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THE RARE SPECIES *GALIUM SAXATILE* L. IN THE ROMANIAN CARPATHIANS: DETAILED DISTRIBUTION AND HABITAT PREFERENCES

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Abstract: Rare species occurrences are important for understanding patterns in regional floras. New records of species in different areas help to examine how recent changes in climate and human pressure could influence species assemblages. In this study, we carried out a detailed analysis of the distribution and habitat requirements of the rare Sub-Atlantic plant species *Galium saxatile* L. in the Romanian Carpathians. To date, the species has been reported only from the Nemira Mountains (Eastern Carpathians). We therefore provide information on several new localities in three other ranges: the Rodna, Cearcănul and Brețcu Mountains. The phytocoenoses where *G. saxatile* was found in Romania belong to *Festuco - Nardetum strictae* Csűrös et Resmeriță 1960, *Violo declinatae-Nardetum strictae* Simon 1966 and *Hieracio transsylvanici-Piceetum abietis* Pawlowski et Br.-Bl. 1939. These are very similar to those described for the species in Western Europe and the Western Carpathians.

Keywords: biogeography, chorology, montane habitats, Romanian Flora, Sub-Atlantic species.

Introduction

Within the very large woody plant family of *Rubiaceae*, centred in the wet tropics, *Galium* L. is the most important genus found in temperate regions [30]. This genus includes more than 600 annual and perennial species, most of its members being herbaceous [31]. *Galium* is a taxonomically problematic genus with many polymorphic species that are often poorly differentiated morphologically. Moreover, some taxa from the closely related genus *Asperula* are very similar to *Galium* species, and therefore their assignation (based mainly on the shape of the corollas) to one or the other genus has changed during the last decades according to different monographs [11, 32, 31]. For that reason, the classification and identification of the taxa have been problematic and there is still no consensus as to the treatment of some insufficiently understood species groups in current regional Floras. For example, the number of *Galium* taxa reported in the Romanian flora has changed according to different sources: 28 species in Paucă and Nyárády (1961), 33 in Ciocârlan (1990), 40 in Oprea (2005), and 38 in Ciocârlan (2009) and Sârbu *et al.* (2013). This is the result of the different taxonomic approaches over time, as well as the discovery of new taxa in the Romanian flora. Our study is focused on the last species of *Galium* reported for the Romanian Carpathians, namely *Galium saxatile*.



Fig. 1: Close-up view of *Galium saxatile* L. in the Rodna Mountains (a) and its habitat on the Știol Peak - Rodna Mts (b) and Nemira Ridge - Nemira Mts (c).

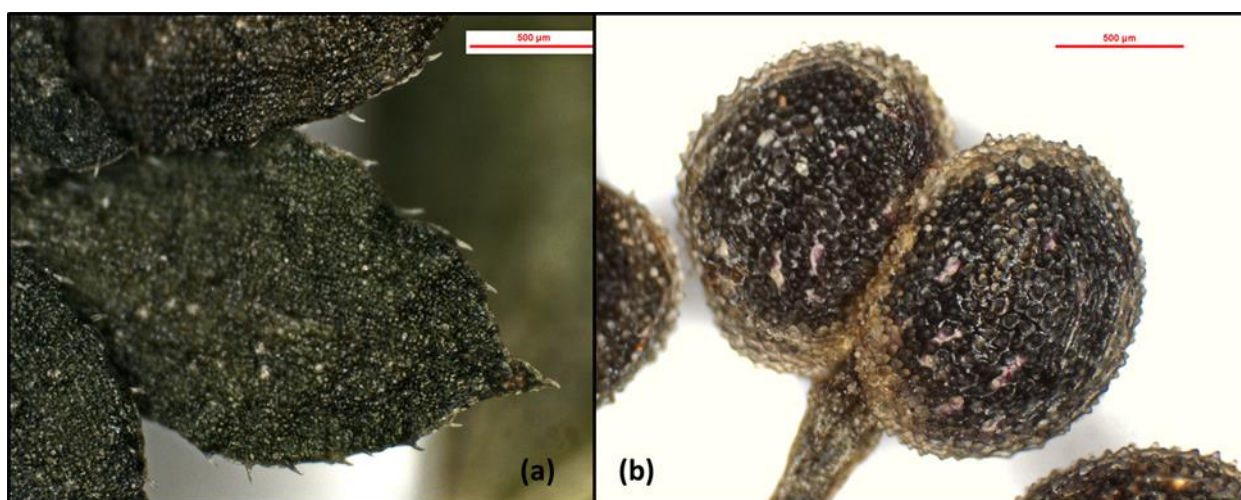


Fig. 2: Morphological details of the leaves (a) and fruits (b) of *Galium saxatile* (Cercănul Mts).

Galium saxatile L. (*G. hircynicum* Weigel - heath bedstraw, Fig. 1) is a typical European Sub-Atlantic biogeographical element [19, 14, 13] with maximum occurrence within the Atlantic region (British Isles and from Southern Scandinavia to Northern Spain), but also locally present in Central Europe [18]. In Western Europe, the species grows mainly in open habitats [2], and is one of the commonest plants of short grasslands and heaths on acid soil [16]. *G. saxatile* is particularly found in nutrient-poor swards and pastures dominated by matgrass (*Nardus stricta*), all over its range: the British Isles [27], Germany [26], Austria [21], Czech Republic [4], etc.

Primarily, it is regarded as a characteristic species for the *Nardetalia strictae* phytosociological order [26]. Besides grassy vegetation, heath bedstraw has been reported from oak, spruce, pine or mixed forests, invariably on acid substrates [12, 23, 10].

Galium saxatile has its Eastern distribution boundary in the Carpathians. The environmental conditions for the species in this area are well documented only for the Western Carpathians (i.e. Poland, especially and Slovakia). Similar to Western Europe, or the Alps and Sudetes, heath bedstraw can be found either in nutrient-poor swards dominated by *Nardus stricta* or in spruce forests (*Plagiothecio - Piceetum tatricum*). It has also often been encountered in human-disturbed habitats such as trails, road margins and forest clearings [34, 19]. For the South-Eastern Carpathians there is poor information on the distribution and habitat requirements of the species. *G. saxatile* was recorded in meadows and wet coniferous forests on acidic bedrocks in the Gorgany and Chyvchyny-Gryniava Mountains (Ukraine, [3]). In the Romanian Carpathians, *G. saxatile* was discovered only recently by Ciocârlan and Costea (1997) in the Nemira Mountains. The only information available from this source is the mention of the *Hyperico maculatae - Polygaletum* phytosociological association. To our best knowledge, there are no published vegetation relevés containing this species from the Romanian Carpathians.

Therefore, the main goals of our study are: (i) to provide a detailed review of available data concerning the occurrence of *Galium saxatile* L. in the Romanian Carpathians, (ii) to report newly discovered localities for the species in this range, and (iii) to characterize the environment and vegetation types using our own field data.

Materials and Methods

Our investigation was based on recent field studies and critical evaluation of herbarium material and botanical literature. The field surveys were carried out in the Nemira, Rodna, Cearcănul and Brețcu Mountains (2004–2016). The vegetation types where the species grows were described by phytosociological relevés performed according to the Central European Phytosociological School [9]. The following herbaria were examined (acronyms according to Thiers, continuously updated): BP (Hungarian National History Museum, Budapest, Hungary), BUAG (University of Agronomical Sciences and Veterinary Medicine, Bucharest), BUC (D. Brândză Botanical Garden, Bucharest), BUCA (Institute of Biology, Romanian Academy), BVS (Transilvania University of Brașov), CL (Babeș-Bolyai University, Cluj-Napoca), CLA (University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca), CRAI (University of Craiova), DE (Debrecen University, Hungary), I (Faculty of Biology, Alexandru Ioan Cuza University, Iași), IAGB (Botanical Garden, Alexandru Ioan Cuza University, Iași), IASI (University of Agricultural Sciences and Veterinary Medicine, Iași) and SIB (Natural History Museum, Sibiu). Species nomenclature follows *Flora Europaea* [33].

Results and Discussion

Distribution in the Carpathians

Western Carpathians: The presence of *G. saxatile* in the Western Carpathians is well documented by literature and herbarium records. It occurs in numerous, scattered sites in the Western Beskids and Tatra Mountains (further details about the distribution and habitat requirements in this range can be found in Mirek and Piękoś-Mirkowa, 1984). Interestingly, the first references for the species in the Western Carpathians are recent, i.e. 1973 and 1975, even

though this mountain range has been deeply explored by botanists starting from the 18th century. Until then, *G. saxatile* was regarded as a good diagnostic biogeographical element, supporting the floristic difference between the Carpathians (where the species was not cited) and the Sudetes (where the species is common, [15]).

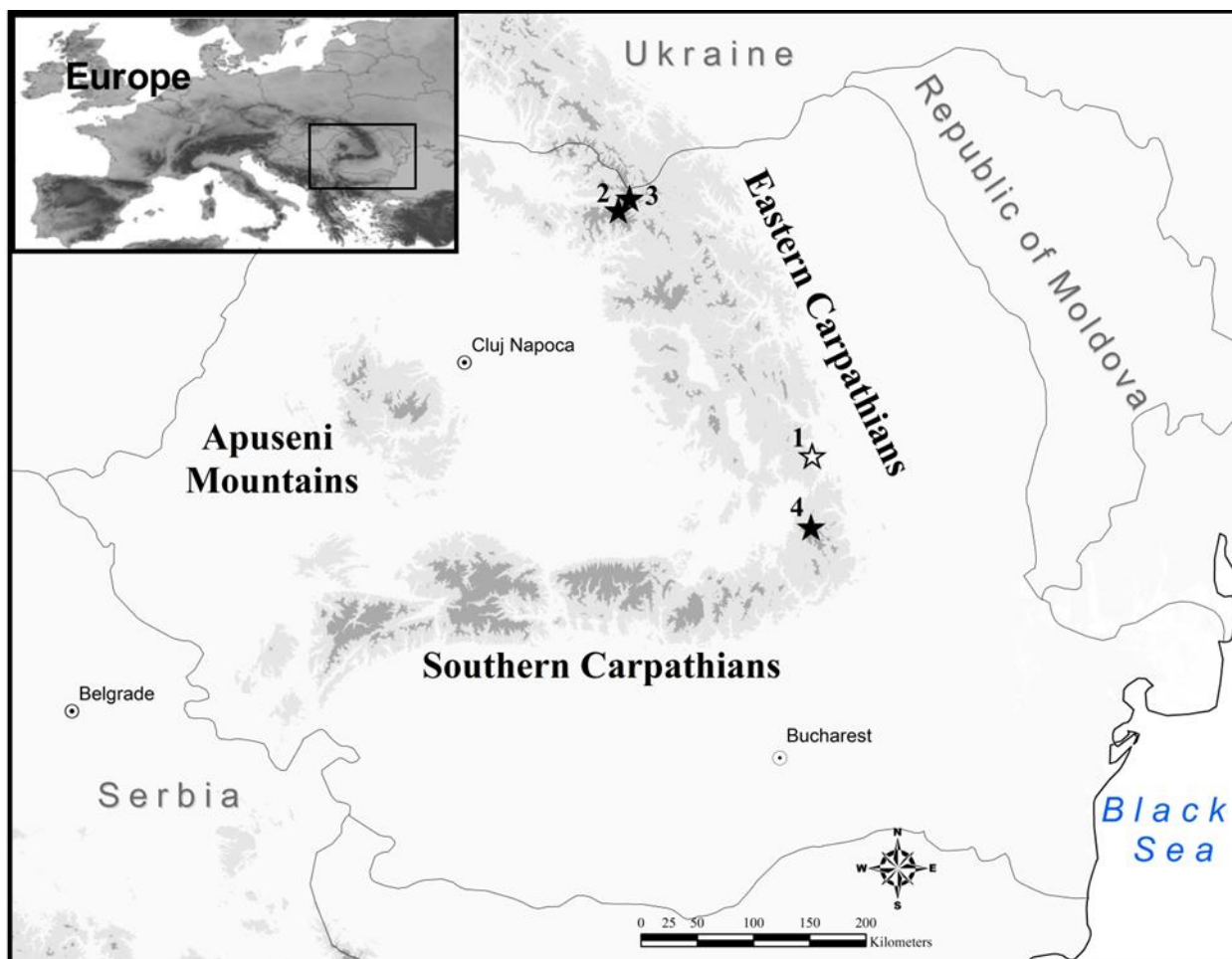


Fig. 3: Distribution of *Galium saxatile* L. in the Romanian Carpathians. The Nemira Mts. are indicated by a white star (1), while the new ranges discovered for the species are represented by black stars (2 - Rodna Mts, 3 - Cearcănul Mts, 4 - Brețcu Mts.). Left inset indicates the location of the South-Eastern Carpathians in Europe.

South-Eastern Carpathians: Up to now, *G. saxatile* has been reported only from the Gorgany and Chyvchyny-Gryniava (Ukraine) and the Nemira Mountains (Romania), as its easternmost occurrences in Europe. The first records of heath bedstraw in the Ukrainian Carpathians date back to 1942 (Mirek and Piękoś-Mirkowa, 1984).

The first observations of *G. saxatile* in the Romanian Eastern Carpathians are much more recent. Ciocârlan and Costea published this species in 1997 from the Nemira Mountains, where they founded it on the Șandru Mare and Țiganca peaks. Even though these new localities were documented by vouchers deposited in BUAG, Negrean (2011) contested the presence of *G. saxatile* in Romania by reason that the species is "at a great distance from the compact areal".

During recent field trips, we discovered *G. saxatile* in three new mountain ranges in the Eastern Carpathians, i.e. the Brețcu (A. Indreica, 2013), Rodna (M. Pușcaș, P.-D. Turtureanu, B.-I. Hurdu and S. Bec, 2014–2016) and Cearcănul Mountains (M. Pușcaș, P.-D. Turtureanu, 2016)

– Fig. 3. Additionally, we reconfirm the presence of the species in the Nemira Mts in several localities.

In the Rodna Mountains we first discovered the species on 13th August 2014 on the Știol Peak (at 1578 m a.s.l., CL no. 665393). We frequently encountered the species during a field trip between 21st and 23rd July 2015, abundant between Poiana Prislopului and Izvorul Bistriței Glacial Cirque (1500 - 1750 m a.s.l., CL no. 665390, 665391, 665392). In 2016, *Galium saxatile* was recorded as well in the western part of the range, namely in the Iezerul Glacial Cirque and Jneapănul-Bătrâna ridge (1750 - 1850 m a.s.l., CL no. 666334, 666335). It is worth mentioning that the Rodna Mountains (including the area of Pietros - Bătrâna or Prislop - Izvorul Bistriței) have been intensively studied by botanists from the 19th century [8] onwards, but there are no indications of this species in the area.

In the Cearcănul Mountains, heath bedstraw was recorded on 29th July 2016, north to the Prislop Pass, along the dirt road towards the Cearcănul Mare Peak and the adjacent pastures (1450 - 1500 m a.s.l., CL no. 666336).

In the Brețcu Mountains the species was observed on 10th July 2015 (BVS no. 64684) close to Covasna city, between Iacob Forest and the Zârna Peak. Along the trail, *G. saxatile* occurs frequently in various habitats. These mountains have not been investigated systematically by botanists, therefore *G. saxatile* could be even more expansive in this range.

In the Nemira Mountains, besides the two localities given by Ciocârlan and Costea in 1997 (Țiganca and Șandru Mare Peaks, BUAG no. 23025, 23026), *G. saxatile* was recorded in the Nemira Mare (G. Coldea 2004) and Farcăul Mic peaks (BVS no. 64687). It is likely that the species occurs along the whole main ridge of this mountain, between 1350-1640 m a.s.l.

Habitat description in the Romanian Eastern Carpathians

G. saxatile was found in the Romanian Eastern Carpathians in very similar habitats to those from Western Europe and the Western Carpathians.

In the Rodna and Cearcănul Mountains, the species grows primarily in open habitats dominated by *Nardus stricta*. The most extensive are the mesic, heavily sheep-grazed pastures on nutrient-poor soils developed on acidic bedrock (crystalline schists), on gentle slopes or flat areas, belonging to *Festuco - Nardetum strictae* Csűrös et Resmeriță 1960 (Syn. *Scorzonero roseae-Festucetum nigricantis* (Pușcaru et al. 1956) Coldea 1978, Table 1). It occurs also in moist *N. stricta*-dominated grasslands with *Deschampsia caespitosa* and *Eriophorum vaginatum*. Up to around 1750 m a.s.l., in the subalpine level (Izvorul Bistriței), the species might be seen close to patches of *Pinus mugo*, *Rhododendron myrtifolium*, *Vaccinium uliginosum* subsp. *microphyllum* and *V. vitis-idaea*.

In the Brețcu Mountains, *G. saxatile* occurs also in grazed pastures dominated by *Nardus stricta* (*Violo declinatae-Nardetum* Simon 1966) on highly acidic soils (the pH in the A horizon is 3.6). This habitat seems to be very favourable for the species, as locally heath bedstraw has a very high abundance (e.g. up to 10–20% cover in the phytocoenoses investigated). Besides, the species was observed on forest edges and disturbed pastures (communities with *Veratrum album*, *Rumex alpinus* and *Sambucus ebulus*).

In the Nemira Mountains, *G. saxatile* was firstly recorded in montane calcifuge communities belonging to *Hyperico maculatae - Polygaletum* (Syn. *Polygalo-Nardetum* Oberd. 1957). Our investigations showed that it could equally be encountered in acidophilous spruce forests (*Hieracio transsylvanici-Piceetum abietis* Pawlowski et Br.-Bl. 1939, Table 1).

Table 1: Vascular plant composition of the relevés in which *Galium saxatile* was recorded.

Relevé no.	1	2	3	4	5	6	7
Phytosociological association	<i>Hieracio transsylvanici-Piceetum abietis</i>			<i>Festuco - Nardetum strictae</i>			
Altitude (m a.s.l.)	1520	1420	1390	1579	1669	1587	1515
Latitude (°) / Longitude (°)	46.2102/26.3402	46.2172/26.3375	46.225/26.3358	47.5975/24.8178	47.5773/24.8113	47.5981/24.8183	47.6012/24.8336
Aspect	E	N	E-NE	SE	E-SE	SE	SW
Slope (°)	15	20	15	20	30	30	25
Tree cover (%)	50	65	75	0	0	0	0
Herbaceous cover (%)	45	15	25	100	100	65	100
Relevé surface (square meters)	400	400	400	100	100	100	100
<u>Char. ass.</u>							
<i>Soldanella hungarica</i> subsp. <i>major</i>	+	-	-	-	-	-	-
<i>Campanula abietina</i>	-	-	-	-	+	-	-
<i>Festuca nigrescens</i>	-	-	-	+	+	+	+
<u>Potentilla-Nardion</u>							
<i>Alchemilla gracilis</i>	-	-	-	-	+	-	-
<i>Campanula serrata</i>	-	-	-	-	+	+	-
<i>Gentiana acaulis</i>	-	-	-	-	+	-	-
<i>Geum montanum</i>	-	-	-	-	+	-	-
<i>Hieracium aurantiacum</i>	-	-	-	-	+	-	-
<i>Hypochoeris uniflora</i>	-	-	-	-	+	-	-
<i>Phleum alpinum</i> subsp. <i>alpinum</i>	-	-	-	-	+	-	+
<i>Potentilla aurea</i> subsp. <i>chrysocraspeda</i>	-	-	-	+	+	+	+
<u>Nardetalia et Calluno-Ulicetea</u>							
<i>Nardus stricta</i>	-	-	-	5	3	3	5
<i>Galium saxatile</i>	+	+	+	1	+	+	2
<i>Arnica montana</i>	-	-	-	-	+	-	-
<i>Carex ovalis</i>	-	-	-	-	-	-	+
<i>Luzula sudetica</i>	-	-	-	-	+	-	-
<i>Potentilla erecta</i>	-	-	-	-	+	-	-
<i>Solidago virgaurea</i> subsp. <i>alpestris</i>	-	-	-	-	+	-	-
<i>Thymus pulegioides</i>	-	-	-	-	+	+	-
<u>Caricetalia curvulae</u>							
<i>Pulsatilla alba</i>	-	-	-	-	+	-	-
<u>Piceion abietis</u>							
<i>Picea abies</i>	4	4	5	-	-	-	+
<i>Calamagrostis villosa</i>	2	-	-	-	-	-	-
<i>Dryopteris dilatata</i>	-	+	2	-	-	-	-
<i>Homogyne alpina</i>	+	-	-	-	+	-	-
<i>Luzula sylvatica</i>	2	+	+	-	-	-	-
<u>Fagetalia</u>							
<i>Fagus sylvatica</i>	-	1	-	-	-	-	-
<i>Acer pseudoplatanus</i>	-	1	-	-	-	-	-
<i>Fagus sylvatica</i> (young individuals)	-	-	+	-	-	-	-
<u>Junipero-Pinetalia mugi et Vaccinio-Piceetalia</u>							
<i>Calamagrostis arundinacea</i>	+	+	1	-	-	-	-
<i>Deschampsia flexuosa</i>	-	-	-	+	+	+	-
<i>Dryopteris carthusiana</i>	+	1	-	-	-	-	-
<i>Juniperus communis</i> subsp. <i>alpina</i>	-	-	-	-	2	+	-
<i>Luzula luzuloides</i>	-	+	1	-	+	+	-
<i>Oxalis acetosella</i>	+	+	+	-	-	-	-
<i>Pinus mugo</i>	-	-	-	-	+	-	-
<i>Ranunculus platanifolius</i>	-	-	-	-	+	-	-
<i>Rhododendron myrtifolium</i>	-	-	-	-	+	-	-
<i>Sorbus aucuparia</i>	-	1	-	-	-	-	-
<i>Vaccinium myrtillus</i>	-	-	-	+	-	2	-
<i>Vaccinium vitis-idaea</i>	-	-	-	-	+	-	-
<u>Varia</u>							
<i>Agrostis capillaris</i>	-	-	-	+	+	+	2
<i>Anemone nemorosa</i>	-	-	-	-	+	-	-
<i>Anthoxanthum odoratum</i>	-	-	-	-	+	+	+
<i>Cerastium fontanum</i> subsp. <i>vulgare</i>	-	-	-	-	-	-	+
<i>Hypericum richeri</i> subsp. <i>grisebachii</i>	-	-	-	-	+	-	-
<i>Leontodon croceus</i> subsp. <i>croceus</i>	-	-	-	-	+	-	-
<i>Poa alpina</i>	-	-	-	-	-	-	+
<i>Polygonum bistorta</i>	-	-	-	-	-	+	-
<i>Prunella vulgaris</i>	-	-	-	-	+	-	-
<i>Ranunculus polyanthemos</i>	-	-	-	-	+	-	-
<i>Rubus hirtus</i>	-	-	+	-	-	-	-
<i>Rumex acetosella</i>	-	-	-	-	-	-	+
<i>Scleranthus uncinatus</i>	-	-	-	-	-	+	-
<i>Senecio ovatus</i>	-	-	+	-	-	-	-
<i>Silene vulgaris</i>	-	-	-	-	+	-	-
<i>Stellaria graminea</i>	-	-	-	-	-	-	+
<i>Trifolium pratense</i>	-	-	-	-	+	-	-
<i>Trifolium repens</i>	-	-	-	-	+	-	+
<i>Veronica officinalis</i>	-	-	-	-	+	+	+

Location, recording date and author: (1 - 3) Ridge in the Nemirei Mts, between the Șandru Mare and Nemira Mică peaks, 27.09.2013, A.I.; 4) The Rodnei Mts, on the Știol peak, 13.08.2014, M.P.; 5) The Rodnei Mts, close to the Izvorul Bistriței Lake, 23.07.2015, P.D.T.; 6) The Rodnei Mts, on the South-west slope of the Știol peak, 21.07.2015, P.D.T.; 7) The Rodnei Mts, between the Știol peak and Poiana Prislopului in a forest clearing, 21.07.2015, P.D.T.

On the main ridge in windy, exposed sites, *G. saxatile* grows in dwarf heaths dominated by *Vaccinium* spp. or in mountain dwarf juniper scrubs.

Based on its habitat preferences, *G. saxatile* is a good example of an edaphic vicariant of the closely related taxa from section *Leptogalium* Lange of the genus *Galium*. In the Romanian Carpathians, the other *Leptogalium* species are *G. pumilum*, *G. anysophyllon* and *G. austriacum* [6]. Besides morphological criteria (reviewed in Ciocârlan and Costea, 1997, Fig. 2), *G. saxatile* is a typical example of species growing in acidophilous habitats, as opposed to the other species from the same section which are primarily considered as basiphilous or calcicole [20, 16, 1].

Conclusions

Galium saxatile L. is a typical Sub-Atlantic species, which has its easternmost European populations in the Romanian Carpathians, where until now it was known to occur only in the Nemira Mountains. In our study, we report three new mountain ranges in which we have recently discovered this species, i.e. the Brețcu, Cearcănul and Rodna Mountains (Eastern Carpathians). *G. saxatile* occurs in two different habitat types, namely the extensively acidophilous pastures dominated by matgrass (*Nardus stricta*) and the montane spruce forests. Some authors have proposed an anthropogenic origin for this species in the Nemira Mountains and for the Carpathians in general [29]. However, *G. saxatile* is not listed as an alien species for the Carpathians, either in the inventory of the alien flora of Slovakia [17] or in the DAISIE database (<http://www.europe-aliens.org/default.do>). Although the argument of Šingliarová *et al.* (2008) could be plausible, that the species is confined mainly to man-made habitats – pastures of secondary origin – there is still no clear evidence for this hypothesis.

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**SPECIA RARĂ *GALIUM SAXATILE* L. ÎN CARPAȚII ROMÂNEȘTI:
DISTRIBUȚIE DETALIATĂ ȘI PREFERINȚELE DE HABITAT**

(Rezumat)

În acest studiu, am efectuat o analiză detaliată a distribuției și a cerințelor de habitat pentru specia *Galium saxatile* L., un element sub-atlantic rar în Carpații Românești. Până în prezent, specia a fost raportată numai din Munții Nemira (Carpații Orientali). Sunt prezentate informații cu privire la mai multe localități noi în care specia a fost semnalată: Munții Rodnei, Cearcănul și Munții Brețcu. Fitocenozele în care a fost găsită *G. saxatile* în România fac parte din asociațiile *Festuco - Nardetum strictae* Csuros et Resmeriță 1960, *Violo declinatae-Nardetum strictae* Simon 1966 și *Hieracio transsylvanici-Piceetum abietis* Pawlowski et Br.-Bl. 1939. Acestea sunt foarte asemănătoare cu cele descrise pentru specie în Europa Occidentală, Alpi, Sudeți și Carpații de Vest.

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