Phytocoenologia Vol. 44 (2014), Issue 3-4, 283–308
Published online May 2014

Article

Numerical classification of alder carr and riparian alder forests in Slovakia

Dedicated to the memory of Prof. Ladislav Šomšák (3.3.1932–2.12.2005)

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With 5 figures, 1 table and 2 appendices

Abstract: Syntaxonomy and ecology of the alder carr (alliance Alnion glutinosae) and riparian alder forests (suballiance Alnenion glutinoso-incanae) of Slovakia have not yet been critically revised. Application of numerical approach allowed us to disentangle and resolve syntaxonomical affinities among vegetation units previously reported in Slovakia. The present synthesis was based on analysis of 918 recent and historical phytosociological relevés originating from the Slovak Vegetation Database and available unpublished sources. Three floristically and ecologically interpretable associations of the Euro-Siberian alder carr forests of Alnion glutinosae (Thelypterido palustris-Alnetum glutinosae Klika 1940, Carici elongatae-Alnetum glutinosae Tüxen 1931, Carici acutiformis-Alnetum glutinosae Scamoni 1935) and seven of the European ash-alder riparian forests of Alnenion glutinoso-incanae (Carici remotae-Fraxinetum excelsioris Koch ex Faber 1936, Stellario nemorum-Alnetum glutinoase Lohmeyer 1957, Pruno padi-Fraxinetum excelsioris Oberdorfer 1953, Matteuccio struthiopteridis-Alnetum glutinosae Magic et Kliment in Kliment et Watzka 2000, Cardamino amarae-Alnetum incanae Šomšák 1961, Piceo abietis-Alnetum glutinosae Mráz 1959, Alnetum incanae Lüdi 1921) have been identified using unsupervised numerical classification. Each association was characterized by list of synonyms, diagnostic, constant and dominant species, overall floristic description, site requirements and chorological aspect. Main environmental gradients responsible for vegetation changes were determined in detrended correspondence analysis and interpreted using the Ellenberg indicator values (EIV) and altitude. Variation in species composition pattern corresponded to the altitudinal gradient and EIV for moisture, nutrients and soil reaction.

Keywords: Alnion glutinosae, Alnenion glutinoso-incanae, ecology, forest vegetation, syntaxonomical revision, unsupervised classification

Introduction

Alder-dominated forests have been present in the alluvial and marshland ecosystems of Central Europe since the Early Holocene, with a most expansion in the Atlantic period (Berglund et al. 1996, Lotter 1999, Finsinger et al. 2006; but see also Brown 1988). Black alder (*Alnus glutinosa*) and grey alder (*Alnus incana*) represent indigenous species to this region which are able to create the canopy-closed broadleaved forests. They are adapted to grow on sites with various environmental qualities, especially concerning moisture and edaphic conditions (McVean 1953, 1956, Schwabe 1985, Claessens et al. 2010). However, their preference for minerotrophic and/or organic substrates on the river terraces, along water reservoirs or in low-lying damp localities and spring fed areas is unambiguous. Soil moisture and nutrient-related variables are predominantly considered to be the principal determinants of variation in their species composition (Douda 2008, Ellenberg 2009).

Alder carr forests dominated by *Alnus glutinosa* occupy permanently waterlogged soils with a high stagnant groundwater table. It may temporarily decline during the year, but the short-term exposed soil surface remains still swampy or moist. Micro-topography of relief with a fine-scale soil moisture gradient, resulting from the alternation of waterlogged hollows and drier hummocks, underlines the peculiar environmental conditions that enable joint occurrence of aquatic, hygrophilous and mesophilous plants (Jeník 1980, Döring 1987, Douda et al. 2012). Forest stands with a similar floristic structure and ecology have been documented throughout the Europe (Solińska-Górnicka 1987, Pott 1992, Prieditis 1997, Neuhäuslová 2003, Willner & Grabherr 2007, Sburlino et al. 2011, Borhidi et al. 2012). Alder carr forests, traditionally assigned to the Euro-Siberian Alnion glutinosae alliance within the separate class Alnetea glutinosae (Mucina 1997, Rodwell et al. 2002), show floristic and habitat differences from the alder riparian communities of the Western Mediterranean alliance Osmundo-Alnion glutinosae (Braun-Blanquet et al. 1956) Dierschke et Rivas-Martínez in Rivas-Martínez 1975 (Amigo et al. 2004, Landi & Angiolini 2010). The first European synthesis of alder carrs was performed by Bodeux (1955) who introduced concept of four associations with a clear geographical preference. Although geographical approach in veg-

DOI: 10.1127/0340-269X/2014/0044-0588
www.borntraeger-cramer.de
0340-269X/2014/0044-0588 $ 12.60

etation classification was used in several latter studies mainly at national scale (e.g. in Poland – Matuszkiewicz et al. 1958, Marek 1965), most of the recent syntaxonomical classifications reflected the soil moisture gradient and soil nutrient/acidity complex rather than geographical pattern (e.g. Neuhäuslová 2003, Willner & Grabherr 2007).

Riparian alder forests most often settle eutrophic fluvial sediments along rivers and small brooks in valleys and foothills from colline to montane zone, but alder and ash-alder vegetation can also be found in spring fed areas. Periodic or episodic floods, which represent important ecological phenomenon for the streamside habitats, affect the water regime with annual fluctuation of groundwater level, soil physical and chemical variables including the amount and availability of nutrients together with the thickness and decomposition of organic matter. Oberdorfer (1953) proposed to unify this azonal forest vegetation in new Alnenion glutinoso-incanae suballiance of the Alno-Ulmion Braun-Blanquet et Tüxen 1943 alliance. This syntaxonomical scheme, slightly corrected for nomenclatural aspects, was adopted in majority of national synopses in Europe (e.g. Oberdorfer 1957, Dovolilová-Novotná 1961, Moravec et al. 1982, Neuhäuslová 2000, Willner & Grabherr 2007, Borhidi et al. 2012, Matuszkiewicz 2012). Hygro- to meso-hygrophilous streamside alder vegetation can be substituted on fluvial sediments of large lowland rivers by Ulmenion hardwood alluvial forests.

Phytosociological research of alder forests has a long tradition in Slovakia (Jurko & Májovský 1956, Šomšák 1959, 1961, Jurko 1961, Krippel 1967, Berta 1970), but their diversity pattern has not been sufficiently described yet. Recently, an increased interest about their syntaxonomy led to sampling of significant number of phytosociological relevés (e.g. Šomšák 2000, Kollár et al. 2005, Slezák et al. 2011, 2013, Hrivnák et al. 2013). However, papers dealing with alder forests are mostly only of local validity and unfortunately, they were often accompanied by neither more formalized approach in classification nor accurate use of nomenclatural rules (*sensu* Weber et al. 2000). Similarly, the syntaxonomical arrangement quoted in the contemporary checklist of Slovak vegetation units (Jarolímek & Šibík 2008) does not account for their variability, as it combines the syntaxon names reported in Slovak scientific literature with those reported in papers from the neighbouring regions without a critical revision. As a consequence, there is still no national synthesis based on numerical classification which would be comparable with some other European countries (e.g. Willner & Grabherr 2007, Douda 2008, Paal et al. 2008).

The aims of the present paper were: 1) to identify the main vegetation types of alder carr and riparian alder forests in Slovakia using a numerical classification; 2) to describe species composition, ecology and distribution patterns of particular plant communities; and 3) to outline their relation to syntaxa reported in other regions of Central Europe.

Material and methods

We focused on all vegetation types of alder carr forests and hygro- to meso-hygrophilous streamside alder forests in Slovakia (Fig. 1), commonly reported in previous national vegetation synopses (Mucina & Maglocký 1985, Jarolímek & Šibík 2008). Phytosociological relevés stored in the Turboveg database software (Hennekens & Schaminée 2001) were taken from the Slovak Vegetation Database (http://ibot.sav.sk/cdf/), local literature sources and completed with available unpublished relevés including also author's phytosociological material. Vegetation data were selected according to their original assignment to one of the associations of the alliance Alnion glutinosae (Alnetea glutinosae) or suballiance Alnenion glutinoso-incanae (Querco-Fagetea). The preliminary analysis included also relevés of the Ulmenion alluvial hardwood forests. This step allowed us to reliably resolve a syntaxonomical position of numerous relevés classified by their original authors only at the level of Alnion incanae alliance. Only relevés with a cover of tree layer ≥ 50% and a plot size of 100–400 m^2 (Chytrý & Otýpková 2003) were selected to achieve higher homogeneity of data matrix and to minimise potential negative impact of different sampling plot sizes on species constancy (Dengler et al. 2009). These selection criteria resulted in selection of 1292 relevés in the initial data set. All vegetation data originating from both published and unpublished sources were collected according to the principles of the Zürich-Montpellier approach in period of 1937–2012. Species taxonomy and nomenclature were unified using the concept of broadly defined taxa (Appendix 1) according to checklists of Marhold & Hindák (1998), Hill et al. (2006) and Söderström et al. (2007). For the purpose of vegetation classification, the same woody and liana species recorded in different layers were merged into one layer in the Juice program (Tichý 2002) and bryophyte species were removed, as several authors did not record them.

The initial data set was classified in PC-ORD program (McCune & Mefford 1999) using the Relative Manhattan's distance as a measure of dissimilarity and the Beta flexible linkage method ($ß = -0.25$) with the square-root data transformation. The first run of numerical classification creating two clusters split the alluvial hardwood forests (Ulmenion) from the alder carr (Alnion glutinosae) and riparian alder vegetation (Alnenion glutinoso-incanae). The Ulmenion relevés were subsequently excluded from further analyses, as they were recently revised by Petrášová & Jarolímek (2012). The remaining 918 relevés (Appendix 2), which represent the object of this study, were repeatedly analysed using analogous settings for

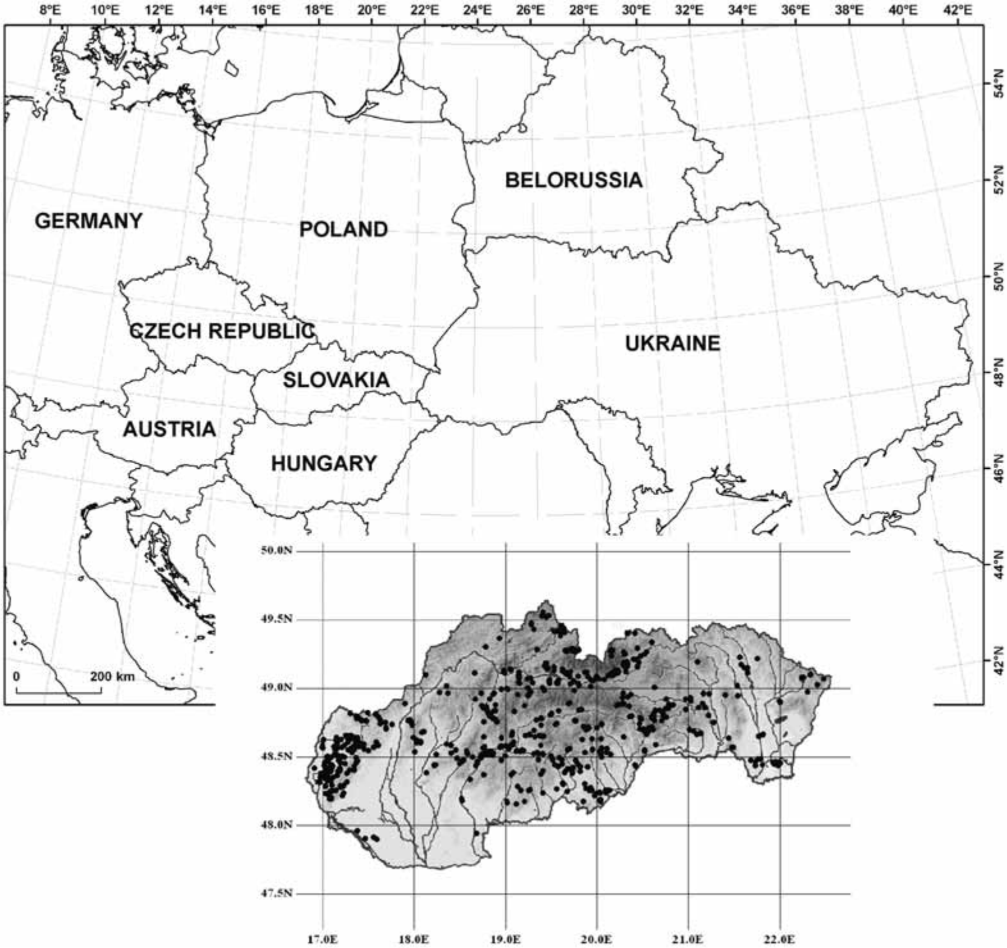

Fig. 1. Location of study area in Europe and distribution map of the 918 phytosociological relevés for alder carr and riparian alder forests in Slovakia.

numerical classification. The OptimClass1 curve method with Fisher's exact test (Tichý et al. 2010) identified first peak at the level of four clusters. This division insufficiently described the vegetation variability in region and provided only slight insight into the structure of data set. Therefore, we arbitrarily accepted the optimal partition indicated by the next peak. Results of classification summarizing in the dendrogram of cluster analysis (Fig. 2) and synoptic table (Table 1) were slightly modified when a few phytosociological relevés were shifted from one cluster to another following the diagnostic species and expert judgement. In order to confirm our results and to achieve better syntaxonomical interpretation of particular clusters, the data set was extended by relevés of original diagnoses of detected vegetation units (Lüdi 1921, Faber 1936, Klika 1940, Lohmeyer 1957, Moor 1958, Mráz 1959, Passarge 1960, Mikyška 1968) and repeatedly analysed.

Diagnostic species of the each group of relevés (cluster) were determined according to combined concept of frequency and fidelity measuring the species concentration in vegetation units (Sokal & Rohlf 1995, Chytrý et al. 2002). To eliminate dependency of the *phi* coefficient (Φ) for presence/absence data on the relative size of relevé groups within data set, the number of relevés belonging to target cluster was virtually standardized to an equal size (Tichý & Chytrý 2006). Only species showing simultaneously (i) $\Phi \geq 0.28$ and the significant occurrence in a particular cluster (Fisher's exact test $P < 0.01$), (ii) frequency $\geq$ 20%, and (iii) difference of frequencies among clusters more than 10%, were encompassed in the list of diagnostic species. Significant diagnostic value of bryophyte species and their important role in the community structure of moisture-demanding shrublands and woodlands have been already proven several times (e.g. Solińska-Górnicka 1987, Jabłońska 2012, Slezák et al. 2013). Although bryophyte records were not available for each relevé in our data set, their fidelity and frequency values were calculated only from subset of relevés with their records (433 rels.). Application of this methodological approach can be observed in some recent syntaxonomical revisions of alder carr and floodplain forests (e.g. Douda 2008) or in the project *Vegetation of the Czech Republic* (Chytrý 2013). Constant species were defined

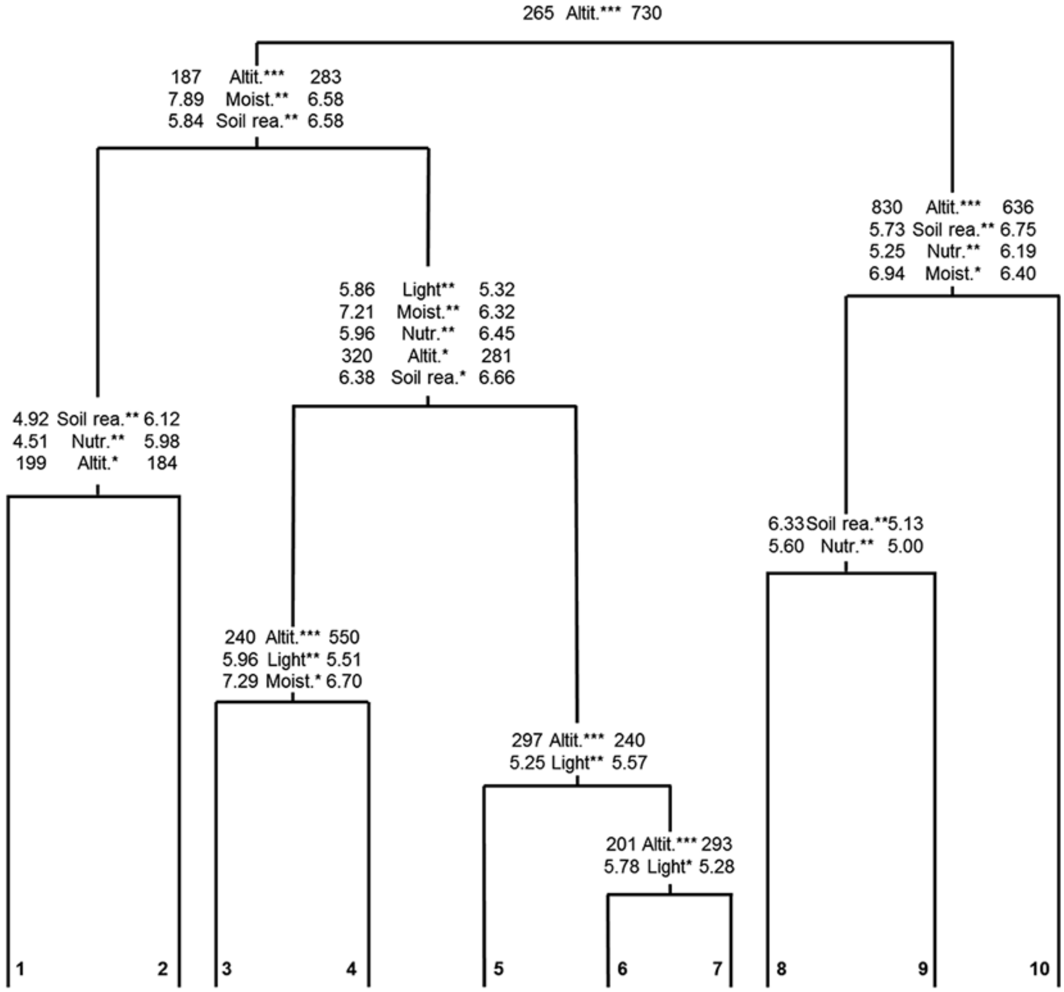

Fig. 2. Dendrogram of numerical classification for the alder carr and riparian alder forests in Slovakia. Environmental differences between two clusters at each step of division were tested by Mann-Whitney U test for altitude (Altit.) and by modified permutation test for EIV of light (Light), moisture (Moist.), soil reaction (Soil rea.) and nutrients (Nutr.). Only statistically significant variables (* $P < 0.05$; ** $P < 0.01$; ***$P < 0.001$) with their median values are shown. The numbers of clusters correspond to the synoptic table (Table 1).

as those with a frequency ≥ 50% inside the vegetation unit (cluster), whereas dominant species were those with a cover value > 25% in at least 20% of relevés belonging to particular vegetation unit. They were alphabetically listed in annotated description of individual syntaxa.

Detrended correspondence analysis (DCA) was performed to show vegetation-environmental relationships in alder forests using the Canoco for Windows package 4.5 (Microcomputer Power, Ithaca, NY, US). DCA ordination was done following detrending by segments and square-root transformation of species cover values. The ecological interpretation of major variation pattern in species composition was done with unweighted means of Ellenberg indicator values (EIV) for light, moisture, soil reaction, nutrients (Ellenberg et al. 1992) and altitude (as suitable surrogate of EIV for temperature). EIV for continentality was excluded from all analyses, because the study area (Fig. 1) is geographically limited to reflect its effect. EIV were derived based on the vascular plants data for each relevé and plotted into the ordination diagrams as supplementary variables. Statistical significance of relationship between DCA axes and EIV was calculated with the modified permutation test proposed by Zelený & Schaffers (2012) using the R software (R Foundation for Statistical Computing, Vienna, AT, US), operated through the Juice program. The importance of altitude (as directly measured parameter) for changes in the community structure was revealed by Spearman correlation coefficient, i.e. its values were correlated with the relevés scores on the first two ordination axes. Differences in the altitude at each level of cluster division were tested by Mann-Whitney U test in Statistica program (version 7.1, StatSoft Inc., Tulsa, OK, US), whereas in EIV by the modified permutation test (Zelený & Schaffers 2012). The distribution maps of all distinguished associations were created in DMAP software (Morton 2005).

Table 1. Shortened synoptic table with frequencies and fidelities (phi coefficient × 100 in the upper indices) for the alder carr and riparian alder forests in Slovakia. Only diagnostic species sorted according to decreasing phi values and species with frequency above 10% in the whole data set are shown.

Number of cluster	1	2	3	4	5	6	7	8	9	10
Number of relevés	32	105	140	49	229	55	18	72	52	166
DgS of *Thelypterido palustris-Alnetum glutinosae* (cluster 1)										
Molinia caerulea agg.	$78^{72.9}$	8^{---}	11^{---}	2^{---}	1^{---}	$.^{---}$	$.^{---}$	$.^{---}$	8^{---}	$.^{---}$
Potentilla erecta	$56^{54.1}$	$.^{---}$	6^{---}	2^{---}	$.^{---}$	4^{---}	$.^{---}$	7^{---}	$17^{9.3}$	1^{---}
Sphagnum palustre (E_0)	$62^{53.5}$	16^{---}	3^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	8^{---}	$23^{12.5}$	$.^{---}$
Aulacomnium palustre (E_0)	$31^{44.4}$	8^{---}	3^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$
Peucedanum palustre	$66^{43.1}$	$46^{25.5}$	$36^{16.6}$	4^{---}	1^{---}	5^{---}	$.^{---}$	3^{---}	10^{---}	1^{---}
Frangula alnus	$69^{42.9}$	$29^{8.5}$	$24^{4.3}$	12^{---}	4^{---}	16^{---}	$.^{---}$	1^{---}	$29^{8.8}$	2^{---}
Pinus sylvestris (E_3)	$31^{42.0}$	3^{---}	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	1^{---}	$10^{7.8}$	1^{---}
Betula pubescens (E_2)	$25^{39.2}$	4^{---}	1^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}	4^{---}	$.^{---}$
Betula pubescens (E_3)	$41^{38.6}$	4^{---}	2^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	7^{---}	$31^{26.8}$	$.^{---}$
Betula pubescens	$25^{36.6}$	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}	$12^{13.3}$	$.^{---}$
Betula pendula (E_3)	$34^{34.3}$	4^{---}	3^{---}	$.^{---}$	1^{---}	5^{---}	$.^{---}$	4^{---}	$21^{17.5}$	2^{---}
Frangula alnus (E_2)	$75^{33.7}$	$60^{22.7}$	$44^{11.2}$	31^{---}	10^{---}	22^{---}	$.^{---}$	7^{---}	37^{---}	6^{---}
Sphagnum squarrosum (E_0)	$31^{30.5}$	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$19^{23.0}$	15^{---}	$.^{---}$
DgS of *Carici elongatae-Alnetum glutinosae* (cluster 2)										
Carex pseudocyperus	$.^{---}$	$34^{51.7}$	4^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	2^{---}	$.^{---}$
Phellandrium aquaticum	$.^{---}$	$30^{51.4}$	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$
Carex elata	6^{---}	$35^{50.4}$	2^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$
Carex elongata	38^{---}	$73^{47.1}$	$49^{25.9}$	6^{---}	4^{---}	$.^{---}$	6^{---}	4^{---}	4^{---}	1^{---}
Carex riparia	12^{---}	$40^{45.6}$	8^{---}	4^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$
Stachys palustris	3^{---}	$38^{41.7}$	8^{---}	14^{---}	1^{---}	2^{---}	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}
Iris pseudacorus	9^{---}	$51^{41.4}$	$34^{22.8}$	$.^{---}$	7^{---}	15^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$
Symphytum officinale	$.^{---}$	$46^{38.3}$	19^{---}	$.^{---}$	7^{---}	22^{---}	$.^{---}$	$.^{---}$	$.^{---}$	11^{---}
Calystegia sepium	$.^{---}$	$33^{34.9}$	$19^{15.4}$	$.^{---}$	7^{---}	9^{---}	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}
Calamagrostis canescens	19^{---}	$36^{29.8}$	11^{---}	4^{---}	1^{---}	4^{---}	$.^{---}$	$.^{---}$	$21^{12.9}$	1^{---}
DgS of *Carici acutiformis-Alnetum glutinosae* (cluster 3)										
Carex acutiformis	$50^{26.7}$	26^{---}	$66^{40.1}$	6^{---}	10^{---}	16^{---}	11^{---}	$.^{---}$	2^{---}	$.^{---}$
Scutellaria galericulata	9^{---}	$30^{17.4}$	$47^{35.3}$	22^{---}	3^{---}	11^{---}	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}
Scirpus sylvaticus	34^{---}	17^{---}	$65^{34.3}$	31^{---}	23^{---}	11^{---}	$.^{---}$	24^{---}	4^{---}	14^{---}
Equisetum arvense	9^{---}	6^{---}	$51^{28.2}$	16^{---}	$33^{12.7}$	22^{---}	$.^{---}$	8^{---}	2^{---}	$34^{14.0}$
DgS of *Carici remotae-Fraxinetum excelsioris* (cluster 4)										
Thuidium delicatulum (E_0)	$.^{---}$	$.^{---}$	4^{---}	$33^{50.3}$	$.^{---}$	$.^{---}$	$.^{---}$	2^{---}	$.^{---}$	$.^{---}$
Circaea x intermedia	$.^{---}$	$.^{---}$	$.^{---}$	$24^{38.5}$	1^{---}	$.^{---}$	$.^{---}$	6^{---}	$.^{---}$	3^{---}
Geranium palustre	$.^{---}$	$.^{---}$	6^{---}	$31^{33.6}$	5^{---}	4^{---}	6^{---}	3^{---}	2^{---}	7^{---}
Fraxinus excelsior (E_2)	$.^{---}$	3^{---}	16^{---}	$49^{33.4}$	$26^{11.2}$	7^{---}	11^{---}	7^{---}	$.^{---}$	22^{---}
Poa palustris	9^{---}	9^{---}	6^{---}	$45^{32.2}$	8^{---}	5^{---}	$.^{---}$	14^{---}	15^{---}	16^{---}
Fraxinus excelsior	3^{---}	1^{---}	19^{---}	$49^{32.0}$	$38^{21.3}$	11^{---}	11^{---}	1^{---}	$.^{---}$	15^{---}
Ribes uva-crispa	3^{---}	$.^{---}$	2^{---}	$33^{31.6}$	7^{---}	$.^{---}$	$.^{---}$	12^{---}	$.^{---}$	$19^{14.0}$
DgS of *Stellario nemorum-Alnetum glutinosae* (cluster 5)										
Circaea lutetiana	$.^{---}$	11^{---}	39^{---}	8^{---}	$68^{41.4}$	$49^{25.6}$	$.^{---}$	1^{---}	$.^{---}$	13^{---}
Acer campestre (E_2)	$.^{---}$	4^{---}	14^{---}	8^{---}	$48^{38.3}$	13^{---}	22^{---}	$.^{---}$	$.^{---}$	7^{---}
Acer campestre (E_3)	$.^{---}$	$.^{---}$	2^{---}	$.^{---}$	$24^{37.3}$	$.^{---}$	6^{---}	$.^{---}$	$.^{---}$	2^{---}
Acer campestre	$.^{---}$	1^{---}	23^{---}	2^{---}	$49^{36.4}$	13^{---}	33^{---}	$.^{---}$	$.^{---}$	5^{---}
Pulmonaria officinalis agg.	$.^{---}$	1^{---}	10^{---}	14^{---}	$55^{32.8}$	15^{---}	39^{---}	11^{---}	$.^{---}$	31^{---}
Swida sanguinea	$.^{---}$	$.^{---}$	11^{---}	$.^{---}$	$27^{31.1}$	11^{---}	$.^{---}$	1^{---}	$.^{---}$	5^{---}
Stellaria holostea	$.^{---}$	1^{---}	1^{---}	$.^{---}$	$21^{29.8}$	4^{---}	6^{---}	$.^{---}$	$.^{---}$	5^{---}
Euonymus europaeus	$.^{---}$	2^{---}	23^{---}	8^{---}	$43^{29.7}$	22^{---}	28^{---}	$.^{---}$	$.^{---}$	4^{---}
Glechoma hederacea agg.	$.^{---}$	9^{---}	31^{---}	29^{---}	$74^{28.8}$	58^{---}	61^{---}	12^{---}	$.^{---}$	$60^{18.5}$

Table 1. cont.

Number of cluster	1	2	3	4	5	6	7	8	9	10
Number of relevés	32	105	140	49	229	55	18	72	52	166
DgS of *Pruno padi-Fraxinetum excelsioris* (cluster 6)										
Cucubalus baccifer	$.^{---}$	2^{---}	$10^{11.2}$	$.^{---}$	2^{---}	$22^{32.2}$	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}
DgS of *Matteuccio struthiopteridis-Alnetum glutinosae* (cluster 7)										
Matteuccia struthiopteris	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	$72^{81.5}$	$.^{---}$	$.^{---}$	3^{---}
Galeobdolon luteum agg.	$.^{---}$	$.^{---}$	11^{---}	12^{---}	$57^{24.7}$	9^{---}	$100^{58.0}$	11^{---}	8^{---}	$40^{12.0}$
Euonymus verrucosus	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	$28^{50.2}$	$.^{---}$	$.^{---}$	$.^{---}$
Juncus inflexus	$.^{---}$	$.^{---}$	2^{---}	$.^{---}$	1^{---}	$.^{---}$	$22^{38.9}$	1^{---}	$.^{---}$	2^{---}
Adoxa moschatellina	$.^{---}$	$.^{---}$	1^{---}	2^{---}	1^{---}	$.^{---}$	$22^{38.4}$	$.^{---}$	$.^{---}$	4^{---}
Dentaria glandulosa	$.^{---}$	$.^{---}$	$.^{---}$	12^{---}	2^{---}	$.^{---}$	$39^{36.7}$	$18^{11.6}$	4^{---}	9^{---}
Galium aparine	3^{---}	6^{---}	41^{---}	29^{---}	$66^{22.7}$	$67^{23.9}$	$83^{35.3}$	3^{---}	$.^{---}$	37^{---}
Chrysosplenium alternifolium	$.^{---}$	8^{---}	29^{---}	47^{---}	$41^{4.5}$	11^{---}	$83^{34.2}$	44^{---}	46^{---}	37^{---}
DgS of *Cardamino amarae-Alnetum incanae* (cluster 8)										
Chaerophyllum hirsutum	$.^{---}$	1^{---}	12^{---}	$59^{17.9}$	12^{---}	2^{---}	22^{---}	$92^{40.7}$	$71^{26.3}$	$67^{23.7}$
Veratrum album ssp. *lobelianum*	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	$29^{37.7}$	10^{---}	8^{---}
Rhytidiadelphus subpinnatus (E_0)	8^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$21^{36.4}$	$.^{---}$	$.^{---}$
Gentiana asclepiadea	$.^{---}$	$.^{---}$	$.^{---}$	12^{---}	1^{---}	$.^{---}$	$.^{---}$	$31^{35.0}$	6^{---}	$10^{5.4}$
DgS of *Piceo abietis-Alnetum glutinosae* (cluster 9)										
Dicranum scoparium (E_0)	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$33^{22.2}$	$75^{66.4}$	6^{---}
Calamagrostis villosa	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$14^{8.9}$	$54^{60.8}$	3^{---}
Vaccinium myrtillus	12^{---}	$.^{---}$	1^{---}	6^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$28^{18.0}$	$62^{54.1}$	1^{---}
Equisetum sylvaticum	$.^{---}$	2^{---}	6^{---}	14^{---}	3^{---}	2^{---}	17^{---}	$40^{20.1}$	$79^{53.9}$	11^{---}
Luzula pilosa	9^{---}	4^{---}	$.^{---}$	2^{---}	1^{---}	$.^{---}$	$.^{---}$	4^{---}	$48^{54.4}$	1^{---}
Vaccinium vitis-idaea	3^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$10^{7.4}$	$37^{48.6}$	$.^{---}$
Calypogeia integristipula (E_0)	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	6^{---}	$29^{46.6}$	$.^{---}$
Sphagnum centrale (E_0)	4^{---}	4^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	2^{---}	$29^{43.5}$	$.^{---}$
Valeriana dioica agg.	12^{---}	4^{---}	$31^{7.9}$	20^{---}	6^{---}	$.^{---}$	$.^{---}$	$42^{16.9}$	$75^{44.2}$	20^{---}
Lonicera nigra (E_2)	$.^{---}$	$.^{---}$	1^{---}	2^{---}	$.^{---}$	$.^{---}$	$.^{---}$	10^{---}	$37^{43.5}$	$10^{5.4}$
Gymnocarpium dryopteris	$.^{---}$	$.^{---}$	$.^{---}$	2^{---}	$.^{---}$	$.^{---}$	$.^{---}$	8^{---}	$31^{42.8}$	3^{---}
Rhytidiadelphus triquetrus (E_0)	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$25^{22.8}$	$40^{41.6}$	8^{---}
Tetraphis pellucida (E_0)	$.^{---}$	4^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	2^{---}	$25^{41.2}$	1^{---}
Plagiochila asplenioides (E_0)	$.^{---}$	$.^{---}$	$.^{---}$	17^{---}	$.^{---}$	$.^{---}$	$.^{---}$	13^{---}	$38^{40.3}$	1^{---}
Chiloscyphus polyanthos (E_0)	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	2^{---}	$21^{40.3}$	$.^{---}$
Lepidozia reptans (E_0)	$.^{---}$	4^{---}	1^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	13^{---}	$31^{40.1}$	$.^{---}$
Pleurozium schreberi (E_0)	4^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$19^{19.9}$	$31^{37.4}$	1^{---}
Carex canescens	$16^{14.7}$	1^{---}	2^{---}	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	6^{---}	$31^{36.7}$	$.^{---}$
Carex echinata	12^{---}	2^{---}	6^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	3^{---}	$29^{35.6}$	$.^{---}$
Galium uliginosum	$.^{---}$	5^{---}	4^{---}	8^{---}	$.^{---}$	$.^{---}$	$.^{---}$	8^{---}	$29^{34.5}$	1^{---}
Eurhynchium angustirete (E_0)	4^{---}	$.^{---}$	4^{---}	17^{---}	1^{---}	$.^{---}$	$.^{---}$	15^{---}	$38^{33.8}$	9^{---}
Stellaria alsine	6^{---}	$.^{---}$	4^{---}	2^{---}	1^{---}	$.^{---}$	$.^{---}$	3^{---}	$23^{32.7}$	1^{---}
Cardamine amara agg.	$.^{---}$	8^{---}	$47^{12.4}$	$53^{16.7}$	29^{---}	$.^{---}$	6^{---}	$53^{16.5}$	$73^{31.3}$	32^{---}
Polytrichum commune (E_0)	8^{---}	8^{---}	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	6^{---}	$23^{29.9}$	$.^{---}$
DgS of *Alnetum incanae* (cluster 10)										
Petasites hybridus	$.^{---}$	$.^{---}$	3^{---}	2^{---}	10^{---}	$.^{---}$	11^{---}	$29^{18.7}$	2^{---}	$57^{47.5}$
Primula elatior	$.^{---}$	$.^{---}$	5^{---}	24^{---}	10^{---}	5^{---}	$.^{---}$	$38^{20.6}$	8^{---}	$62^{43.4}$
Roegneria canina	$.^{---}$	$.^{---}$	6^{---}	18^{---}	10^{---}	9^{---}	6^{---}	4^{---}	$.^{---}$	$47^{41.0}$
Salix purpurea (E_2)	$.^{---}$	$.^{---}$	$.^{---}$	$.^{---}$	1^{---}	2^{---}	$.^{---}$	7^{---}	$.^{---}$	$24^{38.6}$
Thalictrum aquilegiifolium	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	1^{---}	$.^{---}$	$.^{---}$	$17^{16.1}$	6^{---}	$32^{38.2}$
Ranunculus lanuginosus	$.^{---}$	$.^{---}$	4^{---}	6^{---}	$32^{20.4}$	2^{---}	$.^{---}$	29^{---}	2^{---}	$45^{34.1}$
Silene dioica	$.^{---}$	$.^{---}$	$.^{---}$	4^{---}	1^{---}	2^{---}	$.^{---}$	6^{---}	2^{---}	$23^{33.5}$
Chaerophyllum aromaticum	$.^{---}$	2^{---}	6^{---}	8^{---}	16^{---}	11^{---}	6^{---}	7^{---}	$.^{---}$	$38^{32.9}$
Mercurialis perennis	$.^{---}$	$.^{---}$	1^{---}	$.^{---}$	10^{---}	$.^{---}$	$.^{---}$	12^{---}	$.^{---}$	$27^{32.8}$

Table 1. cont.

Number of cluster	1	2	3	4	5	6	7	8	9	10
Number of relevés	32	105	140	49	229	55	18	72	52	166
Asarum europaeum	3 ---	. ---	4 ---	41 ---	34 $^{8.7}$	9 ---	33 ---	36 ---	4 ---	63 $^{32.3}$
Carduus personata	. ---	. ---	4 ---	8 ---	5 ---	4 ---	17 ---	22 $^{14.0}$	. ---	38 $^{31.6}$
Poa nemoralis	3 ---	2 ---	4 ---	. ---	12 ---	4 ---	. ---	7 ---	4 ---	27 $^{28.2}$
Heracleum sphondylium	. ---	. ---	1 ---	2 ---	11 ---	9 ---	6 ---	8 ---	. ---	27 $^{28.0}$
DgS common for two associations										
Thelypteris palustris	41 $^{29.1}$	63 $^{51.8}$	14 ---	2 ---	. ---	. ---	. ---	1 ---	. ---	. ---
Viola palustris	25 $^{28.2}$	3 ---	3 ---	. ---	. ---	. ---	. ---	. ---	25 $^{28.2}$	. ---
Solanum dulcamara	12 ---	78 $^{36.7}$	72 $^{32.3}$	20 ---	34 ---	25 ---	. ---	6 ---	23 ---	13 ---
Lycopus europaeus	38 ---	90 $^{35.0}$	89 $^{33.7}$	35 ---	43 ---	36 ---	28 ---	7 ---	13 ---	13 ---
Geum urbanum	. ---	9 ---	37 ---	45 ---	79 $^{32.9}$	75 $^{30.0}$	33 ---	4 ---	. ---	43 ---
Sambucus nigra (E_2)	. ---	12 ---	26 ---	4 ---	61 $^{29.4}$	65 $^{32.8}$	39 ---	3 ---	2 ---	24 ---
Alliaria petiolata	. ---	1 ---	6 ---	14 ---	50 $^{30.4}$	15 ---	67 $^{45.1}$	. ---	. ---	11 ---
Aegopodium podagraria	. ---	5 ---	43 ---	45 ---	85 $^{29.0}$	47 ---	100 $^{39.0}$	12 ---	2 ---	83 $^{27.6}$
Picea abies (E_3)	6 ---	. ---	1 ---	16 ---	2 ---	. ---	. ---	72 $^{41.4}$	96 $^{59.5}$	26 $^{3.0}$
Picea abies (E_2)	6 ---	. ---	4 ---	22 ---	2 ---	. ---	. ---	68 $^{36.0}$	88 $^{52.2}$	36 $^{10.6}$
Picea abies	16 ---	1 ---	6 ---	8 ---	3 ---	. ---	. ---	54 $^{28.6}$	88 $^{57.2}$	23 $^{2.5}$
Alnus incana (E_3)	6 ---	1 ---	4 ---	12 ---	4 ---	11 ---	. ---	100 $^{51.1}$	62 $^{23.1}$	98 $^{49.8}$
Alnus incana	3 ---	. ---	1 ---	2 ---	1 ---	. ---	. ---	64 $^{49.9}$	19 ---	42 $^{28.0}$
Alnus incana (E_2)	3 ---	. ---	4 ---	12 ---	. ---	2 ---	. ---	78 $^{48.4}$	42 $^{18.7}$	57 $^{31.2}$
Geum rivale	. ---	1 ---	9 ---	24 ---	2 ---	5 ---	. ---	67 $^{37.3}$	42 $^{17.4}$	59 $^{31.1}$
Other species										
E_3 –tree layer										
Alnus glutinosa	94 $^{12.3}$	100 $^{17.4}$	100 $^{17.4}$	100 $^{17.4}$	99 $^{16.3}$	95 $^{13.0}$	100 $^{17.4}$	4 ---	87 ---	8 ---
Salix fragilis	. ---	10 ---	5 ---	10 ---	26 $^{12.7}$	11 ---	33 ---	1 ---	. ---	36 $^{21.8}$
Fraxinus excelsior	3 ---	3 ---	6 ---	27 $^{21.8}$	24 $^{19.3}$	4 ---	6 ---	1 ---	. ---	11 ---
E_2 – shrub layer										
Alnus glutinosa	47 ---	62 $^{20.7}$	29 ---	53 $^{14.5}$	22 ---	31 ---	33 ---	1 ---	46 $^{9.5}$	2 ---
Padus avium	12 ---	10 ---	26 ---	41 $^{17.8}$	19 ---	27 ---	. ---	7 ---	12 ---	42 $^{18.4}$
Corylus avellana	3 ---	6 ---	16 ---	24 ---	42 $^{22.9}$	15 ---	28 ---	10 ---	. ---	24 ---
Euonymus europaeus	. ---	4 ---	14 ---	12 ---	33 $^{18.6}$	33 $^{18.2}$	33 ---	. ---	. ---	9 ---
Viburnum opulus	. ---	13 ---	25 $^{12.1}$	29 $^{15.7}$	13 ---	22 ---	. ---	1 ---	8 ---	17 ---
Swida sanguinea	. ---	4 ---	11 ---	8 ---	34 $^{26.0}$	18 ---	11 ---	. ---	. ---	16 ---
Crataegus monogyna	3 ---	1 ---	14 ---	6 ---	31 $^{26.4}$	27 $^{22.0}$	. ---	. ---	. ---	5 ---
Acer pseudoplatanus	. ---	1 ---	8 ---	22 ---	18 $^{11.1}$	. ---	. ---	12 ---	. ---	24 $^{18.5}$
Sorbus aucuparia	22 ---	8 ---	16 ---	14 ---	1 ---	5 ---	. ---	24 $^{11.6}$	21 ---	11 ---
Salix cinerea	16 ---	30 $^{21.6}$	11 ---	10 ---	1 ---	. ---	. ---	24 $^{13.3}$	12 ---	7 ---
E_1 – herb layer										
Urtica dioica	6 ---	54 ---	66 ---	61 ---	90 $^{16.2}$	91 $^{17.1}$	100 $^{23.6}$	62 ---	52 ---	84 $^{12.1}$
Caltha palustris	16 ---	21 ---	77 $^{14.5}$	92 $^{24.3}$	52 ---	27 ---	17 ---	93 $^{25.1}$	96 $^{27.2}$	65 ---
Impatiens noli-tangere	3 ---	20 ---	57 ---	53 ---	73 $^{19.1}$	45 ---	78 ---	42 ---	15 ---	61 $^{11.1}$
Filipendula ulmaria	16 ---	17 ---	76 $^{19.4}$	67 ---	35 ---	18 ---	28 ---	88 $^{26.8}$	56 ---	73 $^{17.0}$
Ranunculus repens	9 ---	26 ---	74 $^{18.3}$	69 $^{15.5}$	47 ---	47 ---	17 ---	47 ---	69 $^{15.4}$	56 ---
Lysimachia vulgaris	94 $^{28.8}$	90 $^{25.9}$	84 $^{22.4}$	37 ---	43 ---	40 ---	. ---	21 ---	81 $^{20.1}$	17 ---
Dryopteris carthusiana agg.	84 $^{21.5}$	79 $^{17.9}$	63 $^{7.1}$	53 ---	37 ---	44 ---	. ---	51 ---	90 $^{25.5}$	20 ---
Athyrium filix-femina	38 ---	42 ---	54 ---	67 $^{12.8}$	46 ---	47 ---	6 ---	60 ---	87 $^{25.6}$	36 ---
Deschampsia cespitosa	34 ---	26 ---	55 $^{7.1}$	67 $^{15.4}$	25 ---	49 ---	17 ---	65 $^{14.0}$	54 ---	52 $^{4.9}$
Rubus subgen. *Rubus*	56 ---	44 ---	56 $^{14.2}$	41 ---	65 $^{19.9}$	65 $^{20.5}$	6 ---	7 ---	2 ---	18 ---
Rubus idaeus	6 ---	4 ---	32 ---	69 $^{20.1}$	34 ---	18 ---	17 ---	78 $^{25.8}$	79 $^{26.5}$	61 $^{14.7}$
Stachys sylvatica	. ---	4 ---	20 ---	53 ---	73 $^{31.4}$	40 ---	11 ---	25 ---	6 ---	66 $^{26.6}$
Lysimachia nummularia	3 ---	18 ---	59 $^{19.9}$	57 $^{18.4}$	46 $^{10.3}$	58 $^{19.1}$	17 ---	10 ---	2 ---	45 ---
Myosotis scorpioides agg.	6 ---	9 ---	49 $^{6.5}$	69 $^{20.2}$	27 ---	15 ---	33 ---	72 $^{22.1}$	79 $^{26.6}$	38 ---

Table 1. cont.

Number of cluster	1	2	3	4	5	6	7	8	9	10
Number of relevés	32	105	140	49	229	55	18	72	52	166
Oxalis acetosella	47 ---	14 ---	27 ---	61 15.6	34 ---	24 ---	. ---	58 13.6	77 26.4	42 ---
Ajuga reptans	3 ---	1 ---	42 ---	59 21.0	44 9.8	31 ---	11 ---	35 ---	25 ---	51 15.2
Geranium robertianum	3 ---	3 ---	28 ---	41 ---	53 18.5	47 ---	28 ---	29 ---	. ---	51 16.5
Crepis paludosa	16 ---	2 ---	44 7.0	51 11.7	13 ---	11 ---	6 ---	69 24.7	79 31.3	53 13.1
Carex remota	9 ---	20 ---	46 11.5	55 18.4	46 11.9	40 ---	6 ---	36 ---	27 ---	14 ---
Galium palustre	41 ---	78 33.6	70 27.7	22 ---	12 ---	20 ---	6 ---	25 ---	31 ---	9 ---
Festuca gigantea	. ---	6 ---	36 ---	37 ---	56 26.1	35 ---	11 ---	22 ---	. ---	30 ---
Brachypodium sylvaticum	9 ---	7 ---	40 ---	24 ---	55 25.8	47 ---	. ---	6 ---	4 ---	37 ---
Angelica sylvestris	19 ---	12 ---	43 12.8	33 ---	27 ---	25 ---	11 ---	32 ---	6 ---	52 20.1
Lamium maculatum	. ---	5 ---	15 ---	37 ---	54 21.3	36 ---	39 ---	18 ---	12 ---	43 12.9
Cirsium oleraceum	. ---	2 ---	45 15.0	24 ---	31 ---	16 ---	28 ---	44 14.6	15 ---	47 16.6
Stellaria nemorum	. ---	2 ---	14 ---	45 15.4	30 ---	11 ---	33 ---	49 18.3	6 ---	60 26.8
Galeopsis speciosa	. ---	13 ---	24 ---	31 ---	38 14.3	36 ---	33 ---	12 ---	2 ---	19 ---
Eupatorium cannabinum	3 ---	40 18.5	46 23.4	27 ---	19 ---	16 ---	11 ---	3 ---	2 ---	18 ---
Senecio nemorensis agg.	3 ---	. ---	4 ---	39 13.3	8 ---	7 ---	. ---	61 31.2	44 17.7	55 26.6
Humulus lupulus	. ---	23 ---	53 27.5	6 ---	23 ---	55 28.9	33 ---	. ---	. ---	7 ---
Impatiens parviflora	3 ---	7 ---	29 ---	4 ---	50 26.8	20 ---	56 31.7	4 ---	4 ---	9 ---
Poa trivialis	3 ---	21 ---	37 18.2	14 ---	30 11.9	40 20.7	11 ---	1 ---	. ---	10 ---
Carex sylvatica	3 ---	. ---	7 ---	45 26.2	32 14.8	9 ---	6 ---	25 ---	4 ---	30 12.2
Juncus effusus	34 ---	21 ---	44 20.6	20 ---	14 ---	22 ---	. ---	14 ---	19 ---	5 ---
Viburnum opulus	6 ---	5 ---	40 22.6	18 ---	22 ---	22 ---	6 ---	1 ---	23 ---	12 ---
Agrostis stolonifera agg.	12 ---	4 ---	29 9.5	27 ---	14 ---	13 ---	. ---	22 ---	38 18.1	18 ---
Acer pseudoplatanus	. ---	. ---	14 ---	39 24.1	22 ---	. ---	6 ---	29 14.9	2 ---	27 12.9
Alnus glutinosa	44 20.1	15 ---	30 8.6	35 12.5	16 ---	18 ---	. ---	. ---	37 14.0	3 ---
Valeriana officinalis agg.	. ---	. ---	11 ---	43 25.3	4 ---	. ---	. ---	31 14.0	15 ---	51 32.5
Equisetum palustre	25 ---	10 ---	24 5.7	14 ---	3 ---	13 ---	. ---	46 25.4	15 ---	20 ---
Padus avium	19 ---	5 ---	26 12.1	16 ---	14 ---	24 ---	. ---	3 ---	12 ---	21 ---
Sorbus aucuparia	50 25.4	9 ---	21 ---	4 ---	4 ---	9 ---	. ---	33 11.4	52 27.0	14 ---
Dryopteris filix-mas	6 ---	1 ---	13 ---	10 ---	26 10.2	13 ---	. ---	17 ---	15 ---	22 10.7
Dactylis glomerata agg.	6 ---	1 ---	5 ---	18 ---	11 ---	20 ---	. ---	22 ---	. ---	38 26.2
Lythrum salicaria	12 ---	49 35.4	39 25.5	6 ---	7 ---	16 ---	. ---	. ---	. ---	1 ---
Paris quadrifolia	6 ---	10 ---	14 ---	24 ---	10 ---	4 ---	. ---	35 19.3	25 ---	17 ---
Sambucus nigra	. ---	3 ---	8 ---	6 ---	36 30.3	27 20.6	6 ---	. ---	. ---	8 ---
Mycelis muralis	3 ---	7 ---	3 ---	10 ---	15 ---	2 ---	. ---	14 ---	25 ---	29 19.6
Cirsium palustre	41 23.6	22 6.2	18 ---	8 ---	1 ---	7 ---	. ---	21 ---	29 12.6	5 ---
Symphytum tuberosum agg.	. ---	2 ---	2 ---	. ---	23 21.3	4 ---	6 ---	1 ---	. ---	31 32.1
Geranium phaeum	. ---	. ---	1 ---	. ---	12 ---	2 ---	33 ---	15 ---	. ---	39 31.6
Milium effusum	. ---	. ---	6 ---	6 ---	19 13.7	4 ---	. ---	18 ---	4 ---	23 18.3
Persicaria hydropiper	. ---	7 ---	29 22.5	20 ---	17 9.1	18 ---	. ---	. ---	. ---	1 ---
Ficaria bulbifera	. ---	2 ---	3 ---	4 ---	25 28.4	4 ---	. ---	. ---	. ---	19 18.8
Myosoton aquaticum	6 ---	14 ---	15 ---	2 ---	11 ---	24 15.8	6 ---	6 ---	2 ---	11 ---
Maianthemum bifolium	41 25.6	4 ---	9 ---	6 ---	1 ---	4 ---	. ---	21 6.6	42 27.2	13 ---
Anthriscus sylvestris	. ---	1 ---	4 ---	2 ---	19 17.0	15 ---	. ---	1 ---	. ---	22 21.8
Fragaria vesca	. ---	1 ---	6 ---	27 18.1	3 ---	13 ---	. ---	15 ---	13 ---	25 16.1
E_0 – moss layer										
Plagiomnium undulatum	4 ---	20 ---	26 ---	67 ---	46 ---	50 ---	33 ---	33 ---	27 ---	74 24.9
Plagiomnium affine agg.	12 ---	28 ---	64 25.2	17 ---	30 ---	22 ---	. ---	40 ---	44 ---	40 ---
Brachythecium rivulare	. ---	20 ---	51 11.3	67 ---	49 9.6	50 ---	33 ---	23 ---	27 ---	31 ---
Climacium dendroides	35 ---	12 ---	33 ---	. ---	8 ---	17 ---	33 ---	38 ---	58 24.6	26 ---
Atrichum undulatum	23 ---	8 ---	31 ---	33 ---	33 11.0	28 ---	. ---	8 ---	23 ---	13 ---
Rhizomnium punctatum	8 ---	12 ---	17 ---	33 ---	13 ---	6 ---	. ---	37 15.3	48 25.0	13 ---

Table 1. cont.

Number of cluster	1	2	3	4	5	6	7	8	9	10
Number of relevés	32	105	140	49	229	55	18	72	52	166
Oxyrrhynchium hians	. $^{---}$	. $^{---}$	11 $^{---}$	33 $^{---}$	38 $^{20.9}$	28 $^{---}$	. $^{---}$	13 $^{---}$	4 $^{---}$	25 $^{---}$
Calliergonella cuspidata	31 $^{---}$	16 $^{---}$	43 $^{22.5}$	17 $^{---}$	4 $^{---}$	17 $^{---}$	. $^{---}$	17 $^{---}$	23 $^{---}$	6 $^{---}$
Polytrichastrum formosum	27 $^{---}$	20 $^{---}$	13 $^{---}$	17 $^{---}$	. $^{---}$	6 $^{---}$	. $^{---}$	21 $^{---}$	44 $^{26.8}$	3 $^{---}$
Plagiothecium denticulatum	15 $^{---}$	20 $^{---}$	21 $^{---}$	17 $^{---}$	11 $^{---}$	11 $^{---}$	11 $^{---}$	4 $^{---}$	25 $^{10.8}$	2 $^{---}$
Plagiomnium cuspidatum	23 $^{---}$	8 $^{---}$	13 $^{---}$	. $^{---}$	19 $^{---}$	22 $^{---}$	. $^{---}$	4 $^{---}$	. $^{---}$	11 $^{---}$
Hypnum cupressiforme	8 $^{---}$	8 $^{---}$	9 $^{---}$	. $^{---}$	31 $^{25.3}$	6 $^{---}$	22 $^{---}$	. $^{---}$	4 $^{---}$	4 $^{---}$
Brachythecium rutabulum	. $^{---}$	24 $^{---}$	11 $^{---}$	. $^{---}$	17 $^{---}$	6 $^{---}$	11 $^{---}$	6 $^{---}$	6 $^{---}$	11 $^{---}$

The nomenclatural revision of plant communities was carried out in accordance with the International Code of Phytosociological Nomenclature (ICPN; Weber et al. 2000). All names of plant communities, which were not involved in the contemporary checklist of Slovak vegetation units (Jarolímek & Šibík 2008), were displayed with the author's name and year of description.

Results

Numerical classification divided the data into 10 clusters showing considerable variation in the species composition, habitat requirements and their distribution pattern across the country. The identified clusters corresponded to the previously described and traditionally recognized vegetation units. According to the list of diagnostic species, overall floristic description and site conditions (Table 1, Fig. 3, 4), three clusters represented alder carr forests of the Alnion glutinosae alliance, whereas the seven remaining groups of relevés were assigned to the Alnenion glutinoso-incanae suballiance (Alnion incanae). The classification structure, which pointed out chiefly the floristic similarities among clusters, demonstrated also importance of particular factors for each level of division (Fig. 2). DCA ordination indicated similar trends and supported ecological interpretation of classification, when all analysed EIV and altitude showed significant relation ($P < 0.05$) with first two DCA ordination axes (Fig. 3). Two major gradients responsible for vegetation changes reflected combine influence of moisture and altitude (DCA axis 1), but differences in soil nutrient/acidity complex were also obvious (DCA axis 2).

Annotated syntaxonomical synopsis

Alnetea glutinosae Braun-Blanquet et Tüxen ex Westhoff et al. 1946
- Alnetalia glutinosae Tüxen 1937
  - Alnion glutinosae Malcuit 1929
    1. Thelypterido palustris-Alnetum glutinosae Klika 1940
    2. Carici elongatae-Alnetum glutinosae Tüxen 1931
    3. Carici acutiformis-Alnetum glutinosae Scamoni 1935

Querco-Fagetea Braun-Blanquet et Vlieger in Vlieger 1937
- Fagetalia Pawłowski et al. 1928
  - Alnion incanae Pawłowski et al. 1928
  - Alnenion glutinoso-incanae Oberdorfer 1953
    4. Carici remotae-Fraxinetum excelsioris Koch ex Faber 1936
    5. Stellario nemorum-Alnetum glutinosae Lohmeyer 1957
    6. Pruno padi-Fraxinetum excelsioris Oberdorfer 1953
    7. Matteuccio struthiopteridis-Alnetum glutinosae Magic et Kliment in Kliment et Watzka 2000
    8. Cardamino amarae-Alnetum incanae Šomšák 1961
    9. Piceo abietis-Alnetum glutinosae Mráz 1959
    10. Alnetum incanae Lüdi 1921

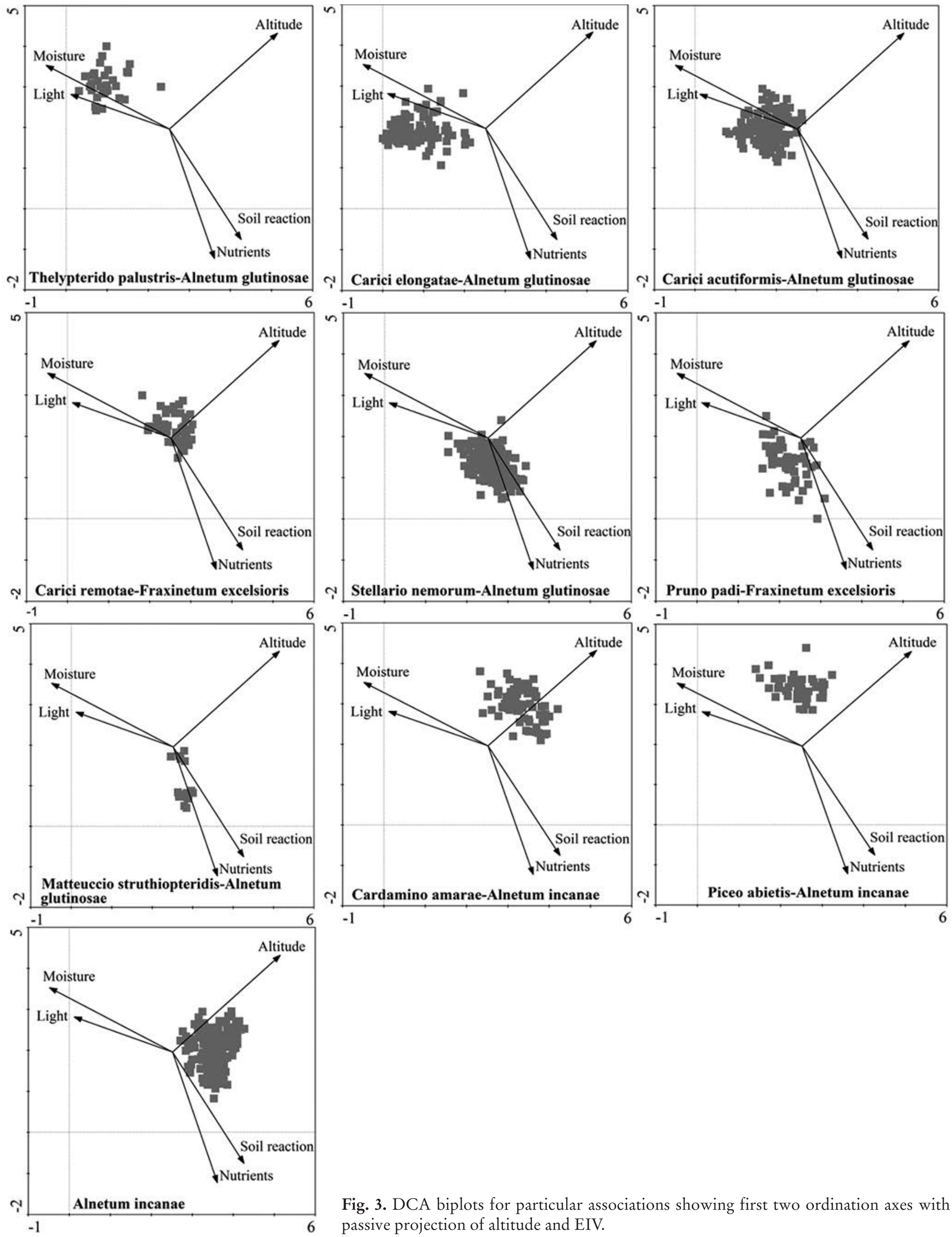

Fig. 3. DCA biplots for particular associations showing first two ordination axes with passive projection of altitude and EIV.

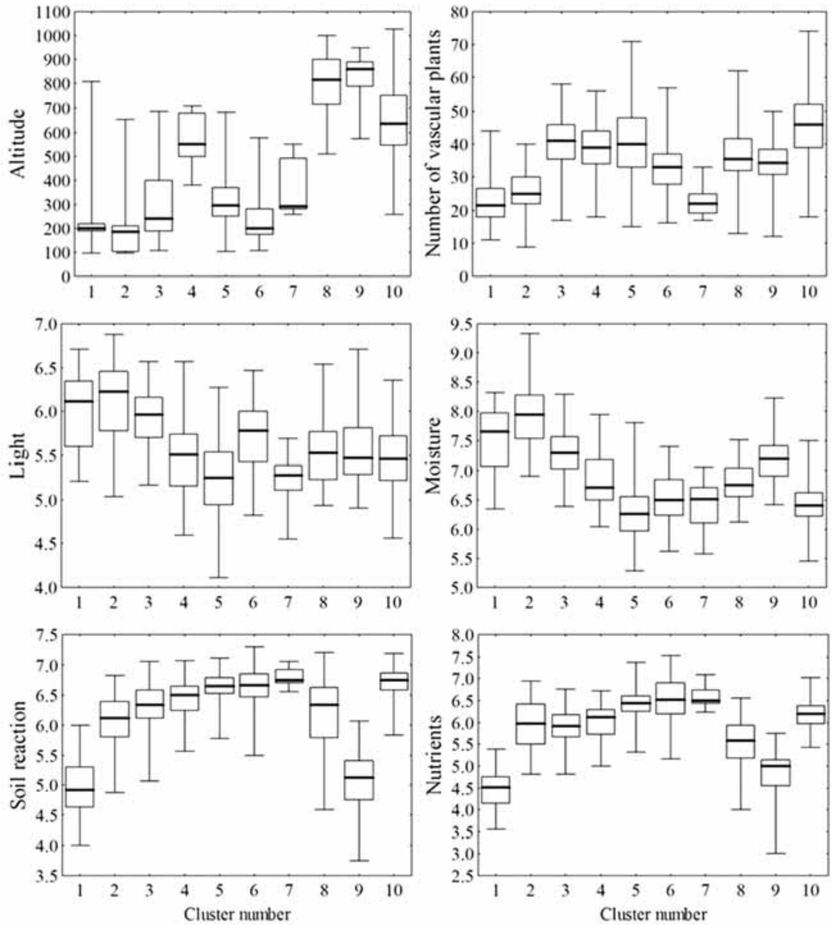

Fig. 4. Variation patterns in the altitude, number of vascular plants and EIV for individual clusters are shown. The central line of each box refers to the median value, boxes to the lower (25%) and upper (75%) quartiles, and whiskers to the range of values. The numbers of clusters correspond to the synoptic table (Table 1).

1. Thelypterido palustris-Alnetum glutinosae Klika 1940 (Oligotrophic *Sphagnum*-rich alder carr)

Original form of the name: Klika (1940); *Alnus glutinosa-Dryopteris thelypteris*-Assoziation (*Dryopteris thelypteris = Thelypteris palustris*)

Nomenclatural type: Klika (1940), p. 100, rel. 3, lectotypus designated by Dengler et al. (2004)

Synonyms: *Alnus glutinosa-Molinia caerulea* Šmarda 1951 (syntax. syn.), Carici elongatae-Alnetum glutinosae betuletosum pubescentis Bodeux 1955 (syntax. syn.), Sphagno squarrosi-Alnetum Solińska-Górnicka ex Prieditis 1997 (syntax. syn.)

Diagnostic species: *Aulacomnium palustre* (E_0), *Betula pendula* (E_3), *B. pubescens* (E_3, E_2, E_1), *Frangula alnus* (E_2, E_1), *Molinia caerulea* agg., *Peucedanum palustre*, *Pinus sylvestris* (E_3), *Potentilla erecta*, *Sphagnum palustre* (E_0), *S. squarrosum* (E_0)

Constant species: *Alnus glutinosa* (E_3), *Carex acutiformis*, *Dryopteris carthusiana* agg., *Frangula alnus* (E_2, E_1), *Lysimachia vulgaris*, *Molinia caerulea* agg., *Peucedanum palustre*, *Potentilla erecta*, *Rubus* subgen. *Rubus*, *Sorbus aucuparia* (E_1), *Sphagnum palustre* (E_0)

Dominant species: *Alnus glutinosa* (E_3), *Frangula alnus* (E_2), *Molinia caerulea* agg.

These three-layered alder carr forests consist of *Alnus glutinosa* and *Betula pubescens*, but light-demanding species such as *Betula pendula* and *Pinus sylvestris* are often admixed in the tree layer. In addition to saplings of overstorey woody species, dominance of *Frangula alnus* is important physiognomic feature of the shrub layer. Herb layer usually contains acidic-tolerant species (*Maianthemum bifolium*, *Molinia caerulea* agg., *Oxalis acetosella*, *Peucedanum palustre*, *Potentilla erecta*, *Viola palustris*) in combination with ferns (*Dryopteris carthusiana* agg., *Thelypteris palustris*) and hygrophilous plants adapted to nutrient-poorer habitats (e.g. *Carex elongata*, *Cirsium palustre*). Markedly developed moss layer is composed mainly of *Sphagnum* spec. div. (incl. *S. palustre*, *S. squarrosum*) together with *Aulacomnium palustre*, *Calliergonella cuspidata*, *Climacium dendroides* and *Polytrichastrum formosum*.

The typically developed stands are confined to low-productive, oligotrophic and acidic substrates (Fig. 4) with naturally water-saturated soils. In Slovakia, this community with typical species composition occurs primarily at lower altitudes in the Záhorská nížina Lowland and Východoslovenská rovina Lowland. A few relevés with transitional features, which were recorded in the submontane areas of the Slovenské rudohorie Mts, Orava region and Podtatranské kotliny Basins, also matched the species composition pattern of such association (Fig. 5). Outside Slovakia, vegetation with similar floristic structure and ecological requirements has been found in the Baltic region (Prieditis 1997), Poland (Solińska-Górnicka 1987), Germany (Döring-Mederake 1990), Austria (Willner & Grabherr 2007), Czech Republic (Douda 2008) and Hungary (Borhidi et al. 2012).

2. Carici elongatae-Alnetum glutinosae Tüxen 1931 (Meso- to eutrophic alder carr)
Original form of the name: Tüxen (1931); Cariceto elongatae-Alnetum glutinosae
Nomenclatural type: Passarge (1960), p. 507, Tab. 4, rel. 5, neotypus designated by Dengler et al. (2004)
Synonyms: Carici elongatae-Alnetum glutinosae Koch 1926 (§ 2b), Carici elongatae-Alnetum glutinosae Schwickerath 1933 (syntax. syn.), *Alnus glutinosa-Dryopteris spinulosa*-Ass. Klika 1940 (syntax. syn.), Cariceto elongatae-Alnetum medioeuropaeum (Koch 1926) Tüxen et Bodeux 1955 (§ 34a), Carici elongatae-Alnetum glutinosae boreale Preising et Bodeux 1955 (§ 34a), Caltho palustris-Alnetum glutinosae Šomšák 1961 p.p. (syntax. syn.), Hottonio-Alnetum Hueck ex Fukarek 1961 (syntax. syn.), Carici ripariae-Alnetum glutinosae Weisser 1970 p.p. (syntax. syn)
Diagnostic species: *Calamagrostis canescens*, *Calystegia sepium*, *Carex elata*, *C. elongata*, *C. pseudocyperus*, *C. riparia*, *Iris pseudacorus*, *Phellandrium aquaticum*, *Stachys palustris*, *Symphytum officinale*, *Thelypteris palustris*
Constant species: *Alnus glutinosa* (E_3, E_2), *Carex elongata*, *Dryopteris carthusiana* agg., *Frangula alnus* (E_2), *Galium palustre*, *Iris pseudacorus*, *Lycopus europaeus*, *Lysimachia vulgaris*, *Solanum dulcamara*, *Thelypteris palustris*, *Urtica dioica*
Dominant species: *Alnus glutinosa* (E_3), *Thelypteris palustris*
Monodominant tree layer is built up of *Alnus glutinosa*, whereas shade-tolerant species such as *Frangula alnus* and *Salix cinerea* are commonly present in the species-poor shrub layer. The mosaic structure of the herb layer results from conspicuous micro-relief heterogeneity, i.e. species showing affinity to drier hummocks (*Calamagrostis canescens*, *Carex elongata*, *Dryopteris carthusiana* agg., *Thelypteris palustris*) are followed by hygrophilous elements preferring waterlogged hollows (*Galium palustre*, *Iris pseudacorus*, *Lycopus europaeus*, *Phellandrium aquaticum*). Floristic spectrum involves also tall-sedges (*Carex elata*, *C. pseudocyperus*, *C. riparia*) and liana species (*Calystegia sepium*, *Solanum dulcamara*). Unlike the higher frequency of nitrophilous and wet meadow's plants (*Lysimachia vulgaris*, *Lythrum salicaria*, *Stachys palustris*, *Symphytum officinale*, *Urtica dioica*), forest mesophilous and acidophilous species are less abundant. The moss layer with numerous generalists of wet habitats (*Brachythecium rivulare*, *Plagiomnium affine* agg., *P. undulatum*) plays an important role in the community structure.

This alder carr develops on waterlogged and nutrient-medium to rich soils, which are usually situated in low-lying damp localities of alluvial zones along rivers, in contact zones of water reservoirs and spring fed areas at altitudes from 100 to 650 m (Fig. 4). It occurs especially in Slovak lowlands (Záhorská nížina Lowland, Podunajská nížina Lowland, Východoslovenská rovina Lowland), in foothills of the Western Carpathians (Hronská pahorkatina Hills, Krupinská planina Plateau, Novohrad region) and at scattered sites in some submontane regions (e.g. Kremnické vrchy Mts, Slánske vrchy Mts, Orava region; Fig. 5). The Carici elongatae-Alnetum glutinosae represents one of the most documented vegetation type of alder carr in Europe (Bodeux 1955, Marek 1965, Coldea 1991, Pott 1992, Prieditis 1993, Neuhäuslová 2003, Lawesson 2004, Willner & Grabherr 2007, Borhidi et al. 2012, Šilc & Čarni 2012, Vukelić 2012).

3. Carici acutiformis-Alnetum glutinosae Scamoni 1935 (Eutrophic black alder carr)
Original form of the name: Scamoni (1935); *Alnus glutinosa-Carex acutiformis*=Assoziation
Nomenclatural type: Mikyška (1968), p. 14–20, Tab. 1, rel. 8, neotypus designated by Neuhäuslová (2003)
Synonyms: *Alnus glutinosa-Phragmites communis* Šmarda 1951 (syntax. syn.), Carici ripariae-Alnetum glutinosae Weisser 1970 p.p. (syntax. syn.), Angelico sylvestris-Alnetum glutinosae Borhidi in Borhidi et Kevey 1996 (syntax. syn.)
Diagnostic species: *Carex acutiformis*, *Equisetum arvense*, *Scirpus sylvaticus*, *Scutellaria galericulata*
Constant species: *Alnus glutinosa* (E_3), *Athyrium filix-femina*, *Brachythecium rivulare* (E_0), *Caltha palustris*, *Carex acutiformis*, *Deschampsia cespitosa*, *Dryopteris carthusiana* agg., *Equisetum arvense*, *Filipendula ulmaria*, *Galium palustre*, *Humulus lupulus*, *Impatiens noli-tangere*, *Lycopus europaeus*, *Lysimachia nummularia*, *L. vulgaris*, *Plagiomnium affine* agg. (E_0), *Ranunculus repens*, *Rubus* subgen. *Rubus*, *Scirpus sylvaticus*, *Solanum dulcamara*, *Urtica dioica*
Dominant species: *Alnus glutinosa* (E_3), *Carex acutiformis*
The typical feature in the vertical structure is the homogeneous tree layer composed of *Alnus glutinosa* and the shrub layer with presence of *Frangula alnus*, *Viburnum*

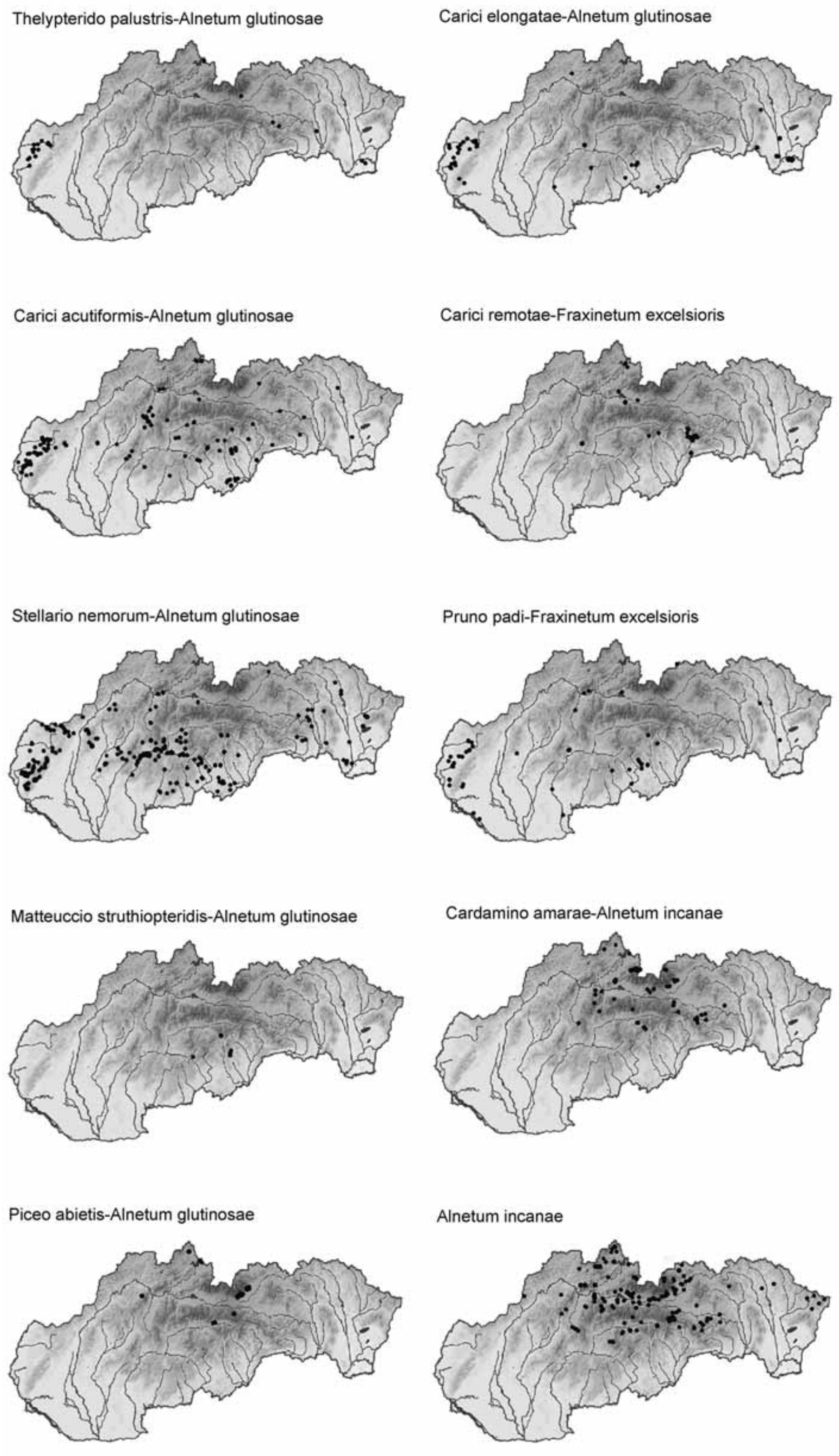

Fig. 5. Distribution of alder carr and riparian alder forests in Slovakia.

opulus and saplings of *Alnus glutinosa*. The physiognomy of forest understorey is determined by dominant tall-sedge *Carex acutiformis*, less frequently by *Scirpus sylvaticus* and *Caltha palustris*. The herb layer displays a significant number of vascular plants with relations to eutrophic wet meadows (*Angelica sylvestris*, *Cirsium oleraceum*, *Filipendula ulmaria*, *Myosotis scorpioides* agg., *Poa trivialis*), which are most often accompanied by moisture-demanding herbs (*Lycopus europaeus*, *Lysimachia vulgaris*, *Scutellaria galericulata*, *Valeriana dioica* agg.). The group of nitrophilous and liana species along with some ferns (*Athyrium filix-femina*, *Deschampsia cespitosa*, *Dryopteris carthusiana* agg., *Equisetum arvense*, *Humulus lupulus*, *Impatiens noli-tangere*, *Ranunculus repens*, *Solanum dulcamara*) is constantly present as well. The moss layer encompasses especially *Brachythecium rivulare*, *Calliergonella cuspidata* and *Plagiomnium affine* agg., but none of them reaches higher cover values.

This community settles eutrophic sites with waterlogged soils or habitats, where the water level reaches the ground surface mainly in spring and can partially sink during late summer. These conditions are typical for the upper litoral of artificial water reservoirs, spring fed areas and terrain depressions located in river alluvia. Some stands represent successional stages at abandoned nonforest wetlands. The Carici acutiformis-Alnetum glutinosae is distributed throughout the country, chiefly in lowland regions, Inner-Carpathian basins (submontane basins situated in central and northern Slovakia), central Carpathian mountain ranges (Tríbeč Mts, Vtáčnik Mts, Slovenské rudohorie Mts) and at the north-eastern edge of Pannonian Basin (Cerová vrchovina Hills, Drienčanský kras Mts, Slovenský kras Mts; Fig. 5). In Central Europe, this association has been recently recognized in Austria (Jeitler 2000) and Czech Republic (Douda 2008), but analogous forest vegetation has also been mentioned by several authors under different names (e.g. Willner & Grabherr 2007, Borhidi et al. 2012).

4. Carici remotae-Fraxinetum excelsioris Koch ex Faber 1936 (Eutrophic spring ash-alder forests)

Original form of the name: Faber (1936); Cariceto remotae-Fraxinetum (W. Koch 1926)

Nomenclatural type: Faber (1936), p. 42–49, column D_1, rel. 1, lectotypus designated by Neuhäuslová-Novotná (1977)

Synonyms: Carici remotae-Fraxinetum Koch 1926 (§ 2b)

Diagnostic species: *Circaea x intermedia*, *Fraxinus excelsior* (E_2, E_1), *Geranium palustre*, *Poa palustris*, *Ribes uva-crispa*, *Thuidium delicatulum* (E_0)

Constant species: *Ajuga reptans*, *Alnus glutinosa* (E_3, E_2), *Athyrium filix-femina*, *Brachythecium rivulare* (E_0), *Caltha palustris*, *Cardamine amara* agg., *Carex remota*, *Chaerophyllum hirsutum*, *Crepis paludosa*, *Deschampsia cespitosa*, *Dryopteris carthusiana* agg., *Filipendula ulmaria*, *Impatiens noli-tangere*, *Lysimachia nummularia*, *Myosotis scorpioides* agg., *Oxalis acetosella*, *Plagiomnium undulatum* (E_0), *Ranunculus repens*, *Rubus idaeus*, *Stachys sylvatica*, *Urtica dioica*

Dominant species: *Alnus glutinosa* (E_3), *Caltha palustris*, *Carex remota*

The tree layer is dominated by *Alnus glutinosa* and *Fraxinus excelsior*. Water-tolerated shrubs (*Padus avium*, *Viburnum opulus*) enriche the regularly developed shrub layer consisting mainly of younger individuals of overstorey tree species. The floristic aspect of the understorey is most often driven by the dominance of *Caltha palustris* or *Carex remota* along with the characteristic prevalence of spring fed area's herbs (*Cardamine amara* agg., *Chaerophyllum hirsutum*, *Chrysosplenium alternifolium*, *Crepis paludosa*). Habitat conditions are suitable for both hygrophilous (*Geranium palustre*, *Myosotis scorpioides* agg., *Poa palustris*) and eutrophic species with diverse moisture requirements (*Carex sylvatica*, *Impatiens noli-tangere*, *Lysimachia nummularia*, *Stellaria nemorum*, *Urtica dioica*). Some typical forest mesophilous plants commonly growing in streamside alder forests are scarce (e.g. *Galeobdolon luteum* agg., *Pulmonaria officinalis* agg., *Ranunculus lanuginosus*, *Stellaria holostea*). Constant bryophyte species (*Brachythecium rivulare*, *Plagiomnium undulatum*) are accompanied by shade-tolerant moss *Thuidium delicatulum* showing higher fidelity to this association.

Most of these stands inhabit meso- to eutrophic spring fed areas and waterlogged sites along brooks on valley bottoms. In Slovakia, distribution area involves central and southern submontane parts of Carpathian mountain ranges (e.g. Kremnické vrchy Mts, Muránska planina Mts, Slovenský kras Mts, Volovské vrchy Mts) and Inner-Carpathian basins (e.g. Liptovská kotlina Basin; Fig. 5). Spring ash-alder forests have also been known from Germany (Oberdorfer 1957, Seibert 1992), Czech Republic (Neuhäuslová-Novotná 1977, Moravec et al. 1982), Baltic region (Prieditis 1997), Austria (Willner & Grabherr 2007), Hungary (Borhidi et al. 2012), Poland (Matuszkiewicz 2012) and Slovenia (Šilc & Čarni 2012).

5. Stellario nemorum-Alnetum glutinosae Lohmeyer 1957 (Riparian alder vegetation on mesic to humid sites along small brooks)

Original form of the name: Lohmeyer (1957); Stellario-Alnetum glutinosae [Kästner 1938]

Nomenclatural type: Lohmeyer (1957), Suppl., Tab. 1, rel. 17, lectotypus designated by Neuhäuslová (2000)

Synonyms: Querceto-Carpinetum alneto-fraxinetosum Šimr 1931 (syntax. syn.), Querceto-Carpinetum alnetosum Mikyška 1939 (syntax. syn.), Arunco sylvestris-Alnetum glutinosae Tüxen 1957 (syntax. syn.), Caltho palustris-Alnetum glutinosae Šomšák 1961 p.p. (syntax. syn.), Aegopodio-Alnetum V. Kárpáti, I. Kárpáti et Jurko 1960 (§ 1), Aegopodio-Alnetum praecarpaticum V. Kár-

páti, I. Kárpáti et Jurko in Jurko 1961 (§ 34a), Aegopodio podagrariae-Alnetum glutinosae V. Kárpáti, I. Kárpáti et Jurko ex Šomšák 1961 (syntax. syn.)
Diagnostic species: *Acer campestre* (E_3, E_2, E_1), *Circaea lutetiana*, *Glechoma hederacea* agg., *Euonymus europaeus* (E_1), *Pulmonaria officinalis* agg., *Stellaria holostea*, *Swida sanguinea* (E_1)
Constant species: *Aegopodium podagraria*, *Alliaria petiolata*, *Alnus glutinosa* (E_3), *Brachypodium sylvaticum*, *Caltha palustris*, *Circaea lutetiana*, *Festuca gigantea*, *Galeobdolon luteum* agg., *Galium aparine*, *Geranium robertianum*, *Geum urbanum*, *Glechoma hederacea* agg., *Impatiens noli-tangere*, *I. parviflora*, *Lamium maculatum*, *Pulmonaria officinalis* agg., *Rubus* subgen. *Rubus*, *Sambucus nigra* (E_2), *Stachys sylvatica*, *Urtica dioica*
Dominant species: *Aegopodium podagraria*, *Alnus glutinosa* (E_3)
Forest stands recorded within this association are usually three-layered. The canopy closed tree layer is almost exclusively dominated by *Alnus glutinosa*, primarily with admixture of *Acer campestre*, *Fraxinus excelsior* and *Salix fragilis*. The species-rich shrub layer consists mainly of woody species, such as *Acer campestre*, *Corylus avellana*, *Sambucus nigra* and *Swida sanguinea*. The forest understorey comprises species typical for various environmental microhabitats. An abundant set of forest mesophilous plants (e.g. *Brachypodium sylvaticum*, *Circaea lutetiana*, *Glechoma hederacea* agg., *Lamium maculatum*, *Pulmonaria officinalis* agg., *Stachys sylvatica*) constantly appears in combination with nitrophilous (*Aegopodium podagraria*, *Alliaria petiolata*, *Galium aparine*, *Geranium robertianum*, *Impatiens noli-tangere*) and hygrophilous species (*Caltha palustris*, *Carex remota*). Mosses preferring shaded habitats with medium moist to swampy soils (*Atrichum undulatum*, *Brachythecium rivulare*, *Oxyrrhynchium hians*, *Plagiomnium undulatum*) exhibit also higher frequency.

The riparian alder vegetation seems to be well adapted to seasonal dynamic of water regime. It is related on relatively drier, periodically or episodically short-time flooded habitats with nutrient-rich soils that subsequently either partially dry out or remain moist for most of the year. The Stellario nemorum-Alnetum glutinosae is most frequent community of the Alnenion glutinoso-incanae suballiance in Slovakia (Fig. 5). Typical stands occupy bottoms of river valleys at altitudes up to 700 m (Fig. 4), where grow in contact with mesophilous temperate broad-leaved forests of the alliances Carpinion betuli and Fagion sylvaticae. Distribution area includes the warmer lowland and upland territories (northern periphery of the Pannonian Basin, fringes of the Western Carpathians) together with the submontane regions having more humid mesoclimate (Inner Carpathian basins, Carpathian mountain ranges). This vegetation becomes rarer towards the northern regions or higher altitudes, where it is gradually replaced by streamside grey alder forests of the Alnetum incanae. Outside Slovakia, it is widespread in similar habitats in various European countries (e.g. Seibert 1992, Lawesson 2004, Willner & Grabherr 2007, Douda 2008, Matuszkiewicz 2012).

6. Pruno padi-Fraxinetum excelsioris Oberdorfer 1953
(Eutrophic alluvial ash-alder forests)
Original form of the name: Oberdorfer (1953); Pruneto-Fraxinetum
Nomenclatural type: Moor (1958), Suppl., Tab. 30, rel. 1, neotypus designated by Neuhäuslová (2000)
Diagnostic species: *Cucubalus baccifer*
Constant species: *Alnus glutinosa* (E_3), *Brachythecium rivulare* (E_0), *Humulus lupulus*, *Galium aparine*, *Geum urbanum*, *Glechoma hederacea* agg., *Lysimachia nummularia*, *Plagiomnium undulatum* (E_0), *Rubus* subgen. *Rubus*, *Sambucus nigra* (E_2), *Urtica dioica*
Dominant species: *Alnus glutinosa* (E_3)
The tree layer is created by dominant *Alnus glutinosa* with rare admixture of *Fraxinus excelsior* and *Salix fragilis*. The well developed shrub layer is composed of species adapted to the medium wet soils such as *Euonymus europaeus* and *Sambucus nigra*. Composition pattern of the herb layer is determined by mosaic of nitrophilous and eutrophic plants indicating favourable mineralization of humus (*Aegopodium podagraria*, *Cucubalus baccifer*, *Galium aparine*, *Humulus lupulus*, *Impatiens noli-tangere*, *Ranunculus repens*, *Urtica dioica*), but drought-sensitive species (*Deschampsia cespitosa*, *Lysimachia nummularia*) and plants of the wet grasslands (e.g. *Lysimachia vulgaris*, *Poa trivialis*) are also significant structural components of these stands. The floristic spectrum is further characterised by presence of common mesophilous species (*Brachypodium sylvaticum*, *Circaea lutetiana*, *Geum urbanum*), although another species typical for mesophilous forest vegetation show only lower frequency. The most common bryophytes are *Brachythecium rivulare* and *Plagiomnium undulatum*.

These eutrophic forests represent transitional community towards the alluvial hardwood vegetation of the Ulmenion suballiance. They are less influenced by flooding than forests recorded within the two floristically closest plant communities (Stellario nemorum-Alnetum glutinosae and Matteuccio struthiopteridis-Alnetum glutinosae; Fig. 2, 3), but their soils do not have completely dry out even in summer. In Slovakia, this association occurs in alluvia of lowland large rivers and river terraces of streams in broad valleys at altitudes 110–580 m (lowland areas, Inner-Carpathian basins, uplands in southern part of Central Slovakia; Fig. 5). It has been reported from Germany (Oberdorfer 1957, Pott 1992), Czech Republic (Neuhäuslová 2000, Douda 2008), Denmark (Lawesson 2004) and Austria (Willner & Grabherr 2007).

7. Matteuccio struthiopteridis-Alnetum glutinosae Magic et Kliment in Kliment et Watzka 2000 (Species poor ostrich fern-dominated riparian alder forests)
Original form of the name: Kliment & Watzka (2000); Matteuccio-Alnetum glutinosae
Nomenclatural type: Kliment & Watzka (2000), p. 206–207, Tab. 4, rel. 5, holotypus
Synonyms: Aegopodium-Alnetum struthiopteridetosum Pócs in Pócs et al. 1962 (§ 2b), Matteuccio-Alnetum glutinosae Magic 1982 (§ 1), Matteuccio-Alnetum Magic 1990 (§ 2b)
Diagnostic species: *Adoxa moschatellina*, *Chrysosplenium alternifolium*, *Dentaria glandulosa*, *Euonymus verrucosus* (E_1), *Galeobdolon luteum* agg., *Galium aparine*, *Juncus inflexus*, *Matteuccia struthiopteris*
Constant species: *Aegopodium podagraria*, *Alliaria petiolata*, *Alnus glutinosa* (E_3), *Chrysosplenium alternifolium*, *Galeobdolon luteum* agg., *Galium aparine*, *Glechoma hederacea* agg., *Impatiens noli-tangere*, *I. parviflora*, *Matteuccia struthiopteris*, *Urtica dioica*
Dominant species: *Alnus glutinosa* (E_3), *Matteuccia struthiopteris*
The uniform tree layer is dominated by *Alnus glutinosa*, whereas *Salix fragilis* has only secondary importance in several stands. The juveniles of *Alnus glutinosa* together with *Corylus avellana* and *Euonymus europaeus* form regular but prevailingly sparse shrub layer. The conspicuous physiognomy of the species-poor and two-layered forest understorey is affected by competitive ability of the dominant species *Matteuccia struthiopteris*. A dense closed canopy of this tall-fern enables mostly only scattered occurrence of widespread shade-tolerant mesophilous (e.g. *Galeobdolon luteum* agg., *Glechoma hederacea* agg.) and constant nitrophilous herbs (*Aegopodium podagraria*, *Alliaria petiolata*, *Galium aparine*, *Impatiens noli-tangere*, *I. parviflora*, *Urtica dioica*). The herb layer is enriched by group of hygrophilous plants growing in wet micro-depression (*Chrysosplenium alternifolium*, *Juncus inflexus*, *Mysosotis scorpioides* agg.), but species such as *Adoxa moschatellina* and *Dentaria glandulosa* show significant affinity to this vegetation type as well. The weakly developed cryptogamic flora is composed of *Brachythecium rivulare*, *Climacium dendroides* and *Plagiomnium undulatum*.

This community is not typical for the floodplains of large lowland rivers such as the alluvial ash-alder forests (Pruno padi-Fraxinetum excelsioris), but it is rather situated on lower stream terraces in narrow valleys with a cooler and more humid microclimate. These submontane habitats on deep mineral soils with a good supply of nutrients are usually flooded for a short time in spring. The association has been noted only from Slovakia where it occurs in two regions of the central Carpathian mountain ranges (Drienčanský kras Mts, Revúcka vrchovina Hills; Fig. 5). A few species-poor relevés from Veporské vrchy Mts were also accidentally assigned to this cluster, what can be addressed to the unsupervised method of numerical classification. Black alder stands with dominance of this clump-forming fern have also been noted from Hungary (e.g. Pócs et al. 1962).

8. Cardamino amarae-Alnetum incanae Šomšák 1961 (Grey alder spring forests)
Original form of the name: Šomšák (1961); Cardamino-Alnetum
Nomenclatural type: Šomšák (1961), p. 425–428, Tab. 4, rel. 9, lectotypus designated by Slezák et al. hoc loco
Synonyms: Caltho laetae-Alnetum incanae (Zarzycki 1963) Stuchlik 1968 (syntax. syn.)
Diagnostic species: *Chaerophyllum hirsutum*, *Gentiana asclepiadea*, *Rhytidiadelphus subpinnatus* (E_0), *Veratrum album* ssp. *lobelianum*
Constant species: *Alnus incana* (E_3, E_2, E_1), *Athyrium filix-femina*, *Caltha palustris*, *Cardamine amara* agg., *Chaerophyllum hirsutum*, *Crepis paludosa*, *Deschampsia cespitosa*, *Dryopteris carthusiana* agg., *Filipendula ulmaria*, *Geum rivale*, *Myosotis scorpioides* agg., *Oxalis acetosella*, *Picea abies* (E_3, E_2, E_1), *Rubus idaeus*, *Senecio nemorensis* agg., *Urtica dioica*
Dominant species: *Alnus incana* (E_3), *Caltha palustris, Chaerophyllum hirsutum*
Woody species *Alnus incana* and *Picea abies* represent important structural components of the tree layer. An analogous species combination enriched by *Salix cinerea* and *Sorbus aucuparia* creates the shrub layer. The broad-leaved eutrophic and hygrophilous herbs *Caltha palustris* and *Chaerophyllum hirsutum* most often alternate as dominant species in the forest understorey. Permanently swampy and/or moist soils promote the development of stands with different plant functional groups such as obligate spring taxa (*Cardamine amara* agg., *Chrysosplenium alternifolium, Crepis paludosa*), wet meadows plants (*Cirsium oleraceum, Filipendula ulmaria, Geum rivale*) and hygrophytes showing a broad realized niche (*Equisetum palustre, Myosotis scorpioides* agg., *Stellaria nemorum, Valeriana dioica* agg.). Ferns (*Athyrium filix-femina, Dryopteris carthusiana* agg.), clump-forming grass *Deschampsia cespitosa* and indicators of more productive and nitrophilous sites (*Rubus idaeus, Urtica dioica*) constantly appear jointly in the herb layer. These stands are characterized by occurrence of submontane elements (e.g. *Equisetum sylvaticum, Gentiana asclepiadea, Oxalis acetosella, Senecio nemorensis* agg., *Veratrum album* ssp. *lobelianum*) and low abundance of forest mesophilous and fen species as well. In addition to bryophyte *Rhytidiadelphus subpinnatus* that attains higher fidelity value, the moss layer with high percentage cover most often involves *Climacium dendroides, Plagiomnium affine* agg. and *Rhizomnium punctatum*.

This grey alder vegetation prefers spring fed areas with waterlogged soils situated in upper parts of stream alluvia or basal parts of slopes in submontane and montane zone, mostly at altitudes 710–900 (1000) m. Most of the Cardamino amarae-Alnetum incanae relevés in our data set were collected in the central part of Carpathian mountain ranges (Volovské vrchy Mts, Západné Tatry Mts, Nízke Tatry Mts) and at scattered localities in a cooler Inner-Carpathian basins (e.g. Liptovská kotlina Basin, Podtatranské kotliny Basins; Fig. 5). Except for Romania (Douda, unpubl. relevés), it has been recorded only in Slovakia, but ecologically and floristically similar stands are reported also from Poland (Zarzycki 1963, Stuchlik 1968) and Germany (Schwabe 1985). Its occurrence in the Carpathian region of Ukraine can be assumed.

9. Piceo abietis-Alnetum glutinosae Mráz 1959 (Submontane and montane oligotrophic spruce-alder forests on waterlogged habitats)
Original form of the name: Mráz (1959); Piceo-Alnetum
Nomenclatural type: Mráz (1959), p. 173–175, Tab. 5, rel. 248, lectotypus designated by Douda (2008)
Synonyms: Piceo-Alnetum Rubner 1954 (§ 2b), Piceo-Alnetum Rubner in Oberdorfer 1957 (§ 2b)
Diagnostic species: *Calamagrostis villosa*, *Calypogeia integristipula* (E_0), *Cardamine amara* agg., *Carex canescens*, *C. echinata*, *Chiloscyphus polyanthos* (E_0), *Dicranum scoparium* (E_0), *Equisetum sylvaticum*, *Eurhynchium angustirete* (E_0), *Galium uliginosum*, *Gymnocarpium dryopteris*, *Lepidozia reptans* (E_0), *Lonicera nigra* (E_2), *Luzula pilosa*, *Plagiochila asplenioides* (E_0), *Pleurozium schreberi* (E_0), *Polytrichum commune* (E_0), *Rhytidiadelphus triquetrus* (E_0), *Sphagnum centrale* (E_0), *Stellaria alsine*, *Tetraphis pellucida* (E_0), *Vaccinium myrtillus*, *V. vitis-idaea*, *Valeriana dioica* agg.
Constant species: *Alnus glutinosa* (E_3), *A. incana* (E_3), *Athyrium filix-femina*, *Calamagrostis villosa*, *Caltha palustris*, *Cardamine amara* agg., *Chaerophyllum hirsutum*, *Climacium dendroides* (E_0), *Crepis paludosa*, *Deschampisa cespitosa*, *Dicranum scoparium* (E_0), *Dryopteris carthusiana* agg., *Equisetum sylvaticum*, *Filipendula ulmaria*, *Lysimachia vulgaris*, *Myosotis scorpioides* agg., *Oxalis acetosella*, *Picea abies* (E_3, E_2, E_1), *Ranunculus repens*, *Rubus idaeus*, *Sorbus aucuparia* (E_1), *Urtica dioica*, *Vaccinium myrtillus*, *Valeriana dioica* agg.
Dominant species: *Alnus glutinosa* (E_3), *Caltha palustris*
Moderately closed canopy of the tree layer is almost always composed of dominant *Alnus glutinosa* with admixture of *Alnus incana* and *Picea abies*, less frequently with their co-dominance. The shrub layer with similar floristic structure than the forest overstorey consists of saplings of woody species, but shrub species *Frangula alnus* and *Lonicera nigra* contribute to the overall floristic variability as well. These stands are well differentiated by abundant set of diagnostic species reflecting specific site conditions. Acidophilous and fen species (*Carex canescens*, *C. echinata*, *Luzula pilosa*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Viola palustris*) are combined with submontane elements (*Calamagrostis villosa*, *Equisetum sylvaticum*, *Lonicera nigra*). The herb layer is rich in hygrophilous and spring plants (e.g. *Caltha palustris*, *Cardamine amara* agg., *Chaerophyllum hirsutum*, *Crepis paludosa*, *Galium uliginosum*, *Stellaria alsine*, *Valeriana dioica* agg.) and several of them reach higher cover values. Mosses with higher frequencies (*Climacium dendroides*, *Rhizomnium punctatum*, *Polytrichastrum formosum*) are predominantly accompanied by diagnostic acidic-tolerant species (e.g. *Calypogeia integristipula*, *Chiloscyphus polyanthos*, *Dicranum scoparium*, *Lepidozia reptans*, *Rhytidadelphus triquetrus*, *Sphagnum centrale*).

This community usually settles acidic and oligotrophic soils with peaty upper layer (Fig. 4). Such well-defined edaphic conditions can be present in a wide range of habitats, including waterlogged sites along slowly running streams, field depressions and slopes with flat to gentle inclination in submontane and montane areas (570–950 m a.s.l.). Distribution of the Piceo abietis-Alnetum glutinosae within the study area has been restricted to Podtatranské kotliny Basins and some isolated localities in the northern parts of the country (Malá Fatra Mts, Orava region, Nízke Tatry Mts and Horehronské podolie Valley; Fig. 5). Outside Slovakia, it has been documented in the Czech Republic (Moravec et al. 1982, Douda 2008) and Ukraine (Onyshchenko 2010), but several another authors used various names for such stands in Central Europe (e.g. Willner & Grabherr 2007, Koczur 2011).

10. Alnetum incanae Lüdi 1921 (Submontane and montane streamside grey alder forests)
Original form of the name: Lüdi (1921); Alnetum incanae
Nomenclatural type: Lüdi (1921), p. 147, holotypus
Synonyms: Alnetum incanae Aicher et Siegrist 1930 (syntax. syn.), Alnetum incanae carpaticum Klika 1936 (§ 34a), Alnetum incanae boreocarpaticum Jurko 1961 (§ 34a), Matteuccio-Alnetum incanae Hadač et Terray 1989 (syntax. syn.)
Diagnostic species: *Asarum europaeum*, *Chaerophyllum aromaticum*, *Carduus personata*, *Heracleum sphondylium*, *Mercurialis perennis*, *Petasites hybridus*, *Poa nemoralis*, *Primula elatior*, *Ranunculus lanuginosus*, *Roegneria canina*, *Salix purpurea* (E_2), *Silene dioica*, *Thalictrum aquilegiifolium*
Constant species: *Ajuga reptans*, *Alnus incana* (E_3, E_2), *Aegopodium podagraria*, *Angelica sylvestris*, *Asarum europaeum*, *Caltha palustris*, *Chaerophyllum hirsutum*, *Crepis paludosa*, *Deschampsia cespitosa*, *Filipendula ulmaria*, *Geranium robertianum*, *Geum rivale*, *Glechoma hederacea* agg., *Impatiens noli-tangere*, *Petasites hybridus*, *Plagiomnium undulatum* (E_0), *Primula elatior*, *Ranunculus repens*, *Rubus idaeus*, *Senecio nemorensis* agg., *Stachys sylvatica*, *Stellaria nemorum*, *Urtica dioica*, *Valeriana officinalis* agg.
Dominant species: *Alnus incana* (E_3)
The tree layer is characteristic by presence of dominant *Alnus incana* with a significant proportion of *Picea abies*

and *Salix fragilis*. These tree species accompanied by *Padus avium* form the shrub layer. The species-rich understorey comprises herbs with relation to cooler climate (*Petasites hybridus*, *Senecio nemorensis* agg., *Silene dioica*, *Thalictrum aquilegiifolium*) and nutrient-rich habitats (*Aegopodium podagraria*, *Carduus personata*, *Chaerophyllum aromaticum*, *Heracleum sphondylium*, *Urtica dioica*). A common feature is coexistence of hygrophilous plants (e.g. *Angelica sylvestris*, *Filipendula ulmaria*, *Geum rivale*), forest mesophilous species (*Ajuga reptans*, *Asarum europaeum*, *Stachys sylvatica*) and nemoral grasses (*Dactylis glomerata* agg., *Poa nemoralis*, *Roegneria canina*). The most frequent bryophytes are *Plagiomnium affine* agg. and *P. undulatum*.

This vegetation type prefers sites with a cooler and more humid mesoclimate, which are usually situated along streams in valleys of submonatne and montane regions. They have been found on suitable habitats throughout Slovakia, including the central, northern and north-eastern parts of Carpathian mountain ranges and Inner-Carpathian basins (Fig. 5). The Alnetum incanae belongs to common streamside alder forests in the countries of the temperate zone (Schwabe 1985, Ellenberg 2009).

Discussion

Alder carr and streamside alder forests represent functional components of marshland and riparian ecosystems that usually form fragmented patches in Central European landscape. Their plant species are characterized by diverse life-history traits allowing them to utilize accessible resources, tolerate disturbance events and competitive relationships. Active fluvial erosion-deposition processes, hydrological regime with fluctuation of water level, different thickness of organic litter, high variation of soil physical and chemical properties create remarkable complex of factors affecting environmental qualities of habitats typical for alder stands. The importance of hydrological regime and nutrient-related parameters as crucial drivers of compositional changes has already been determined at community level (Douda 2008, Naqinezhad et al. 2008, Ellenberg 2009). However, the internal differentiation especially of the Alnenion glutinoso-incanae suballiance along altitudinal gradient seems to be widely accepted pattern in Central Europe (e.g. Moravec et al. 1982, Willner & Grabherr 2007, Matuszkiewicz 2012). Syntaxonomical synopses thus contain mixture of vegetation types with affinities on lower (e.g. Pruno padi-Fraxinetum excelsioris, Stellario nemorum-Alnetum glutinosae) and higher altitudes (e.g. Alnetum incanae, Piceo abietis-Alnetum glutinosae), whereas the eutrophic spring ash-alder forests of the Carici remotae-Fraxinetum excelsioris most frequent show an intermediate position on the altitudinal gradient. However, for a complex interpretation of regional and local distribution of alder forests, their natural dynamic processes (Pokorný et al. 2000), abandonment of traditional management practices in treeless wetlands (Douda et al. 2009) and landscape configuration-related factors (Douda 2010) have to be taken into account as well.

The proposed syntaxonomical scheme largely reflects critically revised phytosociological classifications originating from relevant European regions. The explicitly stated criteria for compilation of data matrix and numerical classification were influential for understanding and disentanglement of relations among all lower hierarchical units (mainly associations) previously reported in Slovakia. Final classification system markedly depends on geographical extent of particular study. Therefore, the present national synthesis modifies local classification systems and allows us to reduce some units to synonyms (e.g. *Alnus glutinosa-Molinia caerulea* Šmarda 1951, Caltho palustris-Alnetum glutinosae Šomšák 1961, Matteuccio-Alnetum incanae Hadač et Terray 1989). The associations Fraxino pannonicae-Alnetum hungaricae and Dryopterido cristatae-Alnetum, reported in the lists of Slovak vegetation units (Mucina & Maglocký 1985, Jarolímek & Šibík 2008), are missing in our study because there are any available relevés for them.

The unsupervised numerical classification (cluster analysis) did not fully reflect structure of hierarchical classification system at level of alliances, as the first step of division split relevés according to dominant tree species *Alnus glutinosa* and *A. incana* (i.e. altitudinal gradient). The oligo- and mesotrophic alder carr forests (Thelypterido palustris-Alnetum glutinosae, Carici elongatae-Alnetum glutinosae; cluster 1–2) were subsequently separated from the eutrophic alder carrs (Carici acutiformis-Alnetum glutinosae; cluster 3) which were grouped together with ash-alder springs (Carici remotae-Fraxinetum excelsioris; cluster 4). This pattern should be explained by comparable moisture and nutrient/acidity requirements of both latter associations. They are able to inhabit waterlogged soils with locally stagnant water and/or sites with slowly running water within soil substrates. Their herb layers thus share numerous moisture-demanding plant taxa (e.g. *Caltha palustris*, *Cardamine amara* agg., *Lycopus europaeus*, *Ranunculus repens*, *Scirpus sylvaticus*, *Scutellaria galericulata*). This finding is not frequent in phytosociological literature, because i) alliances Alnion glutinosae and Alnion incanae are usually analysed independently of each other (e.g. Sburlino et al. 2011), ii) only some parts of these units are elaborated (e.g. Prieditis 1993, Slezák et al. 2013) or iii) syntaxonomical revision follows a formalized and supervised classification approach (e.g. Douda 2008).

Several confusions in use of syntaxon names were revealed by the syntaxonomical evaluation of individual clusters and in the process of nomenclatural revision. Clarifying of some nomenclatural issues requires a more detail explanation. For example, Šomšák (1961) classified part of mesophilous streamside alder forests in the association Aegopodio-Alnetum accompanied by the citation "V. Kárpáti, I. Kárpáti et Jurko 1960" with reference to a study which was only manuscript at that time, i.e. an ineffective publication (ICPN § 1). Although identical authorship was subsequently reported by Jurko (1961) and Kárpáti's manuscript from 1960 was published two years later (Kárpáti et al. 1963), the erroneous citation with different years of description (1961 or 1963) has been often followed in phytosociological literature (e.g. Soó 1963, Borhidi & Kevey 1996). In spite of different opinions on the authorship of this association's name, it was actually validated just by Šomšák (1961) and therefore its correct form should be Aegopodio-Alnetum V. Kárpáti, I. Kárpáti et Jurko ex Šomšák 1961. However, Šomšák (1961) did not consider your own phytosociological material to be representative for such association, as these stands were situated at the border of their geographical distribution and showed close floristic relation to the eutrophic mixed alder spring forests. The present synthesis unambiguously confirmed his assumption, because almost all discussed relevés were placed within the cluster Carici remotae-Fraxinetum excelsioris. In addition, there is no nomenclatural type relevé given in that publication (holotype; ICPN § 19) and our detail bibliographic review suggests absence of its typification. If syntaxonomical differences quoted above are taken into account, we have designated here a neotypus from relevés published by Kárpáti et al. (1963; table 1, relevé no. 9, neotypus hoc loco). Since their data set includes only the association name-giving species *Aegopodium podagraria* in the herb layer and dominant tree *Alnus glutinosa* in the tree layer, we have added epithets (ICPN Recomm. 10C) and interpreted the name as Aegopodio podagrariae-Alnetum glutinosae V. Kárpáti, I. Kárpáti et Jurko ex Šomšák 1961. This association has been used mainly in Hungarian local and national syntaxonomical surveys (e.g. Borhidi & Kevey 1996, Borhidi et al. 2012). Its characteristic combination comprises nitrophilous and forest mesophilous plants with a significant admixture of hygrophilous elements. This community mostly settles nutrient-rich soils on mesic to humid sites along brooks up to submontane zone. Based on the species composition pattern, habitat preference, comparison with the relevant vegetation papers (Lohmeyer 1957, Neuhäuslová-Novotná 1972, Neuhäuslová & Kolbek 1993) and in accord with the outcomes of our numerical classification, when most of the relevés reported by Kárpáti et al. (1963) were diffused within the mesic streamside alder forests (cluster 5, Table 1), the name Aegopodio podagrariae-Alnetum glutinosae V. Kárpáti, I. Kárpáti et Jurko ex Šomšák 1961 can be regarded as a later syntaxonomic synonym of the traditional association Stellario nemorum-Alnetum glutinosae (cf. Neuhäuslová-Novotná 1972, Moravec et al. 1982, Douda 2008, Hrivnák et al. 2013).

The peculiar site conditions of spring fed areas control development of distinctive vegetation types that markedly differ in floristic and structural features from adjacent plant communities. Unlike the usual evaluation of eutrophic ash-alder springs in the association Carici remotae-Fraxinetum excelsioris (e.g. Oberdorfer 1957, Neuhäuslová-Novotná 1977, Matuszkiewicz 2012), syntaxonomical affiliation of submontane and montane springs with prevalence of grey alder has been remained still vague. Some authors have used for them the same unit (e.g. Pott 1992). Schwabe (1985) in an extensive revision of *Alnus incana*-dominated vegetation emphasized different attitudes of central European authors towards grey alder springs and proposed their unification in the provisional unit "*Carex remota-Alnus incana*-community". This proposal, which was also adopted by Seibert (1992), highlighted the need of more complex analysis and most likely resulted from unclear relations between the Carici remotae-Fraxinetum excelsioris and group of syntaxa described from Carpathian region within a few years of each other, namely Cardamino amarae-Alnetum incanae Šomšák 1961, Caltho laetae-Alnetum incanae (Zarzycki 1963) Stuchlik 1968 and Caltho laetae-Alnetum glutinosae Šomšák (1961) 1979 (see also Pancer-Kotejowa 1973). The last name represents a younger homonym of the Caltho palustris-Alnetum glutinosae Šomšák 1961 (ICPN § 31) which has heterogeneous syntaxonomic content (Slezák et al. 2013). The phytosociological material in original diagnoses of two remaining associations is very similar in overall floristic spectrum (Šomšák 1961, Zarzycki 1963, Stuchlik 1968). Both of these data sets lack any phytogeographical differences and show comparable frequencies in proportion of spring plants, generalists of wet habitats together with submontane and montane species. They should not be evidently recorded within separate units and therefore the Cardamino amarae-Alnetum incanae has priority as the older valid name. The Caltho laetae-Alnetum incanae has been sometimes used differently to its original description, e.g. Koczur (2011) ascribed to this unit also stands enriched by acidophilous and fen species (*Carex echinata*, *C. flava*, *Luzula sylvatica*, *Warnstorfia sarmentosa*) that correspond to the Piceo abietis-Alnetum glutinosae. This finding has been accepted by the revised checklist of the Ukrainian Fagetalia sylvaticae forests (Onyshchenko 2010) in which this association is quoted in the synonym list of the Piceo abietis-Alnetum glutinosae. Forest vegetation assigned to the Cardamino amarae-Alnetum incanae differ from the eutrophic spring ash-alder forests by the presence and higher frequency of taxa typical for submontane and montane areas, such as *Alnus incana*, *Equisetum sylvaticum*, *Gentiana asclepiadea*, *Picea abies* and *Veratrum album* ssp. *lobelianum*. The division of alder springs into two independent associations has serious floristic ground with the well-defined groups of diagnostic species for each type and does not follow only the altitudinal aspect.

Coenological variability of floodplain vegetation with *Matteuccia struthiopteris* has been observed throughout the Europe (e.g. Sedláčková 1982, Schwabe 1985, Odland 1992, Paal et al. 2008). Some authors dealing with position of floodplain forests in classification hierarchical system included that species in the group of diagnostic species for the alliance Alno-Ulmion Braun-Blanquet et Tüxen ex Tchou 1948 (syntax. synonym for the Alnion incanae) or suballiance Alnenion glutinoso-incanae (e.g. Oberdorfer 1953, 1957, Dovolilová-Novotná 1961, Schwabe 1985, Borhidi & Kevey 1996). Most of North-European records are connected with *Alnus incana* vegetation, but ostrich fern may also occur within *Alnus glutinosa*-dominated forests in Central Europe. In Carpathian-Pannonian region, it has been most often found in riparian alder forests (Kárpáti et al. 1963, Sedláčková 1982, Slezák et al. 2011), less frequently in ash-alder springs (Borhidi et al. 2012). The submontane riparian black alder stands with high cover of *Matteuccia struthiopteris* (e.g. Pócs et al. 1962, Kliment & Watzka 2000) showed obvious structural and floristic differences against the other Alnenion glutinoso-incanae vegetation (e.g. much lower species richness, less-developed moss layer). Their forest understorey consists mainly of shade-tolerant species of temporarily moist soils, hygrophilous herbs and nitrophilous species with wide ecological amplitude. The herb layer is further impoverished in some important species of riparian alder forests (e.g. *Brachypodium sylvaticum*, *Circaea lutetiana*, *Ranunculus lanuginosus*) and other typical plants of such sites attain only low frequencies (e.g. *Acer campestre*, *Carex remota*, *Festuca gigantea*, *Stachys sylvatica*). In Slovakia, the vegetation of Matteuccio struthiopteridis-Alnetum glutinosae occurs only at a few localities due to lack of suitable habitats. In spite of a relatively small number of analysed phytosociological relevés at the national level, the species poor ostrich fern-dominated riparian alder forests created the separate cluster with diagnostic species. Although it can be considered to meaningful association following results of this study, further effort is needed to clarify compositional pattern and syntaxonomical affinity to similar riparian Alnenion glutinoso-incanae communities in Central European region.

The internal separation of the Alnion glutinosae alliance is commonly attributed to alternations of ecological plant species groups and changes in vegetation physiognomy and structure. Environmental differences can be artificially suppressed by using of broadly conceived concept of association that reflects floristic-environmental variation at the subassociation level. This simplified approach has been more often adopted in the case of Carici elongatae-Alnetum glutinosae association (e.g. Bodeux 1955, Willner & Grabherr 2007). The same is true for preliminary overview of alder carr forests in Slovak part of Carpathians (Šomšák 2000). Our analysis did not support this expert-based proposal with its division into more subassociations (betuletosum pubescentis, cardaminetosum amarae, caricetosum ripariae, dryopteridetosum cristatae, typicum), as we have found pronounced differences in their species composition and ecology at higher syntaxonomical rank. As a consequence, the association Thelypterido palustris-Alnetum glutinosae is firstly mentioned in this form from Slovakia (Mucina & Maglocký 1985, Jarolímek & Šibík 2008), although it belongs to the well-distinguished unit sharing only two diagnostic species *Thelypteris palustris* and *Viola palustris* with floristically closest vegetation types (Carici elongatae-Alnetum glutinosae, Piceo abietis-Alnetum glutinosae). It has been formerly considered to be either part of the meso- to eutrophic alder carr vegetation using subassociation rank (Carici elongatae-Alnetum betuletosum pubescentis; Šomšák 2000, Kollár et al. 2005) or more rarely as the *Alnus glutinosa-Molinia caerulea* community (Šmarda 1951). On the other hand, some of recent Central European authors prefer narrow definition of the Carici elongatae-Alnetum glutinosae in accordance with its type relevé (neotypus designated by Dengler et al. 2004). Our numerical classification provides good support for this approach, because only stands with the peculiar species combination (e.g. *Calamagrostis canescens*, *Carex elongata*, *C. pseudocyperus*, *Iris pseudacorus*, *Phellandrium aquaticum*, *Thelypteris palustris*) and characteristic microrelief structure (hollows, hummocks) were merged in this unit.

In spite of a different approach to classification of eutrophic black alder carrs (e.g. Borhidi 1984, Neuhäuslová 2003, Willner & Grabherr 2007, Borhidi et al. 2012), there is no doubt that they form a distinct vegetation unit in Central Europe. Scamoni (1935) described these forests from the northeast Germany as the Carici acutiformis-Alnetum glutinosae association, whereas Borhidi & Kevey (1996) in Hungarian vegetation overview included them in the new Angelico sylvestris-Alnetum glutinosae association. The latter one has been widely used in the Pannonian Basin, although it has been several times reported from the Western Carpathians as well (e.g. Kliment & Watzka 2000). Syntaxonomic contents of both associations appear to be identical, primarily through the presence of wet meadows plants, moisture-demanding herbs, tall-sedges and nitrophilous species, but also in scarcity of forest mesophilous plants (species of the Fagetalia order). The markedly overlapping in species composition and the mergence of Slovak relevés with those of the Carici acutiformis-Alnetum glutinosae in this study indicate that all such forests with tall-sedges and coexistence of the above-mentioned functional species groups growing on waterlogged and nutrient-rich substrates tend to be assigned to a single association, namely Carici acutiformis-Alnetum glutinosae. Similar syntaxonomical approach and then vegetation patterns of alder carr forests to those in Slovakia were found especially in Czech Republic (Douda 2008).

The floristic spectrum of alder forests seems to be more homogeneous at supra-regional scale (Bodeux 1955, Schwabe 1985, Ellenberg 2009), when a species growing across different areas independently of factors of the vegetation zonality are accompanied by plants reflecting phytogeographical and environmental gradients. The species composition of Slovak alder forests showed good coincidence with analogous communities reported from many parts of Central Europe. The present floristic patterns of widely distributed European associations (e.g. Carici elongatae-Alnetum glutinosae, Carici remotae-Fraxinetum excelsioris, Alnetum incanae, Stellario nemorum-Alnetum glutinosae) exactly correspond to their original descriptions (Lüdi 1921, Tüxen 1931, Faber 1936, Lohmeyer 1957, Passarge 1960) and are in accordance with much more comprehensive phytosociological studies (e.g. Schwabe 1985, Douda 2008). Our data further support syntaxonomical conception of the associations Thelypterido palustris-Alnetum glutinosae (Klika 1940) and Piceo abietis-Alnetum glutinosae (Mráz 1959) that represent the oldest applicable names for the oligotrophic *Sphagnum*-rich alder carrs without oceanic species and the oligotrophic spruce-alder forests on waterlogged soils (cf. Douda 2008, Slezák et al. 2013), respectively. The significant floristic separation of alder communities of the Matteuccio struthiopteridis-Alnetum glutinosae and Cardamino amarae-Alnetum incanae (Table 1) suggests that both vegetation types might be also distributed under similar conditions over the study region. The proposed synthesis unifies the local classification systems and simplifies the previous syntaxonomical schemes of alder forests in Slovakia (Mucina & Maglocký 1985, Jarolímek & Šibík 2008). Higher vegetation variability observed within riparian alder forests (Alnenion glutinoso-incanae) than in alder carr forests (Alnion glutinosae) is in agreement with most of recent syntaxonomical synopses in Central Europe (e.g. Willner & Grabherr 2007, Douda 2008, Borhidi et al. 2012).

Acknowledgements: We would like to thank K. Hegedüšová for data from the Slovak Vegetation Database and our colleagues who provided their unpublished phytosociological relevés or helped us with field sampling (D. Dítě, M. Hájek, K. Hegedüšová, I. Jarolímek, R. Kanka, J. Kliment, V. Piscová, M. Valachovič, R. Watzka, H. Žarnovičan). The authors are very grateful to J. Douda (Praha) and M. Janišová (Banská Bystrica) for valuable comments and suggestions on an earlier version of the manuscript, J. Kliment (Blatnica) and M. Chytrý (Brno) for advice in solving nomenclatural issues, J. Csiky (Pécs) and W. Willner (Vienna) for sending of some difficult accessbile papers. The research was supported by the Science Grant Agency of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences (VEGA 2/0059/11, VEGA 2/0019/14).

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Appendix 1. List of plant species merged to aggregates (agg.), broadly defined taxa (s. lat.), genus (sp. div.) or species level in the data set.

Aconitum firmum agg. (incl. *A. firmum* ssp. *firmum*, *A. firmum* ssp. *moravicum*), *Agrostis stolonifera* agg. (*A. gigantea*, *A. stolonifera*), *Alchemilla* sp. div. (*A. monticola*, *A. xanthochlora*), *Allium ursinum* (*A. ursinum* ssp. *ucrainicum*, *A. ursinum* ssp. *ursinum*), *Aster novi-belgii* agg. (*A. lanceolatus*, *A. novi-belgii*), *Callitriche* sp. div. (*C. cophocarpa*, *C. palustris*, *C. palustris* agg., *C.* sp.), *Caltha palustris* (*C. palustris* ssp. *laeta*, *C. palustris* ssp. *palustris*), *Cardamine amara* agg. (*C. amara*, *C. amara* ssp. *opicii*), *Cardamine pratensis* agg. (*C. pratensis*), *Carex flava* agg. (*C. flava*, *C. tumidicarpa*), *Carex vulpina* agg. (*C. otrubae*, *C. vulpina*), *Cerastium fontanum* agg. (*C. fontanum*, *C. holosteoides*, *C. lucorum*), *Dactylis glomerata* agg. (*D. glomerata*, *D. polygama*), *Dactylorhiza majalis* s. lat. (*D. fuchsii*, *D. maculata*, *D. maculata* ssp. *transsilvanica*, *D. majalis*), *Dryopteris carthusiana* agg. (*D. carthusiana*, *D. dilatata*), *Galeobdolon luteum* agg. (*G. luteum*, *G. montanum*), *Galeopsis tetrahit* s. lat. (*G. bifida*, *G. tetrahit*), *Galium boreale* agg. (*G. boreale*, *G. rubioides*), *Glechoma hederacea* agg. (*G. hederacea*, *G. hirsuta*), *Hylotelephium maximum* agg. (*H. argutum*, *H. telephium* s. lat.), *Melica nutans* agg. (*M. nutans*, *M. picta*), *Molinia caerulea* agg. (*M. arundinacea*, *M. caerulea*), *Myosotis scorpioides* agg. (*M. caespitosa*, *M. laxiflora*, *M. nemorosa*, *M. scorpioides*), *Ornithogalum umbellatum* agg. (*O. divergens*, *O. kochii*, *O. umbellatum*), *Oxycoccus palustris* agg. (*O. microcarpus*, *O. palustris*), *Plagiomnium affine* agg.. (*P. affine*, *P. elatum*, *P. ellipticum*, *P. medium*, *P. rostratum*), *Poa pratensis* agg. (*P. angustifolia*, *P. pratensis*), *Pulmonaria officinalis* agg. (*P. officinalis*, *P. obscura*), *Pyrus communis* agg. (*P. communis*, *P. pyraster*), *Quercus petraea* agg. (*Q. dalechampii*, *Q. petraea* s. str.), *Quercus robur* agg. (*Q. pedunculiflora*, *Q. robur*), *Ranunculus auricomus* agg. (*R. auricomus*, *R. cassubicus* s. lat., *R. niepolomicensis*), *Rubus* subgen. *Rubus* (*R. caesius*, *R. franconicus*, *R. fruticosus* agg., *R. hirtus* s. lat., *R. plicatus*), *Senecio nemorensis* agg. (*S. germanicus*, *S. ovatus*), *Sphagnum recurvum* s. lat. (*S. angustifolium*, *S. fallax*, *S. flexuosum*), *Stellaria media* agg. (*S. media*, *S. neglecta*), *Symphytum tuberosum* agg. (*S. angustifolium*, *S. tuberosum*), *Taraxacum* sp. div. (*T.* sect. *Ruderalia*, *T.* sp.), *Valeriana dioica* agg. (*V. dioica*, *V. simplicifolia*), *Valeriana officinalis* agg. (*V. excelsa* ssp. *sambucifolia*, *V. officinalis*), *Veronica hederifolia* agg. (*V. hederifolia*, *V. sublobata*).

Appendix 2. List of the analysed relevés using in numerical classification and their literature sources in shortened form (author, abbreviated reference, number of relevés). They are given in alphabetical order for each cluster.

Cluster 1: Babicová & Špulerová (2010, Bull. Slov. Bot. Spoločn. 32, Suppl. 2: 11–12) – 1 relevé; Berta (1960, Biologia 15: 3–16) – 2 rels.; Berta (1970, Vegetácia ČSSR, B1: 1–372) – 1 rel.; Kollár et al. (2005, Phytopedon 4: 1–11) – 11 rels.; Krippel (1965, Biol. Práce 11: 1–99) – 1 rel.; Šmarda (1951, Čas. Mor. Mus. 36: 38–68) – 3 rels.; Šoltés et al. (1999, Biologia 54: 118) – 1 rel.; Šoltés (2000, Ochr. Prír. 18: 41–49) – 1 rel.; Šomšák (1963, Acta Fac. Rerum Nat. Univ. Comen., Bot. 8: 229–302) – 7 rels.; Stanová (1991, Master thesis, PrifUK Bratislava) – 1 rel.; Valachovič (unpublished) – 2 rels.; Viceníková (1998, PhD. thesis, PrifUK Bratislava) – 1 rel.;

Cluster 2: Author's original (unpublished) – 8 rels.; Berta (1957, Master thesis, PrifUK Bratislava) – 21 rels.; Berta (1970, Vegetácia ČSSR, B1: 1–372) – 24 rels.; Berta (1993, Biologia 48: 53–59) – 11 rels.; Falťan (1999, Master thesis, PrifUK Bratislava) – 2 rels.; Kollár et al. (2005, Phytopedon 4: 1–11) – 12 rels.; Kollár et al. (2009, Bull. Slov. Bot. Spoločn. 31: 59–71) – 2 rels.; Kováčová (1965, Master thesis, PrifUK Bratislava) – 1 rel.; Krippel (1965, Biol. Práce 11: 1–99) – 6 rels.; Šmarda (1951, Čas. Mor. Mus. 36: 38–68) – 3 rels.; Šomšák (1963, Acta Fac. Rerum Nat. Univ. Comen., Bot. 8: 229–302) – 3 rels.; Šomšák (1967, PhD. thesis, PrifUK Bratislava) – 1 rel.; Šomšák (1992, Biologia

47: 591–592) – 1 rel.; Šomšák (1993, Biologia 48: 417–420) – 1 rel.; Staníková (1998, Master thesis, PrifUK Bratislava) – 3 rels.; Valachovič (unpublished) – 2 rels.; Watzka (unpublished) – 4 rels.;

Cluster 3: Author's original (unpublished) – 40 rels.; Balázs (1996, Ochr. Prír. 14: 29–39) – 8 rels.; Berta (1957, Master thesis, PrifUK Bratislava) – 3 rels.; Berta (1970, Vegetácia ČSSR, B1: 1–372) – 2 rels.; Hrivnák et al. (2013, Hacquetia 12/2: 23–37) – 4 rels.; Jurko (1975, Biol. Práce 21: 7–81) – 2 rels.; Kliment & Watzka (2000, In: Príroda Drienčanského Krasu. ŠOP SR, Banská Bystrica, pp. 191–214) – 7 rels.; Kollár et al. (2005, Phytopedon 4: 1–11) – 15 rels.; Kollár et al. (2009, Bull. Slov. Bot. Spoločn. 31: 59–71) – 5 rels.; Kollár et al. (2012, Phytopedon 11: 6–18) – 5 rels.; Kontriš (1981, Biol. Práce 27: 1–164) – 1 rel.; Kubíček et al. (2006, Ekológia 25: 335–340) – 1 rel.; Novák (2003, Bull. Slov. Bot. Spoločn. 25: 127–130) – 1 rel.; Slezák et al. (2011, Hacquetia 10: 119–136) – 7 rels.; Šomšák (1959, Acta Fac. Rerum Nat. Univ. Comen., Bot. 3: 515–564) – 13 rels.; Šomšák (1961, Acta Fac. Rerum Nat. Univ. Comen., Bot. 6: 407–459) – 1 rel.; Šomšák (1993, Biologia 48: 417–420) – 3 rels.; Ripka (1999, Master thesis, BU SAV Bratislava) – 1 rel.; Stanová (1991, Master thesis, PrifUK Bratislava) – 12 rels.; Valachovič (unpublished) – 2 rels.; Watzka (unpublished) – 7 rels.;

Cluster 4: Author's original (unpublished) – 4 rels.; Babicová & Špulerová (2010, Bull. Slov. Bot. Spoločn. 32, Suppl. 2: 11–12) – 1 rel.; Hrivnák et al. (2009, Reussia 5: 23–33) – 2 rels.; Kárpáti et al. (1963, Biologia 18: 97–120) – 1 rel.; Kontriš (1981, Biol. Práce 27: 1–164) – 8 rels.; Sitášová (1995, Nat. Carpat. 36: 35–38) – 1 rel.; Šomšák (1961, Acta Fac. Rerum Nat. Univ. Comen., Bot. 6: 407–459) – 25 rels.; Šomšák & Háberová (1979, Biol. Práce 25: 5–85) – 2 rels.; Watzka (1997, Master thesis, BU SAV Bratislava) – 1 rel.; Watzka (unpublished) – 4 rels.;

Cluster 5: Author's original (unpublished) – 49 rels.; Babicová (2008, Phytopedon 7: 45–50) – 5 rels.; Babicová (2009, Bull. Slov. Bot. Spoločn. 31: 95–104) – 7 rels.; Balázs (1996, Ochr. Prír. 14: 29–39) – 5 rels.; Balkovič (2002, Phytopedon 1: 17–32) – 7 rels.; Berta (1970, Vegetácia ČSSR, B1: 1–372) – 1 rel.; Ciriaková (1999, PhD. thesis, PrifUK Bratislava) – 6 rels.; Eliáš (1997, Rosalia 12: 37–46) – 1 rel.; Fajmonová (1991, Biologia 46: 443–450) – 7 rels.; Fraňo et al. (1971, Acta Fac. Rerum Nat. Univ. Comen., Bot. 17: 1–60) – 1 rel.; Hegedüšová-Kučerová (2000, PhD. thesis, PrifUK Bratislava) – 4 rels.; Hrivnák (1997, Bull. Slov. Bot. Spoločn. 19: 119–122) – 1 rel.; Hrivnák et al. (2013, Hacquetia 12/2: 23–37) – 15 rels.; Jurko (1952, Biol. Sbor. SAV 7: 81–88) – 1 rel.; Jurko (1975, Biol. Práce 21: 9–81) – 5 rels.; Kanka et al. (unpublished) – 2 rels.; Kárpáti et al. (1963, Biologia 18: 97–120) – 12 rels.; Kliment & Jarolímek (unpublished) – 1 rel.; Kliment & Watzka (2000, In: Príroda Drienčanského Krasu. ŠOP SR, Banská Bystrica, pp. 191–214) – 1 rel.; Kollár et al. (2009, Bull. Slov. Bot. Spoločn. 31: 59–71) – 10 rels.; Kollár et al. (2010, Ekológia 9: 113–122) – 1 rel.; Kollár et al. (2011, Bull. Slov. Bot. Spoločn. 33: 179–197) – 9 rels.; Kollár et al. (2012, Phytopedon 11: 6–18) – 20 rels.; Kontriš (1981, Biol. Práce 27: 1–164) – 1 rel.; Kubíček & Šimonovič (1980, Biologia 35: 27–38) – 1 rel.; Lacika (1998, Master thesis, PrifUK Bratislava) – 1 rel.; Miadok (1971, Acta Fac. Rerum Nat. Univ. Comen., Bot. 19: 215–224) – 2 rels.; Miadok (1974, PhD. thesis, PrifUK Bratislava) – 4 rels.; Michalko (1957, In: Geobotanické pomery pohoria Vihorlat. SAV, Bratislava, 198 p.) – 1 rel.; Michalko (1991, Acta Bot. Slov. Ser. A 11: 1–136) – 1 rel.; Michalko (unpublished) – 1 rel.; Mikyška (1939, Beih. Bot. Cbl. 59B1: 169–244) – 3 rels.; Neuhäuslová-Novotná (1970, Folia Geobot. Phytotax. 5: 265–306) – 13 rels.; Perný (1999, Master thesis, PrifUK Bratislava) – 1 rel.; Slezák et al. (2011, Hacquetia 10: 119–136) – 12 rels.; Šomšák (1961, Acta Fac. Rerum Nat. Univ. Comen., Bot. 6: 407–459) – 1 rel.; Valachovič (unpublished) – 6 rels.; Watzka (unpublished) – 2 rels.; Žarnovičan (2008, Phytopedon 7: 230–239) – 5 rels.; Žarnovičan & Labuda (2011, Phytopedon 10: 59–66) – 3 rels.;

Cluster 6: Author's original (unpublished) – 3 rels.; Berta (1957, Master thesis, PrifUK Bratislava) – 4 rels.; Berta (1970, Vegetácia ČSSR, B1: 1–372) – 6 rels.; Kárpáti et al. (1963, Biologia 18: 97–120) – 1 rel.; Kollár et al. (2009, Bull. Slov. Bot. Spoločn. 31: 59–71) – 10 rels.; Kontriš et al. (2005, Acta Fac. Ecol. 13: 5–9) – 1 rel.; Kontrišová (1980, Biol. Práce 26: 1–159) – 1 rel.; Kontrišová (1980, In: Zborník 3. Zjazdu SBS, Zvolen, pp. 33–36) – 1 rel.; Medovič (1960, Biologia 15: 62–65) – 1 rel.; Miadok (1974, PhD. thesis, PrifUK Bratislava) – 1 rel.; Ripka (1999, Master thesis, BU SAV Bratislava) – 1 rel.; Slezák et al. (2011, Hacquetia 10: 119–136) – 8 rels.; Šomšák (1959, Acta Fac. Rerum Nat. Univ. Comen., Bot. 3: 515–564) – 3 rels.; Šomšák (1967, PhD. thesis, PrifUK Bratislava) – 1 rel.; Stanová (1991, Master thesis, PrifUK Bratislava) – 3 rels.; Uherčíková (1995, PhD. thesis, PrifUK Bratislava) – 3 rels.; Valachovič (unpublished) – 3 rels.; Watzka (unpublished) – 4 rels.;

Cluster 7: Author's original (unpublished) – 4 rels.; Kliment & Watzka (2000, In: Príroda Drienčanského Krasu. ŠOP SR, Banská Bystrica, pp. 191–214) – 5 rels.; Miadok (1974, PhD. thesis, PrifUK Bratislava) – 5 rels.; Watzka (unpublished) – 4 rels.;

Cluster 8: Author's original (unpublished) – 4 rels.; Babicová & Špulerová (2010, Bull. Slov. Bot. Spoločn. 32, Suppl. 2: 11–12) – 1 rel.; Černušáková (1983, PhD. thesis, PrifUK Bratislava) – 17 rels.; Hájek (unpublished) – 1 rel.; Holotová (1994, Master thesis, PrifUK Bratislava) – 1 rel.; Hrivnák et al. (2009, Reussia 5: 23–33) – 2 rels.; Jurko (1961, Biológia 16: 321–339) – 8 rels.; Jurko (1975, Biol. Práce 21: 7–81) – 1 rel.; Jurko & Májovský (1956, Acta Fac. Rerum Nat. Univ. Comen., Bot. 8–9: 363–385) – 1 rel.; Kanka (unpublished) – 1 rel.; Kontriš (1981, Biol. Práce 27: 1–164) – 1 rel.; Kubíček et al. (1997, Štúd. o Tatransk. Nár. Parku 2/35: 143–160) – 1 rel.; Maťová (1994, Master thesis, PrifUK Bratislava) – 1 rel.; Miadok (1974, PhD. thesis, PrifUK Bratislava) – 1 rel.; Samek et al. (1957, Lesn. Čas. 3: 3–38) – 2 rels.; Šomšák (1961, Acta Fac. Rerum Nat. Univ. Comen., Bot. 6: 407–459) – 13 rels.; Šomšák et al. (1993, Bull. Slov. Bot. Spoločn. 15: 37–41) – 5 rels.; Viceníková (1998, PhD. thesis, PrifUK Bratislava) – 2 rels.; Watzka (1997, Master thesis, PrifUK Bratislava) – 5 rels.; Watzka (1999, Bull. Slov. Bot. Spoločn. 21: 151–160) – 3 rels.; Watzka (unpublished) – 1 rel.;

Cluster 9: Author's original (unpublished) – 1 rel.; Babicová & Špulerová (2010, Bull. Slov. Bot. Spoločn. 32, Suppl. 2: 11–12) – 2 rels.; Ferančíková (1994, Master thesis, PrifUK Bratislava) – 1 rel.; Holotová (1994, Master thesis, PrifUK Bratislava) – 5 rels.; Jurko (1961, Biológia 16: 321–339) – 1 rel.; Maťová (1994, Master thesis, PrifUK Bratislava) – 5 rels.; Šomšák (1967, Acta Fac. Rerum Nat. Univ. Comen., Bot. 15: 1–11) – 3 rels.; Šomšák (1979, Acta Fac. Rerum Nat. Univ. Comen., Bot. 27: 1–38) – 8 rels.; Viceníková (1998, PhD. thesis, PrifUK Bratislava) – 25 rels.; Watzka (unpublished) – 1 rel.;

Cluster 10: Author's original (unpublished) – 22 rels.; Fajmonová (1991, Biologia 46: 443–450) – 8 rels.; Ferančíková (1994, Master thesis, PrifUK Bratislava) – 1 rel.; Hadač & Terray (1989, Folia Geobot. Phytotax. 24: 337–370) – 4 rels.; Hegedüšová (unpublished) – 2 rels.; Holotová (1994, Master thesis, PrifUK Bratislava) – 1 rel.; Hrivnák & Cvachová (1999, Acta Fac. Forest. 51: 11–27) – 2 rels.; Jurko (1961, Biológia 16: 321–339) – 9 rels.; Jurko (1975, Biol. Práce 21: 7–81) – 5 rels.; Jurko & Májovský (1956, Acta Fac. Rerum Nat. Univ. Comen., Bot. 8–9: 363–385) – 11 rels.; Kanka (2003, Biosozologia 1: 52–59) – 9 rels.; Kárpáti et al. (1963, Biológia 18: 97–120) – 1 rel.; Klika (1949, Prír. Sborn. 4: 7–36) – 2 rels.; Kontriš (1981, Biol. Práce 27: 1–164) – 16 rels.; Kontriš et al. (2005, Acta Fac. Ecol. 13: 5–9) – 1 rel.; Kučera (2002, Master thesis, PrifUK Bratislava) – 5 rels.; Školek (2004, Bull. Slov. Bot. Spoločn., Suppl. 10: 145–151) – 10 rels.; Šomšák (1961, Acta Fac. Rerum Nat. Univ. Comen., Bot. 6: 407–459) – 9 rels.; Šomšák (1967, Acta Fac. Rerum Nat. Univ. Comen., Bot. 15: 1–11) – 1 rel.; Špániková & Zaliberová (1982, Vegetácia ČSSR, B5: 1–303) – 13 rels.; Urbanová & Kuderjavá (1996, In: Ochrana prírody kysuckého regiónu a spolupráca na jeho trvalo udržateľnom rozvoji. IUCN, Bratislava, pp. 65–81) – 1 rel.; Valachovič (unpublished) – 1 rel.; Viceníková (1998, PhD. thesis, PrifUK Bratislava) – 6 rels.; Watzka (1997, Master thesis, PrifUK Bratislava) – 1 rel.; Watzka (1999, Bull. Slov. Bot. Spoločn. 21: 151–160) – 4 rels.; Watzka (unpublished) – 21 rels.;