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CONTRIBUTIONS TO THE PHYTOCOENOLOGICAL STUDY OF OLIGO-MESOTROPHIC PEAT BOGS / MARSHY MEADOWS IN THE VLĂDEASA MOUNTAINS, WESTERN CARPATHIANS, ROMANIA

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ABSTRACT

The purpose of this research consists in the development of a floristic, phytocoenological, ecological, cytogenetic, syndamic, economic and environmentally-friendly study of the marshy meadows located in the subalpine peats of the Vlădeasa Mountains.

A total of nine phytocoenological surveys were conducted in the most representative sample areas of the phytocenoses of the *Eriophoro vaginati-Sphagnetum recurvi* association, in order to find adequate answers to the five proposed objectives of the study.

The species found as a result of the floristic inventory were included in an association synthetic table by affinity criteria for coenotaxa: alliance, order, class to which they are subordinate. In the results chapter, the phytocoenoses of the association's meadows were analysed statistically based on tables, histograms, diagrams, by weight in ecological categories of bioforms, phytogeographical elements, cytogenetic elements and the ecological behaviour of the species in relation to edaphic moisture, air temperature, and chemical reaction of the soil. The phytocoenoses of the association, the economic and scientific value and the measures of sustainable management and environmentally friendly management of the subalpine meadows were also studied syndamically.

The results thus obtained were compared with two reference works belonging to authors who carried out similar research in different geographical regions.

We formulate seven findings in which the results of the research are summarized.

Keywords: biodiversity, phytocoenoses, association, peat bog, ecological characterization, management.

INTRODUCTION

The peat bog, also known as high peat, high moor or sphagnum, is the sediment of unventilated marshes, formed from plant debris belonging to bryophytes of the genus *Sphagnum*, vascular phanerogams (*Eriophorum vaginatum*, *Eriophorum latifolium*, *Drosera rotundifolia*, *Drosera intermedia*, *Carex limosa*, *Carex echinata*, *Carex pauciflora*, *Carex flava*, *Carex lasiocarpa*, *Carex rostrata*, *Carex nigra ssp. dacica*, *Vaccinium oxycoccos*, *Vaccinium microcarpum*, *Pedicularis limnogena*, *Swertia punctata*, *Menyanthes trifoliata*, *Epilobium palustre*, *Epilobium nutans*, *Dactylorhyza maculata*), which do not rot, but are peat forming plants (carbon-rich plants) due to their high pH (3.5-4.5), thus forming layers of peaty soil and highlighting the successive stages of the genesis of the marsh and the surrounding meadows.

The peat bogs or sphagnums in the Apuseni Mountains were first recorded by the academician Pop (1960) and subsequently researched in great detail in terms of floristics and phytocoenology in the regions neighbouring the territory surveyed by us: Stâna de Vale depression (Rațiu, 1965), Valea Ieduțului valley (Rațiu and Boșcaiu, 1967), Valea Iadului - Poiana Remețului (Rațiu et al., 1983), Gilău Mountains - Peat bogs from Blăjoaia and Dorna on Someșul Rece valley (Pop et al., 1986), Bihor Mountains - The Great Peat Bog from Izbuce

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(*Tinovulcel Mare de la Izbuce*) on Someșul Cald Valley (Pop et al., 1987; Burescu and Togor, 2002), on Valea Drăganului valley (Burescu, 2018).

Research on the subalpine marshy meadows of the Vlădeasa Massif was not done before Resmeriță (1970), who describes for the first time the phytocenoses of the sub-association *Caricetum-Sphagnetosum* nom. prov. in sites from the middle mountain floor of Răcad Valley, Citera, Rogojel, on a flat relief, at altitudes ranging between 870-1,040 m, which are much lower as against those described by us in sites from the subalpine floor, i.e. Vârfuraș Mountain (1,603-1,636 m), Nimăiasa Mountain (1,589 m), and Micău Mountain (1,602-1,633 m).

The peat bogs (sphagnums) within the Vlădeasa Massif were created by swamping the meadows around the springs and the spruce forests in pre-existing depressions or by filling some waterholes, smaller lakes located on plateaus (sinkholes) with species of the *Sphagnum* genus. Thus, the prerequisite was created for the coexistence of oligo-mesotrophic phanerogamous plants with species of peat moss belonging to the *Sphagnum* genus, which imprints the physiognomy, chemistry and living conditions of the phytocoenosis of the peat bog habitat. The soil and the water of the swamp become strongly acidic (ph=3.5-5), colloidal humic acids are formed, which colour the water of the pond in brown or dark brown.

Peat bog plants such as *Sphagnum recurvum*, *Sphagnum cuspidatum*, *Sphagnum magellanicum*, *Sphagnum fuscum*, *Sphagnum rubellum* multiply (stem cloning) at a fast pace, giving rise to compact sphagnums, which do not generally exceed a 5 ha area on the surface of Vârfuraș Mountain, Nimăiasa Mountain, Micău Mountain, and ranging 0.5 to 1.5 ha on Moliviș Mountain.

The peat bog (sphagnum) is fundamental to the entire oligotrophic, shady phytocoenosis of the association ***Eriophoro vaginati-Sphanetum recurvi*** which represents the living flora that isolates from the substrate and becomes almost exclusively tributary to nutrient-bearing precipitation waters (annual average rainfall: 1,395.3 mm), and whose existence is pre-conditioned by the acid substrate (parent rock, crystalline schists, sandstones), humid and cool climate [average annual temperature of 0.9ºC (Cristea, 2004)] distributed over the entire subalpine floor on the Vlădeasa Massif, at altitudes ranging 1,559 to 1,636 m.

The cenosis found by us in the subalpine meadows of the Vlădeasa Mountains gathers communities of rare, glacial relicts, endemic organisms included in the natural habitat of community interest Natura 2000 Site, *7110 Active peatlands, R5101 Southeast Carpathian peatlands, mesoligotrophic, acidic with *Eriophorum vaginatum* and *Sphagnum recurvum* which must be protected by being declared protected areas (Doniță et al., 2005; European Commission - Council Directive 92 (43)/ EEC on the conservation of natural habitats and of wild fauna and flora).

The purpose of this work is to find and describe the phytocenoses of the meadows gathered in the ***Eriophoro vaginati-Sphagnetum recurvi*** association from the active subalpine peatlands in the Vlădeasa Mountains.

The output of the work is intended to be achieved through a set of objectives as follows:

- Finding the floristic composition of the meadows belonging to the subalpine oligo-mesotrophic marshy phytocenoses by drawing up the association synthetic table;
- Classifying species in the association table by their affinity to the coenotaxa, alliance, order and vegetation class to which they are subordinate;
- Performing the ecological characterization of the cormoflora of the peat bogs meadows through the analysis of species belonging to the type of bioform, phytogeographical element, genetic element and to the categories of ecological indices, moisture, temperature and chemical reaction of the soil;
- Establishing the dynamics and trend of evolution of the peat bogs meadows for a certain stage of their existence.

Establishing the sustainable management of the peat bogs meadows, and the necessary measures to maintain the favourable conservation status of the rare, endangered, relict, endemic species that it shelters.

MATERIAL AND METHODS

We conducted surveys on the Vlădeasa Massif, sites from Vârfuraș Mountain, Nimăiasa Mountain, Micău Mountain, and Moliviș Mountain.

The biological material consists of the phytocoenoses of the association ***Eriphoro vaginati-Sphagnetum recurvi***, spread in the subalpine floor on flat lands, sink-holes, near springs or on the surface of small lakes, clogged waterholes, explosively colonized by *Sphagnum recurvum*, *Sphagnum magellanicum* in alliance with boreal phanerogamous plants (circumpolar boreal, circumpolar Arctic alpine), hygrophilous, meso-hygrophilous, on a peaty under-layer (thickness ranging 50-25 m), on which highly acidic oligotrophic histosols are formed.

In order to establish the structure of the living soil cover of the peat bogs, we made use of the phytocoenological research methods of the Central European School elaborated by Braun-Blanquet (1964), adapted to the particularities of the marsh vegetation in Romania by Borza et Boșcaiu (1965).

In the study of phytocoenoses we used, as a basic coenotaxonomic unit, the plant association in the context of the definition given by Géhu and Rivas-Martinez (1981).

In the itinerary and stationary research we followed the estimation of the density, respectively, the degree of soil covering by plants, making use of abundance and dominance indices, according to the Braun-Blanquet and Pavillard system (1928), corroborated with the consistency classes indices (K=I-V) which highlighted the degree of fidelity of the species to the environment of the phytocoenoses of the association.

In order to find the floristic composition of the phytocoenoses of the peat bogs gathered in the vegetal association ***Eriophoro vaginati-Sphagnetum recurvi***, we conducted nine phytocoenological surveys, out of which four surveys in Vârfuraș Mountain (at the following altitudes: 1,585 m, 1,603 m, 1,620 m, and 1,636 m), one survey in Nimăiasa Mountain (at the altitude of 1,559 m), three surveys in Micău Mountain (at the altitudes of 1,631 m, 1,602 m, and 1,633 m), and one survey in Moliviș Mountain (at 1,285 m altitude) during the optimal vegetation period (i.e. 01.08-22.08.2021).

The sampling surfaces (surveys) are homogeneous from the floristic and physiognomic point of view and they were selected from the most representative phytocoenoses, sizing between 20-200 m^2.

The selected surveys were entered in the analytical phytosociological table having the species ordered in the coenotaxa according to constancy criterion, each species providing scientific information on belonging to the type of bioforms (live forms), phytogeographic element, quantification of the size of ecological indices (moisture, temperature, chemical reaction of the soil), and the type of genetic karyotype.

When classifying the phytococenoses of the peat bogs by association and the superior coenotaxa units, alliance, order, vegetation class, we revised the traditional ecological and floristic systems of the following authors: Tüxen (1955), Braun-Blanquet (1964), Soó (1964-1980), Borza et Boșcaiu (1965) and we consulted the more recently published scientific papers of Oberdorfer (1992), Pott (1995), Borhidi (1996), Mucina (1997), Rodwell et al. (2002), Sanda et al. (2008), Coldea et al. (2012), and Chifu et al. (2014).

With regard the classification of species by bioform categories, we reviewed the system developed by Raunkier (1937), improved by Braun-Blanquet (1964), Ellenberg (1979), Sanda et al. (2003), Burescu and Toma (2005), and Ciocârlan (2009).

We carried out the classification of phytocoenosis species by categories of phytogeographic elements according to the classification elaborated by Meusel and Jäger (1992) and the one developed more recently by Cristea et al. (2004).

We made the distribution of species by categories of ecological indices of moisture (M), temperature (T), and chemical reaction of the soil (R) was made according to

Ellenberg (1979) for Central Europe on a scale ranging from 1 to 9, and for Romania according to Sanda et al. (2003) using a scale with values ranging between 1 and 6.

With regard the results of our research, we reviewed, statistically processed and represented them graphically in the form of percentage presented in tables, histograms and diagrams.

RESULTS AND DISCUSSION

The marshy meadows dominated by *Sphagnum recurvum*, *Sphagnum magellanicum* and *Eriophorum vaginatum* colonize the peat bogs located on a substrate of highly acidic organic oligotrophic histosols on the plateaus of the Vlădeasa Mountains.

The surveyed territory is located in an area of temperate continental climate with multiple Scandinavian and Baltic climatic and excessively continental influences that bring cold air masses with high content of moisture.

The floristic composition or the specific biodiversity

Finding the floristic composition of the peat bogs meadows is one of the objectives pursued in this study, the information thus obtained being necessary for the elaboration of the association table which represents the scientific basis of the research results.

The floristic inventory of the meadows of the peat bogs dominated by the phytocoenoses of the association ***Eriophoro vaginati-Sphagnetum recurvi*** Hueck (1925), totals 41 marshy oligo-mesotrophic cormophytes which means a relatively poorer flora in species but which forms an exuberant, exclusivist, vegetation featured by floristic, ecological and physiognomic individuality (Table 1). The dominant species that instils the physiognomy of the phytocoenosis are *Sphagnum recvurvum* with a coverage of 73.6%, maximum constancy (K=V) and *Eriophorum vaginatum* with a coverage of 43.6%, maximum constancy (K=V), both in relation of codominance (Figure 1).

Figure 1. Eriophoro vaginati-Sphagnetum recurvi (*flexuosi*)-*magellanici* (Hueck, 1925), Vârfuraș Mountain (original 14.08.2021)

Coeno-taxonomic units of the association and their floristic structure

Research of the structure of the living soil cover of peatland meadows with the assignment of species to the corresponding coenotaxa is another objective we proposed.

Along with the dominant and characteristic species of the association in the floristic structure of the phytocoenosis are ***Sphagnion magellanici***: *Sphagnum magellanicum*, *Sphagnum russowii*, *Sphagnum acutifolium*, *Carex pauciflora*, order ***Sphagnetalia magellanici***, class ***Oxycocco-Sphagnetea***: *Polytrichum strictum*, *Drosera rotundifolia*, *Calluna vulgaris*, *Vaccinium oxycoccos*, revealing their relict nature and the relic character of the phytocoenosis as a whole.

Table 1. Eriophoro vaginati - Sphagnetum recurvi (*flexuosi*)*-magellanici* (Hueck, 1925)

Bio.	E.f.	U	T	R	2n	Survey no.	1	2	3	4	5	6	7	8	9	K	Adm
						Altitude (mamsl)	1585	1603	1620	1636	1559	1631	1633	1602	1285		
						Gras cover (%)	100	90	100	100	100	100	100	100	100		
						Moss cover (%)	100	50	100	100	60	100	100	100	100		
						Exposition	-	-	S	-	NE	-	-	-	-		
						Slope (°)	-	-	2	-	3	-	-	-	-		
						Area (m²)	100	15	100	12	25	200	200	100	8		
H	Cp	4,5	0	1,5	D	As. *Eriophorum vaginatum*	3	3	4	2	3	4	3	4	3	V	43,6
Brchs	Cp-Bo					As. *Sphagnum recurvum*	4	3	5	5	3	5	5	5	5	V	73,6
						Sphagnion magellanici											
Brchs	Cosm					*Sphagnum magellanicum*	1	.	+	+	.	+	+	+	1	V	3,88
Brchs	Cp					*Sphagnum russowii*	.	.	.	.	+	.	.	.	+	II	0,11
Brchs	Cp					*Sphagnum acutifolium*	.	+	.	.	+	.	.	.	.	II	0,11
G	Cp-Bo	5	2,5	1	P	*Carex pauciflora*	.	.	+	.	.	.	.	.	.	I	0,05
						Sphagnetalia magellanici et Oxycocco-Sphagnetea											
Brchs	Cp-Bo					*Polytrichum strictum*	1	.	.	.	.	1	.	.	.	II	1,11
H	Cp	5	2,5	1	D	*Drosera rotundifolia*	.	.	+	+	.	.	.	.	.	II	0,11
nPh(Ch)	Eua	0	0	1	D	*Calluna vulgaris*	.	.	.	.	.	+	+	.	.	II	0,11
Ch	Cp-Bo	5	0	2	P	*Vaccinium oxycoccos*	.	.	.	.	.	.	+	.	.	I	0,05
						Scheuchzerio-Caricetea nigrae											
H	Carp-B	5	2	2	N	*Pedicularis limnogena*	+	+	+	+	+	.	+	.	.	IV	0,33
H	Cp	5	2	1	P	*Carex echinata*	2	.	+	+	+	.	.	.	1	III	2,61
H	Cosm	4,5	3	3	P	*Juncus effusus*	+	.	.	+	+	.	.	.	+	III	0,22
G	E	4	2	2	P	*Dactylorhiza maculata*	.	+	+	+	.	.	.	.	+	III	0,22
H	Carp-B-Cauc	5	1,5	0	P	*Swertia punctata*	.	3	.	.	+	.	.	.	.	II	8,38
H	Cp	4,5	3	0	P	*Carex flava*	.	.	.	1	+	.	.	.	+	II	0,66
Hh(H)	Cp	5	2	0	P	*Carex rostrata*	.	.	.	.	1	+	+	.	.	II	0,66
H	Cp	5	0	2	P	*Epilobium palustre*	.	+	.	.	+	.	.	.	+	II	0,16
H	Cp-A-a	4	2	2	P	*Juncus alpinoarticulatus*	.	.	.	.	+	.	.	+	+	II	0,16
G	Cp-Bo	4	3	2	P	*Carex nigra ssp. dacica*	+	.	.	.	+	.	.	.	.	II	0,11
H	Eua	5	0	4,5	P	*Eriophorum latifolium*	.	.	.	+	.	.	.	.	+	II	0,11
Hh(H)	Cp	5	2,5	2,5	P	*Carex lasiocarpa*	+	.	.	.	.	.	.	.	.	I	0,05
H	Alp-E	5	2	2	N	*Epilobium nutans*	.	.	.	+	.	.	.	.	.	I	0,05
G	D	4,5	2	2	P	*Dactylorhiza cordigera*	.	.	.	.	+	.	.	.	.	I	0,05
Hh	Cp	5	3	3	P	*Menyanthes trifoliata*	.	.	.	.	.	.	.	+	.	I	0,05
H	Eua	4,5	3	3	P	*Ranunculus flammula*	.	.	.	.	.	.	.	.	+	I	0,05
						Vaccinio-Piceetea											
Ch(nPh)	Cp	3	2	1	D	*Vaccinium vitis-idaea*	+	.	1	.	.	2	2	+	.	III	4,55
Ch(nPh)	Cp	0	2	1	D	*Vaccinium myrtillus*	2	.	+	.	.	+	1	.	.	III	2,61
H	Alp-E	3,5	2,5	2,5	P	*Homogyne alpina*	+	.	+	.	.	.	+	+	+	III	0,27
G-H	Cp	3	2	2,5	D	*Moneses uniflora*	.	+	.	.	+	.	.	+	.	II	0,16
H	Carp-Alp-Balc	3,5	2	1,5	P	*Soldanella montana*	+	.	.	.	.	.	.	.	.	I	0,05
						Molinio-Arrhenatheretea											
H	Cp	5	2	0	P	*Caltha palustris ssp, laeta*	.	2	.	+	+	.	.	+	1	III	2,66
H	Cosm	4	0	0	DP	*Deschampsia caespitosa*	1	.	.	.	.	+	.	.	.	II	0,61
H(Hh)	Eua	5	3	0	P	*Myosotis scorpioides*	.	+	.	.	.	.	.	.	+	II	0,11
H	Eua	2,5	0	0	D	*Leontodon hispidus*	.	.	.	+	+	.	.	.	.	II	0,11
						Nardo-Callunetea											
H	E	0	0	1,5	D	*Nardus stricta*	1	.	+	1	+	+	+	2	+	V	4,44
H	Eua	0	2	2	P	*Luzula sudetica*	+	.	+	+	+	+	.	+	+	IV	0,38
H	Cp-Bo	3	0	0	DP	*Festuca rubra*	+	.	+	.	+	+	.	+	.	III	0,27
H	Eua	4	1	0	P	*Potentilla erecta*	.	+	1	.	.	.	.	.	+	II	0,66
						Alneteaglutinosae											
H	E	3,5	1,5	3	DP	*Crepis paludosa*	.	+	.	1	.	.	.	.	+	II	0,66
						Betulo-Adenostyletea											
H	Carp-Alp-Balc	3,5	1,5	4	DP	*Aconitum variegatum ssp. paniculatum*	.	.	.	+	.	.	.	.	.	I	0,05

Species present in a single survey: *Piceaabies* (7) +; *Juniperussibirica* (7) +; *Equisetum palustre* (5) +; *Galium palustre* (5) +; *Lychnisflos-cuculi* (5) +; *Agrostis gigantea* (7) +; *Anthoxanthumodoratum* (9) +; *Deschampsia flexuosa* (7) +; *Filipendulaulmaria* (9) +; *Stellariauliginosa* (3) +.
Place and date of surveying: 1-46°43′277″N, 022°45′862″E, 2-46°43′365″N, 022°45′963″E, 3-46°43′451″N, 022°45′996″E, 4-46°43′517″N, 022°46′032″E Vârfuraș Mountain (14.08.2021); 5-46°42′166″N, 022°46′897″E Nimăiasa Mountain (21.08.2021); 6-46°41′417″N, 022°46′158″E, 7-46°41′445″N, 022°46′124″E, 8-46°41′422″N, 022°46′466″E Micău Mountain (22.08.2021); 9-46°45′494″N, 022°40′256″E Moliviș Mountain (01.08.2021).

Several meso-oligotrophic, mesotrophic species of the class ***Scheuchzerio-Caricetea nigrae*** are present and vegetate along with the characteristic specifies of the association:

Pedicularis limnogena, *Carex echinata*, *Dactylorhiza maculata, Swertia punctata*, *Carex flava*, *Epilobium palustre*, *Juncus alpinoarticulatus*, *Carex nigra ssp. dacica*, *Carex lasiocarpa*, *Epilobium nutans*, *Menyanthes trifoliata*, etc.

Circumpolar, Alpine-Carpathian, Alpine-European, transgressive species: *Vaccinium vitis-idaea*, *Vaccinium myrtillus*, *Homogyne alpina*, *Moneses uniflora*, *Soldanella montana* belonging to the class ***Vaccinio-Piceetea*** penetrated the peat bogs located in the proximity of spruce forests.

Species such as *Nardus stricta*, *Luzula sudetica*, *Festuca rubra*, *Potentilla erecta* penetrated the peat bogs scattered along the ***Nardo-Callunetea*** class grasslands.

Migrated hygrophilous and meso-hygrophilous species of the ***Molinio-Arrhenatheretea*** class: *Caltha palustris ssp. laeta*, *Myosotis scorpioides*, *Deschampsia caespitosa*, *Crepis paludosa*, *Aconitum variegatum ssp. paniculatum* may also be encountered sporadically.

Ecological characterization of the cormoflora of phytocoenoses of peat bogs

Composition by bioform categories

Knowledge of the type of bioforms is necessary because it highlights the way the plant's corm adapts to the living environment to protect its regenerating buds during vegetative rest, frosty winters, and excessively dry summers.

The analysis of the bioform spectrum (Figure 2) shows the dominance of hemi-cryptophytes (58.5%) followed at a great distance by geophytes (12.1%), helohydatophytes (7.3%), cameophytes (7.3%), and nano-phanerophytes (2.4%).

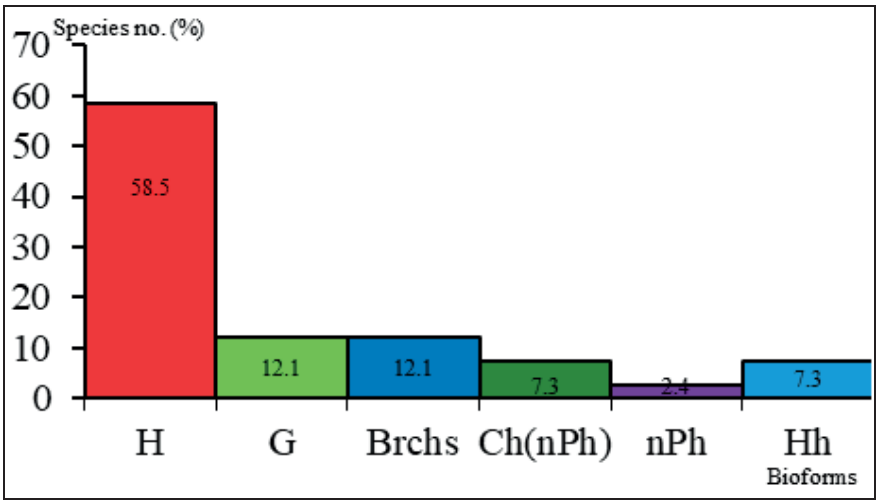

Figure 2. Spectrum of bioforms from the association *Eriophoro vaginati-Sphagnetum recurve*

Composition by categories of phytogeographical elements

Learning the proportions of the categories of phytogeographic elements (geoelements) that make up the flora of the peat bogs in the Vlădeasa Mountains, provides information on the florogenetics abundance, origin and diversity, and especially on the area-geographical interference generated by the migration of plant species in time.

The spectrum of phytogeographic elements (Figure 3) shows the overwhelming share of circumpolar-boreal, circumpolar-Arctic-Alpine species (i.e. 51.2%) followed by Eurasian (17.1%), Carpatho-Balkan, Carpathian-Alpine-Balkan, Carpathian Balkan-Caucasian species (9.7%).

The European (7.3%), Alpine-European (4.8%), cosmopolitan (7.3%), and Dacian (2.4%) phytogeographical elements occur in small percentages.

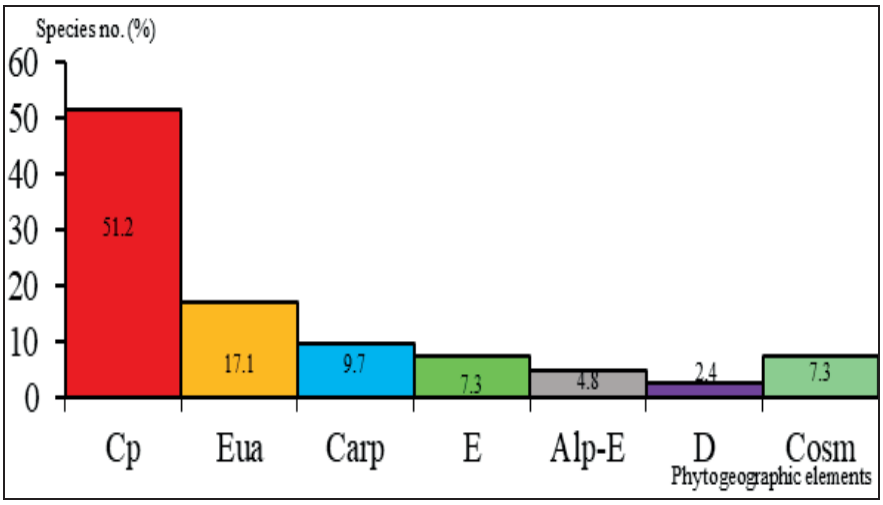

Figure 3. Spectrum of phytogeographic elements in the association *Eriophoro vaginati-Sphagnetum recurve*

Composition by ecological categories with regard moisture, temperature and chemical reaction of the soil

The analysis of phytocoenosis considering the requirements of the species with respect to moisture, temperature, chemical reaction of the soil, is important since it highlights the ecological specificity of the habitat, the impact of the local pedoclimatic factors on habitat, which are faithful ecological indicators of the sites on which plants are growing.

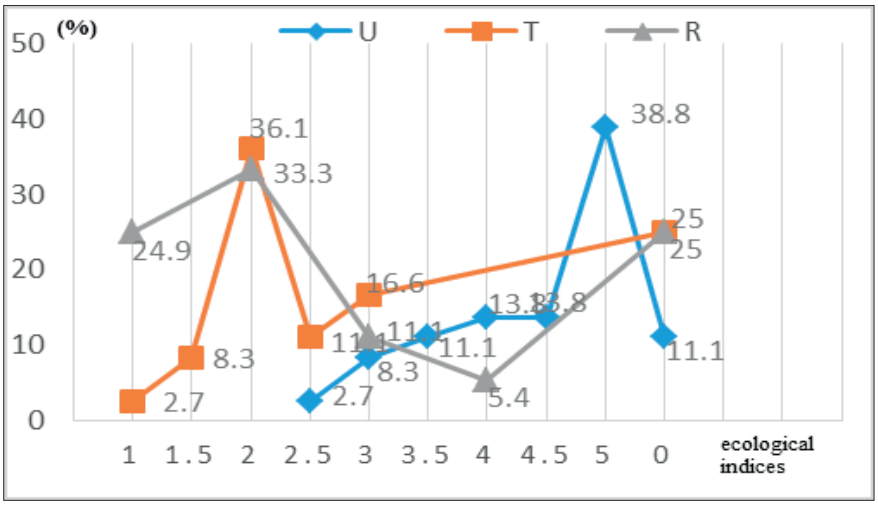

Figure 4. Ecological index diagram for the association *Eriophoro vaginati-Sphagnetum recurvi*

The ecological indices (factors) diagram (Figure 4) highlights the fact that in terms of soil moisture, most of them are hygrophilous species (.8%), followed by meso-hydrophilic species (27.6%), while in terms of temperature, microtherms are dominant (47.2%), accompanied by the eurytherms (25%) and micro-mesotherms (16.6%), and while considering the chemical reaction of the soil, the dominant species are acidophilic species (33.3%), followed by strongly acidophilic (25%) and euriionic species (25%).

The karyological spectrum (Figure 5) of the flora of the peat bogs belonging to the association ***Eriophoro vaginati-Sphagnetum recurvi*** is dominated by polyploid species (61.1%), whose genetic karyotype provides the phytocoenosis populations with a high capacity of competing phytosociologically, and of colonizing the available space within an habitat facing hostile living conditions

caused by extremely acidic peaty substrate, which is poor in assimilated mineral salts and featured by excessive moisture and low average monthly temperatures.

Diploid species occur in a lower percentage (22.2%), but their genotype (genofond) secures the genetic potential of the evolution of phytocoenosis populations through allopolyploidy and autopolyploidy.

Presence of diplo-polyploid species (11.1%) and of those with unknown karyotype (5.5%) is insignificant.

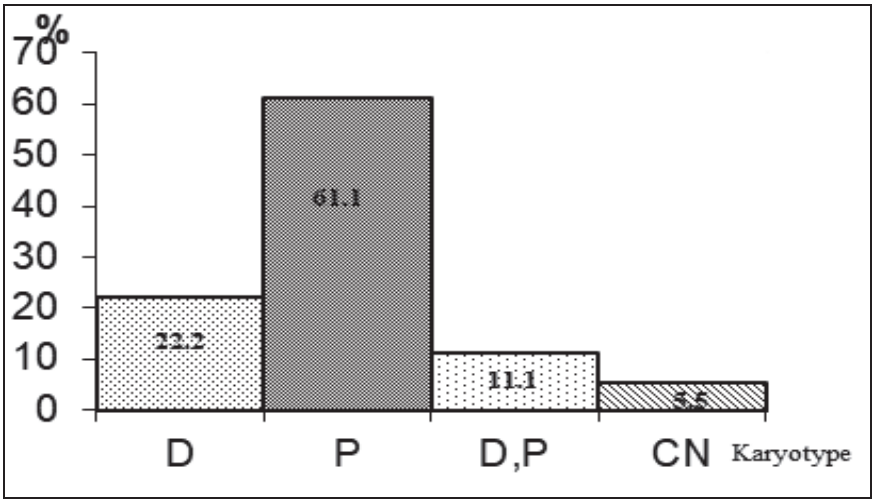

Figure 5. The karyological spectrum of the association *Eriophoro vaginati-Sphagnetum recurvi*

Peat bogs dynamics in the Vlădeasa Mountains

The phytocoenoses of the association ***Eriphoro vaginati-Sphagnetum recurvi*** (***flexuosi***)-***magellanici*** have a long existence, maintaining a dynamic balance between both the *climax* stage and the environment for tens, hundreds, and even thousands of years.

Simultaneously with the decrease of excess moisture, the decrease of the pH to the weakly acidic or slightly neutral range, the decline stage begins which results in the evolution towards phytocoenoses of hygro-nardetum: ***Carici-Nardetum strictae*** Resmeriță and Pop (1986) (Syn: ***Hygronardetum strictae*** Borza (1934), Pușcariu et al. (1956), ***Hygronardetum strictae alpinum***, Buia, Păun, Pavel (1962). Subsequently, hygro-nardetum phytocoenoses can evolve into phytocoenoses of meso-nardetum, xero-nardetum of the association ***Violo declinatae-Nardetum***, Simon (1956) or ***Scorzonero roseae-Festucetum nigricantis*** described in the Biharia Massif by Buia et al. (2021). The evolution towards the meso-nardetum and xero-nardetum meadows can be based on the penetration of the woody shrub species *Pinus mugo* and *Vaccinium uliginosum* into the peat bogs when the herbaceous and moss cover is replaced by that of the phytocoenoses of the association ***Pino mugo-Sphagnetum*** Kästner and Flössner (1933) (Syn: ***Vaccinio Pinetum mugi*** (Hadač, 1956; Pop et al., 1987).

Scientific and economic relevance

Peat storage in large deposits can be a major source for a country's energy industry or it can be used as locally as fuel in the peat-rich geographically areas. From peat dried by distillation there can be extracted peat tar, important chemical compounds, phenols, cresols and even paraffin. From the screened and processed peat one can produce thermal insulators, ad tiles and bricks can be manufactured for industrial and civil engineering constructions. Dust and peat fibers used as packaging material for fruits, vegetables, and fragile objects can be obtained from industrial waste. In the pharmaceutical industry, peat and medicinal charcoal substitutes are made from peat. In agriculture, peat is used as a nitrogen fertilizer by saturating it with ammonia. Compost made of peat mixed with animal manure (cattle, horses) is used as a cellulosic

nutrient in the culture of the following mushrooms: *Agaricus* (*Psaliota*) *bisporus*, *Pleurotus ostreatus*, *Pleurotus florida*, *Pleurotus sajor-caju*, etc. Dry peat is used to insulate the walls of houses in rural areas, and of ice cold storage facilities. Peat soil is used as a fertilizer in the cultivation of flowerpots, in the ecological reconstruction of mineral habitats, and of ash deposits resulting from the burning of coal in thermal power plants.

Oligomezotrophic marshes are unproductive lands, being used for grazing only in years of excessive drought, the grass mowing is incomplete and the fodder thus obtained is of lower quality.

From a scientific point of view, oligotrophic peatlands represent a paleontological archive in the substrates of which the pollen granules of some plant species that lived in ancient phyto-historic ages are preserved unaltered, based on which the secession and evolution of vegetation on Earth could be reconstituted.

The habitats of the peat bogs in the Vlădeasa Mountains are home of glacial relicts: *Carex pauciflora*, *Carex magellanica*, *Drosera rotundifolia*, *Eriophorum vaginatum*, *Vaccinium oxycoccos*; and of endemic species: *Soldanella montana*, *Pedicularis limnogena*; vulnerable species: *Dactylorhiza maculata*, *Dactylorhiza cordigera*, *Menyanthes trifoliata*, included in the red list (Oltean et al., 1994).

Current state of play, potential threats and conservation measures

If for the habitats of oligotrophic peat bogs included in the forestry real estate there are regulations provided in the legislation on management, conservation of structure and biodiversity thereof, for those located outside the forestry real estate there are not such measures, and may be affected by anthropogenic interventions such as: logging trees in order to capitalize on the wood mass, exploiting the peat without legal approvals, draining the peat bogs and collecting the water that feeds them, grazing, herding through the habitat, construction of roads through the habitat, etc. All these aggressions made by man intentionally or unconsciously can have strong negative effects on the very-existence and self-stability of the ecosystem, compaction and destruction of the *Sphagnum* layer, pollution and dysfunctions that may occur in the hydrological regime, change in the floristic composition of the herbaceous layer and, the destruction of the peat bog, and sodding. Given that the differences in terms of classification of oligotrophic peat bogs by including some of them into forestry real estate and leaving other outside is only of administrative nature and not of ecological one, it results that the preservation and protection measures of rare, relict, and endemic species proposed through legislation in force for the peat bogs included into the forestry real estate, and spruce peat bogs can also be applied to peat bogs falling outside the forestry real estate and subalpine marsh meadows.

Discussion and comparison of results with surveys conducted in other geographical regions

The results regarding the biodiversity of the phytocoenoses of association ***Eriophoro vaginati-Sphagnetum recurvi*** present a small variation range from 41 species in the habitats surveyed by us and located in Vlădeasa Mountains, to 32 species in Gilău Mountains and Someșul Rece valley (Pop et al., 1986), and up to 60 species found by Togor (2016) in the Bihor Mountains, Izvoarele Someșului Cald site.

Within the phytocoenoses we surveyed in the Vlădeasa Mountain, bioforms are dominated by hemicryptophytes (58.5%), geophytes (12.1%), and bryophytes (12.1%), but they are also dominated by hemicryptophytes (60%), and geophytes (16%) in the peatlands from the Bihor Mountains at Izvoarele Someșului Cald site, Togor (2016). The bioforms studied by Pop et al. (1986) in the Someșului Rece valley, Gilău Mountains shows the dominance of camaephytes (49%), hemicryptophytes (40.3%), and bryophytes (31%), presenting partially different results from our outcomes.

The analysis of the categories of phytogeographical elements shows similar results obtained by us in terms of the share in the phytocoenoses in the Vlădeasa Mountains having circumpolar (51.2%), and Eurasian (17.1%) as dominant species as compared to the results obtained in Bihor Mountains, Izvoarele Someșului Cald site where circumpolar (52%), and Eurasian (24%) species are dominant, Togor (2016), and when compared to those obtained in Gilău Mountains, Valea Someșului Rece site where also circumpolar (71.3%), and Eurasian (12.4%) species are dominant, Pop et al. (1986).

The analysis of the influence of ecological factors (soil moisture, air temperature, and chemical reaction of the soil) on the habitats of the peat bogs highlights the hygrophilous (38.8%), mesohygrophilous (27.6%), microthermal (47.2%), cryophilic-hechistothermal (11.1%), eurithermal (25%), acidophilic (33.3%), and strongly acidophilic (25%) nature of the phytocoenoses we researched in the Vlădeasa Mountains; these results are close to those obtained by Pop et al. (1986) in Gilău Mountains, Someșului Rece Valley site and partially different from those obtained by Togor (2016) in Bihor Mountains, Izvoarele Someșului Cald site where the phytocoenoses of the same association presented a mesohygrophilous (38%), hygrophilous (32%), microthermal (48%), eurithermal (28%), acidophilic (40%), strongly acidophilic (26%) nature.

CONCLUSIONS

The floristic inventory of the meadows of the oligotrophic marshes gathered in the association ***Eriophoro vaginati-Sphagnetum recurvi (flexuosi)-magellanici*** (Hueck, 1925) totals a number of 41 taxa of which 36 cormophyte species and five bryophyte species.

The analysis of the ecological categories of bioforms highlights the share of hemicryptophytes (58.5%), followed by geophytes (12.1%), cameophytes (7.3%), helohidatophytes (7.3%), and nano-phanerophytes (2.4%).

Phytogeographic elements with reference to the genetic center of origin and the area of geographical distribution in which the speciation process took place shows the dominance of the circumpolar species (51.2%) accompanied by the Eurasian (17.1%), Carpathian (9.7%), European (7.3%), Alpine-European (4.8%), Dacian (2.4%) and cosmopolitan (7.3%) species.

Compared to the influence of ecological factors (soil moisture, air temperature, chemical reaction of the soil), the phytocoenoses of the marshy meadows in the peat bogs located in the Vlădeasa Mountains present a hygrophilous (38.8), mesohygrophilous (27.6%), microthermal (47.2%), eurithermal (25%), acidophilic (33.3%) to strong acidophilic (25%) nature.

Cytogenetic analysis shows the predominance of polyploid species (61.1%), followed by diploid (22.2%) and diplo-polyploid (11.1%) ones.

The peaty underlayer of the peat bogs meadows presents a special economic value and palaeontological-scientific relevance in the archiving of plant pollen grains from distant phyto-historical periods.

The bibliographic index includes a number of 41 references of authors whose scientific papers were reviewed and cited in the text.

ABBREVIATIONS

The following categories of abbreviations are used in this paper:

In terms of classification of plant species by the categories of ecological indices: moisture (M), temperature (T) and chemical reaction of the soil (R);

With regard soil moisture, the species surveyed maybe: Xerophilic = M 1-1.5, Xero-mesophylic = M 2-2.5, Mesophilic = M 3-3.5, Meso-hydrophilic = M 4-4.5, Hydrophilic = M 5, Eurihydrous = M 0;

Considering air temperature, the plant species surveyed can be: Microthermal = T2-2.5, Micro-mesothermal = T3-3.5, Thermal moderate = T4-4.5, thermal = T5, Eurithermal (thermally amphy-tolerant) = T0;

In terms of a chemical reaction of the soil the surveyed plant species can be: Acidophilous = R2, Acid-neutrophilous = R3, Weak acid netrophilic = R4, Neutral

basiphlous = R5, Euriionic (ionical amphytolerant) = R0;

Quantitative phtyto-population indices according to the average abundance-dominance (ADm) scale and the general soil may be: 5 = 87.5% (75-100%), 4 = 62.5% (50-75%), 3 = 37.5% (25-100%), 2 = 17.5% (10-25%), 1 = 5% (1-10%), + = 0.5% (0.1-1%);

The constancy of the species of the general frequency (K) can be: I = the species is present in the samples surveyed in a percentage of less than 20%, II = presence of the species is between 21 and 40%, III = presence of the species ranges 41-60%, IV = presence of the species is between 61-80%, V = presence of species of 81-100%.

Bioforms: H - Hemicryptophytes; G - Geophytes; Ch (nPh) - Cryptophytes; nPh (Ch) - Nanophanerophytes; Hh - Helohidatophytes; Brchs - Bryophytes.

Phytogeographic elements: Cp - Circumpolar, Cp-A-a - Circumpolar-Artic-Alpine, Cp-Bo - Circumpolar-Boreal; Eua - Eurasian; Carp - Carpathian, Carp - Balc-Carpathian-Balkan, Carp-B - Caucasian-Carpathian-Balkan-Caucasian, Carp-Alp-Balc - Carpathian-Alpine-Balkan; E - European; Alp-E - Alpine-European; D - Dacian; Cosm - Cosmopolitan.

Karyotype: D - Diploid; P - Polyploid; DP - Diplo-polyploid; N - Karyotype unknown.

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