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deadwood dwelling bryophyte species
for Turkey and Southwest Asia**

Ayşe Dilek UNAN & Muhammet ÖREN

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New and noteworthy records of deadwood dwelling bryophyte species for Turkey and Southwest Asia

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ABSTRACT

In this study, three deadwood-dependent liverwort species (*Calypogeia suecica* (Arnell & J.Perss.) Müll. Frib., *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl. and *Scapania apiculata* Spruce) are reported upon from forests of North-western Anatolia for the first time for Turkey and Southwest Asia. The results concluded an increasing number of *Scapania* species to 17, *Calypogeia* species to six for these areas. Also, *Crossocalyx* is a new genus record for Turkey and Southwest Asia. All three new records are approximately at the southernmost limit of these species' distribution of Western Asia; also records of *C. hellerianus* and *S. apiculata* are at the southern limit of their Mediterranean distribution. Morphological descriptions, microphotographs, ecological aspects, distinctive taxonomical features, and Turkish conservation suggestions of the new records are presented. In addition, some remarkable deadwood-dependent bryophyte species (*Buxbaumia viridis* (Moug. ex Lam. & DC.) Brid. ex Moug. & Nestl., *Fuscocephaloziopsis lunulifolia* (Dumort.) Vána & L.Söderstr. and *Lophozia guttulata* (Lindb. & Arnell) A.Evans.) in Turkey are discussed.

KEY WORDS
Asia Minor,
Anatolia,
liverworts,
mosses,
epixylic bryophytes,
distribution,
ecology.

RÉSUMÉ

Nouveaux et remarquables enregistrements d'espèces de bryophytes vivant sur le bois mort en Turquie et Asie du Sud-Ouest.

Dans cette étude, trois hépatiques dépendantes des bois morts (*Calypogeia suecica* (Arnell & J.Perss.) Müll.Frib., *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl. et *Scapania apiculata* Spruce) ont été récoltées dans les forêts du Nord-Ouest de l'Anatolie; elles sont nouvelles pour la Turquie et l'Asie du Sud-Ouest. Ainsi, pour ces régions, le nombre d'espèces de *Scapania* est porté à 17, celui des *Calypogeia* à six. De plus, le genre *Crossocalyx* est nouveau pour la Turquie et l'Asie du Sud-Ouest; tandis que *C. hellerianus* et *S. apiculata* atteignent leur limite sud dans leur distribution méditerranéenne. Des descriptions morphologiques accompagnées de microphotographies, les aspects écologiques et leurs traits distinctifs nomenclaturaux ainsi que des suggestions de conservation pour la Turquie sont présentés pour chaque espèce. De plus, *Buxbaumia viridis* (Moug. ex Lam. & DC.) Brid. ex Moug. & Nestl., *Fuscocephaloziopsis lunulifolia* (Dumort.) Vána & L.Söderstr. and *Lophozia guttulata* (Lindb. & Arnell) A.Evans., bryophytes remarquables dépendants des bois morts, sont discutés.

MOTS CLÉS
Asie Mineure,
Anatolie,
hépatiques,
mosses,
bryophytes épixyles,
distribution,
écologie.

INTRODUCTION

Deadwood is the key factor for functioning forest ecosystems due to its important role in forest regeneration, the nutrient cycle, and biodiversity (Merganičová *et al.* 2012). Deadwood-dwelling species are the most diverse organisms in forests and it constitute a large portion of forest biodiversity: in some areas, approximately 25% of the forest species directly or indirectly depend on deadwood (Siitonen 2001; Schuck *et al.* 2004).

In addition to biodiversity, decaying wood debris is also important for conservation. Most of the rare, threatened and relic forest species are associated with deadwood (Radu 2007). Obligatory epixylic bryophytes, especially liverworts, strictly depend on large and well decayed woody debris (Ódor 2002). Because of the reduction in their obligatory substratum and limited dispersal capacities, these organisms can be mainly found in near-natural or natural forests and they are listed in the IUCN threat categories in most European countries (Hallingbäck & Hodgetts 2000; Ódor *et al.* 2006; Söderström 2006). However, more than half of the forests of the world are managed, and only 10% of the forests are designated for biodiversity protection (FAO 2020). In recent decades, more sustainable silviculture methods, like the retention approach, have been preferred instead of clear-cutting, to prevent the decline of large woody debris (Gustafsson *et al.* 2012).

In this paper, three deadwood-dependent liverwort species, *Calypogeia suecica* (Arnell & J.Perss.) Müll.Frib., *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl. and *Scapania apiculata* Spruce, which for the first time, were identified in Turkey and Southwest Asia, are reported upon from managed forests. Also, Turkish status and distribution of some remarkable epixylic bryophytes, *Buxbaumia viridis* (Moug. ex Lam. & DC.) Brid. ex Moug. & Nestl., *Fuscocephaloziopsis lunulifolia* (Dumort.) Váňa & L.Söderstr. and *Lophozia guttulata* (Lindb. & Arnell) A.Evans. are discussed.

MATERIAL AND METHODS

The specimens were collected during the studies dealing with deadwood-inhabiting bryophytes in managed forests of North-western Anatolia (Bartın, Bolu, Düzce, Karabük, Kastamonu, Sinop, and Zonguldak provinces) between 2014-2019 (Fig. 1). In general, the climate in the study area is classified as group C (temperate climate) according to Köppen (1936). Forest vegetation of the area can be summarized as follows: at lower altitudes (to 800-1000 m. a.s.l.), *Fagus orientalis* Lipsky and *Carpinus betulus* L. dominated deciduous forests are common, and *Pinus nigra* J.F.Arnold populations could be seen within drier regions. At this altitude range, *Alnus glutinosa* (L.) Gaertn. populations are frequent alongside streams. At higher altitudes, coniferous forests with pure or mixed *Abies nordmanniana* subsp. *equitrojani* (Asch. & Sint. ex Boiss.) Coode & Cullen and *Pinus sylvestris* L. populations are prevalent. Both in deciduous and coniferous forests, the main soil type is brown forests soil, and near the streams, alluvial soils also can be found.

All the specimens are deposited at the Zonguldak Bülent Ecevit University Bryophyte Herbarium (ZNG).

RESULTS

NEW LIVERWORT RECORDS FOR TURKEY AND SOUTHWEST ASIA

Family CALYPOGEIACEAE Arnell
Genus *Calypogeia* Raddi1. *Calypogeia suecica* (Arnell & J.Perss.) Müll.Frib.
(Fig. 2)

Botanisches Centralblatt 17: 224 (1904).

SPECIMEN EXAMINED. — **Turkey.** Bolu province, Mudurnu district, Derebalık plateau, 40°41'02"N, 031°05'12"E, on decayed *Alnus glutinosa* log, 1349 m. a.s.l., 02.IX.2018, Unan & Ören 237.4A, ZNG.

ECOLOGY. — *Calypogeia suecica* is acidophyte, mesophyte, and adapts to various light conditions (Dierßen 2001). Even though this species mainly colonizes on damp, decorticated logs, it occasionally grows on peat (Paton 1962; Smith 1996; Dierßen 2001; Frey *et al.* 2006; Casas *et al.* 2009).

Turkish *Calypogeia suecica* was collected from very damp *Alnus glutinosa* stump that had decayed to stage 4 according to Ódor & Van Hees (2004) in a brookside habitat in oriental beech and Trojan fir dominated forest. The dimensions of the stump were 20 × 50 cm. 60% of the visible surface of the woody material was covered with the following bryophytes (listed alphabetically): *Cephaloziella divaricata* (Sm.) Schiffn., *Dicranum scoparium* Hedw., *Fuscocephaloziopsis lunulifolia*, *Lophozia ventricosa* (Dicks.) Dumort., *Rhizomnium punctatum* (Hedw.) T.J.Kop., *Riccardia palmata* (Hedw.) Carruth.

DISTRIBUTION. — *Calypogeia suecica* has a wide northern hemisphere distribution. This species has been recorded from various European countries, Russia, and also from the United States and Canada (Stotler & Crandall-Stotler 1977; Potemkin & Sofronova 2009; Hodgetts & Lockhart 2020). The Turkish record of *C. suecica* is at approximately the southernmost limit of the Asian distribution of this species.

CONSERVATION. — Even though *Calypogeia suecica* has a wide European distribution, this species is under threat in various countries (NT in the Great Britain, Czech Republic and Italy; VU in Bulgaria, Sweden and Poland; EN in Finland, Hungary, Serbia, and Spain; CR in Luxemburg, and Portugal). Besides, in Ireland and Northern Ireland, this species is regionally extinct (Hodgetts & Lockhart 2020). Even though *C. suecica* was found on only one sampling point, there is no specific study about peat; the secondary substratum of this species in the study area. Because of that, the Turkish conservation status should be assigned as "DD".

DESCRIPTION

Plants

Green; shoots prostrate, 0.8-1 cm long and 0.8-0.9 mm wide.

Leaves

Incubous, imbricate, entire, subacute to obtuse-rounded, sometimes truncate, 0.5-0.8 mm long and 0.4-0.6 mm wide. Mid-leaf cells mostly ±isodiametric, sometimes elon-

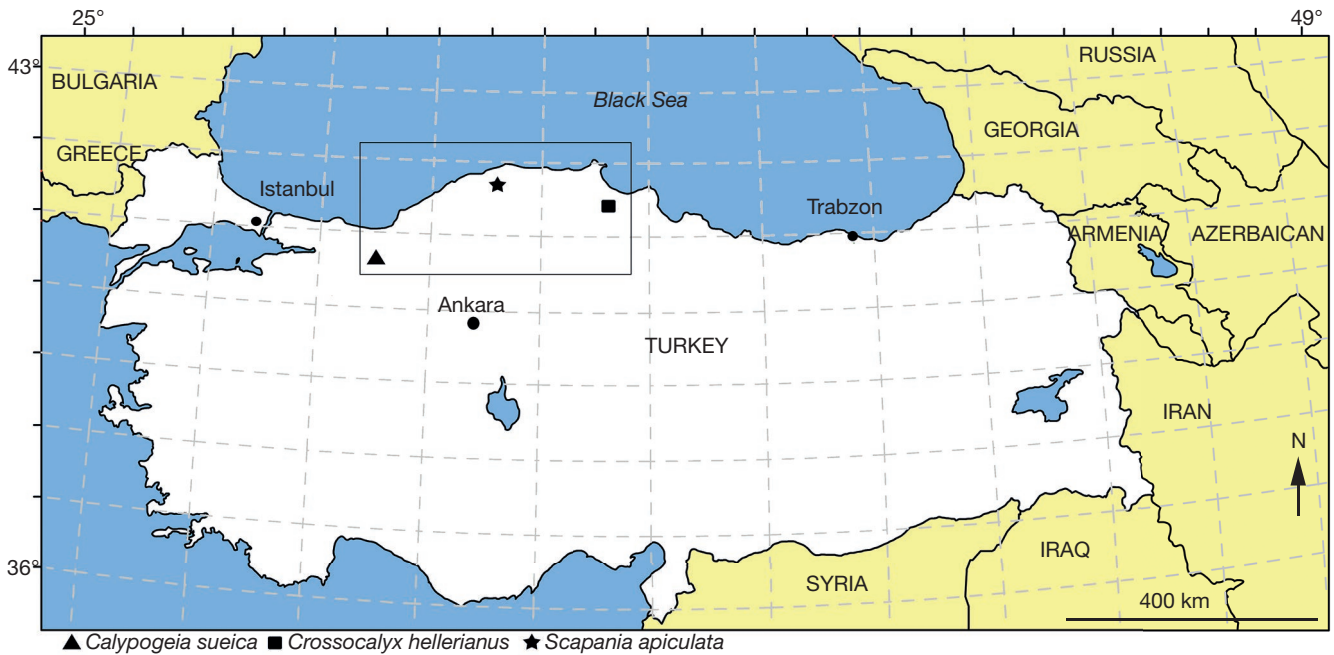


FIG. 1. — Position of Turkey and the investigated area (cornered).

gate, 26–40(45) μm long and 21–33 μm wide; trigones small, triangular, distinct; cuticle smooth.

Underleaves

Subtransversely inserted, suberect, base distinctly decurrent, bilobed to $\frac{1}{2}$ – $\frac{2}{3}$, 2–6 cells deep from sinus to elliptical rhizoidal initial zone; sinus pointed to rounded. Underleaf lobes divergent, slightly acute to obtuse, sometimes with an indistinct tooth or knob at the outer margin near the apex, 0.2–0.4 mm long and 0.3–0.6 mm wide, twice as wide as stem. Underleaf cells are slightly longer than wide, 30–40 μm long and 20–30 μm wide. Oil bodies 1–5 per cell, 5–9 μm long and 3–4 μm wide, simple to 2–5 segmented (Fig. 2E).

Gemmae, perianths, sporophytes and male plants

Not recorded in the studied specimen.

TAXONOMIC NOTE

The vegetative shoots of *Calypogeia suecica* can look alike with *C. fissa* (L.) Raddi and *C. muelleriana* (Schiffn.) Müll. Frib. But shoots of both of the latter species are bigger in width (up to 3.5 mm) than *C. suecica* (up to 1 mm). Also, cells of leaves and underleaves are bigger in *C. fissa* and *C. muelleriana* compared to *C. suecica*, and these two species have more segmented oil bodies (up to 16). In addition, underleaves *C. muelleriana* and *C. suecica* are different. In *C. muelleriana*, underleaves have tiers of more than 4 cells from the sinus to the rhizoidal initial area, whereas, in *C. suecica*, the tiers consist of 2–6 cells. Also, lateral margins of these leaves are mainly entire in *C. muelleriana*, but in *C. suecica* the margins mostly have an indistinct tooth or knob. Underleaf lobe

apices of *C. muelleriana* are mostly rounded, but apices of *C. suecica* are usually subacute to acute (Smith 1996; Paton 1999; Potemkin 2018).

Family ANASTROPHYLLACEAE L. Söderstr.,
De Roo & Hedde.
Genus *Crossocalyx* Meyl.

2. *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl. (Fig. 3)

Bulletin de la Société vaudoise des Sciences naturelles 60: 266 (1939). — *Anastrophyllum hellerianum* (Nees ex Lindenb.) R.M.Schust., *American Midland Naturalist* 42: 575 (1949).

SPECIMEN EXAMINED. — Turkey. Sinop province, Durağan district, around Çandağı village, 41°28'26"N, 035°19'03"E, on decayed *Abies nordmanniana* subsp. *equitrojani* log, 1163 m. a.s.l., 24.VII.15, Ören 525/15, ZNG.

ECOLOGY. — *Crossocalyx hellerianus* is acidophyte, hygrophyte-mesophyte, and sciophyte-photophyte (Dierßen 2001). This sapro-lign species mainly colonizes on decorticated woody debris (Smith 1996; Dierßen 2001; Casas *et al.* 2009), and sometimes on bark (Paton 1999; Frey *et al.* 2006). Sporophytes of *C. hellerianus* are not common, and reproduction of this species is often achieved by gemmae, therefore *C. hellerianus* has a short dispersal range (Pohjamo *et al.* 2006; Hultby 2011). This species is one of the indicators of old boreal forests with continuous cycle of coarse woody material (Nitare 2000; Hultby 2011; Borovichev *et al.* 2017).

Turkish *Crossocalyx hellerianus* was found on *Abies nordmanniana* subsp. *equitrojani* log in a pure forest of Trojan fir, which is endemic for Turkey and is distributed in Northern Anatolia. The log was decayed to stage 3 according to Ódor & Van Hees (2004), moist, and approximately 45 × 260 cm in dimensions. 30% of the visible

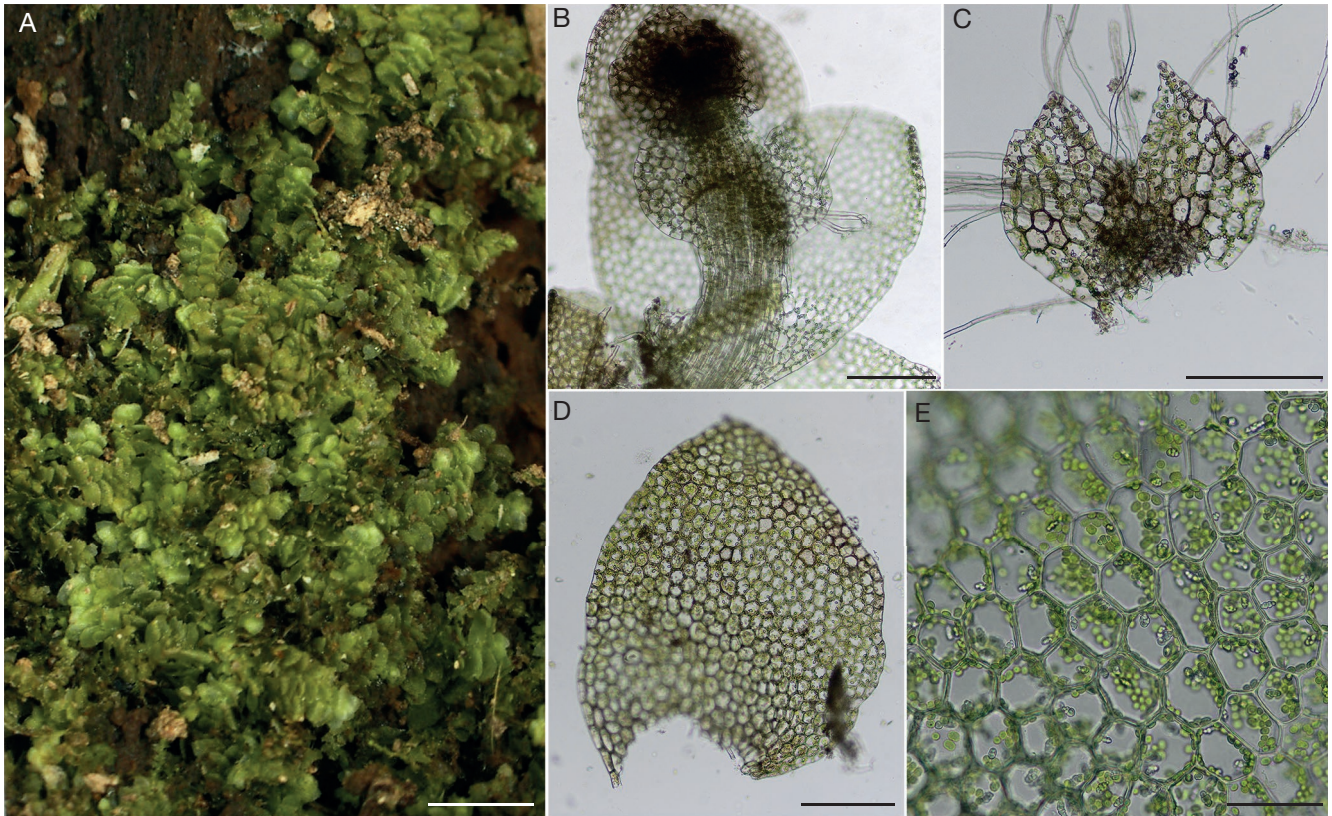


FIG. 2. — *Calypogeia suecica* (Arnell & J.Perss.) Müll.Frib.: **A**, habitus; **B-C**, underleaves; **D**, leaf; **E**, median leaf cells and oil-bodies. Scale bars: A, 3 mm; B-D, 200 µm; E, 50 µm.

surface of the log was covered with the following bryophytes (in alphabetical order): *Buxbaumia viridis*, *Dicranum tauricum* Sappajegin, *Hypnum cupressiforme* Hedw. var. *cupressiforme*, *Lepidozia reptans* (L.) Dumort., *Lophocolea heterophylla* (Schrad.) Dumort., *Nowellia curvifolia* (Dicks.) Mitt. and *Ptilidium pulcherrimum* (Weber) Vain.

DISTRIBUTION. — *Crossocalyx hellerianus* has a wide European distribution (Hodgetts & Lockhart 2020). This species has also been recorded from the Americas (Canada, Colombia, Mexico, and United States) and Asia (Bhutan, China, and Japan) (Schuster 1969; Schill & Long 2002; Frey *et al.* 2006; Alba 2011). The Turkish record is near the southernmost Mediterranean and Western Asian distribution limit of this species.

CONSERVATION. — Despite its wide European distribution, *Crossocalyx hellerianus* is rare in the Mediterranean basin (Dragičević *et al.* 2017), and this species classified in various IUCN categories (NT in Sweden; VU in Finland, Luxemburg, and Slovakia; EN in Czech Republic, Germany, Poland, Romania, and Switzerland; CR in Andorra, Hungary, Italy, and Spain), is also regionally extinct in Northern Ireland (Hodgetts & Lockhart 2020). It's shown that populations of this species are declining rapidly due to silviculture processes in Finland (Pohjamo & Laaka-Lindberg 2003).

Turkish *Crossocalyx hellerianus* was found in one log in the study area. Also this species has a limited dispersal capacity and strict habitat selection. Taking into consideration these facts, it's understood that the area of occupancy (AOO) of this species is less than 10 km². Hence, Turkish conservation status of this species should be assigned as "CR" according to the IUCN Criteria B2a (IUCN 2019).

DESCRIPTION

Plants

Minute, green; sterile shoots prostrate to ascending; gemmiferous shoots erect; up to 6 mm long and 0.25 mm wide.

Leaves

Transversely inserted, mainly suberect, concave, bilobed to 1/3, lobes equal to sub-equal, apices of lobes acute, apices of gemmiferous leaves eroded, 0.2-0.3 mm long and 0.17-0.20 mm wide. Leaf cells ±isodiametric, (14)16-20(22) µm in diameter at the middle; cuticle smooth. Oil bodies 2-4 per cell, spherical, 2-4 µm in diameter.

Gemmae

Abundant, clustered on gemmiferous shoot tips, purplish-red when mature, angular, 1-celled, ± isodiametric, 11-14 µm long and 10-13 µm wide.

Perianths and sporophytes

Not recorded in the studied specimen.

TAXONOMIC NOTE

Despite its small size, *Crossocalyx hellerianus* can be recognizable with erect gemmiferous shoots bearing reddish, one-celled gemmae, even if it is intermixed with other deadwood-dependent liverworts (Smith 1996; Paton 1999). *Sphenolobus minutus*

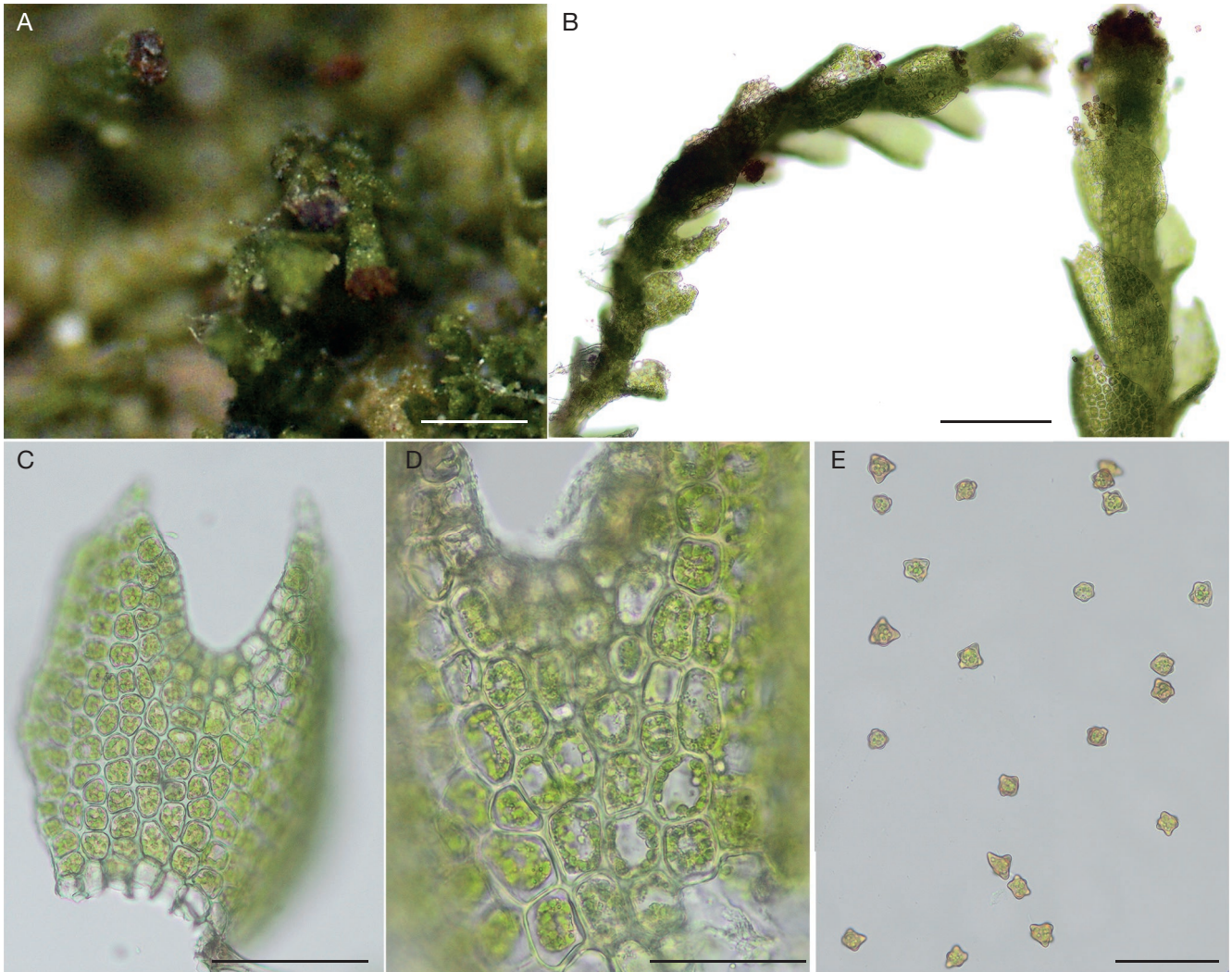


FIG. 3. — *Crossocalyx hellerianus* (Nees ex Lindenb.) Meyl.: **A**, habitus; **B**, shoots; **C**, leaf; **D**, median leaf cells and oil bodies; **E**, gemmae. Scale bars: A, 400 µm; B, 200 µm; C, 100 µm; D, E, 50 µm.

(Schreb. ex D.Crantz) Berggr. [*Anastrophyllum minutum* (Schreb.) R.M.Schust.] is comparable with *C. hellerianus* due to its small size and erect gemma-bearing shoots, but *S. minutus* colonizes on rocks and soil, and gemmae of this species are mostly 2-celled and bigger compared to *C. hellerianus* (Paton 1999; Erata & Batan 2020). *A. lignicola* D.B.Schill & D.G.Long is also related with *C. hellerianus*, and prefers the same habitat, but gemmae of *A. lignicola* are 2-celled and mostly ellipsoid (Schill & Long 2002).

Family SCAPANIACEAE Mig.
Genus *Scapania* (Dumort.) Dumort.

3. *Scapania apiculata* Spruce.
(Fig. 4)

Hepaticae Pyrenaicae: no. 15 (1847).

SPECIMEN EXAMINED. — Turkey. Kastamonu province, Azdavay district, around Zümürüt Village, 41°44'39"N, 033°13'44"E, on

decayed undefined log, 1157 m. a.s.l., 28.VII.2016, Unan & Ören 102.4/A, ZNG.

ECOLOGY. — *Scapania apiculata* is acidophyte, hygrophyte, sciophyte, hemerophobic, and xylicolous species, which mainly colonize on decaying conifer logs that are periodically flooded with water (Dierßen 2001; Frey *et al.* 2006; Hassel *et al.* 2006; Casas *et al.* 2009; Naturvårdsverket 2014). This species is considered as a “poor competitor” and has a limited dispersal capacity (Schuster 1974; Hallingbäck 1998; Hassel *et al.* 2006). Also *S. apiculata* is considered to be an indicator of old and natural boreal forests (Borovichev & Shorohova 2019).

The Turkish specimen was collected on undefined, wet and naturally downed log that had decayed to stage 5 according to Ódor & Van Hees (2004), in a bank of a temporary stream in oriental beech and Trojan fir mixed forest. The dimensions of the log were 32 × 102 cm, and 60% of the visible surface was covered with the following bryophyte species (in alphabetical order): *Blepharostoma trichophyllum* (L.) Dumort., *Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen var. *velutinum*, *Brachythecium salebrosum* (Hoffm. ex F.Weber & D.Mohr) Schimp., *Cephaloziella divaricata*, *Hypnum cupressiforme* var. *cupressiforme*, *Jamesoniella autumnalis* (DC.) Steph., *Jungermannia leiantha* Grolle, *Lophocolea heterophylla*, *Lophozia ventricosa*, *Ptychostomum moravicum* (Podp.) Ros & Mazimpaka,

Rhizomnium punctatum and *Sanionia uncinata* (Hedw.) Loeske.

DISTRIBUTION. — *Scapania apiculata* has a scattered Holarctic distribution (Düll 1983). This species has been recorded from various European countries, also from the Americas (Canada, United States, and Venezuela), Asia (China, Japan, and North Korea), and Russia (Amakawa & Hattori 1953; Schuster 1974; Griffin 1975; Stotler & Crandall-Stotler 1977; Koponen *et al.* 1983; Tong & Yuhuan 1998; Hodgetts & Lockhart 2020). The Turkish record of this species is at southernmost limit of its Mediterranean and Western Asian distribution.

CONSERVATION. — *Scapania apiculata* is threatened in various IUCN categories in European countries (NT in Estonia; VU in Austria, Norway and Switzerland; EN in Sweden; CR in Bulgaria, Finland, and Poland; also Category 1 [Endangered] in Latvia) (Hodgetts & Lockhart 2020). Studies have shown that the populations of this species is decreasing due to the human impact on their habitats in Nordic countries (Hassel *et al.* 2006; Naturvårdsverket 2014; Hassel 2018). This species was found on only one log in the study area (approximately 45 000 km²); thus the area of occupancy (AOO) is less than 10 km². Due to its strict substrate selection, decreasing habitat and small AOO, *S. apiculata* may be classified as “CR” in Turkey according to the IUCN Criteria B2a (IUCN 2019).

DESCRIPTION

Plants

Minute, yellowish green; shoots ascending to erect, 3.3–4.1 mm long and 1.1–1.6 mm wide.

Leaves

Transversely inserted, crowded at stem apex, imbricate, entire, acute, unequally bilobed; postical lobe 0.6–1.1 mm long and 0.3–0.4 mm wide; antical lobe 0.4–0.8 mm long and 0.2–0.3 mm wide. Leaf cells large, isodiametric to longer than wide, 16–33 µm long and 14–22 µm wide in mid-leaf, trigones convex and conspicuous; marginal cells thin walled and not differentiated; cuticle slightly papillose. Oil bodies 2–6 per cell, spheric to ovoid, 4–10 µm long and 4–7 µm wide, not persistent.

Gemmae

Common, clustered on modified tips of reduced upper leaves, reddish brown, elliptical, single-celled, 9–15 µm long and 7–10 µm wide.

Perianths, sporophytes and male plants

Not recorded in the studied specimen.

TAXONOMIC NOTE

Scapania apiculata is quite distinguishable with apiculate leaf tips, but juvenile shoots of this species can resemble *S. umbrosa* (Schrad.) Dumort.; however, it differs from the latter species with its edentate leaf apex, larger trigones, and unicellular gemmae (Konstantinova & Vasiljev 1994; Hallingbäck 1998; Paton 1999). This species can also be confused with another deadwood specific species, *S. glaucocephala* (Taylor) Austin; but the gemmae of the *S. glaucocephala* is two-celled and margins of the leaves of this species with 2–3 rows of thick-walled cells forming a border. *S. brevicaulis* Taylor is another small species with unicellular gemmae, but

this species grows only on soil or rocks and the leaves are not acute (Hong 1980).

Gemmae of Turkish *Scapania apiculata* are slightly smaller (9–15 × 7–10 µm) than reported from North America, Norway, and Russian Far East (11–18 × 7–11 µm) (Hassel *et al.* 2006; Choi *et al.* 2012; Potemkin 2015).

REMARKABLE BRYOPHYTE RECORDS FOR TURKEY

1. *Buxbaumia viridis* (Moug. ex DC.) Brid. ex Moug. & Nestl.

Stirpes Cryptogamae Vogeso-Rhenanae 8: no. 724 (1823).

SPECIMEN EXAMINED. — Collected from 41 points in Bartın, Bolu, Karabük, and Kastamonu provinces.

ECOLOGY. — *Buxbaumia viridis* is an acidophyte, hygrophite, and sciophyte species, which primarily colonizes on well-decayed gymnosperm woody debris (Dierßen 2001; Smith 2004; Frey *et al.* 2006; Kürschner & Frey 2020), but several studies have shown that this species could also be found on acidic soil (Crum & Anderson 1981; Can Gözcü *et al.* 2019; Deme *et al.* 2020).

During the study, all *Buxbaumia viridis* specimens were collected on moderately to well-decayed [3 to 5 according to Ódor & Van Hees (2004)] gymnosperm woody material (in 36 collecting points on *Abies nordmanniana* subsp. *equitrojani*, in 5 on *Pinus sylvestris*), from pure or mixed gymnosperm dominated forests with an altitude range between 650–2000 m. a.s.l. In general, 1 to 5 visible sporophytes could be found on those woody materials, but on a few large ones, the number could go up to 25–35 sporophytes per log or stump. This species is mostly associated with (in alphabetical order) *Brachytecium velutinum* var. *velutinum*, *Fuscocephaloziopsis lunulifolia*, *Cephaloziella divaricata*, *Dicranum scoparium*, *Dicranum tauricum*, *Hypnum cupressiforme* var. *cupressiforme*, *Herzogiella seligeri* (Brid.) Z. Iwats., *Isoetecium alopecuroides* (Lam. ex Dubois) Isov., *Lophocolea heterophylla*, *Plagiothecium curvifolium* Schlieph. ex Limpr., and *Ptychostomum moravicum* through the study area.

DISTRIBUTION. — *Buxbaumia viridis* has a circumpolar distribution (Dierßen 2001). This species has been recorded from throughout Europe, also from China, Russia, United States, and Turkey (Smith 2004; Ros *et al.* 2013; Hodgetts & Lockhart 2020).

TAXONOMIC NOTE

Buxbaumia viridis is an atypical and quite distinguishable moss species with much-reduced gametophytes and relatively large sporophytes. The other European species of the genera, *B. aphylla* Hedw. has a similar appearance, but this species mainly colonizes on acidic humus, and in contrast to *B. viridis*, capsule cuticle of this species does not split and peel with maturity (Smith 2004).

TURKISH DISTRIBUTION

Hitherto Turkish *Buxbaumia viridis* specimens were recorded from limited number of localities in North-western Anatolia, from Bolu, Çankırı, Karabük and Kastamonu provinces (Ursavaş & Abay 2009; Erdağ & Kürschner 2017). Recently this species recorded from one collection point in Kocaeli (Can Gözcü *et al.* 2019) and 3 points in Sinop (Ören & Ursavaş 2020) provinces. Also, there is only one exceptional record from the Taurus Mountains, the South of the country (Antalya province), and the microclimate of this collecting point resembles western the Black Sea region (Özçelik *et al.*

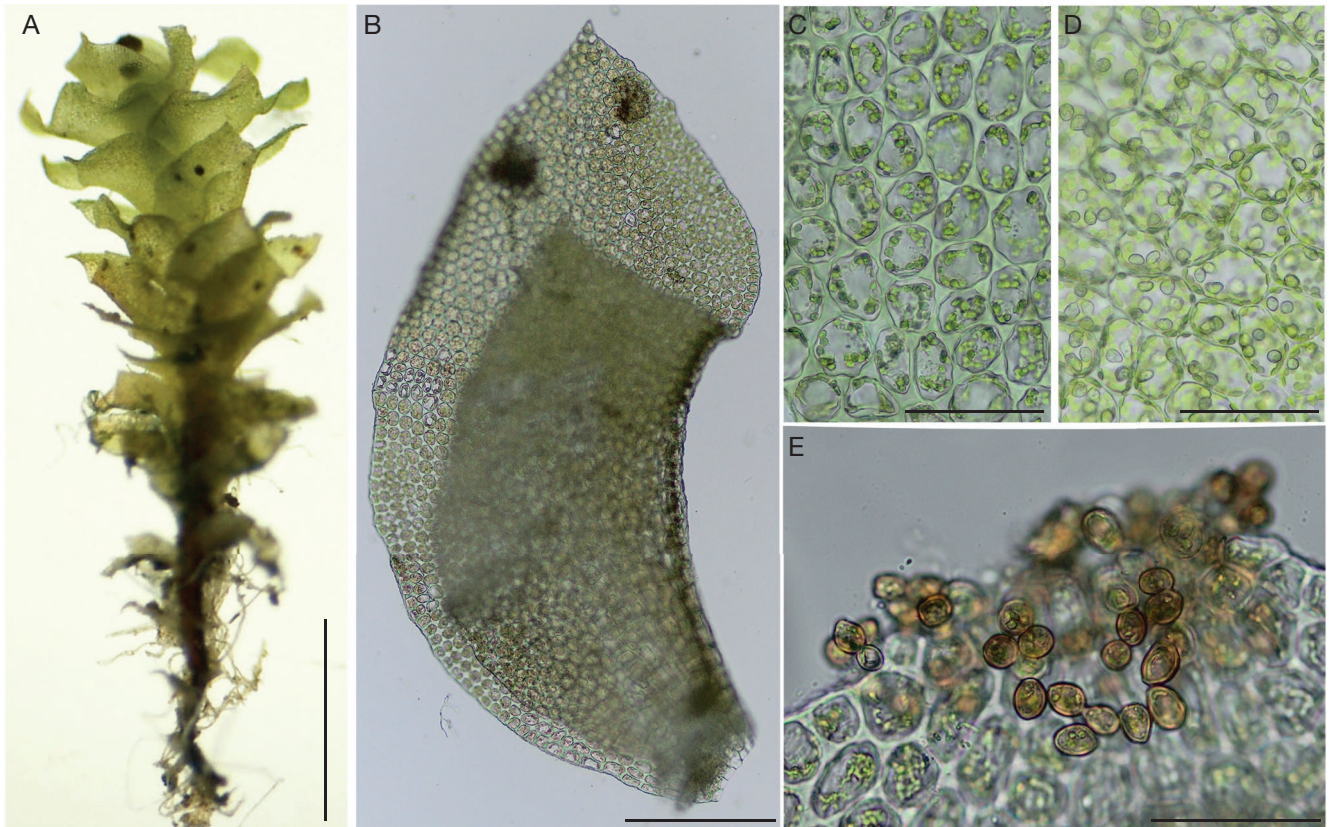


FIG. 4. — *Scapania apiculata* Spruce: **A**, shoot; **B**, leaf; **C**, **D**, median leaf cells and oil-bodies; **E**, gemmae. Scale bars: A, 1 mm; B, 200 µm; C-E, 50 µm.

2016). Nearly all of Turkish *B. viridis* records were on woody debris of fir trees in mixed or pure forests [the North-western records were on *Abies nordmanniana* subsp. *equitrojani*, the Southern record was on *A. cilicica* (Antoine & Kotschy) Carrière]. The only terricolous record of Turkish *B. viridis* is from Kocaeli province, from Trojan fir and deciduous mixed forest. With this study, *B. viridis* has been recorded on Scots pine deadwood for the first time in Turkey.

Although *Buxbaumia viridis* capsules produce a large number of spores (1.4 to 9 million per capsule; Wiklund 2004), this species is thought as “rare” (Frey *et al.* 2006) and under threat in several European countries (Hodgetts & Lockhart 2020), because of its low competitive ability and strict habitat selection. However, according to Spitale & Mair (2017), *B. viridis* could be present at most of the studied areas and remain undetermined due to its microscopic gametophyte and hard to detect sporophytes. This presumption could be applied to Turkish records of *B. viridis*.

2. *Fuscocephaloziopsis lunulifolia* (Dumort.) Vaňa & L.Söderstr.

Phytotaxa 112 (1): 10 (2013).

Cephalozia lunulifolia (Dumort.) Dumort, *Recueil d'Observations sur les Jungermanniacées*: 18 (1835).

SPECIMEN EXAMINED. — Collected from 42 points in Bartın, Bolu, Düzce, Karabük, and Kastamonu provinces.

ECOLOGY. — *Fuscocephaloziopsis lunulifolia* is an acidophyte, hygrophyte and sciophyte species, which colonizes on deadwood, humus soil, and among *Sphagnum* species (Dierßen 2001, Kürschner & Frey 2020). During the study, *F. lunulifolia* specimens were collected on mostly gymnosperm woody debris in pure or mixed forests mainly consisting of *Abies nordmanniana* subsp. *equi-trojani*, *Pinus sylvestris* and *Fagus orientalis*; with a few exceptions of *Alnus glutinosa* logs and stumps near the streams. All the woody material was moderately to well-decayed [stages 3 to 5, according to Ódor & Van Hees (2004)], form an altitude range between 850–2000 meters above sea level. In the study area, this species is mostly associated with (in alphabetical order): *Buxbaumia viridis*, *Cephalozia divaricata*, *Dicranum scoparium*, *Dicranum tauricum*, *Hypnum cupressiforme* var. *cupressiforme*, *Herzogiella seligeri*, *Isoetecium alopecuroides*, *Lepidozia reptans*, *Lophocolea heterophylla*, *Plagiothecium curvifolium*, *Rhizomnium punctatum*, and *Riccardia palmata*.

DISTRIBUTION. — *Fuscocephaloziopsis lunulifolia* is a common species that has been recorded from European countries, also from Asia (China, Iran, Japan and Turkey), North America (Canada, and United States), and Russia (Paton 1999; Potemkin & Sofronova 2009; Hodgetts & Lockhart 2020; Kürschner & Frey 2020).

TAXONOMIC NOTE

Fuscocephaloziopsis lunulifolia is a very variable but easily recognisable liverwort species with almost longitudinally inserted and bilobed leaves, lunulate sinus, and abundant gemmae on shoot tips. Another dioicous Turkish *Fuscocephaloziopsis* species,

F. catenulata (Huebener) Lindb. sometimes shares same habitats with *F. lunulifolia*, but leaf cells of *F. catenulata* are more thick walled and smaller than *F. lunulifolia*. Also, *F. catenulata* looks brownish due to secondary pigmentation both in stem and leaf cells, so colonies of these species can be identified with coloration. *F. pleniceps* (Austin) Lindb. is another Turkish species that can resemble *F. lunulifolia*. But this species is autoicous, and shoots are more robust than *F. lunulifolia*. In addition, in *F. lunulifolia*, there is a distinct wall thickening at the leaf lobe terminal apex cell, whereas in *F. pleniceps* terminal cell is not thickened (Paton 1999; Potemkin & Sofronova 2013).

TURKISH DISTRIBUTION

The first Turkish record of *Fuscocephaloziopsis lunulifolia* was given in 2012 by Keçeli *et al.*, and currently the distribution of this species in the country is restricted with a few records from Sakarya, Bolu, Kastamonu and Sinop provinces, and all of those specimens were collected from deadwood (Erdağ & Kürschner 2017; Ören & Ursavaş 2020; Uyar *et al.* 2020). With this study, Turkish distribution of this species is expanded to Bartın, Düzce, and Karabük provinces. *F. lunulifolia* was one of the most common liverwort species on the decaying woody debris in the investigated area. Therefore, this species could be more common than previously thought and cited in the literature, especially in the moist forests of the North of the country.

3. *Lophozia guttulata* (Lindb. & Arnell) A.Evans. (Fig. 5)

Proceedings of the Washington Academy of Sciences 2 (17): 302 (1900). — *Lophozia ventricosa* var. *guttulata* (Lindb. & Arnell) Bakalin, *Annales Botanici Fennici* 40 (1): 52 (2003).

SPECIMEN EXAMINED. — **Turkey.** Karabük province, Yenice district, around Eğriova lake, 41°04'47"N, 032°26'13"E, on decayed *Abies nordmanniana* subsp. *equitrojani* stump, 1357 m. a.s.l., 29.IV.2018, Unan & Ören 185.2/A, ZNG; Bolu province, Mengen district, 40°52'36"N, 032°16'13"E, on decayed *Abies nordmanniana* subsp. *equitrojani* stump, 1645 m. a.s.l., 01.IX.2018, Unan & Ören 230.1/A, ZNG.

ECOLOGY. — *Lophozia guttulata* is acidophyte, hygrophyte-mesophyte, and adapts to different light conditions (Dierßen 2001). The main substrate for this species is deadwood, but as an exception, it can be found on peat (Dierßen 2001; Bakalin 2016).

New specimens of *Lophozia guttulata* was found on two *Abies nordmanniana* subsp. *equitrojani* stumps. The first stump was in pure Trojan fir forest, decayed to stage 5 according to Ódor & Van Hees (2004), very moist, and 38 × 75 cm in dimensions. 50% of the visible surface of the stump was covered with the following bryophytes (in alphabetical order): *Blepharostoma trichophyllum*, *Fuscocephaloziopsis lunulifolia*, *Dicranum scoparium*, *Herzogiella seligeri*, *Rhizomnium punctatum*, *Riccardia palmata*, *Scapania umbrosa*, and *Tetraphis pellucida* Hedw.. The second stump was in Trojan fir and Scots pine mixed forest, decayed to stage 3 according to Ódor & Van Hees (2004), moist, and 25 × 35 cm in dimensions. 70% of the visible surface of the stump was covered with the following bryophytes (in alphabetical order): *Brachytheciastrum velutinum* var. *velutinum*, *Brachythecium rutabulum* (Hedw.) Schimp., *Dicranum scoparium*, *Herzogiella*, *Lophocolea heterophylla*, *Plagiothecium curvifolium*, and *Sanionia uncinata*. Both two specimens have perianths and gemmae, which is important to the identification of this species.

DISTRIBUTION. — The records of *Lophozia guttulata* are scattered through Europe (Hodgetts & Lockhart 2020). This species has also been recorded from Asia (China, and Turkey), North America (Canada, and United States) and Russia (Schuster 1969; Potemkin & Sofronova 2009; Bakalin 2011; Bakalin & Xiong 2015).

TAXONOMIC NOTE

Lophozia guttulata and *Lophozia longiflora* (Nees) Schiffn. are considered to be closely related and have been the subject of taxonomical debates for some time. Pearson (1890) and Müller (1954) associated *Lophozia longiflora* with *Lophozia ventricosa* (Dicks.) Dumort. (as *Jungermannia ventricosa* var. *longiflora* (Nees) Pearson). According to Schljakov (1981), syntypes of *Jungermannia ventricosa* var. *longiflora* belongs to *L. guttulata*. However, Meinunger & Schröder (2007), treated *Lophozia longiflora* and *Lophozia guttulata* as separate species. Bakalin (2005, 2011), followed Müller (1954) (Söderström *et al.* 2013). Then, Bakalin (2016) lectotypified *L. longiflora*, and listed brief differences between these two species: whereas *L. guttulata* primarily colonizes on deadwood, *L. longiflora* mostly inhabits peaty soil or damp moss cushions; *L. guttulata* has a perianth armature to 3–4 cells long, but at *L. longiflora*, armature is 1–2 cells long; while the leaves of *L. guttulata* are always longer than wide and distinctly canaliculate, *L. longiflora*'s leaves are as long as wide (or sometimes wider than long) and concave to canaliculate-concave. On the most recent liverwort checklist (Söderström *et al.* 2016; Hodgetts *et al.* 2020), *L. guttulata* is an accepted name.

New Turkish *Lophozia guttulata* specimens have some distinct features (reddish tinge, longer than wide and canaliculate leaves, and 3–4 cells long perianth armature) and habitat selection that consistent with Bakalin's (2016) description of this species.

TURKISH DISTRIBUTION

The earliest Turkish records of *Lophozia guttulata* were given as *L. porphyroleuca* (Nees) Schiffner from Trabzon (Handel-Mazzetti 1909; İkinçi 2015) and Bolu provinces (Walther 1967), both on decaying wood. These records, and *L. guttulata* in general treated as synonyms of *L. longiflora* at Turkish checklists (Özenoğlu Kiremit & Keçeli 2009; Erdağ & Kürschner 2017). But in the latest bryological checklist (Hodgetts *et al.* 2020), *L. guttulata* is an accepted name and *L. porphyroleuca* is treated as a synonym for this species. In addition, taking into account of difference in habitat selection of *L. guttulata* and *L. longiflora* according to Bakalin (2016), these earlier records should be treated as *L. guttulata*. Considering all these conclusions, this study shows that this species collected from Turkey for the first time after 50 years.

DISCUSSION

The awareness about the importance of deadwood in terms of biodiversity has been rapidly increasing over the last decades. These unique habitats have a great potential of new, important, and rare records across the globe, as in Turkey.

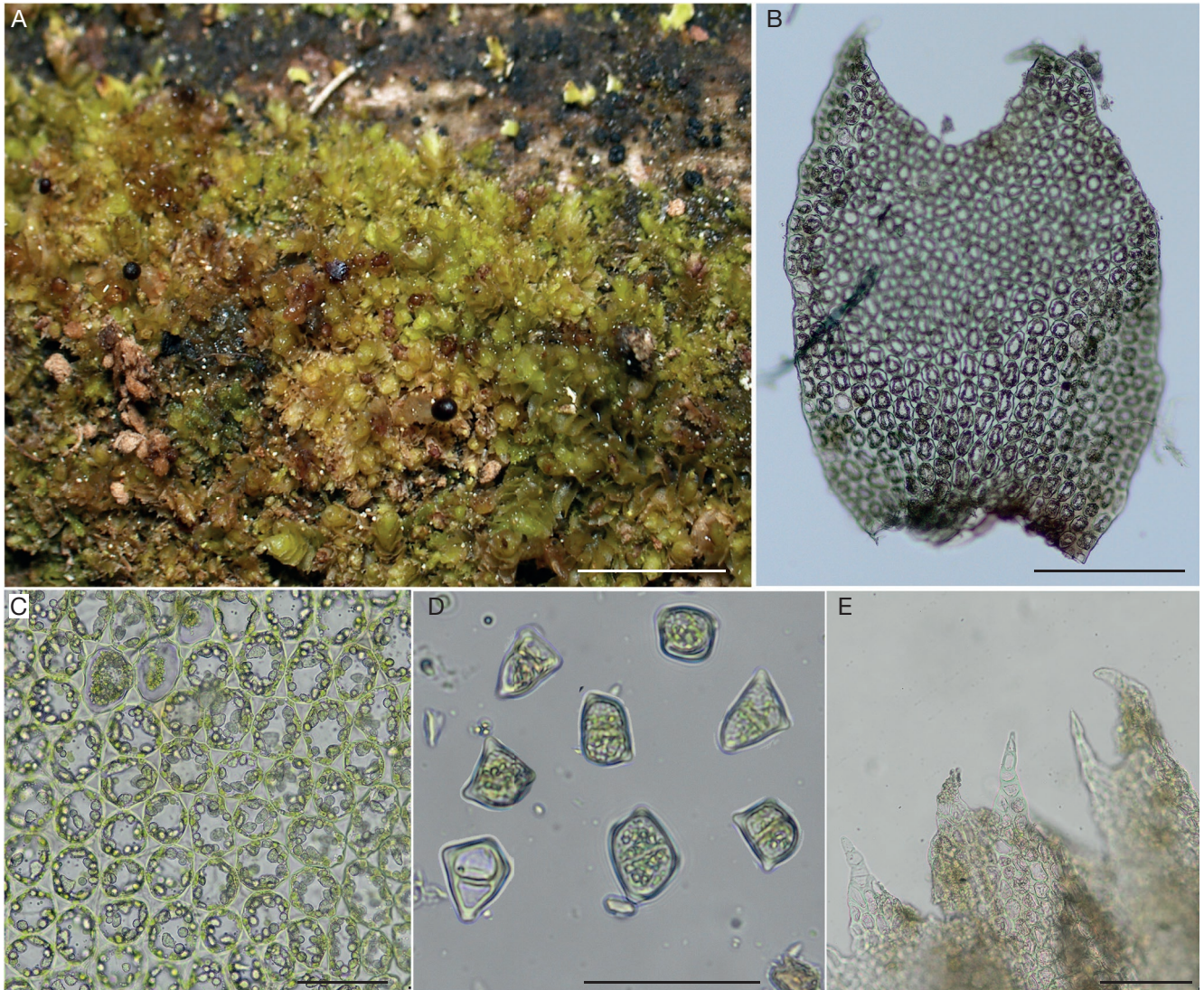


FIG. 5. — *Lophozia guttulata*: **A**, habitus; **B**, leaf; **C**, Median leaf cells and oil-bodies; **D**, Gemmae; **E**, Perianth armature. Scale bars: **A**, 3 mm; **B**, 200 μ m; **C**, **D**, 50 μ m; **E**, 100 μ m.

All new records were collected from managed forests. But, the collecting points were away from local settlements, and not under excess human impact. Logs that specimens collected have been left behind after cutting, and not taken away by people. Therefore, the continuity of the large woody material in studied managed forests has been provided, and these deadwood-dependent species were able to find substrates to colonize on. These findings are emphasizing the importance of the more sustainable applications in the terms of silviculture.

As a result of this paper, the number of the *Calypogeia* Raddi species increased to 6, and *Scapania* (Dumort.) Dumort. species increased to 17 for Turkey and Southwest Asia (Ros *et al.* 2007; Erdağ & Kürschner 2017; Kürschner & Frey 2020; Unan *et al.* 2020). Also, the genus *Crossocalyx* Meyl. is recorded for the first time for these areas. In addition of these new records, *Lophozia guttulata* was recorded for the first time after more than 50 years, and the Turkish status and distribution of this species are discussed. Besides, this study revealed that two

species *Buxbaumia viridis*, and *Fuscocephaloziopsis lunulifolia*, known with their restricted distributions in Turkey, are more abundant in the north-western Anatolia (between 40°30'–41°55'N and 35°26'–30°30'E) than expected, especially on decaying wood in moist fir forests between 800–2000 m. a.s.l.

Future specific studies on these threatened habitats will establish a guideline about understanding distribution, conservation status, and ecology of epixylic bryophyte species, and also forest managing practices at a better point of view.

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