SPRUCE FORESTS WITH *SPHAGNUM GIRGENSOHNII* FROM THE WETLANDS OF THE WESTERN CARPHATIANS MOUNTAINS AND SOMEȘUL CALD-SOMEȘUL RECE INTERFLUVE, AND THEIR PHYTOCENOLOGICAL AND ECOPROTECTIVE IMPORTANCE

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Abstract

Spruce cenoses established on sphagnum grow at altitudes ranging between 1,020 m and rising up to 1,601 m, vegetating near springs, streams, shaded valleys and slopes with high humidity rates, at the edge of oligotrophic and eutrophic peatlands, on turbid, acid moist soils, which are poor in mineral substances.

The spectrum of bioforms (see Figure 1) shows that the majority species are hemicryptophytes (55%), followed by phanerophytes (17.5%), cameophytes (15%), geophytes (10%) and terophytes (2.5%).

The floristic elements (see Figure 2) highlight the predominance of circumpolar species (32.5%), followed by Eurasian (25%), European (15%), cosmopolitan and Central European species in the same percentage (i.e. 7.5%), Carpatho-Balkan species (5%), while the lowest share is represented by endemic-Carpathian, Ponto-Pannonian and Artic-Alpine species (2.5% each).

The diagram of ecological indices (see Figure 3) highlights the dominance of mesophilic species (57.5%), followed by mezzo-hygrophilous ones (25%), eurihydric (10%), and xeromesophilic species (5%). Considering the temperature factor, microtherms (55%), euritherms (27.5%), micro-mesotherms (12.5%), and cryophiles (5%) are dominant. In relation to the chemical reaction of the soil, the species hierarchy encompasses euriionic (27.5%), acidophilic (25%), acid-neutrophilic (22.5%) strongly acidophilic (17.5%) and weakly acid-neutrophilic (7.5%) species.

The karyotype spectrum (see Figure 4) shows the dominance of polyploids (57.5%), followed by diploids (32.5%), and diplo-polyploids (7.5%), and of species with unknown karyotype (i.e. 2.5%). The diploid index is 0.56.

Key words: phytocenoses, bioforms, floristic elements, ecological indices, karyotype.

INTRODUCTION

The floristic composition of the association (see Table 1) totals 40 cormophyte species and 10 bryophyte species, which shows a great biodiversity. The tree line is dominated by the indicator and characteristic

species, *Picea abies*, which has a general coverage of 43.5% ADm and maximum value of constant (K=V). In addition to spruce stands, there are several isolated specimens of *Sorbus aucuparia* and *Fagus sylvatica*. The canopy cover is average, starting from a consistency of 0.5 and rising to 0.8. The height of the trees is generally higher in case of older specimens and lower in case of young specimens, and ranging between 15 and 28 m. The diameters of the tree trunks start from 20-38 cm, which shows the presence of some old trees with slow growth. The layer of poorly developed shrubs and subshrubs consists of only a few species (i.e. *Pinus mugo, Sambucus racemosa, Rubus hirtus, Rubus idaeus*). Within the association, the *Vaccinium myrtillus* plants are present in all surveys, with a good general coverage of 13.15% ADm and maximum value of constant (K = V), which negatively influences the participation of other species that form part of the association.

Extrazonal spruce phytocenoses located on sphagnets were described in Romania in the following areas: Parâng Mountains (Borhidi, 1971), Poiana Stampei (Coldea, 1991), Someşul Rece Valley (I. Pop et al., 1984), Bihor Mountains (Coldea, 1991), Iezer-Păpuşa Mountains (Alexiu, 1998), Arieşul Mare-Arieşul Mic interstream area (Ursu, 2013), and in the northern part of Bihor Mountains (Togor, 2016).

MATERIAL AND METHOD

The surveyed material represents the priority natural ecosystems consisting by dominant spruce forests developed on *Sphagnum girgensohnii* within the Western Carpathians (a.k.a. Apuseni) Mountains, Someșul Cald-Someșul Rece interfluve. We carried out 10 phytocenological surveys on the most representative phytocenoses. All plant species found, with the assessment of abundance and dominance (AD) for each species according to the Braun-Blanquet scale (Braun-Blanquet et Pavillard 1928), were enclosed in the association table (see Table 1). The *Sphagno girgensohni-Piceetum* association was analysed and characterized ecologically, phytocenologically, cytogenetically based on the association table and histograms with reference to the distribution of bioforms, floristic elements, ecological indices, and genetic karyotypes.

Finding and description of the association was made based on the floristic criterion, with the help of characteristic, indicator, dominant and differential species. The name of the association is in accordance with the provisions established by the International Code of Phytosociological Nomenclature (Weber et al., 2000). Classification of species by corresponding coeno-taxonomic units (i.e. subaliances, alliances, orders, classes) was made in accordance with the ecological-floristic systems

elaborated by Tüxen (Tüxen, 1955), and Braun-Blanquet (Braun-Blanquet, 1964), and on the basis of more recent works (Coldea et al., 1997 and Sanda et al., 2003, 2008).

The ecological and phytocenological characterization of the species within the surveyed territory was made according to dedicated literature (Sanda et al., 2003), (Ciocârlan, 2009), (Sârbu et al., 2013).

The information on the value of ecological indices, bioforms, floristic elements, and number of chromosomes are presented according to synthesis works elaborated by various researchers (Pop, 1977, 1982), (Sanda et al., 2003, 2008), (Cristea et al., 2004), (Ciocârlan, 2009), (Burescu et Toma, 2005), (Doniţă et al., 2005).

We carried out the analysis of phytocenoses with regard the influence of ecological factors moisture (M), temperature (T) and soil chemical reaction (R) according to a previous paper works (Sanda et al., 2003), which adapted the ecological indices values for the plants in Central Europe on a 1 to 9 scale (Ellenberg, 1974) to the pedoclimatic conditions specific to Romania, by making use of scale ranging between 1 and 6. We made the classification of the species by the corresponding coenotaxa according to the works of other authors (Borza et Boşcaiu, 1965).

Cytogenetic analysis of species by karyotype thereof was done according to the works of Sanda et al., 2003.

RESULTS AND DISCUSSION

In the composition of the association there are present species characteristic to the ***Abieti-Piceion*** alliance and the ATHYRIO-PICETALIA order (i.e. *Athyrium filix-femina, Veratrum album*), and a large number of species belonging to the **VACCINIO-PICEETEA** class (i.e. *Vaccinium myrtillus, Deschamspia flexuosa, Homogyne alpina, Oxalis acetosella, Calamagrostis villosa, Dryopteris cristata, Sorbus aucuparia, Luzula sylvatica, Polytrichum strictum, Vaccinium vitis-idaea, Gymnocarpium driopteris Licopodium anotinum, Blechnum spicant, Huperzia selago, Pinus mugo,* etc.*)*; in phytocenoses there are also present transgressive species from the **QUERCO-FAGETEA** classes (i.e. *Cystopteris fragilis, Polygonatum latifolium, Polygonatum verticillatum, Senecio nemorensis ssp. jacquinianus, Gentiana asclepiadea, Fagus sylvatica, etc.*). Among the spruce forests containing *Sphagnum girgensohnii* within the Bihor Mountains, Someșul Cald-Someșul Rece interfluve stand out two acidophilic, glacial relict species specific for sphagnums belonging to the **OXYCOCCO-SPHAGNETEA** classes (i.e. *Eriophorum vaginatum, Vaccinium microcarpum*). The well-developed

bryophyte layer is rich in species, maintaining high level of moisture and acidity of phytocenoses.

With regard the floristic composition, following the review of the association table (see Table 1) and histograms, compared to the work of Togor (Togor, 2016) one can notice that we found in the association 40 cormophyte and 10 bryophytes species while Togor (Togor, 2016) found 53 cormophytes and 11 bryophytes. Comparing the spectrum of bioforms shows that hemicryptophyte species are dominant with a percentage of 55% while in the case of Togor's work (Togor, 2016) hemicryptophytes have a share of 56.61%. The phytogeographic elements consist in circumpolar species i.e. 32.5% while in the case of Togor (Togor, 2016) circumpolar species have a share of 47.17% The diagram of ecological indices shows that in our country mesophiles predominate i.e. 57.5% and at Togor (Togor, 2016) mesohigophiles are dominant with 41.51%; moreover, in our case microtherms' share is 55% and 45.28% in the case of Togor (Togor, 2016); in our research euriionic species percentage is 27.5% while in Togor's research (Togor, 2016) acidophilic species have a 37.75%. The karyological analysis shows that polyploid species have the highest percentage of 57.5%, while in the case of Togor's work (Togor, 2016) their share is only 49.06%.

From the analysis above it results that the some results overlap in some points yet they are not similar since the surveyed areas are not impacted by the same pedoclimatic conditions.

Analysis of the spectrum of bioforms (see Figure 1) shows that the majority species are hemicryptophytes (55%), followed by phanerophytes (17.5%), cameophytes (15%), geophytes (10%), and terophytes (2.5%).

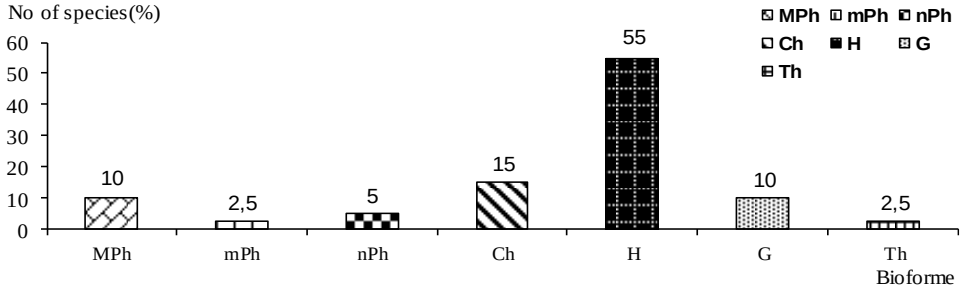

Fig. 1. Spectrum of bioforms in the *Sphagno girgensohnii-Piceetum* association
Legend: MPh = Megaphanerophytes; mPh = Mesophanerophytes; nPh = Nanophanerophytes; Ch = Chamaephytes; H = Hemicriptophytes; G = Geophytes Th = Annual terophytes.

The floristic elements (see Figure 2) shows the predominance of circumpolar species (32.5%), followed by Eurasian (25%), European (15%), cosmopolitan and Central European species in the same percentage (i.e.

7.5%), Carpatho-Balkan species (5%), while the lowest share occurs in the case of endemic-Carpathian, Ponto-Pannonian and Artic-Alpine species (with 2.5% each).

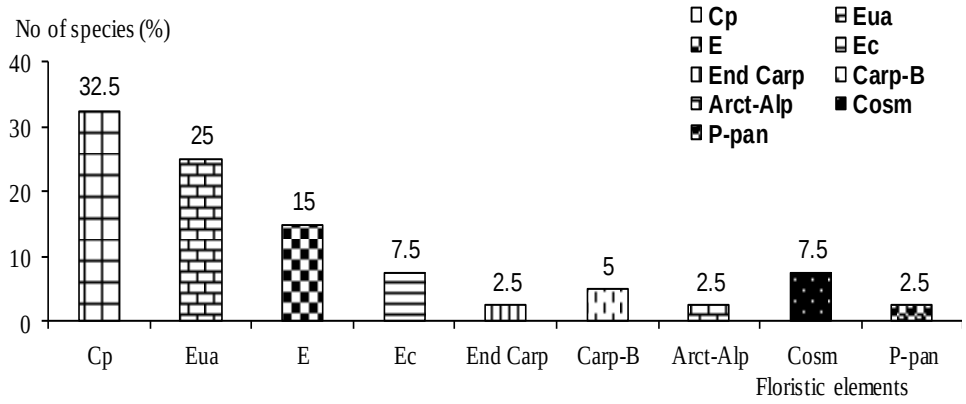

Fig. 2. Spectrum of floristic elements from the *Sphagno girgensohnii-Piceetum* association
Legend: Cp = Circumpolar; Eua = Eurasian; E = European; Ec = Central European; End Carp = Endemit Carpathian; Carp-B = Carpathian-Balkan: Arct-Alp = Arctic-Alpine; Cosm = Cosmopolitan; P-pan = Ponto Pannonian.

The diagram of ecological indices (see Figure 3) highlights the dominance of mesophilic species (57.5%), followed by mesohygrophiles (25%), eurihydres (10%), xeromesophiles (5%). Depending on the temperature, the microtherms (55%), euritherms (27.5%), micro-mesotherms (12.5%), and cryophiles (5%) are dominant. In terms of the chemical reaction of the soil, euriionic (27.5%), acidophilic (25%), acid-neutrophilic (22.5%), strongly acidophilic (17.5%), and weakly acid-neutrophilic (7.5%) species are present.

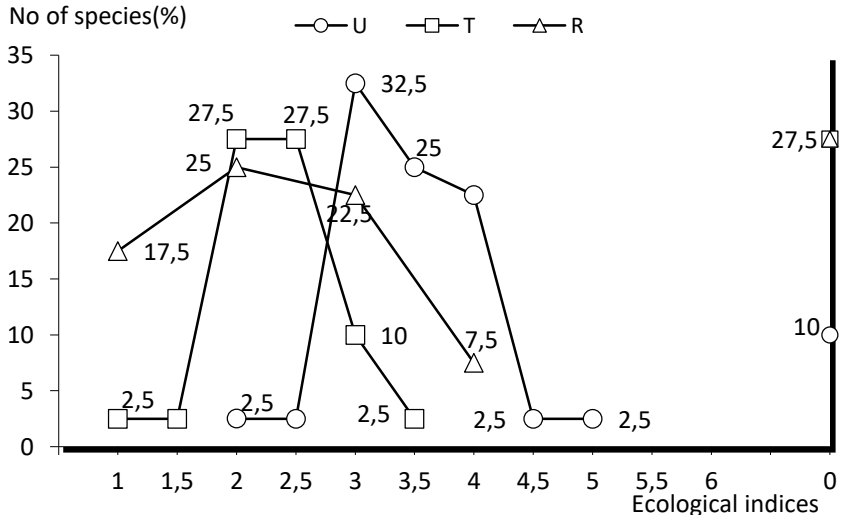

Fig. 3. Ecological indices diagram for the *Sphagno girgensohnii-Piceetum* association

The karyological spectrum (see Figure 4) shows the dominance of polyploids (57.5%), followed by diploids (32.5%), diplo-polyploids (7.5%), and of species with unknown karyotype (2.5%). The diploid index is 0.56.

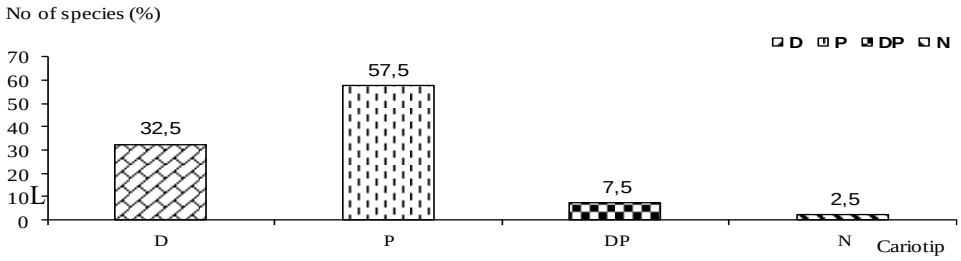

Fig. 4. The karyological spectrum for the *Sphagno girgensohnii-Piceetum* association
Legend: D = Diploids; P = Polypoids; DP = Dipopoliploids; N = Unknown karyotype.

These very valuable forests are included in the habitat type: R4210 Southeastern Carpathian spruce forests with *Sphagnum sp.* (Doniţă et al., 2005). Correspondence: NATURA 2000: 9410 Acidophilous *Picea abies* forests of the montane to alpine levels (**Vaccinio-Piceetea**) PAL.HAB .: 42.2131 Carpathian peat moss spruce forest. Priority habitat, with very high conservation value, including relict species, being included in the list of natural habitats of community interest whose conservation requires the designation of Special Areas of Conservation (AUC) Directive 92/491 EEC, Annex I- in Romania.

Table 1

Sphagno girgensohnii-Piceetum Kuoch 1954

Biof.	Fl. el	M	T	R	G												K	ADm
						Survey No.	1	2	3	4	5	6	7	8	9	10		
						Altitude AMSL (mx10)	121	102	130	115	115	160	161	160	122	108		
						Exposure	SV	N	N	N	N	N	-	-	N	N		
						Slope (º)	4	32	12	28	18	2	-	-	12			
						Tree layer consistency	0.8	0.5	0.6	0.8	0.8	0.6	0.6	0.7	0.7	0.7		
						Tree height (m)	24	26	24	18	20	20	26	28	26	20		
						Tree diameter (cm)	28	38	36	20	22	34	34	36	30	24		
						Tree layer coverage (%)	-	-	-	-	-	-	-	10	-	-		
						Grass layer coverage (%)	90	80	100	100	10	80	90	80	30	20		
						Moss layer coverage (%)	80	90	50	90	90	70	90	90	100	80		
						Surveyed area (m^2)	80	40	80	120	120	40	40	80	80	80		
						As. Sphagnum girgensohnii	2	3	3	2	2	3	4	3	2	2		
MPh	E	0	0	0	D	*As. Picea abies*	3	3	3	4	4	2	2	3	4	4	V	42.87
						Abieti-Piceion, Athyrio-Piceetalia												
H	Cosm	4	2.5	0	P	*Athyrium filix- femina*	+	.	+	.	.	.	.	.	.	.	I	0.1
G	Eua	4	2.5	4	DP	*Veratrum album*	+	.	.	.	.	.	.	.	.	.	I	0.02
						Vaccinio-Piceetea												
Ch-nPh	Cp	0	2	1	D	*Vaccinium myrtillus*	2	1	4	+	1	2	+	2	+	1	V	11.87
H	Cp	2	0	1	P	*Deschampsia flexuosa*	.	+	+	+	1	+	+	.	+	1	V	1.1
H	Alp-E	3.5	2.5	2.5	P	*Homogyne alpina*	1	.	1	.	.	+	.	.	+	.	IV	1.22
H-G	Cp	4	3	3	D	*Oxalis acetosella*	1	+	+	+	+	+	.	.	+	+	IV	0.8
H	Eua	4	2.5	1.5	P	*Calamagrostis villosa*	1	.	+	+	1	+	+	.	+	+	IV	1.3
H	Cp	3.5	2	3	P	*Dryopteris cristata*	.	+	.	+	+	+	.	+	+	+	IV	0.37
						Polytrichum strictum	.	.	1	1	1	1	.	+	2	1	IV	5.15
MPh-mPh	E	3	2.5	2	D	*Sorbus aucuparia*	.	.	+	.	+	.	.	+	+	.	III	0.27
H	Ec	3.5	2.5	2	DP	*Luzula sylvatica*	+	.	+	.	+	.	.	+	+	.	III	0.47
Ch-nPh	Cp	3	2	1	D	*Vaccinium vitis-idaea*	+	+	+	.	.	.	.	+	.	.	II	0.17
G	Cp	3	2.5	2	P	*Gymnocarpium dryopteris*	+	+	.	+	.	.	.	+	.	+	II	0.2
Ch	Cp	4	2.5	2	P	*Lycopodium annotinum*	+	.	+	+	+	.	.	.	.	.	II	0.17
						Dicranum scoparium	1	1	+	.	1	.	.	.	.	.	II	2.8
						Sphagnum magellanicum	.	.	.	.	.	+	+	+	.	.	II	2.25
H	Cp	3.5	2	1.5	P	*Blechnum spicant*	+	+	.	.	.	.	.	.	.	.	I	0.05
Ch	Cosm	3.5	2	2	P	*Huperzia selago*	.	.	+	.	.	.	.	.	.	.	I	0.02

H	Carp-B	3	0	0	D	*Hieracium transylvanicum*	.	+	.	.	+	.	.	.	+	.	I	0.1
H	Cp	3.5	0	0	P	*Luzula luzuloides*	.	.	.	.	.	.	.	.	+	.	I	0.07
H	End	4	2	3	D	*Leucanthemum waldsteinii*	.	.	.	.	+	.	.	.	.	.	I	0.02
						Polytrichum commune	.	.	.	.	.	.	.	.	+	.	I	0.07
						Polytrichum juniperinum	+	2	.	.	.	.	.	.	.	.	I	0.9
						Hylocomium splendens	.	.	.	.	.	.	.	.	.	+	I	0.07
Th	Eua	3	0	1.5	D	*Melampyrum sylvaticum*	.	.	.	.	.	.	+	+	.	.	I	0.1
MPh	Ec-Alp	0	2	0	D	*Pinus mugo*	.	.	.	.	.	.	+	+	.	.	I	0.05
H	Carp-B	3.5	2	2	P	*Campanula abietina*	.	.	.	.	.	.	.	.	+	.	I	0.02
H	Cp	3.5	0	0	P	*Dryopteris dilatata*	.	.	.	.	.	.	.	.	.	+	I	0.02
H	Cosm	3.5	0	0	P	*Cystopteris fragilis*	+	.	.	.	.	.	.	.	.	.	I	0.02
G	P-Pan	3	3.5	4	D	*Polygonatum latifolium*	+	.	.	.	.	.	.	.	.	.	I	0.02
H	Eua	3.5	3	3	P	*Senecio nemorensis* ssp. *jacquinianus*	+	.	.	.	.	.	.	.	+	.	I	0.05
H	Ec	4	2	4	P	*Gentiana asclepiadea*	+	.	.	.	.	.	.	.	.	.	I	0.02
nPh	E	3	2.5	3	P	*Rubus hirtus*	.	+	.	.	.	.	.	.	.	.	I	0.02
G	Eua	3	2.5	2.5	P	*Polygonatum verticillatum*	.	.	.	.	+	.	.	.	.	.	I	0.05
MPh	E	3	2	0	D	*Fagus sylvatica*	+	+	.	.	.	.	.	.	.	.	I	0.05
H	Eua	3	0	3.5	P	*Epilobium montanum*	.	.	.	.	.	.	.	.	.	+	I	0.02
						Oxycocco-Sphagnetea												
H	Cp	4.5	0	1.5	D	*Eriophorum vaginatum*	.	.	.	.	.	+	+	1	.	.	II	1.45
Ch	Arct-Alp	5	0	2	D	*Vaccinium microcarpum*	.	.	.	.	.	.	.	+	.	.	I	0.02
						Sphagnum fallax	.	.	.	.	.	.	+	.	.	.	I	0.07
						Sphagnum fuscum	.	.	.	.	.	+	.	.	.	.	I	0.02
						Variae syntaxa												
						Rhytidiadelphus triquetrus	.	1	2	+	+	.	.	.	.	2	III	5.22
nPh	Cp	3	3	3	DP	*Rubus idaeus*	.	+	.	.	+	.	.	.	+	.	II	0.17
H	Cp	4	1.5	0	P	*Epilobium anagalidifollium*	.	+	.	.	.	+	.	.	.	.	II	0.12
mPh	Eua	3	2	3	P	*Sambucus racemosa*	.	+	.	.	.	.	.	.	.	.	I	0.02
H	Eua	4	3	0	P	*Molinia caerulea*	.	.	.	.	.	+	.	.	.	.	I	0.27
H	Eua	0	0	0	P	*Potentilla erecta*	+	.	.	.	.	.	.	.	.	.	I	0.02
Ch	Eua	2.5	2.5	3	N	*Scutellaria supina*	.	1	.	.	.	.	.	.	.	.	I	0.25
H	E	3	1	2	P	*Festuca nigrescens*	.	.	.	.	.	+	.	.	.	.	I	0.05

Place and date of surveys: 1 Făget, 09.08.2018, GPS 463142.5, 225227.9; 2 Albac-Coșuri Valley,09.08.2018 GPS463017.7,225254.3;3Ursoița-Piciocaru, 14.09.2019, GPS 463229.8, 225334.3; 4 Lina 14.09.2018 GPS 463437.2, 225319.8; 5 Beliș Valley,14.09.2018 GPS 463434, 225213; 6-8 Căpățânei Swamps, 28.07.2019. GPS 462817.5, 230545.9;462815.8, 230602,3; 432817,7, 230608,6; 9 Cracilor-Dobrușu Valley 11.08.2019 GPS 463603,2, 230149,8; 10 Drăguiasa-Poiana Horea Valley 12.09.2019 GPS 463554,5, 225352.

CONCLUSIONS

1. The association entails a very high scientific importance since it includes four (4) rare, endangered, glacial relict species, included in the Red Lists and a tertiary relic e.g. *Dryopteris cristata, Leucanthemum waldstreinii, Eriophorum vaginatum, Vaccinium microcarpum, Blechum spicant*.

2. The phytocenoses of the *Sphagno girgensohnii-Piceetum* association are dominated by hemicryptophytes (55%), followed by phanerophytes (17.5%), cameophytes (15%), geophytes (10%), and terophytes (2.5%).

3. The geographical area of the *Sphagno girgensohnii-Piceetum* association is dominated by circumpolar species (32.5%), followed by Eurasian (25%), European (15%), cosmopolitan and Central European species with the same share (i.e. 7.5%), Carpatho-Balkan species (5%), while the lowest percentage belong to endemic-Carpathian, Ponto-Pannonian, and Arctic-Alpine species (i.e. 2.5% each).

4. Ecological indices highlight the fact that, in terms of soil moisture, there are dominant the following species: mesophiles (57.5%), followed by mesohygrophiles (25%), eurihydrates (10%), and xeromesophiles (5%). With regard the temperature, the dominant species are microthermic (55%), eurythermic (27.5%), micro-mesothermal (12.5%), and cryophilic species (5%). Regarding the chemical reaction of the soil, the euriionic (27.5%), acidophilic (25%), and acid-neutrophilic (22.5%) are dominant followed by strongly acidophilic (17.5%) and weakly acid-neutrophilic (7.5%) species.

5. In the genetic structure of the phytocenoses of the *Sphagno girgensohnii-Piceetum* association, polyploids (57.5%) are dominant, followed by diploids (32.5%), diplo-polyploids (7.5%) and species with unknown karyotype (2.5 %). The diploid index is 0.56.

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