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# The Bryophyte Flora of a Collapse Doline in Niğde (Türkiye)

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**Abstract**

In this study, the bryophyte flora of a collapse doline located in the steppe of Central Anatolia has been investigated. As a result of the identification of 365 bryophyte specimens collected from various habitats of doline, a total of 72 taxa (71mosses and 1 liverwort) belonging to 9 families and 24 genera are determined. Among them *Didymodon icmadophilus* is new for C13 grid-square. The most species-rich families in the study area are Pottiaceae (31 taxa), Bryaceae (13 taxa) and Grimmiaceae (11 taxa) respectively. While the widespread genera are *Syntrichia* (9 taxa), *Didymodon* (9 taxa), *Ptychostomum* (9 taxa) and *Grimmia* (6 taxa). *Syntrichia ruralis, Weissia condensa, Didymodon vinealis* and *Orthotrichum cupulatum* are the most common species in the study area.

**Keywords:** Bryophytes, Central Anatolia, Doline, Türkiye.

## Niğde'deki Bir Çöküntü Dolininin Briyofit Florası (Türkiye)

**Öz**

Bu çalışmada, Orta Anadolu bozkırında yer alan bir çöküntü dolininin briyofit florası araştırılmıştır. Dolinin çeşitli habitatlarından toplanan 365 briyofit örneğinin teşhis çalışmaları sonucunda, 9 familya ve 24 cinse ait toplam 72 takson (71 karayosunu, 1 ciğerotu) tespit edilmiştir. Bunlar arasından *Didymodon icmadophilus* C13 karesi için yenidir. Çalışma alanında tür bakımından en zengin familyalar sırasıyla Pottiaceae (31 takson), Bryaceae (13 takson) ve Grimmiaceae (11 takson)'dir. Yaygın cinsler *Syntrichia* (9 takson), *Didymodon* (9 takson), *Ptychostomum* (9 takson) ve *Grimmia* (6 takson) iken, *Syntrichia ruralis*, *Weissia condensa*, *Didymodon vinealis* ve *Orthotrichum cupulatum* çalışma alanında en yaygın türlerdir.

**Anahtar Kelimeler:** Briyofitler, Orta Anadolu, Dolin, Türkiye.

## 1. Introduction

The bryophytes are land plants that constitute the second most diverse group of the plant kingdom on the earth (Goffinet and Shaw, 2009). They are the largest group with about 15.000-25.000 species in the world after Magnoliophyta (350.00 species) and are found almost everywhere where there is water or moisture (Glime, 2017).

Bryophytes, which are important components of temperate and tropical climates, grow on moist soils, rocks, living and dead logs, tree branches and leaves. The distribution of bryophytes on earth is primarily influenced by microclimatic factors such as rainfall, temperature, latitude and altitude, but they are also affected by microenvironmental conditions such as shade, humidity, humus and temperature (Bahuguna et al., 2013).

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Dolines are characteristic landforms of karstic areas and they affect vegetation, hydrology and anthropological activities in karstic areas. They are also defined as interesting habitats due to their special microclimatic, ecological and vegetative characteristics. For example, the climate of dolines is different from the climate of the surrounding environment. In particular, the concave relief form of the doline favors the formation of an air temperature inversion, filling with cold air at night and with trapped high-temperature air during the day. These microclimatic features create different micro-ecological conditions that can influence the distribution and abundance of plant species found within the doline (Öztürk and Savran, 2020). Due to their micro-ecological conditions, dolines can also be considered habitat islands that harbour many plant species that cannot live in the surrounding habitats or are very rare (Bátori et al., 2014; Öztürk and Savran, 2020). For this reason, dolines have become suitable refuge areas for these plants, including bryophytes, and have become the primary habitats for many species that cannot adapt to habitats with difficult ecological conditions such as steppes.

According to recent bryofloristic studies in Türkiye, the total number of taxa of bryophytes in the country is around ±1063 (±856 mosses, ±203 liverworts, and ±4 hornworts) (Kürschner and Frey, 2020; Özenoğlu and Kırmacı, 2022; Batan et al., 2022; Erata, 2022; Erata et al., 2023; Batan et al., 2023; Özen-Öztürk et al., 2023). The ecology of the doline, which is the study area in the present paper, was studied by Öztürk and Savran (2020), and 156 plant species were determined and only two moss species were reported. No detailed study has been conducted on the bryophytes of the area. The present study aims to reveal in detail for the first time the bryophyte flora of a doline in Central Anatolia, which is a rock depression and has different ecological conditions from its surroundings, and to contribute to the bryophyte flora of Türkiye.

## 2. Material and Methods

### 2.1. Study area

The study area is located in the southeast of Niğde province of Central Anatolia. It is a collapse doline located junction at point 651,886 m. E and 4,195,488 m. N (UTM zone 36). The doline, which has an area of 8.708 m², is approximately 121 m. long and the maximum depth is 59 m. The highest points in the north and south are 1754 and 1722 m. respectively (Öztürk and Savran, 2020). The study area is located in the C13 square according to Henderson's (1961) grid system for Turkish bryophytes (Fig. 1).

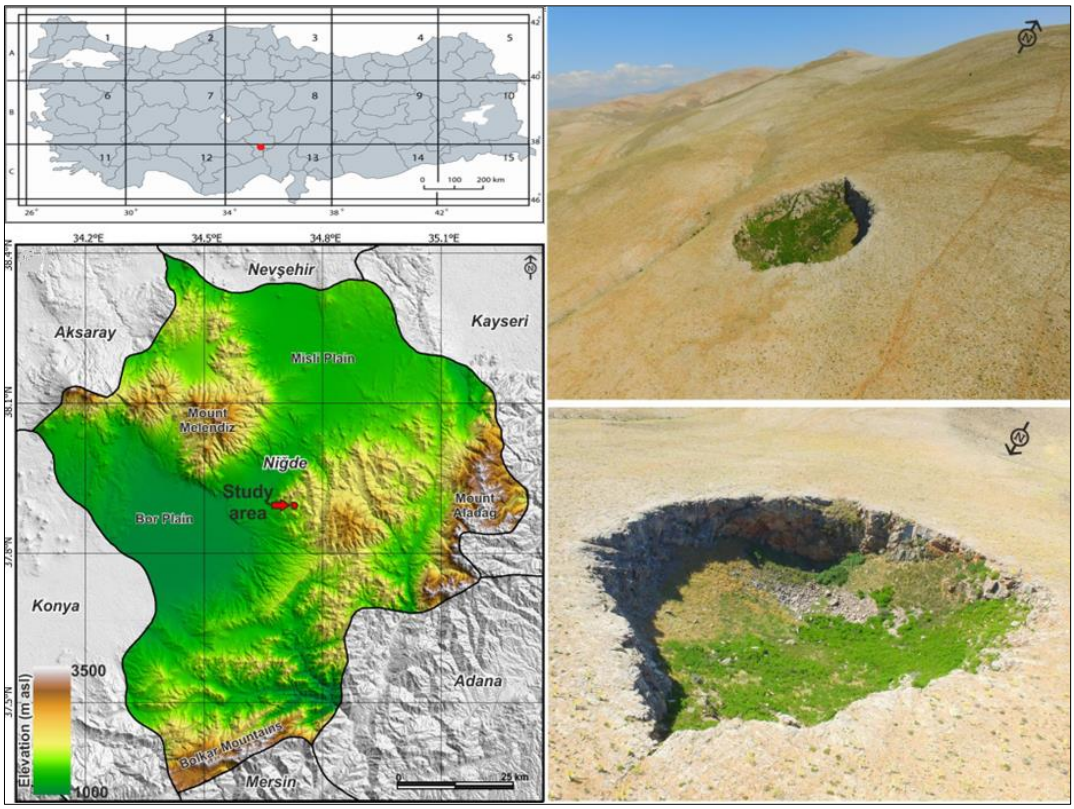


Figure 1. Henderson's (1961) grid-system, location and aerial photographs of the doline (changed from Öztürk and Savran (2020)).

According to Niğde Meteorology station, the total annual precipitation is 335 mm, the annual average temperature is 11.2 ºC in the study area, and it has a cold semi-arid (steppe) climate (Öztürk et al., 2017). Geologically, the study area consists of clastic and carbonate rocks. Niğde group metamorphics consist of white and bluish marbles, quartzite, amphibolite and gneisses (Atabey et al., 1990).

The dominant vegetation of the study area is steppe consisting of shrub and herbaceous forms (Fig 2). Dominant shrub taxa in the doline are *Rhus coriaria* L., *Jasminum fruticans* L., *Rosa pulverulenta* M. Bieb., *Cerasus mahaleb* (L.) Mill. var. *mahaleb*, *Crataegus orientalis* Pall. ex M.Bieb. subsp. *szovitsii* (Pojark.) K.I. Chr., *Pyrus elaeagnifolia* Pall. subsp. *elaeagnifolia*, *Ephedra major* Host. subsp. *major* and *Euphorbia kotschyana* Fenzl. *Marrubium astracanicum* Jack. subsp. *astracanicum*, *Artemisia campestris* L. var. *campestris*, *Urtica dioica* L. subsp. *dioica*, *Astragalus plumosus* Willd., *Alcea biennis* Winterl, *Silene spergulifolia* (Desf.) M.Bieb, *Centaurea urvillei* DC. subsp. *armata* Wagenitz, *Poa bulbosa* L., *Avena fatua* L. var. *fatua*, *Festuca pratensis* Huds, *Sedum acre* L. subsp. *acre*, *Lamium garganicum* L. subsp. *striatum* (Sm.) Hayek var. *striatum*, *Alkanna orientalis* (L.) Boiss. var. *orientalis*, *Chenopodium foliosum* (Moench) Asch, *Paronychia cephalotes* var. *cephalotes* (M. Bieb.) Bess., *Saxifraga tridactylites* L. are some of the herbaceous taxa in the area (Öztürk and Savran, 2020).

Figure 2. Steppe vegetation in the study area (Photos: T. Ezer).

**2.2. Data source**

The bryophyte specimens, which are the materials of the study, were collected from the various substrates such as rocks, soil and shrub trunks within the doline and its surrounding during the field studies in March, April, May and June 2022 (Table 1).

Table 1. Locality details (L.N.: locality numbers)

| L.N. | Locality-GPS coordinete-Date | Altitude (m) |
|---|---|---|
| **1** | **Niğde:** Within the doline-37°53'38.73"N / 34°43'39.07"E, 13.03.2022, 20.04.2022 | 1680-1710 m |
| **2** | **Niğde:** Surroundings of the doline-37°53'40"N / 34°43'6.37"E 13.05.2022, 06.06.2022 | 1690-1750 m |

The specimens were identified using relevant literature (Zander, 1993; Greven, 1995, 2003; Munoz, 1999; Paton, 1999; Cortini Pedrotti, 2001, 2006; Heyn and Herrnstadt, 2004; Smith, 2004; Guerra et al., 2006; Guerra and Cros, 2007; Kürschner and Frey 2020).

Voucher specimens are deposited in the Herbarium of Niğde Ömer Halisdemir University. The nomenclature arrangement on the floristic list follows Hodgetts et al. (2020). The new records for C13 are indicated with an asterisk (*) in the floristic list presented in Table 2.

**3. Results and Discussions**

As a result of the identification of 365 bryophyte specimens collected from different substrates within the doline and its surroundings, 24 genera belonging to 9 families and a total of 72 taxa were determined. Among them, one species is liverwort (Table 2).

Table 2. Floristic list (L.N.: locality number, e: epiphyte, s: soil, r: rock, rs: thin layer of soil covering rocks).

| Families | L.N. | Taxa | Substrates |
|---|---|---|---|
| **MARCHANTIOPHYTA** | | | |
| Pelliaceae | 1 | *Pellia epiphylla* (L.) Corda | r, rs |
| **BRYOPHYTA** | | | |
| Encalyptaceae | 1 | *Encalypta streptocarpa* Hedw. | r, s |
| | 1 | *E. vulgaris* Hedw. | r, s |
| Funariaceae | 1 | *Entosthodon muhlenbergii* (Turner) Fife | s |
| | 1 | *Funaria hygrometrica* Hedw. | rs, s |
| Fissidentaceae | 1 | *Fissidens exilis* Hedw. | r |
| Pottiaceae | 1 | *Barbula unguiculata* Hedw. | r, s |
| | 1, 2 | *Crossidium squamiferum* (Viv.) Jur. | r, rs, s |
| | 1, 2 | *Didymodon acutus* (Brid.) K.Saito | r, s |
| | 1, 2 | *D. cordatus* Jur. | r, s |
| | 1 | *D. fallax* (Hedw.) R.H.Zander | r, rs |
| | 1 | **D. icmadophilus* (Schimp. ex Müll.Hal.) K.Saito | r, s |
| | 1 | *D. insulanus* (De Not.) M.O.Hill | r, rs |
| | 1 | *D. luridus* Hornsch. | r, s |
| | 1 | *D. nicholsonii* Culm. | r, s |
| | 11 | *D. rigidulus* Hedw. | r, s |
| | 1, 2 | *D. vinealis* (Brid.) R.H.Zander | r, s |
| | 1 | *Gymnostomum calcareum* Nees & Hornsch. | r, |
| | 1 | *G. viridulum* Brid. | r, s |
| | 2 | *Pterygoneurum ovatum* (Hedw.) Dixon | rs, s |
| | 1, 2 | *Syntrichia caninervis* Mitt. | r, rs |
| | 1, 2 | *S. handelii* (Schiffn.) S.Agnew & Vondr. | r, rs |
| | 1 | *S. norvegica* F.Weber | r, rs |
| | 1 | *S. papillosissima* (Copp.) Loeske | rs |
| | 1, 2 | *S. princeps* (De Not.) Mitt. | rs, s |
| | 1 | *S. ruraliformis* (Besch.) Mans. | rs, s |
| | 1, 2 | *S. ruralis* (Hedw.) F.Weber & D.Mohr | r, s |
| | 1 | *S. subpapillosissima* (Bizot & R.B.Pierrot ex W.A.Kramer) M.T.Gallego & J.Guerra | r |
| | 1 | *S. virescens* (De Not.) Ochyra | r, rs, e |
| | 2 | *Tortella tortuosa* (Hedw.) Limpr. | r, rs |
| | 1 | *Tortula atrovirens* (Sm.) Lindb. | r |
| | 1 | *T. brevissima* Schiffn. | r, s, rs |
| | 1 | *T. inermis* (Brid.) Mont. | r, s |
| | 1 | *T. muralis* Hedw. | r |
| | 1 | *T. subulata* Hedw. | r, s |
| | 1 | *Weissia condensa* (Voit) Lindb. | r, rs |
| | 1 | *W. controversa* Hedw. | r, s |
| Grimmiaceae | 1 | *Grimmia elatior* Bruch ex Bals.-Criv. & De Not. | r |
| | 1, 2 | *G. laevigata* (Brid.) Brid. | r, rs |
| | 2 | *G. lisae* De Not. | r |
| | 1 | *G. ovalis* (Hedw.) Lindb. | r |
| | 1, 2 | *G. pulvinata* (Hedw.) Sm. | r, rs, e |
| | 2 | *G. reflexidens* Müll.Hal. | r |
| | 1 | *Schistidium atrofuscum* (Schimp.) Limpr. | r |
| | 2 | *S. crassipilum* H.H.Blom | r |
| | 1, 2 | *S. flaccidum* (De Not.) Ochyra | r, rs |
| | 2 | *S. platyphyllum* (Mitt.) H.Perss. | rs |
| | 1 | *S. pruinosum* (Wilson ex Schimp.) G.Roth | r |
| Bryaceae | 1, 2 | *Bryum argenteum* Hedw. | r, rs |
| | 1, 2 | *B. dichotomum* Hedw. | r, rs |

| | | | |
|---|---|---|---|
| | 1 | *Imbribryum alpinum* (Huds. ex With.) N.Pedersen | rs, s |
| | 1, 2 | *I. mildeanum* (Jur.) J.R.Spence | rs, s |
| | 1 | *Ptychostomum capillare* (Hedw.) Holyoak & N.Pedersen | rs, s, e |
| | 1, 2 | *P. compactum* Hornsch. | rs, s |
| | 1, 2 | *P. donianum* (Grev.) Holyoak & N.Pedersen | rs, s |
| | 1 | *P. knowltonii* (Barnes) J.R.Spence | s |
| | 1, 2 | *P. imbricatulum* (Müll.Hal.) Holyoak & N.Pedersen | rs, s |
| | 1, 2 | *P. inclinatum* (Sw. ex Brid.) J.R.Spence | rs, s |
| | 1 | *P. moravicum* (Podp.) Ros & Mazimpaka | rs |
| | 1, 2 | *P. pallescens* (Schleich. ex Schwägr.) J.R.Spence | rs |
| | 2 | *P. torquescens* (Bruch & Schimp.) Ros & Mazimpaka | rs |
| Orthotrichaceae | 1 | *Lewinskya rupestris* (Schleich. ex Schwägr.) F.Lara, Garilleti & Goffinet | r |
| | 1 | *Orthotrichum alpestre* Bruch & Schimp. | r |
| | 1 | *O. bistratosum* (Schiffn.) Guerra | r |
| | 1, 2 | *O. cupulatum* Brid. | r |
| | 1 | *O. urnigerum* Myrin | e |
| Brachytheciaceae | 1 | *Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen | r, e |
| | 1 | *Brachythecium albicans* (Hedw.) Schimp. | r |
| | 1 | *B. capillaceum* (F.Weber & D.Mohr) Giacom. | rs |
| | 1 | *B. salebrosum* (Hoffm. ex F.Weber & D.Mohr) Schimp. | r |
| | 1 | *Homalothecium lutescens* (Hedw.) H.Rob. | r |
| | 1, 2 | *H. philippeanum* (Spruce) Schimp. | r, rs |

The most species-rich families in the general bryoflora of the collapse doline were Pottiaceae with 31 taxa, Bryaceae with 13 taxa and Grimmiaceae with 11 taxa. These families constituted 76% of all families (Fig. 3).

It is not surprising that acrocarpous Pottiaceae is dominant in the study area. The Pottiaceae is the dominant family of the Mediterranean macrobioclimate, containing many desiccation-tolerant members that can adapt to different habitats (Ros et al., 2013). At the same time, the family ranks first among the richest families in terms of the number of species in the Turkish bryoflora (Erdağ and Kürschner, 2017). The acrocarpous moss family Bryaceae with mesophytic character have been relatively widespread in the study area is due to the dominance of mesic habitats within the doline which has special microclimatic conditions and can be considered habitat islands (Öztürk and Savran, 2020).

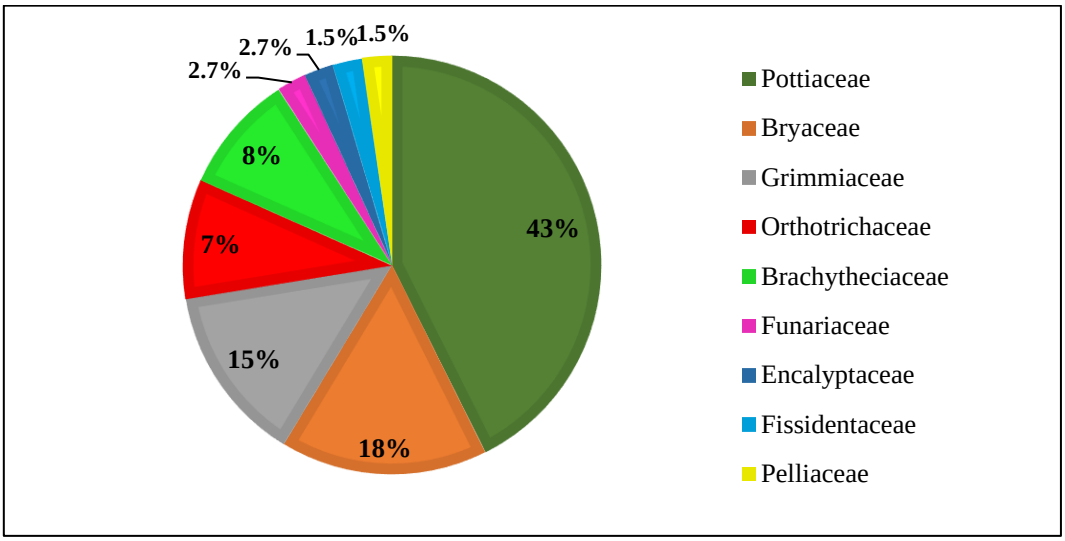


Figure 3. Distribution of taxa according to their families and percentage.

*Syntrichia*, *Didymodon* and *Ptychostomum* are the most common genera sharing the first place in the study area with 9 taxa each. *Grimmia* with 6 taxa, *Tortula* and *Schistidium* with 5 taxa each follow this order (Table 2). *Syntrichia ruralis*, *Weissia condensa*, *Didymodon vinealis* and *Orthotrichum cupulatum* are the most common species in the study area.

The predominance of acrocarpous mosses with the percentage of 73% around the doline is not surprising given the steppe characteristics that are the general vegetation of the area. Pleurocarpous mosses (27%), on the other hand, have been distributed mostly on humid rocks and humid soils within the doline especially on the walls of the doline at the north-facing slopes.

In the present paper, *Didymodon icmadophilus* was recorded as new for C13 square according to the Henderson's grid-square system (Henderson, 1961). The species was previously recorded from localities in various provinces of Türkiye (Ardahan, Iğdır, Ordu, Aydın, Burdur and Konya) (Kürschner and Erdağ, 2021).

This study reveals for the first time in detail the bryophyte flora of a doline, which is a rock depression in Central Anatolia and has different ecological conditions from its surroundings and will contribute to the bryophyte flora of Türkiye.

**Declaration**

**Author contributions:** Idea/Concept, AK, TE; Conceptualization and design, AK, TE; Auditing consulting, AK, TE; References: AK, TE; Materials, AK, TE; Data collection and/or processing, AK, TE; Analysis and/or interpretation, TE; Literature search, TE; Writing phase, TE; Critical review, TE.

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**Ethical approval:** This research did not involve human or animal subjects and therefore does not require ethical approval.

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