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COMPARATIVE ANALYSIS OF THE VASCULAR FLORAS OF THE MORAČA AND CIJEVNA CANYONS (MONTENEGRO)

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Abstract — The vascular floras of the canyons of the Morača and Cijevna Rivers in Southern Montenegro are analyzed. A great number of Mediterranean plants were observed in these canyons, clearly indicating that they belong to the Adriatic sub-Mediterranean floristic subregion. This is additionaly confirmed by the prevailing occurrence of Mediterranean hemicryptophytes, geophytes, and therophytes. The floristic differences observed between these two canyons are mostly caused by their different geographical positions, resulting in stronger Mediterranean influence in the Cijevna Canyon, but stronger continental impact in the Morača Canyon. Thus, the Cijevna Canyon has more Mediterranean and evergreen plant species.

Key words: Vascular flora, canyons, Morača River, Cijevna River, Montenegro, Mediterranean floristic region

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INTRODUCTION

Canyons and gorges in the southern and central part of the Balkan Peninsula are characterized by great floristic diversity, i.e., by species of different origin and distribution, as well as by numerous microhabitats favourable for the development of plants with various ecological requirements. They are also exceptionally interesting from the geobotanical point of view as refugia for both the arctic-Tertiary flora and the Tertiary orophytic flora during the Ice Age. Extensive botanical investigations since the middle of the last century have contributed to knowledge of the flora and vegetation in many canyons of the Dinaric (Illyrian) region in Bosnia and Herzegovina and Montenegro and the western Moesian floristic subregion in Serbia [(Bulić, 1989, 1994, 1998; Grebenščikov, 1950; Janković and Stevanović, 1981; Jovanović and Jovanović-Dunjić, 1986; Jovanović-Dunjić, 1953; Lakušić et al., (1996); Lakušić (1972); Lakušić and Redžić (1989); Mišić (1981); Pulević and Lakušić, (1983); Stefanović, 1979; Stevanović and Bulić (1992); Zlatković and Ranđelović (1993/94) etc.)].

Canyons and gorges are characteristic of the territory of Montenegro. In their southern parts, the canyons of the Morača and Cijevna Rivers are especially interesting for their floristic specificities. Along the narrow valleys of these rivers, which belong to the watershed of the Adriatic Sea, the influence of Mediterranean climate strongly affects the continental part of Montenegro. Given that high mountains (the Moračke Mountains i.e., the Prokletije and Žijovo Ranges) are present in the hinterland of the Morača and Cijevna Canyons, the question arises as to the extent to which these canyons are under Mediterranean influence, i.e., where Mediterranean and continental mountain climates meet, resulting in changes of their floristic-vegetation characteristics. To answer this question, floristic elements and life forms of plants of both canyons were analyzed, with special emphasis on the relationship between plant species with Mediterranean and Central European distribution, as well as between South European and Central European orophytes.

MATERIALS AND METHODS

Material for floristic analyses of the canyons studied was collected over many years of field survey. Herbarium plant specimens were stored in the herbarium of the Nature Protection Institute of Montenegro in Podgorica and in that of the Institute of Botany and Botanical Garden, Faculty of Biology, University of Belgrade (BEOU). Numerous literature data were also used in the analysis (Beck and Szyszylowicz, 1888; Hayek, 1918, 1923; Rohlena, 1942; Pulević and Lakušić, 1983; Bulić, 1998; Vuksanović, 2003; etc.).

The type of floristic element and range were determined for taxa with the rank of species and sub-species (Meusel et al., 1965; Stevanović, 1992a). Chorological analysis identified the distribution type of each taxon. Taxa belonging to the following groups were recorded: cosmopolitan, Holarctic, Eurasian, boreal, Central European, Mediterranean–sub-Mediterranean, Mediterranean–sub-Mediterranean-Pontic, South European mountain, and Central European mountain.

The life forms of plant species were determined according to the classification given by Raunkiaer (1934), supplemented and elaborated according to Mueller-Dombois and Ellenberg (1974) and Stevanović (1992). The degree of floristic similarity between the examined canyons was established using the Jaccard (ISj) and Sorensen (ISs) similarity indices.

The following abbreviations are used for distribution types in Tables 3 and 4 and Figs. 1 and 2: A-A - arctic-alpine, BOR - boreal, CEM – Central European mountain, SEM – South European mountain, CEU – Central European, MED-SUBMED - Mediterranean–sub-Mediterranean, MED-PONT - Mediterranean–sub-Mediterranean-Pontic, EAS - Eurasian, HOL - Holarctic, and COSM – cosmopolitan, including adventive plants. The following abbreviations are used for life forms: P – phanerophytes, P scap – trees, P caesp – shrubs; Ch – chamaephytes; H – hemicryptophytes; G – geophytes; T – therophytes.

RESULTS AND DISCUSSION

Altogether, 838 lower taxa (species and subspecies) of vascular plants were recorded in the canyons of the Morača, its tributaries Mala Rijeka and Mrtvica, and the Cijevna. Of this total number of plants, 589 taxa were found in the Morača Canyon and canyons of its tributaries, and 640 in the Cijevna Canyon. It is interesting that 416 taxa are common to the canyons of both rivers. Floristic similarity between the Morača and Cijevna Canyons is comparatively great, being 66.3% (ISs) or 49.6% (ISj), which might indicate their belonging to the same or very similar phytochoria.

In both canyons the most abundant family is *Compositae*, which is the family richest in both species and genera not only in the Balkans and the Mediterranean region, but also throughout the whole Holarctic realm. In addition, numerous representatives of the families *Labiatae, Orchidaceae, Papilonaceae, Boraginaceae*, and *Liliaceae* were also recorded, being far more common in the Mediterranean region than in the continental region (Table 1). In the total taxonomic spectrum of floras of the canyons surveyed, species of the family *Caryophyllaceae* constitute a comparatively small share, despite its being the second largest family in the Balkan flora after the family *Compositae* (Turrill, 1927).

In both canyons, the genus *Trifolium* stood out by virtue of the large number of species with Mediterranean distribution. In addition, numerous species of the genera *Campanula, Orchis, Euphorbia, Geranium, Galium,* and *Silene* were recorded, mostly ones with Mediterranean distribution and to a considerably lesser extent species with Central European and Eurasian distribution (Table 2). The presence of Mediterranean genera, in only one canyon (*Spartium, Arbutus*, *Romulea*, *Hermodactylus*, and *Rhagadiolus* in the Cijevna Canyon and the genus *Cionura* in the Morača Canyon) or in both canyons (*Phyllirea*, *Securinoga*, *Ophrys*, *Bituminaria*, *Paliurus*, *Petteria, Pistacia,* and *Osyris*) shows that the Mediterranean flora is well presented predominant in both canyons, particularly in the Cijevna Canyon.

Table 1. Families with the greatest number of taxa having species or subspecies rank presented in descending order. Familes with less than 10 taxa are not listed. The percentage represents the contribution of each family to the total flora recorded in the given canyon.

Canyon	Cijevna		Morača	
Family	No.	%	No.	%
Compositae	69	8.2	70	8.4
Labiatae	51	6.1	50	6.0
Papilionaceae	34	4.1	48	5.7
Gramineae	52	6.2	39	4.7
Cruciatae	34	4.1	28	3.3
Umbelliferae	26	3.1	25	3.0
Orchidaceae	18	2.1	22	2.6
Caryophyllaceae	32	3.8	22	2.6
Liliaceae	26	3.1	20	2.4
Boraginaceae	20	2.4	19	2.3
Scrophulariaceae	20	2.4	17	2.0
Rosaceae	15	1.8	17	2.0
Rubicaeae	12	1.4	14	1.7
Ranunculaceae	17	2.0	13	1.6
Campanulaceae	10	1.2	13	1.6
Euphorbiaceae	11	1.3	10	1.2

Table 2. Genera with the greatest number of taxa having species or subspecies rank presented in descending order. Genera with less than six taxa are not listed. The percentage represents the contribution of each genus to the total flora recorded in the given canyon.

Canyon	Cijevna		Morača	
Genus	No.	%	No.	%
Trifolium	14	1.7	11	1.3
Campanula	7	0.8	10	1.2
Orchis	6	0.7	9	1.1
Euphorbia	8	1.0	7	0.8
Geranium	7	0.8	6	0.7
Galium	5	0.6	8	1.0
Silene	7	0.8	5	0.6
Hieracium	8	1.0	5	0.6
Sedum	5	0.6	7	0.8
Centaurea	6	0.7	5	0.6
Lathyrus	7	0.8	4	0.5
Ranunculus	8	1.0	3	0.4
Allium	5	0.6	5	0.6
Quercus	6	0.7	4	0.5
Teucrium	5	0.6	5	0.6
Plantago	5	0.6	5	0.6
Carex	7	0.8	2	0.2
Vicia	4	0.5	5	0.6
Veronica	5	0.6	4	0.5
Lamium	5	0.6	4	0.5
Stachys	4	0.5	5	0.6
Chenopodium	5	0.6	3	0.4
Asperula	5	0.6	4	0.5
Cardamine	5	0.6	3	0.4
Potentilla	3	0.4	5	0.6
Saxifraga	3	0.4	5	0.6
Acer	2	0.2	5	0.6
Ornithogalum	4	0.5	3	0.4
Medicago	4	0.5	3	0.4
Ophrys	5	0.6	2	0.2
Poa	4	0.5	3	0.4
Bromus	4	0.5	3	0.4
Bupleurum	4	0.5	2	0.2
Festuca	3	0.4	3	0.4

The most common life forms in both canyons are hemicryptophytes, followed in descending order by therophytes (annuals), geophytes (bulbous, corm, and rhizome geophytes), and chamaephytes or woody or semi-woody dwarf shrubs (Table 3, Fig. 1). A special place in the spectrum of life forms of both canyons is occupied by trees and shrubs, i.e., scapose and caespitose phanerophytes. To be specific, the woody species *Quercus ilex* (Cijevna), *Carpinus orientalis* (Cijevna, Morača), *Ostrya carpinifolia* (Cijevna, Morača), *Quercus trojana* (Cijevna, Morača), *Q. pubescens* (Cijevna, Morača), *Celtis australis* (Cijevna, Morača), *Phyllirea latifolia* (Cijevna, Morača), *Petteria ramentacea* (Cijevna, Morača), and *Arbutus unedo* (Cijevna) are dominant pioneers or sub-dominant pioneers of forest and shrub vegetation in these canyons. However, the Cijevna Canyon is inhabited by the evergreen Mediterranean holm-oak (*Quercus ilex*), which was not recorded in the Morača Canyon. The presence of this oak and the evergreen species *Arbutus unedo, Lonicera etrusca, Spartium junceum, Phyllirea latifolia*, *Cistus incanus,* and *Osyris alba* is the decisive factor leading us to consider the Cijevna Canyon as an enclave of evergreen sclerophyllous Mediterranean vegetation. Owing to its northeast-southwest orientation, the Cijevna Canyon is to some extent sheltered from direct continental climate impacts. The phytogeographic

Table 3. Number of taxa belonging to main life form and distribution types recorded in the Cijevna and Morača Canyons.

Canyon	CIJEVNA							MORAČA						
Life forms Distribution types	P scap	P caesp	Ch	H	G	T	**Σ**	P scap	P caesp	Ch	H	G	T	**Σ**
A-A	0	0	2	0	0	0	**2**	0	0	2	0	0	0	**2**
BOR	0	0	0	1	0	1	**2**	0	0	0	0	0	0	**0**
CEM	0	4	0	10	0	0	**14**	0	2	6	14	0	0	**22**
SEM	0	0	19	18	4	2	**43**	0	0	18	13	5	1	**37**
CEU	9	4	5	51	15	16	**100**	13	7	5	65	20	8	**118**
MED-SUBMED	19	16	29	57	45	98	**264**	10	11	29	50	35	63	**198**
MED-PONT	0	0	8	36	12	22	**78**	1	1	9	38	11	15	**75**
EAS	0	0	3	56	4	32	**95**	0	0	2	59	8	19	**88**
HOL	0	0	0	8	0	3	**11**	0	0	0	11	0	4	**15**
COSM	0	0	0	17	0	28	**45**	0	0	0	16	0	19	**35**
Σ	**28**	**24**	**66**	**254**	**80**	**202**	**654**	**24**	**21**	**71**	**266**	**79**	**129**	**590**

Table 4A. Number of endemic taxa belonging to main life form and distribution types recorded in the Cijevna and Morača Canyons.

Canyon	CIJEVNA					MORAČA				
Distribution types Life forms	CEM	SEM	CEU	MED	**Σ**	CEM	SEM	CEU	MED	Σ
P	0	0	0	3	**3**	0	0	1	1	**2**
Ch	0	8	0	9	**17**	0	7	0	7	**14**
H	2	9	0	8	**19**	2	7	0	9	**18**
G	0	2	0	3	**5**	0	2	0	3	**5**
T	0	1	0	4	**5**	0	0	0	4	**4**
Σ	**2**	**20**	**0**	**27**	**49**	**2**	**16**	**1**	**24**	**43**

Table 4B. Number of subendemic taxa belonging to main life form and distribution types recorded in the Cijevna and Morača Canyons.

Canyon	CIJEVNA					MORAČA				
Distribution types Life forms	CEM	SEM	CEU	MED	**Σ**	CEM	SEM	CEU	MED	Σ
P	0	0	0	3	**3**	0	0	1	1	**2**
Ch	0	8	0	9	**17**	0	7	0	7	**14**
H	2	9	0	8	**19**	2	7	0	9	**18**
G	0	2	0	3	**5**	0	2	0	3	**5**
T	0	1	0	4	**5**	0	0	0	4	**4**
Σ	**2**	**20**	**0**	**27**	**49**	**2**	**16**	**1**	**24**	**43**

and phytocenological significance of the presence of *Q. ilex* and other Mediterrannean evergreen trees and shrubs in the Cijevna Canyon has been considered in detail by Pulević and Lakušić (1983). On the other hand, the absence of autochthonous evergreen sclerophyllous Mediterranean trees in the Morača Canyon is a result of this canyon's north-south orientation and the direct and strong impact of cold winter winds from the mountain massifs in the hinterland.

Common in both canyons are Mediterranean–sub-Mediterranean woody and semiwoody shrub chamaephytes such as *Salvia officinalis*, *Satureja*

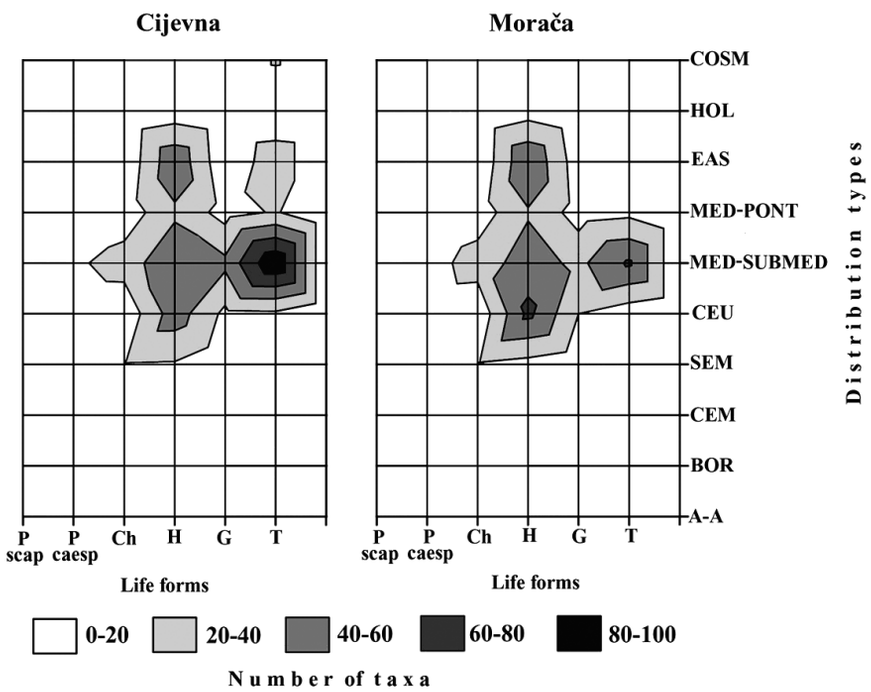

Fig. 1. Relationship between main distribution types and life forms of the total flora recorded in the Cijevna and Morača Canyons (according to data presented in Table 3).

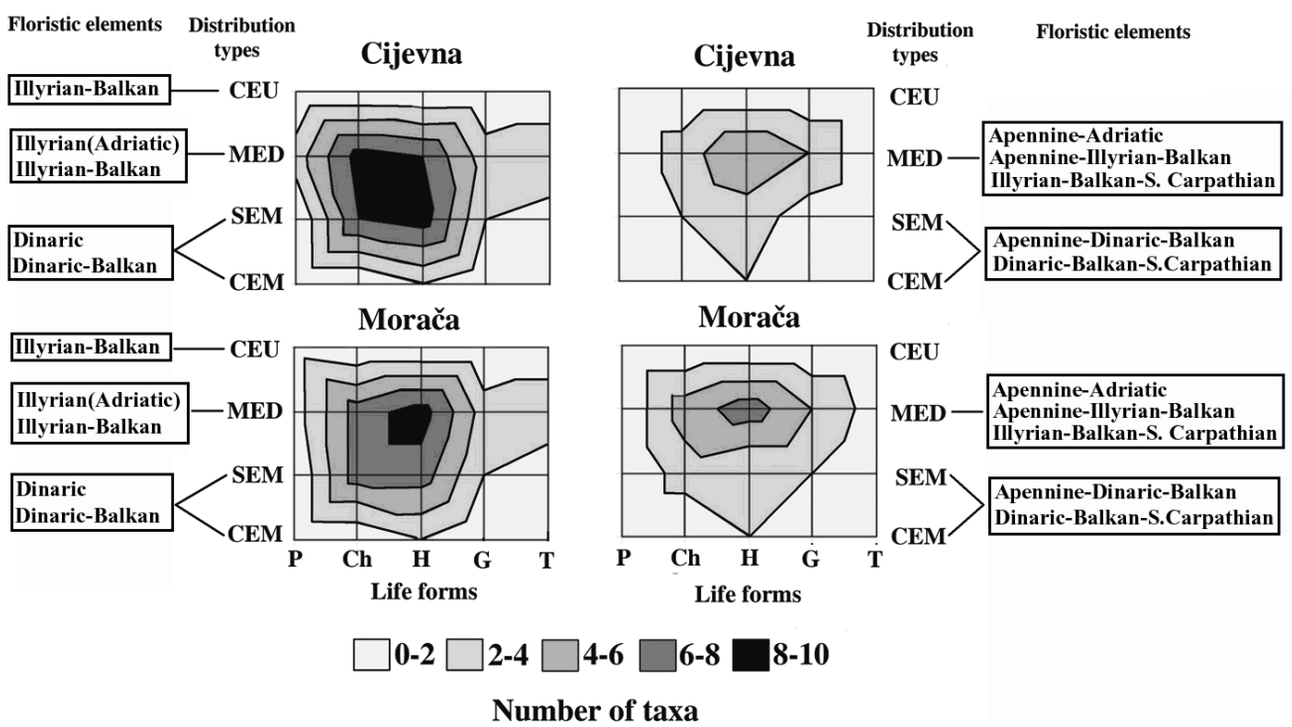

Fig. 2. Relationship between main distribution types and life forms of the endemic and subendemic flora recorded in the Cijevna and Morača Canyons (according to data presented in Tables 4A and 4B).

montana, *Euphorbia spinosa, Cephalaria leucantha*, *Helichrysum italicum*, etc., which are dominant plants of degraded calcareous stony grounds. Both canyons are characterized by large degraded areas and/or burned areas once occupied by natural forest and shrub ecosystems.

The considerable presence, of therophytes or annuals in both canyons (30.9% in the Cijevna Canyon, 18.7% in the Morača Canyon) indicates their belonging to the Mediterranean floristic region on the one hand and testifies to the extent of human impact on the other hand. To be specific, in addition to native Mediterranean therophytes, various ruderal and/or segetal synanthropic species with the wider Holarctic and/or cosmopolitan type of distribution are common. Therophytes with Mediterranean distribution are present in much higher numbers in the Cijevna Canyon than in that of Morača.

In addition, the relatively abundant geophytes (12.2% in the Cijevna Canyon and 13.4% in the Morača Canyon) are mainly ones with Mediterranean–sub-Mediterranean or Mediterranean-Pontic ranges and to a lesser degree species with the Central European type of distribution.

Analysis of distribution types revealed dominance of Mediterranean–sub-Mediterranean species and the presence of a considerable number of Mediterranean-Pontic species, which clearly points to the general Mediterranean, i.e., xerophilous, character of the flora inhabiting the canyons studied. To be specific, 52.3% of plants of the Cijevna Canyon and 43% of plants of the Morača Canyon belong to these distribution types. Plants with the Central European distribution type are less present and restricted to regions of higher altitudes in the canyons, or to sheltered and more humid sites. The number of such plant species is higher in the Morača Canyon (20% of the total flora of this canyon) than in the Cijevna Canyon (15.3%). Eurasian floristic elements are relatively numerous, represented by 14.3% of species in the flora of the Cijevna canyon and 14.9% of species in that of the Morača canyon. Eurasian species and a smaller number of Holarctic and cosmopolitan species are indicators of secondary vegetation and human impact on the autochthonous vegetation in both canyons.

A phytogeographically significant group of plants is composed of South European mountain plants, which are most frequently endemic and relict species. They are somewhat more abundant in the Cijevna Canyon (6.57%) than in the Morača Canyon (6.27%). On the other hand, Central European orophytes, also including two arctic-alpine species aggregates of the species *Saxifraga paniculata* and *Arabis alpina*), account for only about 0.3 % of the total flora in each of the two canyons.

Generally speaking, the Cijevna Canyon is characterized by a larger number of Mediterranean–sub-Mediterranean species of all the mentioned life forms (40.4%) in comparison with the Morača Canyon (33.6%).

A considerable number of endemic species were found in the canyons (49 species or 7.5% of the total flora found in the Cijevna Canyon and 43 species or 7.29% of the total flora recorded in the Morača Canyon). Endemic taxa are mainly Dinaric and Dinaric-Balkan floristic elements with the South-European mountain type of distribution, as well as Illyrian (Adriatic) and Illyrian-Balkan elements with the Mediterranean type of distribution (Table 4, Fig. 3). The majority of endemic taxa are hemicryptophytes and chamaephytes, and only four species are phanerophytes (*Acer intermedium*, *Petteria ramentacea, Rhamnus orbiculatus*, and *Rh. intermedius*). The presence of a large number of endemo-relict species (*Ramonda serbica, Teucrium arduinii, Seseli globiferum, Moltkia petraea, Stachelina uniflosculosa, Viola kosaninii, Asperula scutellaris*, and the like) is conspicuous.

In addition to endemic species, a considerable number of subendemic taxa were recorded in both canyons. These are mostly species whose ranges are characterized by amphi–Adriatic disjunction, such as Apennine-Illyrian species (*Portenschlagiella ramosissima, Genista dalmatica, Campanula pyramidalis, Onosma echioides, Asyneuma limonifolium, Scabiosa crenata, Anemone hortensis, A. apennina, etc.*) or Apennine-Illyrian-Balkan plants (Table 4, Fig. 3).

The presence of endemic and subendemic taxa, particularly ones of a relict character, indicates that the canyons studied are also significant refugia for ancient floras of the Mediterranean or sub-Mediterranean type.

CONCLUSION

The canyons of the Morača and Cijevna Rivers abound in Mediterranean–sub-Mediterranean species of various life forms, which outnumber plants with Central European, South European mountain, and Eurasian distribution. Such a relationship between distribution types present clearly indicates that phytogeographically both canyons belong to the Mediterranean–sub-Mediterranean floristic region, or more precisely to the Adriatic sub-Mediterannean floristic subregion, which is characterized by vegetation of the *Ostryo-Carpinion adriaticum* alliance.

However, there are clear floristic and vegetation differences between these two canyons. Thus, the Cijevna Canyon is characterized by the presence of numerous sclerophyllous evergreen trees and shrubs (*Quercus ilex*, *Arbutus unedo, Phyllirea latifolia,* etc.), which defines it as an enclave and refugium for Mediterranean vegetation of the *Orno-Quercion ilicis* alliance in the hinterland of the southern part of the Adriatic Coast. On the other hand, the Morača Canyon is characterized by a more humid and cooler climate and by the presence of a larger number of Central European plant species, given that it is heavily affected by mountain climate, particularly in the winter period.

The floristic differences observed between these two mediterranean–sub-Mediteranean canyons are mostly caused by their different orientation – north-east-southwest in the case of the Cijevna Canyon and north-south in that of the Morača Canyon. Accordingly, they are exposed to stronger or weaker Mediterranean and continental impacts. As a consequence, spreading of Mediterranean species into the Cijevna Canyon in unhindered, while spreading of such forms and Central European species into the Morača Canyon is limited or unhindered, respectively. The Morača Canyon is typically sub-Mediteranean up to its narrowest part (Platije), after which Central European floristic elements start to prevail. Strong Mediterranean influence on both canyons from inter-glaciation (when climate change occurred) until the present day made them important refugia for the Tertiary flora of Mediterranean origin, to which a number of endemo-relict and relict Mediterranean species belong (*Ramonda serbica, Moltkia petraea, Stachelina uniflosculosa, Portenschlagiella ramosissima, Teucrium arduinii, Stachys menthifolia, Viola kosaninii, Daphne laureola, Ilex aquifolium, Geranium dalmaticum*, etc.). Thus, it may be assumed that orophytes from the surrounding mountains are present in small numbers because these plants could not, in canyons with Mediterranean climate, find refuge during the Ice Age, i.e., they could not find adequate habitats in which to remain until the present day.

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УПОРЕДНА АНАЛИЗА ВАСКУЛАРНЕ ФЛОРЕ КАЊОНА РЕКА ЦИЈЕВНЕ И МОРАЧЕ (ЦРНА ГОРА)

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Клисуре и кањони западног и централног дела Балканског полуострва представљају необично интересантне и значајне објекте за геоботаничка истраживања, пре свега као рефугијуми арктотерцијарне флоре различитог порекла. У раду су обављене хоролошке и еколошке анализе васкуларне флоре два кањона река јадранског слива, Мораче и Цијевне, у јужном делу Црне Горе. Велики број врста медитеранског ареал типа свих животних форми биљака одређује фитогеографску припадност оба кањона Јадранском субмедитеранском региону. Установљене флористичке разлике условљене су, пре свега, правцем пружања речних долина ових кањона и њиховом већом или мањом изложеношћу топлим медитеранским или хладним планинским утицајима. Стога се кањон Цијевне, који се пружа у правцу североисток-југозапад истиче као рефугијум термофилне медитеранске флоре. Насупрот томе, кањон Мораче чији је правац пружања север-југ изложен је директним утицајима планинске климе, посебно током зиме, те је присуство средњеевропских елемената флоре изражено, док је дистрибуција медитеранских елемента ограничена. Међутим, оба кањона су значајни центри ендемичне и субендемичне флоре динарског, динарско-балканског и амфијадранског распрострањења.