Contribution to Rock Flora of the "Bentbaša" Protected Area (Canton Sarajevo, Bosnia and Herzegovina)

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Abstract: Between 2013 and 2018, floristic research of rock ecosystems was carried out in the protected area of Bentbaša, i.e., in the canyon of the Miljacka River. A total of 225 species with two subspecies and one form were identified. The largest number of species was found in the *Asteraceae* family (30 species). Most species belong to the orders of *Brometalia erecti* and *Amphoricarpetalia*. As for indicator values, most species belong to the secondary and primary types of vegetation. Most of the species identified are conventionally hemicryptophytes, and the most important floral element is submediterranean. The most widespread species in the investigated area are: *Thymus praecox* subsp. *jankae* (Čelak.) Jalas, *Micromeria thymifolia* (Scop.) Fritsch, *Asplenium trichomanes* L., *Melica ciliata* L. and others, while the rarest plants are *Onosma stellulatum* W. K., *Malcolmia illyrica* (Halacsy) Hay., *Ajuga chamaepithys* L., *Frangula rupestis* L., etc. In the investigated area, 8 species from the "List of plant species (*Pteridophyta* and *Spermatophyta*) for the Red Book of Bosnia and Herzegovina" were recorded in the category of vulnerable species (V). Also, 9 species are onthe "Red List of Flora Federation Bosnia and Herzegovina, and recorded in the following categories: DD-1, LC-2, NT-1, VU-2, EN-2 and CR-1 species. Eventually, there are also floristic data on individual sides with all the relevant parameters. From a scientific side, this paper gives a specific approach to research: comparative data in researching different sides of the canyon, the comprehensiveness of research: flora under influence different ecological factors and given new fitocenological provisional units; new association *Asplenio ruta-murariae-Saxifragetum aizoon* comb. nov. prov. and facies *Ceteratosum officinarii* comb. nov. prov.

Keywords: flora, rocks, canyon, Miljacka, "Bentbaša" protected area, hemicryptophytes

INTRODUCTION

GENERAL INFORMATION ABOUT ROCK FLORA

Today, the canyons are refugiums for many plant species that managed to survive unfavorable conditions during the period of glaciation. Because of that, the canyons are very rich in rare and endemic plant species, especially in rock flora. Unfortunately, in Bosnia and Herzegovina, besides the Una River canyon, which has been comprehensively studied (Lakušić et al., 1991; Lakušić & Redžić, 1991; Stefanović, 1991; Dizdarević, 1991; Pavlović, 1991; Đug & Redžić, 1991; Redžić, 1991a; Mišić, 1991; Vagner, 1991; Hafner, 1991; Šoljan, 1991), as well the canyon of the Drina River and some of its tributaries (Lakušić & Redžić, 1989), flora and vegetation in other canyons is mainly unexplored.

Plants that grow in rock fissures are called chasmophytes (gr. *khásma*-abyss, fissure and *phytón*-plant, Lakušić, 1990). Chasmophytes most often inhabit exposed places with the most pronounced influence of various ecological factors such as intense solar radiation, wind, temperature, as well as very specific natural habitats with large slopes and scarce and undeveloped soil (Janković, 1963). This results in a whole series of characteristic morphoanatomical adaptations, primarily leaves. Of these morpho-anatomical adaptations, the most important are: the presence of hairs, stunted growth, leaf cover with specific hairs, indumentum built from long glandular hair (Šilić, 1990), etc. Chasmophytes are well adapted to unfavorable external conditions, and in particular to physiological and physical drought. They mostly inhabit limestone, then dolomite and dolomitized limestone. In the Alps, they also inhabit fissures in silicate rocks (Horvat, 1949). Chasmophytes are very often heliophytes, but also sciophytes and semi-sciophytes. The occurrence among some species is interesting, wherethe populations living at high altitudes are heliophytes and the ones at lower altitudes are sciophytes or semi-sciophytes, e.g. *Edraianthus sutjeskae* Lkšić (Lakušić, 1990).

Vegetation in rock fissures forms a special order of *Asplenietea rupestris* (H. Meier) Br.-Bl. Plant communities in rock fissures represent permanent stages conditioned by the rock structure, meaning that these communities, as well vegetation, are of primary character. Jovanović & Jovanović-Dunjić (1986) point out that plants of shady forests and moist habitats are related communities, especially from the surrounding meadows and forests, can be found on rock terracesas well. Likewise, many weed species are able to colonize on terraces. It is important to mention that numerous chasmophytes are found not only in the Bosnian Herzegovinian but also in many European Red books of endangered plant species.

Finally, vegetation in rock fissures often shows significant differences, not only from one forest massif to another, but often rocks, as well, differ on the same mountain range (Horvat 1934) and they have a great variability of habitats, microclimate, and pedological factors on them (Lakušić 1968). Such differences can also be observed in the investigated area.

DESCRIPTION OF THE INVESTIGATED AREA

The investigated area is located to the east of Sarajevo and extends from the area of Bentbaša to Kozija ćuprija. On the northern side of the investigated area, there are no rock terraces, the plant life of the rocks is much poorer, as more favorable conditions are created in these areas. Firstly, it is the accumulation of larger quantities of calcomelanosol and a more favorable water regime. Because of that, plants from other phytocoenological orders often grow on specific microhabitats (terraces or hidden faults between the rocks) in which they find the minimum necessary conditions for their existence. They extend from the extreme slopes beneath Bijela tabija, Obhodža (including the rocks of Dariva), Borija, and Hrastova Glavica, to somewhat before Kozija ćuprija bridge. In the southeast, the investigated area is located in Močila settlement area in Sarajevo and below Jarčedol and Popov gaj and it extends up to the borders of the Canton of Sarajevo, i.e., some what to the east of Kozija ćuprija. In fact, this area represents the northeastern slopes of Trebević mountain. The investigated area is situated between 43° and 44° N longitude and between 18th and 19th E latitude (Fig. 1).

The Miljacka canyon belongs to the climate type marked as Cfb, which means moderately warm and rainy climate with warm summers and without a dry season (Đug et al., 2008). The average monthly temperature of the warmest month of the year ranges from 15°C to 22°C, at least four months have an average monthly temperature of ≥ 10°C, an average monthly temperature of the coldest month is always > -3.0°C, the annual temperature amplitude ranges from 12°C to 22°C, annual precipitation ranges from 700 to 1200 mm of rain, evenly distributed throughout the year (Drešković, 2003). Likewise, the influence of the real Supra-Mediterranean and distant steppe regions is felt in this area (Redžić, 1997b).

The wind is one of the important factors for the formation of vegetation and most often it is in the immediate function of determining the appearance (physiognomy), as well as the structure and certain shapes of vegetation dynamics (Redžić, 1991). The direction of winds in the Miljacka canyon is ENE-WSW. During the day and most of the year, the prevailing direction in the Miljacka canyon is ENE (Drešković, 2003).

Frost is a very important ecological factor for vegetation development. It is formed by the evaporation of wet soil layers (Horvat, 1949). According to Milosavljević (1970), the investigated area belongs to the area with 21-30 average days of frost in the period of vegetation (March-October) and with a maximum of 3-4 days of frost in the period when vegetation has mostly lush character (May). The same author (Milosavljević, 1970) states that the degree of danger of frost is high in narrow and windy valleys. Consequently, plants in Miljac-

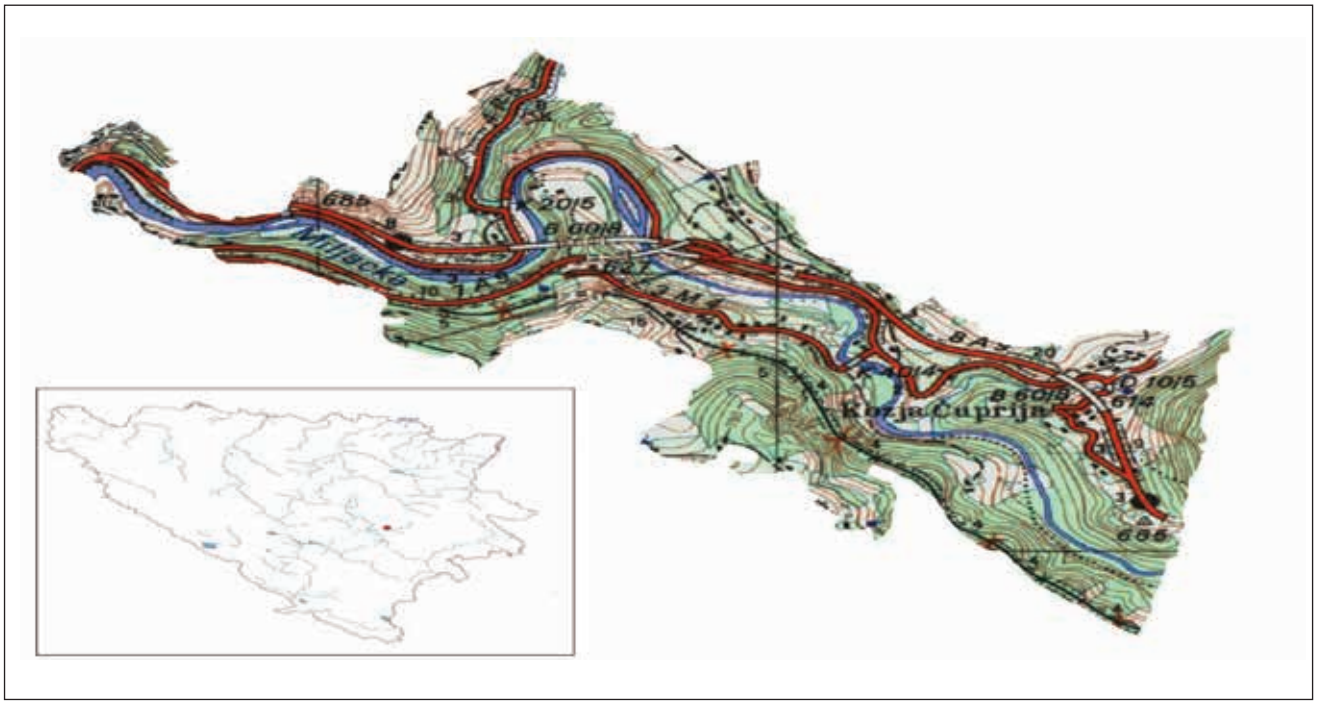

Figure 1. Position and boundaries of PA "Bentbaša" (Adopted from Đug et al., 2008) and position of the investigated area in Bosnia and Herzegovina.

ka canyon are certainly under severe adverse effects of frost during a certain part of the year.

By geological age, the investigated area belongs to the Mesozoic period – the Lower Triassic (Čičić, 1984). As far as tectonics is concerned, this area belongs to the transitional tectonic zone and is very close to the boundary with the inner tectonic zone (Čičić, 1984). By chemical composition, these rocks are labeled as dolomitized limestone (Redžić, 1991). The process of mineralization and the creation of calcite minerals occurs on some rocks. On many rocks of the investigated area, there is a noticeable presence of red color that comes from iron clay. This coloration of rocks was observed on both sides of the investigated area. Processes of metamorphosis can also be noticed. In the investigated area, there are also various relief forms, and the most famous one is the rocky needle of Babin zub, over 30 m high and shaped on Triassic limestone (Lepirica, 2013).

On all the investigated surfaces, lithosol prevails, however, on a smaller part there is calcomelanosol (humus), most often on "terraces" where the opportunity for development and accumulation of this type of soil has been created. According to Škorić at al. (1973), lithosol belongs to a group of undeveloped soils, (A)-C profile. Lithosol is a very shallow soil that is very close to the geological base (Škorić, 1977). For this reason, the character of the rocks and crushing of the detritus will determine the suitability and the possibility of rooting the plants in this, generally speaking, very xerothermic substrate. This soil is very poor in nutrients, the biological activity is weak, so the plant population is poor. Ćirić (1984) states that lithosols are ecologically extremely dry habitats exposed to strong warming and poor in available nutrients and that these automorphic soils, including lithosol, are typically moistened only by atmospheric precipitation, where the percolation of the absorbed water is free and there is no stagnation of water and deficient humidification (wetting).

HISTORY OF EXPLORATION OF THE MILJACKA CANYON AREA

Due to its attractiveness, beauty, and refugial character, a large number of botanists conducted research in the Miljacka canyon. Ami Boué, a French geologist, is the first researcher to visit and pass through this area. Boué (1840) started in Pljevlje, through Čajniče and Goražde, through the Miljacka canyon, to Sarajevo. After that, there was no data until the annexation of Bosnia and Herzegovina by the Austro-Hungarian Monarchy. Hofmann (1882) provides data on the presence of some plants in the Miljacka canyon such as: *Corydalis ochroleuca* Koch, *Genista januensis* Viv., *Lonicera alpigena* L. and others. Svante Murbeck, also visited and explored the Miljacka canyon. Murbeck (1891) mentions a number of herbs found in the Miljacka canyon, such as *Scirpus setaceus* L., *Cyperus fuscus* L., *Alnus incana* (L.) Willd., *Euphorbia stricta* f. *latifolia* Murb., *Galeopsis bifida* Bolum., *Veronica anagalloides* Guss. and many others. This canyon was often visited by Franjo Fiala (1889, 1891, 1896), curator of the National Museum, during his research. Also, Fiala collected and herbarizied a large number of plants from this canyon, and stored them in the Herbarium of the National Museum in Sarajevo (SARA). Beck-Mannagetta (1901, 1903-1921, 1923) in his "Flora Bosne i Herzegovine i

Novopazarskog Sandžaka" offers a large amount of data on the species found in the Miljacka canyon. Another curator of the National Museum who conducted his research in the Miljacka canyon, Protić (1908), gives information on some plants found in the Miljacka Canyon. The same author (Protić, 1897, 1899) provides data on the Diatoms in the Miljacka, and in the second paper, he performs tests on the biological self-cleaning of the Miljacka River (Protić, 1933). Malý (1899, 1904, 1910-1928, 1940, 1948), and in other works (Malý & Zahn 1925, 1926, 1929; Malý 1931, 1932, 1933a, b, 1935) surveyed the Miljacka canyon in detail and collected numerous data on its flora and vegetation.

Botanical exploration of this canyon continues after World War II. Thus, Ritter-Studnička (1958) provides data on the site of some adventive species in the Miljacka canyon. Stefanović (1955) reports that *Ailanthus altissima* (Mill.) Sw. appears in the Bentbaša-Kozija ćuprija region as a weed, while Abadžić (1974) explores the ecology and variability of populations of the species *Scabiosa leucophylla* Borb. on the part of the Miljacka canyon called Orlovo krilo. While investigating the ecological and morphological differentiation among the populations of the species *Edraianthus jugoslavicus* Lkšć, Abadžić (1984) also surveyed the Miljacka canyon. Similarly, Abadžić (1987) notes the presence of *Echinocystis lobata* (Michx.) Torr. & A. Gray in the valley of the Miljacka River, in several places. Strgar (1974, 1981), exploring Dariva rocks, describes a new species of moor grass – *Sesleria ujhelyii* Strgar or Ujhel's Moor Grass. Academician Sulejman Redžić surveyed this canyon on several occasions. Thus, in his doctoral dissertation (Redžić, 1991), he explored this canyon and in two papers in the scientifically popular magazine "FONDEKO svijet" offered a concise description of the flora and other characteristics of this canyon (Redžić, 1997a, b). Also, other researchers explored this canyon, such as Tanović (1995), Jukić (2001), Merdan (2004), Ravlić (2004), Šoljan et al., (2007).

MATERIAL AND METHODS

Materials and methods of work can be divided into two phases: field and laboratory.

Field-work

This work has been done through long-term field trips in all annual vegetation aspects, from 2013 to 2018. The investigated area was studied and monitored through several successive annual weather aspects to determine floral and phenological facts. Throughout the season, the bloom of individual, most characteristic species was observed.

Laboratory-work

Statistical data analysis included descriptive statistics methods in order to obtain data on the total number of taxa, the number of taxa occurring only on the northern or just on the southeastern side, and the number of taxa appearing on both sides of the investigated area. The analysis provides data on life forms, phytocoenological affiliation, indicator values, and floral elements. Graphical depictions of all the above-mentioned items were given for the entire canyon as well as for individual sides, which also enabled a comparative analysis of the floristic composition of the north and southeast of the investigated area. The data on phytocoenological affiliation, indicator value, floral element, and life form was provided for all species.

The objectives of this paper are to:

1. Identify which plants appear on the rocks of the investigated area of the Miljacka canyon,
2. Determine which plants are recorded in the entire investigated area and which are only on the northern and which only on the southeastern side of the canyon,
3. Determine the boundaries of the average distribution of the most characteristic plants,
4. Determine the percentage ratios: life forms, phytocoenological affiliation, indicator values, and floral elements, both for the whole canyon and for individual sides,
5. Identify the most common plants of rock ecosystems,
6. dentify the rarest plants of rock ecosystems,
7. Determine the phenology of the most important plants,
8. Note the presence of plants listed in the "List of Plant Species (*Pterydophyta* and *Spermatophyta*) for the Red Book of Protected Plant Species" and "Red list of Flora of Federation of Bosnia and Herzegovina".

DETERMINATION AND NOMENCLATURE

During the determination of plants, I used a large number of works and keys for determination, both general and specialized for certain genera.

Of the general ones, I used:

Aichele & Schwegler (1998), Beck-Mannagetta (1903-1923, 1927), Beck-Mannagetta et al. (1950, 1967, 1974), Čanak et al. (1978), Domac (1984), Josifović et al. (1970-77), Kojić (1981), Kvakan (1952), Šarić (1991), Šilić (1990, 2002, 2005) and Šoštarić-Pisačić & Kovačević (1968).

Of the specialized keys for certain genera, I used:

For genus *Edraianthus* - Lakušić (1973), for genera *Acinos* and *Micromeria* - Šilić (1979), and genus *Allium* - Radić (1989).

During the determination of plant material, the Herbarium Collection (SARA) of the National Museum of Bosnia and Herzegovina was also used.

Floral elements and life forms were given according to: Lakušić & Redžić (1989, 1991), Oberdorfer (1991), and Redžić (1988).
Phytocoenological affiliation wasgiven according to: Horvat et al. (1974), Lakušić (1989), Lakušić & Redžić (1989, 1991), Oberdorfer (1991), and Redžić (1988).
Indicator values were given according to: Lakušić & Redžić (1989, 1991), Pavlović-Muratspahić (1995), and Redžić (1988).
Life forms were given according to Raunkiaer (1937).
The research history was given by works: Fiala (1892), Fukarek (1954), and Redžić (1997 b).
The nomenclature follows that of *Flora Europaea* (Tutin et al., 1964-1980), Flora CroaticaDatabase (https://hirc.botanic.hr) and www.theplantlist.org.

RESULTS AND DISCUSSION

In the entire research area, a total of 225 species with 2 subspecies and 1 form were identified from 49 families (Tab. 1 and 2). The most numerous families were: *Asteraceae* with 30, *Poaceae* with 25, and *Fabaceae* with 21 taxa. A slightly lower number of species was found from the following families: *Rosaceae* with 14 and *Lamiaceae* and *Apiaceae* with 13, *Scrophulariaceae* 11, and *Caryophyllaceae* with 9 taxa (Tab. 3). Other families were represented with a smaller number of taxa (Fig. 2).

In Figure 2, we can see that most species belong to the orders of *Brometalia erecti* and *Amphoricarpetalia*. A slightly smaller number of species belong to the following orders: *Chenopodietalia*, *Arrhenatheretalia*, *Quercetalia pubescentis*, *Fagetalia*, and *Scorzonero-Chrysopogonetalia*. It should also be noted that representatives from 18 phytocoenological orders were recorded in the entire investigated area (Tab. 1). Also, due to lack of space in the development of the chart, the chart contains data on phytocoenological orders with 1 representative and a percentage value of 0.5%, and these are the following orders: *Quercetalia robori-petraeae*, *Salicetalia purpureae*, *Festuco-Sedetalia*, *Secalinetalia* and *Plantaginetalia majoris*. As for the indicator value, the largest number belongs to secondary and primary vegetation (Fig. 3). Most species belong to the life form of hemicryptophytes, while others are less numerous (Fig. 4). The data in Table 2 show

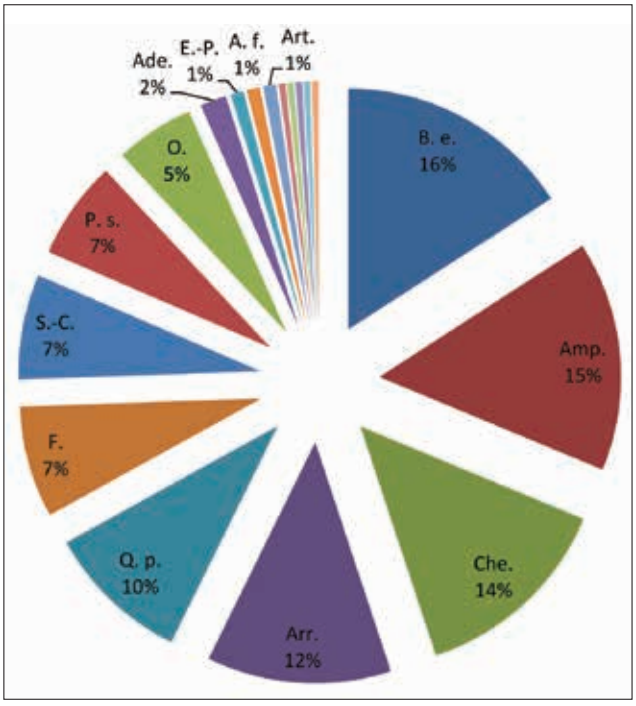

Figure 2. The percentage ratio of the vegetation orders in the entire research area

that the largest number of species in the entire research area belongs to the Submediterranean floral element. A slightly lower percentage belongs to the Eurasian, Eurassubozean, and Nordic Eurasian floral elements. And from this, it can be

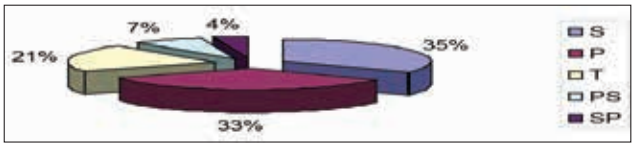

Figure 3. The percentage ratio of the indicator values for the entire investigated area

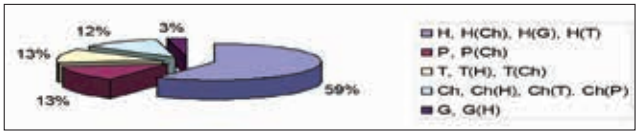

Figure 4. The percentage participation of life forms in the entire investigated area

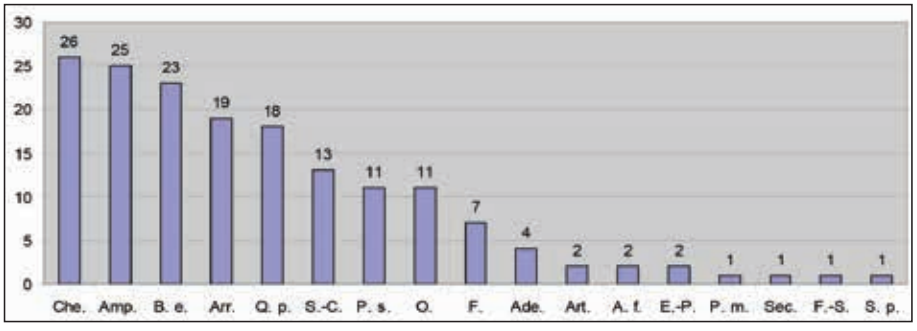

Figure 5. The number of representatives of particular orders on the northern side

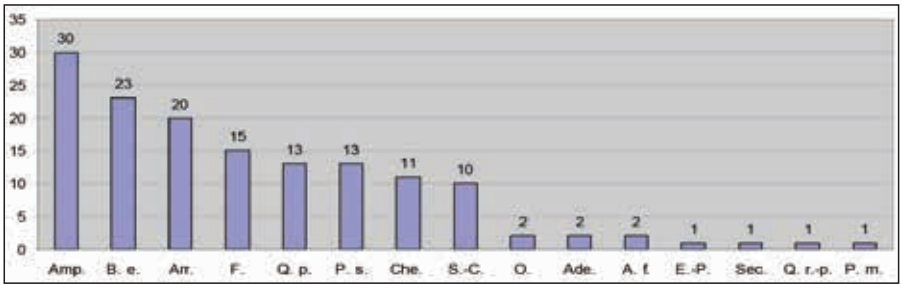

Figure 6. The number of representatives of particular orders on the southeastern side

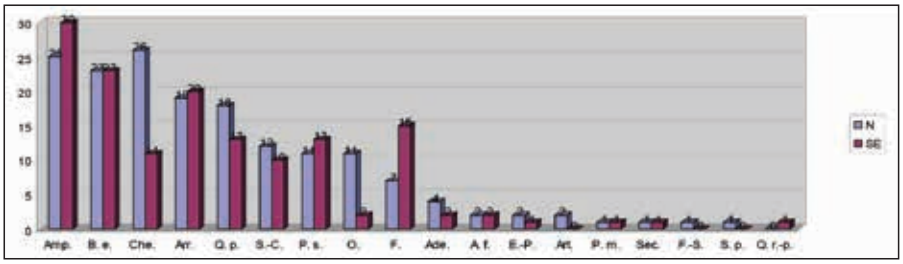

Figure 7. Comparative orders' relation between the investigated sides

concluded that this canyon is very warm and represents the penetration or influence of Supramediterranean, as previously mentioned in the climate section.

Figure 5 shows number of fitocenolgical orders for nothern and Figure 6 for southern side. Figure 7 shows that, in the entire area, a large number of detected species belong to the orders of *Amphoricarpetalia* and *Brometelia erecti*. Interestingly, the number of *Chenopodietalia* order, present on the northern side of the canyon, due to a large number of terraces, there is a very large number of identified taxa, and on the opposite side, where the number of terraces is much smaller, the number of identified types of this order is significantly smaller. Of the other orders, with a slightly smaller number of taxa, we should mention: *Arrhenatheretalia*, *Quercetalia-pubescentis*, *Scorzonero-Chrysopogonetalia*, and *Prunetalia spinosae*. These ecosystems often border with rock ecosystem. Also, the ecosystem of beech forests borders on the southeastern side with the ecosystem of rocks, and the number of species found on this side is far larger than in the north where this ecosystem is not identified. Table 1 shows that the species found on both sides come from 14 phytocoenological orders.

Figure 8 shows percentage ratio of indicators values in the northern and Figure 9 for the southeastern side. Figure 10 shows that representatives of the primary vegetation dominate throughout the entire research area, although the val-

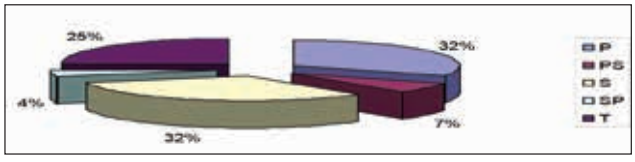

Figure 8. The percentage ratio of indicator values in the northern side of the investigated area

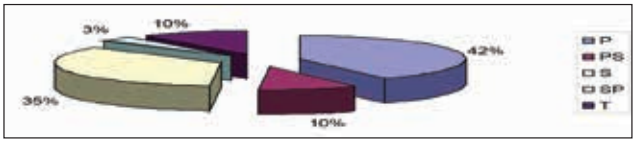

Figure 9. The percentage ratio of indicator values onthe southeastern side of the investigated area

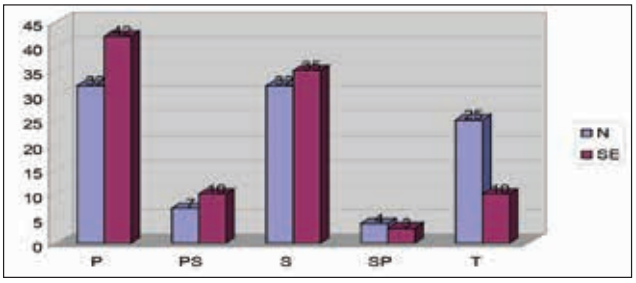

Figure 10. Comparative indicator values between the two sides

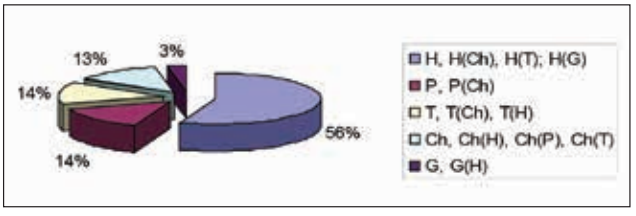

Figure 11. The percentage ratio of life forms in the northern side of the investigated area

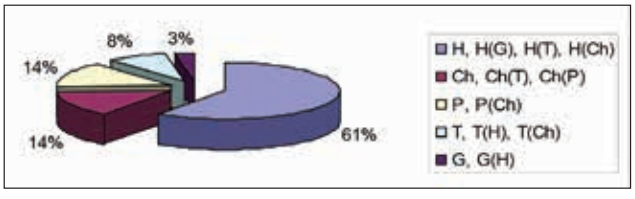

Figure 12. The percentage ratio of life forms on the southeastern side of the investigated area

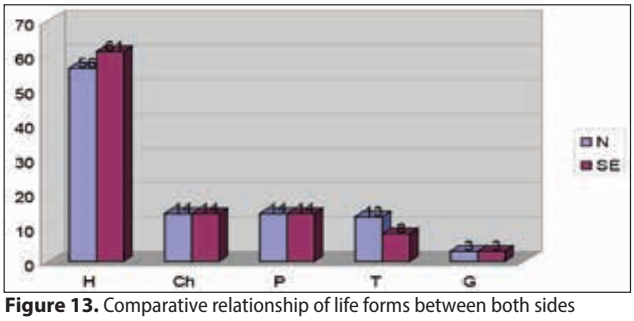

Figure 13. Comparative relationship of life forms between both sides

ue of the members of the secondary vegetation is also high. There is a difference in the number of tertiary species that are lower in the southeast, and the main reason is the small number of terraces suitable for the representatives of this group. On the other hand, there is a slightly higher number of primary-secondary species on the southeastern side. The main cause is the proximity of forest ecosystems, which in some places border with the ecosystem of rocks.

Figure 13 shows that most of the species are on both sides of the investigated area. They are hemicryptophytes. The ratio of chamaephytes and phanerophytes is equal, and a smaller number of therophytes on the southeastern side is the result of a smaller number of terraces. A very small presence of geophytes is also noticeable.

THE MOST WIDESPREAD ROCK PLANTS WITH DATA ON THE AREA OF DISTRIBUTION IN THE INVESTIGATED AREA

1. *Thymus praecox* ssp. *jankae* (Čelak.) Jalas, or Janka's thyme is one of the main edificators of the investigated area, spread both on the northern and southeastern sides, and in some places on the southeastern side of the canyon it is massively widespread.
2. *Melica ciliata* L. is one of the most widespread plants in the entire canyon, and we can say that it is evenly distributed on both sides.
3. *Micromeria thymifolia* (Scop.) Fritsch grows more on the northern than on the southeaster side. It is one of the species that begins to bloom in this area the last. Together with *Malcolmia illyirica* (Halacsy) Hay., it forms a community of *Malcolmio-Micromerietum thymifoliae* (Redžić, 1991), which is spread only on the rocks of Dariva.
4. *Asplenium ruta-muraria* L. is spread all over the canyon but it is mostly distributed on the carbonate embankments of the former narrow-gauge railway where, together with *Saxifraga aizoon* Jacq., it forms a community of *Asplenio ruta-murariae-Saxifragetum aizoon* comb. nov. prov.
5. *Asplenium trichomanes* L. is spread all over the canyon, but the most optimal living conditions are found on carbonate blocks below the forest vegetation of the order *Quercetalia pubescentis*. This fern is best suited the places that are not too exposed to direct sunlight.
6. *Ceterach officinarum* DC. as opposed to *Asplenium trichomanes*, grows in dry places. It is spread all over the canyon. At the end of the investigated area from the southeastern side, on the degraded site, it builds facies of the *Ceteratosum officinarii* comb. nova prov., which is within the association *Asplenio trichomani-Saxifragetum aizoon* comb. nova prov. It is also well represented in the association *Asplenio ruta-murariae-Saxifragetum aizoon* comb. nova prov., which occurs in the open limestone embankment.
7. *Dianthus kitaibelii* Janka in Panč. is spread on both sides of the canyon, massively widespread on the southeastern side while on the northern side it grows only at the end of the investigated area, i.e., behind Dariva's rocks to Kozija ćuprija. This indicates that some specific conditions appear to enable this plant to grow. It is an important member of many communities, especially on the southeastern side where it builds, together with the *Edraianthus jugoslavicus* Lkšić, the community *Edraiantho-Dianthetum kitaibelii* Lakušić that appears on the southeastern side of the rocks at the first houses of the lower part of Jarčedol. Kitaibel's pink is one of the most important edificators on the southeastern side of the Miljacka canyon.
8. *Erysimum linarifolium* Tausch is one of the species typical of this canyon. It is an important member of many communities. It is one of the species that is the first to begin to bloom in this area.
9. *Leontodon crispus* Vill. is spread across the entire investigated area individually or in small groups of 3-5 specimens. Regardless of not being massively spread nor high in number like some other species, this species is constant, and it can be said that it belongs to a group of indicator or edificator species of this canyon.
10. *Stipa calamagrostis* (L.) Wahlenb. is singled out individually or in smaller groups and certain associations it is a constant member. Spear Grass can also be considered an important member of many communities in this area.
11. *Sedum ochroleucum* Chaix is distributed mostly individually or in small groups. In some places, especially on the southeastern side, it also appears in a slightly larger number.
12. *Galium corrudaefolim* Tausch has been recorded on both sides and in a larger number of associations of the investigated area, and can also be considered as a significant indicator of this canyon. It is mostly related to open or slightly shady habitats. It is more numerous on the northern than on the southeastern side.

Of the species belonging to other orders, the following ones have a high prevalence in the investigated area: *Tunica*

saxifraga (L.) Scop. - in a series of communities on both sides, *Silene vulgaris* (Mch.) Garcke - same as the previous, but much more widespread than *Tunica saxifraga*, and it is an edificator of some communities, *Sedum album* L. - is also widespread on both sides, but much more common in the north, *S. acre* L. - also widespread on the northern side, but much less than the *Sedum album*, *Sanguisorba muricata* (Spach.) Focke - on both sides of the canyon and it is a significant member of many communities, *Galium purpureum* L. - more common in the north than in the southeast, *Bromus erectus* Huds. - in many communities on both sides of the investigated area, *Arabis hirsuta* (L.) Scop. - individually or in smaller groups on both sides but more in the southeast than in the north, *Acinos hungaricus* Simon. - mainly on the northern side and much less on the southeast, *A. arvensis* (Lam.) Dandy - as the previous species, *Helianthemum nummularium* (L.) Run. - common species in many associations with both sides of the canyon, *Coronilla emerus* ssp. *emeroides* (Boiss. et Spr.) Hay. - on both sides, in some places, like in the area near Dariva, more common than elsewhere, *Hieracium murorum* L. - mainly in the area of the southeastern canyon where it occurs in many associations and where it found favorable living conditions, as well as other species.

THE RAREST ROCK PLANTS IN THE INVESTIGATED AREA

The following species may be considered the rarest plants in the investigated area:

1. *Onosma stellulatum* W. & K.-one small population near Bentbaša tunnel.
2. *Sempervivum tectorum* L.-two populations with several individuals on the rocks of the tunnel at Bentbaša.
3. *Ajuga chamaepytis* L.-it does not belong to rock plants, it was sampled because of it srarity, because the only one larger population on the rock near Dariva was found,
4. *Malcolmia illyrica* (Halacsy) Hay.-rare species of rock plants in this canyon and it occurs in separate groups of two to three individuals together. In the investigated area, this species can only be found on the rocks of Dariva and it is very scattered. In this area, it builds the community *Malcolmio-Micromerietum thymifoliae* Redžić. The nearest populations of this plant were only found on the rocks of Jekovac, the area not covered by this research. Interestingly, the habitat of these plants is rock crevice where they could not be scattered through the wind, or with difficulty, so it is most likely that the seeds of this species possess a "sweet supplement" or *caruncul* which are dispersed by ants. This is a prominent sciophyte (Šilić, 1990).
5. *Sedum maximum* (L.) Sut.-rare species in the investigated area. It was found on both sides of the canyon but only in small and limited areas and with a smaller number of specimens. Thus, on the north side, it was found on a site near Dariva where it is a bit more widespread, and on the southeastern side, at the end of the investigation area, where it occurs with few specimens.
6. *Frangula rupestris* L.-rare, the most widespread on the rocks before the tunnel at Bentbaša. It is very rare in the other parts of the investigated area. On the southeastern side, it is recorded in two places as individual specimens.
7. *Sesleria ujchelyii* Strgar-Ujchel's Moor Grass is mainly associated with the northern side of the canyon. It is most numerous on the rocks around the Bentbaša tunnel, while further, i.e., in other parts of the canyon, it is quite rare.
8. *Minuartia bosniaca* (Beck) Malý-it is widespread throughout the canyon, in mainly smaller populations, except for one part of the northern side of the *Malcolmio-Micromerietum thymifoliae* Redžić association, whereas on the southeast, it is somewhat more significantly widespread.
9. *Athamanta haynaldii* Borb. et Uechrt.–found on the southeastern part of the canyon, most often in places that are not exposed to direct sunlight, but it can also be found in places with plenty of sun.
10. *Seseli rigidum* W. & K.-in similar habitats as the previous species but is more widespread. Tatić & Veljović (1982) provided interesting data that species *Stipa calamagrostis* and *Melica ciliata* are particularly important in the habitats in which this species occurs and develops specific communities, which is also the case with this investigated area.
11. *Campanula rotundifolia* f. *albiflora* (Don) House-is a white-floral form of the Harebell, that appears only on the rocks before the first houses on Jarčedol.
12. *Genista januensis* Viv.-it does not belong to the order of the rock plant of *Amphoricarpetalia*, this broom is rare in the entire investigated area. It is mostly widespread at the end of the canyon on the north side near the Kozija ćuprija bridge. In the rest of the investigated area, it occurs in single or smaller groups, which is very rare.

Here we should add the information on discovering a very rare fern *Asplenium lepidum* C. Presl that was recorded on the rocks of Dariva and Bentbaša (Nizić, 2007).

RARE AND ENDANGERED PLANT SPECIES IN THE INVESTIGATED AREA

Plant species from the investigated area, that are found on the list of plant species for the "Red Book of Bosnia and Herzegovina" (according to Šilić, 1996), in the category of vulnerable species (V) are: *Minuartia bosniaca* (Beck) Malý, *Malcolmia illyrica* (Halacsy) Hay., *Athamantha haynaldi* Borb. et Uechrt and *Onosma stellulatum* W. K., *Micromeria thymifolia* (Scop.) Fritsch, *Scabiosa leucophylla* Borb., *Edraianthus jugoslavicus*

Lkšić, and *Hieracium waldsteinii* Tausch in "Red list Flora of Federation Bosnia and Herzegovina" (Đug et al., 2103), as well as 9 species from the following categories: DD-*Dactylis aschersoniana* (Graebn.) Hay., LC-*Onosma stellulatum* and *Scabiosa leucophylla*, NT-*Edraianthus jugoslavicus*, VU-*Minuartia bosniaca* and *Asplenium lepidum* C. Presl, EN-*Athamantha haynaldii* and *Hieracium waldsteinii*, CR-*Malcolmia illyrica*.

PHENOLOGY OF THE INVESTIGATED AREA

During the long-term field trips, it was noted that the first plants that begin to bloom mostly in late March or early April are: *Erysimum linarifolium* Tausch, *Sesleria ujchelii* Strgar, *S. angustifolia* (Hack. & Beck) Deyl, and *Arabis caucasica* Willd. In mid-April, these species already begin to bloom massively, and *Arabis glabra* (L.) Bernh., *A. hirsuta* (L.) Scop.,and *A. turritta* L., *Coronilla emerus* ssp. *emeroides* (Boiss. et Spr.) Hay., *Cytisus hirsutus* L. as well start to bloom in the same period. During this period, in the area around Kozija ćuprija *Genista januensis* Viv. also begins to bloom, and on the rocks of Dariva, there is the blooming *Malcolmia illyirica* (Halacsy) Hay. It is also the time when one of the most widespread canyon plants, *Thymus praecox* ssp. *jankae* (Čelak.) Jalas, massively blooms at the beginning of May. This is the period when the following plants begin flowering: *Onosma stellulatum* W. & K. and *Dianthus kitaibelii* Janka in Panč., the latter one massively blooms in mid-May. Other plants are blooming in mid-May, such as *Minuartia bosniaca* (Beck) Maly, *Veronica jacquinii* Baumg., *Galium corrudaefolium* Tausch and *Helianthemum nummularium* (L.) Run. This is the time when *Edraianthus jugoslavicus* Lkšć begins to blossom at eastern exposures. At the beginning of June, the following plants begin to bloom, and massively in the middle of the same month: *Saxifraga aizoon* Jacq. and *Seseli rigidum* W. & K., while *Athamantha haynaldii* Borb. et Uechrt just begins to bloom. However, at the end of June, this species is in full bloom, together with *Campanula rotundifolia* L., *Micromeria thymifolia* (Scop.) Fritsch, and *Leontodon crispus* Vill. In September and October, *Allium sphaerocephalum* and *Euphrasia stricta* Host. is last species which blooming.

FLORISTIC CHARACTERISTICS OF THE NORTHERN SIDE OF THE INVESTIGATED AREA

In this investigated area, a total of 167 taxa was recorded. The most important taxa of this part of the investigated area are: *Micromeria thymifolia*, which is much more common in Bentbaša and Dariva than in the area around Kozija ćuprija, *Silene vulgaris* is well spread across the northern side of the canyon, *Tunica saxifraga*, which is also very widespread in this part of the investigated area as well as *Galium corrudaefolium*, *Sedum album*, *Melica ciliata*, *Erysimum linarifolium*, *Sanguisorba muricata*, *Thymus praecox* ssp. *jankae*, *Stipa calamagrostis,* and others. Figure 5 shows that the largest number of discovered species belongs to the tertiary order of *Chenopodietalia*. The main reason for such a large number of species is a large number of terraces, especially on the rocks of Dariva and Bentbaša, which provide favorable conditions for the development of species not only of this order, but also of other orders. A large number of discovered species also belong to the *Amphoricarpetalia* order and a slightly lower number to the secondary order of thermophilic meadows *Brometalia erecti*. There are also numerous members of orders *Arrhenatheretalia* and *Quercetalia pubescentis* because these ecosystems in some places border the rock ecosystem. Slightly lower percentages but persistent constancy in the investigated area have representatives of the *Prunetalia spinosae* order that can be found in each association of the northern side of the investigated area. A larger part of the Miljacka canyon, especially along the road from Bentbaša to Kozija ćuprija, where constant anthropogenic impact is noticed, is occupied by associations as well as the species of this order. Moreover, representatives of other tertiary orders inhabit these habitats, especially from the order of *Onopordetalia*. The representatives of the *Fagetalia* order are also noted, but to a considerably smaller extent. It is also important to mention the order of *Arabidetalia flavescentis*, the order of talus vegetation, which, especially on high mountains, often borders with orders of vegetation on rocks. On the north side of the investigated area, representatives of this order appear in many places, which points to their constancy. A total of 17 phytocoenologic orders were found. Figure 9 shows that the largest number of species found on the southeastern side belongs to primary vegetation. There is a smaller number of members of secondary vegetation and much lower values have members of primarily, secondary and tertiary vegetation. The smallest number of species was found in the order of secondary primary vegetation. In Figure 8, we can see that primary and secondary vegetation members are the most numerous on this side of the investigated area. As far as the tertiary vegetation representatives are concerned, a slightly smaller number was found, while representatives of primary and secondary primary vegetation are identified with the smallest number of species. In Figure 11, we can see that the largest number of species belongs to hemicryptophytes. Phanerophytes, therophytes, and chamaephytes are noted with fewer specimens, whereas the smallest number of species belong to the geophyte life form. The data presented in Table 4 indicate the most significant floral element on the northern side of the investigated area is Submediterranean. High values include the Eurasian suboceanic, Mediterranean, Eurasian, and Balkan flora elements. From this data, we can see the influence of supra-Mediterranean in Miljacka canyon.

FLORISTIC CHARACTERISTICS OF THE SOUTHEASTERN SIDE OF THE INVESTIGATED AREA

In this investigated area, 145 taxa were identified. The most numerous species of the southeastern part of the investigated area are: *Asplenium trichomanes*, *Thymus praecox* ssp. *jankae*, *Arabis hirsuta*, *Dianthus kitaibeli*, *Fraxinus ornus*, *Sedum ochroleucum*, *Hieracium murorum*, *Sanguisorba muricata*, *Ceterach officinarum*, *Campanula rotundifolia*, *Edraianthus jugoslavicus* and *Saxifraga aizoon,* etc. The data presented in Figure 6 show that the number of species found in this area belongs to the order of rock vegetation *Amphoricarpetalia,* and slightly lower values have secondary orders of *Brometalia erecti* and *Arrhenatheretalia*. Lower values were found for members of orders of the forest ecosystems: *Fagetalia*, *Quercetalia pubescentis* and *Prunetalia spinosae*, which, in particular the *Fagetalia* order, often border in this area with rock ecosystems. There is also a small number of *Chenopodietalia* representatives due to a small number of terraces suitable for their life. Low values are noted for the order *Arabidetalia flavescentis*. A total of 15 phytocoenologic orders were found. Graph 8 shows that the largest number of species found onthe southeastern side belongs to primary vegetation. A smaller number of members of secondary vegetation and lower values have representatives of primary, secondary and tertiary vegetation. The smallest number of species was found in the order of secondary and primary vegetation. Registered representatives of primary and secondary vegetation originate from the *Prunetalia spinosae* order which is again to the result of the presence of this ecosystem in the investigated area. The data presented in Figure 12 shows that hemicryptophytes area is the dominant life form in this investigated area. A much smaller number of chamaephytes and phanerophytes were recorded. It is noticeable, due to the smaller number of terraces, that there is a very small number of therophytes, and the smallest number of the observed species belongs to geophytes. Therophytes are mainly weed species and in this area, they most commonly inhabit terraces. On the other hand, geophytes are also found on the terraces, and since they mainly propagate by bulbs, this habitat, i.e., the rocks, is not suitable for their larger widespread. Finally, in *Table 4* we can see that the largest number of species on the southeastern side of the investigated area belongs to the Submediterranean floral element. High values include also: Dinaric, Balkan, Mediterranean, Eurasian, and Eurasian-subozeanic floral elements. Lower values were found for species from: alpine, prealpine, and subatlantic floral elements which shows the unfavorable conditions for the distribution of these species in this part of the canyon, due to the influence of warm winds.

CONCLUSION

A total of 225 species with 2 subspecies and 1 form from 49 families were recorded in the entire investigated area.

The most numerous families are: *Asteraceae* with 30, *Poaceae* with 25, *Fabaceae* 21, *Rosaceae* 14, *Lamiaceae* and *Apiaceae* with 13 taxa.

In the total investigated area, species were recorded from 18 phytocoenological orders, 17 on the northern side, and 15 on the southeastern side.

The most widespread plants in the entire canyon are: *Thymus praecox* ssp. *jankae* (Čelak.) Jalas, *Minuartia bosniaca* (Beck) Malý, *Melica ciliata* L., *Micromeria thymifolia* (Scop.) Fritsch, *Asplenium ruta-muraria* L., *Asplenium trichomanes* L., *Ceterach officinarum* DC., *Erysimum linarifolium* Tausch. *Leontodon crispus* Vill., *Stipa calamagrostis* (L.) Wahlenb., *Sedum ochroleucum* Chaix, *Dianthus kitaibelii* Janka in Panč. and *Galium corrudaefolium* Tausch,

The largest number of identified taxa of the entire investigated area belongs to *Amphoricarpetalia* order and a smaller number belongs to the following orders: *Brometalia erecti*, *Arrhenatheretalia*, *Chenopodietalia*, *Quercetalia pubescentis*, *Scorzonero-Chrysopogonetalia* and *Fagetalia* and they belong to secondary and primary vegetation.

Of life forms, the largest number of taxa belongs to hemicryptophytes where as fewer of them belong to other forms.

There were species from 17 floral groups with 103 different floral elements. The largest number of species belongs to the Sub-Mediterranean floral element.

Eight species were recorded in the investigated area with a list of plant species (*Pteridophyta* and *Spermatophyta*) for the Red Book of Bosnia and Herzegovina with the category of vulnerable species (V). More over, nine species from the "Red List of Flora of the Federation of Bosnia and Herzegovina were recorded in the following categories: DD-1, LC-2, NT-1, VU-2, EN–2, and CR-1 species.

On the scientific side, this paper has a specific approach to research: comparative data in researching different sides of canyon, comprehensiveness of research: flora under the influence of different ecological factors and given new fitocenological provisional units; new association *Asplenio ruta-murariae-Saxifragetum aizoon* comb. nov. prov. and facies *Ceteratosum officinarii* comb. nov. prov.

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SAŽETAK

U periodu između 2013. i 2018. vršena su floristička istraživanja ekosistema stijena u Zaštićenom području „Bentbaša", tj. kanjonu rijeke Miljacke. Ukupno je konstatovano 228 vrsta sa jednom podvrstom i jednom formom. Najveći broj vrsta konstatovan je iz familije *Asteraceae* sa 30 vrsta; najmnogobrojnije su vrste koje pripadaju vegetacijskim redovima *Brometalia erecti* i *Amphoricarpetalia*; od indikatorskih vrijednosti najveći broj vrsta pripada sekundarnom te primarnom tipu vegetacije; najznačajniji broj konstatovanih vrsta pripada ubjedljivo životnoj formi hemikriptofita a najbrojniji florni element je submediteranski. Najznačajnije vrste istraživanog područja su: *Thymus praecox* ssp. *jankae, Micromeria thymifolia, Asplenium trichomanes, Melica ciliata* i druge a dok su najrjeđe vrste: *Onosma stellulatum, Malcolmia illyrica, Ajuga chamaepithys, Frangula rupestis* i druge. U radu su dati i fenološki podaci za najznačajnije vrste. Na istraživanom području je zabilježeno osam vrsta sa „Spisak biljnih vrsta (*Pteridophyta* i *Spermatophyta*) za Crvenu knjigu Bosne i Hercegovine" i to sa kategorijom ranjivih vrsta (V). Takođe, devet vrsta se nalaze na "Crvenoj listi flore FBiH", zabilježenih u slijedećim kategorijama: DD-1, LC-2, NT-1, VU-2, EN-2 i CR-1 vrsta. Na kraju su dati i floristički podaci posebno za sjevernu i jugoistočnu stranu kanjona Miljacke sa svim relevantnim parametrima. Ovaj rad je imao specifičan pristup u istraživanju tokom kojeg su se uspjeli dobiti komparativni podaci o flori stijena različitih strana kanjona Miljacke, takođe je sveobuhvatno osvijetlio floru ovog područja pod uticajem različitih ekoloških faktora. Istraživanje je rezultiralo definisanjem dviju provisionalnih fitocenoloških jedinica na nivou asocijacije kao *Asplenio ruta-murariae-Saxifragetum aizoon* comb. nova prov. i facies *Ceteratosum officinarii* comb. nova prov.

Ključne riječi: flora, stijene, kanjon, Miljacka, Zaštićeno područje „Bentbaša", hemikriptofite

APPENDIX

Table 1. The list of families with species found in the investigated area of the Miljacka canyon with data on: systematic and phytocoenological affiliation, indicator value, floral element, and life form.

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
I *Aspleniaceae*							
1. *Asplenium ruta-muraria*	Amp.	P	(no-)euras-smed,circ	H	+	+	+
2. *A. trichomanes*	Amp.	P	eurassubozean	H	+	+	+
3. *Ceterach officinarum*	Amp.	P	med-smed(-subatl)	H	+	+	+
II *Polypodiaceae*							
4. *Cystopteris fragilis*	Amp.	P	no-eurassubozean-pralp	H	-	+	-
5. *Polypodium vulgare*	F.	P	eurassubozean-smed	Ch	-	+	-
III *Ranunculaceae*							
6. *Clematis recta*	Q. p.	P	gemässkont(-smed)	P	+	-	-
7. *C. vitalba*	P. s.	PS	smed-subatl(circ)	P	+	+	+
8. *Helleborus odorus*	P. s.	PS	din	H (G)	-	+	-
9. *Ranunculus bulbosus*	Arr.	S	smed-subatl	H (G)	+	-	-
IV *Papaveraceae*							
10. *Chelidonium majus*	Che.	T	euras(subozean)	H	+	-	-
11. *Papaver rhoeas*	Che.	T	euras-med	T	+	-	-

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
V *Fagaceae*							
12. *Quercus petraea*	Q. p.	P	subatl-smed	P	+	+	+
VI *Betulaceae*							
13. *Carpinus betulus*	Q. p.	P	gemässkont-smed	P	-	+	-
14. *C. orientalis*	Q. p.	P	balc-smed	P	+	-	-
15. *Ostrya carpinifolia*	Q. p.	P	osmed	P	+	+	+
VII *Cannabaceae*							
16. *Humulus lupulus*	Che.	T	euras-smed,circ	H	-	+	-
VIII *Crassulaceae*							
17. *Sedum acre*	S.-C.	S	(no-)eurassubozean (-smed)	Ch	+	+	+
18. *S. album*	S.-C.	S	(pralp)smed-subatl	Ch	+	+	+
19. *S. dasyphyllum*	Amp.	P	alp-pralp-smed	Ch	+	+	+
20. *S. maximum*	Amp.	P	osmed-gemässkont	H	+	+	+
21. *S. ochroleucum*	Amp.	P	med	Ch	+	+	+
22. *S. sexangulare*	Amp.	P	gemässkont-osmed	Ch	+	-	-
23. *Sempervivum tectorum*	Amp.	P	pralp	Ch	+	-	-
IX *Saxifragaceae*							
24. *Saxifraga aizoon*	Amp.	P	pralp-alp-arkt (subozean) circ	Ch	-	+	-
25. *S. rotundifolia*	F.	P	pralp	H	-	+	-
26. *S. tridactylites*	Che.	T	med-smed(-subatl)	T	+	+	+
X *Rosaceae*							
27. *Crataegus monogyna*	P. s.	PS	submed(-subatl)	P	+	+	+
28. *Fragaria vesca*	P. s.	PS	no-(eurassubozean)	H	-	+	-
29. *Geum urbanum*	F.	P	eurassubozean-smed	H	+	+	+
30. *Potentilla micrantha*	F.	P	smed	H	+	+	+
31. *P. recta*	B. e.	S	omed-kont	H	+	-	-
32. *P. tommasiniana*	S.-C.	S	s. o. eur	H	-	+	-
33. *P. domestica*	Che.	T	n-persia	P	+	-	-
34. *P. spinosa*	P. s.	PS	eurassubozean-smed	P	+	-	-
35. *Rosa canina*	P. s.	PS	eurassubozean-smed	P	+	+	+
36. *R. glauca*	P. s.	PS	pralp(-smed)	P	-	+	-
37. *Rubus caesius*	Ade.	PS	euras(subozean)-smed	P	+	-	-
38. *R. discolor*	P. s.	PS	(no-)subatl(-smed)	P	+	+	+
39. *Sanguisorba minor*	B. e.	S	smed	H	+	-	-
40. *S. muricata*	B. e.	S	med(-kont)	H	+	+	+
XI *Fabaceae*							
41. *Anthyllis vulneraria*	B. e.	S	smed-subatl	H	-	+	-
42. *Coronilla emerus* ssp. *emeroides*	Q. p.	P	o(smed)	P	+	+	+

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
43. *C. varia*	P. s.	SP	gemässkont-osmed	H	+	+	+
44. *Cytisus hirsutus*	Q. p.	P	osmed	P	-	+	-
45. *Dorycnium herbaceum*	B. e.	S	omed-smed	Ch	+	+	+
46. *Genista januensis*	E.-P.	P	din-so-alp	P (Ch)	+	-	-
47. *G. sagittalis*	B. e.	S	subatl-smed(-pralp)	H	+	-	-
48. *G. tinctoria*	B. e.	S	eurassubozean(-smed)	P (Ch)	-	+	-
49. *Lathyrus pratensis*	Arr.	S	euras(subozean) -smed	H	+	+	+
50. *L. tuberosus*	B. e.	S	euraskont	H	+	-	-
51. *Lembotropis nigricans*	E.-P.	P	gemässkont-osmed	P	+	+	+
52. *Lotus corniculatus*	Arr.	S	eurassubozean-smed	H	-	+	-
53. *Medicago falcata*	B. e.	S	euras(kont)-smed	H	-	+	-
54. *M. lupulina*	B. e.	S	euras-smed	H (T)	+	+	+
55. *M. minima*	B. e.	S	med-smed	T	+	-	-
56. *Melilotus officinalis*	O.	T	eurassubozean(-smed)	H	+	-	-
57. *Ononis spinosa*	B. e.	S	smed	H (Ch)	+	-	-
58. *Trifolium campestre*	B. e.	S	smed-subatl	T	-	+	-
59. *Vicia cracca*	Arr.	S	no-euras	H	+	+	+
60. *V. sepium*	Arr.	S	eurassubozean	H	+	+	+
61. *V. tetrasperma*	Arr.	S	smed-eurassubozean	T	+	+	+
XII *Anacardiaceae*							
62. *Ailanthus altissima*	Che.	T	china	P	+	-	-
XIII *Aceraceae*							
63. *Acer campestre*	F.	P	smed-subatl	P	+	+	+
XIV *Linaceae*							
64. *Linum austriacum*	B. e.	S	osmed	H	-	+	-
65. *L. catharticum*	B. e.	S	eurassubozean-smed	T (H)	+	-	-
XV *Geraniaceae*							
66. *Geranium dissectum*	Che.	T	(med)smed-subatl	T	+	+	+
67. *G. molle*	Arr.	S	med-smed(-subatl)	T	+	+	+
68. *G. robertianum*	F.	P	eurassubozean-smed	H (T)	+	+	+
XVI *Polygalaceae*							
69. *Polygala comosa*	B. e.	S	eurasskont-smed	H	-	+	-
70. *P. vulgaris*	Arr.	S	subatl(-smed)	H (Ch)	-	+	-
XVI *Celastraceae*							
71. *Euonymus verucossus*	Q. p.	P	s. o. eur	P	+	+	+
XVII *Rhamnaceae*							
72. *Frangula rupestris*	Amp.	P	balc-apen	P	+	+	+

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
XIX *Euphorbiaceae*							
73. *Euphorbia amygdaloides*	F.	P	subatl-smed	H	-	+	-
74. *E. cyparissias*	B. e.	S	smed(-euras)	H	+	-	-
75. *E. stricta*	Che.	T	smed-gemässkont	T	+	-	-
XX *Cornaceae*							
76. *Cornus sanguinea*	P. s.	PS	osmed	P	+	+	+
XXI *Araliaceae*							
77. *Hedera helix*	Q. p.	P	subatl-smed	Ch (P)	+	+	+
XXII *Apiaceae*							
78. *Athamanta haynaldii*	Amp.	P	din	H	-	+	-
79. *Bifora radians*	O.	T	omed	T	+	-	-
80. *Daucus carota*	Arr.	S	eurassubozean-smed	H	-	+	-
81. *Eryngium amethystinum*	S.-C.	S	balc-apen	H	+	-	-
82. *E. campestre*	B. e.	S	med-smed	H	+	-	-
83. *Heracleum sphondyllium*	F.	P	subatl	H	-	+	-
84. *Myrrhis odorata*	Ade.	SP	wpralp	H	+	-	-
85. *Orlaya grandiflora*	S.-C.	S	med-smed	T	+	-	-
86. *Pastinaca sativa*	Arr.	S	euras-smed	H	-	+	-
87. *Peucedanum oreoselinum*	Q. p.	P	gemässkont -smed(med)	H	-	+	-
88. *Scandix pecten-veneris*	B. e.	S	med-smed	T	+	-	-
89. *Seseli rigidum*	Amp.	P	s. o. din	H	-	+	-
90. *Smyrnium perfoliatum*	Q. p.	P	osmed	T	+	-	-
XXIII *Hypericaceae*							
91. *Hypericum perforatum*	B. e.	SP	eurassubozean -smed	H	+	+	+
XXIV *Violaceae*							
92. *Viola arvensis*	Che.	T	eurassubozean	T	-	+	-
XXV *Cistaceae*							
93. *Helianthemum nummularium*	B. e.	S	smed	Ch	+	+	+
XXVI *Brassicaceae*							
94. *Alliaria officinalis*	F.	PS	eurassubozean -smed	H	+	-	-
95. *Alyssum murale*	S.-C.	S	osmed	Ch	+	-	-
96. *Arabis caucasica*	Amp.	P	med-südasiat	H (Ch)	-	+	-
97. *A. glabra*	Ade.	SP	w(pralp)	Ch	+	+	+
98. *A. hirsuta*	A. f.	P	euras-smed,circ	H (T)	+	+	+
99. *A. turitta*	Q. p.	P	smed	H	+	+	+
100. *Barbarea vulgaris*	Che.	T	euras-smed	H	+	-	-
101. *Erysimum linarifolium*	Amp.	P	s. o. balc	H	+	+	+

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
102. *Malcolmia illyrica*	Amp.	P	balc	H	+	-	-
XXVII *Resedaceae*							
103. *Reseda lutea*	O.	T	smed-med	H	-	+	-
XXVIII *Salicaceae*							
104. *Populus tremula*	Q. r.-p.	PS	no-euras	P	-	+	-
105. *Salix caprea*	F.	P	no-euras	P	-	+	-
106. *S. purpurea*	S. p.	P	smed -eurassubozean	P	+	-	-
XXIX *Primulaceae*							
107. *Primula veris*	Arr.	S	euras-smed	H	-	+	-
XXX *Malvaceae*							
108. *Malva silvestris*	O.	T	smed-euras	H	+	-	-
XXXI *Caryophyllacea*							
109. *Arenaria serpyllifolia*	Che.	T	euras-med,circ	T	+	-	-
110. *Cerastium arvense*	Arr.	S	eurassubozean -smed,circ	Ch	-	+	-
111. *C. caespitosum*	Che.	T	no-euras(subozean)	Ch (T)	+	+	+
112. *Dianthus kitaibelii*	Amp.	P	din	Ch	+	+	+
113. *Minuartia bosniaca*	Amp.	P	din	Ch	+	+	+
114. *Silene otites*	Q. p.	P	(gemäss)kont (-smed)	H	+	-	-
115. *S. vulgaris*	B. e.	S	no-euras-smed	H (Ch)	+	+	+
116. *Stellaria media*	Che.	T	no-euras-med	T	+	+	+
117. *Tunica saxifraga*	S.-C.	S	(o)smed	Ch	+	+	+
XXXII *Chenopodiaceae*							
118. *Chenopodium album*	Che.	T	no-euras(-med)	T	+	-	-
XXXIII *Polygonaceae*							
119. *Falopia convolvulus*	Che.	T	(no-)euras	T	+	-	-
120. *Rumex crispus*	Che.	T	eurassubozean-smed	H	+	-	-
XXXIV *Rubiaceae*							
121. *Asperula cynanchica*	B. e.	S	smed	H	-	+	-
122. *Galium aparine*	Che.	T	euras(subozean)	T	-	+	-
123. *G. corrudaefolium*	Amp.	P	med	H	+	+	+
124. *G. purpureum*	S.-C.	S	balc	H	+	+	+
125. *G. verum*	B. e.	S	euras-smed	H	+	-	-
XXXV *Caprifoliacea*							
126. *Lonicera caprifolium*	P. s.	PS	osmed	P	+	+	+
XXXVI *Velarianaceae*							
127. *Valeriana officinalis*	Ade.	SP	gemässkont (-osmed)	H	-	+	-

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
XXXVII *Dipsacaceae*							
128. *Scabiosa leucophylla*	S.-C.	S	din	H	+	+	+
XXXVIII *Oleaceae*							
129. *Fraxinus ornus*	Q. p.	P	osmed	P	+	+	+
130. *Ligustrum vulgare*	P. s.	PS	smed	P	+	+	+
131. *Syringa vulgaris*	Q. p.	P	s. o. eur	P	+	-	-
XXXIX *Convolvulaceae*							
132. *Calystegia sepium*	Che.	T	euras(subozean) -smed	G	+	-	-
133. *Convolvulus arvensis*	Che.	T	med-smed-euras	G (H)	-	+	-
XL *Boraginaceae*							
134. *Anchusa officinalis*	O.	T	gemässkont (-osmed)	H	+	-	-
135. *Echium vulgare*	O.	T	euras-smed	H	+	-	-
136. *Onosma stellulatum*	Amp.	P	din	H	+	-	-
XLI *Scrophulariaceae*							
137. *Digitalis ferruginea*	Q. p.	P	s. eur	H	+	-	-
138. *Euphrasia stricta*	B. e.	S	(eurassubozean) subatl (-smed)	T	-	+	-
139. *Melampyrum pratense*	F.	P	no-eurassubozean	T	-	+	-
140. *Scrophularia canina*	A. f.	P	smed	H	+	+	+
141. *Verbascum phlomoides*	O.	T	gemässkont-osmed	H	+	-	-
142. *V. thapsus*	O.	T	euras-smed	H	+	-	-
143. *Veronica acinifolia*	Che.	T	smed	T	+	-	-
144. *V. chamaedrys*	Arr.	S	no-eurassubozean	Ch	+	+	+
145. *V. hederifolia*	Che.	T	eurassubozean-smed	T	+	-	-
146. *V. jacquinii*	S.-C.	S	gemässkont	Ch	-	+	-
147. *V. persica*	Che.	T	sw-asien	T	+	-	-
XLII *Plantaginaceae*							
148. *Plantago lanceolata*	Arr.	S	eurassubozean	H	+	-	-
149. *P. media*	B. e.	S	euras(kont)-smed	H	+	+	+
XLIII *Lamiaceae*							
150. *Acinos arvensis*	S.-C.	S	smed-euras	T (Ch)	+	+	+
151. *A.hungaricus*	S.-C.	S	europkont	T (Ch)	+	-	-
152. *Ajuga chamaepitys*	F.-S.	T	med-smed	H (T)	+	-	-
153. *Ballota nigra*	Che.	T	osmed-gemässkont	H (Ch)	+	-	-
154. *Clinopodium vulgare*	P. s.	PS	euras-smed	H	-	+	-
155. *Lamiastrum galeobdolon*	F.	P	gemässkont	Ch	+	-	-
156. *Lamium purpureum*	Che.	T	(no-)euras-smed	T (H)	-	+	-
157. *Micromeri athymifolia*	Amp.	P	balc	Ch	+	+	+
158. *Origanum vulgare*	Q. p.	SP	euras-smed	H (Ch)	+	-	-

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
159. *Stachys recta*	B. e.	S	smed(-gemässkont)	H	+	+	+
160. *Teucrium chamaedrys*	B. e.	S	smed-med	Ch	+	+	+
161. *Thymus praecox* ssp. *jankae*	Amp.	P	balc	Ch	+	+	+
162. *T. serpyllum*	B. e.	S	europkont	Ch	-	+	-
XLIV *Campanulaceae*							
163. *Campanula cervicaria*	P. s.	SP	gemässkont(-smed)	H	+	-	-
164. *C. rapunculus*	B. e.	SP	smed-euras	H	-		-
165. *C. rotundifolia*	Amp.	P	(no-)eurassubozean	H	-	+	-
166. *C. rotundifolia* f. *albiflora*	Amp.	P	(no-)eurassubozean	H	-	+	-
167. *C. trachelium*	P. s.	PS	eurassubozean-smed	H	+	+	+
168. *Edraianthus jugoslavicus*	Amp.	P	s. o. balc	H	-	+	-
XLV *Asteraceae*							
169. *Achillea millefolium*	Arr.	S	no-eurassubozean	H (Ch)	+	-	-
170. *Anthemis tinctoria*	O.	T	euras(kont)smed	H	+	-	-
171. *Artemisia absinthium*	Art.	T	euraskont(-smed)	Ch (H)	+	-	-
172. *A. vulgaris*	Art.	T	eurassubozean	Ch (H)	+	-	-
173. *Carduus crispus*	O.	T	eurassubozean	H	+	+	+
174. *Centaurea rhenana*	S.-C.	S	s. o. kont	H	+	-	-
175. *C. scabiosa*	B. e.	S	eurassubozean-smed	H	-	+	-
176. *Chondrilla juncea*	Amp.	P	med-smed-kont	H	+	+	+
177. *Cirsium arvense*	Che.	T	no-euras-smed	G	+	-	-
178. *C. oleraceum*	Che.	T	euras(kont)	H	+	+	+
179. *Crepis biennis*	Arr.	S	gemässkont	H	+	-	-
180. *Crupina vulgaris*	S.-C.	S	smed	H	+	-	-
181. *Echinops sphaerocephallus*	O.	T	med-smed(-euras)	H	+	-	-
182. *Eupatorium cannabinum*	Ade.	SP	eurassubozean-smed	H	+	-	-
183. *Hieracium cymosum*	B. e.	S	no-gemässkont	H	+	-	-
184. *H. murorum*	F.	P	no-eurassubozean	H	+	+	+
185. *H. villosum*	Amp.	P	alp	H	-	+	-
186. *H. waldsteinii*	Amp.	P	din	H	+	+	+
187. *Hypochoeris radicata*	Arr.	S	subatl(-smed)	H	+	-	-
188. *Inula conyza*	Q. p.	P	smed(-euras)	H	+	+	+
189. *Leontodon crispus*	Amp.	P	balc	H	+	+	+
190. *Leucanthemum vulgare*	Arr.	S	eurassubozean	H	-	+	-
191. *Mycelis muralis*	F.	P	subatl-smed	H	-	+	-
192. *Picris hieracioides*	B. e.	S	euras(kont)-smed	H	+	+	+
193. *Sonchus arvensis*	Sec.	T	no-eurassubozean	H	+	+	+
194. *S. oleraceus*	Che.	T	euras-smed-med	T (H)	+	-	-
195. *Stenactis annua*	Che.	T	n-am	H	+	-	-
196. *Tanacetum parthenifolium*	O.	T	omed	H	+	-	-
197. *Taraxacum officinale*	Arr.	S	no-euras(subozean)	H	+	+	+
198. *Tussilago farfara*	Che.	T	no-euras-smed	G (H)	+	+	+

The name of the species	Phytocoenological affiliation	Indicator value	Floral element	Life form	Distribution		
					N	SE	Both sides
XLVI *Liliaceae*							
199. *Allium carinatum*	Amp.	P	smed(-subatl)	G	+	-	-
200. *A. sphaerocephalum*	Amp.	P	balc	G	+	+	+
XLVII *Dioscoreaceae*							
201. *Tamus communis*	Q. p.	PS	smed(atl)	G	-	+	-
XLVIII *Cyperaceae*							
202. *Carex humilis*	Q. p.	P	(euras)kont-smed	H	+	-	-
203. *C. silvatica*	F.	P	subatl(-smed)	H	-	+	-
XLIX *Poaceae*							
204. *Agropyron repens*	P. m.	T	no-euras	H (G)	+	+	+
205. *Alopecurus pratensis*	Arr.	S	no-euras	H	-	+	-
206. *Arrhenatherum elatius*	Arr.	S	subatl-smed	H	+	+	+
207. *Bromus erectus*	B. e.	S	smed	H	+	+	+
208. *B. sterilis*	Che.	T	smed	T	+	-	-
209. *Chrysopogon gryllus*	S.-C.	S	med-smed	H	-	+	-
210. *Cynosurus cristatus*	Arr.	S	subatl(-smed)	H	+	-	-
211. *Dactylis aschersoniana*	Q. p.	P	gemässkont	H	+	-	-
212. *D. glomerata*	Arr.	S	euras(-smed)	H	+	-	-
213. *Danthonia alpina*	S.-C.	S	osmed(-europkont)	H	-	+	-
214. *Festuca amethystina*	B. e.	S	opralp(gemässkont)	H	-	+	-
215. *F. rubra*	Arr.	S	no-euras,circ	H	-	+	-
216. *Hordeum murinum*	Che.	T	smed-med	H	+	-	-
217. *Koeleria pyramidata*	B. e.	S	subatl-smed	H	+	-	-
218. *Lolium perenne*	Arr.	S	subatl-smed	H	+	-	-
219. *Melica ciliata*	Amp.	P	smed	H	+	+	+
220. *M. nutans*	F.	P	no-euras(kont)	H (G)	-	+	-
221. *Milium effusum*	F.	P	eurassubozean	H	-	+	-
222. *Poa pratensis*	Arr.	S	euras(kont)(-smed)	H (G)	+	+	+
223. *P. trivialis*	Arr.	S	no-euras(subozean)	H (Ch)	+	+	+
224. *P. vivipara*	Arr.	S	euras(kont)(-smed)	H (G)	+	+	+
225. *Sesleria angustifolia*	Amp.	P	balc	H	-	+	-
226. *S. autumnalis*	Q. p.	P	balc	H	+	+	+
227. *S. ujchelyii*	Amp.	P	din	H	+	+	+
228. *Stipa calamagrostis*	Amp.	P	pralp-smed	H	+	+	+
TOTAL:					**167**	**145**	**91**
49 families					**41**	**43**	**29**
228 taxa							
18 phytocoenological orders					**17**	**15**	**14**

Abbreviations:

Abbreviations for indicator values: P – primary, PS – primary secondary, S – secondary, SP – secondary primary, and T – tertiary vegetation.
Abbreviations for phytocoenological orders arranged alphabetically: Ade. – *Adenostyletalia*, Amp. – *Amphoricarpetalia*, A. f. – *Arabidetalia flavescentis*, Arr. – *Arrhenatheretalia*, Art. – *Artemisietalia*, B. e. – *Brometalia erecti*, Che. – *Chenopodietalia*, E.-P. – *Erico-Pinetalia*, F. – *Fagetalia*, F.-S. – *Festuco-Sedetalia*, O. – *Onopordetalia*, P. m. – *Plantaginetalia maioris*, P. s. – *Prunetalias pinosae*, Q. p. – *Quercetalia pubescentis*, Q. r.-p. – *Quercetalia robori-petraeae*, S. p. – *Salicetalia purpureae*, S.-C. – *Scorzonero-Chrysopogonetalia*, Sec. –*Secalinetalia*.
Abbreviations for life forms: H – *hemicryptophyta*, Ch – *chamaephyta*, P – *phanerophyta*, G – *geophyta* and T – *therophyta*.

Table 2. Taxonomic analysis of the flora of the entire investigated area

Taxa	Pteridophyta	Angiospermae		Total
		Dicotyledones	Monocotyledones	
Families	2	43	4	49
Genera	4	154	20	178
Species and forms	5	193	30	228
%	2.19	84.64	13.15	100

Table 3. The most important families of the entire investigated area

Families	Number of taxa	% of total
Asteraceae	30	13.15
Poaceae	25	10.96
Fabaceae	21	9.21
Rosaceae	14	6.14
Lamiaceae	13	5.70
Apiaceae	13	5.70
Scrophulariaceae	11	4.82
Caryophyllacae	9	3.94

Table 4. Spectrum of floral elements for the entire investigatedarea and for individual sides of the investigated area

Floral element	An established number in the entire research area	Total number	Participation (in %)	North side			Southeastern side		
				An established number	Total number	Participation (in %)	An established number	Total number	Participation (in %)
din s. o. din din-so-alp	8 1 1	10	4.38%	5 - 1	6	3.59%	6 1 -	7	4.82%
balc s. o. balc balc-apen balc-smed	8 2 2 1	13	5.70%	7 1 2 1	11	6.58%	7 2 1 -	10	6.89%
s. eur s. o. eur	1 3	4	1.75%	1 2	3	1.79%	- 2	2	1.37%
alp alp-pralp-smed	1 1	2	0.87%	- 1	1	0.59%	1 1	2	1.37%
pralp wpralp w(pralp) pralp-alp-arkt(subozean)circ pralp-smed pralp(-smed) opralp(gemässkont)	2 1 1 1 1 1 1	8	3.50%	1 1 1 - 1 - -	4	2.39%	1 1 - 1 1 1 1	6	4.13%
smed (pralp)smed-subatl (med)smed-subatl osmed osmed(-europkont) osmed-gemässkont smed(atl) smed(-subatl) smed-subatl smed-subatl.(circ) smed(-gemässkont) smed- gemässkont smed-med smed-euras smed(-euras) smed-eurassubozean o(smed) (o)smed submed(-subatl)	13 1 1 8 1 2 1 1 4 1 1 1 3 3 2 2 1 1 1	48	21.05%	12 1 1 6 - 2 - 1 2 1 1 1 2 2 2 2 1 1 1	39	23.35%	8 1 1 6 1 1 1 - 3 1 1 - 2 2 1 1 1 1 1	33	22.75%
omed omed-smed omed-kont med(-kont) med	2 1 1 1 2			2 1 1 1 2			- 1 - 1 2		

Floral element	An established number in the entire research area	Total number	Participation (in %)	North side			Southeastern side		
				An established number	Total number	Participation (in %)	An established number	Total number	Participation (in %)
med-smed med-smed-euras med-smed(-euras) med-smed-kont med-smed(-subatl) med-südasiat	6 1 1 1 2 1	19	8.33%	5 - 1 1 3 -	17	10.17%	1 1 - 1 3 1	11	7.58%
subatl subatl(-smed) subatl-smed (eurassubozean)subatl(-smed) (no-)subatl(-smed) subatl-smed(-pralp)	1 4 7 1 1 1	15	6.57%	- 2 5 - 1 1	9	5.38%	1 2 5 1 1 -	10	6.89%
euras(kont) euras(kont)smed euras(kont)-smed euras(kont)(-smed) euras(subozean) euras(subozean)-smed euras(-smed) euras-smed euras-smed.circ euras-smed-med euras-med euras-med.circ (no-)euras (no-)euras-smed (no-)euras-smed.circ	1 1 3 2 2 3 1 10 2 1 1 1 1 1 1	31	13.59%	1 1 2 2 1 3 1 6 1 1 1 1 1 - 1	23	13.77%	1 - 3 2 1 1 - 4 2 - - - - 1 1	16	11.03%
no-euras(-med) no-euras-med no-euras-smed no-euras no-euras.circ no-euras(subozean) no-euras(kont) no-eurassubozean-pralp no-eurassubozean no-(eurassubozean) no-gemässkont	1 1 3 5 1 3 1 1 5 1 1	23	10.08%	1 1 3 2 - 3 - - 4 - 1	15	8.98%	- 1 2 5 1 3 1 1 4 1 -	19	13.10%
eurassubozean eurassubozean-smed eurassubozean-smed.circ eurassubozean(-smed) (no-)eurassubozean (no-)eurassubozean(-smed)	8 15 1 2 2 1	29	12.71%	5 12 - 1 - 1	19	11.37%	6 10 1 1 2 1	21	14.48%
euraskont(-smed) euraskont euraskont-smed	1 1 1	3	1.31%	1 1 -	2	1.19%	- - 1	1	0.68%
(gemäss)kont(-smed) (euras)kont-smed s. o. kont europkont	1 1 1 2	5	2.19%	1 1 1 1	4	2.39%	- - - 1	1	0.68%
gemässkont gemässkont-osmed gemässkont-smed gemässkont-smed(med) gemässkont(-osmed) gemässkont(-smed)	4 4 1 1 2 2	14	6.14%	3 4 - - 1 2	10	5.98%	1 2 1 1 1 -	6	4.13%
n-persien	1	1	0.43%	1	1	0.59%	-	-	-
china sw-asien	1 1	2	0.87%	1 1	2	1.19%	-	-	-
n-am	1	1	0.43%	1	1	0.59%	-	-	-
Total number of floral elements: 17				**17**			**14**		
Total number of individual floral elements: 103				**82**			**75**		
TOTAL:	**228**	**228**	**100%**	**167**	**167**	**100%**	**145**	**145**	**100%**