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# CHOROLOGY AND PHYTOCOENOTIC CONTEXT OF *SAPONARIA BELLIDIFOLIA* SM. WITHIN THE APUSENI MOUNTAINS (SOUTHEASTERN CARPATHIANS, ROMANIA)

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**Abstract:** We studied the chorology and the community context of the rare *S. bellidifolia*, based on synthetic phytosociological data and mathematical models. 78 original and 139 phytosociological relevés extracted from literature were used to calculate the constancy, fidelity and indicator value of *S. bellidifolia* for each plant community. Its floristic relationships were explored with Spearman correlations, Fisher’s exact test and binomial logistic regressions. A chorological map of the species within Apuseni Mts. was drawn. The target species registered the highest constancy (with significant fidelity values) only within the *Festuca pallens*- and *Carex humilis*- communities and the highest abundance within the *Teucrium montanum*- and *Festuca pallens*- communities. Its interspecific associations were very weak, whereas its occurrence was best predicted by the abundance of *Festuca pallens*, *Teucrium montanum* and *Anthericum ramosum*. All results were discussed in the light of community dynamics.

**Key words:** *Saponaria bellidifolia*, rare plant, constancy, fidelity, indicator value, interspecific associations, community dynamics

## Introduction

*Saponaria bellidifolia* Sm. (*Caryophyllaceae*) is a submediterranean mountain species with a disjunct distribution area in Southern Europe, being mostly widespread in the Balkan Peninsula [18]. The northeasternmost populations are found in the Apuseni Mountains (Southeastern Carpathians, Romania). Here, the species is confined to dry, warm, south-exposed slopes of crystalline limestone and dolomite outcrops of Triasic or Proterozoic age [17], situated in the northern part of two mountain ranges, Gilău-Muntele Mare Mts. and Trascău Mts.

Previous works [3, 4, 8, 9, 15, 16, 29] have mentioned the species’ occurrence on seven outcrops: Scărița-Belioara, Cheile Poşăgii – including Vulturese, Cheile Pociovaliştei, Cheile Runcului (from Gilău-Muntele Mare Mts.) and Dealul Vidolm (also known under the name Vf. Ugerului), Piatra Urdaşului (also known under the name Ardaşcheia), Vârful Cornului (from Trascău Mts.) (Fig. 1). Detailed phytosociological studies have been conducted in four of its known localities [10, 15, 16, 25], and the species has been identified from six plant associations, four belonging to Cl. *Festuco – Brometea* Br.-Bl. 1943 (As. *Campanulo divergentiformis – Festucetum pallentis* Zólyomi 1966, As. *Asplenio rutae-murariae – Melicetum ciliatae* Soó 1931, As. *Carici humilis – Stipetum joannis* Pop et Hodişan 1985, As. *Thymo comosi – Caricetum humilis* Zólyomi 1939 (Morariu et Danciu 1974)), and two belonging to Cl. *Seslerietea albicantis* Br.-Bl. 1948 em. Oberd. 1978 (As. *Asperulo capitatae – Seslerietum rigidae* (Zólyomi 1939) Coldea 1991, As. *Helictotrichetum decori* Domin 1932). Some of these plant communities belong to the Natura 2000 habitat types 6190 – Rupicolous pannonic grasslands (includes the *Festuca pallens*- and *Melica ciliata*- dominated communities) and 8120 – Calcareous and calcashist screes of the montane to alpine levels (*Thlaspietea rotundifolii*) (includes the *Teucrium montanum*- and *Thymus comosus* – dominated communities) [14].

The occurrence and phytocoenotic context of the rare *S. bellidifolia* is not well known to date. There could be unknown localities which may reveal important features of the species' biogeography within the Apuseni Mts. Similarly, there are no synthetic data available on the frequency and abundance of *S. bellidifolia* within certain plant communities and thus on their role in preserving this rare species within the Apuseni Mts.

The aim of this study was to: 1) map in detail the population distribution of *S. bellidifolia* within the Apuseni Mts.; 2) characterize the phytocoenotic context of the species, based on an intensive survey of all outcrops and literature data; 3) study the floristic relationships of the target species.

## Methods

### *Data collection and transformation*

Unmentioned populations of *S. bellidifolia* were searched for on limestone outcrops situated near the known localities, during 2002-2005.

Phytosociological relevés were performed in all localities according to the Central-European Phytosociological School [5], on 4 x 4 m plots, suitable for open grasslands [7]. Plant communities were recorded regardless the presence or absence of *S. bellidifolia*. The relevés were performed along two horizontal transects that crossed the outcrops along altitude contour lines. Each homogenous habitat patch was sampled by one relevé, whereas transitory habitats were skipped. Species cover classes were visually estimated based on a scale as defined by Tüxen and Ellenberg [32]. Assignment to plant associations was based on synthetic works of Coldea [6], Pop [24], Pop and Hodişan [26], Sanda [28]. Plant species nomenclature follows Flora Europaea [31].

For data analysis purpose, species cover classes were converted into percentages, equating them with the class midpoint. Percentage data were log-transformed in the analyses of abundance values. Accidental species with occurrence below 2% were eliminated from analyses of phytosociological data, whereas those with occurrence below 40% from analyses of interspecific associations.

### *Phytocoenotic context of S. bellidifolia*

Overall 217 phytosociological relevés were analysed: 139 were extracted from the literature [10, 15, 16, 25, manuscripts] and 78 were original. Among all relevés, 99 contained *S. bellidifolia*, with abundance values between 0.5-17.5%.

Floristic identity of the identified plant communities was tested with numerical analyses. In this respect, non-hierarchical "fuzzy" classification analysis was performed. We compared the results of more types of analyses carried out by using different algorithms. The paper presents the results of the fuzzy classification computed with similarity ratio coefficient (coefficient of fuzzyness: 1.25), which proved to be floristically and ecologically well interpretable and was supported by our field experience as well. The optimal number of clusters was determined based on normalized Bezdek partition coefficient and partition entropy. Classifications were computed from log-transformed abundance data. Phytosociological tables were rearranged based on classification outcomes, and species composition of plant communities was summarised in synoptic tables, containing both categorical constancy values [33] and fidelity values based on Fisher's exact test of independence.

The indicator value [12] of *S. bellidifolia* in each identified community was computed based on the concentration of its abundance and frequency in a particular community type, relative to all phytosociological records. The maximum indicator value obtained was tested for significance with 10000 Monte Carlo permutations.

To situate the communities with high indicator values of *S. bellidifolia* in a dynamic perspective, a minimum spanning tree of all plots was constructed using Bray-Curtis similarity coefficient.

Classifications and the minimum spanning tree were computed using Syntax 2000 software [23], the combined synoptic table was executed in Juice software [30], and indicator species analysis was calculated using PC-Ord v. 3.01 [21].

*Floristic relationships of S. bellidifolia*

Standard and partial Spearman nonparametric correlations and Fisher's exact test of independence were performed to explore the interspecific relationships between the most frequent species (>40%) of all plant communities taken together and *S. bellidifolia*, based on species percentage cover values and presence-absence data respectively.

Binomial logistic regression was performed on abundance dataset to model the probability of *S. bellidifolia* occurrence as a function of other plant species' abundance. In the analysis, a forward stepwise variable selection strategy was used and we tested whether there is evidence against the removal of variables by Likelihood Ratio test.

Spearman correlation coefficients and binomial logistic regression were computed in SPSS 15.0.0 (SPSS Inc. 1989-2006), whereas Fisher's exact test was run in Juice software [30].

## Results

*S. bellidifolia distribution within the Apuseni Mts.*

*S. bellidifolia* populations were found within the seven limestone outcrops mentioned in the literature and also in one new locality, Pinet (pertaining to Gilău-Muntele Mare Mts.) (Fig. 1). The populations from Gilău-Muntele Mare develop on larger outcrops and have several thousand individuals. Those from Trascău Mts. occur on smaller and partially forested outcrops and have a small number of individuals (Dealul Vidolm and Piatra Urdaşului encompass less than 1000 individuals, and Vârful Cornului had only 6 individuals in 2005, the last year of the survey). As we did not describe the populations of *S. bellidifolia* from Vidolm and Vârful Cornului in our previous works [8, 9], we will do it now, together with the new locality.

On the hill of Vidolm (Vârful Ugerului), the population of *S. bellidifolia* develops on the southern slope of the outcrop at approximately 1200 m a.s.l., within a narrow band of open limestone grassland that constitutes a transition between the beech forest that covers the southern slope of the outcrop and the plateau covered by meso-xerophilous grasslands. The beech forest develops on rockslides and screes. This band of ecotone is marked by the presence of *Corylus avellana*, *Rosa spinosissima*, *Juniperus communis*, *Berberis vulgaris*, *Cotoneaster integerrima* bushes, *Fraxinus ornus*, *Sorbus dacica* trees. In sites accessible to animals, the population of Vidolm is extended periodically by wild-boar disturbance and cattle grazing, which generate vegetation gaps proper for establishment of new recruitment (Csergő, pers. obs.).

On Vârful Cornului, the six individuals found during 2004-2005 were confined similarly on the southern slope, at 1238 m of elevation, within a few square meters of open limestone grasslands above the beech forest. Because of its small size, this population is severely endangered.

On the similarly southern-faced Pinet, *S. bellidifolia* grows abundantly mostly between 800-1000 m a.s.l. The habitat encompasses flat, inclined rocky surfaces with distanced crevices, similar surfaces with ledges, smaller scree cones and fixed screes with closed vegetation.

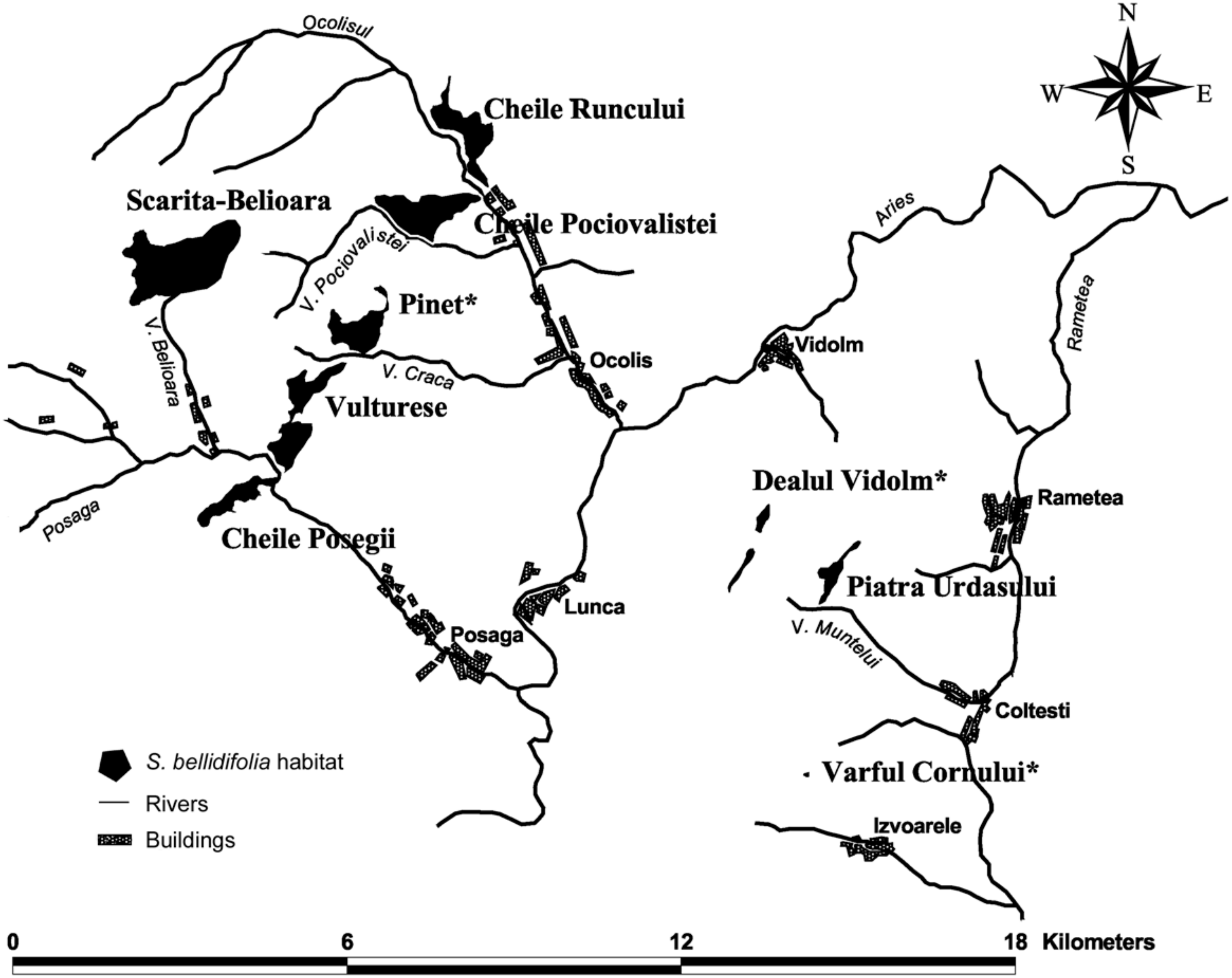

**Fig. 1: Chorology of *Saponaria bellidifolia* Sm. within the Apuseni Mountains, Romania.** Stars indicate populations recently discovered.

*Phytosociological classification of relevés*

*S. bellidifolia* has been identified within almost all plant associations of the southern-faced slopes of the outcrops, except for *Thymetum comosi* Pop et Hodişan 1963 – *galietosum albi* (Pop et Hodişan 1964) Coldea 1991 and *Molinietum caeruleae* Koch 1926. The species was found within the *Thymetum comosi* Pop et Hodişan 1963 – *teucrietosum montani* (Csűrös 1956) Coldea 1991 communities, which were recorded by several authors in various localities, but without mentioning the presence of *S. bellidifolia*. Therefore, the species occurs within the following plant associations (within parentheses acronyms used in this paper):

**CL. THLASPIETEA ROTUNDIFOLII** Br.-Bl. 1926
  **Ord. Thlaspietalia rotundifolii** Br.-Bl. 1926
  *Al. Achnaterion calamagrostis Br.-Bl. 1918*
    1. *As. Thymetum comosi* Pop et Hodişan 1963
      - *typicum* Coldea 1991 **(Th)**
      - *teucrietosum montani* (Csűrös 1956) Coldea 1991 **(Te)**
**CL. FESTUCO-BROMETEA BR.-BL. 1943**
  **Ord. Stipo-Festucetalia pallentis** Pop 1968
  Al. Seslerio-Festucion pallentis Klika 1931
    2. *As. Campanulo divergentiformis – Festucetum pallentis* Zólyomi 1966 **(Fe)**
    *(*Syn. *Seseli gracile – Festucetum pallentis* (Soó 1959) Coldea 1991
    3. *As. Asplenio rutae-murariae – Melicetum ciliatae* Soó 1931 **(Me)**
  Al. Thymo comosi – Festucion rupicolae Pop 1968
    4. *As. Carici humilis – Stipetum joannis* Pop et Hodişan 1985 **(St)**
    (Syn. *Stipetum joannis* Prodan 1939, *Stipetum joannis calcicolum* Pop et al. 1964)
    5. *As. Thymo comosi – Caricetum humilis* Zólyomi 1939 (Morariu et Danciu 1974) **(Ca)**
    (Syn. *Caricetum humilis montanum* Gergely 1964, *Caricetum humilis transsilvanicum* Zólyomi 1939)
**CL. SESLERIETEA ALBICANTIS** Br.-Bl. 1948 em. Oberd. 1978
  **Ord. Seslerietalia albicantis** Br.-Bl. 1926
  Al. Seslerion rigidae Zólyomi 1939
    6. *As. Asperulo capitatae – Seslerietum rigidae* (Zólyomi 1939) Coldea 1991 **(Se)**
    (Syn. *Asplenio – Seslerietum rigidae* Csűrös 1958 **(ASe)**, *Alysso – Seslerietum rigidae* Csűrös et al. 1988)
    7. *As. Helictotrichetum decori* Domin 1932 **(He)**

The fuzzy classification yielded five and eight optimal number of clusters (Fig. 2) that corresponded with few exceptions to the traditionally diagnosed plant associations.

At the dissimilarity level of eight clusters, the exception was the grouping of the pioneer communities from *Thymetum comosi typicum* with the *Asplenio rutae-murariae – Melicetum ciliatae* and a few relevés attributed to *Asplenio – Seslerietum rigidae* in a single cluster. Although traditionally they are diagnosed in different communities, in our analysis the few relevés available were grouped together probably because they underrepresent the phytosociological associations. However, given their potentially similar ecological meaning to *S. bellidifolia* (they are all extreme pioneer communities), we accepted the group under the "pioneer" name in further analyses.

Also, relevés of *Asperulo capitatae – Seslerietum rigidae* were separated in two groups: one contained mostly communities in the Scărița-Belioara locality, whereas the second one contained the relevés from all other localities and also those attributed to *Asplenio – Seslerietum rigidae* from Scărița-Belioara. We interpreted these two groups as different dynamic states of the same community type and, as they showed no differences in the occurrence of *S. bellidifolia*, the two groups have been merged in subsequent analysis.

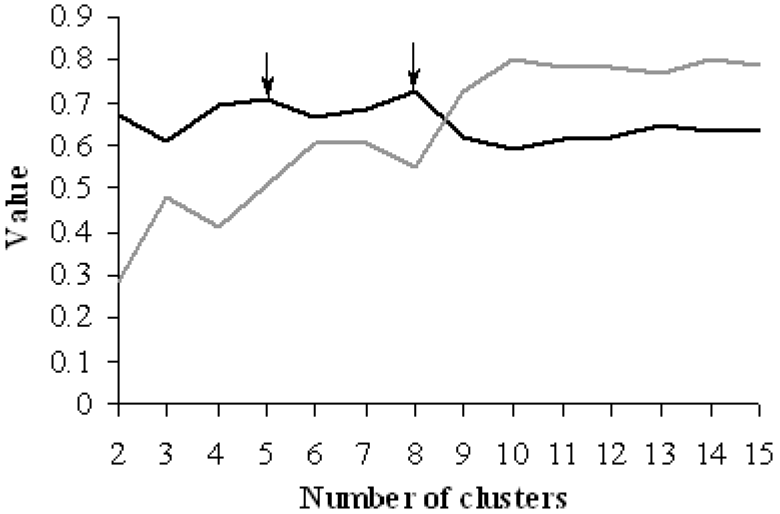

**Fig. 2: Normalized Bezdek partition coefficient (continuous line) and normalized partition entropy (grey line) resulted from the „fuzzy" classification of phytosociological relevés.** Arrows indicate the optimal number of clusters.

At the level of five groups, the fuzzy clusters gathered together: 1) the formerly mentioned communities from the "pioneer" group with *Thymetum comosi – teucrietosum montani*; 2) *Carici humilis – Stipetum joannis* with *Thymo comosi – Caricetum humilis*; 3) the two groups of communities dominated by *Sesleria rigida*.

The minimum spanning tree evidenced two dynamic series of the analysed dataset, one within the vegetation class *Festuco – Brometea* (Fig. 3a) and the other mainly within the vegetation class *Seslerietea albicantis* (Fig. 3b), each of them including communities of *Thlaspietea rotundifolii*. In the first case, *Thymetum comosi – teucrietosum montani* community changed into *Campanulo divergentiformis – Festucetum pallentis*, which collaterally evolved into *Thymo comosi – Caricetum humilis* and some of these communities into *Carici humilis – Stipetum joannis* respectively. In the second case, the open *Asperulo capitatae-Seslerietum rigidae* communities evolved into more closed communities, but at initial steps, they resulted in several collateral branches represented by the pioneer *Thymetum comosi – typicum*, the *Asplenio rutae-murariae – Melicetum ciliatae* or the more closed *Helictotrichetum decori*.

*Phytocoenotic context of S. bellidifolia*

*S. bellidifolia* abundance was generally low in all communities, but it had the highest relative abundance within the *Festuca pallens*- and *Teucrium montanum*- dominated communities and the highest relative frequency within the *Festuca pallens*- and *Carex humilis*-dominated communities. The lowest values for both categories were registered within the pioneer- and *Sesleria rigida*- dominated communities (Tab. 1). The standardized fidelity index (Fisher's exact test) computed from presence-absence data of *S. bellidifolia* was significant for the *Festuca pallens*- and *Carex humilis*- dominated communities, whereas for abundance data it wasn't significant for any community. The global indicator value (combined abundance and frequency) for the *Festuca pallens* community was not significant (Monte Carlo test, p=0.114).

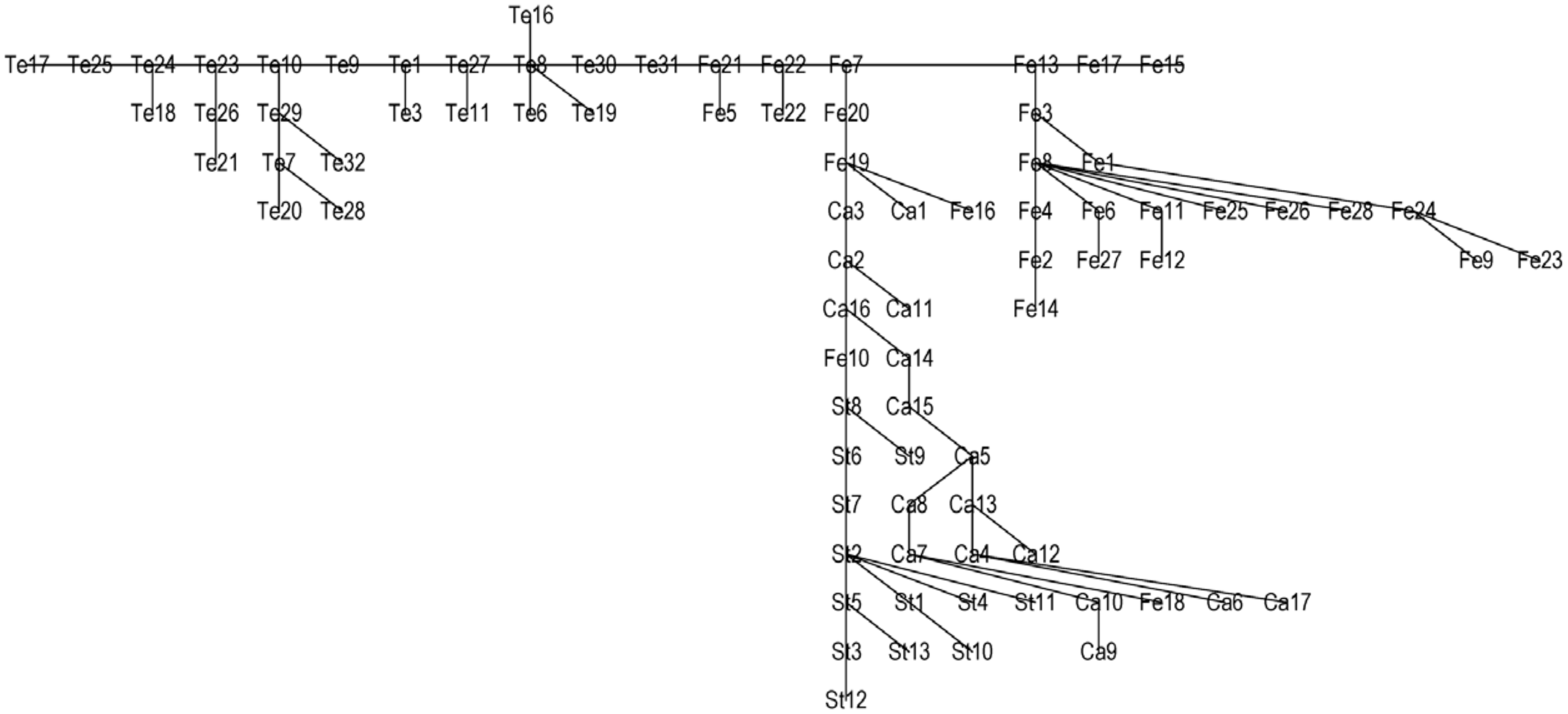

**Fig. 3a: Minimum spanning tree of phytocoenoses pertaining to Cl. *Thlaspietea rotundifolii* and Cl. *Festuco-Brometea* recorded on limestone outcrops of Apuseni Mts.**
(See the conspectus of plant associations for acronyms.)

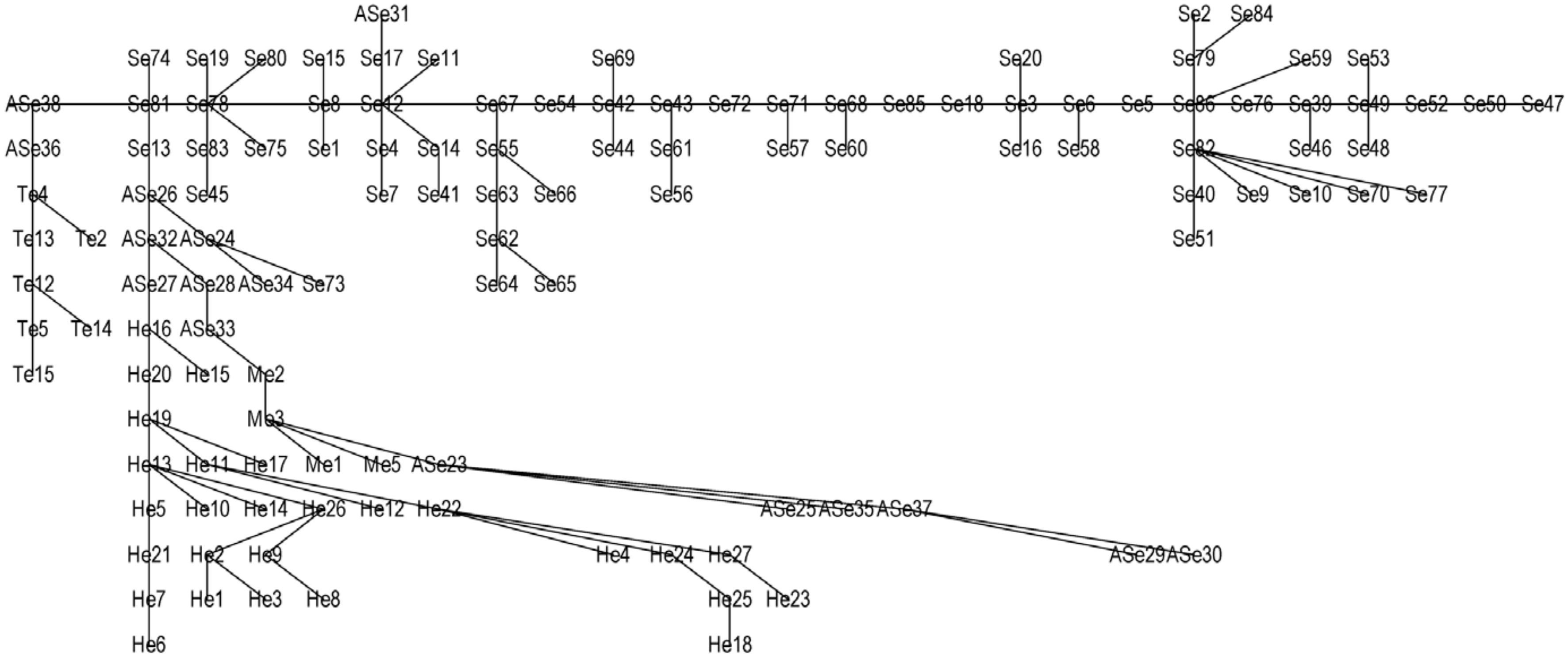

**Fig. 3b: Minimum spanning tree of phytocoenoses pertaining mainly to Cl. *Seslerietea albicantis*, recorded on limestone outcrops of Apuseni Mts.**
(See the conspectus of plant associations for acronyms.)

**Table 1: Indicator values of *S. bellidifolia* for outcrop plant communities of Apuseni Mts.**
Superscript letters indicate significant fidelity values (Fisher's exact test, *=p<0.05, ***=p<0.001). Abbreviations: Pi = pioneer communities (Th, Me, partly As-Se)
(See the conspectus of plant associations for acronyms.)

| | PI | TE | FE | CA | ST | HE | SE |
|---|---|---|---|---|---|---|---|
| Constancy | i | iii | $\text{iv}^{3.5***}$ | $\text{iv}^{1.4*}$ | iii | iii | ii |
| Relative abundance (%) | 2 | 24 | 25 | 18 | 5 | 18 | 8 |
| Maximum cover (%) | 0.5 | 5 | 17.5 | 5 | 0.5 | 5 | 5 |

*Floristic relationships of S. bellidifolia*

The standard Spearman correlation coefficients detected eight positive and two negative significant, but weak relationships of *S. bellidifolia* abundance. The more important correlations were established with the small-sized grass *Festuca pallens* (ρ=0.280, p<0.001), the pioneer *Teucrium montanum* (ρ=0.273, p<0.001) and the short, ring-forming sedge *Carex humilis* (ρ=0.239, p<0.001). Weaker correlations were established with several disturbance-tolerant species like *Stachys recta* (ρ=0.199, p<0.01), *Anthericum ramosum* (ρ=0.187, p<0.01), *Euphorbia cyparissias* (ρ=0.199, p<0.01), *Teucrium chamaedrys* (ρ=0.137, p<0.05), and the shrub *Cytisus nigricans* (ρ=0.146, p<0.05). Weak negative interactions were also recorded with the strong tussock-forming *Sesleria rigida* (ρ=-0.252, p<0.001) and the chamaephyte *Helianthemum nummularium* ssp. *obscurum* (ρ=-0.158, p<0.05). However, the partial Spearman correlation was significant only with *Festuca pallens* (ρ=0.215, p<0.01).

Fisher's exact test detected only positive relationships of *S. bellidifolia* (Fig. 4). The strongest interspecific associations were established with the community-building *Festuca pallens*, *Teucrium montanum* and *Carex humilis*, a series of disturbance-tolerant species like *Cephalaria radiata*, *Euphorbia cyparissias*, *Teucrium chamaedrys*, *Inula ensifolia*, *Potentilla cinerea* and also with the shrub *Cytisus nigricans*.

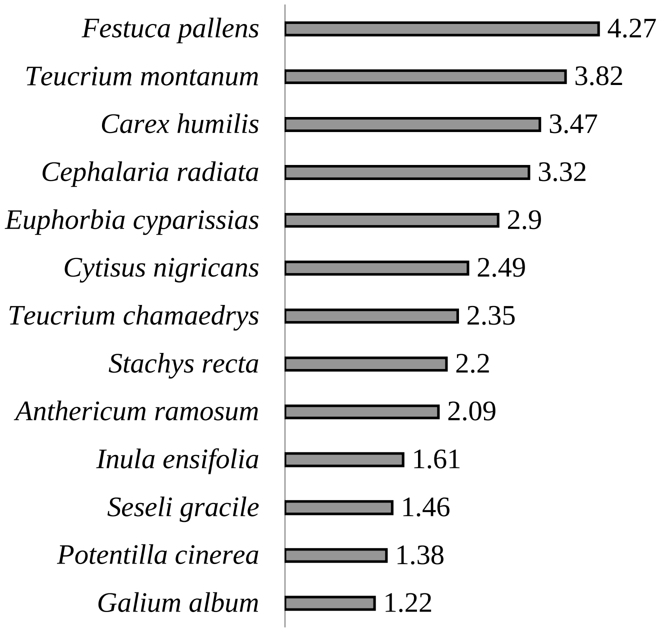

**Fig. 4: Significant positive interspecific associations of *S. bellidifolia* within the outcrop communities of Apuseni Mts., detected by Fisher's exact test performed on presence-absence data (cut-off value=1, significance level <0.001).**

The binomial logistic regression model evidenced the positive effect of three predictors (abundance of *Festuca pallens*, *Anthericum ramosum* and *Teucrium montanum*) on *S. bellidifolia* occurrence ($\chi^2$=15.42, p=0.05) (Tab. 2), and explained 86.3% of absences and 37.5% of presences of the target species. *Festuca pallens* had by far the highest importance for the model (change in –2 log-likelihood= 15.54, $p<0.001$). Although the abundance of *Anthericum ramosum* had a marginal importance for the model (p=0.056), there was evidence against removing it from the model (change in –2 log-likelihood= 8.17, p=0.023).

**Table 2: Binomial logistic regression model of *S. bellidifolia* occurrence as a function of plant species abundance (β=regression coefficient).**

| Variable | β | SE(β) | Wald statistic | p |
|---|---|---|---|---|
| Intercept | -0.713 | 0.180 | 15.603 | 0.000 |
| Festuca pallens | 0.053 | 0.015 | 11.651 | 0.001 |
| Anthericum ramosum | 0.289 | 0.151 | 3.659 | 0.056 |
| Teucrium montanum | 0.036 | 0.017 | 4.592 | 0.032 |

## Discussions

### *S. bellidifolia distribution within the Apuseni Mts.*

The core-populations of *S. bellidifolia* within the Apuseni Mts. are situated in Gilău-Muntele Mare Mts., whereas the marginal populations in Trascău Mts. The localities from Gilău-Muntele Mare Mts. seem to offer suitable conditions for *S. bellidifolia* individuals, but the small populations in the Trascău Mts. are severely exposed to genetic and demographic risks. Based on the topographic conditions of the small-sized outcrops and the presence of beech forests on inclined rocky surfaces and screes, we hypothesize that the suitable habitat of *S. bellidifolia* from Trascău Mts. has undergone a severe reduction because of Holocene reforestation of outcrops, probably since around 4500 BP, when the extension phase of the beech began in the Apuseni Mts. [2].

### *Phytocoenotic context of S. bellidifolia*

The different plant communities largely influence the frequency and abundance of S. bellidifolia. The individuals only rarely establish in pioneer communities dominated by Thymus comosus, Melica ciliata and Sesleria rigida, probably because of thin soils and harsh abiotic conditions. These Sesleria rigida communities, attributed to Asplenio – Seslerietum rigidae, develop in narrow, distanced rock crevices and have a pioneer character. The few Thymus comosus and Melica ciliata communities from our dataset seem to develop on soils resulted from the rock weathering processes induced by these extreme Sesleria rigida communities. The more closed Sesleria rigida communities generally develop in somewhat larger soil pockets of rock ledges, but here the constancy and abundance of S. bellidifolia is also low. The scarcity of soil within these rock communities makes them “biotically closed” [11], where a few, strong competitors occupy most of the available space. Indeed, Sesleria rigida is a compact, tussocky grass, whose abundance is negatively related to that of S. bellidifolia and therefore it seems to outcompete this species from the narrow soil pockets. There are also other empirical evidences that ledge area and soil volume have significant effects on the assembly of rock communities [20]. By contrast, the highest abundance of S. bellidifolia is attained within incipient dynamic states of communities pertaining to Cl. Festuco – Brometea (namely within the Teucrium montanum- and Festuca pallens- dominated communities). Although the Teucrium montanum and the Thymus comosus communities are floristically very similar, the pioneer nature of the first ones is not so accentuated comparatively to that of the second-ones. Often, they are forerunners within the secondary succession after outcrop fires or develop on scree cones, which have deeper soils. In these unstructured communities, as suggested by their positive association, the two chamaephytes: S. bellidifolia and the dominant Teucrium montanum, seem to find suitable, competition-relaxed gaps for establishment and also sufficient belowground resources for survival. On the other hand, S. bellidifolia attained the highest significant fidelity and the highest abundance values within the Festuca pallens- dominated communities, which make them the most favourable to the species establishment. Within the studied outcrops, Festuca pallens develops representative communities on scree cones, geomorphological formations where plant communities are subjected to more frequent stochastic disturbance processes (e.g. substrate shifting and rock weathering) [13, 27]. Recent empirical studies have demonstrated that screes facilitate the coexistence of both dominant and competitively weaker rare species, depending on the extent of disturbance and their successional maturity [27]. Within the studied outcrops, the sandy substrate and intermediate disturbance of screes could be favourable to S. bellidifolia individuals, which seem to prefer conditions of lower competition, deeper soils and, on the other hand, tolerate higher levels of mechanical stress.

The abundance of *S. bellidifolia* is successively reduced towards the most advanced stage of this dynamic series (the *Stipa joannis*- dominated communities), which also suggests the low competitive abilities of this species. However, *S. bellidifolia* is still present with high constancy and significant fidelity values within the *Carex humilis*- dominated communities, preceding their evolution towards the *Stipa joannis* communities. This indicates that once established, *S. bellidifolia* is able to persist also within the more closed vegetation. According to our dataset, the floristic similarity of these two communities is comparable to that of the two subassociations: *Thymetum comosi – tyicum* and *– teucrietosum montani*. However, similarly to them, the *Stipa joannis* and *Carex humilis* communities play different roles in *S. bellidifolia* persistence, with the second one being more favourable to it.

### *Floristic relationships of S. bellidifolia*

The coexistence of *S. bellidifolia* with certain dominant- and non-dominant plant species from the studied communities can be explained by mechanisms operating within the successional niche [22]. Under this scenario, inferior competitors specialize on recently disturbed habitat patches and cannot be excluded by late successional dominant species, even when the latter have unlimited colonization ability. The late successional stages of the habitat contain only the superior competitors and are resistant to invasion by inferior competitors [1]. This would explain the association of *S. bellidifolia* mainly with dominant species related to screes (*Teucrium montanum*, *Festuca pallens*) or inferior competitors that are disturbance-tolerant (*Cephalaria radiata*, *Euphorbia cyparissias*, *Teucrium chamaedrys*, *Inula ensifolia*, *Potentilla cinerea*). These latter species are also typical colonizers of disturbed steppic communities from the Carpathian Basin and it is likely that the frequent disturbances from rocky habitats, especially screes, create suitable gaps for their establishment. *Anthericum ramosum*, the only inferior competitor selected by the logistic regression model is probably also a colonizer of the outcrops, but it seems to be a very successful one after recent disturbances, e.g. fires (Csergő, pers. obs.). By contrast, *Carex humilis*, a phalanx-strategist, ring-forming sedge, probably originating from steppic grasslands, is able to outcompete dominant species like *Teucrium montanum*, *Festuca pallens* and even *Stipa* spp. on calcareous rock grasslands [34]. As *Stipa joannis*, it would narrow the niche of *S. bellidifolia*, during the process of succession. However, many of its phytocoenoses have an open character, with several gaps unoccupied by *Carex humilis* (Csergő, pers. obs.) probably because of belowground limitations to its establishment and slowness of succession and therefore, even the low-competitive species (like *S. bellidifolia*) are not or are only very slowly eliminated.

## Conclusions

Three new populations of *S. bellidifolia* have been discovered by the authors during the last ten years and therefore, it seems that the species' chorology is still not known thoroughly. Similarly, the absence of the species from previous phytosociological relevés pertaining to the *Teucrium montanum* communities, among the most important to its preservation within the Apuseni Mts., means that our knowledge of species' community context and ecology was limited.

The role of outcrop plant communities in preserving *S. bellidifolia* within the Apuseni Mts. is differential. Communities of Cl. *Seslerietea albicantis* are less, whereas those of Cl. *Festuco – Brometea* and Cl. *Thlaspietea rotundifolii* are more suitable to its establishment. However, despite lower frequency and abundance, individuals from apparently inhospitable habitats may perform better, e.g. in seed production or other morphometrical traits [19], and we should not underestimate their role in the survival of populations. Nevertheless, based on the community context of *S. bellidifolia*, we are able to draw one major conclusion regarding its ecological niche within the Apuseni Mts. Namely, the vegetation-free patches have an increased role in sheltering this rare species within the studied area. These patches are characterized by intermediate abiotic stress level and permissive biotic conditions, being probably the most favourable among all rocky habitats. Besides, they have deeper soils – usually positively correlated with soil humidity. By its ability to exploit opportunistically these open habitats, *S. bellidifolia* behaves as a pioneer species that is successively, but very slowly, eliminated by superior competitors.

Its presence within the rocky habitats of European importance from the Apuseni Mts. raises their conservational value and brings additional evidence for their role in preserving taxa of high biogeographical importance.

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## REFERENCES

1. Amarasekare, P., 2003, Competitive coexistence in spatially structured environments: a synthesis, *Ecol. Lett.*, **6**: 1109-1122.
2. Bodnariuc, A., Bouchette, A., Dedoubat, J., Otto, T., Fontugne, M., Jalut, G., 2002, Holocene vegetational history of the Apuseni mountains, central Romania, *Quaternary Sci. Rev.*, **21**: 1465-1488.
3. Borza, Al., 1916, A *Saponaria bellidifolia* Smith erdélyi lelőhelyei (Über die Standorte der *Saponaria bellidifolia* Sm. in Siebenbürgen), *Magyar Bot. Lapok*, **1** (5): 86-87.
4. Borza, Al., 1917, Comorile botanice de la Belioara, *Contribuțiuni Ştiințifice,* Orăştie, **1** (6-7): 87-94.
5. Braun-Blanquet, J., 1964, *Pflanzensoziologie. Grundzüge der Vegetationskunde*, Ed. 3., Springer Verlag, Wien.
6. Coldea, Gh., 1991, Prodrome des associations végétales des Carpates du Sud-Est (Carpates Roumaines), *Doc. Phytosoc.*, **13**, Camerino: 317-539.
7. Cristea, V., Gafta, D., Pedrotti, F., 2004, *Fitosociologie*, Ed. Pres. Univ. Cluj.
8. Csergő, A.-M., 2002, The problem of the refugia of certain preglacial and glacial relict populations from the calciphilous flora of the Apuseni Mountains (Romania), *Contrib. Bot. Cluj*, **37**: 251-262.
9. Csergő, A.-M., 2005, Corologia şi ambianța cenotică a speciei *Saponaria bellidifolia* Sm. în Munții Apuseni, Rezum., Ses. Ştiinț. Anuală „Actualități în biologia vegetală”, Ed. a XIII-a, Fac. de Biol-Geol., Catedra Taxon.-Ecol., Univ. „Babeş-Bolyai”, Cluj-Napoca.
10. Csűrös, I., 1958, Cercetări de vegetație pe masivul Scărişoara-Belioara, *Studia Univ. Babeş-Bolyai*, **3** (7): 103-128.
11. Davis, P.H., 1951, Cliff vegetation in the eastern Mediterranean, *J. Ecol.*, **39** (1): 63 –93.
12. Dufrene, M., Legendre, P., 1997, Species assemblages and indicator species: the need for a flexible assymetrical approach, *Ecol. Monogr.*, **67** (3): 345-366.

13. Fisher, F.J.F., 1952, Observations on the vegetation of screes in Canterbury, New Zealand., *J. Ecol.*, **40** (1): 156-167.
14. Gafta, D., Mountford, O. (eds), 2008, *Manual de interpretare a habitatelor Natura 2000 din România*, Risoprint, Cluj-Napoca.
15. Gergely, I., Rațiu F., 1962, Plante rare în flora Munților Trascăului, *Contrib. Bot. Cluj*, **3**: 151-153.
16. Hodişan, V., 1971, *Flora şi vegetația din bazinul Văii Runcului (Munții Apuseni)*, teză de doctorat, Univ. Babeş-Bolyai Cluj-Napoca: 227-258.
17. Ianovici, V., Borcoş, M., Bleahu, M., Patrulius, D., Lupu, M., Dimitrescu, R., Savu, H., 1976, *Geologia Munților Apuseni*, Ed. Acad. RSR., Bucureşti.
18. Jalas, J., Suominen, J. (eds), 1986, *Atlas Florae Europaeae. Distribution of Vascular Plants in Europe 7 – Caryophyllaceae (Silenoideae)*, The Committee for Mapping the Flora of Europe & Societas Biologica Fennica Vanamo, Helsinki.
19. Kephart, S.R., Paladino, C., 1997, Demographic change and microhabitat variability in a grassland endemic, *Silene douglasii* var. *oraria* (Caryophyllaceae), *Am. J. Bot.*, **84** (2): 179-189.
20. Kuntz, K.L., Larson, D.W., 2006, Microtopographic control of vascular plant, bryophyte and lichen communities on cliff faces, *Plant Ecol.*, **185** (2): 239-253.
21. McCune, B., Mefford, J., 1997, Multivariate analysis of ecological data Version 3.01, MjM Software, Gleneden Beach, Oregon, U.S.A.
22. Pacala, S.W., Rees, M., 1998, Models suggesting field experiments to test two hypotheses explaining successional diversity, *Am. Nat.*, **152**: 729–737.
23. Podani, J., 1997, SYN-TAX 5.1: A new version for PC and Macintosh computers, *Coenoses*, **12**: 149-152.
24. Pop, I., 1991, Considerații generale asupra ordinului *Stipo eriocaulis-Festucetalia pallentis* Pop (1968) emend. 1989, *Contrib. Bot. Cluj*, **36** (2): 3-33.
25. Pop, I., Csűrös, Şt., Kovács, A., Hodişan, I., Moldovan, I., 1964, Flora şi vegetația Cheilor Runc (Reg. Cluj, Raion Turda), *Contrib. Bot. Cluj*, **4**: 205-224.
26. Pop, I., Hodişan, I., 1985, Reconsiderări cenotaxonomice asupra nomenclaturii unor asociații calcofile, *Contrib. Bot. Cluj*, **25**: 171-176.
27. Rejmánek, M., Rejmánková, E., Holzner, W., 2004, Species diversity of plant communities on calcareous screes: the role of intermediate disturbance, *Preslia*, **76**: 207-222.
28. Sanda, V., 2002, *Vademecum ceno-structural privind covorul vegetal din România*, Ed. Vergiliu, Bucureşti.
29. Şuteu, Al., 2002, *Saponaria bellidifolia* Sm. în flora spontană a României, *An. Univ. Oradea*, Fasc. *Biologie*, **9**: 187-191.
30. Tichỳ, L., 2002, JUICE, software for vegetation classification, *J. Veg. Sci.*, **13**: 451-453.
31. Tutin, T.G., Heywood, V.H. (eds.), 1964-1980, *Flora Europaea*, 1-5 :31, Cambridge Univ. Press.
32. Tüxen, R., Ellenberg, H., 1937, Der systematische und der ökologische Gruppenwert. Ein Beitrag zür Begriffsbildung und Methodik der Pflanzensoziologie, *Mitt. Flor.-Soz. Arbeitsgem. Niedersachsen*, **3**: 171-184.
33. Westhoff, V., van der Maarel, E., 1973, The Braun-Blanquet approach, In: Whittaker R.H. (ed.), *Classification of plant communities*. *Handbook of Vegetation Science*, **5**: Junk, Haga: 617-726.
34. Wikberg, S., Mucina, L., 2002, Spatial variation in vegetation and abiotic factors related to the occurrence of a ring-forming sedge, *J. Veg. Sci.*, **13**: 677-684.

## COROLOGIA ŞI AMBIANȚA FITOCENOTICĂ A SPECIEI *SAPONARIA BELLIDIFOLIA* SM. ÎN MUNȚII APUSENI (CARPAȚII DE SUD-EST, ROMÂNIA)

### (Rezumat)

Lucrarea de față îşi propune să aducă noi contribuții la corologia speciei *Saponaria bellidifolia* Sm. în Munții Apuseni, să caracterizeze ambianța fitocenotică a populațiilor şi să analizeze relațiile interspecifice ale taxonului studiat.

În acest scop au fost prelucrate 139 relevee fitosociologice extrase din literatura de specialitate şi 78 relevee fitosociologice originale, efectuate în toate localitățile cunoscute de către autori din Munții Apuseni. A fost calculată constanța, fidelitatea şi valoarea indicatoare a speciei pentru fiecare asociație vegetală în parte. Pentru a explora relațiile interspecifice ale speciei studiate, a fost calculat indicele Spearman pentru datele de abundență şi a fost efectuat testul exact Fisher pentru datele de prezență-absență. Regresia logistică binomială a fost folosită pentru a modela probabilitatea de apariție a speciei în funcție de abundența celorlalte specii prezente în fitocenoze. Rezultatele au fost interpretate din perspectiva dinamicii fitocenozelor.

*S. bellidifolia* a fost înregistrată într-o localitate nouă, Dealul Pinet (Gilău-Muntele Mare Mts.) (Fig. 1). Pe clipele calcaroase din Munții Gilău-Muntele Mare, specia creşte în condiții optime, pe când în Munții Trascăului, habitatul şi populațiile speciei par să fie în regres din cauza extinderii fagului în Holocen.

Specia înregistrează constanța cea mai ridicată şi valori statistic semnificative ale fidelității în fitocenozele asociațiilor vegetale *Campanulo divergentiformis - Festucetum pallentis* Zólyomi 1966 şi *Thymo comosi - Caricetum humilis* Morariu et Danciu 1974, respectiv cea mai ridicată abundență în cadrul fitocenozelor asociațiilor vegetale *Thymetum comosi* Pop et Hodişan 1963 - *teucrietosum montani* (Csűrös 1956) Coldea 1991 şi *Campanulo divergentiformis - Festucetum pallentis* Zólyomi 1966 (Tab. 1). Au fost detectate relații pozitive foarte slabe între *S. bellidifolia* şi speciile edificatoare *Festuca pallens, Teucrium montanum, Carex humilis*, precum şi speciile tolerante la perturbări *Cephalaria radiata, Euphorbia cyparissias, Teucrium chamaedrys, Inula ensifolia, Potentilla cinerea, Stachys recta, Anthericum ramosum* (Fig. 4). Interacțiuni negative slabe au fost înregistrate cu *Sesleria rigida* şi *Helianthemum nummularium* ssp. o*bscurum*. Abundențele a trei specii (*Festuca pallens, Teucrium montanum* şi *Anthericum ramosum)* au fost evidențiate ca fiind cele mai bune predictoare ale apariției taxonului studiat. (Tab. 2).

Preferința speciei *S. bellidifolia* pentru anumite asociații vegetale, precum şi asocierile interspecifice evidențiate sunt determinate de constrângeri ecologice tipice habitatelor de stâncării (volumul de sol acumulat) şi de trăsăturile biologice ale speciei (capacitate competitivă slabă). Acestea situează populațiile de *S. bellidifolia* din zonele studiate în cadrul nişei succesionale. Indivizii ocupă în mod oportunist habitatele şi microhabitatele deschise, supuse sau rezultate în urma perturbărilor, urmând să fie eliminați treptat în timpul succesiunii vegetației. Aceste habitate se caracterizează în general printr-un volum de sol suficient pentru dezvoltarea organelor subterane ale plantei. Prin urmare, fitocenozele de grohotişuri sau cele pioniere în cadrul succesiunii secundare sunt preferate de către *S. bellidifolia* şi reprezintă „refugii fitocenotice” importante pentru persistența speciei în Munții Apuseni.

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