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Analysis of the Central European and Mediterranean orophytic element on the mountains of the W. and Central Balkan Peninsula, with special reference to endemics

Abstract

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The distribution of 1350 vascular orophytes of the W. & Central Balkans was analysed. Each species is attributed to one of the three basic chorological groups (Eurasian, Central S. European to W. Asian, and Central S. European) and eight subgroups, on the basis of its distribution or, in the case of endemics, of the distribution of its closest relative. The analysis of the total orophytic flora (excluding the arctic-alpine and boreal species) results in the establishment of the boundary between alpine-high-nordic and oromediterranean floristic regions, and of transitional zones between them, in the mountains of the W. & Central Balkans.

Introduction

Various floristic influences meet and overlap on the mountains of the Balkan Peninsula, especially in the central ranges. The genesis of the orophytic flora of this part of the Balkans, both before and during the Ice Ages, was most strongly influenced, floristically, from the direction of the Alps, the Carpathians, the mountains of Greece and Asia Minor. Naturally, these influences were not unidirectional. The orophytic flora of the Balkans, a region known as an autonomous centre of origin for many high-mountain plants, contributed in turn to enriching the flora of the surrounding massifs.

The great role of the W. & Central Balkans as a meeting region of floristic elements of varying origin and age was first pointed out by Košanin (1924) who noticed that in the mountains of Macedonia and Albania floristic elements occur that date back to Tertiary and Pleistocene times. His conclusions were subsequently supported by Stojanov (1930) and Horvat (1952).

Due to the composite nature of their floras, which include alpine (Central European and Central S. European mountains), arctic-alpine, boreal, and oromediterranean elements as well as a number of endemic taxa – related to orophytes of Central and S.

Europe, Asia Minor, and theCaucasus – the mountains of the W. and Central Balkans in Yugoslavia and W. Bulgaria were assigned by different authors to different floristic chorions on the basis of partial analysis of their flora and vegetation, altitudinal vegetation zonation, presence and florogenetic position of endemics, etc., as follows:

- to the alpine-high-nordic floristic region, by Horvat (1960), Horvatić (1967) and Lakušić (1968).
- to a separate floristic province of the oromediterranean floristic region, by Trinajstić (1985).

Our aim was to elucidate this complex phytogeographical problem as objectively as possible, taking into consideration the numerous accumulated data on species distribution in the mountains of the Central Balkans. These floristic data provided the basis for an extensive statistical analysis, both of the total orophytic flora of this region and of the flora of its individual mountain massifs, or "high-mountain islands". In the present paper, we endeavour to assess, by analysing the orophytic flora, the chorological appurtenance of the mountains of the Central Balkans in general, and of each mountain or mountain group in particular.

Principles of chorological classification and data analysis

Our analysis is based on the mountain species occurring at altitudes above 1500 m. The species (typical high-mountain plants) are characterized by the following altitudinal range categories: *col* (hill zone)-*salp* (subalpine), *mont* (montane)-*salp* (subalpine), *col-alp* (alpine), *mont-alp* and *salp-alp*. A certain number of species with an altitudinal range of *plan* (lowland), *col* or *r. mont* (rarely montane) to *r. salp* (rarely subalpine), not being typical high-mountain plants, were omitted from the analysis.

Data on the distribution of species in certain mountains or mountain groups were derived from the basic Floras, from more than 600 relevant papers, from the holdings of the herbaria BEOU and BEO, as well as from notes relating to our own field work performed over the years.

Due to the large number of the mountains, and taking into account their height, geological constitution, geographical position, vegetation zonation, timberline altitude, floristic similarity, and degree of floristic investigation, the individual mountains were classified in 25 groups within three major mountain systems (Fig. 1), as follows:

Dinaric mountain system (Dinaric Alps). – 1. Velebit, Kapela and Plješevica mountains (VEL). 2. Dinara, Klekovača, Osječenica, Cincar and Šator mountains (DIN). 3. Mt Biokovo (BIO). 4. Orjen, Lovčen and Rumija mountains (ORJ). 5. Vranica, Vlašić and Raduša mountains (VRA). 6. Prenj, Cvrstnica, Čabulja and Zeč mountains (PRE). 7. Bjelašnica, Treskavica, Romanija and Igman mountains (BJE). 8. Durmitor, Sinjavina, Maglić, Bioč, Zelengora, Volujak, Vojnik and Lola mountains (DUR). 9. Bjelašica, Komovi, Visitor and Prokletije mountains (BER). 10. Golija, Tara, Zlatar and Zlatibor mountains (TAR). All these mountains are located in the former Yugoslavia, except Prokletije which is a border massif with Albania.

Scardo-Pindic mountain system. – 1. Pastrik, Koritnik, Korab (border mountains with Albania), Šar planina and Bistra mountains, in the Former Yugoslav Republic Macedonia or FYRM (SCA). 2. Jakupica, Karadžica, Pepeljak, Kozjak, and Drenova mountains, in the FYRM (JAK). 3. Stogovo, Jablanica (incl. Maje Shebenikut in E. Central Albania) and Galičica (incl. Mt Tomoros in E. Central Albania) mountains, in the FYRM (GAL). 4. Pelister (Varnous), Kajmakčalan and Nidže (Voras), and Kožuf (Tzena) mountains, on the border between the FYRM and Greece (VOR). 5. Mountains of N. Pindhos, in Greece (PIN). 6. Thessalian Olympus and Pieria mountains, in Greece (OLY); the two latter dealt with on the basis of data from Strid (1986) and Strid & Tan (1991).

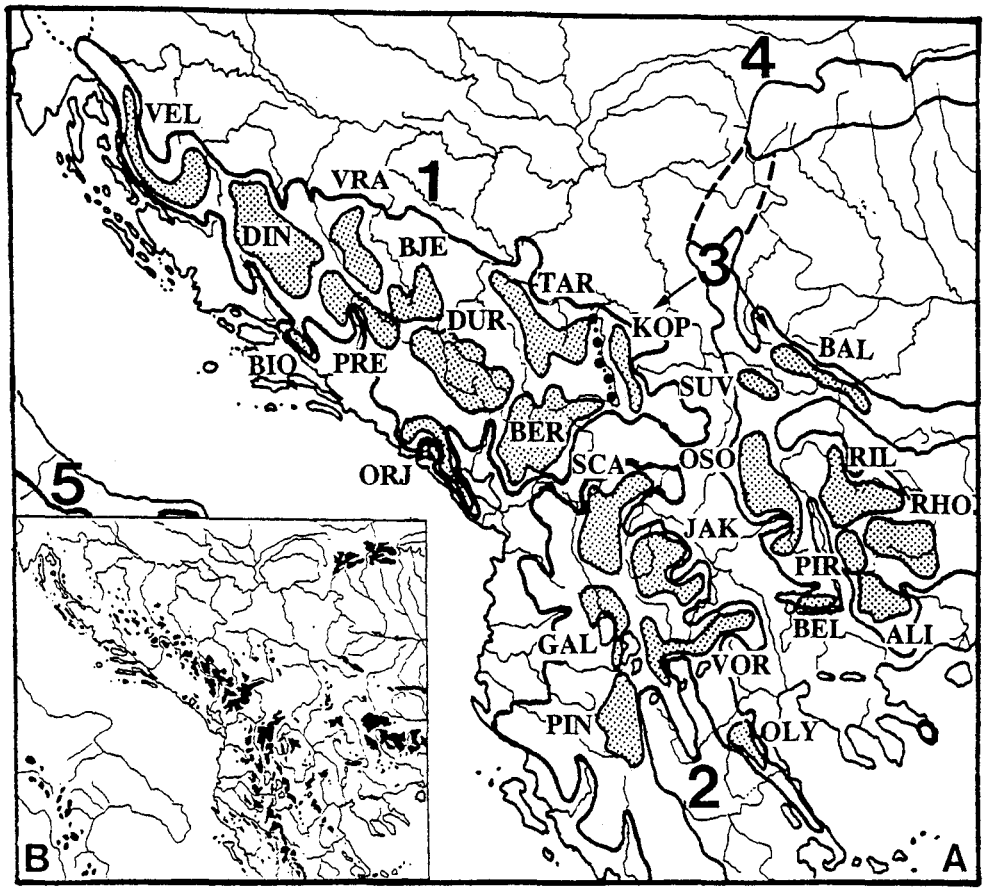

Fig. 1. The geographical position of 25 mountain groups within the major mountain systems of the W. & Central Balkan Peninsula: 1. Dinaric mountains; 2. Scardo-Pindic mountains; 3. Balkan-Rhodope mountains; Carpathians (4) and Apennines (5) are hinted at. The contour lines encircling the shaded massifs (lettering as explained in the text) denotes an altitude of c. 1000-1200 m. On the inset (B), high-mountain islands above 1500 m of altitude appear in black.

Balkan-Rhodope mountain system. – 1. Kopaonik, Željin, and Stolovi mountains, in Central Serbia (KOP). 2. Mt Suva planina, in N.E. & E. Serbia (SUV). 3. W. Stara planina, in E. Serbia and W. Bulgaria (BAL). 4. Mt Osogovske planina, in the E. FYRM and W. Bulgaria, and Mt Plačkovica in FYRM (OSO). 5. Vitoša and Rila mountains, in Bulgaria (RIL). 6. Mt Pirin, in Bulgaria (PIR). 7. Mt Alibotuš (Slavjanka), in S.W. Bulgaria and N.E. Greece, and Mt Falakron, in N.E. Greece (ALI). 8. Mt Belašica (Belles), in the S.E. FYRM, S.W. Bulgaria and N.E. Greece (BEL). 9. W. Rhodope mountains, in S.W. Bulgaria (RHO).

The appurtenance of each species to a corresponding floristic element was determined according to the classification of Meusel & al. (1965). Taken widely, the orophytes growing on the Balkan Peninsula belong to a large chorological "family" of Eurasian mountain plants, within which three major types of distribution can be distinguished:

- *Eurasian* (EA), comprising species extending from the Pyrenees to Altai and the Himalayas;
- *Central S. European to W. Asian* (CSE-WA), comprising species ranging from the Pyrenees to the mountains of Asia Minor, the Caucasus and Iran;
- *Central S. European* (CSE), comprising species ranging from the Pyrenees to the Balkan Peninsula.

The majority of the Balkan orophytic flora belongs to the CSE-WA and CSE groups. Given that species distribution ranges vary widely, not only in west-east but also in north-south extension, these two groups taken together can also be subdivided differently, into the following two main groups and eight subgroups:

Mostly Central European and Central European to W. Asian (CE/CE-WA; temperate or temperate-submeridional to prevailingly temperate floristic zone, according to Meusel & al 1965):

- *Central European* (CE), comprising species extending from the northern part of the Iberian Peninsula across the Alps, Apennines, Sudetes, Tatra and Carpathians to the mountains of the W. and Central Balkans;
- *Central European to W. Asian* (CE-WA), comprising species growing on the Central European mountains but extending to N. Anatolia and the Caucasus in the east;
- *Central (S.) European* (C(S)E), comprising species growing mostly on the mountains of Central Europe, spreading sporadically towards high mountains of the Mediterranean hinterland of Europe;
- *Central (S.)European to W. Asian* (C(S)E-WA), comprising species found mainly on the Central European and N. Anatolian mountains, but sporadically also on the those of the Mediterranean hinterland of Europe and Asia Minor.

Mostly S. European and S. European to W. Asian (SE/SE-WA; meridional-submeridional and submeridional-temperate, mostly submeridional floristic zone, according to Meusel & al. 1965):

- *S. European* (SE), or European oromediterranean species;
- *S. European to W. Asian* (SE-WA), oromediterranean species in the wide sense;

- *(Central) S. European* ((C)SE), comprising species found mainly on the mountains of S. Europe but sporadically spreading to Central European mountains;
- *(Central) S. European to W. Asian* ((C)SE-WA), comprising species current on the mountains of S. Europe and Asia Minor.

For the purpose of the present analysis, endemics are not referred to as a separate category of floristic elements (e.g. illyrian, scardo-pindic, W. moesian, illyrian-scardo-pindic, scardo-pindic-moesian, etc.), but are considered from a phylogenetical point of view and, on the basis of the distribution of their closest relatives, are assigned to the same categories as non-endemic taxa. They were thus included in the analysis of the total orophytic flora. In addition, the relatives themselves, which may or may not be orophytes, are treated as belonging to their own floristic elements: Centeral Asian (CA), arctic-alpine (AA), boreal-subalpine (Bor), Eurasian (EAs), Central European (CEu), Pontic (Pon), and mediterranean-submediterranean (Med) and as such they were analysed separately. Boreal and arctic-alpine elements were not included into the overall analysis.

The analysis of main chorological types and groups (EA, CSE, and CSE-WA; CE, CE-WA, C(S)E, C(S)E-WA, SE, SE-WA, (C)SE and (C)SE-WA; including the corresponding relatives of endemics) shows only the main distributional characteristics. For an accurate delimitation of the alpine-high-nordic and oromediterranean floristic regions in the mountains of the W. and Central Balkans, the ratio between "prevailingly temperate" or "alpine" orophytes (ALP) and "prevailingly submeridional" or "oromediterranean" orophytes (ORM) is essential. For calculating the ALP/ORM ratio, the chorological types of the CE/CE-WA group (CE, CE-WA, C(S)E and C(S)E-WA) were included into ALP, those of the SE/SE-WA group (SE, SE-WA, (C)SE, and (C)SE-WA) into ORM. In addition, Balkan endemics were similarly assigned on the basis of the chorology of their closest relatives, with CA, AA, Bor, CEu, EAs, and Pon being included in ALP, but Med in ORM.

For the purpose of determining the boundary between the alpine-high-nordic and oromediterranean floristic regions in general, the mean ALP/ORM ratio of all mountain systems was taken as threshold value. An ALP/ORM ratio above average indicates a flora of alpine type, a ratio below average, a flora of oromediterranean type.

This is, however, a relatively crude dinstinction. It was thought desirable to define transitional zones, particularly in view of the fact that the orophytic flora of the W. and Central Balkans is markedly heterogeneous.

The threshold ALP/ORM value accepted here as delimiting the alpine-high-nordic and oromediterranean floristic regions, taken in the strict sense, from their respective transitional zones is derived from the mean ALP/ORM ratio for the whole region by adding (or subtracting) the mean positive (or negative) divergence of the ALP/ORM ratios of the corresponding individual mountain groups. In other words, the average ALP/ORM value of all alpine mountain groups (in the wide sense) and that of all mediterranen mountain groups (in the wide sense) delimits the respective transitional zone from the alpine-high-nordic and the oromediterranean floristic regions proper.

Tab. 1. Numerical analysis of alpine and oromediterranean species of the total orophytic flora (including relatives of endemic orophytes) for 25 mountain groups and 3 major mountain systems in the W. & Central Balkans. Abbreviations are explained in the text.

	Floristic zone:			prevailingly temperate								prevailingly submeridional					
	Type of flora:			Alpine								Oromediterranean					
	Σ species		ALP/	CE + CE-WA		C(S)E + C(S)E-WA		CA + AA + BOR		EA + PON + CE		SE + SE-WA		(C)SE + (C)SE-WA		MED	
Massifs	N°	%	ORM	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%
All	**1350**	**100.0**	**1.163**	**369**	**27.3**	**265**	**19.6**	**24**	**1.8**	**68**	**5.0**	**327**	**24.2**	**279**	**20.7**	**18**	**1.3**
VEL	258	19.1	1.966	109	42.2	57	22.1	3	1.2	2	0.8	12	4.7	74	28.7	1	0.4
BIO	134	9.9	1.062	21	15.7	45	33.6	2	1.5	1	0.7	18	13.4	46	34.3	1	0.7
ORJ	243	18.0	1.025	47	19.3	68	28.0	2	0.8	6	2.5	44	18.1	74	30.5	2	0.8
DIN	273	20.2	1.676	105	38.5	60	22.0	2	0.7	4	1.5	13	4.8	89	32.6	0	0.0
PRE	373	27.6	1.376	119	31.9	84	22.5	5	1.3	8	2.1	32	8.6	123	33.0	2	0.5
BER	**542**	40.1	1.475	**185**	34.1	**116**	21.4	**7**	1.3	**15**	2.8	**61**	11.3	**154**	28.4	**4**	0.7
VRA	323	23.9	1.963	147	45.5	59	18.3	3	0.9	5	1.5	8	2.5	101	31.3	0	0.0
BJE	352	26.1	1.607	132	37.5	75	21.3	3	0.9	7	2.0	16	4.5	118	33.5	1	0.3
DUR	441	32.7	1.579	153	34.7	101	22.9	3	0.7	13	2.9	37	8.4	132	29.9	2	0.5
TAR	190	14.1	1.317	48	25.3	54	28.4	0	0.0	6	3.2	17	8.9	63	33.2	2	1.1
Dinaric	**520**	**38.5**	**1.537**	**218**	**41.9**	**69**	**13.3**	**9**	**1.7**	**19**	**3.7**	**34**	**6.5**	**165**	**31.7**	**6**	**1.2**
SCA	**535**	39.6	1.326	**144**	26.9	**138**	25.8	**6**	1.1	17	3.2	88	16.4	**137**	25.6	5	0.9
JAK	280	20.7	1.188	48	17.1	94	33.6	3	1.1	7	2.5	51	18.2	75	26.8	2	0.7
VOR	412	30.5	0.943	66	16.0	105	25.5	5	1.2	24	5.8	107	26.0	99	24.0	6	1.5
GAL	249	18.4	0.754	23	9.2	77	30.9	1	0.4	6	2.4	68	27.3	72	28.9	2	0.8
PIN	448	33.2	0.653	46	10.3	102	22.8	4	0.9	**25**	5.6	**163**	36.4	97	21.7	**11**	2.5
OLY	299	22.1	0.643	25	8.4	65	21.7	5	1.7	22	7.4	108	36.1	68	22.7	6	2.0
Sc.Pind.	**487**	**36.1**	**1.647**	**114**	**23.4**	**131**	**26.9**	**14**	**2.9**	**44**	**9.0**	**83**	**17.0**	**86**	**17.7**	**15**	**3.1**
KOP	266	19.7	1.354	89	33.5	58	21.8	1	0.4	5	1.9	10	3.8	101	38.0	2	0.8
SUV	216	16.0	1.348	49	22.7	69	31.9	1	0.5	5	2.3	24	11.1	68	31.5	0	0.0
BAL	**380**	28.1	1.568	119	31.3	94	24.7	5	1.3	14	3.7	34	8.9	**113**	29.7	1	0.3
OSO	193	14.3	1.298	48	24.9	55	28.5	1	0.5	5	2.6	20	10.4	63	32.6	1	0.5
RIL	359	26.6	1.601	**130**	36.2	69	19.2	**7**	1.9	**15**	4.2	34	9.5	99	27.6	5	1.4
PIR	376	27.9	1.350	116	30.9	**81**	21.5	**7**	1.9	12	3.2	48	12.8	107	28.5	**5**	1.3
ALI	267	19.8	0.757	31	11.6	68	25.5	2	0.7	14	5.2	**72**	27.0	76	28.5	4	1.5
BEL	161	11.9	1.300	25	15.5	54	33.5	0	0.0	12	7.5	26	16.1	43	26.7	1	0.6
RHO	284	21.0	1.219	68	23.9	73	25.7	2	0.7	13	4.6	47	16.5	76	26.8	5	1.8
Balk.Rh.	**472**	**35.0**	**2.717**	**158**	**33.5**	**145**	**30.7**	**14**	**3.0**	**28**	**5.9**	**45**	**9.5**	**71**	**15.0**	**11**	**2.3**

The present study of the W. & Central Balkan orophytic flora was concerned with 1350 species of vascular plants (total analysed flora, including endemics). The detailed species numbers by chorological types and groups, by mountain systems and mountain groups, are presented in Table 1. Corresponding numbers for the relatives of endemic orophytes are evident from Table 2.

The distribution of the non-endemic orophytic flora in the Balkans

Eurasian orophytes – EA (5 species or 0.37 %): *Saussurea discolor, Allium victorialis, Androsace villosa, Rumex arifolus, Polygonum alpinum.*

The few Eurasian mountain plants are relatively uniformly distributed in the mountains of the W. & Central Balkans. In our analysis they are classified separately, due to their wide mountain distribution, but they might just as well have been included into one of the CSE-WA groups.

Mostly Central European and Central European to W. Asian orophytes – CE/CE-WA (347 species or 25.7 %)

- Central European mountains – CE (250 species or 18.5 %), e.g.: *Agrostis rupestris, Alchemilla connivens, Alnus viridis, Androsace lactea, Armeria alpina, Artemisia eriantha, Aster bellidiastrum, Astragalus australis, Calycocorsus stipitatus, Campanula scheuchzeri, Carex curvula, Carex firma, C. sempervirens, C. frigida, Clematis alpina, Cicerbita alpina, Gentiana acaulis, Gentiana punctata, Gentianella ciliata, Geum montanum, Geum reptans, Hutchinsia alpina, Kernera saxatilis, Leontopodium alpinum, Linaria alpina, Lonicera alpigena, Luzula spadicea, Oxytropis pyrenaica, Phyteuma confusum, Phyteuma ovatum, Poa chaixii, Primula halleri, P. minima, Pinus mugo, Ranunculus carinthiacus, Ranunculus crenatus, Rhododendron ferrugineum, Rosa pendulina, Saxifraga androsacea, S. bryoides, Sorbus chamaemespilus, Swertia perennis, Tozzia alpina, Trifolium badium, Veronica aphylla,* and *Veronica bellidioides.*

Typical CE orophytes account for a considerable share of the total orophytic flora of the W. & Central Balkans. Their abundance in some mountains is due not only to the height, mass and geological variety of these mountains (in general terms, the number of orophytes is directly proportional to the height and mass of a mountain) but also to their proximity to the major centres of diversity of the CE orophytic flora, such as the Alps and the Carpathians. Conversely, the mediterranean impact on a given mountain is a significant limiting factor to the occurrence of CE orophytes. The proximity of the Alps may interfere with the Mediterranean impact. Thus, on VEL, near the N. Adriatic coast, a higher number of CE orophytes occurs than on other littoral mountains that are more distant from the Alps. The largest share of CE orophytes, approximately the half of their total number, is found on the high dinaric mountains (BER, VRA, DUR and BJE) as well as on high, mostly crystalline massifs of the N. Scardo-Pindic (SCA) and Balkan-Rhodope system (RIL, PIR, BAL, KOP). In addition, a significant number of CE orophytes is found on Dinaric mountains that are under Mediterranean impact (VEL, DIN, PRE). The number of Central European orophytes is significantly reduced south of the line Šara pl.-Pirin-Rhodopes as well as in relatively low mountains along the Central & S. Adriatic coast. Orophytes with a distribution ranging from the Iberian Peninsula to the Balkans, or from the Alps and Carpathians to the Balkans, account for the greatest number of CE species here analysed. The number of Alpine-Dinaric, Alpine-Apennine-Dinaric and Pyrenean-Alpine-Dinaric species is largest in the Dinaric Alps, especially in VEL, VRA, DUR and BER, whereas on Scardo-Pindic and Balkan-Rhodope mountains

this floristic element is largely absent. Conversely, species of a Carpathian-Balkanic distribution are most frequent on Balkan-Rhodope and N. Scardo-Pindic mountains, and are absent from the Dinarides and the Greek mountains.

- Central European to W. Asian mountains – CE-WA (5 species or 0.37 %): *Avenula versicolor, Alchemilla erythropoda, Rumex alpinus, Juncus thomasii,* and *Crepis aurea.*

CE-WA species, distributed on the mountains of Central Europe and N. Asia Minor, and further estward to the Caucasus, are represented in the Balkans by 5 species only, occurring primarily on high mountains of the Balkan-Rhodope (RIL, PIR and BAL), and on the N. Scardo-Pindic (SCA) and Dinaric (VRA, BER, DUR) mountain systems.

- Central (S.)European mountains – C(S)E (70 species or 5.19 %), e.g.: *Aconitum neapolitanum, Biscutella laevigata, Carlina simplex, Cirsium eriophorum, Euphrasia salisburgensis, Erigeron polymorphus, Festuca paniculata, Scutellaria alpina, Omalotheca hoppeana, Minuartia recurva, Senecio doronicum, Trifolium pallescens, Valeriana montana, Dryopteris villarii, Asplenium fissum, Stachys alopecuros, Achillea clusiana, Erica herbacea, Scorzonera rosea,* and *Senecio rupestris.*

The vast majority of C(S)E species is found on high mountains of all three basic systems. Unlike typical Central European orophytes, these species extend to the mountains of the mediterranean hinterland (PIN, GAL, OLY, VOR, ALI, ORJ, BIO, etc.). They are relatively abundant also on mountains under strong mediterranean impact, but their number is highest on those of the Dinaric and Scardo-Pindic systems, which are also the centres of an alpine type of flora in the Balkans. The distribution of some C(S)E floristic elements may be quite similar to that of CE species.

- Central (S.)European to W. Asian mountains – C(S)E-WA (22 species or 1.63 %), e.g.: *Aconitum anthora, Alopecuros gerardii, Astragalus depressus, Cardamine acris, Carex mucronata, Crepis aurea, Daphne alpina, Doronicum columnae, Plantago gentianoides, Ribes petraeum, Saxifraga moschata, Traunsteinera globosa.*

C(S)E-WA species are more or less evenly distributed throughout the Balkans. Yet, their largest number was recorded from high mostly siliceous or siliceous and calcareous massifs.

Mostly S. European and S. European to W. Asian orophytes – SE/SE-WA (274 species or 20.3 %)

- S. European mountains – SE (33 species or 2.44 %), e.g.: *Rhamnus pumilus, Matthiola fruticosa, Alyssum cuneifolium, Iberis pruitii, Viola parvula, Prunus prostrata, Campanula versicolor, Pinguicula hirtiflora, Erigeron epiroticus, Silene graefferi, Centaurea cana, Drypis linneana, Potentilla apeninna, Saxifraga glabella, S. porophylla, Sedum magellense, Scabiosa crenata,* and *Ranunculus brutius.*

The number of typical oromediterranean plants in the mountains analysed is smaller than that of Central European orophytes. As expected, the largest number of SE species was recorded from PIN, but SCA, OLY, BER, VOR, JAK, ORJ and GAL may also be considered as significant centres of oromediterranean plants. Except for some dinaric

mountains (such as ORJ, PRE and BER), which are exposed to a strong mediterranean impact, the number of oromediterranean species rapidly decreases north of the Šar planina. This is also true for the mountains of the Balkan-Rhodope system, even for some that are subjected to a mediterranean influence (Alibotuš and S.W. Rhodopes), which may be explained by the fact that the greatest number of SE species belongs to apenninic-dinaric or apenninic-dinaric-balkanic species not reaching farther east than the Scardo-Pindic mountains.

- S. European to W. Asian mountains – SE-WA (58 species or 4.3 %), e.g.: *Amelanchier ovalis, Iberis sempervirens, Cerastium roeseri, Myosotis minutiflora, Hieracium pannosum, Hypericum linarioides, Saxifraga juniperifolia, Sibbaldia parviflora, Acantholimon echinus, Arabis bryoides, Minuartia juniperina, Ptilotrichum cyclocarpum, Saxifraga sempervivum, Thymus jankae, Carum multiflorum, Sideritis roeseri, Daphne oleoides, Astragalus angustifolius, Aubrieta deltoidea,* and *Valeriana dioscoridis.*

Unlike the European oromediterranean species (SE), oromediterranean species in the wide sense (SE-WA) are most abundant on the mountains of the Scardo-Pindic and Balkan-Rhodope systems. Their vast majority belongs to the balkanic-anatolian (30) and apenninic-dinaric-balkanic-anatolian (15) floristic elements. The highest number of SE-WA species occurs in PIN, OLY and VOR, and a significant number of them is recorded from ALI, RHO, SCA and GAL. They are mostly of a Balkan-Anatolian type of distribution, whereas on the Dinaric mountains apenninic-dinaric-balkanic-anatolian species predominate. The number of SE-WA species on inland mountains of the W. and Central Balkans is negligible.

- (Central) S. European mountains – (C)SE (135 species or 10 %), e.g.: *Achillea clypeolata, Alyssoides utriculata, Anthyllis jacquinii, Asperula scabra, Asphodelus albus, Asplenium lepidum, Arabis collina, Barbarea bracteosa, Cardamine glauca, Frangula rupestris, Gentianella crispata, Geum molle, Huetia cynapioides, Laserpitium garganicum, Peucedanum longifolium, Pseudofumaria alba, Saponaria bellidifolia, Saxifraga marginata, Scrophularia scopolii, Senecio othonnae, Selaginella helvetica, Silene antelopum, S. multicaulis, S. vallesia, Scabiosa holosericea, Pedicularis petiolaris, Jovibarba heuffelii,* and *Veronica orsiniana.*

Species with a prevailingly S. European mountain distribution represent a relatively large group among Balkan orophytes. They are present on all mountains of the Balkans, but are most numerous on the high Dinaric mountains, Šar planina and the Balkan-Rhodope mountains of Serbia and W. Bulgaria. They are present in much smaller number on the Central Scardo-Pindic and S. Balkan-Rhodope mountains, where typical oromediterranean plants prevail.

- (Central) to S. European to W. Asian mountains – (C)SE-WA (48 species or 3.56 %), e.g.: *Armeria canescens, Aurinia saxatilis, Cerastium banaticum, Chamaecytisus pygmaeus, Euphorbia myrsinites, Geranium subcaulescens, Globularia cordifolia, Minuartia falcata, Primula columnae, Ranunculus sartorianus, Rumex scutatus, Schivereckia doerfleri, Scrophularia heterophylla, Senecio aucheri,* and *Teucrium montanum.*

Tab. 2. Numerical analysis of alpine and oromediterranean relatives of the endemic orophytic flora for 25 mountain groups and 3 major mountain systems in the W. & Central Balkans. Abbreviations are explained in the text.

Floristic zone:					prevailingly temperate Alpine														prevailingly submeridional Oromediterranean					
Type of flora:					CE +		C(S)E +												SE +		(C)SE +			
	Σ species		loc	ALP/	CE-WA		C(S)E-WA		CA		AA		BOR		EAS		PON		CEU		SE-WA		(C)SE-WA		MED	
Massifs	N°	%	end	ORM	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%
All	**729**	**100.0**	**195**	**1.083**	**114**	**15.6**	**180**	**24.7**	**4**	**0.5**	**17**	**2.3**	**3**	**0.4**	**16**	**2.2**	**21**	**2.9**	**24**	**3.3**	**236**	**32.4**	**96**	**13.2**	**18**	**2.5**
VEL	41	5.6	8	2.727	12	29.3	13	31.7	2	4.9	2	4.9	0	0.0	0	0.0	1	2.4	0	0.0	6	14.6	4	9.8	1	2.4
BIO	33	4.5	4	0.650	3	9.1	7	21.2	0	0.0	2	6.1	0	0.0	0	0.0	1	3.0	0	0.0	13	39.4	6	18.2	1	3.0
ORJ	69	9.5	8	1.029	8	11.6	19	27.5	0	0.0	2	2.9	0	0.0	0	0.0	2	2.9	4	5.8	26	37.7	6	8.7	2	2.9
DIN	46	6.3	0	2.286	12	26.1	14	30.4	2	4.3	2	4.3	0	0.0	0	0.0	2	4.3	0	0.0	9	19.6	5	10.9	0	00
PRE	94	12.9	6	2.032	20	21.3	30	31.9	3	3.2	3	3.2	1	1.1	0	0.0	4	4.3	2	2.1	18	19.1	11	11.7	2	2.1
BER	**178**	24.4	**15**	1.871	**39**	21.9	**55**	30.9	1	0.6	**4**	2.2	**3**	1.7	**2**	1.1	**5**	2.8	**7**	3.9	**36**	20.2	**22**	12.4	**4**	2.2
VRA	53	7.3	3	6.571	18	34.0	20	37.7	0	0.0	3	5.7	0	0.0	0	0.0	2	3.8	3	5.7	3	5.7	4	7.5	0	0.0
BJE	75	10.3	1	3.167	19	25.3	28	37.3	2	2.7	3	4.0	0	0.0	0	0.0	3	4.0	2	2.7	8	10.7	9	12.0	1	1.3
DUR	120	16.5	7	2.333	24	20.0	44	36.7	2	1.7	3	2.5	0	0.0	1	0.8	4	3.3	6	5.0	23	19.2	11	9.2	2	1.7
TAR	52	7.1	2	1.889	5	9.6	23	44.2	1	1.9	0	0.0	0	0.0	1	1.9	2	3.8	2	3.8	12	23.1	4	7.7	2	3.8
Dinaric	**255**	**35.0**	**54**	**1.656**	**54**	**21.2**	**77**	**30.2**	**3**	**1.2**	**5**	**2.0**	**3**	**1.2**	**2**	**0.8**	**6**	**2.4**	**9**	**3.5**	**60**	**23.5**	**30**	**11.8**	**6**	**2.4**
SCA	206	28.3	19	1.675	38	18.4	68	33.0	4	1.9	4	1.9	2	1.0	3	1.5	6	2.9	4	1.9	53	25.7	19	9.2	5	2.4
JAK	116	15.9	6	1.578	14	12.1	47	40.5	1	0.9	3	2.6	0	0.0	2	1.7	1	0.9	3	2.6	31	26.7	12	10.3	2	1.7
VOR	201	27.6	14	1.185	24	11.9	56	27.9	2	1.0	3	1.5	2	1.0	7	3.5	5	2.5	10	5.0	66	32.8	20	10.0	6	3.0
GAL	106	14.5	5	0.738	9	8.5	29	27.4	0	0.0	1	0.9	0	0.0	0	0.0	2	1.9	4	3.8	42	39.6	17	16.0	2	1.9
PIN	**243**	33.8	**28**	0.664	21	8.6	47	19.3	1	0.4	3	1.2	0	0.0	**11**	4.5	7	2.9	7	2.9	**101**	41.6	**34**	14.0	**11**	4.5
OLY	153	21.0	24	0.700	14	9.2	22	14.4	2	1.3	4	2.6	0	0.0	7	4.6	7	4.6	7	4.6	61	39.9	23	15.0	6	3.9
Sc.Pind.	**493**	**67.6**	**96**	**0.885**	**68**	**13.8**	**107**	**21.7**	**4**	**0.8**	**8**	**1.6**	**2**	**0.4**	**14**	**2.8**	**13**	**2.6**	**14**	**2.8**	**180**	**36.5**	**65**	**13.2**	**15**	**3.0**
KOP	49	6.7	1	2.769	7	14.3	23	46.9	0	0.0	1	2.0	0	0.0	0	0.0	3	6.1	2	4.1	5	10.2	6	12.2	2	4.1
SUV	48	6.6	1	1.400	1	2.1	21	43.8	0	0.0	1	2.1	0	0.0	0	0.0	2	4.2	3	6.3	14	29.2	6	12.5	0	0.0
BAL	116	15.9	8	2.867	24	20.7	43	27.1	1	0.9	4	3.4	1	0.9	1	0.9	5	4.3	7	6.0	17	14.7	12	10.3	1	0.9
OSO	51	7.0	1	2.400	9	17.6	21	41.2	0	0.0	1	2.0	0	0.0	1	2.0	0	0.0	4	7.8	10	19.6	4	7.8	1	2.0
RIL	108	14.8	6	2.600	26	24.1	30	27.8	2	1.9	5	4.6	1	0.9	3	2.8	2	1.9	9	8.3	16	14.8	9	8.3	5	4.6
PIR	**131**	18.0	**19**	2.047	**30**	22.9	**39**	29.8	1	0.8	**6**	4.6	1	0.8	2	1.5	3	2.3	6	4.6	24	18.3	14	10.7	**5**	3.8
ALI	116	15.9	6	0.933	10	8.6	30	25.9	1	0.9	1	0.9	1	0.9	2	1.7	**6**	5.2	5	4.3	**40**	34.5	**16**	13.8	4	3.4
BEL	60	8.2	0	2.529	8	13.3	23	38.3	0	0.0	0	0.0	0	0.0	2	3.3	3	5.0	7	11.7	11	18.3	5	8.3	1	1.7
RHO	101	13.9	3	1.590	14	13.9	33	32.7	2	2.0	1	1.0	1	1.0	2	2.0	1	1.0	8	7.9	23	22.8	11	10.9	**5**	5.0
Balk.Rh.	**285**	**39.1**	**45**	**1.679**	**54**	**18.9**	**83**	**29.1**	**4**	**1.4**	**10**	**3.5**	**1**	**0.4**	**4**	**1.4**	**12**	**4.2**	**10**	**3.5**	**65**	**22.8**	**30**	**10.5**	**11**	**3.9**

S. European to W. Asian orophytes are distributed in a similar way as those of the (C)SE group, except that their number is highter on the mountains of the Central Balkans (excluding BER and DUR in part) than on the Dinaric mountains.

The distribution of endemic orophytes and their floristic characterization from a phylogenetical point of view

As stated before, endemic species are a very heterogeneous group of floristic elements with distribution areas of all sizes, from pan-balkanic to local and restricted to a single mountain massif.

The present analysis concerns 729 endemic species. Their largest number occurs on the massifs PIN (243), SCA (206), VOR (201), BER (178), OLY (153), PIR (131), DUR (120), BAL, JAK and ALI (116), RIL (109), GAL (106), etc. The number of local endemics is largest on massifs such as PIN (28), OLY (24), PIR and SCA (19), BER (15), VOR (14), BAL, VEL, and ORJ (8), DUR (7), PRE, RIL, ALI, and JAK (6), etc.

As stated before, the appurtenance to a floristic element of the closest relative of each endemic orophyte was determined in the same way as for non-endemic species, except that for some of them, especially the non-orophytic ones, special elements were used (CA, AA, Bor, EAs, CEu, Pon, Med). Relatives limited to the W. Asian mountains (WA) were associated either with the prevailingly temperate element (C(S)E-WA), or with one of the prevailingly submeridional elements ((C)SE-WA or SE-WA), on the basis of their exact distribution. In the following species enumerations, the Balkan endemic is given first, followed by its closest relative in parentheses.

Endemics with ALP relatives (318 species or 23.55 %)

- Relatives in the Central European mountains – CE (111 species or 8.22 %), e.g.: *Thlaspi bellidifolium (T. rotundifolium), Wulfenia blecicii (W. carinthiaca), Pinguicula balcanica (P. leptoceras), Valeriana pancicii (V. saxatilis), Alchemilla pirinica (A. cinerea), Trifolium wettsteinii (T. noricum), Dianthus scardicus (D. nitidus), Asperula beckiana (A. neilreichii), Campanula orbelica (C. alpina), Aconitum pentheri (A. burnatii), Primula kitaibeliana (P. tyrolensis), Ranunculus wettsteinii (R. parnassiifolius), Primula deorum (P. integrifolia), Saxifraga prenja (S. sedoides), Poa pirinica (P. minor), Cicerbita pancicii (C. alpina), Draba korabensis (D. tomentosa), Oxytropis prenja (O. halleri), Androsace hedraeantha (A. obtusifolia), Soldanella pindicola (S. carpathica), Ranunculus montenegrinus (R. seguieri), Hieracium malovanicum (H. chlorifolium* aggr.), *Pedicularis hoermanniana (P. foliosa).*

The largest number of endemics with closest relatives on the Central European mountains (CE) is found on the high Dinaric, N. Scardo-Pindic and Balkan-Rhodope mountains, where the BER and SCA massifs account for almost one third of the total. Other significant centres of such endemics are the mountains of W. Bulgaria (RIL, PIR, and BAL) as well as PIN, VOR, DUR, PRE, VRA and BJE. Low inland mountains, irrespective of substratum, and limestone mountains exposed to Mediterranean influence, are characterized by small numbers of such endemics. Most of the corresponding relatives are relatively widespread orophytes with distributions ranging from the Iberian Peninsula to the Balkans. Some of the relatives of Dinaric mountain endemics have Alpine or Apennino-Alpine distribution areas, whereas the Central Balkan endemics are more often related to Carpathian or Balkano-Carpathian species. If one bears in mind the fact that the relatives of the Balkan endemics often include glacial relics, then the mentioned distribution pattern was predictable.

- Relatives in the Central European to W. Asian mountains – CE-WA (3 species or 0.22 %): *Arenaria pancicii (A. rotundifolia), Poa ophiolitica (P. cenisia), Scrophularia bosniaca (S. divaricata).*

The number of Central European to W. Asian species that are close relatives of Balkan endemics is very small The Balkan distribution of the endemics shows no significant pattern.

- Relatives in the Central (S.) European mountains – C(S)E (154 species or 11.4 %), e.g.: *Potentilla doerfleri (P. valderia), Satureja croatica (S. marginata), Achillea ambrosiaca (A. moschata), Achillea korabensis (A. clavenae), Erysimum kuemmerlei*

(E. carniolicum), Polygala rhodopea (P. supina), Asperula doerfleri (A. hirta), Saxifraga ferdinandi-coburgii (S. aretioides), Viola orphanidis (V. montcaunica), Sedum kostovii (S. alpestre), Silene waldsteinii (S. saxifraga aggr.), Valeriana bertiscea (V. montana), Silene albanica (S. pusilla).

Endemics with closest relatives mainly found on the Central European mountains are the most numerous on the highest mountains of all the three mountain systems. Those of the Dinaric mountains have most often relatives of an Alpine-Dinaric or Alpine-Dinaric-Balkanic type of distribution, those of the mountains of Serbia and Bulgaria, mostly relatives that are either themselves endemic Balkan orophytes (usually of the same or a neighbouring massif) or Balkano-Carpathian species.

- Relatives in the S. Central European to W. Asian mountains – C(S)E-WA (15 species or 1.11 %), e.g.: *Geum rhodopaeum (G. coccineum), Cardamine barbareoides (C. acris), Potentilla regis-borisii (P. geoides), Centaurea achtarovii (C. triumfettii), Saxifraga chrysospleniifolia (S. rotundifolia.*

Endemic orophytes with relatives that are widespread from the Pyrenees to the Caucasus are present primarily on the high Scardo-Pindic and Balkan-Rhodope mountains, such as PIN, PEL, RHO, PIR, SCA, BAL and RIL; they are absent from the Dinaric mountains, except BER.

- Relatives in the temperate W. Asian mountains – WA (11 species or 0.81 %), e.g.: *Acer heldreichii (A. trautvetteri), Ligusticum rhizomaticum (L. alatum), Pancicia serbica (Anatolian-Caucasian Pimpinella species), Pastinaca hirsuta (P. pimpinellifolia), Vicia montenegrina (V. abbreviata), Onosma stellulatum (O. caucasicum), Alchemilla bulgarica (A. sericata), Cynoglossum scardicum (C. biebersteinii).*

Endemics closely related to W. Asian orophytes are rare in the Balkan mountains. They are psychrophilous relict species which differentiated prior to the Ice Ages and spread to the Balkan mountains during the glaciations, which accounts for their relatively uniform distribution in all three mountain systems.

- Relatives in the Central Asian mountains – CA (4 species or 0.29 %): *Rheum rhaponticum (R. altaicum), Sibiraea croatica (S. altaica & S. tjanschanica), Matricaria tempskyana (M. disciformis), Ligusticum olympicum (L. gayodes).*

The number of endemic species with relatives in the mountains of Central Asia, primarily in the Altai and Tjan-Shan, is very small. They are typical Tertiary relics.

- Relatives arctic-alpine – AA (17 species or 1.26 %), e.g.: *Carex tricolor (C. pilulifera), Festuca pirinica (F. hyperborea), Oxytropis dinarica (O. campestris), Papaver degenii (P. alpinum), Primula exigua (P. farinosa), Saxifraga blavii (S. adscendens), Taraxacum deorum (T. ceratophorum).*

Endemic taxa with arctic-alpine relatives are present mostly on high mountains of all three mountain systems of the Peninsula. Their presence indicates a Balkan origin of the arctic-alpine relatives, which have most probably spread from the Alps to arctic regions during and after the last Ice Age. This assumption is strongly supported by the high degree of differentiation between the arctic-alpine and the endemic Balkan taxa.

– Relatives boreal-subalpine – Bor (3 species pairs or 0.22 %): *Petasites doerfleri (P. sibiricus), Pinus peuce (P. monticola), Rumex balcanicus (R. densiflorus).*

The corresponding Balkan endemics are known from a small number of high, mostly silicate mountains of the Scardo-Pindic and Balkan-Rhodope systems, as well as on BER (S.E. Dinarids).

– Relatives Eurasian – EAs (16 species or 1.19 %), e.g.: *Plantago pindica (P. media), Lotus stenodon (L. corniculatus), Teucrium olympicum (T. chamaedrys), Veronica sartoriana (V. arvensis), Stachys olympica (S. recta), Carlina frigida (C. vulgaris).*

– Relatives Central European – CEu (21 species pairs or 1.56 %), e.g.: *Angelica pancicii (A. archangelica), Carduus ramossisimus (C. acanthoides), Centaurea bosniaca (C. stenolepis), Trifolium velenovskyi (T. aureum), Viburnum maculatum (V. lantana).*

– Relatives Pontic – Pon (24 species pairs or 1.78 %), e.g.: *Linum spathulatum (L. hirsutum), Linum serbicum (L. flavum), Minuartia rhodopea (M. glomerata), Scabiosa balcanica (S. ochroleuca), Oxytropis purpurea (O. floribunda), Hyacinthella dalmatica (H. leucophaea).*

Endemic orophytes with Eurasian relatives in a wide sense (incl. EAs in the narrow sense, CEu and Pon) are a very heterogeneous group, from a phytogeographical and historical point of view. They are mostly are neo-endemics that have differentiated relatively recently, probably during the Pleistocene alternation of glacial and interglacial periods, from widespread non-orophytic ancestors, e.g. members of the Cental European nemoral flora.

Endemics with ORM relatives (332 species or 24.5 %)

– Relatives in the S. European mountains – SE (184 species or 13.62 %), e.g.: *Sesleria robusta (S. nitida), Thlaspi microphyllum (T. stylosum), Scabiosa taygetea (S. holosericea), Potentilla stoianovii (P. apennina), Alyssum smolikanum (A. nebrodense), Aquilegia dinarica (A. ottonis), Campanula portenschlagiana (C. garganica), Centranthus slavnicii (C. junceus), Daphne malyana (D. jasminea), Dianthus pinifolius (D. androsaceus), Crocus dalmaticus (C. etruscus), Festucopsis sancta (F. serpentini), Lonicera glutinosa (L. hellenica), Sideritis scardica (S. clandestina), Bornmuellera dieckii (B. thymphaea), Campanula formanekiana (C. lanata), Aubrieta scardica (A. gracilis), Alyssum doerfleri (A. taygeteum).*

The largest number of endemics with relatives on the S. European mountains is found on the Scardo-Pindic mountains, particularly PIN, OLY, VOR, SCA, and GAL. They are also found in significant numbers on ALI, BER, ORJ, etc. More than 5 % of these endemics are most closely related to other endemics restricted to the Central & S. parts of the Balkan Peninsula. This pattern indicates that they are relatively young (of Quaternary age) and may be considered as neo-endemics in the sense of Turrill (1927); as a whole, their parental group may nevertheless be very old, dating back to the Tertiary. Other such endemic orophytes represent typical relics from the Tertiary, having relatives with an extremely disjunct distribution in the mountains of the Iberian Peninsula or on the Apennines or the S. Alps.

– Relatives in the S. European to W. Asian mountains – SE-WA (27 species or 2 %), e.g.: *Ranunculus incomparabilis (R. subhomophyllus), Potentilla deorum (P. speciosa), Solenanthus albanicus (S. stamineus), Thymus degenii (T. sibthorpii), Helichrysum zivojinii (H. plicatum).*

Endemics with relatives that belong to SE-WA group occur mainly in the mountains of the Scardo-Pindic and S. Balkan-Rhodope system of Bulgaria, but are also present in the Dinaric mountains, though in smaller number. The relatives in majority are Balkan-Anatolian or Balkan- Anatolian-Caucasus species, which may explain the extremely low presence of corresponding endemic orophytes on the mountains of the W. Balkans.

– Relatives in the prevailingly submeridional W. Asian mountains – WA (25 species or 1.85 %), e.g.: *Achillea fraasii (A. trojana), Arabis bryoides (A. drabiformis), Arenaria graeca (A. angustifolia), Astragalus creticus (A. gummifer), Dianthus cruentus (D. calocephalus), Erodium absinthoides (E. leucanthum), Erysimum korabense (E. pulchellum), Rindera graeca (R. aucheri), Veronica satureioides (V. kotschyana), Euphorbia capitulata (E. chamaebuxus.*

As for the previous group, the greatest number of endemic orophytes closely related to Anatolian or Anatolian-Caucasian species occur on the N. and Central Scardo-Pindic mountains. Their number gradually decreases towards the Dinaric and Balkan-Rhodope mountains, and they are absent from the W. Dinarides. They are mainly Tertiary relics, since the Balkan and W. Asian orophytic floras drifted apart prior to the Ice Ages, an assumption supported by the large disjuncttions separating the Balkan endemics from their W. Asian relatives.

– Relatives in the (Central) S. European mountains – (C)SE (86 species or 6.37 %), e.g.: *Ranunculus hayekii (R. demissus), Asperula wettsteinii (A. aristata), Anthyllis aurea (A. montana), Genista fukarekiana (G. subcapitata), Gentianella laevicalyx (G. columnae), Pedicularis ferdinadi (P. petiolaris), Knautia dinarica (K. silana).*

– Relatives in the (Central) S. European to W. Asian mountains – (C)SE-WA (8 species pairs or 0.15 %), e.g.: *Scabiosa rhodopensis (S. graminifolia), Minuartia psudosaxifraga (M. saxifraga), Centaurea lacerata (C. affinis), Senecio wagneri (S. papposus).*

– With relatives in the submeridional W. Asian mountains – WA (1 species or 0.02 %): *Lilium rhodopaeum (L. monadelphum).*

The number of endemics most closely related to mainly S. European and/or S.W. Asian orophytes is largest on the high Scardo-Pindic, Balkan-Rhodope and Dinaric mountains.

– Relatives non-orophytic, mediterranean-submediterranean – Med (18 species or 1.33 %), e.g.: *Asyneuma kellerianum (A. limoniifolium), Cardamine carnosa (C. graeca), Euphorbia glabriflora (E. spinosa), Jasione bulgarica (J. heldreichii), Silene haussknechtii (S. sedoides), Fumana bonapartei (F. ericoides), Orobanche baumanniorum (O. amethystea), Thymus stojanovii (T. longicaulis), Vincetoxicum nivale (V. adriaticum).*

In general, the differentiation of Mediterranean species into endemic orophytes took place prior to the Pleistocene glaciations, as confirmed by the relict nature of these taxa. One may however assume that speciation and differentiation in complex genera such as *Thymus, Veronica, Vincetoxicum, Orobanche, Sedum,* etc. continued during the Quaternary period. As one might expect, the vast majority of endemic species with mediterranean species as their closest relatives occurs on Scardo-Pindic mountains. However, a certain number of them is found on high mountains of the Dinaric and Balkan-Rhodope mountain systems, which suggests the existence of ancient links between the mediterranean and oromediterranean flora.

Relationship between the alpine and oromediterranean orophytic flora in the mountains of the W. and Central Balkans

The Dinaric mountain system (Fig. 2A-B; Tables 1-2)

Along the Adriatic coast, the ALP/ORM ratio for the total mountain flora gradually decreases from VEL through BIO to ORJ. Whereas BIO and ORJ are transitional oromediterranean mountains, VEL, in spite of its vicinity to the sea, is of the alpine type, having been strongly influenced from the side of the Alps, during the glaciations.

As far as the endemic flora is concerned, VEL is again characterized by an alpine type of flora, many endemic species, including local ones, are closely related to taxa in the Alps, or to Apennino-Alpine species. The low, calcareous BIO in Central Dalmatia remains an oromediterranean mountain, whereas the somewhat higher, more southwardly ORJ is of a transitional oromediterranean type. This may be due to stronger floristic influences from inland ranges of the Dinarides linked with a colder mountain climate with higher precipitations.

The middle mountain chain of the Dinaric Alps shows an uniform southward decrease of the ALP/ORM ratio. Whereas DIN is a mountain of the alpine type if the total flora is taken into account, PRE, exposed to strong mediterranean penetrations along the Neretva valley, is of a transitional alpine type. The high and massive BER, even though it belongs to the same transitional alpine type judging by its ALP/ORM ratio, has a flora of a somewhat more pronounced alpine character, in keeping with its role as one of the most significant refuges for the glacial and alpine flora in the whole of the Balkans.

The analysis of the endemic flora shows that the middle chain of the Dinaric Alps (DIN, PRE, and BER), judging by the ALP/ORM ratio, belongs by its flora to the transitional alpine type,with the degree of alpine character decreasing from DIN through PRE to BER. All mountains of the chain are characterized by a significant presence of endemics with relatives on Central European mountains, primarily the Alps.

The inner chain of the Dinaric Alps is also characterized by a gradual decrease of the ALP/ORM ratio from north-west to east. VRA, one of silicate mountains of the Central Dinarides, unlike the other mountains of the Dinaric system which are built primarily of limestone, is characterized by a markedly alpine type of flora. The same type predominates both in BJE and DUR, whereas the mountains of W. Serbia (TAR) are of a transitional alpine type, owing to their low altitude and dominant serpentine bedrock.

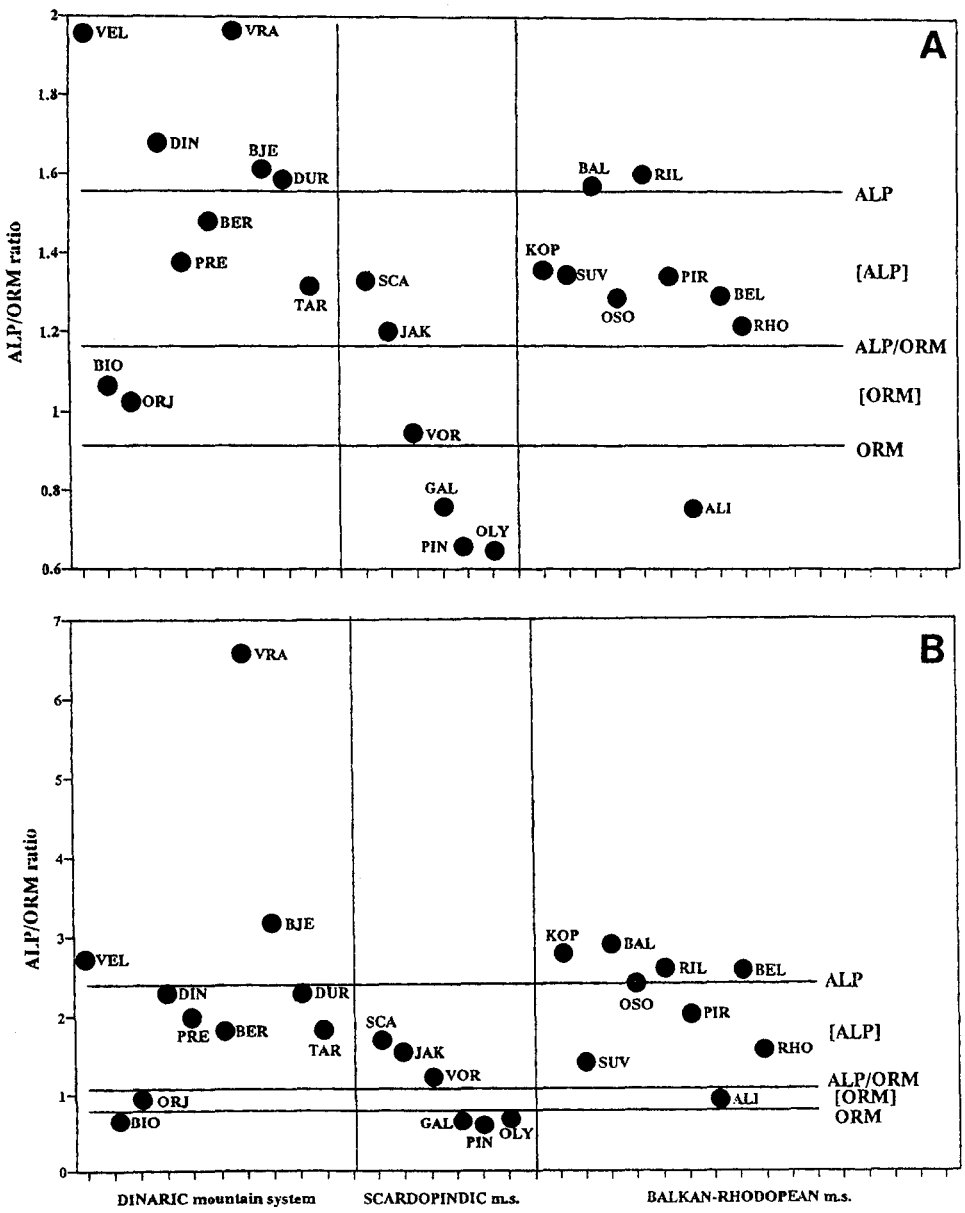

Fig. 2. Diagrams showing the ALP/ORM ratio of each massif in the W. & Central Balkans. – A, based on the total orophytic flora (including endemics); B, based on the endemic orophytic flora alone. (See text and Fig. 1 for the explanation of the letters and position of the corresponding massifs.)

The analysis of the endemic flora of the inner chain of the Dinaric Alps shows some change in the ALP/ORM ratio, with VRA and BJE belonging to the alpine type (great number of relatives among Central European orophytes), but DUR, and especially TAR, to the transitional alpine type. For DUR, however, the ALP/ORM ratio comes close to that characterizing an alpine type of flora.

The Scardo-Pindic mountain system (Fig. 2A-B, Tables 1-2.)

The analysis of the total flora shows that only two mountain groups, the Šar planina (SCA) and Jakupica (JAK), are of a transitional alpine type, which is somewhat more marked for SCA (which with Mt Korab includes one of the most massive and highest Balkan massifs, moreover built of crystalline bedrock). Indeed this mountain group is one of the most significant centres of glacial calcifuge flora of alpine and arctic-alpine type (Stevanović 1989). VOR belongs to the transitional oromediterranean type of flora. GAL, PIN, and OLY are typical oromediterranean mountains.

The endemic flora of SCA, JAK, and VOR, shows closer links with Central European orophytes than that of GAL, PIN, and OLY, which are again found to be typically oromediterranean. The strength of the endemic link with Central Europe gradually decreases from SCA through JAK to VOR.

The Balkan-Rhodope mountain system (Fig. 2A-B, Tables 1-2)

According to the analysis of the total flora, all mountains of the Balkan-Rhodope system except ALI belong to the alpine (BAL and RIL) or more or less pronounced transitional alpine type (KOP, SUV, OSO, PIR, BEL, and RHO).

The endemic flora of these same mountains is more closely related to Central European (alpine, alpine-carpathian, arctic-alpine, carpathian) elements than to those of mediterranean mountains. KOP, RIL and BEL are distinctly alpine, whereas on the basis of its ALP/ORM ratio OSO may already be considered as transitional. SUV, PIR, and RHO are of the transitional alpine type, with the alpine character of the flora being least evident in the low and isolated limestone massif of SUV, in E. Serbia. ALI, judging from the phylogenetic links of its endemic flora, is a typically oromediterranean.

Conclusion

In spite of the intrinsic difficulties of phytogeographical analysis and subdivision of a floristically rich and varied region such as the Balkans, it is now possible to draw the following conclusions (Fig. 3-4):

- In the Balkans, the boundary of the oromediterranean floristic region extends along the mountains of mediterranean Albania, then bends eastward from the Galičica through the mountains of N. Greece to Mts Alibotuš and Falakron. All Greek and Albanian mountains south of this boundary belong to the oromediterranean floristic region. This boundary more or less coincides with that of the zonal occurrence of *Abies borisii-regis*, along the Greek-Bulgarian border.
- The mountain chain stretching from BIO through ORJ south-eastward to VOR, on the border between the FYRM and Greece, is of a transitional oromediterranean type.

- The middle to inner chains of the Dinaric Alps, from PRE, BER, and TAR through SCA and JAK eastward to KOP, SUV, OSO, BEL, and RHO, are of the transitional alpine-high-nordic type.
- The innermost chain of the Dinaric Alps, from VEL, DIN, and VRA to DUR, belongs typically to alpine-high-nordic floristic region, as do the massifs of BAL and RIL.

When established on the basis of the endemic flora, the boundaries between the omediterranean and alpine-high-nordic floristic regions will somewhat differ from those obtained from analysis of the total flora. According to that second analysis:

- The genuine oromediterranean region includes just GAL, PIN, and OLY, plus BIO as an isolated exclave in the W. Balkans.

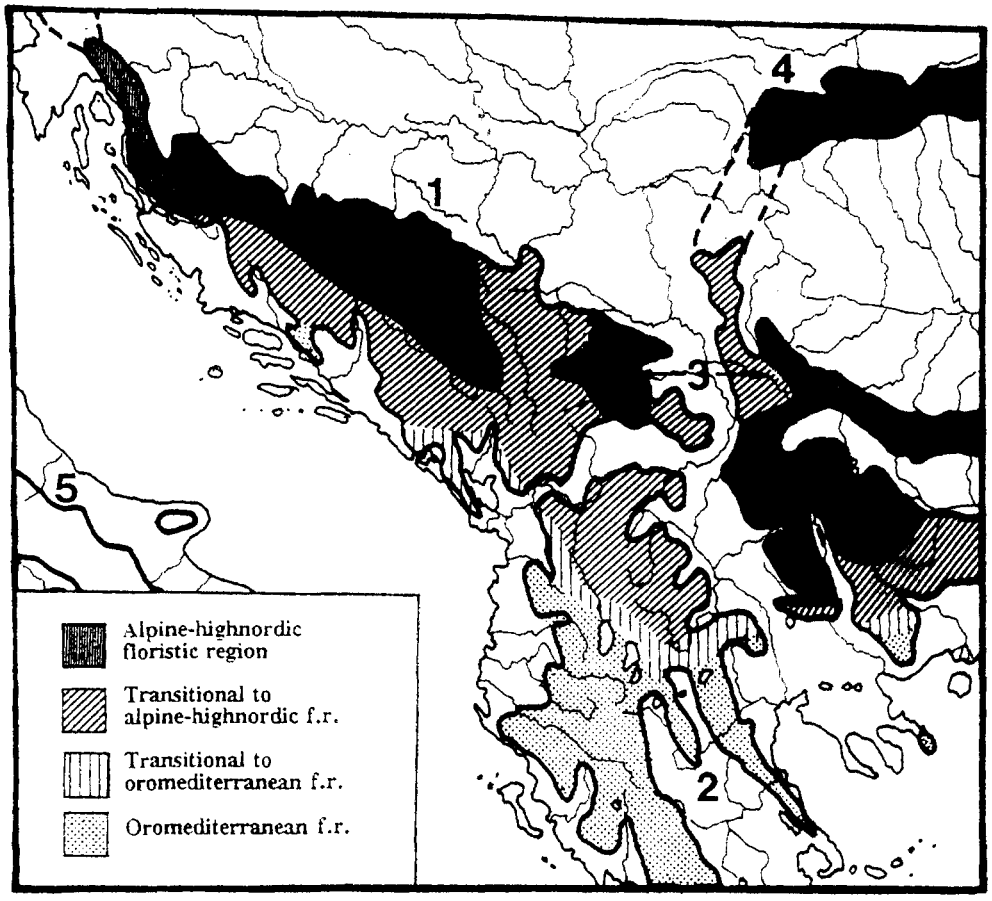

Fig. 3. The boundaries of the alpine-high-nordic and oromediterranean floristic regions and their respective transitinal zones, in the W. & Central Balkans, drawn on the basis of an analysis of the total orophytic flora.

- The transitional oromediterranean zone comprises ORJ, the Albanian mountains, limestone ranges of VOR, and ALI to the east.
- The transitional alpine-high-nordic zone consists of DIN, PRE, DUR, BER, TAR, SCA, JAK, VOR, SUV, PIR, and RHO.
- The typical alpine-high-nordic mountains are VEL, VRA, KOP, BAL, and RIL, plus siliceous BEL as an isolated southern exclave.

The analysis of endemic flora, when applied to the delimitation of floristic regions, shows phytogeographic relations that reflect the state and composition of past rather than present-day floras, since it is based on phylogenetic links of endemic orophytes. The analysis of the total flora better reveals the real floristic interrelationships and boundaries within the chorologically and historically most complex and heterogeneous

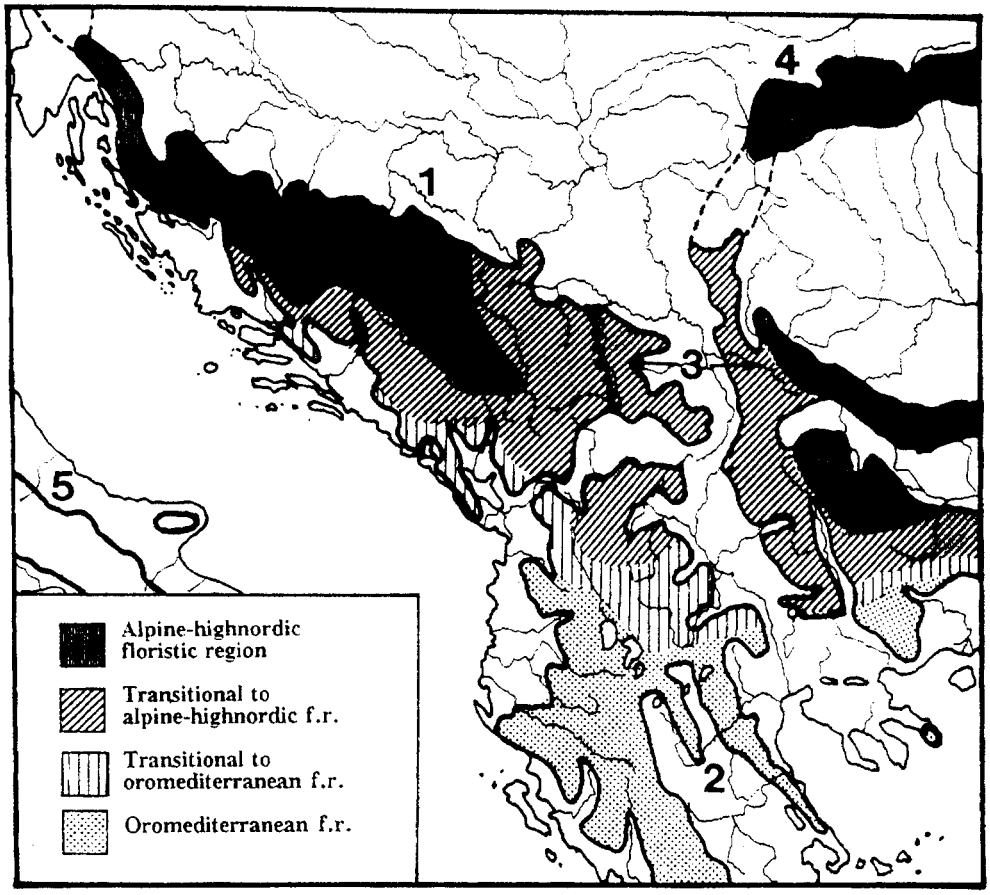

Fig. 4. The boundaries of the alpine-high-nordic and oromediterranean floristic regions and their respective transitinal zones, in the W. & Central Balkans, drawn on the basis of an analysis of the relatives of endemic orophytes alone.

orophytic flora of the W. & Central Balkans. As mentioned before, the arcto-alpine and boreal species were omitted from the analysis of the total flora. Their inclusion would not, however, have significantly changed the boundaries between the alpine-high-nordic and oromediterranean floristic regions. It would have made the mountains of the alpine type even more alpine, and the oromediterranean mountains somewhat less oromediterranean, particularly the high and massive ones, including typically oromediterranean ones like GAL, PIN, OLY, and ALI, all of which were affected by glaciation.

At the beginning of this paper, the existence of two conflicting concepts on the boundaries between alpine-high-nordic and oromediterranean region in the W. & Central Balkans was mentioned. We can now conclude that the concept proposed by Horvat (1960), Horvatić (1967), and Lakušić (1968) is far more accurate than that of Trinajstić (1985), who took into consideration only the relict element of the orophytic flora, notably the endemics.

The present new delimitation between the alpine-high-nordic and oromediterranean floristic regions in the Balkans is not just a compromise between two conflicting concepts but truely reflects the floristic relationships of the Balkan mountains. Nevertheless, the present work can be no more than a small and limited contribution to the study of overall phytogeographical, floristic and florogenetic relationships of the orophytic flora of the Balkans.

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