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# High mountain flora of Bulgaria – Statistics, ecological characteristics and phytogeography

**Abstract**

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The flora of 11 Bulgarian mountains, representing about 80% of total area of *Balkan-Rhodope mountain system* is analysed. In calculation are included 2018 taxa with populations in altitude range 1000 – 2925 m. Vertical distribution of the flora is valuated using altitudinal steps of 500 m. Hypsometric interval of 1000 – 2000 m shows more or less constant number of species (ab. 1300) and diversity decreases in altitude with about 400 taxa in every 500 m reaching value of 257 species in the highest part of the mountains. Indifferent species to basic rock prevails (62%) but flora on limestone terrains is 11% richer than that one on silicate. More than 50% of the species prefers terrains with moderate humidity and about 30% are xerophytes. Hemicryptophytes represent 60% of all species and other life forms show quite equal values (geophytes 10,1%, chamaephytes 10,0%, therophytes 9,8% and phanerophytes 9,0%,). Analysis of the chorological spectra shows prevalence of European chorotype 26,9% followed by Balkan endemics 23,4%, Euro-Asiatic 13,2% and Sub-Mediterranean 11,1% species. All other chorological groups are less than 10% and all together represent 25,3% of the all species.

## Introduction

High mountain ecosystems representing "islands" of wild nature are object of different phytogeographic studies aiming to describe the patterns of mountain flora diversity and suggest causes for these pattern; to develop a framework for predicting how biodiversity may change; and to discuss the ecosystem consequences of biodiversity changes. Aim of the study is to frame the main characteristics of high mountain flora of Central Balkans – taxonomic diversity, ecological structure and phytogeography.

## Studied area

To separate mountain areas from different upland regions of Bulgaria are used the following criteria: geographic (massifs reaching altitude at least 1500 m and having local mountain climate), vegetation (presence of beech, coniferous, sub-alpine and/or alpine vegetation zone) and floristic (presence both of *Fagus sylvatica* and *Picea abies*). Following these criteria the flora of 11 mountains is analyzed: 1. Stara Planina Mt.; 2.

Vitosha Mt.; 3. Osogovska Mt.; 4. Vlahina Mt.; 5. Malashevska Mt.; 6. Belasica Mt.; 7. Slavianka Mt.; 8. Pirin Mt.; 9. Rila Mt.; 10. Sredna Gora Mt.; 11. Rhodope Mt. (Fig. 1). The study covers altitudinal range 1000 – 2925 m a.s.l. and area about 22 000 km$^2$ representing more than 80% of total area of Balkan-Rhodope mountain system (Stevanović 1996).

In the studied territory four vegetation zones (Bondev 1998) are present (Fig. 1):

ZONE OF THE BEECH FORESTS: Developed from 900 - 1000 up to 1300 - 1500 m a.s.l. formed by communities of *Fagus sylvatica*. Beech forests are often mixed with *Pinus nigra* subsp. *pallasiana*, *Carpinus betulus*, *Pinus sylvestris*, *Abies alba* and in the upper part of the zone with *Picea abies*.

ZONE OF THE CONIFEROUS FORESTS: Developed from 1300 - 1600 up to 2000 - 2200 m a.s.l. formed by *Pinus sylvestris*, *Picea abies*, *Pinus peuce* on silicate terrains and *Pinus heldreichii*, *Pinus nigra* subsp. *pallasiana* on limestone.

SUB-ALPINE ZONE: from 1900 - 2000 up to 2400 - 2500 m a.s.l. characterised by *Pinus mugo* and *Juniperus communis* subsp. *alpina*. The herbaceous communities on calcareous terrains are formed by *Festuca penzesii*, *Sesleria coerulans*, *S. rigida*, etc. and on silicate by *Festuca valida, F. paniculata*, *Nardus stricta*, *Poa media*, *P. alpina*, *Bellardiochloa violacea*, *Agrostis capillaris*, etc.

ALPINE ZONE: above 2400 - 2500 m. Calcareous terrains are dominated by communities of *Sesleria coerulans*, *S. korabensis*, *Dryas octopetala*, *Salix reticulata*, etc. and on silicate

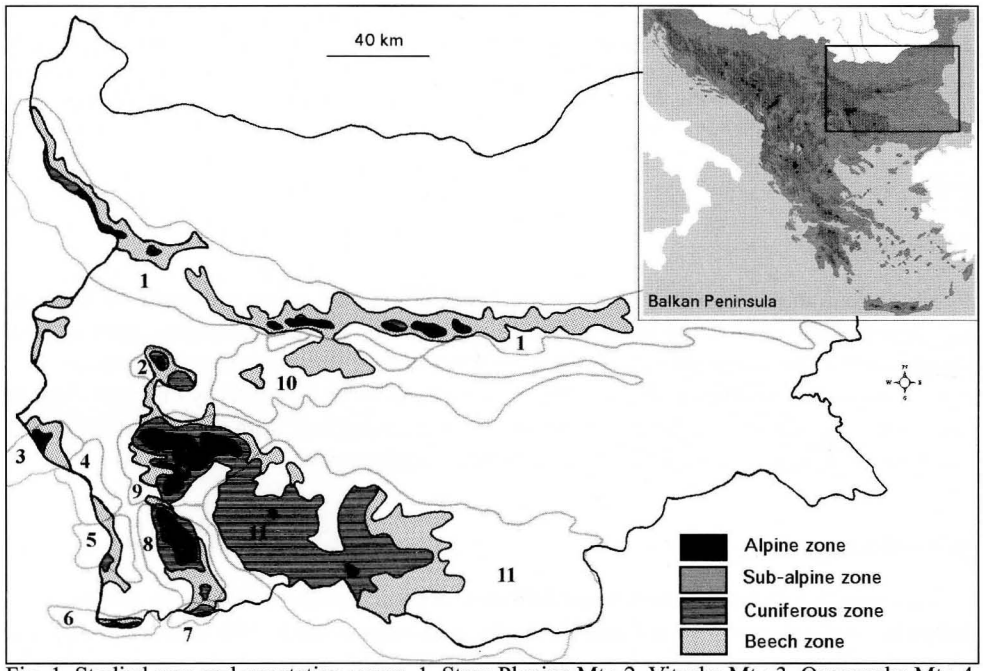


Fig. 1. Studied area and vegetation zones. 1. Stara Planina Mt.; 2. Vitosha Mt.; 3. Osogovska Mt.; 4. Vlahina Mt.; 5. Malashevska Mt.; 6. Belasica Mt.; 7. Slavianka Mt.; 8. Pirin Mt.; 9. Rila Mt.; 10. Sredna Gora Mt.; 11. Rhodope Mt. Gray lines show geographic boundaries of the mountains.

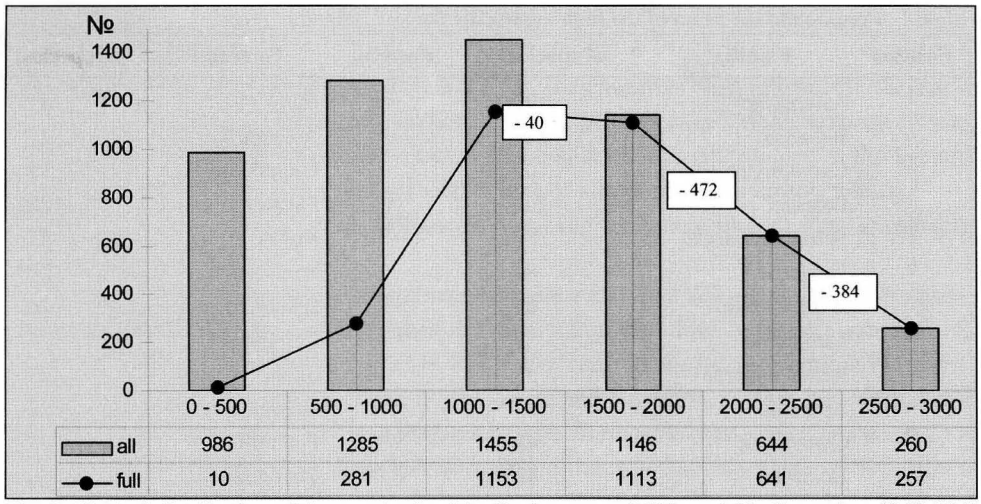


Fig. 2. Vertical distribution of the species in altitudinal ranges of 500 m. (all) all species; (full) "full member" only.

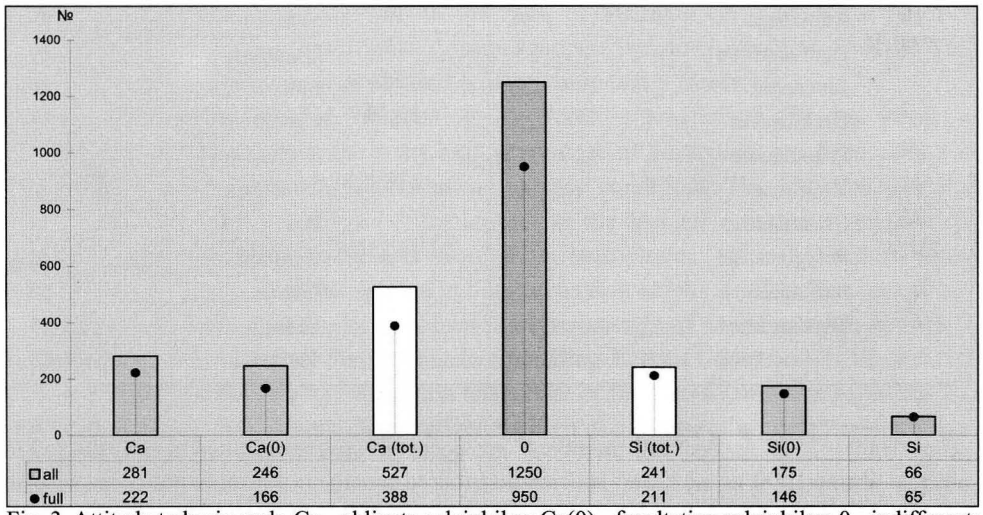


Fig. 3. Attitude to basic rock. Ca - obligate calciphiles; Ca(0) - facultative calciphiles; 0 - indifferent; Si - obligate siliciphiles and Si(0) - facultative siliciphiles. Ca(tot.) = Ca + Ca(0), Si(tot.) = Si + Si(0). (all) all species; (full) "full member" only.

by *Carex curvula*, *Agrostis rupestris*, *Festuca airoides*, *Sesleria comosa*, *Juncus trifidus*, *Vaccinium uliginosum*, etc.

## Material and methods

In calculation are included all species and subspecies with population in the altitude

Table 1. Taxsonomic spectrum of the high mountaim flora of Bulgaria.

| Position | Familia | ¹ of species | Position | Genera | ¹ of species |
|---|---|---|---|---|---|
| 1 | Asteraceae | 190 | 1 | Carex | 41 |
| 2 | Rosaceae | 129 | 2/3 | Alchemilla | 35 |
| 3 | Caryophyllaceae | 103 | | Hieracium | 35 |
| 4 | Poaceae | 102 | 4 | Festuca | 28 |
| 5 | Scrophulariaceae | 87 | 5/6 | Rubus | 27 |
| 6 | Fabaceae | 80 | | Saxifraga | 27 |
| 7 | Brassicaceae | 63 | 7 | Ranunculus | 26 |
| 8 | Lamiaceae | 59 | 8/9 | Campanula | 24 |
| 9 | Ranunculaceae | 55 | | Silene | 24 |
| 10 | Apiaceae | 51 | 10 | Veronica | 22 |
| 11 | Cyperaceae | 49 | 11 | Potentilla | 21 |
| 12 | Liliaceae | 42 | 12/13/14/15 | Centaurea | 20 |
| 13 | Saxifragaceae | 33 | | Galium | 20 |
| 14 | Campanulaceae | 32 | | Trifolium | 20 |
| 15 | Boraginaceae | 29 | | Viola | 20 |
| 16 | Rubiaceae | 28 | 16 | Senecio | 19 |
| 17/18/19 | Gentianaceae | 25 | 17 | Dianthus | 17 |
| | Juncaceae | 25 | 18 | Salix | 16 |
| | Orchidaceae | 25 | 19/20 | Cerastium | 15 |
| 20 | Primulaceae | 22 | | Verbascum | 15 |
| 21 | Violaceae | 20 | 21/22 | Minuartia | 14 |
| 22 | Crassulaceae | 18 | | Poa | 14 |
| 23/24 | Polygonaceae | 17 | 23/24/25/26 | Gentiana | 13 |
| | Salicaceae | 17 | | Luzula | 13 |
| 25 | Dipsacaceae | 16 | | Sedum | 13 |
| | | | | Thymus | 13 |

range 1000 – 2925 m. As "full members" are accepted species exclusively distributed in altitude above 1000 m a.s.l. and species distributed mostly in the mountains but also in hilly regions. Other species with population mainly in hilly regions and lowland but reaching also high altitude are considerate as "associate members".

As taxonomical base are used Flora na Republika Balgarija, 1-10 (Jordanov 1963) and Opredelitel na vishite rastenija v Balgaria (Kozuharov & al. 1992). Taxa belonging to genera *Hieracium* and *Taraxacum* are accepted *sensu lato* after Flora Europaea (Tutin & al. 1976).

Vertical distribution of the flora is valuated using altitudinal steps of 500 m summarizing data mainly from Guide of the Higher Plants in Bulgaria (Kozuharov 1992) with many modifications of the authors. Distribution of the species on calcareous or siliceous terrains is assessed using 5 categories (Fig. 3): **Ca** - obligate calciphiles; **Ca(0)** - facultative calciphiles; **0** - indifferent; **Si** - obligate siliciphiles and **S(0)** - facultative siliciphiles. For iden-

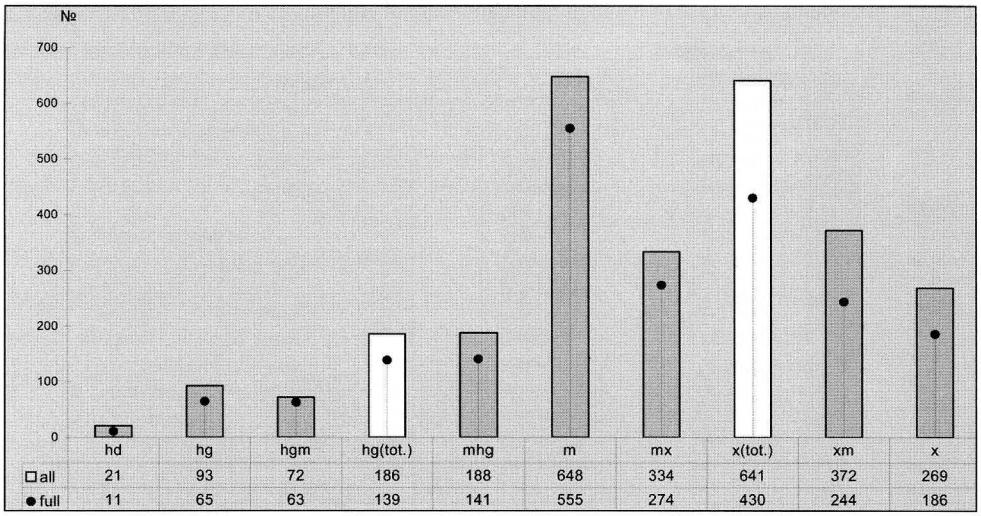


Fig. 4. Attitude to water regime. (hd) hydrophytes; (hg) hygrophytes; (m) mesophytes; (x) xerophytes; (hgm) hygro-mesopytes; (mhg) meso-hygrophytes; (mx) meso-xerophytes; (xm) xero-mesophytes. hg (tot.) = hd+hg+hgm; x (tot.) = xm+x. (all) all species; (full) "full member" only.

tification of moisture-reaction category (Fig. 4) are used 4 main group – hydrophytes (**hd**) species permanently immersed; hygrophytes (**hg**) requiring very wet substrata; mesophytes (**m**) living in places with moderate soil humidity and xerophytes (**x**) living in places where water is scarce and 4 intermediate groups as well as – hygro-mesopytes (**hgm**), meso-hygrophytes (**mhg**), meso-xerophytes (**mx**), xero-mesophytes (**xm**) for species with more large ecological characteristics (or in few cases with uncertain data). Identification of the life forms is after Raunkiaer (1934). For identification of ecological characteristics and life forms are used data available in different Floras and Field Guides (Jordanov 1963; Josifovic 1970; Beldie 1977; Pignatti 1982; Kozuharov & al. 1992; Laubert & Wagner 1996) in many floristic, phitogeographical and phytocoenological publications as well as in several thematic papers (Andreev 1989; Kojic & al. 1997; Uzunov 1997; Velchev 1998). Literature data were valuated critically according to observation of the authors from different field studies.

The appurtenance of each species (subspecies) to a corresponding floristic element was determined according to Walter (1954) and Walter & Straka (1970). For generalization and final presentation of chorological types was used modified classification schema after Andreev (1989) where 11 "classes" are present (Fig. 6): Cosmopolitan (**CO**); Holarctic (**HO**); Arctic with one group arctic-alpine (**AR**); Boreal (**BO**); Palearctic with one group Euro-Asiatic (**EA**); European (**EU**) with two groups Central and Sub-Central European (**eu**) and Central and Sub-Central European Mountain (**eum**); Balkan (**BA**) with four groups Balkan (**ba**); Balkan Orophytic (**bao**), Balkan Endemic to Studied Area (**bae**) and Sub-Balkan (**sba**); Atlantic (**ATL**) with one group Atlantic Sub-Mediterranean; Mediterranean (**M**) with two groups Mediterranean (**me**) and Sub-Mediterranean (**sme**); Pontic (**PO**) and Irano-Turanian (**IT**).

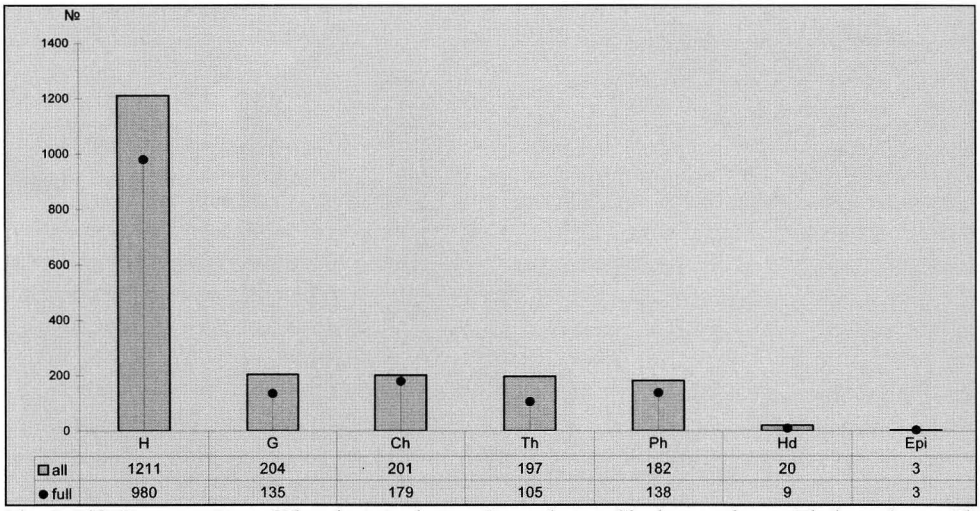


Fig. 5. Life form spectrum. H hemicryptophytes; G geophytes; Ch chamaephytes; Th therophytes; Ph phanerophytes; Hd hydrophytes; Epi Epiphytes. (all) all species; (full) "full member" only.

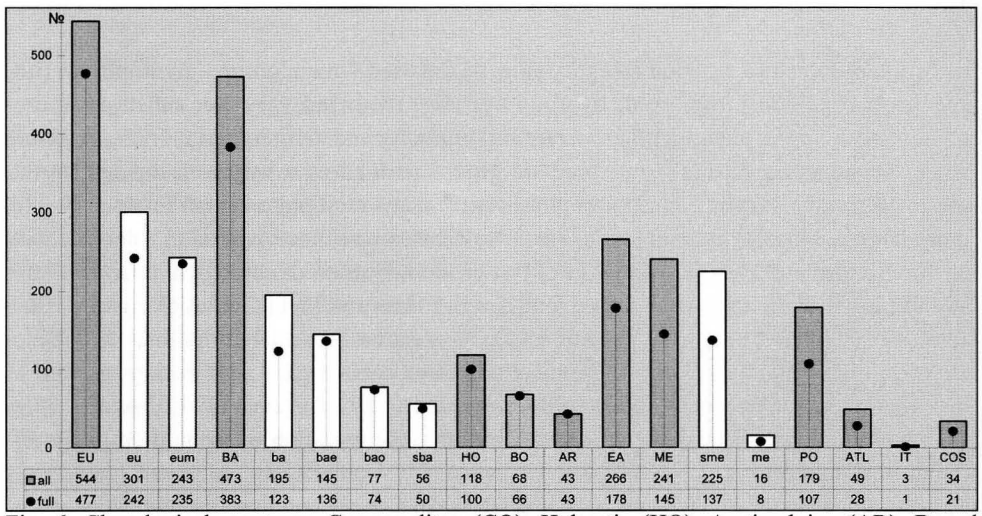


Fig. 6. Chorological spectrum. Cosmopolitan (CO); Holarctic (HO); Arctic-alpine (AR); Boreal (BO); Euro-Asiatic (EA); European (EU); Central and Sub-Central European (eu); Central and Sub-Central European Mountain (eum); Balkan (BA); Balkan (ba); Balkan Orophytic (bao); Balkan Endemic to Studied Area (bae); Sub-Balkan (sba); Atlantic Sub-Mediterranean (ATL); Mediterranean (ME); Mediterranean (me); Sub-Mediterranean (sme); Pontic (PO); Irano-Turanian (IT). (all) all species; (full) "full member" only.

## Results and discussion

For the area under study was calculated 2018 taxa of vascular plants (excluding Briophyta) – 1826 species and 192 subspecies. "Full members" are 1549 taxa (1388

species and 161 subspecies) in which 728 taxa (670 species and 58 subspecies) exclusively distributed in mountains and 821 taxa (718 species and 103 subspecies) distributed mostly in the mountains but also in hilly regions. "Associate members" are 469 taxa (438 species and 31 subspecies).

Taxonomic structure of the flora, taking in consideration "full members" only, includes 405 genera and 96 families the most rich of them presented in Table 1. In this way 59 genera and 9 familia including only "associate members" are excluded from calculations.

Distribution of the number of species in altitudinal steps of 500 m shows differences in the way of changing of this value taking in consideration all species or "full members" only (Fig. 2). In the first case hypsometric zone 0 – 1500 is much more rich of species due to concentration of "associate members" in this zone. In the second case hypsometric interval of 1000 – 2000 shows more or less constant number of species about 1300 taxa. In following elevation ranges, the species number decreases with about 400 taxa in every 500 m (1113 taxa in 1500-2000 and 641 taxa in 2000-2500) reaching value of 257 species in the highest part of the mountains. The way of decreasing of species richness reflects the zonation of mountain vegetation – constant number of species for forest zones and decreasing in higher elevations.

Distribution of the species in habitats with different basic rock (Fig. 3) shows prevalence of indifferent species and flora on limestone terrains richer than those on silicates. It is interesting to note 14% of differences [%Ca(tot.) minus %Si(tot.)] taking in consideration all species and 11% for "full member" only. Higher percentage in the first case mirrors peculiarity of lowland chasmophyte calcifiles often reaching high altitudes.

In accordance with climatic conditions, region belongs to Temperate Continental bioclimatic sub-region (Rivas-Martinez 1996), mesophyte species (**m** + **mhg** + **mx**) are the most numerous groups (58,0% all species and 62,6% "full members" only) followed by xerophytes (**x** + **xm**) 31,8% for all species and 27,8% for "full members" only.

Analysis of life form spectrum shows typical for temperate climate zone, dominance of hemicryptophytes (60%) and more or less equal presence of other life forms (geophytes 10,1%, chamaephytes 10,0%, therophytes 9,8%, phanerophytes 9,0%,) except hydrophytes 1,0% and epiphytes 0,1%. The same proportions are kept also in spectrum of "full members" but percent of chamaephytes (1,6% more) and hemicriptophytes (3,3% more) increase instead percentage of therophytes (3,0% less) and geophytes (1,4% less) decrease.

Analysis of the chorological spectrum (Fig. 6) taking in consideration all species shows prevalence of European 26,9% (14,9% for forest group and 12,0% for alpine group) and Balkans 23,4% (9,7% Balkan peninsula endemics, 7,2% distributed in mountains of Balkan peninsula, 3,8% endemic to Balkan-Rhodope mountain system and 2,8% subendemic species) followed by Euro-Asiatic species - 13,2 % and Mediterranean (11,1% Sub-Mediterranean and 0,8% of Mediterranean group). All other chorotypes are less than 10% and all together form 25,3% of species richness. Species with distribution in Pontic region and Central Asia represent a relatively high percentage - 179 (8,9%). Nordic chorotype (Holarctic, Boreal and Arctic-Alpine) is presented by 229 taxa (11,3%). Taking in consideration "full members" only except Arctic-Alpine floristic element, all other loose members but trends remain quite a same. Some changes could be seen in decreasing percentage of Sub-Mediterranean (2,3% less), Pontic (2,0% less) and Euro-Asiatic (1,7% less) and increasing percentage of European (3,8% more), Balkan (1,3% more) and Nordic (2,1% more) floristic element.

## Conclusion

Mountain flora of Bulgaria consists of 728 species and subspecies distributed exclusively in altitude above 1000 m a.s.l. and 821 species and subspecies distributed mainly in mountains.

Species diversity decreasing in altitude with about 400 species in every 500 m a.s.l.

More rich is flora on limestone rock substrate. Plants inhabiting terrain with moderate humidity are more numerous but tendency of xerophytisation of the flora is well demonstrated. Predomination of hemicryptophytes determinates studied flora as temperate – mountain. Chorological spectrum shows that studied flora is a characteristic synthesis of species with Central European and Sub-Mediterranean (including Balkan peninsula endemic species) distribution and connections with floras of Asiatic mountains and Boreal and Arctic regions.

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