

*Original research***Turkish blanket bogs and *Sphagnum* (Bryophyta) diversity of these blanket bogs**Mesut KIRMACI¹, Aslı SEMİZ², Fulya FİLİZ¹, Uğur ÇATAK¹¹Adnan Menderes Üniversitesi, Fen Edebiyat Fakültesi, Biyoloji Bölümü, Merkez Kampüs, 09010, Aydın, Türkiye²Pamukkale Üniversitesi, Teknoloji Fakültesi, Biyomedikal Mühendisliği Bölümü, Kınıklı Kampüsü, 20160 Denizli, Türkiye

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Abstract: Ombrotrophic bogs (called raised/blanket bogs), which are one of the special habitats that host bryophytes, are acidic and poor in mineral salts, and very limited numbers of organisms can cope with such extreme conditions. There are very limited blanket bogs in Turkey such as the Ağaçbaşı Peatland, Barma Yaylası Peatland, Yılanlıtaş Yaylası Peatland (Trabzon), Kabaca–Petek Yaylası Peatland, Sazak Peatland (Artvin) and Ciğer Gölü Peatland (Çanakkale). Except the Ciğer Gölü Peatland, all of them are located at the north-eastern part of Turkey. Among them Yılanlıtaş Yaylası and Ciğer Gölü are almost extinct. Although the diversity of moss on peatlands is poor, *Sphagnum* is the most known and remarkable taxon of these areas. A total of 21 taxa belong to genus *Sphagnum* were collected from these peatlands. *S. subsecundum*, *S. platyphyllum*, *S. nemoreum*, *S. girgensohnii*, *S. compactum*, *S. centrale* and *S. angustifolium* were found as the most common taxa.

Keywords: Blanket Bog, *Sphagnum*, Turkey, Doğu Karadeniz Dağları

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Introduction

It is well known that, bryophytes are the second biggest group of the plant kingdom with 15000-25000 taxa (Crum, 2001; Grandstein et al., 2001). They are represented in different ecosystems and common from deserts to the arctic zone. Ombrotrophic bogs (sometimes called raised/blanket bogs), which are one of the special habitats that host bryophytes, are acidic and poor in mineral salts. Therefore, very limited numbers organisms can cope with such extreme conditions. The most remarkable taxa of these areas include the genus *Sphagnum* (L.). Members of this genus have been occurring in peat for thousands of years. It is well known that, peat is a heterogeneous mixture of more or less decomposed plant (humus) material that has accumulated in a water-saturated environment and in the absence of oxygen. Peatlands cover an estimated area of ca. 400 million ha equivalent to 3% of the Earth's land surface. Approximately 350 million ha of these (covering large areas in North America, Russia

and Europe) are in the northern hemisphere (Immirzi et al., 1992; Joosten and Clarke, 2002; Strack, 2008). These areas are very important for ecology, biodiversity and global carbon balance. According to Joosten and Couwenberg (2008), peatlands are the largest long-term carbon store in the terrestrial biosphere.

Among other countries, Turkey could be considered poor in terms of the formation of peat bogs, especially limited high peatlands. Louis, who pointed out the existence of peatlands in Turkey for the first time, mentioned the high peatlands formed by the *Sphagnum* above the forest boundary in the Yalnızçam Mountains between Artvin and Ardahan (Louise, 1939). In 1944, Kayacık (Forestry Faculty, Istanbul University) also conducted a study which included the Ağaçbaşı Peatland (Kayacık, 1956). Irmak (1968) pointed out the existence of a local 'slope peat' (transition peatland) predominantly formed by the *Calluna*, *Vaccinium* and *Sphagnum* species on the granite bedrock at an altitude of 2000 m a.s.l. in

Bursa-Uludağ. The most comprehensive study on Turkey's peatlands was carried out by Çolak et al. (2001). In this study, the Ağaçaş and Barma Yaylası high peatlands were mentioned in detail, but the species content of *Sphagnum* was not reported.

Currently, the genus *Sphagnum* is represented by 24 taxa in Turkey (Kırmacı and Kürschner, 2017; Ören et al., 2017, Kürschner et al., 2019; Erata and Batan, 2019). The first record from Turkey was given by Schiffner (1896). Additionally, Handel-Mazzetti (1909), Robinson and Godfrey (1960), Henderson (1961), Henderson and Prentice (1969) and Walther (1967) were other botanists who recorded further species from the country. Payne et al. (2007) added *S. fuscum* (Schimp.) H. Klinggr. from Ağaçaş Yayla (Trabzon province). Also, Abay et al. (2009) published a report on *S. centrale* from the Kaçkar Mountains (Rize province). The study by Kırmacı and Kürschner (2013) on the genus is more detailed among the others. It is including 4 new record and 5 re-collected taxa (more than 40 years later) were published. Moreover, the first hints to the occurrence of Oxycocco-Sphagnetea communities (e.g., *Sphagnetalia magellanici*) in Turkey were given. The latest country records that belonged to the genus *Sphagnum* were given by some researchers such as Tonguç Yayıntaş (2013), Kırmacı and Kürschner (2013), Abay and Keçeli (2014), Kırmacı and Kürschner (2017), Ören et al. (2017), Kürschner et al. (2019) and Erata and Batan (2019).

In this study, the blanket bogs in Turkey are described with their characteristics and *Sphagnum* diversity.

Material and Method

Blanket bogs were determined during a revisional project on Turkish *Sphagnum* supported by TÜBİTAK (Scientific and Technological Research Council of Turkey) between 2013 and 2017. Thickness of peat was measured from the peat beds by digging holes. The *Sphagnum* taxa were collected from the areas at the same time and determined using relevant floras, revisions and monographs. All taxa samples were photographed in the field and kept at the Herbarium of Adnan Menderes University (Aydın, Turkey).

Results and Discussion

A blanket bog is defined by the Habitats Directive (EC, 2007) as: "Extensive bog communities or landscapes on flat or sloping ground with poor surface drainage, in

oceanic climates with heavy rainfall, characteristic of western and northern Britain and Ireland. In spite of some lateral water flow, blanket bogs are mostly ombrotrophic. They often cover extensive areas with local topographic features supporting distinct communities." A blanket bog forms in conditions of high rainfall and humidity, limiting rates of evapotranspiration (O'Connell, 1990). The balance of these parameters is very important for the formation of these ecosystems. Plenty of studies have been carried out about the relationship between climatic characteristics and blanket bogs (Lindsay et al., 1988; Moore, 1993; Wheeler and Shaw, 1995).

Turkey is one of the richest areas in the temperate latitudes in terms of plant diversity. The main reasons for plant diversity are climate varieties (oceanic, Mediterranean and continental), geomorphological and soil diversities, and the location of the area at the junction of three floristic regions (Euro-Siberian, Mediterranean and Irano-Turanian). When all these factors are combined, it provides many opportunities for diversity and plant growth (Avcı, 2005). Blanket bogs develop in places under the influence of the Euro-Siberian climate which affects the northern parts of the country. There are very limited blanket bogs in Turkey such as the Ağaçaş Peatland, Barma Yaylası Peatland, Yılanlıtaş Yaylası Peatland (Trabzon), Kabaca-Petek Yaylası Peatland, Sazak Peatland (Artvin) and Ciğir Gölü Peatland (Çanakkale). Except the Ciğir Gölü Peatland, all of these are located in the north-eastern part of Turkey (North-Eastern Black Sea Region) (Figure 1). According to peatland distribution map of Turkey, this seems to be compatible with annual precipitation, temperature and evaporation maps (Figure 2-4).

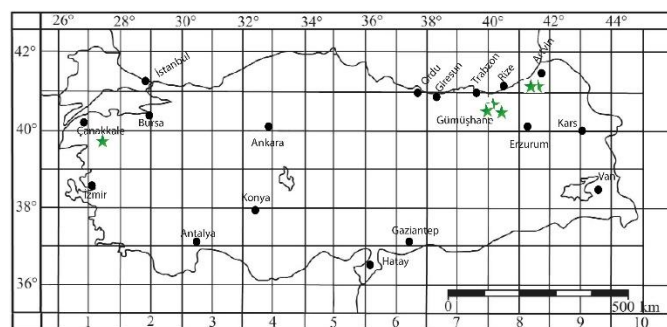


Figure 1. Distribution of the Turkish peatlands



Figure 2. Annual precipitation map of Turkey (1981-2010) (URL 1)

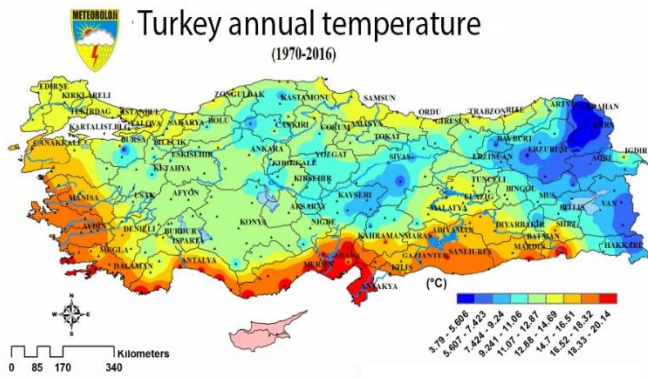


Figure 3. Annual temperature map of Turkey (URL 2)

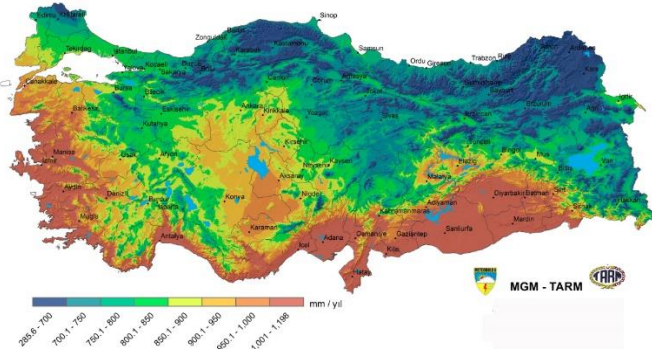


Figure 4. Evaporation map of Turkey (1981-2010) (URL 3)

The most remarkable taxa of these areas include the genus *Sphagnum*. A total of 21 *Sphagnum* taxa were collected from these areas. *S. subsecundum*, *S. platyphyllum*, *S. nemoreum*, *S. girgensohnii*, *S. compactum*, *S. centrale* and *S. angustifolium* were found as the most common taxa (Table 1).

Sürmene Ağaçaşası Peatland
(Trabzon, Ağaçaşası, 2000m; 40°42'24,2"N-40°05'40,6"E)

The Sürmene Ağaçaşası Peatland is the most known mountain blanket peat bog in Turkey. It is located in the

upper forest zone at 2000 m a.s.l., between the Mincana and Vizera Plateaus on the northern skirts of the Soğanlı Mountains (Sürmene, Köprübaşı, Trabzon province) and has a width of about 100-150 hectares. Within this area, approximately 20 hectares consist of very good quality peats about 2.5 meters deep. Ağaçaşası is the richest peatland in terms of *Sphagnum* diversity with 15 taxa. *S. centrale*, *S. compactum*, *S. fuscum* and *S. nemoreum* are the most common taxa and formed in low hummocks. *S. subsecundum* is another common taxon found along stream-sides and sometimes in water. According to Boatman (1983), a hummock-hollow structure indicates high quality and active blanket bog.

Table 1. Turkish blanket bog and *Sphagnum* diversity. 1) Ağaçaşası (Trabzon), 2) Barma Yaylası (Trabzon), 3) Sazak (Artvin), 4) Kabaca-Petek (Artvin), 5) Yılanlıtaş Yaylası (Trabzon) (almost extinct), 6) Ciğer Gölü (Çanakkale) (almost extinct)

<i>Sphagnum</i> Species	1	2	3	4	5	6
<i>S. angustifolium</i>	-	-	+	+	+	-
<i>S. auriculatum</i>	-	-	+	-	-	-
<i>S. centrale</i>	+	+	+	-	-	-
<i>S. compactum</i>	+	+	+	+	+	-
<i>S. divinum</i>	+	-	+	-	-	-
<i>S. fallax</i>	-	-	+	+	-	+
<i>S. fuscum</i>	+	+	-	-	-	-
<i>S. girgensohnii</i>	+	+	+	+	-	-
<i>S. inundatum</i>	+	+	-	-	-	-
<i>S. medium</i>	+	-	+	-	-	-
<i>S. molle</i>	+	+	-	-	-	-
<i>S. nemoreum</i>	+	+	+	-	-	-
<i>S. palustre</i>	+	-	-	-	-	-
<i>S. platyphyllum</i>	+	+	+	-	-	-
<i>S. rubellum</i>	+	-	+	-	-	-
<i>S. squarrosum</i>	-	-	+	+	-	-
<i>S. subfulvum</i>	+	+	-	-	-	-
<i>S. subsecundum</i>	+	+	+	+	-	-
<i>S. tenellum</i>	-	-	+	+	-	-
<i>S. teres</i>	-	+	-	-	-	-
<i>S. warnstorffii</i>	+	-	-	-	-	-
TOTAL	15	11	14	7	2	1

Ağaçaşası Yayla, like other peatlands, harbors many plant species that are extremely rare in Turkey such as *Andromeda polifolia*, *Carex echinata*, *C. lasiocarpa*, *C. magellania* subsp. *irrigua*, *C. panicea*, *C. pauciflora*, *C. pontica*, *Drosera rotundifolia*, *Eriophorum angustifolium*, *Lycopodium inundatum*, *Nardus stricta*, *Narthecium balansae*, *Parnassia palustris*, *Pedicularis comosa*,

Potentilla erecta, *Rhynchospora alba* and *Swertia iberica* (Kırmacı and Kürschner, 2013). Lack of nutrients, low oxygen levels and high acidity are the main factor for plants to adaptation to these special environments. Especially certain plants such as *Carex* spp., *Eriophorum angustifolium*, *Drosera rotundifolia* and *Lycopodium inundatum* will grow in these special environments and also indicate high quality and active blanket bog. These taxa may seen in all Turkish blanket bogs except Yılanlıtaş and Ciğer Gölü Peatland (Figure 5).



Figure 5. A) *Carex* spp., B) *Eriophorum angustifolium*, C) *Drosera rotundifolia*, D) *Lycopodium inundatum*

Conservation of the area that hides the 9,000-year-old ecological (fauna-flora, climate) history of the region is very important for the ecological history of both Turkey and the world. Valuable data about the climate change in the past period and the changes that occur in the vegetation due to this change were obtained from the studies that were conducted in the field. The first study in the area was based on pollen analyses and the C14 method (Aytuğ et al. 1975). It was shown how this peat, estimated to be about 9,000 years old, has changed since the past in terms of climate and related plant composition. In the samples taken from the eastern part of the Mincana Plateau, the following findings were reached from the bottom to the top;

- (A) Zone: 9,000-7,000 years; damp and cold
- (B) Zone: 7,000-4,000 years; slightly humid-temperate
- (C) Zone: 4,000-2,000 years; humid-temperate
- (D) Zone: 2,000-0 years; humid-cold

At this drilling point, *Alnus sp.* participates in the forest community in inverse proportion to spruce [*Picea*

orientalis (L.) Carr.]. It is seen that the common alder [*Alnus glutinosa* (L.) Gaertner] is increasing like *Castanea sativa* Mill. in the depths of spruce decline. This indicates that alder is a species that requires less humidity than spruce. These studies are very important for forestry applications, because the main vegetation of all Eastern Black Sea Mountains consists of spruce, chestnut, beech, alnus and yellow pine.

Today, the site is seriously threatened by peat cutting and settlement. The surrounding villagers use dried peat bricks as their main source of energy. Additionally, the peat is used in horticulture as a component of garden plant substrates (Figure 6). Also the construction industry is one of the major problem in Ağaçaşlı Yayla and all other Black Sea highlands.



Figure 6. The general view of peat cutting area

Information boards and booklets have been prepared by the local government and non-governmental organizations for protection of the Ağaçaşlı Peatland by the local government and non-governmental organizations for protection of the Ağaçaşlı Peatland (Figure 7).



Figure 7. Information board for the protection of the Ağaçaş Peatland

Çaykara-Barma Peatland

(Trabzon, Çaykara-Barma, 1860 m; 40°42'11,2"N-40°08'57,7"E)

The Çaykara-Barma Peatland is 1800 m a.s.l. above the *Picea orientalis* forest border, located 45 km away from İyidere and 15 km away from Çaykara. It is located in the western part of Vizera (2073 m) and Harmantepe (2044 m) in a slightly broad valley. Approximately a 15-hectare area consists of very good quality peat about 2.5-3 m deep. The Çaykara-Barma Peatland, which is very close to the Ağaçaş Peatland, is the second biggest blanket bog of Turkey. 10 *Sphagnum* taxa are represented in the area. Large holes were formed in the area due to peat removal. Re-vegetation in peat removal areas is an indication that the use of peat does not continue. *S. subsecundum* is the dominant submerse species. *S. centrale*, *S. nemoreum* and *S. compactum* are the most common species in the area. Although there are not many settlements around the area yet, it has a large potential because of its highly impressive landscape, which means a potential destruction of the area in the future (Figure 8). Furthermore, the development of cattle breeding in the region which was not common in the past may seem to be the most important factor that will threaten the future.

Sazak (Bataklık) Peatland

(Artvin, Arhavi, (21 km to Arhavi), 1650 m; 41°13'14,2"N-41°20'00,5"E)

The Sazak Peatland is located on the highland mountain road between Arhavi and Artvin. It is 20 km away from Arhavi and 1600 m above the sea level. The area is approximately 6 hectares, surrounded by spruce forests. The sub-vegetation and deforested areas are covered with *Rhododendron ponticum* shrub formation. Another dominant taxon near the water is *Rubus* sp. The highland

mountain road divides the peatland into two parts. The thickness of the peat is (50) 70 (100) cm and may be easily seen from the road bank (Figure 9).



Figure 8. General view of Barma Yaylası



Figure 9. The thickness of peat in the road bank

There are numerous small puddles fully covered by *Sphagnum*, which is represented by 14 taxa in the area.

This number is almost equal to Turkey's biggest blanket bog Ağaçbaşı. *S. compactum* and *S. centrale* were determined as the dominant species. *S. angustifolium* and *S. subsecundum* are other taxa that are abundant in percentage. In parallel with the reduction of water in the slope areas, the *Sphagnum*s are replaced with *Polytrichum commune* Hedw. Although the area is so small in comparison to the others which are rich in taxa, it is very natural and not destroyed due to its location away from residential areas.

This area with a very impressive landscape (Figure 10) may be included in the ecotourism zone with appropriate arrangements. It may be used for educational purposes such as samples abroad.



Figure 11. General view of the Kabaca-Petek blanket bog

Ciğer Gölü Peatland

(Çanakale, Çan, Söğütalan Village, 650 m, 39°52'37"N-26°55'40"E)

The Ciğer Gölü Peatland, which has a history of 1250 years, is located on the western side of the Ağrı Mountain in the northeast of the Kazdağlar Massif (Çan/Çanakale) near a creek. The peatland, which has an altitude of 650 m from the sea level is approximately 100 m in diameter and has an acidic character (pH 4.5) (Öner, 2009). About 25 years ago, the small stream which feed the lake was taken to the village of Söğütalan as drinking water and the lake began to dry. Ecological succession was started, and the general vegetation was replaced by *Alnus glutinosa* L., *Castanea sativa* Miller, *Pinus nigra* Arnold subsp. *pallasiana* (Lamb.) Holmboe var. *pallasiana*, *Rhododendron luteum* Sweet, *Rubus canescens* DC and some ferns (Figure 12). There is almost no moisture in the area where the water leaks from small cracks. *S. palustre*, the only taxon found in the area, is represented by very few individuals (Figure 13).

The other problem in the area is the removal of peat soil without permission. Although the peatland is inland from the forest road, it was excavated. Unfortunately, this natural heritage of thousands of years has been destroyed by horticultural producers by using peat soil (Figure 14).

The area is the most southern western point of the peatlands that were formed by *Sphagnum*s, which are very limited in Turkey. Officials were contacted for the recovery of the area and preparations were started for a recreation project.



Figure 10. The landscape of Sazak Peatland

Kabaca-Petek Peatland

(Artvin, Murgul, 1745 m; 41°09'53,4"N-41°30'58,0"E)

The Kabaca-Petek Peatland, which covers about 6 hectares, is located on the foothills of Mount Şevval and half an hour away from Murgul (Artvin). *Carex* spp. are the predominant flowering plants within the peatland surrounded by *Picea orientalis* and *Fagus orientalis* (Figure 11). There are many water canals in the area which are about 20 cm wide and half a meter deep. This flatness formed among the high mountains formed a very good habitat for the survival of the *Sphagnum*s which are represented by 7 taxa. *S. compactum* is the most common taxon. The peat thickness hardly reaches 30 cm in the area which is not very old. The most important advantage in the continuation of the blanket bog is that there is no settlement area close to the region. Another type of life that is striking in the field is a species of ant that is highly toxic and lives with the *Sphagnum*s. Extremely aggressive, these creatures cause a very painful rash and swelling around 3-4 days.



Figure 12. Current view of Ciğergölü (Çanakkale)



Figure 13. The last taxon which belongs to *S. palustre* from the area



Figure 14. The general view of the destroyed area

Yılanlıtaş Peatland

(Trabzon, Araklı, 1200 m; 40°43'37,2"N-40°00'58,7"E)

The Yılanlıtaş Peatland, which is 5 km away from the Ağaçbaşı Plateau, is located on a 5% sloping land that covers about 5 hectares (Figure 15). Yılanlıtaş, which is

an almost extinct peatland dominated by *S. compactum*, is very poor in terms of the genus *Sphagnum*. *S. auriculatum* is the only accompanying taxon to *S. compactum*. According to the information we received from the villagers, the area had been previously used for peat, which could be understood from the holes in the bog. At many points in the area, other bryophytes (*Polytrichum* sp. is very common) have been dominated, and *Pinguicula* sp. is the most common flowering plant among bryophytes.



Figure 15. Yılanlıtaş Peatland

Turkey's blanket bogs and *Sphagnum* diversity are dealt with for the first time in this study. Besides, Sazak and Kabaca-Petek Peatland are mentioned for the first time. Turkey's blanket bogs constitute the most southern border of the northern hemisphere peatlands are of international importance and absolute protection is required. In spite of this, no conservation or awareness activities have been conducted except for Ağaçbaşı Peatland. In this regard, an information letter was written to the Ministry of Forestry and Water Management. We hope that this study will be the basis for future studies and will contribute to the conservation of peatlands.

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