CONTRIBUTIONS TO THE PHYTOSOCIOLOGICAL STUDY OF THE ASSOCIATION *Pulmonario rubrae-Fagetum* IN THE NORTHERN PART OF THE SEMENIC MOUNTAINS (SOUTHWESTERN ROMANIA)

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Abstract. In the present study, we conduct a phytosociological analysis of the *Pulmonario rubrae-Fagetum* association, identified in the northern part of the Semenic Mountains in southwestern Romania.

The aim of the research is to perform a floristic, phytocenological, ecological, ecoprotective and bioeconomic study of the beech forests in the Banat region, formed by *Fagus sylvatica*, *Abies alba*, *Pulmonaria rubra* and *Symphytum cordatum*, identified in the northern part of the Semenic Mountains.

The phytocoenoses of these forests have been analyzed in terms of physiognomy, floristic composition, spectrum of life forms, floristic elements and the influence of ecological factors.

The discussions summarize the main differences in biodiversity research between the Semenic Mountains and the results of research in the Orăştie River Basin (Şureanu Mountains).

Key words: *Pulmonaria rubra*; association; phytocoenoses; relevés; life forms; floristic elements; ecological indicators.

INTRODUCTION

The Semenic Mountains are located in the southwestern part of the country, well individualized, marking the core of the orogeny. They are situated between 45°00' and 45°23' north latitude and 21°58' and 22°18' east longitude, covering an area of 1180 km^2, representing 0.4% of the country's surface [17].

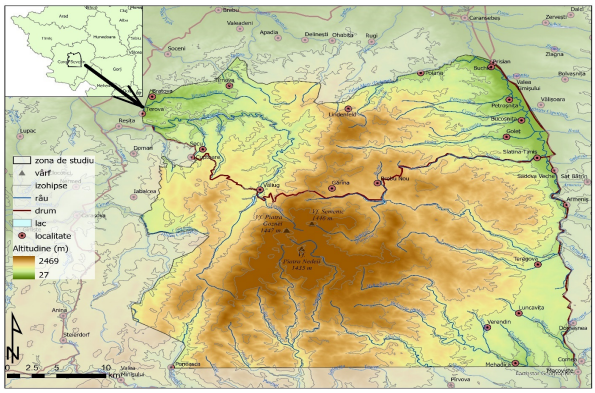

Figure 1. Geographic location and delimitation of the Northern part of Semenic Mountains (taken from Stereo 70 cartographic projection)

The Semenic Mountains are located within the Caraş-Severin county, which has an area of 8514 km^2, of which a geographic area of 980 km^2 (Fig. 1) has been studied, including the territories of the production units within the Reşiţa and Văliug Forest Districts. Geologically, these mountains are composed of crystalline metamorphic rocks, mainly schists and paragneisses, with occasional intercalations of quartzites. In the basins of the Secu and Râul Alb valleys, the foundation of the mountains consists of crystalline schists, overlain by Paleozoic and Mesozoic sedimentary deposits, the oldest of which are represented by conglomerates and sandstones. In depressions and along the main valleys, sedimentary formations predominated by marls, clays, and alluvium (gravels and sands) can be found [17].

The most frequently encountered altitude within the studied forested areas ranges from 480 to 920 m. The exposure is largely determined by the direction of the main watercourses' flow (Bârzava, Secu, Râul Alb, Timiş, Stârnic, Groposu, Pietrosu, Bârzăviţa) [17].

Within the study area, the relevés were described in the northern part of the Semenic Mountains, within the two forest districts, where the phytocoenoses of the *Pulmonario rubrae-Fagetum* association (Soó 1964) Täuber 1987 were identified. Synonymy: *Pulmonario rubrae-Abieti-Fagetum* Soó 1964; *Abieti-Fagetum* sensu auct.; *Abieti-Fagetum dacicum* Beldie 1967; *Fagetum dacicum abietetosum* Beldie 1951.

The majority of the studied area falls within the temperate continental climatic zone, with Mediterranean influences. The thermal regime is fairly constant, with monthly precipitation throughout the year not falling below 300 mm, reaching a peak in early summer. The variations in the average monthly air temperature and the annual temperature range give the studied area the character of a continental climate with Mediterranean influences for the most part. The number of favorable days for forest development is 210-250 days per year [17].

The average annual temperature for the Semenic Mountains sector ranges from 8°C to 4°C, indicating a relatively balanced thermal equilibrium and a significant humidity regime of the climate. The highest average monthly temperature occurs in July, at 16°C, while the lowest average monthly temperature is in January, at -6°C, and the average temperature during the vegetation season is 7-8°C [17].

Atmospheric precipitation in the Semenic Mountains is abundant and its distribution throughout the year is uneven, with a minimum in January and

February and a maximum during the months of May and June [17].

Within the atmospheric precipitation, snowfall plays an important role, resulting in a thick snow cover that persists throughout the cold months of the year. The first snowfall occurs in early November, while the last snowfall happens at the end of April [17].

The most significant winds predominantly blow from the south, southwest, west (Austro and Foehn), and southeast sector (Coșava) [17].

The *Pulmonario rubrae-Fagetum* association (Soó 1964) Täuber 1987 is widespread in almost all Romanian Carpathians and has previously been described in the Western, Southern, and Eastern Carpathians [10, 27, 29, 35, 38, 41, 42, 44].

The phytocenoses of the *Pulmonario rubrae-Fagetum* association (Soó 1964) Täuber 1987 (Fig. 2) are frequently distributed in the northern part of Semenic Mountains, on soils rich in humus, with a limestone substrate. In the beech forests established by *Pulmonaria rubra* and *Fagus sylvatica*, we have identified other forest associations that have not been published, such as *Hieracio rotundati-Făgetum* (Vida 1963) Täuber 1987, *Luzulo albidae-Fagetum sylvaticae* Zólyomi 1955, *Festuco drymejae-Fagetum* Morariu et al. 1968, *Phyllitidi-Fagetum* Vida (1959) 1963, *Symphyto cordati-Fagetum* Vida (1959) 1963, *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987, *Carpino-Fagetum* Paucă 1941, except for the association *Festuco drymejae-Fagetum* Morariu et al. 1968, which was published in the journal Annals of the University of Oradea, Environmental Protection Series, vol. 31, pp. 97-106 (2018) [1].

In the historical research on beech forests in the Semenic Mountains, Borza 1946 describes the *Abieto-Fagetum semenicense* association with poor biodiversity (30 vascular plant species). The characteristic species of the ***Symphyto cordati-Fagion*** alliance, such as *Symphytum cordatum* and *Pulmonaria rubra*, are absent from the floristic inventory, except for *Abies alba*, which is well represented with high constancy [3].

From the neighboring mountains of Țarcu-Godeanu and Cernei, Boșcaiu N. (1971) [5] describes the *Pulmonaria-rubro-Abieti-Fagetum* association, Borza (1946) [3], Knapp (1942) [18], Soó (1964) [40], which is sporadically found, and its floristic composition includes characteristic species of the ***Fagion dacicum*** alliance.

Beech forests mixed with conifers provide timber and ancillary products for the wood industry, chemical industry, pulp and paper industry, and other local community products. Distilling beech wood produces acetic acid, creosote and the tar contains a high amount of drying oil. Spruce wood is widely used in construction, match production, and pulp production, and its young bark contains 5-8% tannin that can be utilized. These plant communities contain medicinal species (*Cardamine glanduligera*, *Cystopteris fragilis*, *Digitalis grandiflora*, *Galium odoratum*, *Asarum europaeum*, *Fragaria vesca*, *Helleborus purpurascens*, *Cardamine bulbifera*), honey plants (*Veronica urticifolia*, *Fragaria vesca*, *Allium ursinum*, *Myosotis sylvatica*, *Lamium maculatum ssp. maculatum*, *Corydalis cava*, *Anemone ranunculoides*, *Corylus avellana*, *Picea abies*, *Abies alba*, etc.), toxic plants (*Mercurialis perennis*, *Daphne mezereum*, *Paris quadrifolia*, *Geranium robertianum*, *Digitalis grandiflora*), and plants for food use (*Oxalis acetosella*, *Fragaria vesca*, *Allium ursinum*, *Rubus idaeus*) [26].

Mixed beech habitats with spruce and fir have moderate conservation importance, containing some endemic, relic, rare, vulnerable and protected plants listed in the red list: *Leucojum vernum* [25], *Listera ovata* [5, 13], *Lilium martagon* [25], *Galanthus nivalis* [5], *Platanthera bifolia* [5].

Figure 2. *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987, Stârnicul Valley

MATERIALS AND METHODS

Vegetation studies of the northern part of Semenic Mountains (southwestern Romania) were conducted between 2015 and 2022, with the objectives of establishing the floristic inventory [31], analyzing ecological categories of bioforms, phytogeographic elements and ecological indices (humidity, temperature, soil chemical reaction) [12, 36] concerning the *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987 association. The phytosociological research methods developed by Braun-Blanquet (1964) [7] were employed in vegetation research. Sampling techniques and notations (quantitative assessments) were carried out according to the guidelines provided by Borza and Boșcaiu (1965) [4]. Associations were identified using characteristic species, without neglecting differential and dominant species [7, 13].

To comprehensively identify the phytocoenoses of the association, a total of 26 phytosociological relevés were conducted, with 12 relevés included in the synthetic table of the association (Table 1), while the remaining 14 were excluded from the table due to similar site conditions. Sampling relevés were performed in 800-square-meter areas that were as homogeneous as possible in terms of floristic composition and pedoclimatic conditions, while

avoiding ecotonal zones [7]. The age of the beech forests established by *Fagus sylvatica* and *Pulmonaria rubra* was taken from the forest management plans archived at the Caraș-Severin County Forest Directorate [46].

The phytosociological records contain information about the site conditions of the habitat where the phytocoenoses evolve, including rock type, soil, altitude, exposure, slope and vegetation cover. During the compilation of records defining each relevé, a quantitative assessment of the participation of each species in terms of abundance and dominance was provided using the method proposed by Braun-Blanquet et Pavillard (1928) [6]. Additionally, information on overall vegetation cover was completed using methods developed by Tüxen (1955) [43] and Ellenberg (1974) [15].

The phytosociological table of the association was structured according to the methodology developed by Braun-Blanquet (1964) [7] and improved by Ellenberg (1974) [15]. To classify the association within higher cenotaxonomic units such as suballiance, alliance, order and class, we considered both traditional ecological-floristic systems developed by Tüxen (1955) [43], Braun-Blanquet (1964) [7], Borza and Boșcaiu (1965) [4], Soó (1964) [40], Gehu (1981) [16], Majovszky (1987) [19], Meusel (1992) [22], Oberdorfer (1992) [24], as well as more recent works by researchers such as Mucina et al. (1993) [23], Pott (1995) [30], Borhidi (1996) [2], Pignatti (1996) [28], Weber et al. (2000) [45], Chifu et al. (2014) [8], Sanda, V., Kinga, Ö., Burescu, P. (2008) [39]. To classify the *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987 association (analyzed in this study) within higher cenotaxonomic units, we considered the studies of Sanda et al. (2008) [39]. The stratification of the phytocenosis of the association was done following Doniță et al. (2005) [14].

The constancy degree of species (K), whose classes are marked with Roman numerals from I to V, reflects the extent to which each species is faithful to the cenotic environment of the phytocoenoses of the association. The values of the synthetic phytosociological index, constancy (K), were calculated using the methods proposed by Braun-Blanquet et Pavillard (1928) [6], Raunkier (1937) [32], Rodwell et al. (2002) [33], Cristea et al. (2004) [11].

Taxonomic nomenclature was performed according to Ciocârlan (2009) [9], Rothmaler (2000) [34], McNeill et al. [20, 21] and the plant association was analyzed using the main ecological indices of the component species, bioforms and floristic elements, presenting the data graphically in the form of spectra and diagrams [37-39].

RESULTS

Phytocoenoses of the *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987 association were identified at: Bețițu marsh, Poiana Văranului hill, Cioaca Bălean, Poiana Cozia, Liscovu Mic valley, Bârzava ridge, Liscovu Mare valley, Stârnicului valley, Culmea Mică, Groparul Trei Movile, Cracul Sebeșului, Tâlva Cireșnei.

The analyzed phytocoenoses are ancient, virgin forests with trees aged between 120 and 160 years, consisting of 108 plant species (Table 1), with wind-felled and decomposed woody materials accounting for 10%, indicating rich biodiversity. The dominant species of the association are beech (*Fagus sylvatica*), with a coverage of 67.08% ADm and maximum constancy (K=V), and *Pulmonaria rubra* with an overall coverage, summed up across the 12 relevés, of 13.17% ADm and maximum constancy (K=V). The phytocenosis of the *Pulmonario rubrae-Fagetum* association is three-layered. The tree layer is composed of species such as fir (*Abies alba*), sycamore (*Acer pseudoplatanus*), elm (*Ulmus glabra*), field maple (*Acer campestre*), spruce (*Picea abies*), and less frequently ash (*Fraxinus excelsior*). The canopy closure ranges from 0.4 to 0.9, tree height varies between 28 m and 35 m for fir and 25-30 m for beech at over 120 years old, and trunk diameters range from 42-68 cm.

The shrub layer has a coverage of up to 15% of the basal area (ADm) and is relatively rich in species, with notable ones such as *Sambucus nigra*, *Viburnum opulus*, *Rubus hirtus*, *Corylus avellana*, *Rubus idaeus*, *Ribes petraeum*, *Daphne mezereum*, etc. In the herbaceous layer, the characteristic species of the association, *Pulmonaria rubra*, stands out, alongside which subordinate species of the ***Symphyto-Fagenion*** suballiance and the ***Symphyto cordati-Fagion*** alliance (*Acer pseudoplatanus*, *Moehringia muscosa*, *Festuca drymeja*, *Luzula luzuloides*, *Abies alba*, *Cardamine glanduligera*, *Cephalanthera rubra*, *Fraxinus excelsior*, *Leucojum vernum*, *Polystichum aculeatum*, *Symphytum cordatum*), the ***Fagetalia sylvaticae*** order (*Impatiens noli-tangere*, *Oxalis acetosella*, *Circaea lutetiana*, *Dryopteris filix-mas*, *Daphne mezereum*, *Euphorbia amygdaloides*, *Rubus hirtus*, *Salvia glutinosa*, *Carex sylvatica*, *Galium odoratum*, *Helleborus purpurascens*, *Maianthemum bifolium*, *Stachys sylvatica*), and the ***Querco-Fagetea*** class (*Geranium robertianum*, *Mycelis muralis*, *Poa nemoralis*, *Brachypodium sylvaticum*, *Anemone nemorosa*, *Athyrium filix-femina*, *Cardamine bulbifera*, *Corylus avellana*, *Galium schultesii*, *Ulmus glabra*).

In addition to the species belonging to the suballiance, alliance, order and class, in the association's phytocoenoses, characteristic species of mountain meadows, forests and forest clearings, can be found nearby, subordinate to the ***Betulo-Adenostyletea*** classes (*Veratrum album*, *Petasites albus*, *Doronicum columnae*, *Rubus idaeus*, *Senecio nemorensis*), as well as shrubby and subshrub species characteristic of forest edges and forest clearings classified in the ***Rhamno Prunetea*** class (*Sambucus nigra*, *Galeopsis speciosa*, *Acer campestre*, *Lamium maculatum ssp. maculatum*, *Verbascum nigrum*), along with species from

Table 1. *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987

Bioforms	Phytogeographic elements	U	T	R	G	Nr. Relevé	1	2	3	4	5	6	7	8	9	10	11	12	K	ADm
						Altitude (m)	527	480	870	650	550	920	880	920	610	895	600	678		
						Exposure	E	SV	N	N	SV	N	N	V	N	N	N	V		
						Consistency	0.9	0.9	0.6	0.7	0.9	0.8	0.4	0.9	0.9	0.6	0.8	0.9		
						Tree height (m)	32	28	30	28	32	26	34	30	32	34	30	26		
						Tree diameter	48	46	40	42	54	46	58	64	64	60	56	40		
						Slope (°)	16	8	10	4	6	12	10	4	14	4	20	18		
						Herbaceous layer coverage (%)	40	50	60	55	40	60	55	60	40	55	50	60		
						Area (sqm)	800	800	800	800	800	800	800	800	800	800	800	800		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
H	Carp	3.5	2	3	D	*Pulmonaria rubra*	1	3	2	1	2	1	3	1	1	+	2	1	V	13.17
MPh	E	3	3	0	D	*Fagus sylvatica*	5	5	3	4	5	4	2	5	5	3	4	5	V	67.08
						Symphyto-Fagenion, Symphyto cordati-Fagion														
MPh	Ec	3.5	3	3	P	*Acer pseudoplatanus*	+	-	+	1	+	+	2	+	+	1	+	-	V	2.58
G-H	Ec	4	2	3	D	*Festuca drymeja*	+	+	1	-	+	+	+	-	+	+	+	+	V	0.79
H	E	2.5	2.5	2	D.P	*Luzula luzuloides*	+	1	+	-	+	-	+	2	+	+	+	+	V	2.21
H	Ec	4	2	4	D	*Moehringia muscosa*	+	+	+	-	+	+	+	+	+	+	-	+	V	0.42
MPh	Ec	4	3	0	D	*Abies alba*	-	+	+	+	-	+	-	-	+	+	-	+	III	0.29
G	End	4	2.5	4	P	*Cardamine glanduligera*	-	-	+	+	+	-	+	+	+	+	-	-	III	0.29
G	E	2	3	5	P	*Cephalanthera rubra*	-	+	-	+	-	-	+	+	-	-	+	-	III	0.21
MPh	E	3	3	4	D	*Fraxinus excelsior*	+	-	-	-	+	-	+	-	+	-	+	+	III	0.25
G	Ec	4	3	3	D	*Leucojum vernum*	+	-	-	+	+	-	-	-	-	+	-	+	III	0.21
H	Eua	3.5	3.5	3.5	P	*Polystichum aculeatum*	-	-	+	+	-	-	+	+	-	+	+	-	III	0.25
H-G	End	3	2	3	D	*Symphytum cordatum*	-	+	-	+	-	+	+	-	+	-	+	+	III	0.29
G	Cp	3.5	3	5	D	*Asplenium scolopendrium*	-	-	-	+	-	+	-	+	-	-	-	-	II	0.13
H	E	4	3	4	P	*Lunaria rediviva*	-	-	-	-	-	-	-	-	+	+	+	-	II	0.13
H	M	3	2	5	D	*Primula veris*	-	-	+	-	+	+	-	-	-	-	-	-	II	0.13
H	Ec	3	2.5	3.5	D	*Aposeris foetida*	-	-	-	-	-	+	-	-	-	-	+	-	I	0.08
H	Cosm	3.5	0	0	P	*Cystopteris fragilis*	+	-	-	-	-	-	-	-	-	-	-	-	I	0.04
G	Carp	3	2	1	D.P	*Crocus vernus*	-	-	-	-	-	-	-	+	-	+	-	-	I	0.08
G	Cp	3	2.5	2	P	*Gymnocarpium dryopteris*	-	+	-	-	-	-	-	-	-	-	-	-	I	0.04
TH-H	Ec	3.5	3	0	P	*Cerastium sylvaticum*	-	-	-	-	-	-	-	-	-	+	-	-	I	0.04
H	Eua	3	3	0	D	*Campanula persicifolia*	-	+	-	-	-	-	-	-	-	+	-	-	I	0.08
G	Eua	3.5	0	4	D	*Listera ovata*	-	-	-	+	-	-	-	-	-	-	-	-	I	0.04
H	Eua	3	3	4	D	*Primula elatior*	-	-	+	-	-	-	-	-	-	-	-	-	I	0.04
H	Ec	3	2.5	4	D	*Veronica urticifolia*	+	-	-	-	-	-	-	-	-	-	-	+	I	0.08
						Fagetalia sylvaticae														
H	Eua	3	2.5	0	D	*Fragaria vesca*	+	+	+	+	+	+	-	+	-	+	+	+	V	0.42
Th	Eua	4	3	4	D.P	*Impatiens noli-tangere*	-	+	+	+	+	+	+	-	+	+	+	+	V	0.42
H-G	Cp	4	3	3	D	*Oxalis acetosella*	+	+	+	+	+	+	+	+	-	+	+	+	V	0.46
G	Eua	3.5	3	4	D	*Circaea lutetiana*	+	+	+	+	-	+	-	+	+	-	+	-	IV	0.33
H	Eua	4	3	0	P	*Dryopteris filix-mas*	+	+	-	+	-	+	+	+	+	-	+	+	IV	0.38
nPh	Eua	3.5	3	3	D	*Daphne mezereum*	+	-	+	+	+	-	+	-	+	+	+	+	IV	0.38
Ch	Ec	3	3.5	4	D.P	*Euphorbia amygdaloides*	+	+	-	-	-	+	+	+	+	+	+	+	IV	0.38
nPh	E	3	2.5	3	P	*Rubus hirtus*	+	+	+	+	+	-	+	-	+	+	+	-	IV	0.38

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
H	Eua	3.5	3	4	D	*Salvia glutinosa*	+	-	+	+	-	-	+	+	+	+	+	+	IV	0.38
H-Hh	Cp	3.5	3	4	P	*Carex sylvatica*	+	-	-	+	+	-	+	+	-	+	-	+	III	0.29
G	Eua	3	3	3	P	*Galium odoratum*	-	+	+	+	+	+	-	+	+	-	-	-	III	0.29
H	Carp	2.5	3	4	P	*Helleborus purpurascens*	+	-	-	+	-	-	+	-	-	+	-	+	III	0.21
G	Eua	3	3	0	P	*Maianthemum bifolium*	-	+	+	-	+	-	+	+	-	+	-	+	III	0.29
H	Eua	3.5	0	0	P	*Stachys sylvatica*	-	-	+	+	+	+	-	+	-	+	-	-	III	0.25
G	E	3.5	3	4	P	*Anemone ranunculoides*	-	-	+	-	+	-	-	+	-	+	-	-	II	0.17
H	Eua	3.5	3	4	D.P	*Asarum europaeum*	-	-	+	-	-	-	+	-	-	-	-	+	II	0.13
H	Eua	3	0	3.5	P	*Epilobium montanum*	+	-	-	-	+	-	-	-	+	-	-	-	II	0.13
G-H	E	3.5	3	5	P	*Mercurialis perennis*	-	+	-	+	+	-	-	-	-	-	-	-	II	0.13
H-Ch	Ec	3	0	4	D	*Lamium galeobdolon*	+	-	-	+	-	-	-	-	-	-	+	-	II	0.13
H	Ec	4	2.5	4	D	*Aconitum lycoctonum ssp. vulparia*	-	-	-	-	-	-	-	-	-	+	-	-	I	0.04
G	Mp	3.5	3.5	4	D	*Allium ursinum*	+	-	-	-	+	-	-	-	-	-	-	-	I	0.08
G	Ec	3	3	0	D	*Corydalis cava*	-	-	-	-	-	-	-	-	-	+	-	-	I	0.04
G	E	3	3	4	D.P	*Corydalis solida*	-	-	-	-	-	-	+	-	-	+	-	-	I	0.08
G	Ec	3.5	3	4	D	*Galanthus nivalis*	+	-	-	-	-	-	-	-	-	-	-	+	I	0.08
H	Eua	3	3	3	D	*Lathyrus vernus*	-	-	-	-	-	-	+	-	-	+	-	-	I	0.08
G	Eua	3	0	4	D	*Lilium martagon*	-	-	-	-	-	+	+	-	-	-	-	-	I	0.08
H	Eua	3.5	3	3	D.P	*Myosotis sylvatica*	-	+	-	-	-	-	-	-	+	-	-	-	I	0.08
H	Eua	3.5	0	4	P	*Paris quadrifolia*	-	-	-	-	-	+	-	-	-	-	-	-	I	0.04
						Querco-Fagetea														
Th-TH	Cosm	3.5	3	3	P	*Geranium robertianum*	-	+	+	+	+	+	+	+	+	+	-	+	V	0.42
H	E	3	3	3	D	*Mycelis muralis*	+	+	+	+	+	-	+	-	+	+	+	+	V	0.42
H	Cp	3	3	0	D.P	*Poa nemoralis*	+	+	-	-	+	+	+	+	+	+	+	+	V	0.42
H	Eua	3	3	4	D.P	*Brachypodium sylvaticum*	+	-	+	+	+	+	-	-	+	+	+	+	IV	0.38
G	E	3.5	4	0	P	*Anemone nemorosa*	-	+	+	+	+	+	+	-	-	+	-	-	III	0.29
H	Cosm	4	2.5	0	P	*Athyrium filix-femina*	-	+	-	+	-	+	-	-	+	-	-	+	III	0.21
G	Ec	3	3	4	P	*Cardamine bulbifera*	+	-	-	-	+	-	+	-	-	+	-	+	III	0.21
mPh	E	3	3	3	D	*Corylus avellana*	-	+	+	-	+	-	+	-	+	+	-	+	III	0.29
G	Ec	2.5	3	3	P	*Galium schultesii*	+	-	+	-	+	-	+	+	+	-	-	-	III	0.25
MPh	Eua	4	3	3	P	*Ulmus glabra*	-	+	+	+	-	+	-	-	-	-	+	+	-	III	0.25
H	Eua	3	3	4	D	*Anthriscus sylvestris*	-	-	-	+	-	-	-	+	+	-	-	-	II	0.13
H-Ch	Mp	2.5	3	4	P	*Glechoma hirsuta*	+	-	-	+	-	+	-	-	-	-	-	-	II	0.13
H	Cp	3	3	4	D	*Hepatica nobilis*	-	+	+	-	-	+	-	-	-	-	+	-	II	0.17
H	Eua	3	2.5	3	P	*Viola reichenbachiana*	+	-	-	+	-	-	-	-	-	+	-	-	II	0.13
H	Ec	2.5	3	3	P	*Digitalis grandiflora*	+	-	-	-	-	-	-	+	-	-	-	-	I	0.08
H	Cp	3.5	0	4	P	*Elymus caninus*	-	-	-	-	-	-	-	-	-	+	-	-	I	0.04
H-Ch	Eua	3.5	3	4	D	*Lamium maculatum ssp. cupreum*	-	-	-	-	+	-	-	-	-	+	-	-	I	0.08
Th-TH	Eua	2.5	3	3	D	*Lapsana communis*	-	-	-	-	+	-	-	-	-	-	-	-	I	0.04
mPh	Eua	3	3	4	D	*Lonicera xylosteum*	-	-	-	+	-	-	-	-	-	-	-	-	I	0.04
G	Eua	3.5	0	3	P	*Platanthera bifolia*	-	-	-	-	-	-	-	-	-	-	+	-	I	0.04
G	E	3.5	3	4	P	*Scilla bifolia*	-	-	-	-	+	-	-	-	-	-	-	-	I	0.04
H	Ec	3	2	0	P	*Stachys alpina*	-	-	+	-	-	-	-	-	-	-	-	-	I	0.04
H	E	3.5	3	3	D	*Stellaria nemorum*	-	-	-	-	+	-	+	-	-	-	-	-	I	0.08

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
						Betulo-Adenostyletea														
G	Eua	4	2.5	4	D.P	*Veratrum album*	+	+	+	-	+	+	+	+	+	+	+	-	V	0.42
G	Eua	4	0	0	P	*Petasites albus*	-	-	+	-	+	-	+	-	+	-	-	+	III	0.21
G	Alp-Carp-B	3.5	2	3.5	P	*Doronicum columnae*	-	-	-	-	+	+	-	-	-	+	-	-	II	0.13
nPh	Cp	3	3	3	D.P	*Rubus idaeus*	+	-	-	+	-	-	-	-	-	-	-	+	II	0.13
H	Eua	3.5	3	3	P	*Senecio nemorensis*	+	-	-	+	-	-	-	-	-	+	-	-	II	0.13
H	Alp-Carp	2.5	2.5	4.5	P	*Aconitum napellus ssp. firmum*	-	-	+	-	-	-	-	-	-	-	-	-	I	0.04
H	Ec	4	2	4	P	*Gentiana asclepiadea*	-	+	-	-	-	-	-	-	-	-	-	-	I	0.04
G	Eua	3	2.5	2.5	P	*Polygonatum verticillatum*	-	-	-	+	-	-	-	-	-	-	+	-	I	0.08
H	E	3.5	2	0	D	*Cicerbita alpina*	-	-	-	+	-	-	-	-	+	-	-	-	I	0.08
mPh	Alp-E	4	2	3.5	D	*Ribes petraeum*	-	-	-	-	-	-	-	+	-	-	-	-	I	0.04
H	Eua	3	3	0	D	*Cortusa matthioli*	-	-	-	-	-	+	-	-	-	-	-	-	I	0.04
						Rhamno-Prunetea														
mPh	E	3	3	3	P	*Sambucus nigra*	+	1	+	+	+	2	+	1	+	+	+	+	V	2.67
MPh	E	2.5	3	3	D	*Acer campestre*	-	+	-	-	+	-	+	+	+	-	-	+	III	0.25
Th	Eua-C	3	2	0	D	*Galeopsis speciosa*	+	-	-	+	-	+	-	+	+	+	+	-	III	0.29
H	E	3.5	0	4	D	*Lamium maculatum ssp. maculatum*	-	+	-	+	+	-	+	+	+	-	+	-	III	0.29
H	Eua	2	3	4	D	*Verbascum nigrum*	-	+	-	-	+	-	+	+	-	+	-	+	III	0.25
H	Ec	4	3	3	D.P	*Geranium phaeum*	-	+	-	-	-	+	-	-	-	-	-	-	I	0.08
H-Ch	Eua	3.5	3	0	D.P	*Glechoma hederacea*	-	-	-	-	-	-	-	-	-	-	-	+	I	0.04
H	Eua	3.5	0	4	D	*Silene dioica*	-	-	-	-	-	-	-	-	-	+	-	-	I	0.04
mPh	Cp	4	3	4	D	*Viburnum opulus*	-	-	-	-	+	-	-	-	-	-	-	-	I	0.04
						Vaccinio-Piceetea														
H	Eua	2.5	3	2	P	*Calamagrostis arundinacea*	-	+	-	+	+	-	+	-	+	+	+	+	IV	0.33
MPh	E	0	0	0	D	*Picea abies*	+	+	+	-	+	+	-	+	+	-	-	+	IV	0.33
H	E	3.5	2.5	2.5	P	*Homogyne alpina*	+	-	-	-	-	-	+	-	+	-	-	+	II	0.17
H	End	3.5	2	2	P	*Campanula abietina*	-	-	+	-	-	-	-	-	-	-	+	-	I	0.08
l-nPh	Eua	3	2	2	D	*Clematis alpina*	-	-	-	-	-	-	-	-	+	-	-	-	I	0.04
mPh	Ec	3	2	3	D	*Lonicera nigra*	-	-	-	+	-	-	-	-	-	-	-	-	I	0.04
H	Ec	3.5	2.5	2	D.P	*Luzula sylvatica*	-	-	-	-	-	-	-	+	-	+	-	-	I	0.08
						Variae syntaxa														
G	Eua	2	3	4	D	*Polygonatum odoratum*	+	+	+	-	-	-	+	+	-	-	+	-	III	0.25
H	E	2.5	3	5	D	*Melittis melissophyllum*	-	-	-	+	+	-	-	+	-	-	-	-	II	0.13
H	Cosm	3	3	4	D.P	*Urtica dioica*	-	-	-	+	-	+	-	-	-	+	+	-	II	0.17
H	E	3.5	2.5	0	P	*Ajuga reptans*	-	+	-	-	-	-	+	-	-	-	-	-	I	0.08
H	End	2.5	3	4.5	D	*Scabiosa columbaria ssp. pseudobanatica*	-	+	-	-	-	-	-	-	-	-	-	-	I	0.04

Place and date of conducted relevés: 1. Bețiu marsh 09.05.2016; 2. Poiana Văranului hill 09.05.2016; 3. Cioaca Bălean 09.05.2016; 4. Poiana Cozia 09.05.2016; 5. Liscovu Mic valley 10.05.2016; 6. Bârzava ridge 10.05.2016; 7. Liscovu Mare valley 11.05.2016; 8. Stârnicului valley 11.05.2016; 9. Culmea Mică 12.05.2016; 10. Groparul Trei Movile 12.05.2016; 11. Cracul Sebeșului 07.05.2016; 12. Tâlva Cireșnei 07.05.2016.

coniferous forests and shrubs characteristic of the ***Vaccinio-Piceetea*** class (*Calamagrostis arundinacea*, *Picea abies*, *Homogyne alpina*). It is worth mentioning the species that exhibit high constancy (K=V): *Acer pseudoplatanus*, *Festuca drymeja*, *Luzula luzuloides*, *Moehringia muscosa*, *Fragaria vesca*, *Impatiens noli-tangere*, *Oxalis acetosella*, *Geranium robertianum*, *Mycelis muralis*, *Poa nemoralis*.

The spectrum of bioforms (Fig. 3) is dominated by hemicryptophytes (52.78%), followed by geophytes (25.93%) and phanerophytes (15.74%, including megaphanerophytes, mesophanerophytes, nanophanerophytes, lianas), therophytes and chamaephytes, occurring only occasionally in the phytocoenoses of this association.

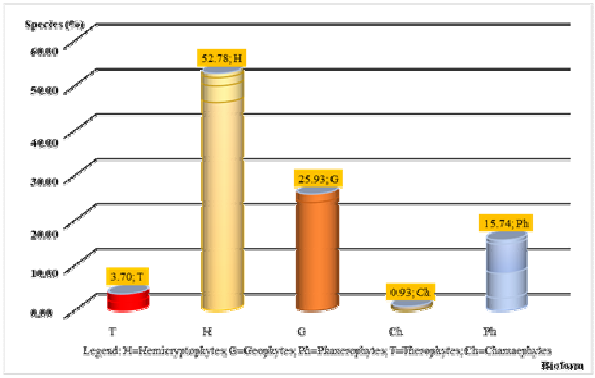

Figure 3. The spectrum of bioforms in the *Pulmonario rubrae-Fagetum* association (Soó 1964) Täuber 1987

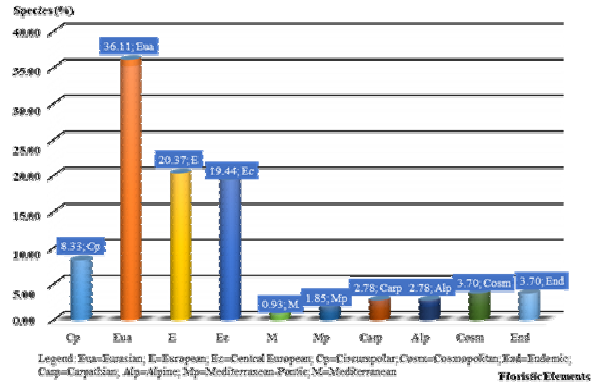

Figure 4. The spectrum of floristic elements in the association *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987

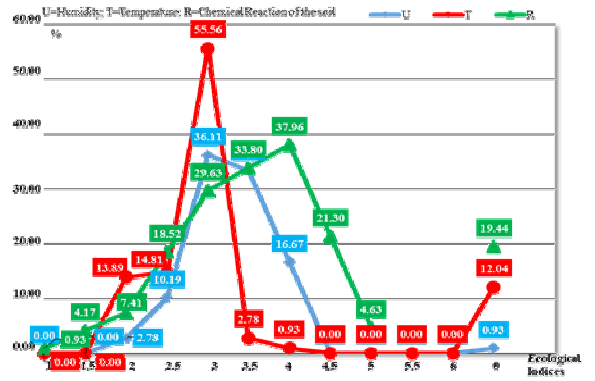

Figure 5. Diagram of ecological indices for the association *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987

The phytogeographic origin of the species indicates a high heterogeneity, with the spectrum of floristic elements (Fig. 4) being dominated by Eurasian (36.11%), followed by European (20.37%) and Central European (19.44%), Circumpolar, Cosmopolitan, Endemic, Alpine, Carpathian, Mediterranean-Pontic and Mediterranean.

Distribution based on the requirements of ecological factors (Fig. 5) highlights that in terms of soil moisture, the majority of species in the phytocoenoses of the association are: mesophytes (69.44%), followed by meso-hygrophytes (16.67%), xero-mesophytes (12.97%) and euryhydric species. Regarding temperature, micro-mesothermal species dominate (58.34%), followed by microthermal species (28.70%), eurithermal species, and moderately thermophilic species. The chemical reaction of the soil favors the predominant development of species: weakly acid-neutral species (37.96%), acid-neutral species (29.63%), and euryionic species (19.44%), with acidophytes, neutro-basicophytes, and strongly acidophilic species also present.

DISCUSSION

The research conducted in the northern part of Semenic Mountains, during the period 2015-2022, reveals that the vegetation of Banat beech forests is predominantly represented by the phytocoenoses of the *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987 association. The analysis carried out on the *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987 association demonstrates its stability in terms of both ecological and dynamic balance.

With regard to the composition of the *Pulmonario rubrae-Fagetum* association (Soó 1964) Täuber 1987, the conducted research highlights significant results regarding the biodiversity in Semenic Mountains, compared to that of the Orăștie River Basin (Șureanu Mountains), as described by Vințan (2014, p. 508). The conducted analysis highlighted numerous similarities between the two regions, regarding pedoclimatic conditions, geological structure of the relief and the floristic composition of the forests, which is why we chose to compare ourselves with the phytocenoses of beech forests in the Southern Carpathians (Șureanu Mountains).

The floristic inventory of beech forests with *Pulmonaria rubra* species in the northern part of the Semenic Mountains encompasses a total of 108 species, of which 76 are attributed to the subordinated cenotaxa of this association, while 32 are transgressive and accompanying species from other phytocoenoses. In contrast, similar forests in the Șureanu Mountains contain 69 species, of which 50 fall into the same group of cenotaxa, while 19 are transgressive and accompanying species from other phytocoenoses.

Analyzing the bioforms presented in the phytocoenoses of the Semenic Mountains and the Șureanu Mountains, it can be observed that the

quantitative results obtained by us are similar to those illustrated by Vinţan (2014) [39] regarding the dominance of hemicryptophyte, geophyte, and phanerophyte species in the two geographic regions. In the Semenic Mountains, our research indicated a percentage of 52.78% for hemicryptophytes, 25.93% for geophytes, and 15.74% for phanerophytes (Table 2). These figures are close to those obtained in the Şureanu Mountains, studied by Vinţan in 2014 [39], where the percentages correspond to the following values: hemicryptophytes - 52.72%, geophytes - 20.28%, and phanerophytes - 18.82%.

Regarding the peculiarities of the arboreal communities within the *Pulmonario rubrae-Fagetum* association from a phytocenotic perspective, the phytocenoses of the association are subordinated to the sub-alliance ***Symphyto-Fagenion***, which, in turn, belongs to the alliance ***Symphyto cordati-Fagion***. They share a nucleus of 23 vascular plant species, each with a different numerical distribution for each relevé. Thus, the richest relevés in differential species for the sub-alliance and alliance are relevé 10, which comprises 12 species, and relevés 3, 4, 7, 9 and 11, each with 9 species, representing the ecological optimum adapted to the pedoclimatic conditions of the habitat. Relevés 1, 2, 5, 6, 8 and 12, containing a lower number of species (8 vascular plants), are more distant in the phytocenosis from the ecological optimum of the forest ecosystem.

Regarding the distribution of species for the cenotaxa *Fagetalia sylvaticae* and the class *Querco-Fagetea*, there are no significant discrepancies concerning their presence in the relevés, reflecting cohesion with the phytocenosis and a greater affinity with the specific environmental requirements of the habitat.

The phytocenoses of the association are not affected by zooanthropic factors (such as logging, grazing and animal transit through arboreal ecosystems). This is evidenced by the very low number of ecological categories (bioforms - therophytes, annuals and biennials) present in the association table, such as *Cerastium sylvaticum*, *Impatiens noli-tangere*, *Geranium robertianum*, *Lapsana communis* and *Galeopsis speciosa*.

In the research on the beech forests of the Banat region, located in the northern part of the Semenic Mountains, Borza (1946) [3] did not identify the presence of the species *Picea abies*, *Pulmonaria rubra* and *Symphytum cordatum* in the surveys and association table. He argued that their absence in the territory was due to its geographical isolation from the forest beech vegetation in the Southern Carpathians of Romania, as well as from the geographic regions of the Tatra Mountains and the Black Forest, situated in the central and western part of the European continent.

In our meticulous research, which lasted for 6 years, we covered the entire territory in the northern part of the Semenic Mountains, including locations such as Poiana Văranului hill, Poiana Cozia, Beţiţu marsh, Liscovu Mare valley, Culmea Mică, Cracul Sebeşului and Tâlva Cireşnei. This extensive coverage was in contrast to the limited time Borza had to explore the area, as he himself admitted, "*these two excursions were too short for a thorough exploration of the entire massif*" (20-25 August 1941; 20-22 June 1942) [3].

The presence of the species *Festuca drymeja*, *Luzula luzuloides*, *Moehringia muscosa* in numerous *Fagus sylvatica* stands in the northern part of the Semenic Mountains is caused by the superficial soil structure with fine gravel on crystalline schists, as found in the aforementioned localities.

The spatial distribution of geoelements within the association *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987, based on their origin in the geographical area, reveals extremely similar results to those obtained in our own research. These findings are supported by the predominance of Eurasian species in both geographical regions, with a percentage of 36.11% in the Semenic Mountains, the territory investigated by us, and 30.43% in the Şureanu Mountains, according to Vinţan's study in 2014 [39]. European species rank next, with a percentage of 20.37% in the Semenic Mountains and 24.63% in the Şureanu Mountains, while Central European species account for 19.44% in the Semenic Mountains and 14.49% in the Şureanu Mountains (Table 3).

Table 2. Comparative spectrum of bioforms for the phytocoenoses of the *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987 association, analyzed separately for the habitats of Semenic Mountains and Şureanu Mountains.

Location	Bioform	H	G	Ph	T	Ch	Total Species
Semenic M.	Species	57	28	17	5	1	108
	Percentages (%)	52.78	25.93	15.74	4.63	0.93	
Şureanu M.	Species	36	14	13	5	1	69
	Percentages (%)	52.72	20.28	18.82	7.23	1.44	

Table 3. Comparative spectrum of floristic elements for the phytocoenoses of the association *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987, analyzed separately for the habitats of Semenic Mountains and Şureanu Mountains.

Location	Floristic Elements	Eua	E	Ec	Cp	Carp	Cosm	M	End	Alp	Mp
Semenic M.	Species	39	22	21	9	3	4	1	4	3	2
	Percentages (%)	36.11	20.37	19.44	8.33	2.78	3.70	0.93	3.70	2.78	1.85
Şureanu M.	Species	21	17	10	9	3	4	1	2	1	1
	Percentages (%)	30.43	24.63	14.49	13.04	4.34	5.79	1.44	2.89	1.44	1.44

Table 4. Comparative spectrum of ecological indices (U=soil moisture, T=air temperature, R=soil chemical reaction) for the phytocoenoses of the association *Pulmonario rubrae-Fagetum* (Soó 1964) Täuber 1987, analyzed separately for the habitats of Semenic Mountains and Șureanu Mountains

Location	Ecological indices	The value of ecological indices and the percentage of species										
		1	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**6**	**0**
Semenic M.	U nr. sp.	-	-	3	11	39	36	18	-	-	-	1
	%	-	-	2.78	10.19	36.11	33.33	16.67	-	-	-	0.93
	T nr. sp.	-	-	15	16	60	3	1	-	-	-	13
	%	-	-	13.89	14.81	55.56	2.78	0.93	-	-	-	12.04
	R nr. sp.	1		8		32		41		5	-	21
	%	0.93		7.41		29.63		37.96		4.63	-	19.44
Șureanu M.	U nr. sp.	-	-	-	4	26	27	11	-	-	-	1
	%	-	-	-	5.79	37.68	39.13	15.94	-	-	-	1.44
	T nr. sp.	-	-	11	11	32	3	1	-	-	-	11
	%	-	-	15.94	15.94	46.37	4.34	1.44	-	-	-	15.94
	R nr. sp.	1		8		21		22		-	-	17
	%	1.44		11.59		30.43		31.88		-	-	24.63

Analyzing the ecological characteristics of species in relation to environmental factors such as soil moisture, air temperature and soil pH, a similarity in values is observed, with some minor exceptions, when comparing the results for the two geographical regions.

Regarding soil moisture, the phytocenoses associated with the ecosystem of the association exhibit a mesophilic character ($U_{3-3.5}$=69.44%), tending towards meso-hygrophilic ($U_{4-4.5}$=16.68%) and xero-mesophilic ($U_{2-2.5}$=12.97%) in the Semenic Mountains. Similarly, in the Șureanu Mountains, the dominant character is also mesophilic ($U_{3-3.5}$=76.81%), followed by meso-hygrophilic ($U_{4-4.5}$=15.24%) and xero-mesophilic ($U_{2-2.5}$=5.79%) (Table 4).

Regarding temperature, a stronger similarity is observed in the quantified values. The phytocenoses associated with the association in both geographical regions exhibit a micro-mesothermal character ($T_{3-3.5}$=58.34%), microthermal ($T_{2-2.5}$=28.70%) and amphotolerant (eurithermic) (T_0=12.04%) in the Semenic Mountains. In the Șureanu Mountains (according to the study conducted by Vințan [39]), a similar micro-mesothermal character is also noted ($T_{3-3.5}$=50.71%), tending towards microthermal ($T_{2-2.5}$=31.88%) and amphotolerant (eurithermic) (T_0=15.94%) (Table 4).

Regarding the chemical reaction of the soil, the phytocenoses associated with the association exhibit a predominantly weak acid-neutral (R_4=37.96%), acid-neutral (R_3=29.63%) and amphotolerant (euryionic) (R_0=19.44%) character in the Semenic Mountains. In the Șureanu Mountains (according to the study conducted by Vințan) [39], a similar weak acid-neutral (R_4=31.88%), acid-neutral (R_3=30.42%) and amphotolerant (euryionic) (R_0=24.63%) character is also observed (Table 4).

The following conclusions can be drawn from the conducted phytocenological, ecological, ecoprotective and bioeconomic study of the associations:

– The composition of the phytocenosis in biological categories of bioforms is dominated by hemicryptophyte species, geophytes and phanerophytes, which constitute the main components of the herbaceous layer and vegetation.

– The composition of the phytocenosis in categories of floristic elements (geoelements) reveals the predominance of Eurasian species, which have interacted in different phytohistorical stages, accompanied by European elements and Central European elements.

– The vegetation of the investigated ecosystem, exhibits a predominantly mesophilic character in terms of soil moisture, leaning towards meso-hygrophilic. Regarding plant behavior towards temperature, a predominant micro-mesothermal character is observed, tending towards microthermal. The chemical reaction of the soil is favorable for the development of weak acid-neutral species, leaning towards acid-neutral.

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