ROMANIAN AGRICULTURAL RESEARCH, NO. 38, 2021
First Online: March, 2021. DII 2067-5720 RAR 2021-3

CONTRIBUTIONS TO KNOWLEDGE OF SUBALPINE MEADOWS IN THE APUSENI MOUNTAINS - BIHARIA MASSIF

Ana Maria Buia[1], Laviniu Ioan Nuțu Burescu[2*], Iosif Constantin Mateș[1], Ioana Andra Vlad[3], Simina Florica Ștef[1], Szilárd Bartha[2]

[1]Doctoral School of Biomedical Sciences, University of Oradea, 26 Magheru Blvd, Oradea, Bihor County, Romania
[2]Department of Forestry and Forest Engineering, University of Oradea, 26 Magheru Blvd, Oradea, Bihor County, Romania
[3]Department of Food Engineering, University of Oradea, 26 Magheru Blvd, Oradea, Bihor County, Romania
[*]Corresponding author. E-mail: laviniuburescu@gmail.com

ABSTRACT

The main purpose of this work is the development of a phytocenologic, ecological, bioeconomic and eco-protective study of the natural meadows dominated by *Festuca nigrescens* and *Scorzonera rosea* in the Biharia Massif, Western Carpathians. In order to achieve the objectives pursued, a number of 11 phytocenologic surveys were performed on the most representative sample surfaces, homogeneous in terms of flora, with the same seasonal requirements and a similar physiognomy. The species from the floristic inventory were recorded in the association table subordinated to the corresponding coenotaxa, alliance, order, class, noted with the corresponding abundance and dominance coefficients. As a result, the phytocenoses of the association *Scorzonero roseae-Festucetum nigricantis* were surveyed on the basis of tables, charts, diagrams, histograms on the distribution of species according to the ecological factors i.e. humidity, temperature, soil chemical reaction, ecological categories of bioforms, phytogeographic and cytogenetic elements. The succession dynamics, the importance, and the sustainable and eco-protective management of these meadows were dealt with in our study. The results thus obtained were compared with four reference papers of some authors who have carried out research in different geographical areas. We found the rare, endangered, endemic species for which suitable household and conservation measures have been proposed.

Keywords: bioforms, categories, coenotaxa, management, meadows, phytocenoses, resulted.

INTRODUCTION

The vegetation of the meadows of the Biharia Massif, the Western Carpathians has a very large potential for the grass production needed to feed the domestic and wild fauna, yet insufficiently known from the point of view of the floristic composition, the structure of the ecological groups, as a depository of the rare germplasm genetic resources, and for its rare species ofen dangered, endemic, medicinal, aromatic plants, and from the the sustainable management point of view.

Numerous papers have been written about the meadows of the Romanian Carpathians by the pratologists scientists (Pușcaru-Soroceanu et al., 1963, 1981; Pușcaru et al., 1956; Samoilă et al., 1979; Anghel and Turcu, 1985; Anghel et al., 1965, 1967, 1985; Buia et al., 1962; Buia et al., 1960; Resmeriță, 1970, 1975; Cernelea and Bistriceanu, 1977; Cernelea and Simtea, 1985; Cernelea, 2004; Coldea et al., 2012).

Starting from the scientific work of the ancestors we attempt in this work to broaden the scope of scientific understanding and interdisciplinary approach of the meadows dominated by the phytocenoses of the association *Scorzonero roseae-Festucetum nigricantis* (Pușcaru et al., 1956; Coldea, 1987).

The association brings together the primary, permanent meadows, included in a natural ecosystem of community interest, hosting its habitat on the sub-alpine floor of the Biharia Massif, Western Carpathians.

The purpose of the research consists in the elaboration of a phytocenologic, ecological, bioeconomic and ecoprotective study, of the living soil cover made by the natural meadows of *Festuca nigrescens* and *Scorzonera rosea*.

Received 14 January 2020; accepted 8 March 2021.

In order to achieve this goal, we have set ourselves as research objectives and questions to answer the following:

- establishing the floristic composition of the meadows and development of the association table, encompassing the values of the ecological and biodiversity indices;
- identification of the coenotaxonomy related groups of the association with regard the alliance, order, class and ecological characterization of the species, through the analysis of the type of bioform, phytogeographic element, cytogenetic karyotype; requirements in terms of moisture, temperature and soil chemical reaction;
- syndynamics or evolution direction of the association phytocenoses for a certain stage in the existence of the *Festuca nigrescens* and *Scorzonera rosea* meadow ecosystem;
- economic importance through the appreciation of the pasture value, the weight of the medicinal, aromatic and honey species;
- establishing the sustainable management method of the meadows and the measures to protect the habitat, in which some of the rare, endangered, vulnerable and endemic species have found shelter.

Such phytocenoses were reported by Pușcaru et al. (1956), in the Bucegi Mountains; Csűrös and Resmeriță (1960), in the Southern and Eastern Carpathians; Boșcaiu and Marossy (1979), in the Cepelor Valley - the Bihor Mountains; Resmeriță (1979), in the Maramureș Mountains; Beldie (1967), in the Bucegi Mountains; Dihoru (1975), in the Siriu Mountain; Pușcaru-Soroceanu et al. (1981), in the Făgăraș Mountains; Coldea (1987, 1991), in Rodnei Mountains; Coldea and Pop (1988), in Cozia Mountain; Alexiu (1998), in Iezer-Păpușa Mountains; Sârbu et al. (1999), in Lăcăuți-Izvoarele Putnei Reservation; Mihăilescu, (2001) in Piatra-Craiului Mountains; Nechita (2003), in Hășmaș Mountains; Niculescu (2004), in Luncavățului water basin (Vâlcea); Chifu et al. (2014), in the Romanian Carpathians; Nicolaie (2005), in the Bucegi Mountains and Ursu (2013), in the upper basin of the Arieș Valley.

MATERIAL AND METHODS

The scientific research was carried out in the Apuseni Mountains (Western Charpatians), namely the district of Southern Bihor, the Biharia Massif. The biological material surveyed consists of subalpine natural meadows, dominated by *Festuca nigrescens* and *Scorzonera rosea*, in co-dominance with *Nardus stricta*, wide spread in the researched area, and colonizing an area of about 1200-1500 ha, especially in the forest sites Cucurbăta Big Peak, the saddle between Cucurbăta Big Peak and Cucurbăta Small Peak and on the upper third of the southern slope of Church Hill. To examine the structure of the subalpine meadow living soil cover dominated by *Festuca nigrescens* we used the phytosociological research methods of the Central-European school elaborated by Braun-Blanquet (1964) and adapted by Borza and Boșcaiu (1965), to the particularities of the vegetation in our country. The quantitative criterion pursued in the itinerary research of the phytocenoses of the association *Scorzonero roseae-Festucetum nigricantis* was the abundance and dominance of the phytoindividuals according to the Braun-Blanquet scale completed by Tüxen (1955), in conjunction with the establishment of the constancy classes (K=I-V). The data necessary to decipher the structure of the meadow living soil cover and to goin depth with the characterisation of the phytocenoses of the association come from the phytocenologic surveys. A number of 20 phytocenologic surveys were performed in the most representative phytocenoses during the optimum vegetation period. The homogeneous floristic and physiognomic sample surfaces with a size ranging between 50-100 m^2, were selected from 11 surveys and recorded in the phytocenologic table. This table contains information regarding the floristic (plant species or biodiversity) and coeno-taxonomic composition, the groups related coenotaxonomy (alliance, order, class) of plant populations that make up the phytocenosis of the association with regard the type of bioform, phytogeographic element,

the value of the phytogeographic element, the value of ecological indices (moisture, temperature, soil chemical reaction), genetic karyotype, number of surveys, altitude (m.a.s.l.), area (m^2), degree of soil cover (%), differentiated by vegetation layers or synusia cover.

The identification and name of the association, was made on the basis of the floristic criterion, with the help of the specific and dominating species relevant for the association, in accordance with the provisions of the International Code of Phytosociological Nomenclature developed by Weber et al. (2000). The classification in the types of bioforms was done after the scale developed by Raunkiaer (1937), improved by Braun-Blanquet (1964), the synthesis works elaborated by Ellenberg (1979), Pop (1977, 1982), Sanda et al. (1983, 2003, 2008), Ciocârlan (2009), Burescu and Toma (2005), Doniță et al. (2005), while the distribution by phytogeographic elements was made according to the classification adopted by Meusel and Jäger (1992).

Pastures analysis by categories of ecological indices, moisture (M), temperature (T) and soil chemical reaction (R), was performed according to the works of Sanda et al. (1983, 2003); these scientists adapted the ecological indices values (MTR) according to Ellenberg (1979), for Central Europe, on a scale graded from 1 to 9, which we tailored to the specific pedoclimatic conditions of Romania, and thus using a scale graded between 1 and 6. Cytogenetic analysis of the species, by karyotype was made according to the works of the authors Sanda et al. (2003), Ciocârlan (2009).

In the phytocenologic, ecological, karyological and bioeconomic study of the meadows, dominated by *Festuca nigrescens* and *Scorzonera rosea*, we paid special attention to the analysis of bioforms, phytogeographic elements, ecological indices, and cytogenetic categories by interpreting graphically their share using spectra in histograms and charts. At the end of the phytocenologic table, the synthetic phytocenologic indices, constant (K) and average abundance-dominance (ADm), were recorded in the last two columns.

Constance (K) highlights the degree of cenotic fidelity of each species to the phytocenosis environment of the association.

Average abundance-dominance (ADm) highlights the percentage of average soil cover by each species according to a scale coded as follows: "+"=0.5%, "1"=5%, "2"=17.5%, "3"=37.5%, "4"=62.5%, "5"=87.5%.

The characterization and classification of meadows surveyed in the habitat type was done according to works on habitats and forest sites of community importance in Romania of Doniță et al. (2005), Schneider and Drăgulescu (2005), Drăgulescu et al. (2007).

RESULTS AND DISCUSSION

The meadows of *Festuca nigrescens* and *Scorzonera rosea* grow on acid brown, cryptopodzolic soils, podzols, alpine meadow soils, rich in humus with short depth (22-44 cm) and with a strongly acid reaction (pH=4-4.5), districambo soil, kind of slightly moist soils, with variable moisture, and with a depth substrate of crystalline rock-shale. The relief is diversified ranging from the relatively smooth plateau, to moderate slopes (0-18°), with predominantly southern exposition, located at an altitude between 1572 and 1835 m.

The floristic composition or the specific biodiversity

The floristic inventory of the phytocenoses of the association *Scorzonero roseae-Festucetum nigricantis* contains a total of 35 cormophytes (Table 1a and 1b), which shows a poorer biodiversity caused by the hard living conditions in the habitat and partly by intensive grazing.

Table 1a. ***Scorzonero roseae-Festucetum nigricantis*** (Puşcaru et al., 1956; Coldea, 1987) [(Syn.: ***Festucetum rubrae montanum*** (Csűrös and Resmeriţă, 1960)]

	Biof.	Phyto elem.	M	T	R	Kar
Car. ass.						
Scorzonera rosea	G	Alp-Carp-B	2	0	4	D
Festuca nigrescens	H	Cp-Bo	3	1	2	P
Potentillo-Nardion						
Nardus stricta	H	Eua	0	0	1.5	D
Campanula serrata	H	End-Carp	0	2.5	0	DP
Potentilla ternata	H	Carp-B	0	1.5	2	CN
Carex pallescens	H	Cp-Bo	3.5	3	3	P
Campanula rotundifolia ssp. *polymorpha*	H	End-Carp	2	0	3	DP
Thymus bihoriensis	Ch	End-Carp	2.5	2	4	CN
Genistion pillosae						
Vaccinium vitis - idaea	Ch-nPh	Cp-Bo	3	2	1	D
Vaccinium myrtillus	Ch-nPh	Cp (Bor)	0	2	1	P
Nardetalia						
Hypericum maculatum	H	Eua	4	3	2	D
Luzula sudetica	H	Arct-Alp-Eua	0	2	2	P
Antennaria dioica	H(Ch)	Eua (Cp)	3	1	2.5	P
Nardo-Callunetea						
Luzula campestris	H	Cp (Bor)	3	0	3	DP
Potentilla erecta	H	Eua	4	1	0	P
Achilea distans	H	Alp-Carp-B	2.5	3	4	P
Vaccinio-Piceetea						
Dechampsia flexuosa	H	Cp (Bor)	2	0	1	DP
Juniperus communis ssp. *alpina*	mPh	Cp (Bor)	2	0	0	D
Laserpitium krapfii	H	Alp-Carp-B	0	0	3	CN
Homogyne alpina	H	Alp-E	3.5	2.5	2.5	P
Vaccinium uliginosum ssp. *microphyllum*	Ch- nPh	Cp	0	0	1	P
Picea abies	MPh	E	0	0	0	D
Bruckenthalia spiculifolia	nPh	Carp-B	2.5	2.5	1.5	P
Calamagrostis arundinacea	H	Eua	2.5	3	2	P
Luzula sylvatica	H	Ec	3.5	2.5	2	DP
Hieracium transylvanicum	H	Carp-B	3	0	0	CN
Molinio-Arrhenatheretea						
Molinia caerulea	H	Eua	4	3	0	P
Agrostis canina	H	Eua	3.5	0	0	D
Agrostis capillaris	H	Cp (Bor)	0	0	0	P
Laserpitium prutenicum	H	Ec	4	3.5	4	D
Betulo-Adenostyletea						
Knautia dipsacifolia	H	Ec	3.5	2.5	0	P
Veratrum album	G	Eua	4	2.5	4	D
Epilobietea angustifolii						
Salix silesiaca	mPh	Carp-B-Sudet	4	2	2	D
Salix caprea	mPh	Eua	3	3	3	D
Variae syntaxa						
Festuca gigantea	H	Eua	4	3	2.5	P

Places and dates of surveying: 1-5 - Cucurbăta Big Peak (03.08.2018); 6-8 - Saddle between Cucurbăta Big Peak and Cucurbăta Small Peak (03.08.2018); 9-11 - Church Hill slope (04.08.2018).

Table 1b. ***Scorzonero roseae-Festucetum nigricantis*** (Puşcaru et al., 1956; Coldea, 1987) [(Syn.: ***Festucetum rubrae montanum*** (Csűrös and Resmeriţă, 1960)]

Survey no.	1	2	3	4	5	6	7	8	9	10	11	K	ADm
Altitude (m.a.s.l.)	1835	1829	1832	1815	1831	1785	1781	1780	1572	1606	1621		
Exposition	SV	V	S	NV	S	E	-	-	S	S	S		
Slope (º)	5	4	6	3	18	15	0	0	15	8	4		
Vegetation cover (%)	86.5	86.5	87.5	92.5	91.5	100	98.5	93.0	78.5	96.5	78.5		
Surface surveyed (m^2)	100	100	100	100	100	100	50	100	100	100	100		
Car. ass.													
Scorzonera rosea	+	+	+	+	+	+	+	+	+	+	+	V	0.50
Festuca nigrescens	2	2	2	2	3	3	2	3	4	4	2	V	30.94
Potentillo-Nardion													
Nardus stricta	4	4	4	4	3	3	4	3	1	2	3	V	41.13
Campanula serrata	+	+	+	+	+	+	.	.	.	+	+	IV	0.36
Potentilla ternata	.	.	.	.	.	1	+	1	.	.	.	II	0.95
Carex pallescens	.	+	.	.	.	.	.	.	.	.	.	I	0.04
Campanula rotundifolia ssp. *polymorpha*	.	.	+	.	.	.	.	.	.	+	.	I	0.09
Thymus bihoriensis	.	.	.	.	+	.	.	.	.	+	.	I	0.09
Genistion pillosae													
Vaccinium vitis - idaea	+	.	.	.	+	+	+	+	+	+	+	IV	0.77
Vaccinium myrtillus	.	+	+	.	1	+	.	+	+	+	2	IV	2.31
Nardetalia													
Hypericum maculatum	+	+	+	.	+	+	+	.	+	+	+	V	0.40
Luzula sudetica	.	+	+	+	.	+	.	+	.	.	.	III	0.22
Antennaria dioica	.	.	.	+	.	+	.	.	.	.	.	I	0.09
Nardo-Callunetea													
Luzula campestris	+	.	+	+	.	+	+	.	+	+	+	IV	0.36
Potentilla erecta	+	+	+	.	+	+	.	.	+	.	.	III	0.27
Achilea distans	+	.	.	.	.	.	.	.	.	.	.	I	0.04
Vaccinio-Piceetea													
Dechampsia flexuosa	+	+	+	+	+	1	1	1	1	+	+	V	2.13
Juniperus communis ssp. *alpina*	+	+	+	+	1	+	1	+	+	+	+	V	1.68
Laserpitium krapfii	+	.	+	+	+	.	+	.	+	+	+	IV	0.36
Homogyne alpina	+	+	.	.	+	.	.	.	.	.	.	II	0.13
Vaccinium uliginosum ssp. *microphyllum*	.	.	.	+	.	1	1	1	.	.	.	II	1.40
Picea abies	.	.	.	.	.	.	.	.	+	1	+	II	0.54
Bruckenthalia spiculifolia	.	.	.	.	.	.	.	.	+	1	+	II	0.54
Calamagrostis arundinacea	.	.	.	.	+	.	.	.	.	.	.	I	0.04
Luzula sylvatica	.	.	.	.	.	.	.	.	+	.	.	I	0.04
Hieracium transylvanicum	.	.	.	.	.	.	.	.	.	.	+	I	0.04
Molinio-Arrhenatheretea													
Molinia caerulea	+	+	+	.	+	.	+	+	.	+	.	IV	0.27
Agrostis canina	+	+	+	+	+	.	.	.	.	.	.	III	0.22
Agrostis capillaris	.	.	.	.	+	.	.	.	+	.	.	I	0.09
Laserpitium prutenicum	.	.	.	.	.	1	.	.	.	.	.	I	0.45
Betulo-Adenostyletea													
Knautia dipsacifolia	.	.	+	.	.	.	.	.	.	.	.	I	0.09
Veratrum album	.	.	+	.	.	.	.	.	.	.	.	I	0.09
Epilobietea angustifolii													
Salix silesiaca	.	.	.	.	.	.	.	.	.	+	.	I	0.09
Salix caprea	.	.	.	.	.	.	.	.	.	.	+	I	0.09
Variae syntaxa													
Festuca gigantea	.	+	.	.	.	.	.	.	.	.	.	I	0,09

Places and dates of surveying: 1-5 - Cucurbăta Big Peak (03.08.2018); 6-8 - Saddle between Cucurbăta Big Peak and Cucurbăta Small Peak (03.08.2018); 9-11 - Church Hill slope (04.08.2018).

The species that are dominant and shape the association are *Festuca nigrescens,* with a general coverage of 30.94%, maximum constancy (K=V) and *Nardus stricta,* with a general coverage of 41.13%, maximum constancy (K=V), both in codominance.

Characteristic species i.e. *Scorzonera rosea*, *Campanula serrata (C. napuligera), Campanula rotundifolia* ssp. *polymorpha (C. polymorpha), Thymus bihariensis (T. marginatus), Luzula sudetica* confers the association a regional specificity by which the meadows of *Festuca nigrescens* with *Scorzonera rosea* from the Apuseni Mountains (Western Carpathians), differ from those in the remaining Carpathians and can be considered as a geographical vicariance of the *Nardo-Festuca* species in the Romanian Carpathians, subordinated to the association *Scorzonero roseae-Festucetum nigricantis*.

Groups coenotaxonomy and structure

Along with the dominant and characteristic species *Festuca nigrescens, Viola declinata, Scorzonera rosea,* in the population of phytocenoses, a number of 16 different species vegetate in the case of the basic coenotaxa of the association, alliance *Potentillo-Nardion: Nardus stricta, Potentilla ternata, Carex pallescens, Thymus bihariensis,* order: *Nardetalia: Hypericum maculatum, Luzula sudetica, Antennaria dioica,* class *Nardo-Callunetea: Luzula campestris, Potentilla erecta, Achillea distans*. A number of 19 species are transgressive in the classes *Vaccinio-Piceetea, Molinio-Arrhenatheretea, Betulo-Adenostyletea* and *Epilobietea angustifolii*.

Ecological characterization of the meadows plant species

To do that we have carefully analysed the phytocenoses of the association by ecological categories of bioforms, phytogeographic elements, ecological indices and genetic categories.

Composition by bioform categories

The bioforms criterion shows us, how different plant species manage to protect their regenerative parts (vegetative buds, generative parts) during periods unfavourable to vegetation (cold winters, drought), as a result of corm differentiation, and their morphological, anatomical, physiological and ecological adaptation to habitat conditions during a long evolutionary process.

The analysis of bioforms, from the Biharia Massif-Bihor Mountains massif meadows, is paramount for the characterization of the local flora species, since it highlights some features of habitats and influences exerted on them by the environmental, natural and anthropic factors.

The spectrum of bioforms (Figure 1), show the obvious dominance of the Hemicryptophytes (68.58%), followed by Chamaephytes (11.43%), and by Mesophanerophytes (8.58%), Geophytes (5.71%), Megaphanerophytes (2.85%) and Nanophanerophytes (2.85%).

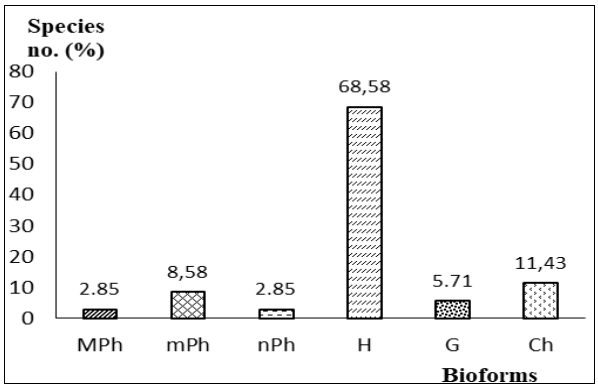

Figure 1. Spectrum of bioforms from the association *Scorzonero roseae-Festucetum nigricantis*

Legend:
MPh=Megaphanerophytes, mPh=Mesophanerophytes, nPh=Nano-phanerophytes, H=Hemicryptophytes, G=Geophytes, Ch=Chamaephytes.

Composition by categories of phytogeographic elements

The distribution of the phytogeographic elements presented by the histogram (Figure 2) shows that in the phytocenoses of the meadows of association *Scorzonero roseae-Festucetum nigricantis*, the species of Eurasian origin (28.58%) are dominant, followed at a very narrow range from the circumpolar ones (25.72%), and by Carpathian-Balkan (11.43%), Alpine-Carpathian-Balkan (11.43%), Central

European (8.57%), European (2.85%) and Arctic-Alpine (2.85%) species. The slightly lower percentages of the Carpathian-Balkan and Alpine-Carpathian species, show us the floristic connections of vegetation with the Balkan Mountains and with the Alps.

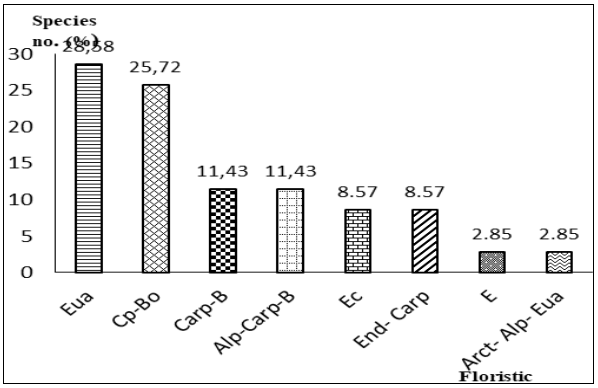

Figure 2. Spectrum of floristic elements in the association *Scorzonero roseae-Festucetum nigricantis*
Legend: Eua=Eurasian, Cp-Bo=Circumpolar-Boreal, Carp-B=Carpathian-Balkan, Alp-Carp-B=Alpine-Carpathian-Balkan, Central European=EC, End-Carp=Carpathian endemite, E=European, Arct-Alp-Eua=Arctic-Alpine-Eurasian.

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

The diagram of the ecological indices (Figure 3), shows that compared to the soil moisture, the mesophilic species ($M_{3-3.5}$= 31.42%) are dominant, in the meadows of *Festuca nigrescens*, followed at a close range by the amphi-tolerantones (M_0=25.71%), xero-mesophylls ($M_{2-2.5}$= 22.84%) and meso-hydrophilic ($M_{4-4.5}$=20.0%) species.

Depending on the temperature and the solar radiation of the subalpine habitat, in which the phytocenosis these meadows develops, the species adapted to large variations of temperature are relevant i.e. eritherms (T_0=34.28%), microtherms at low temperatures ($T_{2-2.5}$=31.42%), hekistotherms ($T_{1-1.5}$=8.57%), while there are numerous species adapted to average and mesothermal specific temperatures ($T_{3-3.5}$=22.58%).

With regard the chemical reaction of the soil, the meadows of the association are dominated by acidophilous (R_2=28.57%), strongly acidophilous (R_1=17.41%), acid-neutrophilous (R_3=14.28%) weakly acid-neutrophilous (R_4=14.28%) species, and a rather large number of euriionic species (R_0=25.71%), are indifferent to the pH reaction of the soil.

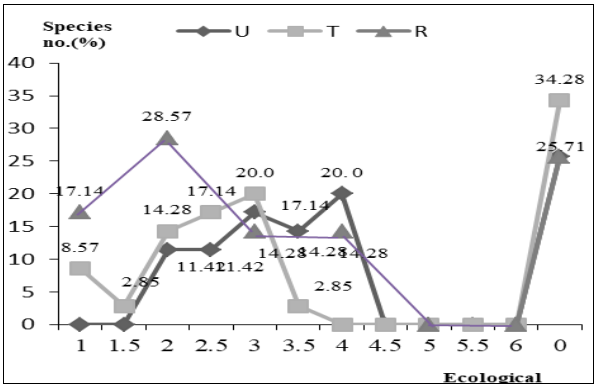

Figure 3. Ecological index diagram for the association *Scorzonero roseae-Festucetum nigricantis*
Legend: U=soil moisture, T=air temperature, R=soil chemical reaction.

Composition by karyotype genetic categories

From a cytogenetic point of view (Figure 4), most species are polyploids (42.86%), since they have the highest ability to colonize the territory and to adapt to the extreme living conditions of the subalpine climate. The diploid species have an average share (31.43%) and represent the reserve of genes for evolution, and the diplo-polyploids species (14.29%) and those with an unknown karyotype (11.42%) have a much lower participation in the total.

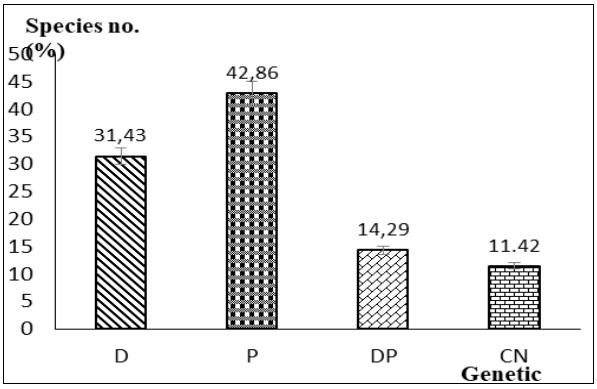

Figure 4. The karyological spectrum of the association *Scorzonero roseae-Festucetum nigricantis*
Legend: D=Diploid, P=Polyploid, DP=Diplo-polyploid, CN=Unknown karyotype.

Sindynamics or succession dynamics of the meadows

Amid increased soil acidity and high oligotrophism, due to the ability of microtrophic nutrition (Coldea, 1990; Chifu et al., 2014), *Nardus stricta* species has a fulminant development, and competes with *Festuca nigrescens* the latter being over whelmed and eliminated progressively, and the meadows evolve towards monodominant phytocenoses of *Nardus stricta*, specific to the association *Violo declinatae-Nardetum*.

After the cessation of pasture, these meadows can be invaded in time by *Juniperus communis* ssp. *alpina*, or by *Picea abies*, and the evolution of the vegetation unfolds towards the bush phytocenoses specific to the associations *Junipero-Bruckenthalietum spiculifoliae*, and *Bruckenthalio-Piceetum abietis*.

Economic, aesthetic and eco-protective importance

These meadows are widespread at high altitudes and are used for extensive and selective grazing, from summer to autumn, which favours spreading of the invasive species *Nardus stricta*.

The pastoral value is heterogeneous, ranging from mediocre to good, with yields of 5-10 t/ha green mass (g.m.), a grazing capacity of 0.5-1.5 beef cattle animal units (AU) per hectare and a coefficient of 85-90% grass consumption.

The meadow is depreciated by the fact that significant areas are invaded by the invaluable species of *Nardus stricta* (mat-grass), *Deschampsia flexuosa* (wavy hair-grass), woody vegetation represented by *Juniperus communis* ssp. *alpina*, undershurbs of *Vaccinium myrtillus* and *Vaccinium vitis-idaea* and young plants of *Picea abies* (spruce). These meadows can be improved both qualitatively and quantitatively by implementing suitable agro-technical measures. They are important in the local industry, because in their floristic composition, there are a number of six medicinal species, six honey species, five decorative species, and three culinary and aromatic species.

The dominant species *Festuca nigrescens* and *Nardus stricta* through their strong rhizomes and the bushy shrubs, are swarding strongly the soil playing a critical role in the soil controlling, soil erosion and regulating the water circuit in nature. Through their polychromatic appearance of seasonal colours during flowering, these plants paint a geographical, mystical, recreational landscape that can be used for tourism purposes.

Management and conservation of meadows in the Biharia Massif

The meadows made by the phytocenoses of the association *Scorzonero roseae-Festucetum nigricantis,* have a high conservation value, and are part of the South-eastern Carpathian endemites habitat, of European priority-code 6230*, R 3608-Mountain and subalpine meadows of *Nardus stricta*, *Festuca nigrescens*, rich in species growing on silicon soil substrates (Doniță et al., 2005; Gafta and Mountford, 2008). Many endemic species *Thymus bihoriensis*, *Campanula rotundifolia* ssp. *polymorpha*, *Campanula serrata*, rare *Scorzonera rosea*, *Bruckenthalia spiculifolia*, *Laserpitium prutenicum*, *Vaccinium uliginosum* ssp. *Microphyllum*, have found shelter in these meadows (Oltean et al., 1994; Ciocârlan, 2009).

The experiments carried out regarding the floristic composition of the *Nardus stricta* meadows, by altitudinal levels (Maruşca, 1997) show a decreasing trend in the number of species, i.e. a six species decrease for every 100 m altitude going upwards.

In order to counteract the reduction of biodiversity by altitude in the natural subalpine meadows of *Festuca nigrescens* in the Biharia Massif and to preserve their identity, and to maintain a favourable conservation status, it is necessary to adopt specific management and monitoring measures such as: ensuring optimal loading with animals for the consumption of the whole quantity of phytomass used a feed; reducing as much as possible the litter resulting from leftovers after feeding the animals; the introduction of rational grazing on plots; observing an optimal sheepfolding, respectively 5-6 nights from one sheep per

6 m^2 or a cattleper 6 m^2; observing the optimum grazing time of about 80 days, corresponding to the meadows at this altitude; periodic quantification of biodiversity indices for the entire meadow and of numerical abundance indices for populations of rare and protected species.

The main objective of this study, was to identify and characterize the meadows phytocenoses for the association *Scorzonero roseae-Festucetum nigricantis*, from the Biharia Massif, the Apuseni Mountains (Western Carpathians). The results are substantiated with solid scientific data on the distribution of the 35 species, in the floral composition of the association, by ecological categories of bioforms, phytogeographic elements and cytogenetic categories. Moreover, the results were completed with the statistical analysis of the data according to the distribution of species by categories of ecological indices, and according to their requirements with respect to soil moisture, temperature and chemical reaction of the soil.

The scientific results we obtained, were illustrated, both numerically and as percentage by means of tables and charts with histograms and diagrams, and the outcomes can be compared with the results of more or less complex recent studies carried out by (Mihăilescu, 2001; Nechita, 2003). Thus, for the Eastern Carpathians-the Hăşmaş Massif and the Bicaz Gorges area, Nechita (2003), describes the phytocenoses of the *Scorzonero roseae-Festucetum nigricantis* association in the secondary meadows, resulting from deforestation, in the area of coniferous forests at altitudes ranging between 1200-1600 m, by carrying out seven phytocenologic surveys. The association brings together a number of 58 species, compared to only 35 species identified by us, of which 16 species (a similar number with the number found in the association described by us) are included in the basic coenotaxa of the associations *Potentillo-Nardion* (six species), *Nardetalia* et *Nardo-Callunetea* (eight species); two species are specific for the association and a number of 42 species are accompanying the association without being differentiated by vegetation classes, compared with 19 species in the phytocenoses described by us as transgressive species from the vegetation classes *Vaccinio-Picetea* (10 species), *Molinio-Arrhenatheretea* (four species), *Betulo-Adenostyletea* (two species), *Epilobietea angustifolii* (two species), *Variae syntaxa* (one species). The characteristic species *Scorzonera roseae*, is present in all 7 surveys, with a maximum constant (K=V), average abundance-dominance (ADm=1.78%), the results being very close to those obtained by us.

The species *Festuca nigrescensis* characteristic for but also the dominant in the association with a maximum constancy (K=V), average abundance-dominance 33.5% - these results are almost identical to those obtained by us, K=V, average abundance-dominance = 30.94%. There are some differences with respect to the species *Nardus stricta* characterised by a low constancy (K=III), and that species is present only in four out of the seven surveys, with a very low average abundance-dominance i.e. 0.28% as against our results where it has maximum constancy (K=V) and the average abundance-dominance is 41.13%; this phenomenon can be explained by the fact that the phytocenoses of the association from the Hăşmaş Mountains vegetate on acidic brown soils, but also on the weak acid-neutrophilic soils, on conglomerates and sandstone with limestone compared to the habitat of the exclusively acidic soils from Bihor Mountains with crystalline shale soil substrate.

From an ecological point of view, the phytocenoses of the meadows of the Hăşmaş Mountains are composed of a mix of mesophiles (54%), xero-mesophiles (24%), mesotherms (39%), eurithermes (36%), microtherms (20%), hekistotherms (5%), euriionic (36%), acid-neutrophilous (24%), acidophilous (19%) species compared to the meadows of the Bihor Mountains, the Biharia Massif, whose composition includes 31.42% mesohophiles, 28.57% eurihides, 22.84% xero-mesophiles, 37.14% eurotherms, 31.42% microtherms, 22.58% micro-mesotherms,

8.26% hekistotherms, 28.57% acidophilous, 25.71% euryionics and 17.14% extreme-acidophilous.

It results that the association described by us, has an oligo-mesotrophic, mesophilic, micro to eurithermal, acidophilic characteristics, in comparison with the mesophilic, euryionic to acid-neutrophilic mesotherm al characteristics of the phytocenoses of meadows described by Nechita (2003).

The spectrum of bioforms in the Bihor Mountains meadows is dominated by the hemicryptophytes (68.58%), chamaephytes (11.43%), mesophanerophytes (8.58%), geophytes (5.71%), while the bioforms living in the Hăşmaş Mountains meadows are made up of hemicryptophytes (76%) terophytes (16%), chamaephytes (4%) and geophytes (4%). The categories of bioforms and the percentages for the species that make up the two associations in the Biharia and Hăşmaş massifs are obviously different due to the different pedoclimatic conditions of the habitats in which they develop.

The phytogeographic spectrum of the species populating the Hăşmaş Massif highlights the clear dominance of Eurasian species (43%) followed by European (27%), Circumpolar (9%), Central-European (7%), Alpine-Carpathian (5%), Cosmopolite (3%), Carpathian-Balkan (2%), Ponto-Mediterranean (2%), Adventive (2%) species, while the phytogeographic spectrum of the species from the Biharia Massif highlights the share of Eurasian species in a much smaller percentage of only 28.58%, followed closely by Circumpolar-Boreal (25.72), Carpathian-Balkan (11.43%), Alpine-Carpathian-Balkan (11.43%), Carpathian endemites (8.57%), Central-European (8.57%) and Arctic-Alpine-Eurasian (2.85%) species. The high percentages of Circumpolar-Boreal, Carpathian-Balkan, Alpine-Carpathian-Balkan, Carpathian endemites and Arctic-Alpine-Eurasian species in the meadows of the Biharia Masif make the clear difference between the phytocenoses of the two associations.

Phytocenoses of the association *Scorzonero roseae-Festucetum nigricantis* were also been described in the Piatra Craiului Massif - the Eastern Carpathians by Mihăilescu (2001), on the north-western slopes, at an altitude ranging between 850-910 m, which is much lower than the 1580-1835 m altitude of Biharia Massif. The floristic inventory of the association comprises 99 species, of which 17 species characterize the alliance, order, and class, and 82 species are transgressive from other vegetation classes, providing phytocenoses with mesophilic (47%), xero-mesophilic (33%), mesothermal (37%), microtermal (22%), acid-neutrophilic (23.7%), weak acid-neutrophilic (23.7%) and acidophilic (10.2%) nature.

The spectrum of bioforms is composed of a mixture of Hemicryptophytes (74%), chamaephytes (11%), geophytes (8%), and therophytes (7%). The spectrum of phytogeographic elements highlights the dominance of Eurasian species (48.3%) followed by Central-European (15.3%), Circumpolar (9.3%), Carpathian-Balkan (3.4%) and Dacian-Balkan (3.4%).

It can be noticed that in the phytocenoses of the association found in Piatra Craiului Massif, the number of Circumpolar-Boreal species is much smaller, and both the Alpine-Carpathian, Carpathian endemites and Arctic-Alpine-Eurasian species are missing in the floristic composition due to the fact that these meadows are specific for a mountain floor habitat which living conditions are very different from those found on sub-alpine floor such as the meadows growing in the Bihor Mountains.

From a cytogenetic point of view, the species with diploid (55.5%) and polyploid (39.5%) karyotype are dominant in these meadows, and these are different from the meadows we have studied in which the polyploid species (42.86%) are dominant followed by diploids (31.43%), diplo-polyploids (14.29%) and those of unknown karyotype (11.42%).

CONCLUSIONS

The natural, primary meadows of the Biharia Massif, have an oligo-mesotrophic, mesophilic, micro-thermal, acidophilic nature, as an result of the interactions with the environmental factors, specific to the

subalpine habitat. Depending on the unfavourable season of vegetation cold winter, dry summer, the hemicryptophyte bioforms manifest both numerically and as percentage in the meadows, followed by the chamaephytes.

Depending on their genetic and historical origin, the geographical distribution area in which the speciation process took place, the Eurasian species predominate in the phytocenoses of the association over which the Circumpolar, Carpathian-Balkan, Alpino-Carpatho-Balkan, and Central-European ones have overlapped.

With regard the genetic karyotype, the meadows are dominated by polyploid species with high territorial colonization capacity and better adapted to the pedoclimatic conditions; these species are followed by the diploids that store the genetic reserve for evolution.

The floristic composition of the meadows has been established, we found the rare, endangered, endemic species for which suitable household and conservation measures have been proposed.

ABBREVIATIONS

The following categories of abbreviations are used in this paper:

(i) 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 may be: xerophilic=$M_{1-1.5}$, xero-mesophylic=$M_{2-2.5}$, mesophylic=$M_{3-3.5}$, meso-hydrophilic=$M_{4-4.5}$, eurihydrous=M_0.

Considering air temperature, the plant species surveyed can be: hekistothermal (cryophites)=$T_{1-1.5}$, microthermal=$T_{2-2.5}$, micro-mesothermal=$T_{3-3.5}$, eurithermal (thermally amphi-tolerant)=T_0.

In terms of chemical reaction of the soil the surveyedplant species can be: strongly acidophilous=R_1, acidophilous=R_2, acid-neutrophilous=R_3, weak acid-neutrophilous=R_4, euriionic (ionic amphi-tolerant)=R_0.

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

(iii) The constancy of the species or 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%.

REFERENCES

Alexiu, V., 1998. *Vegetation of the Iezer-Păpuşa Massif. A Phytocenological study*. "Cultura" Publishing House, Piteşti: 242-262.

Anghel, G., Niedermaier, K., Burcea, P., Şerbănescu, I., 1965. *The study and mapping of pastures in the Crinț body, the Cibin Mountains*. Botany Communications, Society of Natural Geographic Sciences, Bucharest, 3: 47-80.

Anghel, G., Ciocârlan, V., Turcu, G., Baciu, E., Ungureanu, L., 1967. *The flora and vegetation of the meadows in the Sasului-Muscel hill.* Scientific Papers, Agronomic Institute „Nicolae Bălcescu" Bucharest, Series A, 10: 275-301.

Anghel, G., Cardaşol, V., Neacşu, M., Ţucra, I., Vasu, A., 1985. *The meadows of the Cindrel Mountains-Cibinului Mountains, Sibiului Mountains.* Scientific Papers, Institute of Research and Production for the Cultivation of Meadows "Măgurele-Braşov" in the Romanian Carpathians, 10: 279-295.

Anghel, G., and Turcu, G., 1985. *The meadows in the Bran-Rucăr corridor.* Scientific papers of the Institute of Research and Production for the Cultivation of Meadows "Măgurele-Braşov". The meadows of the Romanian Carpathians, Bucharest, 10: 215-233.

Beldie, A., 1967. *The flora and vegetation of the Bucegi Mountains*. Publishing House of the Romanian Academy, Bucharest.

Borza, A., and Boşcaiu, N., 1965. *An introduction to the study of the living soil cover*. Publishing House of the Romanian Academy, Bucharest.

Boşcaiu, N., and Marossy, A., 1979. *Aspect of vegetation in the Cepelor Valley-Biharia Massif. Nymphaea*. Folia Naturae Bihariae Journal, Oradea, 7: 301-321.

Braun-Blanquet, J., 1964. *Phytosociology*. Springer-Verlag Publishing House, Berlin.

Buia, A., Safta, I., Păun, M., Pavel, C., 1960. *The grasslands of the Parang Massif. A Geobotanical study and their improvement*. Scientific Annals of

"Alexandru Ioan Cuza" University, Section 2, Biology, 6(2): 821-846.

Buia, A., Păun, M., Pavel, C., 1962. *In: Geobotanical study of the meadows, "The meadows in the Parâng Massif and their improvement"*. Agronomic Institute "Tudor Vladimirescu" of Craiova, Agrosilvică Publishing House, Bucharest.

Burescu, P., and Toma, I., 2005. *Handbook of practical botany work*. Publishing House of the University of Oradea, Oradea.

Cernelea, E., and Bistriceanu, C., 1977. *Cultivation and exploitation of mountain meadows*. Ceres Publishing House, Bucharest.

Cernelea, E., and Simtea, N., 1985. *The meadows of the Retezat Massif*. Scientific papers of the Institute of Research and Production for the Cultivation of Meadows "Măgurele-Braşov". The meadows of the Romanian Carpathians, Bucharest, 10: 309-323.

Cernelea, E., 2004. *Meadows and pasture in Retezat National Park*. Călăuza Publishing House, Deva.

Chifu, T., Irimia, I., Zamfirescu, O., 2014. *Phytosociological diversity of Romania's vegetation. Natural herbaceous vegetation*. European Institute Publishing House, Iaşi.

Ciocârlan, V., 2009. *The illustrated flora of Romania. Pteridophyta and Spermatophyta*. Ceres Publishing House, Bucharest.

Coldea, G., 1987. *Contributions to the syntaxonomic and ecologic study of some acidophilous-mezophill meadows in the subalpine belt of the Romanian Carpathians*. Contrib. Bot. Journal, Cluj-Napoca, 27: 121-131.

Coldea, G., and Pop, I., 1988. *Phytocenological research in Cozia Mountain*. Contrib. Bot. Journal, Cluj-Napoca: 51-55.

Coldea, G., 1990. *The Rodna Mountains. Geobotanical study*. Publishing House of the Romanian Academy, Bucharest.

Coldea, G., 1991. *Prodrome of plant associations of the South-East Carpathians (Romanian Carpathians)*. Documents Phytosociologiques, Publishing House: Camerino.

Coldea, G., Oprea, A., Sârbu, I., Sârbu, C., Ştefan, N., 2012. *The vegetable associations of Romania*. Cluj University Press Publishing House, Cluj-Napoca.

Csűrös, S., and Resmeriţă, I., 1960. *Studies on the grasslands of Festuca rubra in Transylvania*. "Contribuții Botanice" Journal, Cluj-Napoca: 149-173.

Dihoru, G., 1975. *The living soil cover of the Siriu Massif*. Publishing House of the Romanian Academy, Bucharest.

Doniţă, N., Popescu, A., Paucă-Comănescu, M., Mihăilescu, S., Biriş, I.A., 2005. *Habitats in Romania*. "Editura Tehnică Silvică" Publishing House, Bucharest.

Drăgulescu, C., Schneider, E., Benedek, A.M., 2007. *Phytodiversity of Carpathian habitats*. Publishing House of the University "Lucian Blaga", Sibiu.

Ellenberg, H., 1979. *Values of the vascular plants*. Scripta Geobotanica, 9: 1-121.

Gafta, D., and Mountford, O.J., 2008. *Manual for the interpretation of Natura 2000 habitats*. "Risoprint" Publishing House, Cluj-Napoca.

Maruşca, T., 1997. *Means of balancing the grazing pressure to save the biodiversity of the meadows in Romania*. 4th National Conference on Environmental Protection from Braşov, "Transylvania University", Braşov: 332-339.

Meusel, H., and Jäger, E.J., 1992. *Comparative Chorology of Central European Flora 3*. "Gustav Fischer Verlag" Publishing House, Jena.

Mihăilescu, S., 2001. *The flora and vegetation of the Piatra Craiului Massif*. "Vergiliu" Publishing House, Bucharest.

Nechita, N., 2003. *The flora and vegetation of the ecosystems from the Hăşmaş Massif, the Bicaz Gorges and the Red Lake*. Constantin Silata Foundation, Piatra Neamţ.

Nicolaie, C.D., 2005. *The flora and vegetation of the upper basin of the Prahova river*. PhD thesis, Institute of Biology of the Academy, Bucharest.

Niculescu, M., 2004. *Contributions regarding the study of the Nardo-Callunetea Prsg. 1949 class in the upper basin of Luncavăţ River (Vâlcea county)*. "Contribuții Botanice" Journal, Cluj-Napoca, 39: 89-93.

Oltean, M., Negrean, G., Popescu, A., Roman, N., Dihoru, G., Sanda, V., Mihăilescu, S., 1994. *Red list of top plants in Romania. Studies, abstracts, ecology documentation 1*. Romanian Academy, Institute of Biology, Bucharest, 1: 1-52.

Pop, I., 1977. *Ecological Biogeography*. Dacia Publishing House, Cluj-Napoca.

Pop, I., 1982. *Spontaneous and subspontaneous plants with economic value from the flora R.S.R.* Botanical Contributions, XXII: 131-142.

Puşcaru, D., Puşcaru-Soroceanu, E., Paucă, A., Şerbănescu, I., Beldie, A., Ştefureac, T., Tascenco, V., 1956. *Alpine meadows in the Bucegi Mountains*. Publishing House of the Romanian Academy, Bucharest.

Puşcaru-Soroceanu, E., Puşcaru, D., Buia, A., Burduja, C., Csűrös, S., Grâneanu, A., Velea, C., 1963. *Grasslands and meadows in the Romanian People's Republic. Geobotanical and agro-productive study*. Publishing House of the Romanian Academy, Bucharest.

Puşcaru-Soroceanu, E., Csűrös, S., Puşcaru, D. Popova-Cucu, A., 1981. *The vegetation of the meadows and pastures of the Făgăraş Mountains in the Southern Carpathians Phytocenology*. Stuttgart-Braunschweig, 9(2): 257-309.

Raunkiaer, C., 1937. *Plant life forms*. Clarendon Press, Oxford.

Resmeriţă, I., 1970. *Flora, vegetation and economic potential on the Vlădeasa Massif*. Publishing House of the Romanian Academy, Bucharest.

Resmeriţă, I., 1975. *Nardo-Callunetea Prsg. 1949 in the Romanian Carpathians*. Phytosociological documents, Lille, 1: 265-278.

Samoilă, Z., Safta, I., Grigore, S., Popa, T., Lauer, C., Teaci, D., Cresan, I., Coste, I., Arvat, N., Olteanu, D., Cristoi, I., 1979. *The types of permanent grasslands and their agro-economic value in: „Meadows of Banat"*. Agricultural technical propaganda editorial office, Bucharest: 57-64.

Sanda, V., Popescu, A., Doltu, M.I., Doniţă, N., 1983. *Ecological and phytocenological characterization of the spontaneous flora species of Romania*. Studies and papers on Natural Sciences of Bruckenthal Museum, Sibiu, 25: 1-126.

Sanda, V., Mihăilescu, S., Popescu, A., 2003. *Main characteristics of the beech forests from Bucegi Mountains (Romanian Carpathians)*. "Contribuţii Botanice" Journal, Cluj-Napoca, 38(2): 93-104.

Sanda, V., Öllerer, K., Burescu, P., 2008. *Phytocenoses in Romania. Syntax, structure, dynamics and evolution*. Ars Docendi Publishing House, University of Bucharest, Bucharest.

Sârbu, I., Ştefan, N., Oprea, A., 1999. *"Izvoarele Putnei" Natural Reservation (Vrancea County)*. "Buletinul Grădinii Botanice" Journal, Iaşi, 8: 83-92.

Schneider, E., and Drăgulescu, C., 2005. *Habitast and sites of community interest*. Publishing House of the University "Lucian Blaga", Sibiu.

Tüxen, R., 1955. *Das System der nordwestdeutschen Pfhanzengesellschaften Mitt D. Flour. Soz. Arbeit*. m.n. Folge, 5: 155-156.

Ursu, T.M., 2013. *The vegetation from the upper part of the Arieşul Mare-Arieşul Mic rivers basin (Bihor Mountains)*. PhD thesis, Babeş-Bolyai University, Cluj-Napoca.

Weber, H.E., Moravec, J., Theurillat, J.P., 2000. *International Code of Phytosociological Nomenclature*. 3rd edition, Journal of Vegetation Science 2, Opulus Press Uppsalla: 739-768.