



THE HORNWORTS (ANTHOCEROTAE) AND LIVERWORTS (HEPATICAE)
OF THE MOUNT MUSA (HATAY-TURKEY)

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ABSTRACT. In this study, hornworts and liverworts of Mount Musa were surveyed between 2004–2006 years. A total of 39 horn-liverwort species were recorded, including 38 liverworts and one hornwort. All taxa in Mount Musa belong to 24 genera and 20 families. The largest familia in the liverwort-flora is *Porellaceae* (five taxa). The largest genus is *Porella* L. (five taxa) and the second are *Fossombronia* Raddi (three taxa) and *Frullania* Raddi (three taxa). *Metzgeria furcata*, *Radula complanata* and *Frullania dilatata* are the most common species found the Mount Musa. Also some remarkable moss taxa collected from the study area and discussed in the text.

KEY WORDS: hornwort, liverwort, flora, Mount Musa, East Mediterranean, Turkey

INTRODUCTION

Although, contributions on the bryoflora of Turkey has increased over last decades, but most of these contributions have focused on the western and northern parts of Turkey where the conditions of boreal climate dominate (GOKLER and OZTURK 1989, GOKLER 1998, CETIN 1999 a, OZENOGU and GOKLER 2002, KECELI and CETIN 2006, KIRMACI 2007). Southern and eastern parts of Turkey under the Mediterranean climate are still largely unknown, significant discoveries and contributions to the bryoflora from this region are possible in future studies. There are a few studies that are mostly reporting some bryophytes collections of the southern parts of Turkey, as contribution to the bryoflora of Turkey (EVEREST et AL. 1998, EVEREST and ELLIS 1999, 2003). However, in recent years, the studies in the Mediterranean region are proceeding rapidly (EZER 2008, EZER et AL. 2008 a, KARA 2008). The study area is very interesting in respect to its natural structure. Moreover, no detailed study has yet been made on the bryophytes of Mount Musa which was chosen as the study area. The aim of the study was to determine the hornwort and liverwort flora of the Mount Musa (Hatay-Turkey) and to make a contribution to the bryoflora of Turkey.

MATERIAL AND METHODS

Study area

Mount Musa is situated in the southern part of the Amanos mountain range in the Mediterranean phyto-geographic region. Its main summit (up to 1280 m asl) runs from the northeast to the southwest (Fig. 1).

Though there are more recent flora and vegetation studies in the area (AKMAN 1973, JOHN and NIMIS 1998, KEHL 1998, DÜZENLİ and ÇAKAN 2001) none of these include bryophytes.

Lithologically, Mount Musa is primarily comprised of magmatic, sedimentary and metamorphic (sparsely) rock. Most of magmatic rock is ophiolitic. The sediments of the lower altitude and plain are of lower Paleozoic and Quaternary origin (YILMAZ et AL. 1984).

The climate of the research area is Mediterranean (Fig. 1). Average annual rainfall at Samandağ (Hatay) is 937 mm and average annual temperature is 18.8°C. In particular, the southern slopes are dry, but humidity at the bottom of deep valleys and on the northern slopes of the mountain is relatively higher.

The main types of vegetation in Mount Musa are maquis and forests. Maquis is a shrubby vegetation type that occurs on shallow soils on calcareous rock formations from sea level up to 600 m at the southern and eastern slopes. It includes common tall shrubs such as *Pistacia terebinthus* L. subsp. *palaestina* (Boiss.) Engler, *Laurus nobilis* L., *Arbutus andrachne* L. and *Myrtus communis* L. subsp. *communis*. Some low shrub members such as *Daphne sericea* Vahl, *Euphorbia macrostegia*

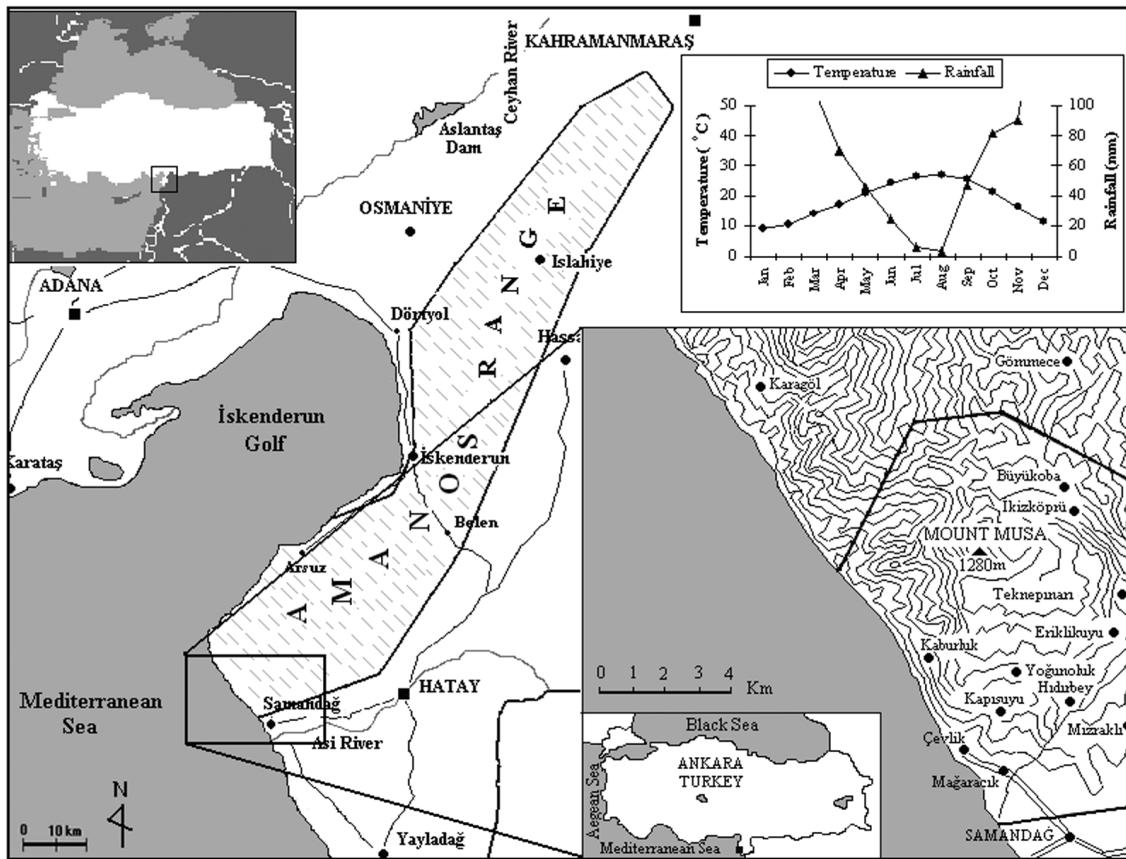


FIG. 1. Topographic map of the study area and climatic diagram of Samandağ

Boiss. and *Hypericum pallens* Banks & Sol. are also frequently associated with this community. The deciduous forests in Mount Musa contain *Carpinus orientalis*, *Buxus sempervirens*, *Ostrya carpinifolia* Scop., *Quercus cerris* L. var. *cerris* and *Fagus orientalis* trees, among others. These forests are mostly common in the deep shaded valleys and at the northern slopes where they may form pure stands. The evergreen forests consist of *Pinus brutia* Ten. and *Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe (DÜZENLİ and ÇAKAN 2001).

Data source

The specimens were collected from rock and soil surface, trunks of trees in Mount Musa and nearest surroundings between 2004 and 2006 years. The collected specimens were kept in standard collecting envelopes including information of their collection number, moisture, exposure, substratum, the date of collecting, etc. The specimens collected from the study area were identified using appropriate literature which are widely used by European and Turkish bryologists (ARNELL 1981, WATSON 1981, SMITH 1991, 1996, PATON 1999, HEYN and HERRNSTADT 2004, KÜRSCHNER and ERDAG 2005, OZENOGLU KIREMIT and KECELI 2009).

Arrangement of taxa in the list of the study site flora follows the system which is proposed by ROS et AL. (2007). In addition, the distribution of species in regional scale for Turkey was determined by reviewing the recent literature (EVEREST and ELLIS 1999, KÜRSCHNER and ERDAG 2005, OZENOGLU KIREMIT and KECELI

2009). Humidity preference of taxa in the study area has been assessed using DIERSSEN (2001). For each taxon, only one station number and only one collector number (i.e., T.E.1301d) was given to avoid repetition in the floristic list (Table 2). Specimens are deposited in the herbaria of Çukurova Üniversitesi, Adana, Turkey (ADA) and Ezer and Kara (Niğde).

RESULTS AND DISCUSSION

As a result of this study 39 taxa were determined of which one hornwort and 38 liverworts. All taxa in Mount Musa belong to 24 genera and 20 families (Table 2). *Frullania fragilifolia* (Taylor) Gottsche, Lindenb. & Nees was recorded for the first time for Turkish bryoflora by EZER et AL. (2008 b).

Anthoceros punctatus, *Calypogeia fissa*, *Cephaloziella baumgartneri*, *C. turneri*, *Chiloscyphus polyanthos*, *Cololejeunea rossetiana*, *Fossombronia angulosa*, *F. foveolata*, *Frullania dilatata*, *F. tamarisci*, *Gongylanthus ericetorum*, *Jungermannia atrovirens*, *J. obovata*, *Leiocolea turbinata*, *Lejeunea cavifolia*, *L. patens*, *Lophocolea bidentata*, *L. heterophylla*, *Lophozia excisa*, *L. longidens*, *Lunularia cruciata*, *Marchantia polymorpha*, *Metzgeria furcata*, *Pellia endiviifolia*, *P. epiphylla*, *Porella arboris-vitae*, *P. cordeana*, *P. obtusata*, *P. pinnata*, *P. platyphylla*, *Radula complanata*, *R. lindenbergiana*, *Reboulia hemisphaerica*, *Riccardia multifida*, *Riccia crozalsii*, *Southbya tophacea* and *Targionia hypophylla* have been cited for many European countries. They were classified as threatened for Europe and categorized as Least Concern (LC) according

TABLE 1. Collecting localities

SN	Date	Altitude (m)	Latitude-Longitude	Locality	Vascular syntaxa (CAKAN 1997)
1	27.11.2005	779-804	36°11' N 35°56' E	Ahmetinsuyu	Under the <i>Quercus cerris</i> , <i>Carpinus orientalis</i> and <i>Platanus orientalis</i> mixed forest
2	26.08.2004	700-730	36°12' N 35°55' E	Bakacak	Under the <i>Buxus sempervirens</i> and <i>Carpinus orientalis</i> mixed forest
3	12.03.2006	190-245	36°11' N 35°58' E	Çağlıköz	Karaçay river and road sides
4	30.04.2004	540-750	36°10' N 35°58' E	Çatak	Under the <i>Hyperico thymifolii-Quercetum cocciferae</i> aff. <i>calliprini</i> and open areas
5	29.05.2004	600-750	36°10' N 35°58' E	Direklimağra	Under the <i>Hyperico thymifolii-Quercetum cocciferae</i> aff. <i>calliprini</i> and open areas
6	19.02.2005	198-260	36°09' N 35°00' E	Eriklikuyu	Under the <i>Hyperico thymifolii-Quercetum cocciferae</i> aff. <i>calliprini</i>
7	31.01.2006	520-570	36°12' N 35°56' E	Fakıgelen	Under the <i>Violo cilicicae-Fagetum orientalis</i>
8	29.04.2004	540-700	36°11' N 35°55' E	Güldenderesi	Under the <i>Quercus cerris</i> and <i>Carpinus orientalis</i> mixed forest
9	29.04.2004	670-700	36°12' N 35°55' E	Hamut	Under the <i>Crepido reuterianae-Pinetum nigrae</i>
10	29.04.2004	500-750	36°12' N 35°55' E	Hamutuderesi	Under the <i>Taxo baccatae-Buxetum sempervirendis</i>
11	27.01.2005	250-450	36°11' N 35°58' E	İkizköprü	Karaçay river, road sides and slopes
12	19.03.2005	1110-1140	36°14' N 35°54' E	İkiztepe, Dumangözü	Under the <i>Centaureo ptosimopappae-Pinetum nigrae</i>
13	27.05.2004	200-275	36°11' N 35°58' E	İlaçlısu	Under the <i>Pinus brutia</i> and <i>Platanus orientalis</i> mixed forest
14	17.06.2004	680-720	36°11' N 35°57' E	Karlıpınar	Under the <i>Pinus brutia</i> forest
15	27.05.2004	410-440	36°11' N 35°58' E	Kılınçlı	Under the <i>Pinus brutia</i> and <i>Platanus orientalis</i> mixed forest
16	30.04.2004	1101-1116	36°11' N 35°56' E	Kısığıntepesi	Under the <i>Euphorbio macrostegiae-Carpinetum orientalis</i>
17	20.08.2005	1101-1216	36°11' N 35°56' E	Kısığıntepesi	Under the <i>Taxo baccatae-Buxetum sempervirendis</i>
18	30.04.2004	1040-1100	36°11' N 35°56' E	Kızılca	Under the <i>Primulo sibthorpii-Quercetum cerridis</i>
19	20.05.2005	785-1070	36°11' N 35°55' E	Kirazlıgedik	Under the <i>Euphorbio macrostegiae-Carpinetum orientalis</i>
20	11.03.2006	330-400	36°13' N 35°57' E	Büyükoba	Under the <i>Pinus brutia</i> and <i>Quercus cerris</i> mixed forest
21	30.10.2004	930-1080	36°11' N 35°55' E	Soğukoluk	Under the <i>Euphorbio macrostegiae-Carpinetum orientalis</i>
22	18.03.2005	500-650	36°11' N 35°55' E	Sulumağra	Under the <i>Primulo sibthorpii-Quercetum cerridis</i>
23	11.03.2006	270-470	36°11' N 35°58' E	Tetirliyazı	Under the <i>Centaureo ptosimopappae-Pinetum brutiae</i>
24	15.06.2004	880-934	36°10' N 35°56' E	Vapur	Under the <i>Buxus sempervirens</i> forest
25	19.02.2005	230-276	36°08' N 35°59' E	Yoğunoluk	Under the <i>Hyperico thymifolii-Quercetum cocciferae</i> aff. <i>calliprini</i>
26	01.02.2006	413-650	36°11' N 35°57' E	Zindan	Under the <i>Centaureo ptosimopappae-Pinetum brutiae</i>
27	27.01.2005	600-760	36°12' N 35°54' E	Ziyaretçayı	Under the <i>Violo cilicicae-Fagetum orientalis</i>
28	20.03.2005	250-430	36°12' N 35°57' E	Zobbeçayı	Under the <i>Centaureo ptosimopappae-Pinetum brutiae</i>

Explanation of abbreviations: SN – station number

TABLE 2. The floristic list

Families	Bryophyta		Humidity	SN	Substratum				HN
	Taxa				S	R	LT		
							r	t	
Anthocerotae									
Anthocerotaceae	<i>Anthoceros punctatus</i> L.		h	26	+				T.E. 1370a
Hepaticae									
Calypogeiaceae	<i>Calypogeia fissa</i> (L.) Raddi		h-m	7	+				T.E. 1387a
Cephaloziellaceae	<i>Cephaloziella baumgartneri</i> Schiffn.		m	11	+				T.E. 1198b
	<i>C. turneri</i> (Hook.) Müll. Frib.		h-x	13	+				T.E. 616b
Geocalyceae	<i>Chiloscyphus polyanthus</i> (L.) Corda		h	15	+				T.E. 603a
	<i>Lophocolea bidentata</i> (L.) Dumort.		h	22	+				T.E. 1254b
	<i>L. heterophylla</i> (Schrad.) Dumort.		h-m	23	+				T.E. 683c
Lejeuneaceae	<i>Cololejeunea rossettiana</i> (C. Massal.) Schiffn.		h	17		+			T.E. 1352b
Fossombroniaceae	<i>Fossombronia angulosa</i> (Dicks.) Raddi		h-m	28	+				T.E. 1301d
	<i>F. foveolata</i> Lindb.		h	3	+				T.E. 1403
	<i>F. pusilla</i> (L.) Nees		h-m	23	+				T.E. 1392b
Frullaniaceae	<i>Frullania dilatata</i> (L.) Dumort.		h-x	20				+	T.E. 1415d
	<i>F. fragilifolia</i> (Taylor) Gottsche, Lindenb. & Nees		h-m	12				+	T.E. 1285c
	<i>F. tamarisci</i> (L.) Dumort.		m-x	10		+			T.E. 324a
Arnelliaceae	<i>Gongylanthus ericetorum</i> (Raddi) Nees		h-x	6	+				T.E. 1210b
	<i>Southbya tophacea</i> (Spruce) Spruce		h	25	+				T.E. 1225b
Jungermanniaceae	<i>Jungermannia atrovirens</i> Dumort.		h-m	27				+	T.E. 943
	<i>J. obovata</i> Nees		h	27				+	T.E. 1192
Lophoziaceae	<i>Leiocolea turbinata</i> (Raddi) H. Buch		h-m	3	+				T.E. 623b
	<i>Lophozia excisa</i> (Dicks.) Dumort.		m-x	26	+				T.E. 1368
	<i>L. longidens</i> (Lindb.) Macoun		h-x	11	+				T.E. 634a
Lejeuneaceae	<i>Lejeunea cavifolia</i> (Ehrh.) Lindb.		h-m	10		+			T.E. 324b
	<i>L. patens</i> Lindb.		h	22	+				T.E. 684d
Lunulariaceae	<i>Lunularia cruciata</i> (L.) Lindb.		m-x	16	+				T.E. 400a
Marchantiaceae	<i>Marchantia polymorpha</i> L.		h	6	+				T.E. 1206
Metzgeriaceae	<i>Metzgeria furcata</i> (L.) Dumort.		m-x	20				+	T.E. 1031b
Pelliaceae	<i>Pellia endiviifolia</i> (Dicks.) Dumort.		h	1		+			T.E. 910a
	<i>P. epiphylla</i> (L.) Corda		h-m	8		+			T.E. 350a
Porellaceae	<i>Porella arboris-vitae</i> (With.) Grolle		x	21		+			T.E. 1049e
	<i>P. cordaeana</i> (Huebener) Moore		h	14				+	T.E. 870a
	<i>P. obtusata</i> (Taylor) Trevis.		h-x	5				+	T.E. 757
	<i>P. pinnata</i> L.		h	24		+			T.E. 808c
	<i>P. platyphylla</i> (L.) Pfeiff.		m-x	19				+	T.E. 1333f
Radulaceae	<i>Radula complanata</i> (L.) Dumort.		h-x	9				+	T.E. 301
	<i>R. lindenberghiana</i> Gottsche ex C. Hartm.		h	2				+	T.E. 959b
Aytoniaceae	<i>Reboulia hemisphaerica</i> (L.) Raddi		h-x	18	+				T.E. 455a
Aneuraceae	<i>Riccardia multifida</i> (L.) Gray		h	7	+				T.E. 1385b
Ricciaceae	<i>Riccia crozalsii</i> Levier		h-x	26	+				T.E. 1390a
Targioniaceae	<i>Targionia hypophylla</i> L.		h-x	4	+				T.E. 505a

Explanation of abbreviations: SN – station number, S – soil, R – rock, LT – living tree, r – root, t – trunk, HN – herbarium number, T.E. – Tülay Ezer, h – hygrophyte, m – mesophyte, x – xerophyte, h-m – hygrophyte-mesophyte, h-x – hygrophyte-xerophyte, m-x – mesophyte-xerophyte.

TABLE 3. Percentage of taxa according to total number of taxa

Families	Number of taxon	Percentage (%)
Porellaceae	5	12.91
Frullaniaceae	3	7.69
Lejeuneaceae	3	7.69
Fossombroniaceae	3	7.69
Lophoziaceae	3	7.69
Geocalycaceae	3	7.69
Radulaceae	2	5.12
Pelliaceae	2	5.12
Jungermanniaceae	2	5.12
Arnellaceae	2	5.12
Cephaloziellaceae	2	5.12
Aytoniaceae	1	2.56
Targioniaceae	1	2.56
Lunulariaceae	1	2.56
Marchantiaceae	1	2.56
Ricciaceae	1	2.56
Metzgeriaceae	1	2.56
Aneuraceae	1	2.56
Calypogeiaceae	1	2.56
Anthocerotaceae	1	2.56
Total 20 Families	39	100

TABLE 4. First three richest genera in the study area

Generas	Number of taxa	Percentage of taxa according to total number of taxa (%)
<i>Porella</i>	5	12.94
<i>Fossombronia</i>	3	7.69
<i>Frullania</i>	3	7.69
Total	11	28.32

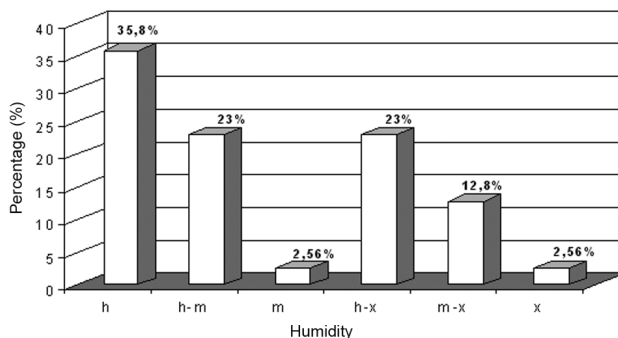


FIG. 2. The percentage of taxa according to the humidity preference in the study area

to European Committee for Conservation of Bryophytes (RED DATA BOOK... 1995).

The Porellaceae (12.91%) is the most species-rich family in Mount Musa (Table 3), with five species. Other dominated families are Frullaniaceae, Lejeuneaceae, Fossombroniaceae, Lophoziaceae and Geocalycaceae. While these families make up 51.36% of the total taxa in this study and the other families constitute 48.64% (Table 3).

The genera with the highest number of taxa are *Porella* (12.94%), with five species (Table 4). It is very important that all *Porella* taxa that occur in Turkey are seen in the study area. Because, the study area has the characteristics of the oceanic as well as Mediterranean climate (AKMAN 1990). In the Mount Musa, at higher altitudes, where the oceanic influence can be seen, the amount of annual rainfall is higher than that at lower altitudes, where significant summer dryness, characteristic of the Mediterranean climate, occurs. The other genera (*Fossombronia* and *Frullania*) constitute 15.38% (Table 4).

The hornwort and liverworts of the study area have shown that the area is rich in liverwort diversity when the results are compared with other studies in Turkey (Table 5).

In Table 5, a comparison between studies carried out in the Black Sea region and the Mediterranean show that the percentage of taxa in Mount Musa is very similar to the results of other studies (GOKLER and OZTURK 1989, GOKLER 1998, OZENOGLU 2005, KIRMACI 2007). Most of them were carried out in the Black Sea region where the conditions of the oceanic climate dominate. The reason is that the Mount Musa is under the effect of the humid and rainy local climate, in addition, it has not got a subalpine or alpine zone. In other words the area has Mediterranean characteristics in macroclimate level and oceanic characteristics at microclimate level.

It is known that phylogenetically liverworts which are more primitive than mosses are more sensitive to drought. And as a consequence they prefer more humid and shady habitats. The results of the present study show that the local humid climate and shady deep valleys could give favourable conditions to the liverworts in the Mount Musa.

As might be expected from the climate in this area, hygrophytes (35.8%) are dominant there. These are followed by hygrophyte-mesophyte, hygrophyte-xerophyte (23%) and then mesophyte-xerophyte (12.8%), others (2.56%) occurred in the region (Fig. 2). The high rate of hygrophytes found in Mount Musa is meaningful. These values indicate that the investigated area has humid and shady habitats due to its various climate and topography. The present study area is also take parts in a geographical area not known well bryologically and still under exploring.

TABLE 5. A comparison of the liverworts richness on study area with the other regions in Turkey

Families	Mount Musa		West Blacksea Region (KECELI and CETIN 2006)		Sinop province (CETIN 1999 a)		Blacksea Region (GOKLER and OZTURK 1989)		Altridere Valley (GOKLER 1998)		Dilek Peninsula (OZENOGU and GOKLER 2002)		Uludag National Park (CETIN 1999 b)		Antalya Bey Mountains (OZENOGU 2005)		Denizli Mountains (KIRMACI 2007)	
	NT	%	NT	%	NT	%	NT	%	NT	%	NT	%	NT	%	NT	%	NT	%
Porellaceae	5	12.9	3	5.46	1	5.26	2	7.40	4	12.2	1	3.8	2	8.69	3	6.98	4	12.9
Frullaniaceae	3	7.69	2	3.63	2	10.5	1	3.70	2	6.06	1	3.8	1	4.34	2	4.65	1	3.22
Lejeuneaceae	3	7.69	2	3.63	1	5.26	-	-	2	6.06	1	3.8	-	-	1	1.82	-	-
Fossombroniaceae	3	7.69	2	3.63	1	5.26	1	3.70	1	3.03	2	7.6	-	-	3	6.98	2	6.44
Lophoziaaceae	3	7.69	4	7.27	-	-	-	-	-	-	2	7.6	2	8.69	1	1.82	1	3.22
Geocalycaceae	3	7.69	5	9.1	3	15.7	3	11.1	4	12.1	-	-	4	17.3	1	1.82	-	-
Radulaceae	2	5.12	2	3.63	1	5.26	1	3.70	2	6.06	1	3.8	1	4.34	1	2.3	-	-
Pelliaceae	2	5.12	2	3.63	2	10.5	2	7.40	2	6.06	2	7.6	2	8.69	2	4.65	2	6.44
Jungermanniaceae	2	5.12	4	7.27	-	-	-	-	-	-	2	7.6	1	4.34	2	4.65	2	6.44
Arnelliaceae	2	5.12	1	1.82	-	-	-	-	-	-	2	7.6	-	-	3	6.98	2	6.44
Cephalozeliaceae	2	5.12	1	1.82	-	-	-	-	-	-	1	3.8	-	-	2	4.65	2	6.44
Total number of taxa	30		28		11		10		17		15		13		21		16	

Explanation of abbreviations: NT – number of taxa, % – percentage of taxa according to the total number of taxa.

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