Fl. Medit. 31 (Special Issue): 361-369
https://doi.org/10.7320/FlMedit31SI.361
Version of Record published online on 3 October 2021

Gheorghe Coldea & Vasile Cristea

Syntaxonomic characterization of the vegetation belts from the South-eastern Carpathians (Romanian Carpathians)

Abstract

Coldea, G. & Cristea, V.: Syntaxonomic characterization of the vegetation belts from the South-eastern Carpathians (Romanian Carpathians). — Fl. Medit. 31 (Special Issue): 361-369. 2021. — ISSN: 1120-4052 printed, 2240-4538 online.

Based on studies carried out in the mountain ranges of the South-eastern Carpathians (Romanian Carpathians) and on local geobotanical (phytosociological) data, we present a detailed syntaxonomical characterization of the 4 vegetation belts (hill, montane, subalpine and alpine) of this region. The syntaxa for each vegetation belt are analogous to those described in the North-western Carpathians (Tatra Mountains) regarding the dominant species, but have different regional and local endemic species. The latter supported the description of new regional syntaxa by Romanian phytosociologists, which are employed in the characterization of each vegetation belt.

Key words: Plant communities, altitudinal belts, Romanian mountains.

Introduction

The South-eastern Carpathians, situated in the Carpathian chain between the Tisza and Danube rivers, stretch out in the center of Romania as a 910 km long arch of variable width (40-100 km), subdivided into different sectors. The geomorphologists who studied intensively the Romanian Carpathians (De Martonne 1907; Mihăilescu 1963; Ficheux 1996; etc.) divided them according to their tectonic character into three main branches: (Inner) Eastern Carpathians, Southern Carpathians and Western Carpathians (commonly called the Apuseni Mountains). The Eastern Carpathians, with the highest altitude over 2,000 m (Pietrosul Rodnei Peak - 2,305 m), are the most intricate in terms of structure, lithology and tectonics. They encompass Hercynian blocks in the upwarped mountains and volcanic areas in the northwest. The Southern branch ("*the Transylvanian Alps*", as De Martonne called them) is more uniform lithologically (being dominated by crystalline schists), but very diverse tectonically, which caused its highest rising during tectonic movements, to over 2,500 m altitude. The Western Carpathian (Apuseni Mountains) branch is the lowest of Romanian Carpathians (the Cucurbăta Peak reaching 1,848 m) and the most fragmented tectonically, but through its formation, structure and evolution, it shows affinities with the crystalline (Hercynian) chain of the Eastern Carpathians.

The intensive study of the Romanian Carpathians flora started in the early 19th century (Baumgarten 1816) and was then continued by Schur (1866), Brandză (1879-1883), Simonkai (1886), and Grecescu (1898), which allowed the botanists of the 20th century to delimit the floristic sub-provinces of the Romanian Carpathians (Pax 1919; Borza 1960; Meusel 1965; Georgescu & Doniță 1965), based on the Carpathian endemic and sub-endemic plant species, along with some rare species with areal limited to some Carpathian massifs.

Of the 132 plant species endemic to the Carpathian chain, 105 are endemic to the Romanian Carpathians (Hurdu & al. 2012). Compared to the works discussing the delimitation of the floristic sub-provinces, those referring to the vegetation belts of the Romanian Carpathians are few and encompass only some mountain massifs (Borza 1934, 1959; Beldie 1967; Doniţă 1962; Boşcaiu 1971; Puşcaru-Soroceanu & al. 1981; Coldea 1990, 1991; Cristea 1993).

In this paper we present the vegetation belts of the Romanian Carpathians and characterize them based on specifically described regional syntaxa, following the laborious works published by Pignatti (1980), Zarzycki (1991), Ozenda (1994), Ellenberg (1996) and Rivas-Martinez (1988).

Materials and Method

Based on field research that we conducted over the years in numerous mountain ranges of the Romanian Carpathians and on geobotanical (phytosociological) data published recently by some botanists (Muică 1995; Drăgulescu 1995; Mihăilescu 2001; Nechita 2003; Oprea & Sîrbu 2009), we selected three mountain massifs that have different altitudes and geological structure from each of the three main branches of the Romanian Carpathians. The mountain ranges chosen for this study are (Fig. 1): Rodnei, Călimani, and Hăşmaş Mts. - from the Eastern Carpathians branch; Bucegi, Făgăraş and Retezat Mts. - from the Southern Carpathians branch; and Poiana Ruscă, Biharia, and Plopiş Mts. - from the Western Carpathians branch (Apuseni Mts.) The main geological, geographical and climatic data regarding these mountain ranges are presented in Table 1.

The vegetation belts delimited for each analyzed massif, based on the identified syntaxa, and their altitudinal distribution are represented graphically (Fig. 2), following the model used by Ozenda (1994) in describing the vegetation belts of the Polish Carpathians.

Results and discussion

In the South-eastern Carpathians the following 4 vegetation belts are well-evident in terms of plant communities, soil, ecological, and climatic conditions: hill, montane, subalpine and alpine. The representative syntaxa for each vegetation belt cover a larger or smaller area in the selected mountains, in relation to their geographical position within the Carpathian branch, the geological substratum of the massifs and the basic orographic factors (altitude, aspect, and slope) which influence the vegetation composition (Boşcaiu 1971).

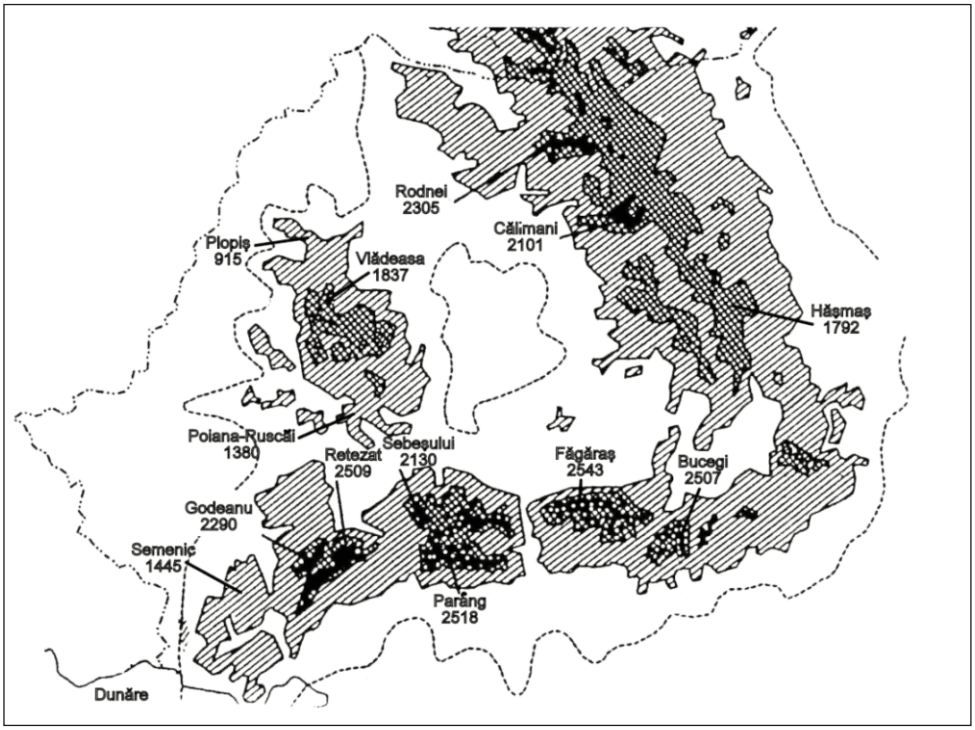

Fig. 1. Geographic location of the nine mountains under study within the South-eastern Carpathians.

Woody plant communities are the best to characterize the vegetation belts (Beldie 1967; Pignatti 1980; Zarzycki 1991). Since the current altitudinal limits of the belts changed considerably due to human activities in the last centuries, in their syntaxonomic characterization we also employed the secondary herbaceous vegetation, along with the zonal woody vegetation.

1. The hill belt, located in the outer areas of the massifs, between 400-700 m, has a temperate-moderate climate, with average annual temperatures of 6-7 °C and annual rainfall of 600-700 mm and is characterized by mesothermophilic forests, grouped in the regional alliance ***Lathyro hallersteinii-Carpinion*** Boșcaiu 1979 - including the associations *Lathyro hallersteinii-Carpinetum* Coldea 1975 and *Carpino-Fagetum* Paucă 1941- and the alliance ***Quercion petraeae*** Zólyomi et Jakus 1957 comprising the associations *Cytiso nigricantis-Quercetum petraeae* Paucă 1941 and *Luzulo luzuloidis-Quercetum petraeae* Hilitzer 1932. In some places, on the sunny slopes of the western part of the Apuseni Mountains and southwest of the Southern Carpathians, there are communities of thermophilic oaks grouped in the associations *Quercetum petraeae-cerris* Soó 1957 and *Quercetum frainetto-cerris* Rudski 1949. The communities of secondary grasslands, established after the felling of mesothermal forests, are grouped into the alliances ***Arrhenatherion elatioris*** W. Koch 1926 and ***Cynosurion*** Tx. 1947, while the thermophilic forests were replaced by xerophillic grasslands included in the alliance ***Festucion valesiacae*** Klika 1931.

Table 1. Geographical, geological and climatic data on the 9 investigated mountains of the South-eastern Carpathians.

Nº.	Mountain Name	Summit	Altitude (m.s.m.)	Geographical Co-ordinate	Geological substratum	Mean Temperature (ºC)	Yearly precipitation (mm/m²)
1.	Rodnei	Pietrosul Mare	2,305	47º36'00"N 24º37'48"E	Crystalline and limestone rocks	- 1.6	1,330
2.	Călimani	Pietrosul Călimanilor	2,101	47º08'01"N 25º10'60"E	Volcanics rocks	- 1.2	1,200
3.	Hăşmaş	Hăşmaşul Mare	1,792	46º42'17"N 25º48'18"E	Crystalline and limestone rocks	1.3	1,000
4.	Bucegi	Omul	2,507	45º26'45"N 25º27'23"E	Pudding stone and granitic rocks	- 2.5	1,320
5.	Făgăraş	Moldoveanu	2,543	45º35'58"N 24º44'11"E	Crystalline and granitic rocks	- 2.6	1,330
6.	Retezat	Peleaga	2,509	45º21'57"N 22º53'33"E	Crystalline and limestone rocks	- 2.1	1,240
7.	Poiana Ruscă	Padeş	1,380	45º39'46"N 22º19'18"E	Crystalline rocks	5.1	900
8.	Apuseni	Vlădeasa	1,837	46º45'33"N 22º47'38"E	Crystalline and limestone rocks	1.1	1.200
9.	Plopiş	Măgura Mare	915	47º5'35"N 22º31'44"E	Crystalline rocks	6.0	830

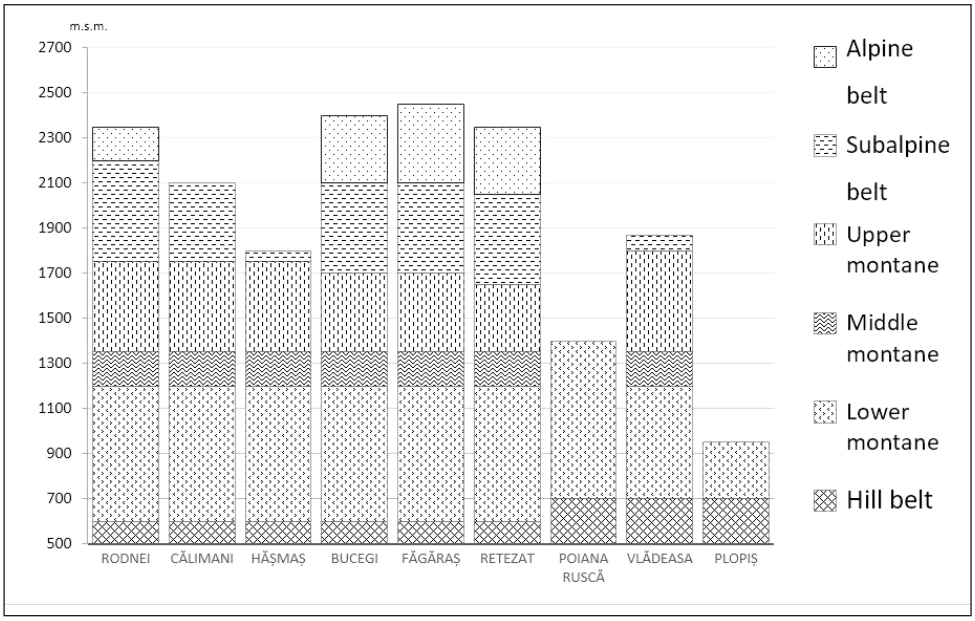

Fig. 2. Correspondence between elevation and vegetation belts in the South-eastern Carpathians.

2. The montane belt, situated between 700-1800 m, is characterized by a cooler climate, but with positive average annual temperatures (+ 2°C to 6°C) and annual rainfall between 700 and 1,100 mm, which is favorable for the development of beech forests, either pure or mixed with spruce and fir, and of boreal spruce forests (Doniţă 1965). Within this belt, as in the case of the Alps (Nikelfeld 1993), three sub-belts can be delimited, depending on the dominant woody vegetation, geological substrate and soil types (Beldie 1967; Boşcaiu 1971).

The lower montane sub-belt, between 700 and 1,100 m is dominated by pure beech forests, developed on acid brown soils, framed in the associations *Symphyto cordati-Fagetum* Vida 1959, *Festuco drymejae-Fagetum* Morariu ex Resmeriţă 1977 and, in the southwestern part of the Southern Carpathians, *Aremonio agrimonioidi-Fagetum* Boşcaiu 1971.

The middle montane sub-belt, situated between 1,100 and 1,350 m comprises acidophilic forests of beech mixed with fir or with spruce, grouped in the regional associations *Pulmonario rubrae-Abietetum* Beldie ex Coldea 2015 and *Leucanthemo waldsteinii-Fagetum* (Soó 1964) Täuber 1987, and also the basophilic beech forests included in the associations *Phyllitidi-Fagetum* Vida 1963 and *Seslerio rigidae-Fagetum* Soó ex. Coldea 2015. All the woody communities with beech from the Romanian Carpathians are included in the regional alliance ***Symphyto cordati-Fagion*** Vida (1959) 1963. Scattered, with intrazonal distribution in the beech area there can be found communities of *Pinus sylvestris* grouped within the acidophilic alliance ***Dicrano-Pinion sylvestris*** Matusz. 1962 and in the basophilic alliance ***Seslerio rigidae-Pinion sylvestris*** Coldea 1991.

The upper montane sub-belt includes mainly spruce forests, distributed between 1,350 and 1,800 m. They vegetate on cryptopodzoles and superficial podzols, with a strong acid reaction (pH 4.2-4.7). The zonal spruce communities are grouped into the regional associations *Hieracio transsilvanici-Piceetum* Pawl. et Br.-Bl. 1939, *Soldanello oreodoxae-Piceetum* Coldea et Wagner 1998, and *Chrysanthemo rotundifolii-Piceetum* Krajina 1933, while the intrazonal ones, on limestone, are included in the association *Doronico columnae-Piceetum* Coldea 2002. At the upper limit of spruce forests, between 1,700-1,800 m, on the northern aspects of glacial cirques, and on the summits of some peaks, there can be found communities of *Picea abies* together with *Pinus cembra* and *Larix decidua*, described as *Rhododendro myrtifolii-Pinetum cembrae* (Borza 1934) Coldea 2015, *Rhododendro myrtifolii-Piceetum* Coldea et Pânzaru 1986, *Bruckenthalio-Piceetum* Borhidi 1971 and *Saxifrago cuneifolii-Laricetum* (Leandru 1954) Coldea 1991. These treeline forest communities make the transition towards the *Pinus mugo* communities that dominate the subalpine belt of the Eastern and Southern Carpathians. In the montane belt, after the felling of beech forests, mesophilic grasslands developed, grouped in the alliances ***Polygono-Trisetion*** Tx. et Marsch 1947 and ***Violion caninae*** Schwick 1944.

3. The subalpine belt, stretching between 1,800–2,200 m, is characterized climatically by average annual temperatures of 0°C to 2°C and annual precipitation between 1,100–1,200 mm, and pedologically by the dominance of podzolic soils. Physiognomically, the subalpine belt includes mainly coenoses grouped in order *Junipero-Pinetalia mugo* Boşcaiu 1971, respectively the alliances ***Pinion mugo*** Pawl. & al. 1928 and ***Bruckenthalio-Juniperion*** (Horv. 1949) Boşcaiu 1971.

The regional associations specific to the South-eastern Carpathians are *Rhododendro myrtifollii-Pinetum mugo* Coldea 1991, *Campanulo abietinae-Juniperetum nanae* Simon 1966 and *Bruckenthalio-Juniperetum nanae* Horvat ex Boşcaiu 1971. At altitudes higher than 2,100 m, due to the unfavorable climatic conditions, the communities of *Pinus mugo* and *Juniperus communis* ssp. *alpina* become dwarf and repent, resembling the coenoses of the shrub *Loiseleuria procumbens* specific to the alpine belt. Frequently, in contact with the *Pinus mugo* bushes, on the northern, steep slopes of the siliceous, moist rockeries along streams, there can be communities of *Alnus alnobetula* with *Salix silesiaca*, included in the alliance ***Alnion viridis*** Aichinger 1933. These shrub communities, along with the mesophilic grasslands grouped in alliances ***Calamagrostion villosae*** Pawl. 1928 and ***Potentillo ternatae-Nardion*** Simon 1958 and with the hygrophilic communities from the alliance ***Adenostylion alliariae*** Br.-Bl. 1925, complete the physiognomy of the subalpine belt of the Romanian Carpathians.

4. The alpine belt, extending between 2,200-2,543 m, is characterized by negative average annual temperatures (between -2°C and 0°C) and annual rainfall of 1,200–1,400 mm. The length of the growing season is, on average, 4 months. The alpine vegetation type is represented by the primary microthermic grasslands dominated by *Carex curvula, Juncus trifidus* and *Festuca supina* on acidic substrate (crystalline schists), grouped in the alliance ***Caricion curvulae*** Br.-Bl. 1925, and the oligothermic dwarf shrub communities grouped in the alliance ***Loiseleurio-Vaccinion*** Br.-Bl. in Br.-Bl. et Jenny 1926, while on calcareous substrates there are the primary basophilic grasslands dominated by *Elyna myosuroides, Sesleria bielzii, Festuca versicolor, F. amethystina, F. carpatica,* grouped in the alliances ***Oxytropido-Elynion*** Br.-Bl. 1949 and ***Festuco saxatilis-Seslerion bielzii*** (Pawl. & Walas 1948) Coldea 1984. Specific to the alpine belt are also the chionophilic, microthermic communities included in the alliance ***Salicion herbaceae*** Br.-Bl in Br.-Bl. et Jenny 1926 and the basophilic communities grouped in ***Salicion retusae*** Horv. 1949. Also, the saxicolous and rupicolous communities grouped in alliances ***Silenion lerchenfeldianae*** Simon 1957 and ***Veronicion baumgartenii*** Coldea 1991, complete the specificity of the alpine belt from the Southeastern Carpathians.

In the Eastern Carpathians branch, the alpine belt is limited to the highest peaks of the Rodna Mountains (Pietrosul Mare - 2,305 m, Rebra - 2,201 m, Puzdrele - 2,188 m, Gărgălău - 2,159 m, Ineu - 2,280 and Ineuț - 2,222 m). In the branch of the Southern Carpathians, the alpine belt is widely spread in all massifs with altitudes over 2,200 m (Bucegi, Făgăraş, Parâng, Retezat, Ţarcu, Godeanu Mountains), where alpine phytocoenoses form 200-300 m wide "bands". In the Western Carpathians (Apuseni Mountains) the alpine belt is missing.

An analysis of the floristic structure of the syntaxa employed for the characterization of the vegetation belts from the Southeastern Carpathians, compared to the structure of the syntaxa described from the Northwestern Carpathians (Kornaś & Medwecka-Kornaś 1967; Zarzycki 1991; Matuszkiewicz 2008), reveals that the dominant species for montane and subalpine associations are largely the same, the syntaxa described in the two montane regions differing only as regards the presence of local and regional Carpathian endemics. More pronounced syntaxonomic differences are evident in the composition of the woody and herbaceous plant communities in the hill and alpine belts of the Carpathians. In the Northwestern Carpathians the hill belt is dominated mainly by the associations *Tilio-*

Carpinetum and *Pino-Quercetum* (Kornas 1968; Zarzycki 1991). In the Southeastern Carpathians, along with the mesophilic associations of the alliance ***Lathyro-Carpinion,*** mesoxerophilic phytocoenoses of the alliances ***Quercion petraeae*** and ***Quercion frainetto*** are also present, hosting many Balkan thermophilic species. Also, in the southwestern part of the Southern Carpathians (Cerna and Domogled Mts.), relict communities of *Pinus nigra* ssp. *pallasiana,* on limestone, were described, grouped in the association *Genisto radiatae-Pinetum pallasianae* Resmeriță 1972. These mesoxerophilic syntaxa widen the structural differences between the hill belts of the two mountain regions.

Syntaxonomic differences also exist in the structure of the alpine belt. In the South-eastern Carpathians the representative communities for the alpine belt are mainly those dominated by *Carex curvula,* as in the Alps (Nikelfeld 1993). Such microthermic communities, grouped in the association *Primulo-Caricetum curvulae* Br.-Bl. 1926 em. Oberd. 1959 are often found in all mountain ranges with altitudes between 2,200-2,500 m, but are missing from the North-western Carpathians (Matuszkiewicz 2008).

Also specific for the alpine belt of the Carpathian Mountains are the communities dominated by *Juncus trifidus, Oreochloa disticha* and *Festuca supina,* grouped in a specific alliance, ***Juncion trifidi*** Krajina 1933 (Grabherr 1993; Koči 2007; Dubravcova & Jarolimek 2007). These communities are also widespread in the alpine belt of the South-eastern Carpathians, where they populate mountain ridges and peaks. Based on the microthermic communities dominated by *Oreochloa disticha* from Tatra Mountains (2,400-2,660 m), Pawlowski (1925) highlighted a subnival vegetation belt, that he characterized through the association *Oreochloetum distichae* (*subnivale*) Pawl. 1926. Although all the alpine species included in this association are also present in the association *Oreochloo-Juncetum trifidi,* described from the South-eastern Carpathians, Romanian geobotanists assigned such plant communities to the alpine belt, (Beldie 1967; Boșcaiu 1971). As early as 1934, Borza, referring to the Retezat Mountains, points out that: "*One cannot speak of a proper subnival belt ...*" (p. 12).

Conclusion

In the South-eastern Carpathians 4 vegetation belts are well characterized regarding physiognomy, syntaxonomy and ecology.

The hill belt (400-700 m), situated at the base of the mountain massifs, is distinguished by mesophilic syntaxa grouped in the alliance *Lathyro hallersteinii-Carpinion* and by meso-xerophilic syntaxa of the alliances *Quercion petraeae* and *Quercion frainetto*.

The montane belt (700-1,800 m) is characterized by the presence of nemoral forest associations dominated by *Fagus sylvatica*, grouped in the alliance *Symphyto cordati-Fagion* and of the boreal forests with *Picea abies* grouped in the alliances *Soldanello majori-Piceion* and *Chrysanthemo rotundifolii-Piceion.*

The subalpine belt (1,800-2,200 m) is identifiable physiognomically through the shrub communities of *Pinus mugo* and *Juniperus communis* ssp. *alpina*, adapted to the microthermic climate and to snow accumulation in winter. The associations dominated by these shrub species are grouped in the alliances *Pinion mugo* and *Bruckenthalio-Juniperion.*

The alpine belt (2,200-2,540 m) is characterized, physiognomically and ecologically, by grasslands and oligothermic dwarf shrubs grouped in the alliances *Caricion curvulae* and *Loiseleurio-Vaccinion.*

Acknowledgements

The authors are grateful to Dr. Tudor Ursu for the English translation of the original manuscript.

References

Baumgarten, J. Ch. 1816: Enumeratio stirpium Magno Transsilvaniae principatui, **1-2.** – Vindobanae.

Beldie, A. 1967: Flora şi vegetaţia munţilor Bucegi. – Bucureşti.

Borza, A. 1934: Studii fitosociologice în Munţii Retezatului. – Bul. Grăd. Bot. Muz. Bot. Univ. din Cluj, **14(1-2):** 1-84

— 1959: Flora şi vegetaţia Văii Sebeşului. – Bucureşti.

— 1960: Gheobotaniceskoe rainoirovanie Rumînskii Karpat i sosednih oblastei. – Pp. 44-67 in: Flora i fauna Karpat. – Moscva.

Boşcaiu, N. 1971: Flora şi vegetaţia munţilor Ţarcu, Godeanu şi Cernei. – Bucureşti.

Brândza, D. 1879-1883: Prodromul florei României. – Bucureşti.

Coldea, G. 1990: Munţii Rodnei. Studiu geobotanic. – Bucureşti.

— 1991: Prodrome des associations végétales des Carpates du sud-est (Carpates roumains). – Doc. Phytosociol. N.S. **XIII:** 317-539.

Cristea, V. 1993: Fitosociologie şi vegetaţia României. – Cluj-Napoca.

Doniţă, N. 1962: Elemente pentru interpretarea zonalităţii vegetaţiei din R.P.R. – Acta Bot. Horti Bucurestiensis, **1961-1962:** 919-935.

— 1965: Vegetationsstufen in den Karpaten Rumäniens. – Rev. Roum. Biol.-Botanique **10(60):** 455-467.

Drăgulescu, C. 1995: Flora şi vegetaţia din bazinul Văii Sadului. – Sibiu.

Dubravcova, Z. & Jarolimek, I. 2007: *Caricetea curvulae* Br.-Bl. 1948. – In: Kliment, J. & Valachović, M. (eds), Rastlinne spolocenstva Slovenska, **4.** Vysokohonska vegetacia. – Bratislava.

Ellenberg, H. 1996: Vegetation Mitteleuropas mit den Alpen, in ökologischer, dynamischer und historischer Sicht. – Stuttgart.

Georgescu, C. C. & Doniţă, N. 1965: La division floristic des Carpates de Roumanie. – I. Rev. Roum. Biol.-Botanique **10(5):** 357-369.

Grabherr, G. 1993: *Caricetea curvulae* Br.-Bl. 1948. – In: Grabherr, G. & Mucina, L. (eds), Die Pflanzengesellschaften Österreich, 2. Natürliche waldfreie Vegetation. – Jena-Stuttgart-New York.

Grecescu, D. 1898: Conspectul Florei României. – Bucureşti.

Hurdu, B. I., Puşcaş, M., Turtureanu, D., Niketić, M., Coldea, G. & Zimmermann, N. 2012: Patterns of plant endemism in the Romanian Carpathian (South-eastern Carpathians). – Contrib. Bot. **47:** 25-38.

Ivan, D. (ed.) 1993: Vegetation potentielle de la Roumanie. – Braun-Blanquetia **9:** 1-79.

Koči, M. 2007: Acidofilni al inské teávniky (*Juncetea trifidi*). – In Chytrý, M. (ed.), Vegetace České republiky **1.** Travina a keričkeva vegetace. – Praha.

Kornaś, J. 1968: Der Linden-Eichen-Heinbuchenwald (*Tilio-Carpinetum*) in den polnischen Karpaten. – Feddes Repert. **77:** 167-176.

— & Medwecka-Kornaś, A. 1967: Zespoty roślinne Gorców I. Naturalne i na wpól naturalne zespoty meleśne. – Fragm. Flor. Geobot. **13(2):** 167-316.
Martonne, E. de 1907: Recherches sur l'évolution morphologique des Alpes de la Transylvanie. – Paris.
Matuszkiewicz, W. 2008: Przewodnik do ozneczania zbiorowisk roślinnych Polski. – Warszawa.
Meusel, H. 1965: Die Gliederung Europas in Florenregionen und Florenprovinzen auf floristischer und pflanzengeographischer Grundlage. – Rev. Roum. Biol.-Botanique **10(1-2):** 99-107.
Mihăilescu, S. 2001: Flora şi vegetaţia masivului Piatra Craiului. – Bucureşti.
Mihăilescu, V. 1963: Carpații sud-estici de pe teritoriul R. P. Române. – București.
Muică, C. 1995: Munții Vâlcanului. Structura şi evoluția peisajului. – Bucureşti.
Nechita, N. 2003: Flora şi vegetaţia cormofitelor din masivul Hăşmaş, Cheile Bicazului şi lacul Roşu, Piatra Neamţ.
Nikelfeld, H. 1993: Pflanzengeographische Charakteristik Österreichs. – In: Mucina, L., Grabherr, G. & Ellmaner, T. (eds), Die Pflanzengesellschaften Österreich. I. Anthropogene Vegetation. – Jena.
Oprea, A. & Sîrbu, C. 2009: Munţii Stânişoarei (Carpaţii Orientali). Studiu fitosociologic. – Iaşi.
Ozenda, P. 1994: Végétation du Continent Européen Delachaux et Niestle. – Lausanne-Paris.
Pawlowski, B. 1925: Über die subnivale Vegetationsstufe im Tatragebirge. – Bull. Inst. Acad. Polon. Sci. Lett. et. SC. Math.-Nat., ser. B, Cracovie: 769-775.
Pax, F. 1898, 1909: Gründzuge der Pflanzenverbreitung in der Karpathen, 1-2**.** – Leipzig.
— 1919: Pflanzengeographie von Rumänien. – Nova Acta, Eop. **35.** – Halle.
Pignatti, S. 1980: Zur Probleme der Höhenstufen und Vegetationszonen. – Phytocoenologia **7:** 52-64.
Puşcaru-Soroceanu, E., Csűrös, Şt., Puşcaru, D. & Popova-Cucu, A. 1981: Die Vegetation der Wiesen und Weiden des Făgăraş-Gebirge in den Südkarpaten. – Phytocoenolgia **9(3):** 257-309.
Rivas-Martinez, S. 1988: La vegetación del piso alpino superior de los Pirineos. – Monogr. Inst. Piren. de Ecologia, Jaca **4:** 719-728.
Schur, F. 1866: Enumeratio plantarum Transsilvaniae. – Vindobonae.
Simonkai, L. 1886: Enumeratio florae Transsilvanicae vasculosae critica. – Budapesta.
Zarzycki, K. 1991: L'étagement de la végétation dans les Carpates du Nord. – Veröff. Geobot. Inst, ETH, Stiftung Rübel, Zürich **106:** 109-121.

Addresses of the authors:
Gheorghe Coldea[1] & Vasile Cristea[2]
[1]Institutul de Cercetări Biologice, str. Republicii nr. 48, RO - 400015, Cluj-Napoca, Romania. E-mail: icbcluj@gmail.com
[2]Universitatea Babeș-Bolyai, Departamentul de Taxonomie și Ecologie, RO - 400015, str. Republicii nr. 42, Cluj-Napoca, Romania.
E-mail: vasile.cristea@ubbcluj.ro