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Comparative analysis of North Pirin (Mt.) and Madonie Mt. floras

Abstract

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The study contributes to the knowledge of distribution and expression of phytodiversity (floristic and taxonomic richness) of the mountain floras in Sub-Mediterranean and Mediterranean floristic regions. The comparison deals with mountain floras of North Pirin Mt. (Bulgaria) and Madonie Mt. (Sicily). Analyses are made by assessing floristic richness from one hands and taxonomic structure at family and genera level from other of both local floras using U-test as statistic method. Biological (after Raunkiaer), ecological spectra and distribution of the taxa in altitude are confronted and main trends are pointed out. Comparison of the geographical distribution of the species of the two floras is made by separate analysis of the different geoelements and special attention is paid to the endemic species.

Introduction

Like two sides of the same coin, comparative floristics may be approached from two opposite directions. One is based essentially on qualitative characters, while the other is based on quantitative ones. The evaluation of qualitative characters in floristic studies implies a mostly superficial perception at the visual or emotional background. It is highly subjective and depends on good judgment and the erudition of the researcher. In contrast, the quantitative approach implies analysis on a statistical or formal basis; it diminishes or even eliminates excessive subjectivity (Malyshev 1991).

Applying basically the quantitative methods for analysing species richness, main parameters of taxonomic diversity and taxonomic structure, ecological and biological characteristics of the floras of North Pirin (Bulgaria) and Madonie Mountains (Sicily), present study aims to contribute to the knowledge of distribution and expression of phyto-diversity of the mountain floras in Sub-Mediterranean and Mediterranean floristic regions.

Material and methods

For choosing sample areas is followed the concept for Operational Geographic Units (OGU) Crovello (1981). The method for "concrete" or "elementary" floras proposed by Tolmachev (1986) is also adopted. Because of the mountain character of the studied regions, for increase comparability, under study are taken the valleys of two rivers respectively for

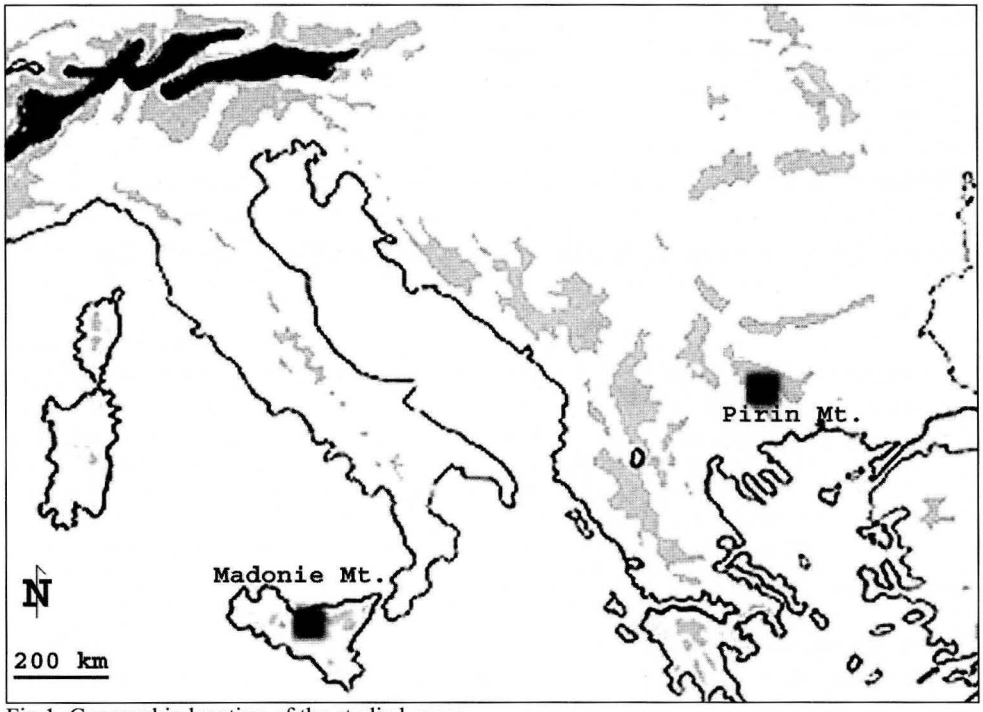

Fig.1. Geographic location of the studied areas.

North Pirin and Madonie Mts. in this way altitudinal and moisture gradients are considered. In comparison are included floras of Banderica valley (ca. 91 km^2) as representative for the flora of North Pirin Mountain and valley of Castelbuono river (ca. 107 km^2) as representative for the flora of Madonie Mt. (Fig. 1). Both valleys reach the highest peaks, respectively of North Pirin and Madonie Mountains, in both areas calcareous and siliceous geological substrata are present and the area of both regions is quite equal, so in this way the sample areas are considered representative and comparable from statistical and floristic point of view.

In calculation are included all species and subspecies presented in both floras. The lists are produced using available data in numerous floristic and phytocoenological papers and data from different field floristic studies by the authors (first author for the flora of Pirin Mt. and second for the flora of Madonie Mt.). The specimens collected during the floristic studies are deposited respectively in herbaria of Sofia (SO) and Palermo (PAL). As a taxonomical base for unification of taxonomic concept of both floras, Flora Europaea (Tutin & al. 1976) is accepted. Vertical distribution of the species is valuated using altitudinal steps of 500 m. For identification of moisture-reaction category (Fig. 4) four main group are applied – hydrophytes (**hd**); hygrophytes (**hg**); mesophytes (**m**); xerophytes (**x**) and four intermediate as well as – hygro-mesopytes (**hgm**), meso-hygrophytes (**mhg**), meso-xerophytes (**mx**), xero-mesophytes (**xm**). Identification of the life forms is after Raunkiaer (1934). The appurtenance of each species (subspecies) to a corresponding floristic element

are determined according to Walter (1945) and Walter & Straka (1970). For generalization and final presentation of different chorological types was adopted classification schema after Andreev (1989) where 11 classes are present (Fig. 6): Cosmopolitan (**Cosmpolit**.); Holarctic (**Holarct**); Boreal (**Boreal**); Palearctic with one group Euro-Asiatic (**Euroasiat**.); European (**Europ.**); Endemic (**Endem.**) endemics to Balkan peninsula from one hand and Sicily and South Italy from other; Atlantic (**Alant.**); Mediterranean with two groups StenoMediterranean (**StenoMedit.**) and Euri-Mediterranean including: Medit.- Sub Atlantic, Medit.-Turanian, Medit.- Sub Pontic, Medit.- Maccaronesian and Medit.- Sub Tropic (**EuriMedit**.); Sub-Mediterranean (**SubMedit.**) and Pontic-Pannonic (**Pont.-Panon**.).

For comparison of the floristic similarities on species level, the coefficient of Jaccard is calculated as recommended by Schmidt (1980) who discussing among six different coefficients, point out that the Jaccard coefficient is more applicable for floristic studies.

For analysis of taxonomic structure and comparison of the taxonomic spectra at family and genus level is applied the rank correlation method (U test) proposed by Kendall (1938, 1975).

Studied area

Pirin Mt. belongs to the East-Moesian floristic provinces (Horvat & al. 1974) of Sub-Mediterranean floristic region. Banderitza valley is situated in the south part of North Pirin. The valley is closed to South-West by the main ridge of Pirin - the picks Banski Suhodol (2884 m), Vichren (2914 m), Banderishki Tchukar (2737 m) and Vasilashki Tchukar (2615 m); to West - by the ridge of Dunino Kutche pick (2469 m); to East - by the pick rich of Todorka (2776 m). The basic rock of the region consists of granites, granitogneisses, crystalline schist (ca 60%) and marbles (40%). Pirin belongs to the South Bulgarian climate subregion of the South Bulgarian climate region with Mediterranean influence.

The following vegetation zones are presented:

1. Zone of the coniferous forests: Developed from 1500-1600 up to 2000-2200 m alt. Formed by *Pinus sylvestris*, *Picea abies*, *Pinus peuce*, on silicate bedrock and *Pinus heldreichii*, *Pinus nigra* subsp. *pallasiana* on limestone (marble) bedrock.
2. Subalpine zone: from 2000 up to 2500 m alt. Formed by communities of *Pinus mugo* and *Juniperus communis* subsp. *alpina*.
3. Alpine zone: above 2400-2500 m alt. The marble terrain is dominated by *Sesleria korabensis*, *Dryas octopetala*, *Salix reticulata*, etc. On silicate bedrock communities of *Carex curvula*, *Agrostis rupestris*, *Festuca airoides*, *Sesleria comosa*, *Juncus trifidus*, *Vaccinium uliginosum*, etc., are present.

Madonie Mt. belongs to the Sicilian floristic province of Mediterranean floristic region. It consists of mountainous system placed in North Sicily and that represent the southern most part of the Apennine. Area considered for this study (river Castelbuono valley) is placed in the central part of the mountain, between the villages of Collesano and Castelbuono, and includes the highest peaks of Madonie: Pizzo Carbonara (1979 m),

Monte Ferro (1906 m), Pizzo Antenna della Principessa (1977 m), Pizzo Scolonazzo (1903 m). Geologically it is very heterogeneous with alternate calcareous (ca. 60%) and silice-arenaceous substrata (40%). Climate is Mesomediterranean, and Submediterranean on the highest part of the mountain. Vegetation belongs to three altitudinal zones even that vertical zonation is not well differentiated:

1. From (800) 1000 m to 1200 (1400) m vegetation is characterised by oak forests with *Quercus ilex*, *Acer campestre*, *Acer monspessulanum*, *Sorbus graeca*, etc. and shrubs like *Erica arborea* and *Cytisus villosus*.
2. From (1100) 1200 m to 1600 (1900) m beech forests are distributed characterised by the presence of species with Atlantic distribution (*Ilex aquifolium*, *Daphne laureola*, *Ruscus aculeatus*, etc.).
3. Only on the upper peaks, above 1800 m, the forests are substituted by dwarf shrubby vegetation characterised by species with pulvinate habit (*Astragalus nebrodensis*, *Genista cupani*, *Thymus spinulosus*, etc.). On the rocky terrain chasmophytic vegetation with participation of *Minuartia verne* subsp. *grandiflora*, *Saxifraga australis*, *Potentilla caulescens* subsp. *nebrodensis*, *Asplenium ruta-muraria*, etc. is present.

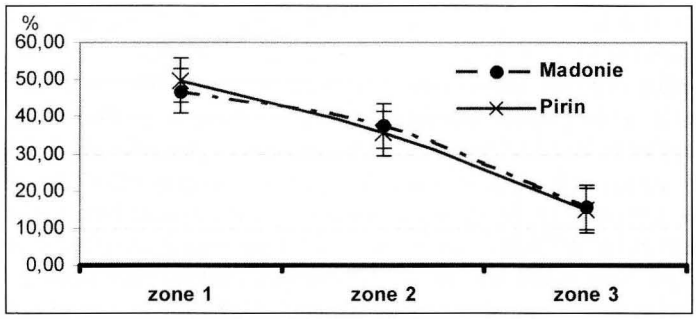

Fig. 2. Vertical distribution of the species in vegetation zone.

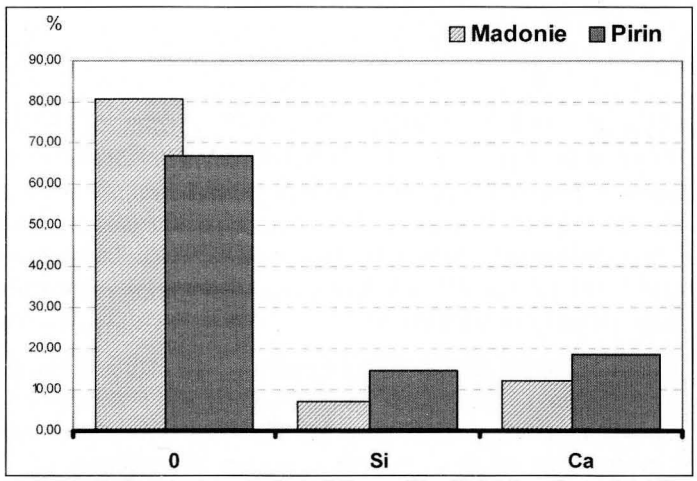

Fig. 4. Attitude to basic rock. 0 - indifferent; Si - siliciphiles; Ca - calciphiles.

Results and discussion

For the Flora of Banderica valley (North Pirin Mt.) are reported 828 taxa of vascular plants (excluding Bryophyta) – 804 species and 24 subspecies. They belong to 319 genera and 78 families - the richest of them are presented in Table 1. For the Flora of river Castelbuono valley (Madonie Mt.) are reported 1187 taxa of vascular plants (excluding Bryophyta) – 1176 species and 11 subspecies belonging to 465 genera and 105 families - the richest of them are presented in Table 1.

Species abundance calculated for given area is one of the central questions in comparative floristic. There was proposed different methods for calculating the number of species per unit area (Arrhenius 1920; Gleason 1922; Vestal 1949; Evans & al. 1955; Preston 1962; Williams 1964; Tjorve 2003; etc.). Calculation of this value depends from the species abundance from one side and floristic heterogeneity from other. For correct estimation of this parameter is essential the way of choosing and the extension of the sampled area.

Analysis of the floristic richness of the local, "elementary" *sensu* Tolmachev (1986), floras based on floristic inventory is of particular interest for phytogeography because it is the only known direct way for estimation of species/area relationship. For the standard area size for small floras is widely accepted value of 100 km^2 (Malyshev 1991). For the South Europe, the same author calculates floristic richness as 700-1000 species per 100 km^2. Our data support this values considering from one hand that the sample areas is quite equal of 100 km^2 and the species number is in the interval 700-1000 from other. The value for Madonie Mt. is slightly higher probably due to the lower altitude of the mountain and interruptions of the vegetation belts because of the anthropic influence which permit to the not typically mountain species to rich higher altitude. Other important factor to take in consideration to explain this value is the Mediterranean climate that favorite the more large altitudinal interval of some species.

This is supported also by calculation of the similarity (Jaccard) coefficient equal to 0,12 taking in consideration the all species and 0,14 calculated without species with distribution favored by the anthropic factor. In second case from the calculation are excluded 314 not-Mediterranean species reaching relatively high altitude in the flora of Castelbuono River and present in the flora of Pirin Mt. at lower altitude (under 1000-1200 m. a.s.l.). The Jaccards coefficient demonstrates in any case very low value, considering that it is not less than 0,34 comparing some local mountain floras from Moesian provinces (Andreev 1989).

This because, at first place, of different floristic regions where are placed studied areas and different origin of the floras.

For comparison of both lists at family level is applied the method of taxonomic spectra – descending order from more rich to monotypic for the studied floras families. As demonstrated by Khokhryakov (2000) of primary significance are the place of the first 3 or 6 families and in these level taxonomic spectra could be confronted without particular statistic approach. In both floras (Table 1.) *Asteraceae* and *Poaceae*, as families with high number of species in the Euro-Asiatic floras, occupies the first two places. In the flora of North Pirin Mt. *Rosaceae* is at relatively high position and in flora of Madonie Mt. in same position is placed *Fabaceae*. In first case the high position of *Rosaceae*, characteristic for Central Balkans mountain floras (Uzunov & Gussev 2003) is due to the high number of species belonging to genus *Alchemilla* completely absent in flora of Sicily. The third position (and high number of species) of *Fabaceae* in second case is significant for Mediterranean

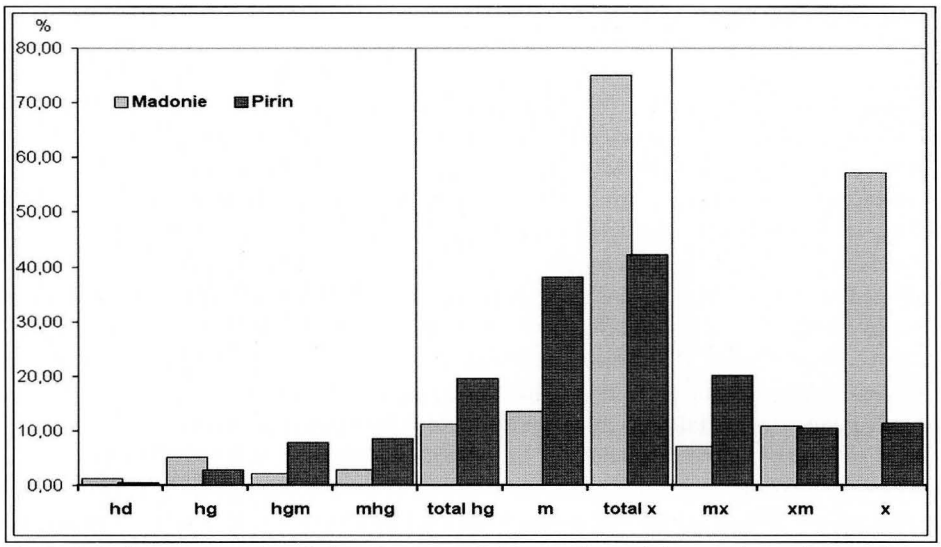

Fig. 3. Attitude to water regime. (hd) hydrophytes; (hg) hygrophytes; (m) mesophytes; (x) xerophytes; (hgm) hygro-mesopytes; (mhg) meso-hygrophytes; (mx) meso-xerophytes; (xm) xero-mesophytes. total hg = hd+hg+hgm; total x = mx+xm+x.

character of the flora taking in consideration that Mediterranean region is a central of origin of different genus belonging to this family. In the spectrum 2 families (written in expanded)

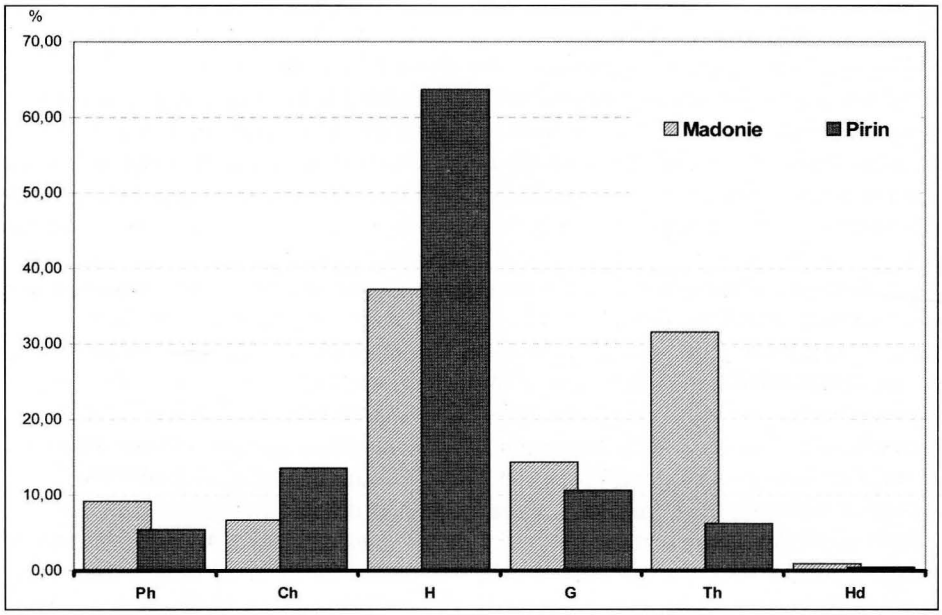

Fig. 5. Life form spectrum. H hemicryptophytes; G geophytes; Ch chamaephytes; Th therophytes; Ph phanerophytes; Hd hydrophytes.

Table 1. Taxonomic spectra at genus and families level.

Genera

PIRIN			MADONIE		
Position	Genera	N sp	N sp.	Genera	Position
1	Carex	20	29	Trifolium	1
2	Saxifraga	18	20	***Allium***	2
3	***Hieracium***	15	19	Galium	3
4\5	Silene	14	19	***Vicia***	4
	Alchemilla	14	16	Carex	5
6	Festuca	13	16	Ranunculus	6
7\8\9	***Campanula***	12	15	Silene	7\8\9
	Ranunculus	12	13	***Bromus***	
	Veronica	12	13	***Rumex***	
10\16	***Centaurea***	11	12	***Orchis***	10
	Cerastium	11	11	***Euphorbia***	11\12\13
	Trifolium	11	11	Geranium	
	Potentilla	11	11	Juncus	
	Viola	11	10	***Quercus***	14\15\16
	Luzula	11	10	***Rosa***	
	Poa	11	10	Sedum	
					17\18\19\2
17\18\19	***Achillea***	10	9	Cerastium	0
	Myosotis	10	9	Festuca	
	Sedum	10	9	Poa	
20\21	Geranium	9	9	Veronica	
	Euphrasia	9	8	***Lathyrus***	21\23
22\23	Galium	8	8	***Medicago***	
	Juncus	7	8	Saxifraga	

Familia

PIRIN			MADONIE		
Position	Familia	N sp.	N sp.	Familia	Position
1	Asteraceae	102	133	Asteraceae	1
2	Poaceae	59	119	Poaceae	2
3	Caryophyllaceae	52	106	Fabaceae	3
4	ROSACEAE	48	64	Caryophyllaceae	4\5
5	Fabaceae	40	64	BRASSICACEAE	
6	SCROPHULARIACEAE	39	52	LAMIACEAE	6\7
7	Brassicaceae	38	52	Apiaceae	
8	Lamiaceae	36	48	Liliaceae	8
9\10	Cyperaceae	27	46	Rosaceae	9
	Apiaceae	27	36	Scrophulariaceae	10
11	Ranunculaceae	23	35	Orchidaceae	11
12	***Saxifragaceae***	22	32	Rubiaceae	12
13	Boraginaceae	20	26	Ranunculaceae	13
14\15\16	Orchidaceae	18	25	Cyperaceae	14
	Liliaceae	18	22	Boraginaceae	15
	Juncaceae	18	19	***Polygonaceae***	16
17	Campanulaceae	17	15	Geraniaceae	17
18\19	Crassulaceae	14	14	Juncaceae	18\19
	Rubiaceae	14	14	***Euphorbiaceae***	
20	Primulaceae	12	12	***Fagaceae***	20\21
21\22\23	***Dipsacaceae***	10	12	Crassulaceae	
	Gentianaceae	10	10	Primulaceae	22\23
	Geraniaceae	10	10	Campanulaceae	

did not reach the sixth position respectively for North Pirin and Madonie Mts. instead 3 are different in the spectra of 23 families.

For more detail analysis of the similarity is calculate the rank correlation index – τ (Kendall 1938, 1975) that show value of 0,66. In calculation are included the first 71 families common for both floras from 117 in total. This value is relatively high if it is taken in consideration that for some mountain floras in Moesian floristic province (Andreev 1989) this value is between 0,6 and 0,8 and only comparing local floras from the same mountain reach 0,9.

This fact could be explained by the mountain character of both floras, where different genera/species but from the same families contribute to the species richness. In fact, considering genera spectrum (Table 1) from 23 genera in first places only 13 are common for the compared floras. The high differences in the genera spectrum of both floras is demonstrated as well as by low value of rank correlation index equal of 0,13 where in comparison, for satisfy the condition of presence of the same genera in compared spectra, are included 302 genera (almost all genera from North Pirin Mt. flora) from 647 in total and genus *Alchemilla* is not considered.

Principal differences of the compared floras are seen also by analysing ecological and biological characteristics. Altitudinal distribution of the taxa by vegetation zones is presented in Figure 2. The tendency of decreasing the species number in altitude and the way of this decrease is quite the same in both cases. It seems that this characteristic

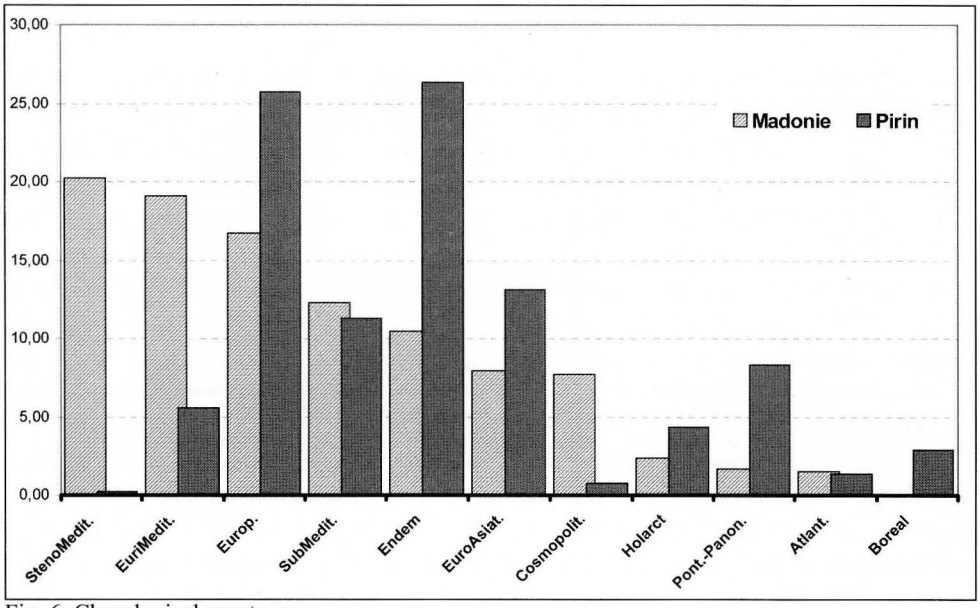

Fig. 6. Chorological spectrum.

determinate by ecological factors is constant for Mediterranean and Sub-Mediterranean floristic regions. The Madonie Mt. flora could be considered xerophytic while those of North Pirin Mt. Mesoxerophytic even that tendency of xerophytisation is well demonstrated (Fig. 3). In both floras the species indifferent to the basic rock are prevalent (Fig. 4) but the mountain flora of North Pirin is more specialized for the substrata. Life form spectrum (Fig. 5) shows prevalence of hemicryptophytes in both cases. The differences in the first place are in the high percentage (31,61%) of therophytes in the flora of Madonie Mt. (Mediterranean type flora) while for the flora of North Pirin Mt the same life form shows value of 6,21% mainly due to the species whit distribution favoured by the man.

Analysis of the geoelements spectrum (Fig. 6) shows the different chorological structure and different origin of both floras. Mediterranean and Central European for the flora of Madonie Mt. and Central European and Sub-Mediterranean for North Pirin Mt. Other peculiarities are connected with percentage of the endemic species. More than double value for the Balkan endemic species in comparison with South Italian (including Sicilian) endemics mirrors the different way of genesis of both floras. The flora of Madonie Mt. is a synthesis of Mediterranean species (40,30%) adapted to the mountain ecological conditions, which together whit Central European (16,72%) and endemic (10,45%) taxa forms about 70% (67,47%) of all species. Instead the flora of North Pirin Mt. is modified Central European flora with high level of Sub-Mediterranean (Sub-Mediterranean + Balkan endemics reach 37,74%) species and well-demonstrated Asiatic influence (EuroAsiatic + Pontic-Pannonic forms 21,44%). Local endemism of both floras is quite equal: 1,60% for Madonie Mt. and 1,45% for North Pirin Mt.

Conclusion

Presented data show that flora of Madonie Mt. is richer than North Pirin Mt. one due to the lower altitude of the mountain, higher anthropic influence and Mediterranean climate that favorites more large altitudinal interval of the species. For comparison of the floristic composition is calculated the Jaccard coefficient of similarities that shows value of 0,14 which is rather low because of the different floristic regions where studied areas are situated and different origin of the floras.

In taxonomic spectrum of the two floras *Asteraceae* and *Poaceae* are in the first position.

Main differences are demonstrated by analyzing the third position occupied by *Rosaceae* in the case of North Pirin Mt. and *Fabaceae* in the case of Madonie Mt. Three families; respectively *Saxifragaceae*, *Dipsacaceae* and *Gentianaceae* are not presented in the spectrum of Madonie Mt. and *Polygonaceae*, *Euphorbiaceae* and *Fagaceae* in the spectrum of North Pirin Mt. The rank correlation index – τ shows value of 0,66 that is relatively high and indicate high similarities at families level. The same index for genera spectrum shows a low value (0,13) because of different taxonomic composition at genus and species level. In fact some genera (*Alchemilla*, *Gentiana*, *Pinus*, etc.) well presented in North Pirin Mt. completely lack in the flora of Madonie Mt. and others (*Ophris*, *Valerianella*, *Vulpia*, etc.) presented in flora of Madonie lack in North Pirin. Only 13 from the 23 richer are common and at the first 6 places only one – *Carex*.

Hemicryptophytes are the dominating life form, characteristic for the floras of Temperate zone. Differences are in the high percentage of Therophytes and Geophytes in Madonie Mt. flora because of Mediterranean climatic conditions. This could be seen also from the results from the analysis of the attitude of the species to the water regime – in Madonie xerophytes dominate and in North Pirin mesophytes. Vertical distribution and attitude to the basic rock of the species in both mountains shows similar characteristics.

Analysis of chorological spectra shows high percentage of Mediterranean species in Madonie Mt. flora and Sub-Mediterranean (including Balkan Endemics) in the flora of North Pirin Mt. Because of the mountain characters of the floras European geoelement is well presented. Both floras are characterized by high percentage of regional endemics and quite equal percentage of local endemism.

Situated in the center of Mediterranean floristic region Sicilian mountain flora is composed mainly by species with Mediterranean distribution (including regional endemics) from one hand and species originated in Central Europe but with more large distribution (Sub-Central European) from other. The flora of North Pirin Mt. instead is a modified Central European mountain flora with high percentage of Sub-Mediterranean (included regional endemics 37,64%) species and well-manifested eastern influence.

The comparative analysis of both mountain floras, revealing their peculiarities supports the phytogeographic division of Europe in which Sub Mediterranean zone is accepted as a different floristic region, placed between Mediterranean and Central European regions. To clarify the relations and the origin, to precise the variation of floristic diversity and the

exact limits between Mediterranean and Sub Mediterranean Mountain floras further research is necessary.

Acknowledgements

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