

LIVERWORTS FROM THE MORAČA RIVER BASIN - TAXONOMIC AND ECOLOGICAL ANALYSIS

SNEŽANA DRAGIĆEVIĆ¹, M. VELJIĆ², and P. D. MARIN²

¹Natural History Museum of Montenegro, 81000 Podgorica, Montenegro

²Institute of Botany and Jevremovac Botanical Garden, Faculty of Biology, University of Belgrade, 11000 Belgrade, Serbia

Abstract — During the period of 1997-2007, we carried out detailed bryological research in the Morača River basin, Montenegro. Liverworts were collected at 45 locations. Thirty-five liverworts were recorded, including representatives of 24 genera and 19 families. The most frequent liverwort was *Radula complanata*, which was found at 17 localities. Seventeen taxa were registered at only one location in the investigated area. *Scapania aequiloba* is treated as endangered, and *Athalamia hyalina* as critically endangered, *Leiocolea collaris*, *L. bantriensis* and *L. turbinata* as vulnerable species. In addition, *Fossombronia caespitiformis*, *Lophocolea bidentata* var. *bidentata*, *Riccia cavernosa*, and *Tritomaria quinquedentata* are here registered for the first time in the bryoflora of Montenegro.

Key words: Liverworts, taxonomy, ecology, Morača River, Montenegro

UDC 582.674(497.16)(282):574

INTRODUCTION

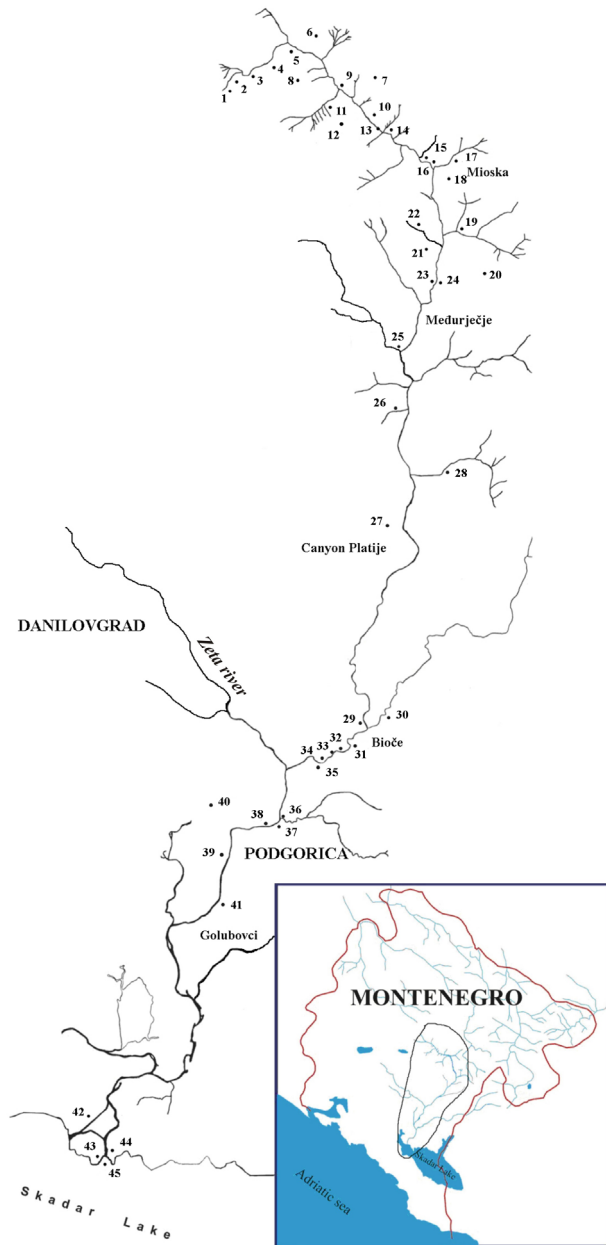
Bryological research in Montenegro started in the middle of the 19th century. Many foreign researchers, travel writers, and others have collected bryophytes on the coast (Boka Kotorska, Budva) and in some mountain areas (Rijeka Crnojevića, Komovi, Prokletije and Durmitor, and canyons of the Tara, Piva, and Komarnica Rivers). However, the largest part of Montenegro has still not been investigated from the bryological point of view. This statement applies especially to canyons, gorges, and high mountainous areas.

According to the check-list of liverworts and hornworts of Southeast Europe (Sabovljević and Natcheva, 2006), most countries have more liverwort species than Montenegro (Romania-193, Bulgaria-167, Slovenia-165, Croatia-155, Greece incl. Crete-140). Bryological research has undergone intensification during the last ten years. Dragićević and Veljić (2006) summarized bryological data for this area and mentioned 569 moss taxa, 101 of which are liverworts. Erzberger and Papp (2007) found 28 new bryophytes in Montenegro, of which 10 species are liverworts

(from the mountains Rumija and Lovćen and the environs of Kotor). Also, Papp and Erzberger (2007) reported an additional eight liverworts for the bryoflora of Montenegro.

From what has been said above, it is evident that there is both terrain and time discontinuity in research on mosses in this area. As a result, we have insufficient knowledge about the bryoflora, its resources and taxonomic diversity, ecology, and vulnerability. Almost every new investigation yielded species new for the bryophyte flora of Montenegro.

The Morača is a mountainous-lowland river whose basin lies between high mountains in the north and Zeta Valley and the Lake Skadar basin in the south of Montenegro. Because of its areas, length (app. 97 km), extremely high average fall of the river (the source is located at 1,650 m and estuary at app. 6 m above sea level), heterogeneous geological and pedological substratum, characteristic flora and fauna, and specific climate (lying between Adriatic-Mediterranean and temperate-continental zones), we expected that this would be a very attractive region from the bryological point of view.



Map 1. Examined area with localities 1-45 and its position in Montenegro (insert).

The Morača canyon is not unknown in bryological literature. To be specific, initial research was carried out by Pavletić and Pulević (1980). Since that time, we have not been able to collect a certain number of taxa recorded by the mentioned authors

at different localities in the research area (some of them representing unique finding places for certain mosses). Also, Milikić et al. (2001) worked on several springs in the Morača basin (these data are included in the present paper). In neighboring countries (Serbia, Croatia, and Macedonia), a limited number of published data refer to watercourse areas (Pavletić, 1957, 1959, 1960; Veljić et al. 2001; Veljić et al. 2006).

The main goals of this paper were to investigate taxonomic diversity, ecology, and threatened status of bryophytes from the Morača River basin, with special reference to liverworts, which are poorly known in the given region. The obtained results could be important for the near future, since the building of several new hydroelectric power stations is planned in the Morača basin, which will have a number of negative consequences for its flora and fauna.

MATERIAL AND METHODS

Bryological investigations of the Morača basin were performed in the period of 1997-2007. Liverworts were collected from 45 locations between the source of the Morača River and its estuary in Lake Skadar (Map 1). The bryophyte collection is housed in the Natural History Museum of Montenegro in Podgorica.

For identification of the collected material, the following bryological literature was used: Pavletić (1968), Grochovska (1971), Petrov (1975), Landwehr et al. (1980), and Smith (1990). Nomenclature is given according to Ross et al. (2007). Data on ecological parameters were taken from Soó (1964) and Boros and Járαι-Komlódi (1975), while information about floristic elements and distribution is given according to Duell (1983) and Duell et al. (1999).

RESULTS AND DISCUSSION

Thirty-five taxa representing the class Marchantiopsida (liverworts) were identified in research on the Morača River and its few tributaries (Table 1).

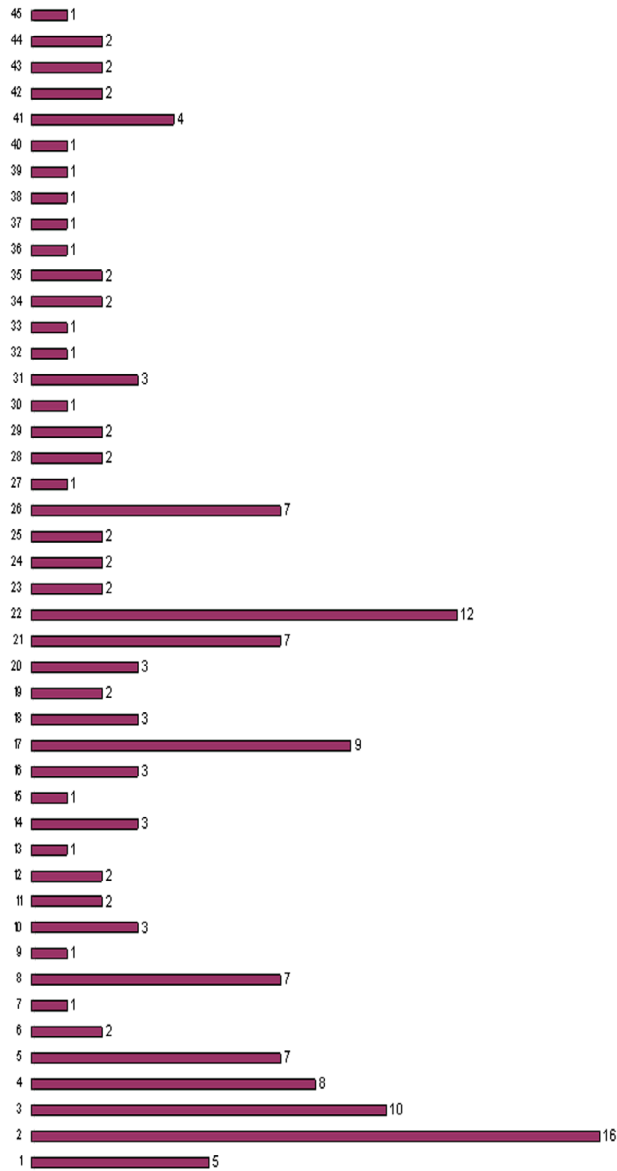


Fig. 1. Number of taxa from localities.

The registered taxa belong to 19 families and 24 genera. The majority of families are represented by just one genus. The genera with the most species are *Lophocolea* and *Leiocolea* with three, other genera being represented by one or two taxa. The families Geocalycaceae and Lophoziaaceae have the highest number of representatives, with six and four species, respectively. Other families are represented by one or two taxa.

Table 1. List of recorded liverwort taxa with locality number (*species new for the bryophyte flora of Montenegro).

| |
|--|
| <i>Athalamia hyalina</i> (Sommerf.) S. Hatt. - 11 |
| <i>Cephalozia bicuspidata</i> (L.) Dumort. - 13 |
| <i>Chiloscyphus pallescens</i> (Ehrh. ex Hoffm.) Dumort. - 16 |
| <i>Chiloscyphus polyanthos</i> (L.) Corda - 2, 3, 40 |
| <i>Conocephalum conicum</i> (L.) Dumort. - 2, 3, 4, 5, 22, 25, 26, 31, 33, 41 |
| * <i>Fossombronina caespitififormis</i> De Not. ex Rabenh. - 35 |
| <i>Frullania dilatata</i> (L.) Dumort. - 8, 12, 14, 15, 17, 18, 19, 20, 21, 22, 24, 26, 28, 38, 41, 44 |
| <i>Jungermannia atrovirens</i> Dumort. - 2, 17, 22 |
| <i>Leiocolea bantriensis</i> (Hook) Jørg. - 25 |
| <i>Leiocolea collaris</i> (Nees) Schljakov - 2 |
| <i>Leiocolea turbinata</i> (Raddi) H. Buch - 27 |
| <i>Lejeunea cavifolia</i> (Ehrh.) Lindb. - 18, 21, 22 |
| * <i>Lophocolea bidentata</i> (L.) Dumort. var. <i>bidentata</i> - 2, 4, 8, 17, 22, 26 |
| <i>Lophocolea heterophylla</i> (Schrud.) Dumort. - 11 |
| <i>Lophocolea minor</i> Nees - 20 |
| <i>Lunularia cruciata</i> (L.) Lindb. - 29, 35, 41, 43 |
| <i>Marchantia polymorpha</i> L. - 2, 12, 23 |
| <i>Metzgeria conjugata</i> Lindb. - 2, 3, 8, 22 |
| <i>Metzgeria furcata</i> (L.) Dumort. - 6, 8, 17, 21 |
| <i>Pedinophyllum interruptum</i> (Nees) Kaal. - 1, 2, 4, 5, 17, 21, 22, 26 |
| <i>Pellia endiviifolia</i> (Dicks.) Dumort. - 22, 26 |
| <i>Pellia epiphylla</i> (L.) Corda - 2, 3, 4, 5, 10, 14, 16, 17, 20, 21, 22, 26, 41 |
| <i>Plagiochasma rupestre</i> (J.R.Forst. et G.Forst.) Steph. - 34 |
| <i>Plagiochila asplenioides</i> (L. Emend. Taylor) Dumort. - 1, 2, 3, 4, 5, 8, 9, 10, 17, 21, 22 |
| <i>Porella cordaeana</i> (Huebener) Moore - 1 |
| <i>Porella platyphylla</i> (L.) Pfeiff. - 1, 2, 3, 4, 5, 10, 14, 22, 28, 31 |
| <i>Preissia quadrata</i> (Scop.) Nees - 1, 2, 3, 4, 5, 26, 30, 32, 39, 42, 43 |
| <i>Radula complanata</i> (L.) Dumort. - 2, 3, 6, 7, 8, 16, 17, 18, 19, 21, 22, 23, 24, 29, 31, 42, 44 |
| <i>Radula lindenbergiana</i> Gottsche ex C. Hartm. - 8 |
| <i>Reboulia hemisphaerica</i> (L.) Raddi - 2, 3, 36, 37 |
| * <i>Riccia cavernosa</i> Hoffm. - 45 |
| <i>Riccia subbifurca</i> Warnst. ex Croz. - 34 |
| <i>Scapania aequiloba</i> (Schwägr.) Dumort. - 2 |
| <i>Scapania aspera</i> Bernet et M.Bernet - 2, 3, 4, 5 |
| * <i>Tritomaria quinqueidentata</i> (Huds.) H. Buch - 17 |

The most frequent liverwort (*Radula complanata*) was collected at 17 localities. *Frullania dilatata* was found at 16, *Pellia epiphylla* at 13, and *Plagiochila asplenioides* at 11 places in the researched area. Sixteen species were collected at only one locality (*Athalamia hyalina*, *Cephalozia bicuspidata*, *Chiloscyphus pallescens*, *Fossombronina caespitififormis*, *Leiocolea bantriensis*, *L. collaris*, *L. turbinata*, *Lophocolea heterophylla*, *L. minor*, *Plagiochasma*

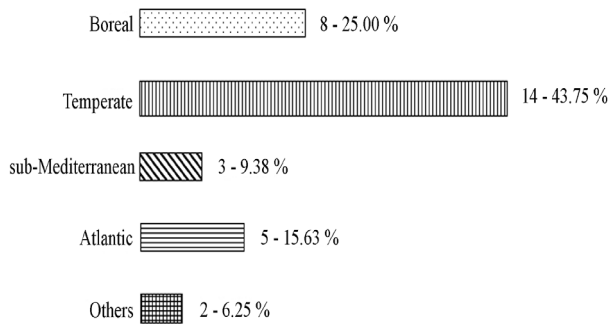


Fig. 2. Number and percentage of floristic elements present.

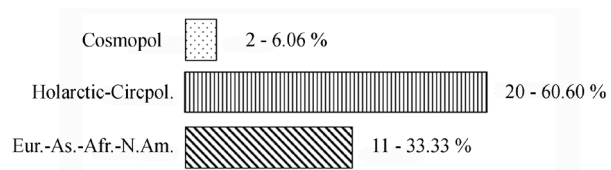


Fig. 3. Number and percentage of main distribution types represented.

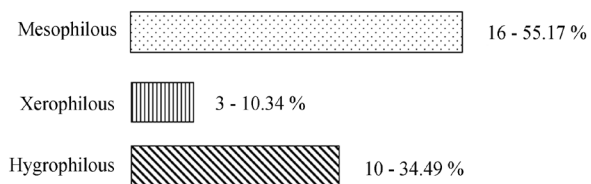


Fig. 4. Number and percentage of taxa in relation to humidity.

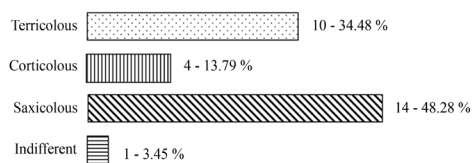


Fig. 5. Number and percentage of taxa in relation to substratum type.

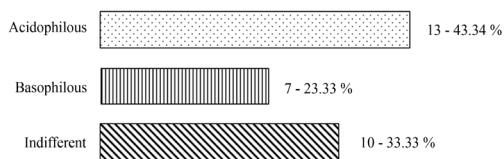


Fig. 6. Number and percentage of taxa in relation to substratum pH.



Fig. 7. Number and percentage of taxa in relation to light.

rupestre, *Porella cordaeana*, *Radula lindenberiana*, *Riccia subbifurca*, *R. cavernosa*, *Scapania aequiloba*, and *Tritomaria quinquedentata*).

Figure 1 shows the number of taxa at each locality individually. The number of species at the investigated localities varies from one taxon (at localities 7, 9, 13, 15, 27, 30, 32, 33, 36-40, and 45) to 16 taxa (at locality 2). The dearth of liverworts at some localities could be a result of huge urban influence, conditions unfavorable for this group of plants, or insufficient investigation.

Analysis of floristic elements

From phyto-geographical analysis of liverworts found in the investigated area, one can conclude that the majority of taxa are temporal floristic elements. Slightly fewer are boreal, Atlantic, and sub-Mediterranean species (Fig. 2). The two liverworts which do not belong to the mentioned types of floristic elements represented only 6.25% of the total number of taxa.

Types of distribution of liverworts

The types of distribution of liverworts from the Morača River basin are given according to D u e l l et al. (1999). In keeping with expectations, the greatest number of taxa are of the holarctic type, almost half as many are Euro-Asian-African-North American taxa, and the smallest number are cosmopolitan species (Fig. 3).

Analysis of ecological parameters

Humidity, substratum type, substratum pH, and daylight are the most important ecological factors responsible for the character, structure, and composition of bryophyte vegetation.

Humidity – Of 35 taxa registered in the researched area, 33 have been processed. Most of the recorded liverworts were mesophilous. Bryophytes which prefer water, increased humidity, marshland, or habitats near or in contact with water create a group of hygrophilous species. As expected, the fewest species are xerophilous (Fig. 4).

Substratum type – This analysis encompassed 29

taxa. Bryophytes which grow only on soil, humus, or a similar substratum are classified as terricolous taxa (10). The corticolous group consists of four taxa. These species could only be found on tree bark. Cliffs are the only substratum type inhabited by saxicolous taxa. In the present investigation, 14 species grow on this substratum type. Only one liverwort inhabits three substratum types and that is *Plagiochila asplenoides* (an indifferent terri-humid-saxicolous species) (Fig. 5).

Substratum pH - Thirty taxa inhabiting substrata with different pH values were analyzed. Most of them are liverworts which prefer acidic substrata (Fig. 6). Liverworts which prefer basic habitats, especially limestone, from a group with seven taxa or 23.33%. A third group – indifferent taxa - consists of 10 representatives.

Liverworts are dominant in the mesophilous group because they require humid habitats. Since limestone is slightly drier, the more frequent presence of taxa which prefer acidic substrata was expected.

Daylight – This analysis encompassed 28 taxa. The number and percentage of types are shown in Fig. 7.

The majority of liverworts were sciophilous species (26-92.86 %), and only two taxa belonged to the group of indifferent species. This analysis and ones performed earlier show how one ecological factor can influence another one. Some things are therefore predictable. To be specific, since most of the recorded liverworts were mesophilous (ecological factor - humidity) and acidophilous (ecological factor – substratum pH) forms, it was to be expected that the greatest number of them belong to the sciophilous category (avoiding daylight).

Investigation of the flora of bryophytes in the Morača River basin revealed the presence of a significant number of liverworts and mosses. Of the total of 101 liverworts cited in Dragičević and Veljić (2006), 35 taxa were found in this basin. Four taxa are here recorded for the first time in Montenegro. The presence of several species from the red list makes this region interesting

and indicate the need for further investigations. Phytogeographic analysis showed that many species have temporal types of distribution. The study area lies between zones with Mediterranean and continental climates. Even though the investigated area belongs to the Mediterranean region, the dominance of mesophilous and skiophilous taxa emphasizes the significant humidity of canyons and gorges at the investigated localities. It can be concluded that such diversity of liverworts is predominantly caused by specific microclimatic conditions in the Morača River basin.

Acknowledgments - This work was supported by the Ministry of Science of the Republic of Serbia (Contract No. 143049).

REFERENCES

- Boros, A., and M. Járαι-Komlódi (1975). *An Atlas of Recent European Moss Spores*. Akadémiai Kiadó, Budapest.
- Dragičević, S., and M. Veljić (2006). Pregled mahovina Crne Gore. *Posebna izdanja Prirodnjackog muzeja Crne Gore*. Knjiga I. Podgorica.
- Duell, R. (1983). Distribution of the European and Macaronesian liverworts (Hepaticophytina). *Bryologische Beitrage*, Band 2, Duisburg.
- Duell, R., Ganeva, A., Martinčić, A., and Z. Pavletić (1999). *Contribution to Knowledge of the Bryoflora of Former Yugoslavia and Bulgaria*. IDH-Verlag Bad Münstereifel.
- Erzberger, P., and B. Papp (2007). New and noteworthy bryophyte records from Montenegro and Serbia. *Willdenowia*, **39**, 339-351.
- Grochowska, I. (1971). *Flora Sladkovodna Polski. Bryophyta II, Hepaticae*. Polska Akademia Nauk, Krakow.
- Landwehr, J., and J. J. Barkman (1966). *Atlas Van de Nederlandse Bladmossen*. Koninklijke Nederlandse Natuurhistorische Vereniging, Amsterdam.
- Milikić, S., Veljić, M., Marin, P. D., and B. Petković (2001). Mosses of some springs of the Morača River basin. *Arch. Biol. Sci. (Belgrade)* **53** (1-2), 45-49.
- Papp, B., and P. Erzberger (2007). Contributions to the bryophyte flora of Montenegro. *Stud. Bot. Hung.* **38**, 79-94.
- Pavletić, Z. (1957). Ekološki odnosi briofitske vegetacije na slapovima Plitvičkih jezera. *Acta Bot. Croat.* **16**, 63-88. Zagreb.
- Pavletić, Z. (1959). In: *Izveštaj o istraživanjima briofita na slapovima rijeke Une*. 361-366. Jugoslavenska akademija znanosti i umjetnosti, Zagreb.

- Pavletić, Z. (1960). In: *Istraživanja briofitske vegetacije na slapovima rijeke Une i Plive*, 308-314. Jugoslavenska akademija znanosti i umjetnosti, Zagreb.
- Pavletić, Z. (1968). *Flora mahovina Jugoslavije*. Institut za botaniku Sveučilišta u Zagrebu.
- Pavletić, Z., and V. Pulević (1980). Prilog za briofitsku floru Crne Gore. *Glas. Odj. Prir. Nauka, CANU*, **3**, 111-131.
- Petrov, S. (1975). *Bryophyta Bulgarica Clavis Diagnostica*, 536 pp. Academia Scientiarum Bulgarica. Sofia.
- Ros, R. M., Mazimpaka, V., Abou-Salama, U., Aleffi, M., Blockeel, T. L., Bruges, M., Cano, M. J., Cros, R. M., Dia, M. G., Dirkse, G. M., El Saadawi, W., Erdağ, A., Ganeva, A., Gonzales-Mancebo, J. M., Herrnstadt, I., Khalil, K., Kürchner, H., Lanfranco, E., Losada-Lima, A., Refai, M. S., Rodrigues-Nuñez, S., Sabovljević, M., Sérgio, C., Shabbara, H., Sim-Sim, M., and L. Söderström (2007). Hepatics and anthocerotous of the Mediterranean, an annotated checklist. *Cryptogam. Bryol.* **28** (4), 351-437.
- Sabovljević, M., and R. Natcheva (2006). A check-list of the liverworts and hornworts of Southeast Europe. *Phytol. Balcan.* **12** (2), 169-180.
- Smith, A. J. E. (1990). *The Liverworts of Britain and Ireland*. University Press, Cambridge.
- Soó, R. (1964). A Magyar flóra és Vegetáció Rendszertani-Növényföldrajzi Kézikönyve I. *Synopsis systematico-geobotanica Florae Vegetationisque Hungariae I. Magyarország növényföldrajza és magasabb szervezettségű (száraz) növényeinek rendszertani feldolgozása, ökológiai-növényföldrajzi jellemzése*. Akadémiai Kiadó, Budapest.
- Veljić, M. (1996). *Flora mahovina odabranih vrela Dinarskog i Karpatkog krša u Srbiji*. Master's Thesis, University of Novi Sad.
- Veljić, M., Marin, D., Lakušić, D., and B. Ljubić (2006). Bryophyte flora of the Uvac River Gorge (Southwest Serbia). *Arch. Biol. Sci. (Belgrade)* **58** (3), 187-194. Belgrade.
- Watson, E. V., and P. Richards (1955). *British Mosses and Liverworts*. University Press, Cambridge.

ЈЕТРЕЊАЧЕ СЛИВА РЕКЕ МОРАЧЕ - ТАКСОНОМСКА И ЕКОЛОШКА АНАЛИЗА

СНЕЖАНА ДРАГИЋЕВИЋ¹, М. ВЕЉИЋ² и П. Д. МАРИН²

¹Природњачки музеј Црне Горе, 81000 Подгорица, Црна Гора

²Институт за ботанику и Ботаничка башта "Јевремовац", Биолошки факултет, Универзитет у Београду, 11000 Београд, Србија

У периоду од 1997-2007. обавили смо детаљна бриолошка истраживања сливног подручја реке Мораче. Маховине су сакупљане на 45 локалитета. Идентификовано је 35 јетрењача, представника 19 фамилија и 24 рода. Најчешћа јетрењача је *Radula complanata*, која је сакупљена на 17 локалитета. Седамнаест таксона регистровано је на по само једном од локалитета истраживаног подручја. На

том подручју је утврђено 5 јетрењача које се у "Црвеној књизи маховина Европе" третирају као: угрожене (*Scapania aequiloba*), крајње угрожене (*Athalamia hyalina*) и рањиве врсте (*Leiocolea collaris*, *L. bantriensis*, *L. turbinata*). Поред тога, *Fossombronina caespitifformis*, *Lophocolea bidentata* var. *bidentata*, *Riccia cavernosa* i *Tritomaria quinquedentata* су по први пут регистроване за бриофлору Црне Горе.