

The bryophyte flora of Göllüdağ Volcano (Niğde/Turkey)

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Received: February 23, 2017 ▷ Accepted: June 09, 2017

Abstract. In this study, the bryophytes of Göllüdağ Volcano were investigated. As a result of identification of the bryophyte specimens collected from several habitats, a total 103 taxa (100 mosses, three liverworts) were determined, belonging to 20 families and 43 genera. Nine of them are new records for B8 grid-square. The two largest families in the study area are *Pottiaceae* (27 taxa) and *Grimmiaceae* (18 taxa). The widespread genera are *Grimmia* (12 taxa) and *Syntrichia* (nine taxa). *Tortula subulata* and *Syntrichia ruralis* are the most common species in the study area.

Key words: Bryophyte, Göllüdağ, Niğde, Turkey, volcano

Introduction

Turkey is one of the countries with the richest biodiversity in the world. The reason for this are the three different types of climate, namely, Mediterranean, continental, and oceanic, and the three biogeographical areas: Euro-Siberian, Mediterranean, and Irano-Turanian. Thanks to this, Turkey has a great variety of ecosystems, habitats, and a rich floral diversity, including bryophytes.

Although few studies of the bryophyte flora have been conducted in Turkey so far, the bryophyte taxa in the country include 780 mosses, 182 liverworts, and four hornworts. With a total 966 bryophyte taxa, Turkey has the richest bryodiversity in Southwest Asia (Batan & al. 2016a). In recent years, bryofloristic studies have rapidly increased in many regions of Turkey (such as, Özdemir & Batan 2014; Batan & al. 2014; Alataş & Batan 2016; Ezer 2016; Kırmacı & Ağcagil 2016; Özdemir & Batan 2016a; Özdemir & Batan 2016b; Batan & al. 2016b; Özenoğlu Kiremit & al. 2016; Kırmacı & Kürschner 2017). On the other hand, no book has been written yet on the bryophyte flora of Turkey. The present paper is another contribution to this subject.

Material and methods

Study area

Göllüdağ Volcano, the oldest known archaeological settlement in Anatolia, is a stratovolcano in the north of Niğde (Turkey). Göllüdağ is 2172 m high and there is a volcanic crater lake on its summit. The volcano is rated as a first-degree archaeological site and a third-degree natural highlight (Fig. 1). Göllüdağ Volcano, located in the Irano-Turanian phytogeographic region, lies in the B8 square of the grid system of Turkey adopted by Henderson (1961) (Fig. 2).

The climate type of the study area is semi-arid and continental, with a severe frost period in winter (Akman 1990).

The main types of vegetation in the study area are residual forest vegetation, mainly consisting of oak species, and steppe vegetation. The residual oak forest vegetation in the study area mainly consists of *Quercus pubescens* Willd., *Q. trojana* Webb, *Q. cerris* L., *Q. vulcanica* Willd., *Q. ithaburensis* subsp. *macrolepis* (Kotschy) Hedge & Yalt., and *Q. infectoria* Oliver subsp. *boissieri* (Reut.) O.Schwarz. The steppe vegetation covers most of

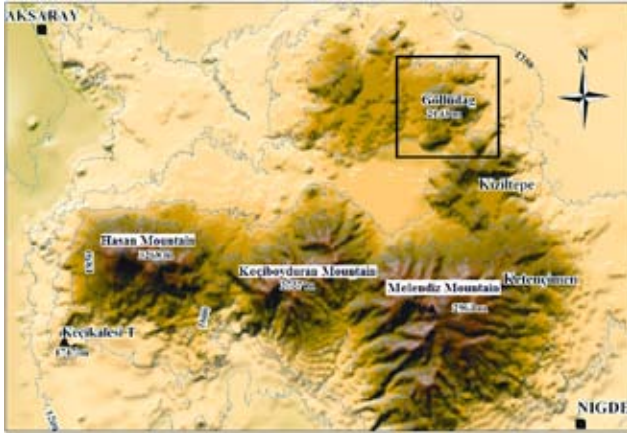


Fig. 1. Göllüdağ Volcano region (modified from Bayer Altın 2010).

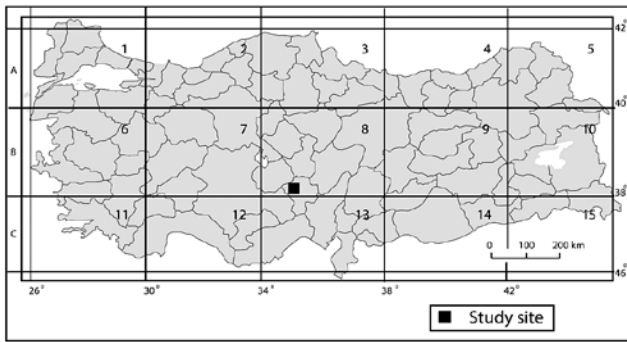


Fig. 2. Grid system of Turkey (Henderson 1961) and the study site.

the study area and is mainly characterised by *Astragalus angustifolius* Lam., *A. microcephalus* Wild., *A. acmophyllus* Bunge, *Thymus sipyleus* Boiss., *Salvia absconditiflora* Greuter & Burdet, *Festuca valesiaca* Schleich. ex Gaudin, *Eremogone ledebouriana* (Fenzl) Ikonn., *Bromus tomentellus* Boiss., and *Poa bulbosa* L. (Kenar 2014).

Geologically, the study area is composed of andesite, basalt, tuff, obsidian, and agglomerate with volcanoclastic characteristics (Binder & al. 2011; Kenar 2014).

Data source

Bryophyte specimens, materials of the present study, were collected from various localities, habitats and substrates in Göllüdağ Volcano between September 2015 and May 2016 (Table 1). The specimens were identified using relevant literature (Zander 1993; Greven 1995; Munoz 1999; Paton 1999; Cortini Pedrotti 2001, 2006; Greven 2003; Heyn & Herrnstadt 2004; Smith 2004; Guerra & al. 2006, 2007). Voucher specimens are deposited in the Herbarium of Niğde Ömer Halisdemir University.

The latest taxonomic and distributional status of the bryophyte taxa on regional scale for Turkey and Southwest Asia was determined by reviewing the recent publications (Uyar & Çetin 2004; Kürschner &

Table 1. Locality details (L.N. – locality number).

L.N.	Altitude (m)	GPS Coordinates	Location	Date	Topography
1	1729-1740	38°16'496"N 34°33'012"E	Aşağıseki	19.05.2015	Slope
				14.05.2016	
2	1958	38°15'473"N 34°33'480"E	Direkli	06.09.2015	Slope
				15.05.2016	
3	2067	38°15'478"N 34°33'337"E	Direkliüstü	30.04.2016	Slope
				01.05.2016	
4	1817	38°16'076"N 34°33'568"E	Göçyolu	19.05.2015	Valley
5	2045	38°15'511"N 34°32'663"E	Gölkayası	06.09.2015	Valley
6	1800	38°16'074"N 34°33'573"E	Göllüdağ North-west Slope	14.05.2016	Slope
7	1810	38°16'076"N 34°33'568"E	Göllüdağ Meşelik	06.09.2015	Forest
8	2050	38°15'509"N 34°32'660"E	Göllüdağ summit	15.05.2016	Valley
9	2094	38°15'530"N 34°33'203"E	Kartalpınarı	06.09.2015	Slope
10	1550	38°16'745"N 34°33'971"E	Kömürcü Northern Slope	30.04.2016	Slope
11	1817-1826	38°16'076"N 34°33'568"E 38°16'128"N 34°33'072"E	Laleli	19.05.2015	Forest
12	1826	38°16'128"N 34°33'072"E	Laleli Valley	14.05.2016	Valley
13	1575-1577	38°16'745"N 34°33'971"E 38°16'747"N 34°33'925"E	Mağara	23.04.2015	Slope
				06.09.2015	
				01.05.2016	
14	1790-1798	38°16'750"N 34°33'923"E	Ortaseki	19.05.2015	Slope
15	1808	38°16'074"N 34°33'573"E	Pınar	01.05.2016	Valley
				19.05.2015	
16	1936	38°15'526"N 34°33'575"E	Sarıkaya	06.09.2015	Slope
17	2091-2095	38°15'513"N 34°32'446"E	Sur	15.05.2016	Slope
				06.09.2015	
				15.05.2016	
18	1906	38°16'459"N 34°32'446"E	Yarıkkaya	05.06.2016	Slope
19	1955	38°15'567"N 34°32'187"E	Gedik	05.06.2016	Slope
20	1950	38°16'254"N 34°32'203"E	Halkalı	05.06.2016	Slope
21	1870	38°15'914"N 34°32'696"E	Büyükaleli	05.06.2016	Slope
22	1904	38°15'903"N 34°32'580"E	Kuzeykayası	05.06.2016	Slope

Erdağ 2005; Özenoğlu Kiremit & Keçeli 2009; Kürschner & Frey 2011; Ros & al. 2013). Nomenclature arrangement on the floristic list follows Ros & al. (2013) and Söderström & al. (2016). For each taxon, only one collector number (i.e., M.K.35) was given to avoid repetition in the floristic list. The new records for B8 are indicated with (*) in the floristic list presented in Table 2.

Results and discussion

Identification of bryophyte samples collected from different habitats resulted in a total of 103 taxa. While the mosses are represented by 100 taxa belonging to 18 families and 41 genera, the liverworts are represented by only three species belonging to two families and two genera in the Göllüdağ Volcano. Of the

Table 2. Floristic list (* – new records for B8, L.N. – locality number, r – rock, s – soil, t – tree, rs – the soil covering the rock, H.N. – herbarium number).

Families	Taxa	L.N.	Substrates				H.N.
			r	s	t	rs	
Liverworts							
Cephaloziellaceae	* <i>Cephaloziella hampeana</i> (Nees) Schiffn.	11				+	M.K.58a
	* <i>Cephaloziella rubella</i> (Nees) Warnst.	5				+	M.K.74c
Porellaceae	<i>Porella platyphylla</i> Wall Scalewort	3				+	M.K.82b
Mosses							
Amblystegiaceae	<i>Amblystegium serpens</i> (Hedw.) Schimp.	8,16				+	M.K.89a
Bartramiaceae	<i>Philonotis caespitosa</i> Jur	9				+	M.K.79b
	<i>Philonotis capillaris</i> Lindb.	9				+	M.K.79c
Brachytheciaceae	<i>Brachythecium velutinum</i> (Hedw.) Ignatov & Huttunen	4				+	M.K.42b
	<i>Brachythecium glareosum</i> (Bruch ex Spruce) Schimp.	2,4,5,7,11				+	M.K.116c
	<i>Brachythecium mildeanum</i> (Schimp.) Schimp.	4				+	M.K.44b
	<i>Eurhynchium pulchellum</i> (Hedw.) Ignatov & Huttunen	6,11,14				+	M.K.111a
	* <i>Eurhynchium angustirete</i> (Broth.) T.J.Kop.	4,7,8,12,15,16				+	M.K.117a
	<i>Eurhynchium striatum</i> (Hedw.) Schimp.	5,7,12,14,15				+	M.K.69b
	<i>Homalothecium lutescens</i> (Hedw.) H.Rob.	3				+	M.K.81a
	<i>Homalothecium philippeanum</i> (Spruce) Schimp.	3,5,11,13,16,18,21,22				+	M.K.54a
	<i>Homalothecium sericeum</i> (Hedw.) Schimp.	4				+	M.K.44c
	<i>Oxyrrhynchium hians</i> (Hedw.) Loeske	15				+	M.K.37b
	<i>Rhynchostegium murale</i> (Hedw.) Schimp.	16				+	M.K.89c
	<i>Bryum argenteum</i> Hedw.	11,13				+	M.K.105
	<i>Bryum dichotomum</i> Hedw.	1				+	M.K.64a
Bryaceae	* <i>Bryum gemmiparum</i> De Not.	15				+	M.K.38a
	<i>Ptychostomum archangelicum</i> (Bruch & Schimp.) J.R.Spence	1,13,14,15,16,19,20				+	M.K.112
	<i>Ptychostomum compactum</i> Hornsch.	10,13,14,16,20				+	M.K.31a
	<i>Ptychostomum imbricatum</i> (Müll.Hal.) Holyoak & N.Pedersen	7,10,13,14,17				+	M.K.28
	<i>Ptychostomum pallens</i> (Sw.) J.R.Spence	15				+	M.K.39b
	<i>Ptychostomum psedotriquetrum</i> (Hedw.) J.R.Spence & H.P.Ramsay	9,16				+	M.K.79d
	Dicranaceae	<i>Dicranella heteromalla</i> (Hedw.) Schimp.	16				+
<i>Dicrenella varia</i> (Hedw.) Schimp.		4				+	M.K.76a
Ditrichaceae	<i>Ceratodon conicus</i> (Hampe) Lindb.	1,13,15,18,19,20				+	M.K.127
	<i>Ceratodon purpureus</i> (Hedw.) Brid.	16				+	M.K.91b
	<i>Distichum capillaceum</i> (Hedw.) Brunch & Schimp	12				+	M.K.125b
	<i>Ditrichum heteromallum</i> (Hedw.) E.Britton	16				+	M.K.87b
Encalyptaceae	<i>Encalypta alpina</i> Sm.	15				+	M.K.32a
	<i>Encalypta ciliata</i> Hedw.	7				+	M.K.120a
	<i>Encalypta raptocarpa</i> Schwägr. var. <i>raptocarpa</i>	1,11,12,14,15,20				+	M.K.113
	* <i>Encalypta raptocarpa</i> var. <i>leptodon</i> Lindb.	4,14				+	M.K.52d
	<i>Encalypta pathulata</i> Müll.Hal.	1,13,14,20				+	M.K.24a
	<i>Encalypta vulgaris</i> Hedw.	1,13				+	M.K.109b
Fissidentaceae	<i>Fissidens exillis</i> Hedw.	13				+	M.K.12a

Table 2. Continuation.

Families	Taxa	L.N.	Substrates				H.N.
			r	s	t	rs	
Funariaceae	<i>Entosthodon pulchellus</i> (H.Philib.) Brugués	13		+			M.K.27a
	<i>Funaria hygrometrica</i> Hedw.	1		+			M.K.63a
	<i>Coscinodon cribrosus</i> (Hedw.) Spruce	2,5,16,17	+				M.K.138b
	<i>Grimmia alpestris</i> (F.Weber & D.Mohr) Schleich.	5,16	+				M.K.72a
	<i>Grimmia anodon</i> Bruch & Schimp.	2,3,4,11,13	+				M.K.13a
	* <i>Grimmia crinitoleucophaea</i> Cardot	2	+				M.K.138a
	<i>Grimmia funalis</i> (Schwägr.) Bruch & Schimp.	8	+				M.K.131a
	<i>Grimmia incurva</i> Schwägr.	6	+				M.K.64b
	<i>Grimmia laevigata</i> (Brid.) Brid.	2,10,13,16,17,21	+				M.K.15
	* <i>Grimmia longirostris</i> Hook.	3				+	M.K.137b
Grimmiaceae	<i>Grimmia montana</i> Bruch & Schimp.	18	+				M.K.144d
	<i>Grimmia orbicularis</i> Bruch ex Wilson	6	+				M.K.128
	<i>Grimmia ovalis</i> (Hedw.) Lindb.	10,11,13,17,18,21,22	+				M.K.14a
	<i>Grimmia pulvinata</i> (Hedw.) Sm.	4,11,13	+				M.K.48a
	<i>Grimmia reflexidens</i> Müll. Hal.	2,3,5,8,10,13,16,18,21,22	+				M.K.75c
	<i>Schistidium apocarpum</i> (Hedw.) Bruch & Schimp.	13	+				M.K.101
	<i>Schistidium atrofusum</i> (Schimp.) Limpr.	13	+				M.K.06b
	<i>Schistidium brunnescens</i> Limpr.	13	+				M.K.06c
	<i>Schistidium flaccidum</i> (De Not.) Ochyra	5	+				M.K.72b
	<i>Schistidium umbrosum</i> (J.E.Zetterst.) H.H.Blom	16	+				M.K.90c
Hypnaceae	<i>Hypnum bambergeri</i> Schimp.	3,8				+	M.K.80c
	<i>Epipterygium tozeri</i> (Grev.) Lindb.	8,13				+	M.K.134c
Mniaceae	<i>Pohlia cruda</i> (Hedw.) Lindb.	1,4,5,8,11,14,16				+	M.K.59a
	<i>Pohlia elongata</i> Hedw.	7		+			M.K.120b
Orthotrichaceae	<i>Orthotrichum alpestre</i> Bruch & Schimp.	4			+		M.K.47
	<i>Orthotrichum anomalum</i> Hedw.	10,13	+				M.K.94
	<i>Orthotrichum cupulatum</i> Hoffm. ex Brid.	2,8,13,16,21			+		M.K.60b
	<i>Orthotrichum pallens</i> Bruch ex Brid.	11			+		M.K.57a
	<i>Orthotrichum pumilum</i> Sw. ex anon	20			+		M.K.149a
	<i>Orthotrichum rupestre</i> Schleich. ex Schwägr.	4,5,11,12,13,16	+				M.K.50b
	<i>Orthotrichum urginerum</i> Myrin.	4,11,12,13			+		M.K.55a
Polytrichaceae	* <i>Polytrichum formosum</i> Hedw.	11				+	M.K.58c
	<i>Polytrichum juniperinum</i> Hedw.	5,6,9,11,15,16		+			M.K.79a
	<i>Polytrichum strictum</i> Menzies ex Brid.	16		+			M.K.40

mosses, *Grimmia incurva* and *Schistidium umbrosum* were recorded from the study area as new for Turkey and Southwest Asia (Karakas & Ezer 2016). Moreover, nine taxa (two liverworts, seven mosses) are new to B8 square in the grid system of Turkey adopted by Henderson (1961).

In the bryoflora of Göllüdağ Volcano, *Pottiaceae* is the most species-rich family, with 27 taxa in 10 genera. The acrocarpous moss family *Pottiaceae* contains many desiccation-tolerant members (Zander 1993). Therefore, this result is not surprising in the study area. The second richest family is *Grimmiaceae* (18 species) which is characteristically common on the basalt

rocks at the xeric slopes of the study area. The pleurocarpous *Brachytheciaceae* with 11 species is another common moss family on the basalt soil in the residual oak forests of the Göllüdağ Volcano. The residual oak forests floor with more humid habitats provides suitable shelters for the hygrophytic *Brachytheciaceae* members in the study area. Along with this, the floor of residual forests is inhabited by mesophytic species belonging to *Bryaceae*.

Grimmia is the most common and abundant in the study area. On all continents, *Grimmia* members mostly grow on rocks at low to high altitudes, and most of them are drought-resistant. Therefore, they

Table 2. Continuation.

Families	Taxa	L.N.	Substrates				H.N.
			r	s	t	rs	
	<i>Barbula unguiculata</i> Hedw.	15		+			M.K.39a
	<i>Bryoerythrophyllum recurvirostrum</i> (Hedw.) P.C.Chen	4,11,13		+			M.K.21d
	<i>Bryoerythrophyllum rubrum</i> (Jur. ex Geh.) P.C.Chen	5,7,11		+			M.K.120c
	<i>Crossidium squamiferum</i> (Viv.) Jur.	13		+			M.K.17a
	<i>Didymodon acutus</i> (Brid.) R.H.K. Saito	17	+				M.K.77c
	<i>Didymodon fallax</i> (Hedw.) R.H.Zander	13		+			M.K.104b
	<i>Didymodon rigudulus</i> Hedw.	5,13				+	M.K.73c
	<i>Didymodon vinealis</i> (Brid.) R.H.Zander	5,13				+	M.K.76d
	<i>Gyroweisia tenuis</i> (Hedw.) Schimp.	16	+				M.K.140b
	<i>Microbryum starckeanum</i> (Hedw.) R.H. Zander	11		+			M.K.57c
	<i>Pterygoneurum ovatum</i> (Hedw.) Dixon	13		+			M.K.19a
	<i>Syntrichia caninervis</i> Mitt. var. <i>caninervis</i>	13				+	M.K.25f
	<i>Syntrichia caninervis</i> Mitt. var. <i>pseudodesertorum</i> (Vondr.) M.T. Gallego	13		+			M.K.20b
Pottiaceae	* <i>Syntrichia echinata</i> (Schiffn.) Herrnst. & Ben-Sasson	10,11,13				+	M.K.96b
	<i>Syntrichia handelii</i> (Schiffn.) S. Agnew & Vondr.	13		+			M.K.21e
	<i>Syntrichia montana</i> Nees	5		+			M.K.69a
	<i>Syntrichia norvegica</i> F. Weber	8	+				M.K.130a
	<i>Syntrichia princeps</i> (De Not.) Mitt.	3,4,12,17,21				+	M.K.135b
	<i>Syntrichia ruralis</i> (Hedw.) F.Weber & D.Mohr	1,4,5,10,12,13,14,15,16,18,19		+			M.K.33a
	<i>Syntrichia virescens</i> (De Not.) Ochyra	3,7,11,13,16,20				+	M.K.116b
	<i>Tortella tortuosa</i> (Hedw.) Limpr.	3,4,5				+	M.K.76c
	<i>Tortula acaulon</i> var. <i>pilifera</i> (Hedw.) R.H.Zander	20				+	M.K.150c
	<i>Tortula brevissima</i> Schiffn	15	+				M.K.36
	<i>Tortula inermis</i> (Brid.) Mont.	13,17				+	M.K.109a
	<i>Tortula lindbergii</i> Broth.	5	+				M.K.75d
	<i>Tortula subulata</i> Hedw.	1,5,7,12,13,14,15,16,17,20		+			M.K.30a
	<i>Weisia controversa</i> Hedw.	13				+	M.K.12b
Pseudoleskeaceae	<i>Lescuraea incurvata</i> (Hedw.) E. Lawton	16	+				M.K.90b
	<i>Lescuraea saxicola</i> (Schimp.) Molendo	5	+				M.K.68a
Pterigynandraceae	<i>Myurella julacea</i> (Schwägr.) Schimp.	4,5,8,17				+	M.K.76e
Timmiaaceae	<i>Timmia bavarica</i> Hessel.	22	+				M.K.155a

can withstand extremely harsh cold and dry climates (Ignatova & Muñoz 2004). Genus *Syntrichia* has xerophytic taxa very common on soil surface, genus *Orthotrichum* has generally epiphytic members common and abundant on the trunks of oak species in the Göllüdağ Volcano. Furthermore, *Tortula subulata*, *Syntrichia ruralis*, *Pohlia cruda*, and *Orthotrichum rupestre* are the most common species in the study area.

Ultimately, the bryoflora of Göllüdağ Volcano reflects the typical dry climate conditions and typical vegetation of the Inner Anatolian Region.

Acknowledgements. The authors are indebted for financial support to the Niğde Ömer Halisdemir University, Research Project Units (Project Number: FEB2015/35).

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