, B – of *Mercurialis perennis*; III – *Quercetum glechomoso-urticosum*. For other notes, see Table 1.

References

1. R. Marstaller, Haussknechtia, **13** (2006)
2. A. Notov, Wulfenia, **17** (2010)
3. P. Stoutjesdijk, J. Barkman, Microclimate, vegetation and fauna (Uppsala, Opulus, 1992)
4. H. Ellenberg, H. Weber, R. Düll, W. Wirth, W. Werner, D. Paulißen, Scripta Geobot., **18** (1992)
5. I. Kucherov, G. Grishutkina, V. Teleganova, A. Potemkin, TvSU Bulletin, Biology and Ecology, **1** (**61**) (2021)