

STUDIES CONCERNING CORMOFLORA OF THE SCREES OF *THLASPIETEA ROTUNDIFOLII* Br.-Bl. 1948 CLASS FROM MERIDIONAL CARPATHIANS (ROMANIA)

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Abstract

This paper presents the screes cormoflora from Meridional Carpathians that was characterized taking into account: taxonomy, life forms, geoelements and ecological indices. The screes habitats are important for the conservation of endemic and rare plant species. They have, in generally, a favorable state of conservation in terms of surface, structure, functions and future expectations. The pressures and threats that can affect the long-term viability of this habitats can be: overgrazing, tourists traveling on unmarked routes or trails, climbing, waste storage, collection of species.

Keywords: flora, Meridional Carpathians, Romania, screes.

1. INTRODUCTION

Thlaspietea rotundifolii class includes the screes from the mountain, subalpine and alpine level of the Romanian Carpathians, formed by cryogenic processes during the Pleistocene, which favored formation and persistence of an arcto-tertiary vegetation consisting of different petrophilous species whose roots deeply penetrate the edafic substrate, ensuring their perenniality (Coldea, 2017).

Vegetal groupings of this class are characterized by a low coenotic cohesion (Coldea 2017), and are grouped according to the mobility and size of the substrate, the humidity and the rock types on which they develop (Sanda et al., 2001).

According to Coldea et al. (2017) two orders (*Thlaspietalia rotundifolii* and *Androsacetalia alpinae*) with 17 plant associations of *Thlaspietea rotundifolii* class have been described from the Romanian vegetation, out of which 15 plant communities exist in the Meridional Carpathians (excepting *Saxifragetum carpathicae-cymosae* Coldea (1986) 1990 and *Cerastio calcicolae-Saxifragetum moschatae* Coldea (1986) 1990 identified only in Rodna Mountains).

Cerastio transsilvanici-Galietum lucidi M. et N. Boşcaiu 1998 was not mentioned by Coldea et al. (2017), but it was included in the screes vegetation of Southern Carpathians by Sanda et al. (2008) and Chifu et al. (2014).

Plant associations from *Thlaspietalia rotundifolii* order Br.-Bl. in Br.-Bl. et Jenny 1926 vegetate on calcareous screes from mountain to alpine level and the characteristic species are: *Gymnocarpium robertianum*, *Campanula cochlearifolia*, *Moehringia muscosa*, *Cerastium arvense* subsp. *arvense*, *Galium album*, *Plantago atrata* subsp. *carpatica*, *Veronica aphylla*, *Senecio rupestris*, *Hornungia alpina* subsp. *brevicaulis*. *Androsacetalia alpinae* Br.-Bl. 1926 order is characterized by plant communities that develop on semifixed or mobile siliceous screes and its characteristic species are:

Cardamine resedifolia, *Geum reptans*, *Poa cenisia*, *Leucanthemopsis alpina*, *Poa laxa*, *Saxifraga bryoides*, *Doronicum clusii* (Sanda et al., 2008; Chifu et al., 2014; Coldea et al., 2017).

The most representative screes of the Southern Carpathians are found in Piatra Craiului Mountains, especially on the western slope of the mountain chain, in the central area known as the Grand Grohotiș (Doniță, 1992). These screes are characterized by a high fragmentation degree and reduced ecological amplitude (Pop, 2009).

In this paper we presented a characterization of the screes cormoflora from *Thlaspietea rotundifolii* class which is very diversified due to varied stational conditions. The screes habitats from Meridional Carpathians provided suitable conditions for 78 rare species such as: *Veronica baumgartenii*, *Viola dacica*, *Trisetum fuscum*, *Noccaea dacica*, *Silene nutans* subsp. *dubia*, *Jacobaea abrotanifolia* subsp. *carpathica*, *Scabiosa lucida* subsp. *barbata*, *Saxifraga carpathica*, *Plantago atrata*, *Poa cenisia*, *Papaver alpinum*, *Melampyrum saxosum*, *Onobrychis montana*, *Hesperis nivea*, *Gypsophila petraea*, *Dianthus callizonus*, *D. henteri*, *Cerastium transsilvanicum*, *Anthemis cretica* subsp. *pyrethriiformis*.

2. MATERIAL AND METHOD

Floristic inventory of the cormophytes characteristic to the *Thlaspietea rotundifolii* class was done both on the basis of personal data in the field and of information from literature concerning flora and vegetation of screes from Meridional Carpathians that had been published or unpublished until 2018 by the Romanian botanists (Csűrös et al., 1956; Niedermaier, 1965; Beldie, 1967; Schneider, 1970; Boșcaiu, 1971; Diaconescu, 1973; Popescu, 1974; Voik, 1976; Sanda and Popescu, 1976; Sanda et al., 1977; Boșcaiu et al., 1977; Voik and Schneider, 1978; Păun and Popescu, 1978; Pușcaru-Soroceanu et al., 1981; Sanda and Popescu, 1991; Drăghici, 1994; Drăgulescu, 1995; Sanda et al., 1996; Alexiu, 1998; Mihăilescu, 2001; Stancu, 2005; Nicolae-Biță, 2005; Neblea, 2007; Răduțoiu, 2008; Pop, 2009; Neblea, 2012; Simon and Pócs, 2012; Bartók and Irimia, 2016; Neblea, 2016).

Therefore, data from 441 phytosociological surveys (18 personal surveys and 423 surveys from other scientific papers that had been published), belonging to 16 plant associations of the *Thlaspietea rotundifolii* class from Meridional Carpathians were processed (table1).

Table 1. List of plant associations of *Thlaspietea rotundifolii* class from Meridional Carpathians and surveys location

Plant association	Authors	Year	Surveys number	Massif/Locality
<i>Cerastio lerchenfeldiani-Papaveretum</i> Boșcaiu, Täuber et Coldea 1977	Csűrös Șt., Csűrös Kaptalan M., Pap S.	1956	4	Retezat Mts.
	Boșcaiu N., Täuber F., Coldea Gh.	1977	10	Retezat Mts.
	Voik W., Schneider-Binder E.	1978	5	Făgăraș Mts.
	Pușcaru-Soroceanu E., Csűrös Șt., Pușcaru D., Popova-Cucu A.	1981	5	Făgăraș Mts.
	Mihăilescu S.	2001	14	Piatra Craiului Mts.
	Stancu D.	2005	6	Făgăraș Mts.
	Nicolae Biță C.	2005	5	Bucegi Mts.
	Pop O.	2009	22	Piatra Craiului Mts.
<i>Cardaminopsis neglectae-Papaveretum</i> Coldea et Pânzaru 1986	Beldie Al.	1967	8	Bucegi Mts.
<i>Acino-Galietum anisophylli</i> Beldie 1967	Beldie Al.	1967	10	Bucegi Mts.
	Boșcaiu N.	1971	5	Țarcu Mts., Godeanu

				Mts.
	Drăghici B.	1994	5	Piatra Craiului Mts.
	Mihăilescu S.	2001	5	Piatra Craiului Mts.
	Stancu D.	2005	8	Făgăraș Mts.
	Nicolae Biță C.	2005	5	Bucegi Mts.
<i>Doronicum columnae-Rumicetum scutati</i> Boșcaiu et al. 1977	Boșcaiu N.	1971	6	Țarcu Mts., Godeanu Mts.
	Boșcaiu N., Täuber F., Coldea Gh.	1977	7	Retezat Mts.
	Păun M., Popescu Gh.	1978	4	Buila-Vânturarița Mts.
	Păun M., Popescu Gh.	1978	2	Vâlcan Mts.
	Voik W., Schneider-Binder E.	1978	7	Făgăraș Mts.
<i>Saxifragetum moschatae-aizoidis</i> Boșcaiu 1971	Boșcaiu N.	1971	15	Țarcu Mts., Godeanu Mts.
	Voik W.	1976	9	Făgăraș Mts.
	Voik W., Schneider-Binder E.	1978	9	Făgăraș Mts.
	Nicolae Biță C.	2005	5	Bucegi Mts.
<i>Cerastium transsilvanicum-Galietum lucidi</i> M. et N. Boșcaiu 1998	Mihăilescu S.	2001	7	Piatra Craiului Mts.
	Pop O.	2009	6	Piatra Craiului Mts.
<i>Achnatheretum calamagrostis</i> Br.- Bl. 1918	Boșcaiu N.	1971	10	Țarcu Mts., Godeanu Mts., Cernei Mts.
	Bartók A., Irimia I.	2016	1	Mehedinți Mts.
<i>Gymnocarpium robertianae</i> (Kaiser 1926) Tx. 1937	Boșcaiu N.	1971	5	Țarcu Mts., Godeanu Mts., Cernei Mts.
	Diaconescu F.	1973	6	Leaota Mts.
	Alexiu V.	1998	10	Dâmbovița Gorges
	Nicolae Biță C.	2005	5	Bucegi Mts.
	Neblea M.	2007	5	Leaota Mts.
	Răduțoiu D.	2008	5	Munții Căpățâni Mts.
	Pop O.	2009	5	Piatra Craiului Mts.
	Neblea M.	2016	2	Leaota Mts.
<i>Sedo fabariae-Geranium macrorrhizum</i> Boșcaiu et Täuber 1977	Boșcaiu N.	1971	22	Țarcu Mts., Godeanu Mts., Cernei Mts.
	Sanda V., Popescu A.	1976	5	Piatra Craiului Mts.
	Sanda V., Popescu A., Doltu M.	1977	2	Piatra Craiului Mts.
	Drăghici B.	1994	5	Piatra Craiului Mts.
	Mihăilescu S.	2001	7	Piatra Craiului Mts.
<i>Thymetum comosum</i> Pop et Hodișan 1963	Schneider-Binder E.	1970	7	Tâlmaci-Podul Olt
	Diaconescu F.	1973	16	Leaota Mts.
	Popescu Gheorghe	1974	6	Buila-Vânturarița Mts.
	Păun M., Popescu Gh.	1978	3	Vâlcan Mts.
	Sanda V., Popescu A., Fișteag G.	1996	11	Bucegi Mts.
	Alexiu V.	1998	5	Dâmbovița Gorges
	Nicolae Biță C.	2005	5	Bucegi Mts.
	Neblea M.	2007	7	Leaota Mts.
	Neblea M.	2012	1	Buila-Vânturarița Mts.
	Neblea M.	2016	3	Leaota Mts.
<i>Parietarium officinale</i> Csürös 1958	Popescu Gh.	1974	3	Buila-Vânturarița Mts.
	Păun M., Popescu Gh.	1978	6	Vâlcan Mts.
<i>Saxifraga carpathicae-Oxyrietum digynae</i> Pawl. et al. 1928	Voik W., Schneider-Binder E.	1978	6	Făgăraș Mts.
<i>Poa contractae-Oxyrietum</i>	Boșcaiu N.	1971	7	Țarcu Mts.

<i>digynae</i> Horv. et al. 1937	Puşcaru-Soroceanu E., Csűrös Şt., Puşcaru D., Popova-Cucu A.	1981	8	Făgăraş Mts.
	Stancu D.	2005	7	Făgăraş Mts.
<i>Saxifraga bryoidis-Silenetum acaulis</i> Boşcaiu, Täuber et Coldea 1977	Boşcaiu N., Täuber F., Coldea Gh.	1977	10	Retezat Mts.
	Stancu D.	2005	9	Făgăraş Mts.
<i>Veronico baumgartenii- Saxifragetum bryoidis</i> Boşcaiu et al. 1977	Boşcaiu N., Täuber F., Coldea Gh.	1977	10	Retezat Mts.
	Stancu D.	2005	2	Făgăraş Mts.
<i>Festucetum picturatae</i> Krajina 1933 corr. Malinovsky et Kricsfalusy 2000	Puşcaru-Soroceanu E., Csűrös Şt., Puşcaru D., Popova-Cucu A.	1981	15	Făgăraş Mts.
	Simon T., Pócs T.	2012	5	Parâng Mts.

The scientific name of the taxa was updated after Flora Europaea, the on-line database (<http://ww2.bgbm.org/EuroPlusMed/query.asp>). The scree cormoflora of *Thlaspietea rotundifolii* class from Meridional Carpathians was characterized taking into account some aspects, such as: taxonomy, life forms, floristic elements and ecological indices (light, temperature, humidity, soil reaction and nitrogen amount in soil). For this aim, we used information from literature: Flora R.P.R.-R.S.R., 1952-1969; Sanda et al., 2003; Ciocârlan, 2009; Sârbu et al., 2013.

3. RESULTS AND DISCUSSIONS

Taxonomic analysis

The inventory of calcareous scree cormoflora made up in the area of Meridional Carpathians contained 551 species (including 57 subspecies) distributed in 252 genus and 74 families. The *Asteraceae* (63 sp.-11.43%), *Poaceae* (61 sp.-11%), *Caryophyllaceae* (40 sp.-7.25%), *Brassicaceae* (34 sp.-6.17%), *Scrophulariaceae* (32 sp.-5.8%), *Lamiaceae* (26 sp.-4.71%), *Ranunculaceae* (22 sp.-3.99%), *Apiaceae* (21 sp.-3.81%), *Rosaceae* (20 sp.-3.62%), *Saxifragaceae* (18 sp.-3.26%), *Fabaceae* (16 sp.-2.9%), *Campanulaceae* (14 sp.-2.54%), *Primulaceae* (12 sp.-2.17%), *Rubiaceae* (12 sp.-2.17%), *Crassulaceae* (10 sp.-1.81%) families had the highest number of species. The families with less than 10 species represented 27.36% (figure 1).

On the other hand, the siliceous scree offered conditions for survival only for 114 plant species (included 12 subspecies) that belong to 67 genus and 29 families. The *Asteraceae* (15 sp.-13.15%), *Poaceae* (14 sp.-12.28%), *Caryophyllaceae* (12 sp.-10.52%), *Saxifragaceae* (11 sp.-9.64%), *Ranunculaceae* (6 sp.-5.26%), *Rosaceae* (6 sp.-5.26%) families were the most well represented (figure 2). In fact, the small number of species that were founded on the siliceous scree from Meridional Carpathians was due to the substrate on the one hand and the reduced diversity of plant associations compared with calcareous scree. 82 of plant species were founded both on the siliceous and calcareous scree and the most frequently were: *Achillea oxyloba* subsp. *schurii*, *Arabis alpina*, *Arenaria biflora*, *Cerastium alpinum*, *Dianthus glacialis* subsp. *gelidus*, *Galium anisophyllum*, *Doronicum carpaticum*, *Saxifraga moschata*, *S. pedemontana* subsp. *cymosa*, *Veronica aphylla*, *V. baumgartenii*.

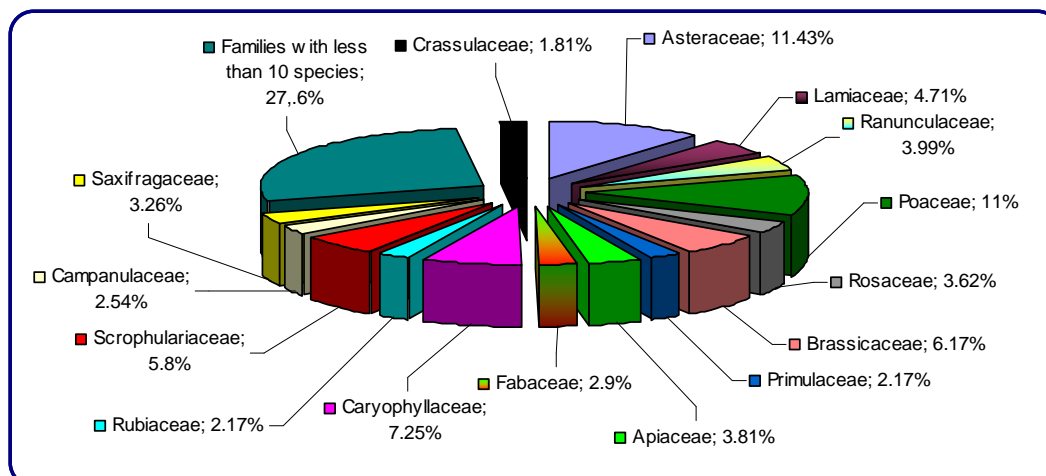


Figure 1. Percentage of plant species recorded in different families from calcareous screes

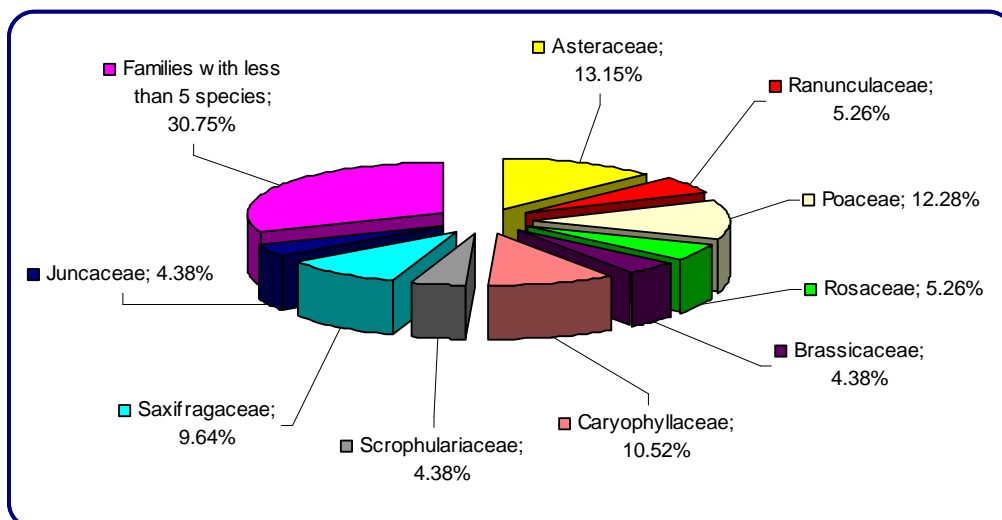


Figure 2. Percentage of plant species recorded in different families from siliceous screes

Life forms analysis

The calcareous cormoflora included 10 types of life forms (hemicryptophytes, mega-, meso-, nanophanerophytes, geophytes, therophytes-hemiterophytes, chamaephytes, hemiterophytes, hemiterophytes-hemicryptophytes and therophytes species), while the siliceous screes had been populated only by 6 life forms categories. Both on the calcareous and siliceous screes, the hemicryptophytes (62.11%; 71.68%), chamaephytes (10.92%; 22.12%) and geophytes (5.08%; 2.65%) were dominant (figure 3). Out of the whole life forms, therophytes registered an important percentage of 5.64% on the calcareous screes.

Geolements analysis

The basic fund of the floristic elements for calcareous screes cormoflora was formed by Eurasian (27.22%), European (10.55%) and Central-European (12.59%) species that had a variety of subtypes as montane, alpine, mediterranean, sub-mediterranean, continental, arctic-alpine etc (table 2). There are more than 40 categories of geolements in calcareous screes cormoflora, some of them with phytogeographical importance like: Carpathian-Endemic (*Achillea oxyloba* subsp. *schurii*,

Campanula rotundifolia subsp. *polymorpha*, *Centaurea pinnatifida*, *Dianthus glacialis* subsp. *gelidus*, *Festuca pachyphylla*, *Gypsophila petraea*, *Hesperis nivea*, *Melampyrum saxosum*, *Noccaea banatica*, *Papaver alpinum*, *Plantago atrata*, *Thymus comosus*, *T. pulcherrimus*, *Trisetum fuscum*), Carpathian-Balkan (*Dianthus petraeus*, *Cephalaria laevigata*, *Poa cenisia*, *Rhododendron myrtifolium*, *Saxifraga carpathica*, *Saxifraga pedemontana* subsp. *cymosa*, *Draba lasiocarpa*, *Thymus dacicus*), Endemic (*Anthemis cretica* subsp. *pyrethriiformis*, *Athamantha turbith* subsp. *hungarica*, *Cerastium transsilvanicum*, *Dianthus henteri*, *Poa molinerii* subsp. *glacialis*, *Noccaea dacica*), Subendemic (*Campanula abietina*, *C. kladniana*, *Cerastium lerchenfeldianum*, *Dianthus spiculifolius*), Carpathian (*Veronica baumgartenii*, *Cerastium alpinum* subsp. *lanatum*), Dacian-Endemic (*Thesium kernerianum*, *Dianthus callizonus*).

The cormoflora of siliceous screes is not so diversified, the highest predominance had the Alpine-European (19.81%), Circumpolar (Arctic-Alpine) (17.11%) and Eurasian (14.41%) species, followed by Carpathian-Balkan (9%), Alpine-Carpathian-Balkan (7.2%), Alpine-Carpathian (6.3%).

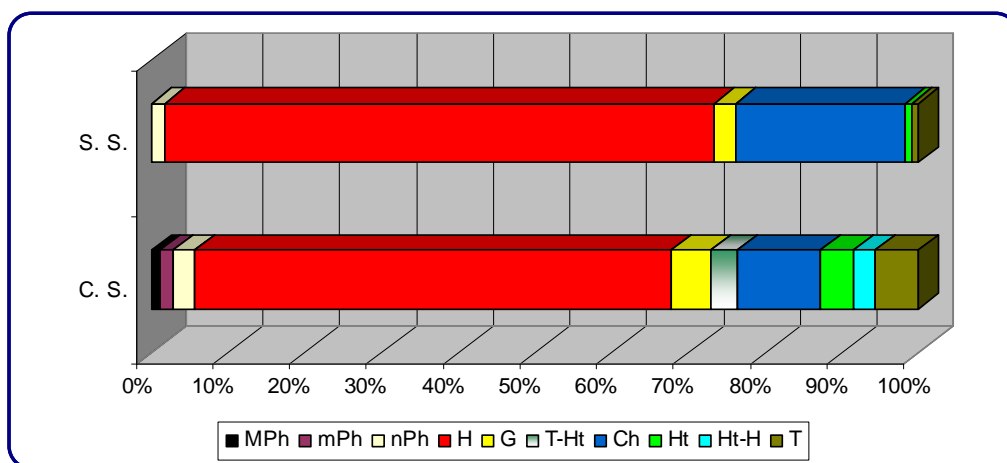


Figure 3. Life forms spectrum of screes cormoflora from Meridional Carpathians (C.S. – calcareous screes; S.S. – siliceous screes)

Table 2. Weighting of the goeelements for screes cormoflora (C.S.-calcareous screes; S.S.- siliceous screes)

Geoelement	Eua s.l.	E s.l.	Euc s.l.	Alp-E	Carp-End	Alp-Carp	Carp-Balc	Alp-Carp-Balc	Circ (Arct.alp)	Balc-Pan
C.S.	27.22%	10.55%	12.59%	6.66%	5%	2.4%	5.74%	2.77%	4.25%	0.18%
S.S.	14.41%	1.8%	3.6%	19.81%	4.5%	6.3%	9%	7.2%	17.11%	0.9%
Geoelement	Cosm	End(Carp-Balc)	Carp-Balc-Anat	Circ	Subend	Circ(Alp)	Carp	End	Alp-Eua	Balc
C.S.	2.96%	0.18%	0.55%	5.36%	0.74%	0.37%	0.55%	1.29%	0.37%	1.85%
S.S.	1.8%	0.9%	1.8%	2.7%	0.9%	1.8%	3.6%	0.9%	0.9%	-
Geoelement	Pont-Balc	Med	Dac-Balc	Alp-Med	Balc-Dac-Pan	Pont-Med	Pont-Pan-Balc	Atl-Med	Dac-End	Subend (Carp)
C.S.	0.55%	0.92%	0.55%	0.18%	0.18%	1.11%	0.74%	0.55%	0.36%	0.18%
Geoelement	Pont-Med-Euc	Carp-Sudet	Carp-End-Orient	Apen-Balc-Dac	Arct.Alp	Subarct.Ap-E	Adv	Dac-Moesic	Carp-Balc-Cauc	Alp
C.S.	0.37%	0.55%	0.18%	0.36%	0.18%	0.18%	0.18%	0.18%	0.37%	0.37%

Ecological analysis

Taking into account the species preferences for light, both on calcareous and on siliceous scree, the dominant were heliophytes ($L_{8\text{ C.S.}}=32.46\%$, $L_{8\text{ S.S.}}=38.18\%$), followed by the species that tolerated partial shade ($L_{7\text{ C.S.}}=26.86\%$, $L_{7\text{ S.S.}}=27.27\%$) (figure 4). A percentage of 12.5% of species grows only in full light on calcareous or siliceous scree (21.81%) such us: *Artemisia eriantha*, *Cardamine resedifolia*, *Cerastium alpinum*, *Dryas octopetala*, *Festuca supina*, *Galium anisophyllum*, *Gentiana frigida*, *Minuartia sedoides*, *Oxyria digyna*, *Ranunculus alpestris*, *Saxifraga bryoides*, *Sedum atratum*, *Sesleria bielzii*, *Silene acaulis* etc. The meso-heliophytes had an important weight from the total of species on calcareous scree ($L_{6\text{ C.S.}}=11.56\%$).

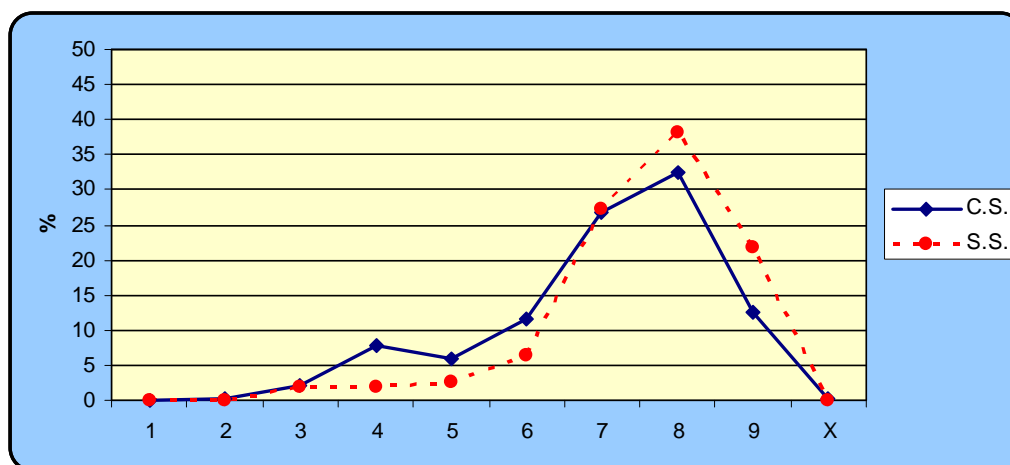


Figure 4. The species weighting according to light preferences on calcareous and siliceous screes (C.S. – calcareous screes; S.S. – siliceous screes)

The phytocoenosis of the siliceous screes can be found especially on steep slopes of the glacial cirques where snow persisted long periods, so cryophilous species are well represented ($T_{1\text{ S.S.}}=14.41\%$; $T_{2\text{ S.S.}}=44.14\%$), followed by microthermophytes ($T_{3\text{ S.S.}}=19.81\%$; $T_{4\text{ S.S.}}=14.41\%$) (figure 5). The calcareous screes are very diversified with phytocoenosis that vegetate from mountain to alpine level, at the basis of glacial cirques, on sunny and moderately inclined slopes, sometimes on soil with high humidity due to snow melting. Those topo-climatic features are reflected in the floristic composition, characterized by a variety of elements: cryophilous ($T_{1\text{ C.S.}}=3.17\%$; $T_{2\text{ C.S.}}=11.75\%$); microthermophilous ($T_{3\text{ C.S.}}=11.19\%$; $T_{4\text{ C.S.}}=17.91\%$); mesothermophilous ($T_{5\text{ C.S.}}=14.73\%$; $T_{6\text{ C.S.}}=13.61\%$); eurithermophilous ($T_{x\text{ C.S.}}=26.86\%$).

From the soil humidity point of view, the mesophilous species had registered the high percentage both on the calcareous scree and on siliceous scree ($U_{5\text{ C.S.}}=26.3\%$; $U_{5\text{ S.S.}}=36.93\%$) (figure 6). The plant communities from *Androsacetalia alpinae* order vegetate often on soils with more than 50% of moisture, therefore mesophilous ($U_{6\text{ S.S.}}=21.62\%$) and meso-higrophilous ($U_{7\text{ S.S.}}=13.51\%$) species had a considerable weight. Xero-mesophilous species ($U_{3\text{ C.S.}}=17.5\%$; $U_{4\text{ C.S.}}=24.44\%$) are characteristic especially to calcareous screes (plant associations: *Thymetum comosi* Pop et Hodişan 1963; *Achnatheretum calamagrostis* Br.- Bl. 1918; *Acino-Galietum anisophylli* Beldie 1967; *Cerastio lerchenfeldiani-Papaveretum* Boşcaiu, Täuber et Coldea 1977).

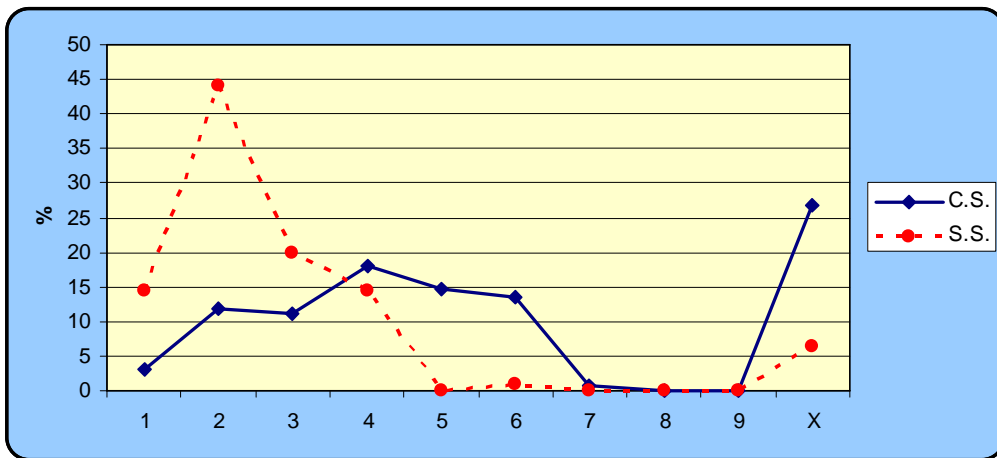


Figure 5. The species weighting according to temperature preferences on calcareous and siliceous screes (C.S. – calcareous screes; S.S. – siliceous screes)

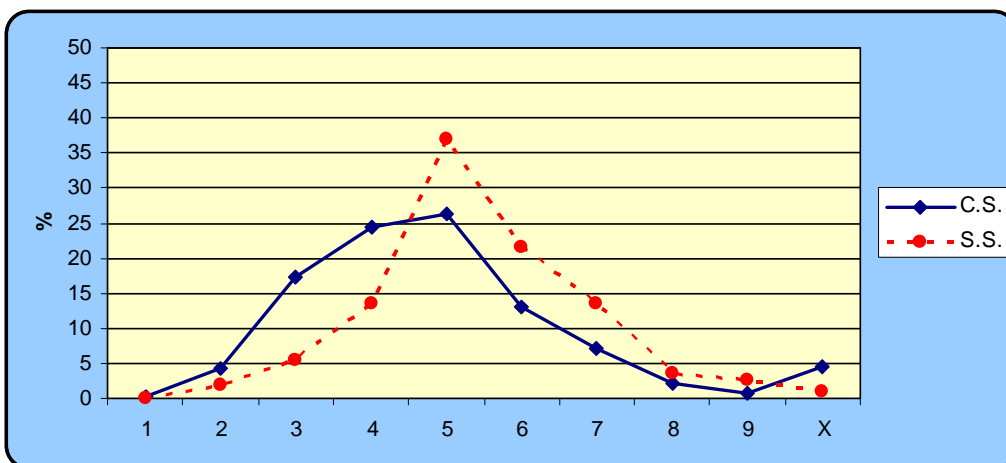


Figure 6. Ecological spectrum of humidity for the calcareous and siliceous screes cormoflora (C.S. – calcareous screes; S.S. – siliceous screes)

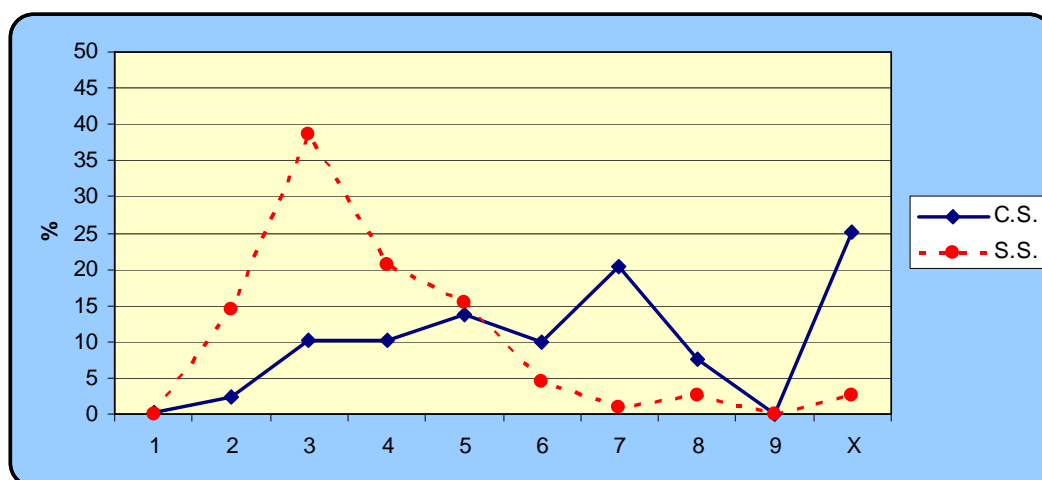


Figure 7. Ecological spectrum of soil reaction for the calcareous and siliceous screes cormoflora (C.S. – calcareous screes; S.S. – siliceous screes)

Regarding the behavior of cormophytes in relation to soil reaction, strongly acidophilic species had the highest proportion ($R_{2\text{ S.S.}}=14.41\%$; $R_{3\text{ S.S.}}=38.73\%$) on siliceous screes, followed by moderately acidophilic species ($R_{4\text{ S.S.}}=20.72\%$; $R_{5\text{ S.S.}}=15.31\%$) (figure 7). The euriionic species from the calcareous screes had been most abundantly ($R_{X\text{ C.S.}}=25.09\%$). Phytocoenoses of *Thlaspietalia* order are developed on screes that contain also fragments of crystalline schists, therefore an important percentage registered strongly acidophilic ($R_{3\text{ C.S.}}=10.29\%$) and moderately acidophilic species ($R_{4\text{ C.S.}}=10.29\%$; $R_{5\text{ C.S.}}=13.67\%$), together with low acidophilic ($R_{6\text{ C.S.}}=9.92\%$) and neutrophilic species ($R_{7\text{ C.S.}}=20.41\%$).

4. CONCLUSION

High microstational diversity of the screes from Meridional Carpathians is reflected in the cormoflora diversity. The screes phytocoenoses are characterized by their persistence and strong conservative character, that included species protected both at the European and national level. For the habitats conservation, the following measures must be taken: avoidance of overgrazing; the prohibition of the geological resources exploitation (extracting stones for garden landscape); the regulation of the tourism; the awareness of the residents and tourists about the importance of preserving species and their habitats; restriction the scientific collection of species.

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