DOI: 10.26672/anatolianbryology.1811585

Anatolian Bryology
Anadolu Briyoloji
Dergisi
Research Article
e-ISSN:2458-8474
Online

Notes on a Rare Hornwort Species from Türkiye: *Phymatoceros bulbiculosus* (Brot.) Stotler, W.T. Doyle & Crand.-Stotl. (Anthocerotophyta)

Hatice ÖZENOĞLU[1,*], Gözde ASLAN[2], Mesut KIRMACI[3]

[1]Aydın Adnan Menderes University, Faculty of Education, Department of Science and Mathematics Education 09010 Aydın, TÜRKİYE
2 Aydın Adnan Menderes University, Koçarlı Vocational School, Department of Plant and Animal Processing, Medicinal and Aromatic Plants 09010, Aydın, TÜRKİYE
3 Aydın Adnan Menderes University, Faculty of Science, Department of Biology, 09010 Kepez- Aydın, TÜRKİYE

Received: 27 October 2025 **Revised: 16 November 2025** **Accepted: 24 November 2025**

Abstract

Phmatoceros bulbiculosus is one of the rare hornwort species known from Türkiye. The species was first recorded from İzmir by Bornmüller in 1906; however, the accuracy of this identification was later questioned. The presence of distinctly stalked ventral tubers, a well-developed midrib, and smooth spores clearly distinguishes *P. bulbiculosus* from *Phaeoceros laevis.* In the present study, the stalked tubers considered the most diagnostic morphological feature for separating this species are clearly illustrated and described. In addition, a revised identification key for the members of Anthocerotophyta in Türkiye are provided.

Key words: Anthocerotophyta, hornwort, Muğla, ventral tuber

Türkiye'den Nadir Bir Boynuzluot Türü Üzerine Notlar: Phymatoceros bulbiculosus (Brot.) Stotler, W.T. Doyle & Crand.-Stotl. (Anthocerotophyta)

Öz

Phmatoceros bulbiculosus, Türkiye'den bilinen, nadir boynuzlu ot türlerinden biridir. Tür, ilk olarak 1906 yılında Bornmüller tarafından İzmir'den kaydedilmiş, ancak bu tanımlamanın doğruluğu sonradan tartışmalı bulunmuştur. Ventral yüzeyden çıkan belirgin saplı tüberler, iyi gelişmiş orta damar (midrib) ve düzgün yüzeyli sporlar, *P. bulbiculosus*'u, *Phaeoceros laevis*'ten açık biçimde ayıran karakterlerdir. Bu çalışmada, türün ayırt edilmesinde en önemli morfolojik özellik olan saplı tüberler açık biçimde ortaya konulmuştur. Ayrıca, Türkiye'deki Anthocerotophyta üyeleri için yenilenmiş bir teşhis anahtarı sunulmuştur.

Anahtar kelimeler: Anthocerotophyta, boynuzluot, Muğla, ventral tuber

* Corresponding author: hozenoglu@adu.edu.tr
To cite this article: *Özenoğlu H. Aslan G. Kırmacı M. 2025. Notes on a Rare Hornwort Species from Türkiye: Phymatoceros bulbiculosus (Brot.) Stotler, W.T. Doyle & Crand.-Stotl. (Anthocerotophyta). Anatolian Bryology. 11:2, 149-153.*

1. Introduction

The hornworts are a small group of plants comprising about 250 taxa, whose affinities with bryophytes and vascular plants remain uncertain (Plášek et al., 2024). They probably represent a long and separate evolutionary lineage (Frey et al., 2006). Approximately 1,892 bryophyte taxa are naturally distributed in Europe, including 1,390 species of mosses, 494 species of liverworts, and 8 species of hornworts (Hodgetts et al., 2020). The total number of bryophytes recorded in Türkiye has increased to 1,280 taxa, including 1,051 mosses, 224 liverworts, and 5 hornworts (Erdağ and Kürschner, 2024; Aslan et al., 2024). Members of Anthocerotophyta appear to be more distantly related to other bryophytes, and genetic evidence suggests that they may be more closely allied with ferns. However, certain chemical evidence places them nearer to the liverworts; for instance, both hornworts and liverworts lack isoprene emission, whereas mosses and ferns produce it (Glime, 2017).

The hornworts are divided into two classes (Anthocerotopsida and Leiosporocerotopsida) (Stotler and Crandall-Stotler, 2005), a concept supported by molecular data (Frey and Stech, 2005). Anthocerotopsida is the largest and best known of these, the *Nostoc* colonies are scattered in discrete globose colonies. The class is Leiosporocerotopsida differs from members of the other class, having the *Nostoc* in longitudinal canals (Villarreal and Renzaglia, 2006). All taxa distributed in our country are included in Anthocerotopsida.

Members of Anthocerotophyta are considered among the most ancient lineages of land plants and play an important role in understanding early plant evolution. They typically inhabit moist or periodically flooded areas such as stream banks, wet soils, and shaded valleys. The genus *Phaeoceros* (Prosk.) Hassel is one of the most characteristic representatives of this group, recognized by its thin, green thalli and distinct horn-like sporophytes. In Türkiye, *Phmatoceros bulbiculosus* is a particularly rare species, previously reported from only a few localities (Erdağ and Kürschner, 2024). The discovery of new populations of this taxon provides valuable insights into the diversity, ecology and biogeographical distribution of hornworts in the Mediterranean region.

2. Findings

Phymatoceros bulbiculosus (Brotero) Stotler, W.T.Doyle & Crand.-Stotl., Phytologia 87: 114 (2005).

Turkish name: Dikboynuz

Syn: *Anthoceros dichotomus* Raddi, *Phaeoceros bu*lbiculosus (Brot.) Prosk.

Thallus narrow lingulate, 6-15 mm in diameter, usually divided into irregular segments with entire, undulate margins. Unlike other hornwort species, *P. bulbiculosus* does not form rosettes. Stalked tubers frequent on ventral side of thallus. Spores yellow, brownish when mature, proximal nearly smooth or with 1-3 protuberances. Proximal face of spores finely spinose to finely papillose, or weakly papillose at centre in *Phaeoceros laevis*.

Tubers are more frequently on the ventral side of the thallus in *P. bulbiculosus* than *Phaeroceros laevis*. The capsules of *P. bulbiculosus* are usually thicker. However these two characters do not permit to keep the two taxa apart with certainty. Only spore coat ornamentation clearly separates them.

Türkiye: Province Muğla, Köyceğiz, N 36°59'55" E 28°42'29", on soil, 180 m, 23 March 2024, *leg.* H. Özenoğlu, G. Aslan & M. Kırmacı, AYDN 5075 and AYDN 5076 (SND 20 and 30).

The general vegetation consists of a *Pinus brutia* Ten. forest, degraded maquis elements dominated by *Quercus coccifera* L., and *Olea europaea* L. plantation.

Associated bryophytes are *Corsinia coriandrina* (Spreng.) Lindb., *Riccia crozalsii* Levier, *Lunularia cruciata* (L.) Dumort. ex Lindb., *Ptychostomum imbricatulum* (Müll.Hal.) Holyoak & N.Pedersen, *Timmiella barbuloides* (Brid.) Mönk., *Fissidens viridulus* (Sw. ex anon.) Wahlenb., *Weissia condensa* (Voit) Lindb., *Tortula acaulon* var. *marginata* (Herrnst. & Heyn) R.H. Zander.

General distribution: recorded from Southwest Asia (Israel & Cis-Jordan, Lebanon, Türkiye), Azores, Albania, Canary Islands, Corsica, Crete, Croatia, Cyprus, France, Greece, Italy, Ireland, Madeira, Malta, Montenegro, Portugal, Sardinia, Scotland, Sicily, Spain, the Baltic State, N. W. Russia, North and Central America. (Frey et al., 2006; Heyn and Herrnstadt, 2004; Söderström et al. 2016; Erdağ and Kürshner, 2021; Hodgetts and Lockhart, 2020).

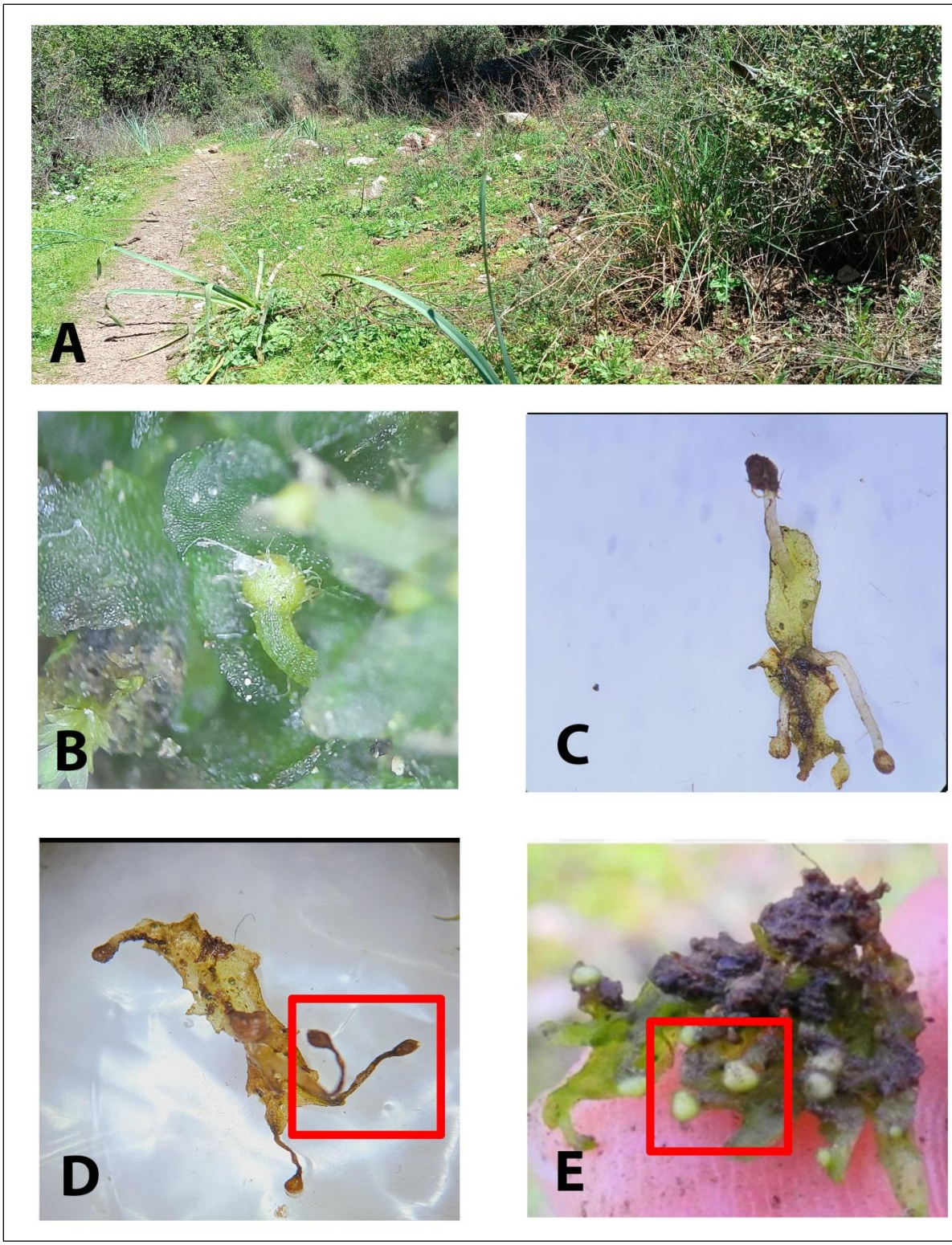

Figure 1. A: General view of collected area, B: Plant with tuber in natural habitat, C and D The appearance of plant with tubers under the microscope, E. The photograph provided by Söylemez (2017) showing the tubers of *P. bulbiculosus*.

Key to families, genera and species of Anthocerotophyta in Türkiye (This key was created by revising the assignment keys in studies Frey et al., 2006; Kürschner and Frey, 2011; Kürschner and Erdağ, 2023).

1. Thallus cavernous, usually pale green with crisped margins forming concave rosettes, 1.5-3.0 cm in diameter; thallus in cross section 10-20 (30) cells thick, with numerous cavities; spores blackish to brownish Anthocerotaceae Dumort.-*Anthoceros* L. ……...2
1* Thallus solid, usually dark green, margins rarely crisped, cavities absent; spores yellowish ……..…..4

2 Spores proximal bluntly spinose; sides of tetraeder letches smooth and conspicouos; on moist soil and rocks ……*A. caucasicus* Steph.
2* Spores proximal reticulate-faveolate; sides of tetraeder edges not smooth and insconsipicouos …. 3

3 Mature antheridia 100-130 (150) µm long; ……..……*A. punctatus* L.
3* Mature antheridia 50-90 µm long; …… *A. agrestis* Paton

4. Thallus narrow lingulate, costa-like thickened in middle part; spores yellow, brownish when mature, proximal (distal face) nearly smotth or with 1-3 protuberances; on moist soil and cultivated ground ……..…Phymatocerotaceae R.J. Duff-Phymatoceros Stotler, W.T Doyle & Crand. ……. *P. bulbiculosus* (Brotero) Proskauer
4* Thallus lobed, thin; spores yellow when mature, proximal (distal face) spinose to tuberculate; on moist soil and cultivated ground, paths, on banks of ponds and lakes…….……Notothladaceae Müll. Frib. ex Prosk. – Phaeoceros Prosk. ……..….. *P. laevis* (L.) Prosk.

3. Results and Discussion

The species *Phymatoceros bulbiculosus* was first included in the flora of Türkiye by Bornmüller in 1906, when it was collected at an altitude of about 900 m in the Tire district of İzmir (Bornmüller, 1908). Henderson (1961) confirmed the distribution of this species in İzmir Province in their publications by citing Bornmüller's record. However, Walter (1967) added a note regarding this species and stated that the information previously given was incorrect. According to Reimers (1927), the specimen collected by Bornmüller near Tire in 1906 actually belonged to *Phaeoceros laevis* (Bornmüller, 1931).

The specimen housed at Herbarium-Hamburgense (Hamburg/Germany) and collected by Bornmüller does not possess tuber-like structures arising from the ventral surface, which are the main diagnostic features distinguishing *P. bulbiculosus* from related taxa. In addition, the costa-like structure in the central part of the thallus is not very prominent, and the spores are densely papillate. In contrast, in Walter's (1967) study, the material collected from İzmir–Narlıdere was described as having ventral tubers, a distinct midrib-like structure on the thallus, and smooth spores. More recently, the species was collected from Sinop by Söylemez et al. (2017) (Sinop Peninsula, Abalı, 42°03'16.3"N, 34°56'14.3"E, 35 m, deciduous forest, 12 October 2015).

The most recent record of the species was collected from Muğla. The stalked tubers protruding ventrally are very prominent in the Muğla specimens. In the photographs provided by Söylemez in her thesis (Söylemez, 2017), the stalked tubers are not clearly visible; they appear more similar to the small tubercles located at the thallus tips of *Phaeoceros laevis*. The absence of a distinct stalk in the tubers shown in the photograph provided by Söylemez (Figure 1E) suggests that the researcher may have made the same misidentification as Bornmüller. Nevertheless, it would not be appropriate to draw a definitive conclusion without a thorough examination of the specimen. Since these structures cannot be clearly observed on herbarium materials, additional samples were not requested from the researchers. The issue can only be clarified with fresh specimens collected from the field during the appropriate collection period.

Declarations

Acknowledgements
Many thanks to Dr. Uğur ÇATAK for taken microscopic photographs and Dilara TEMİZ for kind help during the field trips.

Authors' contributions
Idea/Concept: HÖ, GA, MK. Conceptualization and design: HÖ, GA, MK. Auditing/ Consulting: HÖ, GA, MK. Resources: HÖ, GA, MK. Materials: HÖ, GA, MK. Data Collection & Processing: HÖ, GA, MK. Analysis & Interpretation: HÖ, GA, MK. Literature Review: HÖ, GA, MK. Writing: HÖ, GA, MK. Critical Review: HÖ, GA, MK.

Funding
We cordially thank to TÜBİTAK for financial support to Gözde ASLAN (TBAG 123Z053).

Conflict of interest
The authors declare that there is no real, potential, or perceived conflict of interest for this article.

Ethics approval and consent to participate
The authors declare that ethical approval was not required for this study.

References

Aslan G. Özenoğlu H. Kırmacı M. 2024. New national and regional bryophyte records, 78. Journal of Bryology. 46:3, 226-243.

Bornmüller J. 1908. Florula Lydiae, Mittelungen des Thüringischen Botanischen Vereins, 24: 1-140.

Bornmüller J. 1931. Zur Bryophyten-Flora Kleinasiens, Magyar Bot. Lapok. 30, 1-21.

Erdağ A. Kürschner H. 2021. Bryophyte locality data from the Near and Middle East 1775–2019: Anthocerotophyta, Marchantiophyta (Vol. 1). Hiperlink. ISBN 9786257280662.

Erdağ A. Kürschner H. 2024. Türkiye Bitkileri Listesi, Karayosunları: Eklentiler 2021 – 2023. Bağbahçe Bilim Dergisi. 11:1, 20-24. https://doi.org/10.35163/bagbahce.1403714.

Frey W. Frahm J.P. Fischer E. Lobin W. 2006. The Liverworts, Mosses and Ferns of Europe (English edition revised and edited by T.L. Blockeel). Colchester: Harley Books, 512 p.

Frey W. Stech M. 2005. A morpho-molecular classification of the Anthocerotophyta (hornworts). Nova Hedwigia. 80: 541-546.

Glime J.M. 2017. Anthocerotophyta. Chapt. 2-8. In: Glime, J. M. Bryophyte Ecology. Volume 1. Physiological Ecology. Ebook 2-8-1 sponsored by Michigan Technological University and the International Association of Bryologists.

Henderson D.M. 1961. Contributions to the bryophyte flora of Turkey IV, Notes, R.B.G. Edinburg. 23: 263-278.

Heyn C.C. Herrnstadt I. 2004. The Bryophyte Flora of Israel and Adjacent Regions. Jerusalem, Israel: Israel Academy of Sciences and Humanities.

Hodgetts N.G. Lockhart N.D. 2020. Checklist and country status of European bryophytes – update 2020. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Dublin, Ireland. pp 168.

Kürschner H. Erdağ A. 2023. Türkiye Karayosunları Florası – Bryophyte Flora of Türkiye. Hiperyayın, İstanbul.

Kürschner H. Frey W. 2011. Liverworts, mosses and horn worts of Southwest Asia. (Marchantiophyta, Bryophyta, Anthocerotophyta). Nova Hedwigia. 139: 1–240.

Plášek V. Číhal L. Müller F. Pöltl M. Wierzgoń M. Ochyra R. 2024. Newly found and rediscovered hornworts (Anthocerotophyta) in Poland: Indicators of climate change impact in Central Europe. PhytoKeys. 248: 237-261. doi: 10.3897/phytokeys.248.134729. PMID: 39525526; PMCID: PMC11544306.

Reimers H. 1927. Die von K. Krause in Kleinasien besonders im Pontus, 1926 gesammelten Leber – und Laubmoose, Notizblatt Bot. Gart. Berlin. 10: 27-42.

Söderström L. Hagborg A. von Konrat M. Bartholomew-Began S. Bell D. Briscoe L. Brown E. Cargill D.C. Costa D.P. Crandall-Stotler B.J. et al. 2016. World checklist of hornworts and liverworts. PhytoKeys. 59: 1–828.

Söylemez B. 2017. The bryophyte flora of Sinop Peninsula. Yüksek Lisans Tezi. Zonguldak: Bülent Ecevit Üniversitesi Fen Bilimleri Enstitüsü.

Söylemez B. Ören M. Ursavaş S. Keçeli T. 2017. The bryophyte flora of Sinop Peninsula (Turkey). Biological Diversity and Conservation. 10:3, 120-129.

Stotler R.E. Doyle, W.T. Crandall Stotler B.J. 2005. Phymatoceros Stotler, W. T. Doyle & Crand.-Stotl., Gen. Nov. (Anthocerotophyta). Phytologia. 87:2, 114-117.

Villarreal A.J.C. Renzaglia K.S. 2006. Structure and development of Nostoc strands in Leiosporoceros dussii (Anthocerotophyta): A novel symbiosis in land plants. Amer. J. Bot. 93: 693-705.

Walther K. 1967. Beitrage zur moosflora Westanatoliens I. Mitt Staatsinst Allg Bot.12, 129-186.