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COMPARATIVE PHYTOSOCIOLOGICAL STUDY OF THE RELICT SPECIES *LIGULARIA SIBIRICA* (L.) CASS. IN THE WESTERN SECTOR OF THE BUCEGI MOUNTAINS

Andreea Natalia Matei [1*]

[1] University of Piteşti, Faculty of Sciences, Physical Education and Informatics, Târgu din Vale St. 1, 110040, Piteşti, Romania

Abstract
The glacial periods with numerous successive climatic oscillations and simultaneously with major changes at the ecological level have determined over time the migration of a significant number of species in search for optimal survival conditions. Through these species it can be found the subject of the present paper, Ligularia sibirica (L.) Cass.
The aim of this paper is to present the species of community importance Ligularia sibirica (L.) Cass. integrated in two vegetal associations from Romania, within the Bucegi Natural Park in Zănoagei Gorges: Ligulario sibiricae - Ribetum petraei Neblea et Alexiu 2003 and Asperulo capitatae - Seslerietum rigidae (Zólyomi1939) Coldea (1991).
The purpose of this paper is the comparative study of the two associations from the biodiversity, taxonomy, bioforms and geoelements point of view and their analysis in terms of genetic structure. The Ellenberg index analysis complements this study, with a significant detail of the ecological structural evolution in time on the studied populations. Analysis of the Ellenberg indices includes factors such as light, temperature, humidity, soil reaction and nitrogen content. The work also includes an analysis of the conservation and biodiversity status offered by the two studied associations in which Ligularia sibirica (L.) Cass. relict species is part of. In order to highlight the biodiversity degree, the number of the existing individuals in each association will be specified as well as the phenological condition from the moment of study.

Keywords: Ligularia sibirica, habitat, population, vegetal communities.

1. INTRODUCTION

The loss and degradation of the habitats quality is the greatest threat to the species populations (Vitousek et al. 1997; Hobbs and Yates 2003; Aguilar et al. 2006; Fischer and Lindenmayer 2007).
Growing sporadically on Romania's territory, *L. sibirica* can be seen from sessile oak up to spruce level in habitats from meadows, forests, eutrophic and oligotrophic marshes and in river banks habitats. (Sârbu et al., 2013; Matei, 2016).
On Romania's territory the species of community interest is distributed in 32 Natura 2000 sites. (Brînzan T., 2013). The relict species is mentioned by the Bern Convention as strictly protected flora species, by IUCN as Data Deficient, and mentioned by the Habitat Directive and by the Carpathian Red List of Forest Habitats and Species as a near threatened species. (Kadlečík, 2014; Mihăilescu, 2015; Matei, 2016).
Ialomița River integrates the relict species in a few vegetal associations; the next two associations were taken into study: *Ligulario sibiricae - Ribetum petraei* Neblea et Alexiu 2003 and *Asperulo capitatae - Seslerietum rigidae* (Zólyomi 1939) Coldea 1991.

*Corresponding author, E-mail address: mateiandreeanatalia@gmail.com

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2. MATERIALS AND METHODS

The subject of the study is represented by relict species of community importance *Ligularia sibirica* (L.) Cass.. The study was carried out along the Ialomița River from Bucegi Natural Park (Bucegi ROSCI0013), where the *L. sibirica* relict species was found in the Zănoaga Mică and Zănoaga Mare Gorges. (www.bucegi park. ro – management plan).

In order to achieve the purpose of this paper, phytosociological studies were conducted using the methodology of the Zurich-Montpellier Phytosociological School. Habitats codes used in this paper correspond to the Natura 2000 network, the EUNIS classification system, likewise the *Carpathians Red List of Habitats*.

Associations and Habitat

Ligularia sibirica (L.) Cass. was identified in two vegetal associations: *Ligulario sibiricae - Ribetum petraei* Neblea et Alexiu 2003 and *Asperulo capitatae - Seslerietum rigidae* (Zólyomi1939) Coldea 1991, during a research developed in 2 years, 2015-2016.

The association *Ligulario sibiricae - Ribetum petraei* Neblea et Alexiu 2003 is classified as follows:

- *MULGEDIO-ACONITETEA* Hadać et Klika in Klika et Hadać,
- *ADENOSTYLETALIA ALLIARIAE* Br.-Bl. 1931
- *Adenostylion alliariae* Br.-Bl. 1925.

The association is characteristic for the eutrophic marshes, located on acidophilic substrate. The Natura 2000 habitat, 6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (EMERALD: 37.7 Humid tall herb fringes, PALHAB: 37.716 Continental mixed riverine screens, EUNIS: E5.414 Continental river bank dominated by *Filipendula*) encloses the studied association. (Mihăilescu, 2015, Matei, 2016)

The association *Asperulo capitatae - Seslerietum rigidae* (Zólyomi1939) Coldea 1991 (Syn: *Seslerietum rigidae praebiharicum* Zólyomi 1939, *Asplenio - Seslerietum rigidae* Csürös 1958, *Alysso - Seslerietum rigidae* Csürös et al., 1958), built by *Sesleria rigida* subsp. *rigida* and *Asperula capitata*, as Carpathian-Balkan elements, its included in:

- *SESLERIETEA ALBICANTIS* Br.-Bl. 1948 em. Oberdorfer 1978
- *SESLERIETALIA ALBICANTIS* Br.-Bl. in Br.-Bl. et Jenny 1926
- *Seslerion rigidae* Zolyomi 1939

The *Asperulo capitatae - Seslerietum rigidae* (Zólyomi1939) Coldea 1991 association, is included by Natura 2000 network in the habitat: 6170 Alpine and subalpine calcareous grasslands, corresponding to the R3401 Habitat - Southeast Carpathian meadows of *Asperula capitata* and *Sesleria rigida*, but Gafta D. does not accept the habitat R3401 presented by Doniță N. because the association appears in the mountain floor not in the alpine and subalpine floor. The habitat corresponds to: CORINE: 36.4 Alpine and subalpine calciphilous grasslands, PALHAB 1999: 36.43921 East Carpathian *Sesleria*-evergreen sedge grasslands, EUNIS: E4.4392 East Carpathian calciphile stepped grasslands (Mihilescu et al., 2015). On the territory of Romania, the habitat is considered to be vulnerable (Barančok et al., 2014) being endemic with a high conservative value. (Doniță N. et al., 2005).

In order to attain the objective of the present study, the flora of the two studied associations was analysed, as well as the comparison of flora of the same association analysed according to the phytosociological surveys performed in different years. The establishment of synonyms as well as the coenotic integration of the studied species was carried out using *Flora of China* (Wu et al., 2016), *Les associations végétales de Roumanie* (Coldea, 1997), *Manual de interpretare a habitatelor Natura 2000 din România* (Gafta et Mountford, eds., 2008), *Habitatele din România* (Doniță et al., 2005), *Fitocenozele din România* (Sanda et al., 2008), Flora Europaea (Chater, 1976),

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Flora ilustrată a României (Ciocârlan, 2009), *Aspects of Vegetation from Zănoaga and Tătaru gorges (The Bucegi Mountains)* (Neblea and Alexiu, 2005), *Habitats humides* (Gaudillat, 2002). For the analysis of Ellenberg indices the following bibliographical sources were used: *Indicator values of vascular plants in Central Europe* (Ellenberg, 1974) and *Vegetation Ecology of Central Europe* (Ellenberg, 2009), while for the analysis of the genetic structure as well as of the bioforms and the geoelements, the *Flora cormofitelor spontaneous and cultivated in Romania* (Sanda, et al., 2004) was utilized.

Ellenberg's indicators for light (L), temperature (T), humidity (U), soil reaction (R) and available nitrogen (N) (Ellenberg et al., 1992) were calculated for each association and also for the same association analysed as a comparison between different years of surveys, following the ecological differences developed in time for the studied association. At the same time, the analysis of the Ellenberg indices has led to a more accurate identification of the habitat in which the two associations are included.

Abbreviations: K - constancy, ADm – abundance-dominance average, Bioforms: MM-megafanerophytes, M-microfanerophytes, N-nanofanerophytes, Ch-camephytes, H-hemicryptophytes, G-geophytes, Th-annual therophytes, TH-bisannual therophytes, HH-helohydatophytes, G-Geoelements: Circ-Circumpolar, Eua–Eurasian, Eur–European, Atl–Atlantic, Euc–Central European, Pont–Pontic, Alp–Alpic, Carp–Carpathian, Balc–The Balkan Peninsula as a whole, Med–Mediterranean, Cosm–Cosmopolitan, End–endemic, D-diploids, D-P-diplo-polyploids, P-polyploids.

3. RESULTS AND DISCUSSIONS

1. Taxonomic analysis

From the comparative taxonomic analysis carried out on *Asperulo capitatae-Seslerietum rigidae* in 2015 between author surveys and the one carried out by Alexiu V. and Neblea M. in 2003, it can be noticed that the 2015 floral inventory includes 66 species integrated in 31 families, while the floristical inventory carried out in 2003 describes 72 species integrated in 31 families. The families with the highest share in 2015 correspond to those of 2003: *Asteraceae* (13.8%-2003, 11.8%-2015), *Apiaceae* (9.7%-2003, 10.3%-2015), *Campanulaceae* (7%-2003, 8.8%-2015) and *Ranunculaceae* (7%-2003, 7.3%-2015). (Fig.1) Species which weren't identified in 2015 surveys are: *Saxifraga corymbosa*, *Primula verris* subsp. *columnae*, *Achillea oxyloba.* subsp. *schurii*, *Asplenium viride*, *Solidago virgaurea* subsp. *minuta*, *Pinguicula vulgaris*. The species that appear in the 2015 surveys and were not identified in 2003 are: *Gentianella bulgarica* and *Phyteuma orbiculare*. (Table 1).

From the comparative taxonomic analysis carried out on *Ligulario sibiricae-Ribetum petraei* association in 2015 and that performed by Alexiu V. and Neblea M. in 2003, it can be noticed that the 2015 floral inventory carried out by the author describe 71 individuals included in 34 families, the largest share being occupied by families: *Rosaceae* (10%), *Asteraceae* (8.4%), *Poaceae* (8.4%) and *Apiaceae* (8.4%). In the floral inventory of 2003, 70 taxa were registered in 37 families. Families with the highest share were: *Asteraceae* (11.5%), *Rosaceae (*10 %), *Ranunculaceae* (7%) and *Apiaceae* (6%). (Figure 1)

The species identified in 2003 survey but not found in 2015 on *Ligulario sibiricae-Ribetum petraei* association are: *Gymnocarpium robertianum*, *Thymus comosus*, *Scrophularia scopolii*, *Sedum vulgare*, *Saxifraga luteo-viridis*, *Valeriana tripteris*, *Silene nutans* subsp. *dubia*, *Campanula carpatica*, *Asplenium viride*, *Polystichum lonchitis*, *Calamagrostis arundinacea*, *Sorbus aucuparia*, *Salix caprea*, *Hepatica transsilvanica*, *Acer pseudoplatanus*, *Thelypteris limbosperma*, *Carduus personatus*, *Achillea distans*, *Senecio hercynicus.*

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Table 1. Asperulo capitatae - Seslerietum rigidae (Zoly. 1939) Coldea 1991 – from Zănoagei Gorges: 1-5, K1, ADm - Matei A. N. 2015; K2 – 5 reference surveys after Alexiu & Neblea 2003

***Asperulo capitatae - Seslerietum rigidae* (Zoly. 1939) Coldea 1991**								
Survey	**1**	**2**	**3**	**4**	**5**	**K1**	**K2**	**ADm**
Altitude (m s.m.)	**1380**	**1380**	**1380**	**1380**	**1380**			
Exposition	**V**	**V**	**V**	**V**	**V**			
Slope (□)	**45**	**45**	**45**	**45**	**45**			
Surface (m²)	**15**	**15**	**15**	**15**	**15**			
Coverage of the herbaceous layer (%)	**52**	**56**	**52**	**59**	**56**			
Characteristic species of the association								
Sesleria rigida	3	3	3	3	3	V	V	37.5
Asperula capitata	+	-	+	-	+	III	II	0.3
Seslerion rigidae								
Aconitum anthora	-	-	+	+	-	II	II	0.2
Bupleurum falcatum	-	-	-	+	+	II	II	0.2
Melica ciliata	-	-	-	+	-	I	I	0.1
Saxifraga corymbosa	-	-	-	-	-	-	IV	-
Primula verris subsp. *columnae*	-	-	-	-	-	-	II	-
Achillea oxyloba. subsp. *schurii*	-	-	-	-	-	-	II	-
Seslerietalia								
Dianthus spiculifolius	+	+	-	+	+	IV	V	0.4
Potentilla crantzii	+	+	+	+	-	IV	IV	0.4
Ranunculus oreophilus	-	+	+	+	+	IV	IV	0.4
Scabiosa lucida	-	-	+	+	+	III	IV	0.3
Carex sempervirens	+	+	-	+	-	III	II	0.3
Phyteuma orbiculare	+	-	-	+	+	III	-	0.3
Euphrasia salisburgensis	+	-	+	-	+	III	IV	0.3
Festuca versicolor	+	-	-	+	-	II	II	0.2
Doronicum columnae	+	-	-	-	+	II	I	0.2
Helianthemum nummularium	+	+	-	-	-	II	III	0.2
Helianthemum oelandicum subsp. *alpestre*	-	-	-	+	+	II	II	0.2
Seslerion - Festucion pallentis								
Thymus comosus	+	+	+	+	-	IV	IV	0.4
Asplenium trichomanes	+	-	-	+	+	III	I	0.3
Gymnocarpium robertianum	+	-	-	+	-	II	I	0.2
Asplenium ruta-muraria	-	-	+	-	-	I	I	0.1
Potentilletalia caulescentis* et *Asplenietea								
Poa nemoralis	+	1	+	1	1	V	V	3.2
Cystopteris fragilis	+	+	+	+	+	V	V	0.5
Silene nutans subsp. *dubia*	-	+	-	-	+	II	I	0.2
Valeriana tripteris	+	-	-	+	-	II	I	0.2
Campanula carpatica	-	-	+	-	-	I	III	0.1
Cardaminopsis arenosa	-	+	-	-	-	I	II	0.1
Asplenium viride	-	-	-	-	-	-	III	-
Geranion sanguinei								
Galium lucidum	+	-	+	-	-	II	IV	0.2
Trifolium alpestre	-	-	-	+	+	II	I	0.2
Campanula rapunculoides	-	-	+	+	-	II	I	0.2
Laserpitium latifolium	+	-	-	-	-	I	I	0.1
Digitalis grandiflora	-	+	-	-	-	I	II	0.1
Festucetalia* et *Festuco-Brometea								
Pimpinella saxifraga	+	-	-	+	+	III	IV	0.3
Campanula sibirica	-	-	-	+	-	I	I	0.1

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Varie syntaxa								
Cirsium erisithales	+	+	+	+	+	V	V	0.5
Cnidium silaifolium	+	+	+	+	+	V	II	0.5
Luzula luzuloides	+	+	-	+	+	IV	I	0.4
Ligularia sibirica	+	-	+	+	+	IV	I	0.4
Parnassia palustris	+	+	-	+	-	III	II	0.3
Silene pusilla	+	+	-	+	-	III	IV	0.3
Soldanella hungarica subsp. *major*	+	-	-	+	+	III	I	0.3
Anthemis tinctoria	-	+	+	-	+	III	II	0.3
Astrantia major	-	-	+	+	+	III	III	0.3
Campanula patula subsp. *abietina*	-	+	-	+	+	III	II	0.3
Clematis alpina	+	-	-	-	+	II	II	0.2
Picea abies	-	-	+	+	-	II	II	0.2
Cortusa mathioli	-	+	+	-	-	II	II	0.2
Mycelis muralis	-	+	-	+	-	II	I	0.2
Valeriana montana	-	+	+	-	-	II	III	0.2
Polygonum viviparum	-	-	+	-	+	II	II	0.2
Veronica urticifolia	-	-	+	-	+	II	I	0.2
Achillea distans	-	+	-	+	-	II	I	0.2
Viola biflora	+	-	-	+	-	II	II	0.2
Chaerophyllum hirsutum	-	+	+	-	-	II	I	0.2
Angelica sylvestris	-	+	-	-	-	I	II	0.1
Saxifraga demissa	-	+	-	-	-	I	II	0.1
Valeriana sambucifolia	+	-	-	-	-	I	II	0.1
Scrophularia scopolii	-	+	-	-	-	I	I	0.1
Salix silesiaca	-	-	+	-	-	I	III	0.1
Erigeron acer	-	-	+	-	-	I	I	0.1
Coeloglossum viride	-	-	-	-	+	I	I	0.1
Vaccinium vitis-idaea	+	-	-	-	-	I	I	0.1
Saxifraga cuneifolia	-	-	+	-	-	I	I	0.1
Campanula persicifolia	-	+	-	-	-	I	I	0.1
Daphne mezereum	-	-	+	-	-	I	I	0.1
Delphinium elatum	-	+	-	-	-	I	I	0.1
Gentiana bulgarica	-	-	-	+	-	I	-	0.1
Aconitum toxicum	-	-	+	-	-	I	I	0.1
Leucanthemum waldsteinii	-	-	-	-	+	I	I	0.1
Solidago virgaurea subsp. *minuta*	-	-	-	-	-	-	I	-
Pinguicula vulgaris	-	-	-	-	-	-	I	-

The new species identified for the studied association in 2015 are: *Silene heufeli, Senecio ovatus, Heracleum sphondyliums* subsp. *transsilvanicum, Valeriana montana, Elymus caninus, Brachypodium sylvaticum, Anthriscus sylvestris, Geranium phaeum, Geranium sylvaticum, Valeriana officinalis, Luzula luzuloides, Paris quadrifolia, Digitalis grandiflora, Salix silessiaca, Dactylis glomerata, Phleum alpinum, Spiraea chamaedrifolia, Carex ovalis, Campanula persicifolia, Cystopteris fragilis, Dryopteris filix-max, Polygonum viviparum* (Table 2).

2. Bioforms Analysis

By analysing the comparative study from 2003 with the one carried out in 2015 for the *Asperulo capitatae - Seslerietum rigidae* (Zoly. 1939) Coldea 1991 association (Fig.2), it can be noticed that the percentage of hemicryptophytes, cormophytes and geophytes does not change. Meanwhile in the case of *Ligulario sibiricae – Ribetum petraei* Neblea et Alexiu 2003 association, the percentage of hemicrypthytes species increases from 62% to 70% being higher in 2015; geophytes have a minor

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variation and the place occupied by phanerophytes in 2003 is now occupied by chamephytes. Following the analysis of the two associations studied in the field by the author, it can be seen that on both associations the percentage prevail for hemicryptophytes with 69% for *Asperulo capitatae - Seslerietum rigidae* (Zoly. 1939) Coldea 1991 and 70% for *Ligulario sibiricae - Ribetum petraei* Neblea et Alexiu 2003.

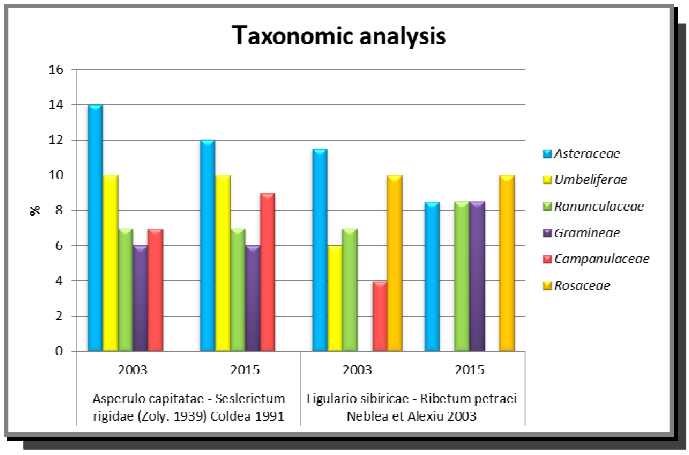

Figure 1. Comparative taxonomic analysis of the studied associations from Zănoagei Gorges, Dâmbovița County

Table 2. Ligulario sibiricae - Ribetum petraei Neblea et Alexiu 2003 – Zănoagei Gorges; 1-10, K1, ADm - Matei A. N. 2015; K2 – 5 reference surveys after Alexiu V & Neblea M. 2003

***Ligulario sibiricae - Ribetum petraei* Neblea et Alexiu 2003 - Zănoagei Gorges**													
Survey	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**K1**	**K2**	**ADm**
Altitude (m s.m.)	**1367**	**1381**	**1370**	**1374**	**1380**	**1369**	**1381**	**1378**	**1367**	**1375**			
Exposition	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**			
Slope (□)	**50**	**10**	**5**	**45**	**10**	**5**	**10**	**45**	**50**	**45**			
Surface (m²)	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**	**15**			
Coverage of the herbaceous layer (%)	**73.5**	**67.5**	**65.5**	**74**	**68.5**	**70**	**79**	**78**	**73.5**	**67.5**			
Characteristic species of the association													
Ligularia sibirica	2	3	2	3	3	3	2	2	2	3	V	V	27.5
Ribes petraeum	1	1	2	1	1	1	2	2	2	1	V	V	10
Adenostyletalia s.1.													
Aconitum variegatum subsp. *paniculatum*	+	+	+	+	+	+	+	+	+	+	V	III	0.5
Silene heufeli	+	+	+	+	+	+	0	+	+	+	V	-	0.45
Polygonatum verticillatum	-	+	+	+	-	+	+	+	+	+	IV	II	0.4
Senecio ovatus	+	+	+	-	+	+	+	-	-	+	IV	-	0.35
Alnus viridis	-	+	-	+	-	+	+	+	+	+	IV	IV	0.35
Thalictrum aquilegifolium	-	+	+	+	+	-	-	+	+	+	IV	IV	0.35
Heracleum sphondylium subsp. *transsilvanicum*	+	+	+	+	-	+	+	-	-	-	III	-	0.3
Rosa pendulina	-	+	+	-	+	-	-	+	+	+	III	I	0.3
Valeriana montana	-	+	+	-	-	+	+	-	+	-	III	-	0.25
Cortusa matthioli	-	+	-	+	-	-	-	+	-	-	II	III	0.15
Gentiana asclepiadea	+	-	-	-	+	-	-	+	-	-	II	II	0.15
Valeriana officinalis subsp. *sambucifolia*	+	-	-	+	-	-	+	-	-	-	II	II	0.15

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Delphinium elatum	-	-	-	-	+	-	-	-	+	-	I	III	0.1
Rumex alpestris	-	-	-	+	-	-	+	-	-	-	I	I	0.1
Senecio hercynicus	-	-	-	-	-	-	-	-	-	-	-	V	-
Achillea distans	-	-	-	-	-	-	-	-	-	-	-	I	-
Thelypteris limbosperma	-	-	-	-	-	-	-	-	-	-	-	I	-
Carduus personatus	-	-	-	-	-	-	-	-	-	-	-	I	-
Alno-Ulmion													
Elymus caninus	2	1	2	1	1	1	2	2	1	1	V	-	10
Urtica dioica	+	+	+	+	+	+	+	+	+	+	V	II	0.5
Equisetum sylvaticum	-	+	-	+	+	+	+	+	+	+	IV	I	0.4
Stellaria nemorum	+	+	-	+	+	+	-	+	+	+	IV	V	0.4
Aegopodium podagraria	+	+	+	+	+	+	+	-	-	-	IV	IV	0.35
Brachypodium sylvaticum	+	+	+	-	-	+	+	+	+	-	IV	-	0.35
Geum rivale	+	+	+	-	+	+	-	-	+	+	IV	IV	0.35
Anthriscus sylvestris	-	+	+	-	+	+	-	-	+	+	III	-	0.3
Geranium phaeum	-	+	-	+	-	+	+	+	-	-	III	-	0.25
Valeriana officinalis	+	-	-	-	-	-	+	-	+	+	II	-	0.2
Filipendula ulmaria	-	+	-	-	+	+	-	-	-	+	II	III	0.2
Astrantia major	-	-	-	+	+	-	-	-	-	-	I	I	0.1
Athyrium filix-femina	+	-	-	-	-	-	+	-	-	-	I	II	0.1
Chaerophyllum hirsutum	-	-	-	+	-	-	-	-	+	-	I	IV	0.1
Geranium sylvaticum	-	-	-	-	-	-	-	-	-	-	I	-	-
Fagetalia													
Luzula luzuloides	2	+	1	1	1	1	1	1	2	1	V	-	7.05
Poa nemoralis	+	+	-	+	-	+	+	+	+	+	IV	II	0.4
Veronica urticifolia	+	+	+	+	-	+	+	-	+	-	IV	III	0.35
Hordelymus europaeus	-	+	+	+	-	+	-	+	+	-	III	I	0.3
Simphytum tuberosum	-	+	-	+	+	+	+	+	-	-	III	I	0.3
Daphne mezereum	-	+	-	-	+	-	+	-	+	+	III	III	0.25
Lilium martagon	-	+	-	-	+	-	-	+	-	+	II	I	0.2
Paris quadrifolia	-	+	+	-	+	-	-	-	-	+	II	-	0.2
Pulmonaria rubra	-	-	-	+	-	+	+	+	-	-	II	I	0.2
Hepatica transsilvanica	-	-	-	-	-	-	-	-	-	-	-	II	-
Acer pseudoplatanus	-	-	-	-	-	-	-	-	-	-	-	II	-
Vaccinio-Piceion													
Oxalis acetosella	+	+	+	1	+	+	1	1	+	+	V	II	1.85
Clematis alpina	+	+	+	-	-	+	+	+	+	+	IV	III	0.4
Campanula patula subsp. *abietina*	-	+	-	-	-	+	+	+	+	-	III	I	0.25
Lonicera nigra	-	+	-	+	+	+	-	-	-	+	III	III	0.25
Picea abies	+	-	-	-	+	+	+	-	+	-	III	V	0.25
Vaccinium vitis-idaea	-	+	+	+	-	-	-	+	-	+	III	II	0.25
Lycopodium annotinum	-	-	-	-	-	-	-	-	-	-	-	I	-
Saxifraga cuneifolia	-	-	-	-	-	-	-	-	-	-	-	I	-
Sambuco-Salicion													
Rubus idaeus	+	+	+	+	+	+	+	+	+	+	V	III	0.5
Sambucus racemosa	-	+	-	+	-	-	+	+	-	-	II	III	0.2
Sorbus aucuparia	-	-	-	-	-	-	-	-	-	-	-	IV	-
Salix caprea	-	-	-	-	-	-	-	-	-	-	-	IV	-
Convolvulion													
Petasites hybridus	-	-	-	+	-	+	-	-	+	-	II	II	0.15
Epilobietalia													

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Fragaria vesca	+	+	+	+	+	+	+	+	+	+	V	III	0.5
Solidago virgaurea	+	-	-	-	+	-	-	-	-	+	II	II	0.15
Digitalis grandiflora	+	-	-	-	-	+	-	-	-	-	I	-	0.1
Epilobium angustifolium	-	-	-	+	-	-	-	+	-	-	I	I	0.1
Calamagrostis arundinacea	-	-	-	-	-	-	-	-	-	-	-	IV	-
Varie syntaxa													
Scabiosa lucida	+	+	+	+	+	+	+	+	+	+	V	II	0.5
Salix silessiaca	+	+	+	+	+	+	-	+	-	+	IV	-	0.4
Dactylis glomerata	-	+	+	-	-	+	+	+	+	+	IV	-	0.35
Phleum alpinum	-	+	+	-	-	-	+	+	+	-	III	-	0.25
Alchemilla xanthochlora	-	-	+	+	-	-	+	-	-	+	II	III	0.2
Spiraea chamaedrifolia	+	-	-	-	+	-	+	-	-	-	II	-	0.15
Carex ovalis	+	-	-	+	+	-	-	-	-	-	II	-	0.15
Anthemis tinctoria	-	-	-	+	-	-	-	+	-	-	I	I	0.1
Campanula cochlearifolia	+	-	-	-	+	-	-	-	-	-	I	I	0.1
Campanula persicifolia	+	-	-	-	-	-	-	-	+	-	I	-	0.1
Cirsium erisithales	-	-	-	-	+	-	-	+	-	-	I	III	0.1
Hypericum maculatum	+	-	-	-	-	-	+	-	-	-	I	IV	0.1
Parnassia palustris	+	-	-	-	-	-	-	-	-	+	I	III	0.1
Cystopteris fragilis	+	-	-	-	-	+	-	-	-	-	I	-	0.1
Dryopteris filix-max	+	-	-	-	-	-	+	-	-	-	I	-	0.1
Polygonum viviparum	-	+	-	-	-	-	-	-	+	-	I	-	0.1
Cnidium silaifolium	-	-	-	-	-	+	-	-	-	-	I	I	0.05
Dianthus spiculifolius	-	-	-	-	+	-	-	-	-	-	I	I	0.05
Gymnocarpium robertianum	-	-	-	-	-	-	-	-	-	-	-	II	-
Thymus comosus	-	-	-	-	-	-	-	-	-	-	-	II	-
Scrophularia scopolii	-	-	-	-	-	-	-	-	-	-	-	I	-
Sedum vulgare	-	-	-	-	-	-	-	-	-	-	-	I	-
Saxifraga luteo-viridis	-	-	-	-	-	-	-	-	-	-	-	I	-
Valeriana tripteris	-	-	-	-	-	-	-	-	-	-	-	I	-
Silene nutans ssp. dubia	-	-	-	-	-	-	-	-	-	-	-	I	-
Campanula carpatica	-	-	-	-	-	-	-	-	-	-	-	I	-
Asplenium viride	-	-	-	-	-	-	-	-	-	-	-	II	-
Polystichum lonchitis	-	-	-	-	-	-	-	-	-	-	-	I	-

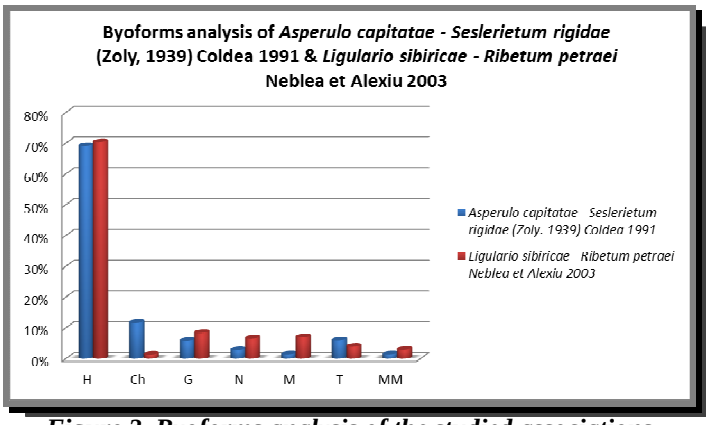

Figure 2. Byoforms analysis of the studied associations from Zănoagei Gorges – Dâmbovița County (Romania)

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3. Geoelements Analysis

Following the comparative analysis of the geoelements, for the association *Asperulo capitatae-Seslerietum rigidae,* the Circumpolar elements hold almost the same percentage while the Carpathian and European elements change the share value insignificantly.

Regarding the comparative analysis of the geoelements for *Ligulario sibiricae-Ribetum petraei* association, it can be noticed the constant percentage value of the Eurasian, Circumpolar and Central European elements. (Figure 3). By conducting the comparative study of the geoelements from the studied associations, the Eurasian elements prevail in the *Ligulario sibiricae -Ribetum petraei* association, while for *Asperulo capitatae-Seslerietum rigidae* the Central European and Carpathian elements prevail.

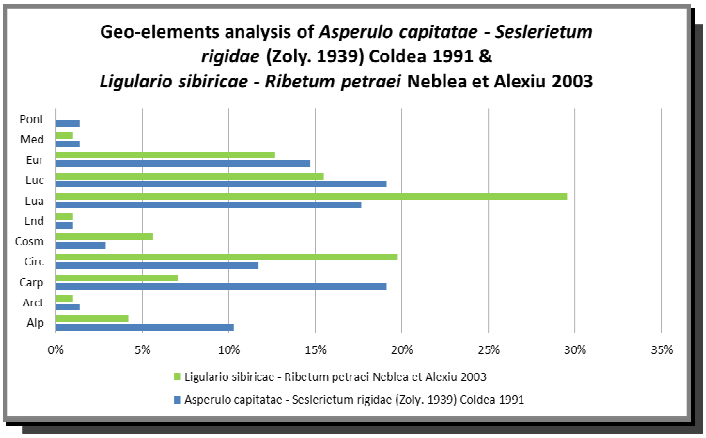

Figure 3. Geo-elements analysis of the studied associations from Zănoagei Gorges – Dâmbovița County (Romania)

4. Karyological analysis

From the kariological point of view, regarding the analysis of the two associations, the share similarity of the diploid and polyploid elements was noted. Thus it can be concluded that for both associations the presence of relict elements, resistant to extreme ecological conditions, is possible due to the high degree of conservation offered by the site and the Zănoagei Gorges reserve. Meanwhile, the diplo-polyploid elements have a higher presence in the association *Ligulario sibiricae - Ribetum petraei*, than on *Asperulo capitatae-Seslerietum rigidae* (Figure 4).

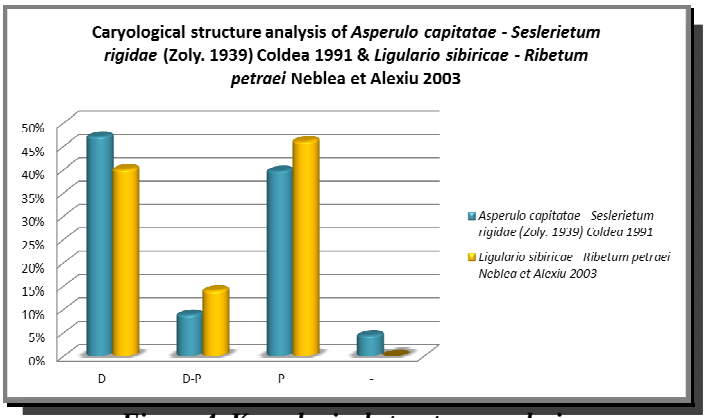

Figure 4. Karyological structure analysis

*Corresponding author, E-mail address: mateiandreeanatalia@gmail.com

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Ecological structure analysis

The analysis of the Ellenberg indices for the two associations: *Apserulo capitatae-Seslerietum rigidae* and *Ligulario sibiricae-Ribetum petraei*, was performed for the light factor. Light tolerant species (L7) predominate, followed by light-loving species which only for a short time endures the shadow conditions (L8). (Figure 5).

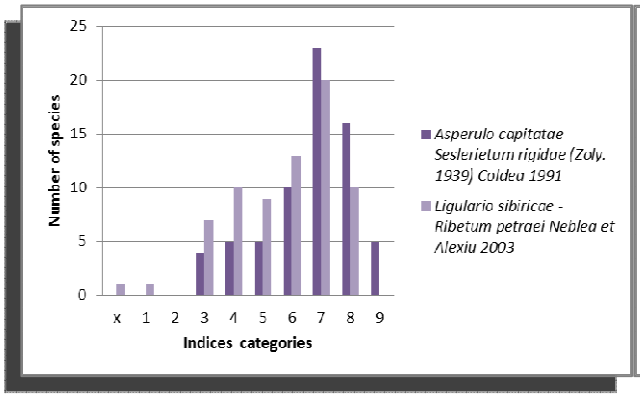

Figure 5. Distribution of species to light factor (L)

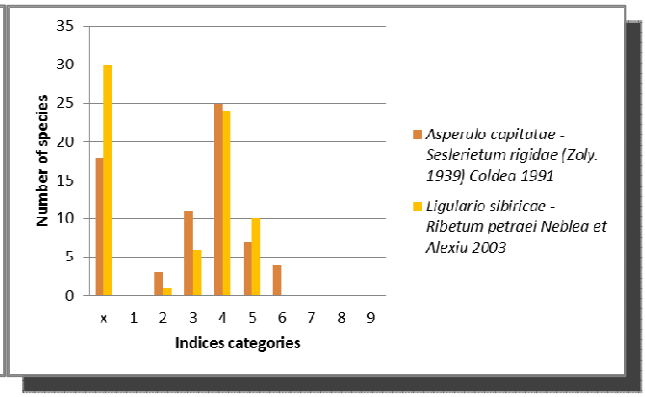

Figure 6. Species distribution versus temperature factor (T)

Regarding the temperature requirements, on *Asperulo capitatae - Seslerietum rigidae* associatiation the widespread species in the montane and high montane levels prevail (T_4), being followed by the eurithermal species (T_x). In the *Ligulario sibiricae – Ribetum petraei* association the eurithermal species (T_x) holds the biggest share, followed by the species spread on the mountain and high mountain levels (T_4) (Figure 6).

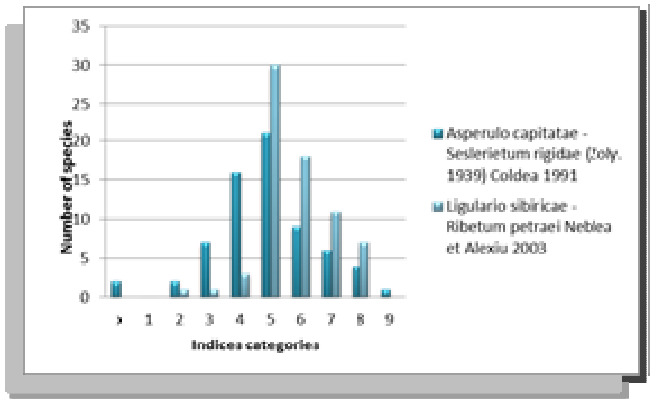

Figure 7. Species distribution versus humidity factor

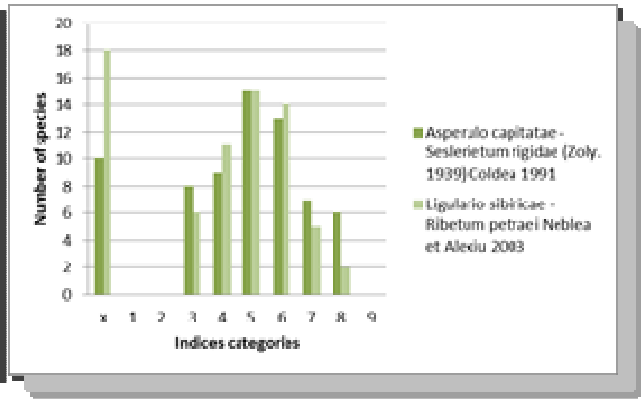

Figure 8. Species distribution versus soil response factor

The Ellenberg indices were used to reveal the necessary humidity conditions for the species within each association. Thus meso-hygrophilic species with preference for moderately wet soils can be found in both associations. Within *Asperulo capitatae-Seslerietum rigidae*, meso-higrophilic species are predominant (U_5), meanwhile, in the *Ligulario sibiricae-Ribetum petraei association*, most species are meso-hygrophilic followed by those which prefer wetter soils, (U_6) (Figure 7).
Regarding the species tolerance in relation with the soil reaction, an important category within *Asperulo capitatae-Seslerietum rigidae* is represented by species which prefer moderate poor acid soils (R_5), followed by poor acid soils to neutral (R_6). For *Ligularia sibiricae - Ribetum petraei*, prevail indifferent, eurionic (R_x) species, followed by species with preference for moderate poor acid soils (R_5) (Figure 8).

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Taking into account the distribution of the species in relation to the amount of nitrogen in soil, in *Asperulo capitatae-Seslerietum rigidae* association most of the species prefer very poor or poor in mineral nitrogen substrate (N_2, N_3). In the *Ligulario sibiricae-ribetum petraei* association, predominant species are those that prefer soils with moderate mineral content of nitrogen (N_5), being followed by eurinitrophile species (N_x) (Figure 9). In the 2015 the ecological survey from the Zănoagei Gorges, revealed 175 individuals of *Ligularia sibirica* (L.) Cass. identified on *Asperulo capitatae-Seslerietum rigidae* association, of which the highest share (94%) is occupied by individuals in vegetative state. In the association *Ligulario sibiricae-Ribetum petraei*, 309 individuals were found, the largest share being occupied by the individuals in the vegetative state (92%).

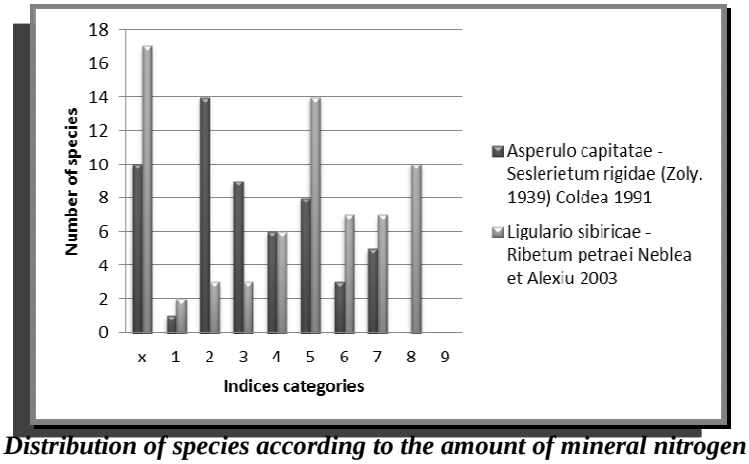

Figure 9. Distribution of species according to the amount of mineral nitrogen in the soil

4. CONCLUSIONS

Within the *Asperulo capitatae-Seslerietum rigidae* association, the decline in biodiversity can be observed, thus the number of hemicryptophytes registered in 2003 diminished in comparison with those registered in 2015, at the same time the number of families remained constant. Regarding *Ligulario sibiricae-Ribetum Petraei* association, the surveys conducted in 2003 revealed the presence of 37 families, the number of families was decreasing in 2015 to 34 but with an almost constant number of species, 70-71. For both associations, the family with the highest share in both 2003 and 2015 year is *Asteraceae*.

From the bioforms point of view, can be observed the highest share in both associations of hemicryptophyte elements. By conducting the comparative study of the geoelements encountered in the studied associations, it can be noticed that the Eurasian elements prevail in the *Ligulario sibiricae-Ribetum petraei* association, while for the *Asperulo capitatae-Seslerietum rigidae* association prevail the Central European and Carpathian elements.

From the kariological point of view, following the analysis of the two vegetal associations, the high percentage of the polyploid elements was noted in the *Ligulario sibiricae-Ribetum petraei* association. Meanwhile in *Asperulo capitatae-Seslerietum rigidae* association the diploid elements have the highest share; as a result the biodiversity of the association can decline in time, due to their low adaptability to the new environmental conditions.

After the analysis of the Ellenberg indices, meso-hygrophilic, light-loving species predominates in both associations. Regarding the temperature factor, in *Asperulo capitatae - Seslerietum rigidae* prevail the species spread on moderately-poor acidic soils, very poor or poor in mineral nitrogen from the mountain and up mountain floor. In *Ligulario sibiricae - Ribetum petraei* association, the

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*Corresponding author, E-mail address: mateiandreeanatalia@gmail.com

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eurionic elements that prefer soils with a low content in mineral nitrogen, eurinitrophilic elements predominate; which reveal a higher tolerance of the species on the ecological changes in time.

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*Corresponding author, E-mail address: mateiandreeanatalia@gmail.com