

Taxonomic and Biogeographical Analysis of Bryophytes in the Coastal Area of the Ukrina River (Bosnia and Herzegovina)

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Abstract

Bryophytes are a blind branch in the evolution of plants, but they are a very significant group, which makes a remarkable component of the whole biodiversity owing to the number of described species and its wide coverage. This work shows a taxonomic and biogeographical analysis of Bryophytes in the coastal area of the Ukrina River (Bosnia and Herzegovina). There have been 43 species sampled and determined in the researched localities. The Hepaticopsida class is represented by only one species, *Radula complanata*, the Bryopsida class dominates almost completely. Among Bryopsida, the representatives of the Hypnales order occur in a great percentage (40.48%). Further, 27 genera have been identified in the bryoflora of the researched area. The species of the *Bryum* genus (5) take the greatest proportion. In the bryoflora of the researched area the most prevailing is temperate, i.e. a floral element of moderate zones, with 88.37%, then a submediterranean floral element follows with 6.98% and boreal (4.65%). At the researched locality, the most represented are chamephyta with 74.29%, whereas life forms of hemicriptophyta and epiphyte cover significantly lower percentage of Bryophyte flora. Apart from the ecology, the research on Bryophyte is also notable for the areas of pharmacy and medicine because many of their species are capable to synthesize antibiotic substances.

Key words: Bryophyte, river basin, taxonomic analysis, biogeographical analysis

Introduction

Bryophytes are a very old group of plants according to the evolutionary aspect and they are put together in three classes: Anthocerotopsida, Hepaticopsida and Bryopsida. It is considered there are around 27000 species on the Earth (Tatić and Blečić, 1984, Jančić, 2004). Beside the significant diversity of species, this group of plants is recognizable for many common features: relatively simple anatomic form, weakly differentiated conducting elements, fertilization by water, domination of a gametophyte phase in their life cycle (Jančić, 2004).

Although Bryophyte represent a blind branch in the evolution of plants (Tucić and Cvetković, 2000), they provide ecological and economic benefits (Tatić and Blečić, 1984). In spite of the scarce annual growth, their part in organic matter production, especially in the pioneer habitats and peat bogs of cold areas, is dominant (Stevanović and Janković, 2001). Bryophytes are excellent bio-indicators of the living environment conditions because of their deposition of heavy metals and radioactive elements from the atmosphere during a longer time period (Mäkinen, 1987; Cvijan, 2000). Some species are considered to be the best indicators of clean waters among higher plants (Stevanović et al., 1995). Considering the number of described species, Bryophyte take place as a significant component of biodiversity on the Earth (Sabovljević et al., 2001). Without biodiversity there is no matter cycling and flow of energy within the ecosystem, the oxygen production, photosynthesis or the organic matter dissolving. Biodiversity contributes to climate regulation, diminishing the greenhouse effect, maintaining the quality of all the components of the environment (Popović, 2015; Dražić, 2015).

Some Bryophyte species (*Sphagnum squarrosum* and *Polytrichum commune*) are used in medicine due to their antibiotic features (Jančić, 2004). According to everything that has been mentioned, the goal of this work is to research Bryophyte flora in the coastal area of the Ukrina River (Bosnia and Herzegovina). Taxonomic and biogeographical analysis that has been conducted aims to point out the resource and diversity, that is, diversity of Bryophyte among the vegetation of the researched area.

Material and Methods

Three basic types of samples of Bryophyte flora, namely epiphytic (from trees), terrestrial (from ground) and epilithic (from rocks) were taken at the researched localities. The material sampling was done in dry and sunny weather.

Collected material was dried on paper for 20 days at room temperature (25⁰C) in order to decrease the percentage of moisture in the cells. The dried material was packed up in paper envelopes. During the research, 43 species were sampled and analyzed. Determination of species (taxa) was done on the basis of morphological and anatomic features using a CARLZEISS JENA microscope and a binocular magnifier MBS-9 and based on the following literature: Petrov (1975), Smith (1991; 1997), Pavletić (1968), Perry (1992), Watson (1968), and Gallego (2002). The biogeographical analysis is based on the data by Düll et al. (1999).

The area under study

The coastal area of the Ukrina River (Bosnia and Herzegovina) is settled in the valley of the middle flow of the Sava River and the low part of the Bosnia River. The southern part of the area belongs to the slopes of the Ljubić and Čavka mountains. According to their genesis, these mountains make separate geological-orthographic unit. The rest of the area is a slightly raised hilly terrain which, in geographical terms, belongs to the Panonic depression with the features of a wide alluvial plain. The territory of the Ukrina river basin is enclosed by ophyolitic massives of Čavka and Borja in the south and the parts of the Motajica horst in the north. The part of the southern edge of the Panonic graben also belongs to its territory (Sofilj et al., 1985).

The length of the Ukrina watercourse from the spring to its mouth is 119.3 km long. Flowing through the middle of the said terrain, the river receives most part of surface waters. The Vijaka River with Lišnja and Planuša, then the Jadovica River, the Velika Kremnica River and a series of smaller watercourses, flow into it from its left side. The right tributaries of the Ukrina River are the Radnja River, the Ilova River and the Lupljanica River with many brooks that flow into them. The Ukrina River is a smaller right tributary of the Sava River. The overall surface that belongs to the basin covers about 1500 km² and represents a relatively small basin area. The spring is at the altitude of about 800 m and the mouth into the Sava River is at 88 m altitude. For the most part of its watercourse, the Ukrina River flows through alluvial drifts and in the period of high water level, the watercourse of the river also increases. This is due to watercourse meanders, which are also significantly divided into rapids and coastal lakes (Korene et al., 2005). A geological substratum of the river bed is made of sand, gravel, clay or rocks. In the coastal area of the Ukrina River and the depressions close to smaller watercourses, there is hygromorph soil. The area of the Ukrina river basin consists of a great number of beds and sites of different mineral material (Sofilj et al., 1985).

Researching biogeographical classifications of former Yugoslavia, it could be concluded that the area under research belongs to the parts of European, mostly deciduous forests of a moderate zone with a temperate climate on brown forest grounds. These parts are recognizable in the first place for the forests of mostly deciduous trees or deciduous brushwoods or bushes. On the parts without forests and bushes, the ground is covered in gentle, soft grass or other herbaceous plants that grow in clusters, completely covering the ground and forming plant communities of a meadow like type. The characteristic types of plants are the following: *Fagus sylvatica* L., *Carpinus betulus* L., *Quercus robur* L., *Q. petraea* (Matt.) Liebl., *Berberis vulgaris* L., *Evonymus europaeus* L., *Acer campestre* L., *Acer pseudoplatanus* L., *Ligustrum vulgare* L., *Prunus avium* L., *Betula* sp. By the river more common are: *Alnus glutinosa* Gaertn, *Salix alba* L., *Populus alba* L. Evergreen types such as *Ruscus hypoglossum* L., *Cyclamen europaeum* L. and other grow on the ground level (Matvejev, 1973). A great part of former natural vegetation has been degraded by the anthropogenic influence and it is used for production of cultivated plants. Preserved natural vegetation has remains in relatively unreachable places.

Results and Discussion

In the locality under research 43 species were collected (Table 1). The Hapticopsida class is present with only one species, *Radula complanata*, which belongs to the Jungermaniales order. The Bryopsida class dominates almost completely.

Tab. 1. Review of the identified Bryopsida species

Преглед идентификованих врста класе Bryopsida

	Species	Life form	Floral Element	Habitat
1.	<i>Radula complanata</i> (L.) Dumor	H	temperate	on ground
2.	<i>Amblystegium serpens</i> (Hedw.) B.S.G.	C	temperate	on ground
3.	<i>Anomodon attenuatus</i> (Hedw.) Heub.	C	temperate	on ground
4.	<i>Anomodon viticulosus</i> (Hedw.) Hook&Tayl.	C	temperate	on ground
5.	<i>Atrichum undulatum</i> (Hedw.) P.Beauv.	H	temperate	on ground
6.	<i>Barbula unguiculata</i> Hedw.	C	temperate	on ground
7.	<i>Brachythecium glaerosum</i> (Spruce) B.S.G.	C	temperate	a concrete wall
8.	<i>Brachythecium rutabulum</i> (Hedw.) B.S.G.	C	temperate	on ground
9.	<i>Brachythecium salebrosum</i> (Web.&Mohr.) B.S.G.	C	temperate	on ground
10.	<i>Brachythecium velutinum</i> (Hedw.) B.S.G.	E	temperate	on a wild apple (on tree, forest)

Tab. 1. Review of the identified Bryopsida species (continued)

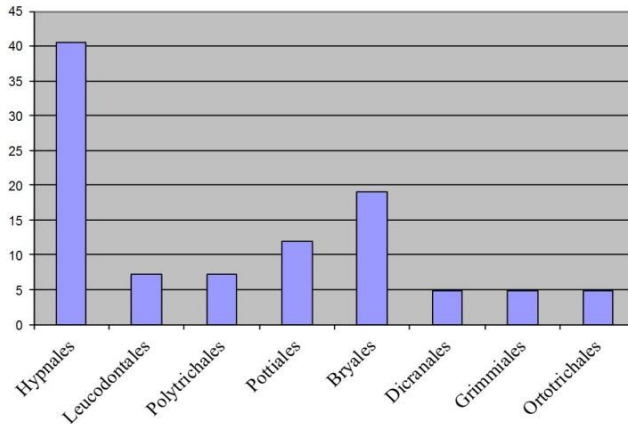
Преглед идентификованих врста класе *Bryopsida* (наставак)

	Species	Life form	Floral Element	Habitat
11.	<i>Bryum argenteum</i> Hedw.	C	temperate	on ground
12.	<i>Bryum bicolor</i> Dicks	C	temperate	on ground
13.	<i>Bryum caespiticum</i> Hedw.	C	temperate	on ground
14.	<i>Bryum capillare</i> Hedw.	C	temperate	on ground
15.	<i>Bryum laevifilum</i> Syed (<i>flaccidum</i>)	C	temperate	from the rock
16.	<i>Dicranella varia</i> (Hedw.) Schimp.	C	temperate	on ground
17.	<i>Didymodon vinealis</i> (Bird.) Zander	C	submediterranean	on ground
18.	<i>Ditrichum heteromallum</i> (Hedw.) Britt.	C	temperate	on ground
19.	<i>Eurhynchium hians</i> (Hedw.) Sande Lac.	C	temperate	on the ground, by the river
20.	<i>Eurhynchium praelognum</i> (Hedw.) B.S.G.	C	temperate	from the rock
21.	<i>Grimmia pulvinata</i> (Hedw.) Sm.	C	temperate	a concrete wall
22.	<i>Homalothecium philippeanum</i> (Spruce) B.S.G.	C	boreal	from the rock
23.	<i>Homalothecium sericeum</i> (Hedw.) B.S.G.	E	temperate	on a wild apple (near the ground, on the tree)
24.	<i>Hypnum cupressiforme</i> Hedw. ssp. <i>cupressiforme</i>	C	temperate	on ground
25.	<i>Hypnum cupressiforme</i> Hedw. ssp. <i>resupinatum</i> (Tayl ex Spruce) C.H.	E	temperate	on the tree
26.	<i>Hypnum mammilatum</i> (Brid.) Loeske	C	temperate	on ground
27.	<i>Isothecium alopecuroides</i> (Dubois) Isov.	C	temperate	on ground
28.	<i>Isothecium myosuroides</i> Brid.	C	temperate	on ground
29.	<i>Leucodon sciuroides</i> (Hedw.) Schwaegr	E	submed.	on the tree (two-metre height)
30.	<i>Mnium spinosum</i> (Voit) Schwaegr	H	temperate	on ground
31.	<i>Orthotrichum tenellum</i> Bruch ex Brid.	C	temperate	on ground
32.	<i>Orthotrichum urnigerum</i> Myrin	C	temperate	a concrete wall
33.	<i>Plagiomnium undulatum</i> (Hedw.) T.Kop.	H	temperate	on ground
34.	<i>Plagiothecium succulentum</i> (Wils.) Lindb.	H	temperate	on ground
35.	<i>Pohlia nutans</i> (Hedw.) Lindb.	C	temperate	on ground
36.	<i>Polytrichum formosum</i> Hedw.	H	temperate	on ground
37.	<i>Polytrichum piliferum</i> Hedw.	H	boreal	on the decomposed oak tree stump
38.	<i>Pseudocrossidium hornschuchianum</i> (Schultz) R.H. Zander	C	submediterranean	on ground
39.	<i>Pylaisia polyantha</i> (Hedw.) Schimp.	C	temperate	on ground
40.	<i>Rhynostegium murale</i> (Hedw.) B.S.G.	C	temperate	on the ground - the closeness of the river
41.	<i>Schistidium apocarpum</i> (Hedw.) Bruch & Schimp.	C	temperate	a concrete wall
42.	<i>Tortula muralis</i> Hedw.	C	temperate	on ground
43.	<i>Tortula subulata</i> Hedw.	C	temperate	on ground

Legend: Life form C = chamaephytes, E = epiphytes, H = hemiepiphytes.

Among Bryopsida, the representatives of the Hypnales order occur in great percentage (40.48%) (Graph 1).

These mosses occasionally suffer dry state as well as a periodical eutrofication of the habitat by flooding (During, 1979). They are usually found in small woods along the Ukrina River and smaller watercourses, on the edge of floodable zones and often on tree barks. The representatives of the Bryales order (Graph 1) are also present with a significant share (19.06%).



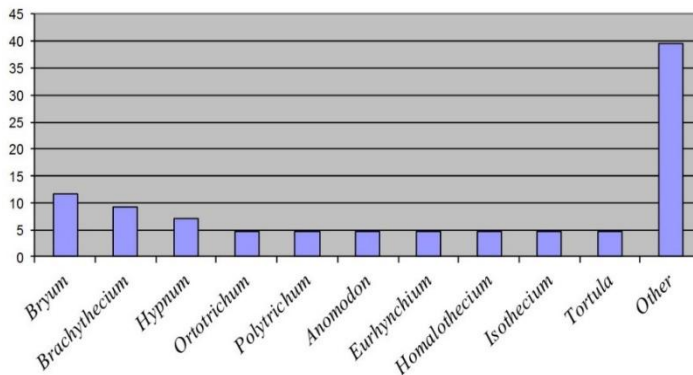
Graph 1. Percentage representation of the orders of the Bryopsida class by the Ukrina River (Bosnia and Herzegovina)

*Релативни удио родова класе Bryopsida ријеке Укрине
(Босна и Херцеговина)*

Most representatives of this order have a living strategy of colonizers and they colonize occasionally and permanently distracted habitats, that is, inhospitable habitats such as arable land which are characterized by the ability to change as a result of habitat conditions. Colonizing Bryophytes invest a visible effort in vegetative reproduction which allows them to colonize such habitats (During, 1979). The representatives of the Pottiales order take 11.90% (Graph 1).

They are adapted to drier parts of habitat, mainly to arable land where the edges of fields and roads are usually burnt (During, 1979). The representatives of the Leucodontales and Polytrichales order are present in lower percentage of 7.14%, whereas the lowest percentage is taken by the representatives of the Dicranales (4.76%), Grimmales (4.76%) and Ortotrichales order (4.76%).

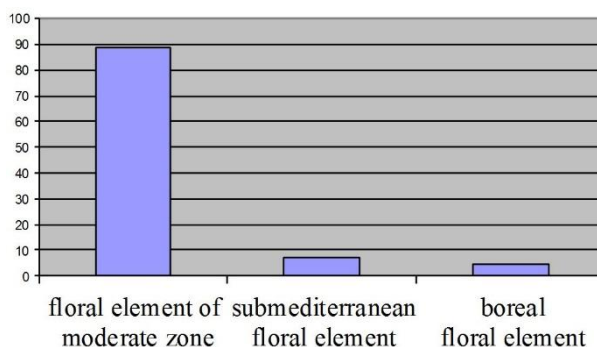
There have been 27 genera identified in the bryoflora of the researched area. The species of the *Bryum* genus (5) take the greatest proportion, then they are followed by *Brachythecium* (4), *Hypnum* (3), and the *Ortotrichum*, *Polytrichum*, *Anomodon*, *Eurhynchium*, *Homalothecium*, *Isothecium* and *Tortula* genera are present with just two species. Significant percentage of the genera (39.53%) occur with only one species (Graph 2).



Graph 2. The most common genera of the Bryopsida class by the Ukrina River (Bosnia and Herzegovina)

Најзаступљенији родови из класе Bryopsida ријеке Укрине (Босна и Херцеговина)

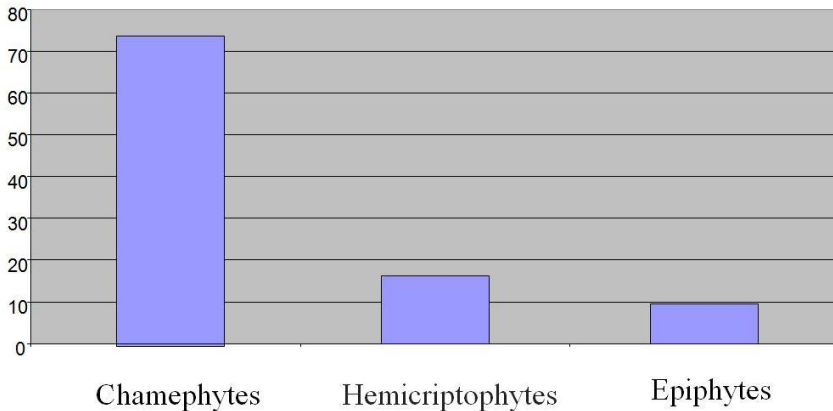
As expected, the most present is temperate, that is, a floral element of moderate zones (88.37%) (Graph 3).



Graph 3. Areal types spectrum of the Bryophyte plant species by the Ukrina River (Bosnia and Herzegovina)

Просторна расподела врста из класе Bryopsida ријеке Укрине (Босна и Херцеговина)

Then, a submediterranean floral element follows (6.98%), which includes the species whose areals are in the back of a mediterranean area (Janković, 1990). The presence of this xerophyl bryoflora is not surprising in the researched climate area which is known for summer periods of drieness and high temperatures and the absence of an extremely cold winter periods. A boreal floral element (Graph 4), which includes the species whose areals are found in the zones of taiga (Janković, 1990), takes the lowest percentage (4.65%), which might be a consequence of relatively mild and short winters in the area under research.



Graph 4. Life forms of Bryophyte by the Ukrina River (Bosnia and Herzegovina)
Животне форме класе Bryopsida ријеке Укрине (Босна и Херцеговина)

Chamephytes prevail with 74.29%, hemicriptophytes are present with 16.18% and a living form of epiphyte takes lower percentage, namely 9.53% of Bryophyte flora in the researched locality.

Conclusion

The floral research of Bryophytes in the coastal area of the Ukrina River (Bosnia and Herzegovina) provides some significant data about diversity, ecology and range of this group of plants in Bosnia and Herzegovina. 43 species were collected, out of which one belongs to the Hepaticopsida class and the others belong to the Bryopsida class.

The species of the Hypnales order dominate with 40.48% in the bryoflora of the researched area. Further, Pottiales are present with 11.90% and they are mostly limited to drier conditions of habitat.

Bryales (19.06%) have a substantial share on the plough land in the first place, because of the colonization of permanently disturbed habitats, which is possible owing to the great effort they invest in vegetative reproduction (During, 1979). The *Bryum* genus (5) is the richest in species, then *Brachythecium* (4) and *Hypnum* (3) follow, whereas other genera are represented by one or two species. These genera are better adapted to dry conditions and arid habitats (During, 1979).

Temperate floral element dominates with 88.37% in the researched area, while the percentage of submediterranean and boreal is considerably lower, 6.98% and 4.65% respectively.

Chamephytes are present with the highest proportion (74.29%) at the researched locality, while hemicriptophytes and epiphytes presence is considerably lower.

Diversity of Bryophytes in the area under research is important because diversity of a microhabitat itself enables the resource of moss flora. This work is only a small contribution to the introduction the Bryophyte flora of Bosnia and Herzegovina.

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Таксономска и биогеографска анализа Bryophyta приобалног подручја ријеке Укрине (Босна и Херцеговина)

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Сажетак

Bryophyta представљају слијепу грану у еволуцији биљака, али су изузетно значајна група која, бројношћу описаних врста и широком распрострањеношћу, чини значајну компоненту укупног биодиверзитета. У раду је приказана таксономска и биогеографска анализа флоре Bryophyta у приобалном подручју ријеке Укрине (Босна и Херцеговина). На истраживаним локалитетима, сакупљене су и детерминисане 43 врсте. Класа Hepaticopsida представљена је само врстом *Radula complanata*, готово у потпуности доминира класа Bryopsida. Међу Bryopsida, у највећем проценту (40,48%) јављају се представници реда Hurnales. У бриофлори истраживаног подручја, идентификовано је 27 родова. Најзаступљеније су врсте рода *Bryum* (5). Највише је заступљен темперални флорни елемент са 88,37%, затим слиједи субмедитерански са 6,98% и бореални (4,65%). На истраживаном подручју, најзаступљеније су хамефите са 74,29%, док животној форми хемикриптофита и епифита припада знатно мањи проценат флоре Bryophyta. Осим у области екологије, истраживање Bryophyta значајно је и за подручје фармације и медицине јер многе врсте посједују способност синтезе антибиотских материја.

Кључне ријечи: Bryophyta, ријечни слив, таксономска анализа, биогеографска анализа.

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