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PLANT COMMUNITIES WITH *ARNICA MONTANA* IN NATURAL HABITATS FROM THE CENTRAL REGION OF ROMANIAN EASTERN CARPATHIANS

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Abstract: *Arnica montana* is a species of European Union interest, whose harvest from the wild and exploitation should be made under certain management measures. In Romania it is a vulnerable species due to excessive collection. It is a species with European areal occuring in pastures, meadows, forest glades, shrubs communities of mountain to the subalpine regions and, isolated, up to the alpine belt. Most of the plant communities with *Arnica montana* are semi-natural, with a floristic composition in which there are numerous rare or threatened species also supporting the need of their conservation. Our study was focused on a numerical classification (hierarchical, using Flexible ß algorithm and Bray-Curtis dissimilarity) based on 48 plots, of the plant communities with *Arnica montana* from the central region of Romanian Eastern Carpathians and on the investigation of the effect of some environmental variables (Ellenberg indicator values, altitude, heat load index) on their floristic composition (100 m^2 scale). Vegetation – environment relationship was assessed via detrended correspondence analysis and canonical correspondence analysis with Monte Carlo test. Six plant communities with *Arnica montana* were identified (communities of *Festuca rubra* with *Agrostis capillaris, Festuca nigrescens, Vaccinium myrtillus, Nardus stricta, Vaccinium gaultherioides* and *Juniperus sibirica*) with a floristic composition mainly shaped by altitude, temperature and soil nitrogen content. Details related to location and sites characteristics, diagnostic species, floristic composition, presence of other rare or threatened species and *Arnica montana* abundance were presented for all these plant communities.

Key words: vegetation, *Arnica montana*, floristic composition, ecology, habitats

Introduction

Arnica montana, a species well-known for its medicinal properties, has an European (montane) areal: it is native in numerous countries (e.g. Italy, Germany, Austria etc.), or large-scale cultivated as in Estonia [EURO+MED PLANTBASE, 2006-]. In some other countries (as Hungary) it is considered extinct [EURO+MED PLANTBASE, 2006-]. In Romania, due to excessive collection it is considered a vulnerable species and is included in the Red List of Plants from Romania [OLTEAN et al. 1994]. Also the species was inserted in the Habitats Directive of the European Union (1992), in Appendix 5, in which there are listed the animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures. In Romania, *Arnica montana*

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frequently occurs in secondary communities developed after the cutting of forest vegetation or in mesophytic grasslands, preferring more acid and poor in nutrients soils [ELLENBERG, 1992]. It is a species which grows in pastures, meadows, forest glades, shrubs communities from mountain to the subalpine regions and, isolated, up to the alpine areas. It is considered as diagnostic species for *Calluno-Ulicetea* Br.-Bl. et R. Tx. ex Klika et Hadać 1944 (*Nardo-Callunetea* Preising 1944), a vegetation class including grasslands and shrubs communities on acid substrata developed in montane and subalpine vegetation belts [MUCINA, 1997]. For Romanian vegetation, significant constancies were recorded in vegetal communities within *Potentillo-Nardion* Simon 1958 alliance [COLDEA & al. 2012; CHIFU & al. 2015].

In the present study, the main objective was to identify the main plant communities with *Arnica montana* in the central region of Romanian Eastern Carpathians using a vegetation dataset with 48 relevés and hierarchical clustering procedures. For each identified plant community we wanted to highlight the diagnostic and dominant species, the floristic and phytosociological composition, the cover of *Arnica montana* individuals, other rare and threatened species and the habitat type.

Material and methods

The study area (Fig. 1), situated in the central region of Romanian Eastern Carpathians, included different localities (Farcaşa, Borca, Broşteni, Barnar, Chiril, Ortoaia, Dorna Arini, Neagra Şarului, Gura Haitii) from several mountain ranges (Stânişoarei, Bistriţei, Rarău, Călimani Mountains and Dorna Depression) in two counties (Neamț and Suceava). This area's geology is varied and represented by crystalline rocks (Bistriţei Mountains), limestones (Rarău and Stânişoarei Mountains), volcanic rocks (Călimani Mountains) and sedimentary deposits (Dorna Depression) [MIHAILESCU, 1963]. The main soil types are the cambisols (corresponding to mixed beech forests), spodosols (corresponding to spruce forests) and lithosols (corresponding to subalpine and alpine grasslands) [BARBU & al. 1984]. The climate is temperate continental, with mean annual precipitations ranging between 600 (in lower areas) and 1100 mm (1200, in upper areas) and mean annul temperatures ranging between 0 and 4 ºC. From a phytogeographical perspective, the study area is included in the Euro-Siberian floristic region with Carpathian

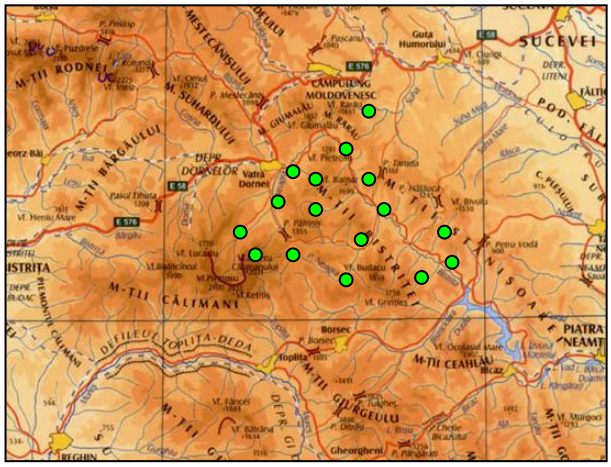

Fig. 1. Geographical localization of the study area. The green points represents the main localities where vegetation plots were sampled.

Province [CHIFU & al. 2006]. According to Habitats Directive of the European Union (1992), the studied territory is considered as a part of the alpine biogeographical region.

In order to identify the main plant communities with *Arnica montana* in the central region of Romanian Eastern Carpathians, 48 relevés (including 208 species) were used. The relevés were realized using the method of the Central European School for vegetation study adapted for Romanian vegetation [BORZA & BOȘCAIU, 1965]. Plant species cover was visually estimated using a 6 level scale: + (<5%); 1 (5–10%); 2 (10–25%); 3 (25–50%); 4 (50–75%); 5 (>75%). All relevés had 100 m^2 in size and were made at altitudes ranging between 700-2000 m in the summer periods of 2014-2015. Species present only in one relevé were removed (final dataset included 48 relevés x 156 species). Vegetation classification was performed by hierarchical agglomerative clustering (using Bray-Curtis dissimilarity and Flexible β (β = -0.25) algorithm). Optimum number of clusters was detected using the corrected Rand index and the silhouette index. For each cluster the diagnostic species were identified by the indicator value index [DUFRÊNE & LEGENDRE, 1997] and validated by a permutation test [DE CÁCERES & LEGENDRE, 2009] (the threshold value, subjectively chosen, for a species considered as diagnostic was 0.400, $p < 0.5$). The environmental factors with significant influence on the floristic composition were identified via detrended (square root transformation, detrending by segments and non-weighted average values of the Ellenberg indices -EIVs- for light (L), temperature (T), soil moisture (U), soil pH (R) and nutrients (N) [ELLENBERG & al. 1992], alongside altitude and heat load index) and canonical correspondence analysis (square root transformation, same indices as in DCA and Monte Carlo test). Differences among ecological characteristics the six associations were highlighted using the Kruskal-Wallis non-parametric ANOVA and the Mann-Whitney post-hoc test (Bonferroni corrected). Nomenclature of plants species follows CIOCÂRLAN (2000).

For each plant community were presented the localities, some characteristic of the stations, diagnostic and dominant species, floristic and phytosociological composition, cover of *Arnica montana* individuals, the rare and threatened species [OLTEAN & al. 1994; Habitats Directive, 1992; Bern Convention, 1979] and the habitat type according to GAFTA & al. (2008) and DONIȚĂ & al. (2005).

Results and discussion

The dendrogram resulted from hierarchical clustering was cut into 15 partitions with 2-14 clusters (Fig. 2). The optimal number of clusters was identified by the corrected Rand index which had the highest values when partitions with 6 and 7 clusters were compared. In addition, the Silhouette index showed a local maximum for the partition with 6 clusters, and consequently, the partition 6 clusters was considered for the association level (Fig. 2). Next, for each of the six clusters were identified the diagnostic species and, based on them, the clusters were related to plant associations described in the literature.

In the central region of Eastern Carpathians, plant communities with *Arnica montana* were represented by secondary grasslands developed on moderate and nutrient richer soils and also by dwarf boreal and subalpine shrubs communities developed on more acid and nutrient poor soils. In terms of life-forms, all communities were dominated by hemicryptophyte species. In their floristic composition, an altitudinal transition was highlighted, from communities in which the European and Eurasian elements were more

frequent to communities where the circumpolar (and circumpolar-arctic-alpine) were more frequent. The plant communities were assigned to the next syntaxonomical system:

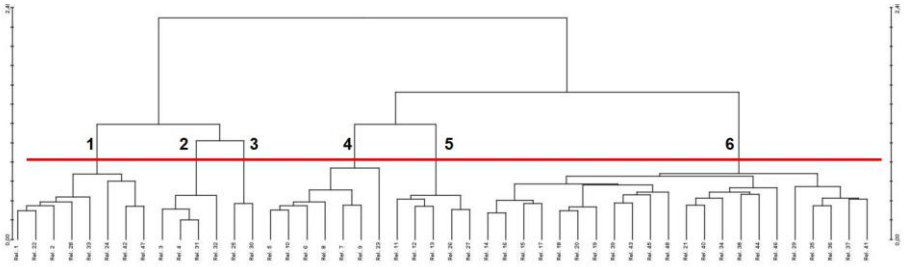

Fig. 2. Classification of plant communities with *Arnica montana* from the central region of Eastern Carpathians. The dendrogram resulted in hierarchical agglomerative clustering (Flexible β algorithm and Bray-Curtis dissimilarity) showing the reports of floristic similarity among plant communities. The red segment highlights the optimum number of clusters according to corrected *Rand* index and *Silhouette* index. 1 – *Campanulo abietinae-Vaccinietum*; 2 – *Campanulo abietinae-Juniperetum nanae*; 3 – *Cetrario-Vaccinietum gaultherioidis*; 4 – *Scorzonero roseae-Festucetum nigricantis*; 5 – *Violo declinatae-Nardetum*; 6 – *Festuco rubrae-Agrostietum capillaris*.

MOLINIO – ARRHENATHERETEA R. Tx. 1937
ARRHETANTHERETALIA R. Tx. 1937
Cynosurion R. Tx. 1947
1. *Festuco rubrae-Agrostietum capillaris* Horvat 1951

NARDO – CALLUNETEA Preising 1949
NARDETALIA Oberd. 1949
Potentillo ternatae – Nardion Simon 1958
2. *Scorzonero roseae-Festucetum nigricantis* (Puşcaru et al. 1956) Coldea 1987
3. *Violo declinatae-Nardetum* Simon 1966

LOISELEURIO – VACCINIETEA Eggler ex Schubert 1960
RHODODENDRO – VACCINIETALIA Br.-Bl. in Br.-Bl. et Jenny 1926
Juniperion nanae Br.-Bl. et al. 1949
4. *Campanulo abietinae-Juniperetum nanae* Simon 1966
Loiseleurio – Vaccinion Br.-Bl. in Br.-Bl. et Jenny 1926
5. *Cetrario-Vaccinietum gaultherioidis* Hadač 1956
Rhododendro – Vaccinion J. Br.-Bl. ex G. Br.-Bl. et J. Br.-Bl. 1931
6. *Campanulo abietinae-Vaccinietum* (Buia et al. 1962) Boşcaiu 1971

A) *Festuco rubrae – Agrostietum capillaris* Horvat 1951 (**6520** Mountain hay meadows. **R 3803** South-Eastern Carpathian meadows of *Agrostis capillaris* and *Festuca rubra*).

Location and sites characteristics: is the most frequent plant community with *Arnica montana* in the studied region, occurring on significant areas from Farcaşa, Borca, Broşteni, Chiril, Ortoaia, Dorna Arini, Şaru Dornei, Gura Haitii localities (Stânişoarei, Bistriţei, Rarău or Călimani Mountains and Dornelor Depression), at altitudes ranging from 693 to 1500 m.a.s.l (973±184 m.a.s.l.), on terrains with various slopes and aspects (from

plane terrains to 50 º slopes). In certain sites, the field management - excessive grazing facilitated its invasion by *Nardus stricta* and *Vaccinium myrtillus*.

Diagnostic species: *Centaurea phrygia* (0.853***), *Agrostis capillaris* (0.838***), *Festuca rubra* (0.831***), *Alchemilla xanthochlora* (0.603**), *Carum carvi* (0.603*), *Leucanthemum vulgare* (0.596**), *Campanula glomerata* (0.564*), *Holcus lanatus* (0.564*).

Floristic composition: the community includes secondary meadows edified by *Festuca rubra* and *Agrostis capillaris*, in various co-dominance reports. The floristic composition was diverse and the herbs layer had (almost in all sites) 100% cover. Besides diagnostic species, the most frequent (and sometimes with significant cover) were: *Cynosurus cristatus, Arrhenatherum elatius, Briza media, Stachys officinalis, Deschampsia caespitosa, Trifolium pratense, Anthoxanthum odoratum, Viola tricolor, Luzula luzuloides, Veratrum album* etc. From the phytosociological perspective, high constancy presented plants considered as diagnostic species for Cynosurion (*Cynosurus cristatus, Gentiana cruciata, Leontodon autumnalis* etc.), Arrhenatherion (*Centaurea phrygia, Stellaria graminea* etc.), and Deschampsion alliances (*Deschampsia caespitosa, Carex pallescens* etc.), for Arrhenatheretalia (*Thymus pulegioides, Dactylis glomerata* etc.) and Molinietalia orders (*Succisa pratensis, Lychnis flos-cuculi, Linum catharticum* etc.) and also for Molinio – Arrhenatheretea class (*Rhinanthus angustifolius, Lotus corniculatus, Polygala vulgaris, Trifolium repens, Prunella vulgaris, Lathyrus pratensis* etc.). Also, the floristic composition included diagnostic species for the meso-xeric grasslands of Festuco – Brometea class (*Pimpinella saxifraga, Anthyllis vulneraria* etc. and species infiltrated from the vegetation of Epilobietea angustifolii (*Digitalis grandiflora, Fragaria vesca* etc.), Vaccinio – Piceetea (*Campanula abietina, Luzula luzuloides, Vaccinium myrtillus* etc.) or Trifolio – Geranietea classes (*Trifolium ochroleucon, Astrantia major, Veronica chamaedrys, Agrimonia eupatoria* etc.). *Arnica montana* (Photo 1) had, in certain sites (as in Gura Haitii village), significant covers (up to 25% of plot area).

Rare/threatened/endemic species: *Arnica montana* (RL, HD), *Trollius europaeus* (RL), *Primula elatior* ssp. *leucophylla* (RL), *Phyteuma tetramerum* (RL), *Gymnadenia conopsea* (RL), *G. odoratissima* (RL), *Traunsteinera globosa* (RL), *Anacamptis pyramidalis* (RL), *Dactylorhiza maculata* (RL), *Dactylorhiza majalis* (RL).

Photo 1. *Arnica montana* in mountain hay meadows (*Festuco rubrae – Agrostietum capillaris*)

B) *Scorzonero roseae – Festucetum nigricantis* (Puşcaru et al. 1956) Coldea 1987, *Violo declinatae – Nardetum* Simon 1966 (**6230*** Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and sub-mountain areas, in Continental Europe). **R 3608** South-Eastern Carpathian meadows of *Scorzonera rosea* şi *Festuca nigrescens*; **R 3609** South-Eastern Carpathian meadows of *Nardus stricta* and *Viola declinata*).

Location and sites characteristics: secondary communities with *Festuca nigrescens* and *Nardus stricta* (with maximum cover of 50%) were identified on smaller areas compared to the previous one, in Bistriței and Călimani Mountains, in an altitudinal range of 972 – 1700 m.a.s.l. (1464±264 m.a.s.l.), preponderantly on south-western and north-western slopes, with pronounced inclinations (35 º).

Diagnostic species: *Scorzonero roseae – Festucetum nigricantis*: *Festuca nigrescens* (0.953***), *Scorzonera rosea* (0.702*); *Violo declinatae – Nardetum*: *Luzula campestris* (0.827**), *Viola declinata* (0.825**), *Nardus stricta* (0.796***), *Prunella vulgaris* (0.587*).

Floristic composition: is species-rich and relative homogenous. The herbs layer presented 80 – 100% cover and included, besides diagnostic and dominant species, some other species with high frequency and cover: *Hieracium pilosella, Briza media, Euphrasia stricta, Rumex acetosella* etc. High constancies had diagnostic species Potentillo ternatae – Nardion alliance (*Campanula serrata, Hieracium lactucella, Gentiana acaulis, Carex pallescens, Hypochoeris uniflora, Hypericum maculatum* etc.), for Festucetalia spadiceae order (*Hieracium aurantiacum, Carlina acaulis, Antennaria dioica*) and Nardo – Callunetea class (*Antennaria dioica* etc.). Also, in the floristic composition there were species from the mountain grasslands of Molinio – Arrhenatheretea (*Agrostis capillaris, Thymus pulegioides, Cynosurus cristatus, Centaurea phrygia, Stellaria graminea* etc.) or from the alpine communities of Juncetea trifidi class (*Potentilla aurea, Phleum alpinum* etc.). ***Arnica montana*** was commonly identified in small groups but, in some locations, had significant cover, up to 10% plot area.

Rare/threatened/endemic species: *Arnica montana* (RL, DH), *Dianthus barbatus* subsp. *compactus* (RL), *Phyteuma tetramerum* (RL), *Scorzonera rosea* (RL), *Gymnadenia conopsea* (RL), *Campanula serrata* (DH), *Phyteuma orbiculare* (RL).

Photo 2, 3. *Arnica montana* in species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and sub-mountain areas, in Continental Europe). 2) *Scorzonero roseae – Festucetum nigricantis*; 3) *Violo declinatae – Nardetum*

C) *Campanulo abietinae – Vaccinietum myrtilli* (Buia et al. 1962) Boşcaiu 1971, *Campanulo abietinae – Juniperetum nanae* Simon 1966, *Cetrario – Vaccinietum gaultherioidis* Hadač 1956 (**4060** Alpine and Boreal heaths. **R 3111** South-Eastern Carpathian *Vaccinium myrtillus* heaths; **R 3108** South-Eastern Carpathian *Juniperus sibirica* heaths; **R 3109** South-Eastern Carpathian *Vaccinium gaultherioides* heaths).

Location and sites characteristics: these subalpine dwarf-shrubs communities occured on the slopes and around Căliman Izvor and Căliman Cerbuc peaks (Călimani Mountains) or Pietrosul Bistriței (Bistriței Mountains), from the upper limit of the forests (widespread communities with *Vaccinium myrtillus*) to highest mountaintops (communities with *Juniperus sibirica* and *Vaccinium gaultherioides* restricted to higher elevations). They were developed on terrains with various slopes and aspects, on moderate humid, acid and nutrient poor soils.

Diagnostic species: *Campanulo abietinae – Vaccinietum myrtilli*: *Vaccinium myrtillus* (0.850^{***}), *Vaccinium vitis-idaea* (0.660^{*}); *Campanulo abietinae – Juniperetum nanae*: *Juniperus sibirica* (0.948^{***}), *Gnaphalium supinum* (0.866^{**}), *Calamagrostis villosa* (0.757^{**}), *Hieracium alpinum* (0.750^{**}), *Homogyne alpina* (0.747^{**}), *Luzula luzuloides* (0.659^{*}), *Pulsatilla alba* (0.588^{*}); *Cetrario-Vaccinietum gaultherioidis*: *Vaccinium gaultherioides* (0.947^{***}), *Festuca supina* (0.728^{**}), *Deschampsia flexuosa* (0.678^{*}).

Floristic composition: the communities of *Vaccinium gaultherioides* or *Juniperus sibirica* (from the subalpine belt) and *Vaccinium myrtillus* (which descends in the montane belt) were characterized by an compact shrubs layer, with covers ranging between 70 – 90% and a species poor floristic composition. Besides dominant species it included also other shrubs species: *Rhododendron myrtifolium*, *Vaccinium vitis-idaea*, *Pinus mugo* etc. The herbs layer had decreased cover (5 – 20%) and included few species among the most frequent were: *Ligusticum mutellina, Antennaria dioica, Homogyne alpina, Festuca supina, Nardus stricta, Luzula sudetica, Veratrum album, Phleum alpinum, Hypericum richeri* ssp. *grisebachii* etc. In some communities from higher elevations a well-developed lichen layer was highlighted. High constancies had species considered as diagnostic for Rhododendro – Vaccinion alliance, Rhododendro – Vaccinietalia order (*Calamagrostis villosa*, *Ligusticum mutellina*, *Vaccinium gaultherioides*) and Loiseleurio–Vaccinietea class (*Primula minima*, *Cetraria islandica*, *Vaccinium myrtillus*, *Thamnolia vermicularis* etc.). In addition, in these plant communities were identified species from the alpine grasslands of Juncetea trifidi class (*Juncus trifidus*, *Hypochoeris uniflora*, *Pulsatilla alba*, *Potentilla ternata*, *Hieracium alpinum* etc.) and from the forests of Vaccinio – Piceetea class (*Lycopodium selago*, *Pinus mugo* etc.). *Arnica montana* was identified as isolated individuals or in small groups (2-3 individuals).

Rare/threatened/endemic species: *Arnica montana* (RL, HD), *Rhododendron myrtifolium* (RL), *Campanula abietina* (BC), *Lycopodium clavatum* (HD), *Leucorchis albida* (RL).

Photo 4, 5. *Arnica montana* in Alpine and Boreal heaths. 4) *Campanulo abietinae – Vaccinietum myrtilli*; 5) *Campanulo abietinae – Juniperetum nanae*

Tab. 1. Ecological characteristics of the six plant communities with *Arnica montana* in the central region of Eastern Carpathians. Means and standard deviations for EIVs for light (L), temperature (T), soil moisture (U), soil reaction (R), soil nutrients (N), altitude and heat load (Hload) are given. *P*-values are derived from Kruskal-Wallis test. Different letters (on columns) indicate significant differences among communities ($\alpha \leq 0.05$ according to Mann-Whitney post hoc test, n.s. – not significant).

Com. no.	EIV L	EIV T	EIV U	EIV R	EIV N	Alt	Hload
1.	7.03 ± 0.21^{a}	4.55 ± 0.43^{a}	4.93 ± 0.24^{a}	4.95 ± 0.68^{a}	3.25 ± 0.29^{a}	973.04 ± 183.45^{a}	0.06 ± 0.52^{a}
2.	7.20 ± 0.18^{a}	4.40 ± 0.38^{ab}	4.78 ± 0.19^{a}	4.58 ± 0.14^{ab}	3.06 ± 0.05^{ab}	1277.00 ± 130.96^{ab}	-0.05 ± 0.28^{a}
3.	7.10 ± 0.40^{a}	3.80 ± 0.27^{bc}	4.91 ± 0.13^{a}	3.98 ± 0.34^{bc}	2.80 ± 0.36^{ac}	1418.57 ± 169.05^{bc}	0.09 ± 0.19^{a}
4.	6.83 ± 0.36^{a}	3.35 ± 0.51^{bd}	4.78 ± 0.12^{a}	3.25 ± 0.57^{bd}	2.46 ± 0.38^{bcd}	1493.12 ± 341.55^{bd}	0.12 ± 0.30^{a}
5.	7.00 ± 0.14^{a}	2.95 ± 0.07^{acde}	4.95 ± 0.07^{a}	2.95 ± 0.21^{acde}	2.25 ± 0.07^{ade}	1797.25 ± 109.60^{acde}	0.50 ± 0.70^{a}
6.	6.97 ± 0.17^{a}	2.92 ± 0.09^{be}	5.15 ± 0.05^{a}	3.10 ± 0.24^{be}	2.50 ± 0.14^{bce}	1821.30 ± 25.28^{be}	0.17 ± 0.20^{a}
p	n.s.	< 0.001	n.s.	< 0.001	< 0.001	< 0.001	n.s.

The ecological characteristics of the six plant communities with *Arnica montana* are shown in Tab. 1 – averages and standard deviations of the factors expressing plant species preferences (ELLENBERG & al. 1992) for light (L), temperature (T), soil moisture (U) soil reaction (R), soil nutrient content (N), altitude and heat load (relating land slope and aspect). It was observed that among the investigated communities there was no significant difference in terms of plant species preferences for light, soil moisture and heat load (in all communities the most of the plant species in the floristic composition were heliophyte, mesophyte species and which can grow on any aspect and slope of the land). The temperature, soil nutrients and pH and altitude differentiated the communities from low altitudes apart from those of high altitudes. Thus, concomitant with the altitude increase, the floristic composition changed, from species adapted to boreal climate from the mountain vegetation belt to species preferring the colder conditions of subalpine and alpine belts. Also there was a transition from moderate acidophilous species growing on nutrients-rich soils at lower elevations, to the more acidophilous species on very nutrients-poor soils at higher altitudes.

In order to confirm the results on variation of the floristic composition, a detrended correspondence analysis was performed (Fig. 3), analysis in which the relevés were arranged along the first two axes depending on the gradients of floristic similarity. From this analysis resulted that the first two axes are the most important, they explained both the largest variation in species data and mostly from the relationships between species and the environment. At the same time, the length of the gradients of floristic similarity along the first axis (the most important according to its eigenvalue) was about 4 units of standard deviation, indicating a unimodal pattern of variation in the floristic composition. Therefore a canonical correspondence analysis with Monte Carlo test was applied, in order to observe the effect of each variable on the floristic composition.

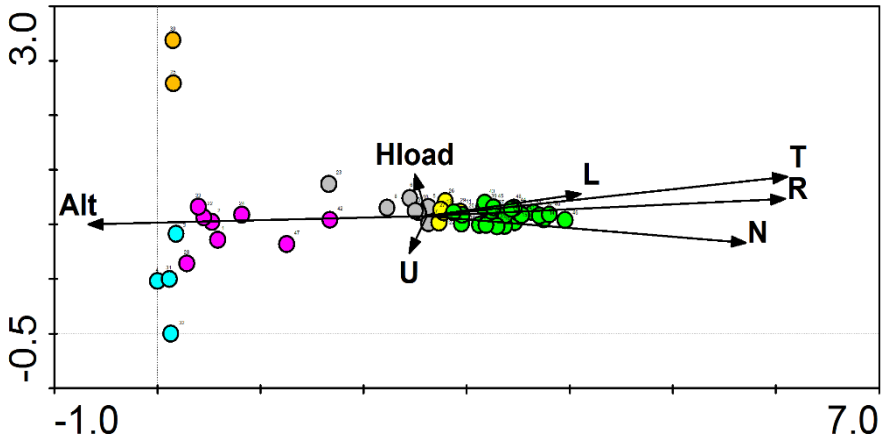

Fig. 3. DCA ordination of the 48 relevés. First two axes are presented, with EIVs for light (L), temperature (T), soil moisture (U), soil reaction (R) and soil nutrients (N), altitude (Alt) and heat load (Hload) passively projected on the ordinogram. The groups generated by agglomerative clustering were colored as follow: *Campanulo abietinae-Vaccinietum myrtilli* - grey, *Campanulo abietinae-Juniperetum nanae* - blue, *Cetrario-Vaccinietum gaultherioidis* - brown, *Scorzonero roseae-Festucetum nigricantis* - violet, *Violo declinatae-Nardetum* - yellow, *Festuco rubrae-Agrostietum capillaris* - green. Correlations with first two axes: L (0.384 and 0.056), T (0.900 and 0.106), U (-0.043 and 0.077), R (0.894 and 0.060), N (0.795 and -0.033), Alt (-0.844 and -0.040) Hload (-0.029 and 0.086).

Tab. 2. Effect of each variable on the floristic composition of plant communities with *Arnica montana* in the central region of Romanian Eastern Carpathians - CCA analysis and Monte Carlo test

Variabilă	EIV T	EIV N	Alt	EIV U	EIV L	EIV R	Hload
***F*-ratio**	8.42	1.98	1.78	1.43	1.24	1.20	1.18
p	0.002	0.002	0.012	0.086	0.12	0.18	0.28

The results of this analysis were presented in Tab. 2 where in the values of the F-ratio expresses the strength of the effect of each variable floristic composition. It could be noted, as in Tab. 1, that temperature, nutrients in the soil and altitude are the main

ecological factors which shape these communities floristic structure and, unlike previous analysis, soil reaction no longer has a significant effect on these communities.

Conclusion

Vegetal communities with *Arnica montana* in the central region on the Romanian Eastern Carpathians are represented by secondary mesophytic montane grasslands (*Festuco rubrae – Agrostietum capillaris*, *Scorzonero roseae – Festucetum nigricantis*, *Violo declinatae – Nardetum strictae*) and also boreal and subalpine dwarf shrubs communities (*Campanulo abietinae – Vaccinietum myrtilli*, *Campanulo abietinae – Juniperetum nanae*, *Cetrario – Vaccinietum gaultherioidis*). These communities corresponds to three habitat types: 6520 Mountain hay meadows, 6230* Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and sub-mountain areas, in Continental Europe) and 4060 Alpine and Boreal heaths. The abundance of *Arnica montana* was higher in mown meadows at relative low altitudes. At higher elevations the species was represented by solitary individuals or in numerically small groups.

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