

Tricholoma (Fr.) Staude in the Aegean region of Turkey

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Abstract: The *Tricholoma* biodiversity of the Aegean region of Turkey has been determined and reported in this study. As a consequence of field and laboratory studies, 31 *Tricholoma* species have been identified, and five of them (*T. filamentosum*, *T. frondosae*, *T. quercetorum*, *T. rufenum*, and *T. sudum*) have been reported for the first time from Turkey. The identification key of the determined taxa is given with this study.

Key words: *Tricholoma*, biodiversity, identification key, Aegean region, Turkey

1. Introduction

Tricholoma (Fr.) Staude is one of the classic genera of Agaricales, and more than 1200 members of this genus were globally recorded in Index Fungorum to date (www.indexfungorum.org, access date 23 April 2018), but many of them are placed in other genera such as *Lepista* (Fr.) W.G. Sm., *Melanoleuca* Pat., and *Lyophyllum* P. Karst. (Christensen and Heilmann-Clausen, 2013). According to the current literature, it seems that there are almost 70 species distributed in Europe (Bon, 1991; Riva, 2003; Galli, 2005; Christensen and Heilmann-Clausen, 2008; Kibby, 2012; Christensen and Heilmann-Clausen, 2013), while more than 100 species are found in North America (Bessette et al., 2013). Recently, a comprehensive study on the taxonomy of the genus *Tricholoma* in Northern Europe was conducted by Heilmann-Clausen et al. (2017) and 72 species were discussed based on morphological characters and ITS sequence data. Similarly, another comprehensive study was published by Reschke et al. (2018) from Yunnan Province of China and six *Tricholoma* species new to science were described. The diversity and taxonomy of 70 species were discussed based on morphological and ITS sequences data. These observations show that the knowledge of the taxonomy and diversity of the genus *Tricholoma* is not enough in the world.

In Turkey, 54 *Tricholoma* species have been reported by several researchers (Intini et al., 2003; Sesli and Denchev, 2008; Vizzini et al., 2015; Şen et al., 2018). In recent years, two *Tricholoma* taxa have been reported from Turkey as new species. These new taxa are *T. anatolicum* H.H. Doğan

& Intini (this species, called “sedir mantarı”, is collected by local people for both its gastronomic and financial value) and *T. virgatum* var. *fulvoumbonatum* E. Sesli, Contu & Vizzini (Intini et al., 2003; Vizzini et al., 2015). Additionally, Heilmann-Clausen et al. (2017) described *Tricholoma ilkkae* Mort. Chr., Heilm.-Claus., Ryman & N. Bergius as a new species and they reported that this species grows in Turkey (Konya Province) as well as Sweden, Norway, and Spain. We thus assume that many more *Tricholoma* species are waiting to be discovered in Turkey.

Turkey is the meeting point of three continents: Europe, Asia, and Africa. It is also surrounded by sea on three sides, forming a peninsula. Moreover, Davis et al. (1971) reported that three phytogeographical regions, the Euro-Siberian, Mediterranean, and Irano-Turanian, meet in Anatolia as a consequence of this unique geographical structure, called the Anatolian Diagonal. This geographical structure encourages plant and animal biodiversity. Additionally, diverse climate conditions are found in Turkey due to this unique geographical position (Ünal et al., 2003). Therefore, Turkey has unique ecological features in terms of fungi growth with its diverse plant species and suitable climatic conditions.

The Aegean region is in the southwestern part of Turkey (Figure 1) in the Mediterranean and Irano-Turanian phytogeographical regions. The region has rich plant diversity and natural forests such as *Cupressus sempervirens* L., *Juniperus oxycedrus* L., *J. sabina* L., *J. excelsa* M. Bieb., *J. phoenicea* L., *Abies nordmanniana* (Steven) Spach subsp. *equi-trojani* (Asch. & Sint. ex Boiss.)

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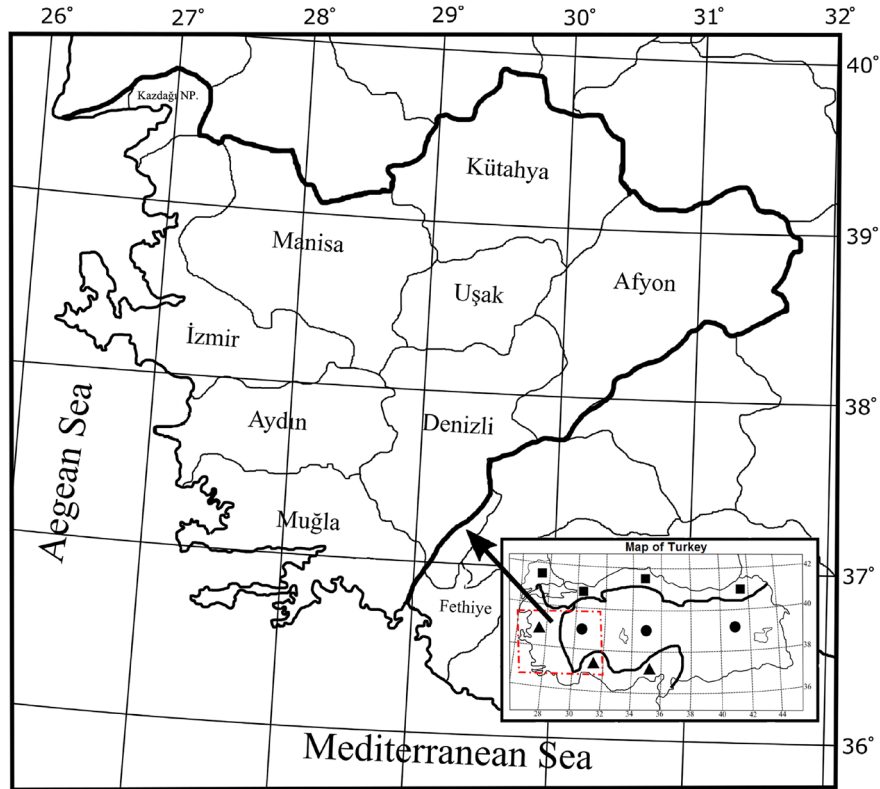


Figure 1. Aegean Region of Turkey (■Euro-Siberian, ●Irano-Turanian, ▲Mediterranean phytogeographic regions).

Coode & Cullen (endemic species), *Cedrus libani* A. Rich., *Pinus sylvestris* L., *P. nigra* Arn., *P. brutia* Ten., *P. pinea* L., *Alnus orientalis* Decne., *Platanus orientalis* L., *Liquidambar orientalis* Mill. (endemic species), *Ulmus minor* Mill., *Morus alba* L., *Ficus carica* L., *Juglans regia* L., *Castanea sativa* Mill., *Quercus frainetto* Ten., *Q. infectoria* Oliver, *Q. pubescens* Wild., *Q. cerris* L., *Q. ithaburensis* Decne., *Q. ilex* L., *Q. aucherii* Jaub. & Spach, *Q. coccifera* L., *Tilia argentea* Desf. ex DC., *Salix alba* L., *Populus alba* L., *P. tremula* L., *Fraxinus ornus* L., and *Olea europaea* L. are located in the region (Durmuşkahya, 2006).

Even though studies on biodiversity of macrofungi in Turkey have been conducted for more than 100 years (Sesli and Denchev, 2008), no study has focused on the taxonomy of the genus *Tricholoma* in Turkey to date. In the present study, an attempt is made to determine the *Tricholoma* biodiversity of the Aegean region of Turkey with the following goals:

1. This study will be the first step in preparing a monograph of *Tricholoma* species in Turkey.
2. The identification key of *Tricholoma* species in the Aegean region of Turkey is presented with this study.

3. Contributions are made to the macrofungi biodiversity of Turkey by the presentation of new records.

2. Materials and methods

A total of 224 *Tricholoma* specimens were collected from 70 different localities in the Aegean region of Turkey between 2013 and 2015 as a consequence of routine field studies. The localities and their habitats are given in the Table.

In the field, macroscopic characters of specimens such as shape, color, texture, and habitat features were recorded, and specimens were photographed. The colors of the specimens were observed in daylight in accordance with Kornerup and Wanscher (1978). Both unbroken and broken basidiocarps' odors were noted as soon as the specimens were picked. Tastes of basidiocarps were also noted.

Spores from gill fragments of dried basidiocarps were measured in 3%–5% KOH solution using a light microscope (Leica DM 750; oil immersion objective 100×). In order to conduct spore measurements, 30–50 spores were measured and calculated to an accuracy of

Table. Locations and habitats.

Province	Area	Habitat ^a
1. Afyonkarahisar	a. Çay	1. Urban forest <i>C.lib</i>
	b. Sandıklı	1. City center <i>Pnig, C.lib, Que</i>
	c. Sinanpaşa	1. Çataloluk <i>Pnig</i>
		2. Çayhisar <i>Que</i>
3. Yörükmezarı <i>Que, Juni, Pnig</i>		
d. Sultandağı	1. Dereçine <i>Que</i>	
2. Aydın	a. Bozdoğan	1. Bozdoğan–Kavaklıdere highway, 15 km <i>Pbru</i>
		2. City center <i>Po.nig</i>
		3. Hışımlar <i>Pbru, Ppin</i>
		4. Örentaht <i>Pbru</i>
	b. Çine	1. Çatak <i>Pbru, Que</i>
	c. Güzelçamlı	1. Dilek Peninsula National Park <i>Pbru</i>
d. Koçarlı	1. Kiraderesi <i>Ppin</i>	
3. Balıkesir	a. Edremit	1. Kazdağı National Park entrance gate <i>Pnig, Que</i>
		2. Kazdağı NP <i>A.nord, Pnig, Po.nig</i>
		3. Kazdağı NP <i>Pnig</i>
4. Denizli	a. Beyağaç	1. Center <i>Pbru</i>
		2. Çamlık <i>Pbru, Que</i>
		3. Kartal Lake highway turnout <i>Pbru</i>
		4. Sazak <i>Que, Juni</i>
		5. Topuklu Plateau <i>Pnig, Que</i>
	b. Buldan	1. Center <i>Pnig</i>
	c. Cankurtaran	1. City center <i>Pbru, C.lib</i>
d. Kale	1. City center <i>P brutia</i>	
5. İzmir	a. Bergama	1. Kozak Plateau <i>Pbru, Que</i>
		2. Kozak Plateau <i>Ppin</i>
		3. Yukarıbey <i>Pbru</i>
	b. Gaziemir	1. Menderes highway turnout <i>Pbru</i>
		2. Ören <i>Pbru</i>
	c. Ödemiş	1.Bozdağ–Salihli highway, 10 km <i>C.lib, Pnig</i>
		2. Gölcük <i>Pnig</i>
d. Selçuk	1. Şirince <i>Pbru, Que</i>	
6. Kütahya	a. Domaniç	1. Küçükköy <i>C.lib, Pnig, Que</i>
	b. Gediz	1. Abide <i>Pnig, Que</i>
		2. Ilcasu <i>Pbru</i>
		3. Old Gediz <i>Pbru</i>
	c. Hisarcık	1. Simav highway, 10 km <i>Pnig</i>
	d. Simav	1. Aksaz <i>Que</i>
		2. Donuzkiran <i>Pnig, Que</i>
3. Gölcük Mountain <i>Pnig</i>		
e. Tavşanlı	1. Yeniköy <i>Pnig</i>	

Table. (Continued).

7. Manisa	a. Demirci	1 Bardakçı	<i>Pnig</i>
		2. Çanakçı	<i>Pnig, Que</i>
		3. İmrenler	<i>Pnig, Que</i>
	b. Soma	1. Değirmeneli	<i>Pbru</i>
		2. Sevişler	<i>Pbru, Que</i>
	c. Spil Mountain NP	1. Beşpınar	<i>Pnig</i>
		2. Excursion area	<i>Pnig</i>
		3. Kirgebeoluk	<i>C.lib, Pnig</i>
		4. Armut Suyu	<i>Juni, Abi, Pnig, C.lib</i>
		5. Observation terrace	<i>Pbru</i>
	6. Wild horse area	<i>Pnig, Juni, Que</i>	
8. Muğla	a. Bodrum	1. Mumcular	<i>Pbru</i>
	b. Kavaklıdere	1. Gökçukur	<i>Pnig</i>
		2. Göktepe	<i>Pnig</i>
		3. Kavak	<i>Pbru</i>
		4. Salkım	<i>Pbru</i>
		5. Şenyayla	<i>Pnig, Que</i>
	c. Köyceğiz	1. Esentepe	<i>Pbru, Que</i>
	d. Menteşe	1. Düzen area	<i>Pbru</i>
		2. Gazeller	<i>Pbru</i>
		3. Gölcük	<i>Pbru</i>
		4. Kozagaç	<i>Pbru</i>
		5. Kötekli	<i>Pbru, Que</i>
		6. Yılanlı	<i>C.lib, Pbru, Que</i>
	e. Milas	1. Kuyucak	<i>Pbru, Que</i>
		2. Ören	<i>Pbru</i>
	f. Ula	1. Çiçekli	<i>Pbru</i>
		2. Gülağzı	<i>Pbru</i>
	9. Uşak	a. City center	1. Uşak University campus

^a *Abi*: *Abies* sp., *A.nord*: *Abies nordmanniana* subsp. *equi-trojani*, *C.lib*: *Cedrus libani*, *Juni*: *Juniperus* sp., *P.bru*: *Pinus brutia*, *P.nig*: *Pinus nigra*, *P.pin*: *Pinus pinea*, *Po.nig*: *Populus nigra*, *Que*: *Quercus* sp.

95%. The Q values of spores (length/width ratio) were calculated in order to find spore shapes. The spore shapes were distinguished in accordance with Q values (Largent et al., 1977).

The basidia shapes were analyzed in the same way. The lack of clamp connections of the specimens was discussed from pileipellis.

The specimens were identified morphologically by using macroscopic, microscopic, and ecological features with the references of Noordeloos and Christensen (1999), Riva (2003), Galli (2005), Christensen and Heilmann-Clausen (2008, 2012, 2013), and Kibby (2012).

The specimens were dried and stored as fungarium materials in the Biology Department of Muğla Sıtkı Koçman University.

3. Results

In this study, 31 taxa were identified from the Aegean region. Five of them are reported here as new records for Turkish Mycota. The new records are *T. filamentosum* (Alessio) Alessio, *T. frondosae* Kalamees & Shchukin, *T. quercetorum* Contu, *T. rufenum* P. Donati, and *T. sudum* (Fr.) Qué. The descriptions of new records and a list of other taxa are alphabetically given below (in the list,

locations of the taxa are abbreviated according to the Table; for example, “Loc. 1a1” means “Afyonkarahisar Province (1), Çay area (a), urban forest (1), *Cedrus libani* forest”). The systematics of the taxa are given in accordance with Christensen and Heilmann-Clausen (2013) and Heilmann-Clausen et al. (2017). The authors of the taxa were checked in accordance with Index Fungorum (access date: 23 April 2018). Similarly, identification keys of the determined taxa are given.

3.1. List of *Tricholoma* species

3.1.1. *Tricholoma acerbum* (Bull.) Quél.

Specimens examined: Loc. 6b1, 12.10.2013, Şen 200; Loc. 1c2, 20.10.2014, Şen 953.

3.1.2. *Tricholoma albobrunneum* (Pers.) P. Kumm.

Specimens examined: Loc. 5a1, 03.11.2013, Şen 264; Loc. 6d2, 24.11.2013, Şen 389; Loc. 5b1, 30.11.2013, Şen 475; Loc. 7c1, 30.11.2013, Şen 490; Loc. 7c6, 30.11.2013, Şen 494; Loc. 8d6, 08.12.2013, Şen 538; Loc. 6e1, 07.10.2014, Şen 856; Loc. 1c1, 20.10.2014, Şen 959; Loc. 3a3, 25.10.2014, Şen 1028; Loc. 8d4, 05.11.2014, Şen 1154; Loc. 8b1, 05.11.2014, Şen 1164; Loc. 3a3, 08.11.2014, Şen 1276; Loc. 7c2, 10.11.2014, Şen 1335; Loc. 8b1, 16.11.2014, Şen 1339; Loc. 6d2, 22.11.2014, Şen 1383; Loc. 6b1, 22.11.2014, Şen 1401; Loc. 8d5, 27.11.2014, Şen 1422; Loc. 8f1, 29.11.2014, Şen 1426; Loc. 8b4, 01.12.2014, Şen 1437; Loc. 4a2, 02.12.2014, Şen 1454; Loc. 4a5, 02.12.2014, Şen 1457, 1461; Loc. 8a1, 21.12.2014, Şen 1517.

3.1.3. *Tricholoma atosquamosum* Sacc.

Specimen examined: Loc. 2b1, 29.11.2013, Şen 432.

3.1.4. *Tricholoma basirubens* (Bon) A. Riva & Bon

Specimens examined: Loc. 7a2, 10.05.2014, Şen 742; Loc. 6d1, 10.05.2014, Şen 753, 756; Loc. 8b1, 05.11.2014, Şen 1185.

3.1.5. *Tricholoma batschii* Gulden

Specimens examined: Loc. 7c4, 02.11.2013, Şen 233, 237; Loc. 5a1, 03.11.2013, Şen 265; Loc. 5a3, 03.11.2013, Şen 268; Loc. 7b1, 04.11.2013, Şen 274; Loc. 7a3, 23.11.2013, Şen 350; Loc. 6c1, 24.11.2013, Şen 404; Loc. 5b2, 30.11.2013, Şen 474; Loc. 4a2, 09.12.2013, Şen 565; Loc. 1c3, 19.05.2014, Şen 847; Loc. 6e1, 25.05.2014, Şen 855, 862; Loc. 6b1, 08.10.2014, Şen 865; Loc. 6e1, 08.10.2014, Şen 871; Loc. 1b1, 20.10.2014, Şen 943; Loc. 1c1, 20.10.2014, Şen 970; Loc. 8d4, 05.11.2014, Şen 1152; Loc. 7c2, 10.11.2014, Şen 1336; Loc. 8b1, 16.11.2014, Şen 1344; Loc. 8f2, 20.11.2014, Şen 1349; Loc. 6b2, 22.11.2014, Şen 1397; Loc. 9a1, 23.11.2014, Şen 1406; Loc. 4c1, 23.11.2014, Şen 1413; Loc. 8b3, 01.12.2014, Şen 1427; Loc. 8b4, 01.12.2014, Şen 1436; Loc. 8d2, 02.12.2014, Şen 1442, 1443; Loc. 4a3, 02.12.2014, Şen 1448; Loc. 4a5, 02.12.2014, Şen 1456; Loc. 8d5, 03.12.2014, Şen 1464; Loc. 3a1, 14.12.2014, Şen 1492; Loc. 8a1, 21.12.2014, Şen 1519.

3.1.6. *Tricholoma bonii* Basso & Candusso

Specimens examined: Loc. 1b1, 11.05.2014, Şen 790, Şen 791; Loc. 8b4, 01.12.2014, Şen 1434.

3.1.7. *Tricholoma caligatum* (Viv.) Ricken

Specimens examined: Loc. 4a1, 09.12.2013, Şen 564; Loc. 6b2, 22.11.2014, Şen 1398; Loc. 8f2, 03.12.2014, Şen 1467; Loc. 7c5, 15.12.2014, Şen 1499.

3.1.8. *Tricholoma cedretorum* (Bon) A. Riva

Specimens examined: Loc. 1b1, 20.10.2014, Şen 940, 941, 947; Loc. 7c3, 10.11.2014, Şen 1322, 1323; Loc. 5c1, 21.11.2014, Şen 1368; Loc. 7c3, 15.12.2014, Şen 1508.

3.1.9. *Tricholoma chrysophyllum* A. Riva, C.E. Hermos. & Jul. Sánchez

Specimens examined: Loc. 7c6, 31.11.2013, Şen 501; Loc. 4a2, 02.12.2014, Şen 1450.

3.1.10. *Tricholoma equestre* (L.) P. Kumm.

Specimens examined: Loc. 7a1, 23.11.2013, Şen 360; Loc. 4a2, 09.12.2013, Şen 569; Loc. 8b1, 17.10.2014, Şen 886; Loc. 3a3, 25.10.2014, Şen 1039; Loc. 8b1, 05.11.2014, Şen 1181; Loc. 8b2, 16.11.2014, Şen 1340; Loc. 6d2, 22.11.2014, Şen 1378; Loc. 8f1, 29.11.2014, Şen 1424; Loc. 8a1, 21.12.2014, Şen 1521.

3.1.11. *Tricholoma filamentosum* (Alessio) Alessio (Figure 2)

Syn.: *Tricholoma pardinum* var. *filamentosum* Alessio

Cap 60–95 mm, convex to plane, sometimes slightly depressed at the center, coarsely scaly, often breaking up in concentrically arranged coarse scales when old, olivaceous buff, but generally with little contrast between scales and background. Gills adnate to emarginate, white to pale yellow, becoming isabelline with age. Stipe 50–95 × 10–15 mm, cylindrical and widened to the base, whitish, with innately darker gray fibers, cream to clay buff towards the base. Flesh white. Odor weak to rancid farinaceous. Taste rancid farinaceous. Spore 7.25–8.50 × 4.65–5.40 µm (Q value: 1.38–1.58), ellipsoid, hyaline. Basidia 32–42.7 × 6.4–8.9 µm, 4-spored. Pileipellis cutis with trichoderm scales, 5–14 µm wide. Clamp connections present.

Tricholoma filamentosum is mainly associated with deciduous trees, especially *Castanea*, *Fagus*, and *Quercus*. Additionally, Kibby (2012) reported that this species sometimes occurs under conifers.

Specimen examined: Balıkesir, Edremit, Kazdağı National Park entrance gate, *Pinus nigra*, *Quercus* sp. mixed forest (Loc. 3a1), 25.10.2014, Şen 1030.

3.1.12. *Tricholoma focale* (Fr.) Ricken

Specimens examined: Loc. 7c6, 02.11.2013, Şen 235; Loc. 7a1, 23.11.2013, Şen 355; Loc. 6d2, 24.11.2013, Şen 390; Loc. 6d3, 24.11.2013, Şen 403; Loc. 8b2, 17.10.2014, Şen 888; Loc. 3a1, 26.10.2014, Şen 1138; Loc. 8d4, 05.11.2014, Şen 1163, 1165; Loc. 8b1, 05.11.2014, Şen 1176; Loc. 3a3, 09.11.2014, Şen 1328.



Figure 2. *Tricholoma filamentosum*: a-b. basidiocarp, c. basidiospores, d. basidia, e. pileipellis.

3.1.13. *Tricholoma frondosae* Kalamees & Shchukin (Figure 3)

Syn.: *Tricholoma equestre* var. *populinum* Mort. Chr. & Noordel.

Cap 50–85 mm, at first broadly conical to convex, later flattened, often broadly umbonate, concentrically distinct appressed scaly especially at center, scales yellowish brown, brownish olivaceous on greenish yellow, pale yellow or light yellow background. Gills emarginate, greenish yellow to sulfur yellow. Stipe 60–85 × 10–15 mm, cylindrical, smooth to slightly fibrillose, straw yellow to sulfur yellow. Flesh whitish. Odor farinaceous, taste mild and farinaceous.

Spore 5.65–7.80 × 3.75–5.25 µm, ellipsoid (Q value: 1.40–1.60), hyaline. Basidia 24–30.5 × 5.80–6.95 µm, 4-spored. Pileipellis cutis to trichoderm, 3–6 µm wide. Clamp connections absent.

This species associates with deciduous trees, especially *Populus* and *Picea*. It can also grow under *Abies* (Christensen and Heilmann-Clausen, 2013).

Specimen examined: Balıkesir, Edremit, Kazdağı National Park, *Abies nordmanniana* subsp. *equi-trojani*, *Pinus nigra*, *Populus nigra* mixed forest (Loc. 3a2), 08.11.2014, Şen 1259.

3.1.14. *Tricholoma imbricatum* (Fr.) P. Kumm.

Specimens examined: Loc. 8b2, 17.10.2014, Şen 889; Loc. 8b1, 05.11.2014, Şen 1194; Loc. 8b1, 16.11.2014, Şen 1342; Loc. 3a1, 14.12.2014, Şen 1497.

3.1.15. *Tricholoma orirubens* Quél.

Specimen examined: Loc. 4a5, 02.12.2014, Şen 1460.

3.1.16. *Tricholoma pardinum* (Pers.) Quél.

Specimen examined: Loc. 3a2, 06.11.2015, Şen 1544.

3.1.17. *Tricholoma pessundatum* (Fr.) Quél.

Specimens examined: Loc. 5c1, 21.11.2014, Şen 1368; Loc. 3a2, 06.11.2015, Şen 1545.

3.1.18. *Tricholoma populinum* J. E. Lange

Specimen examined: Loc. 2a2, 04.11.2015, Şen 1543.

3.1.19. *Tricholoma portentosum* (Fr.) Quél.

Specimens examined: Loc. 3a2, 26.10.2014, Şen 1122; Loc. 8b1, 05.11.2014, Şen 1180.

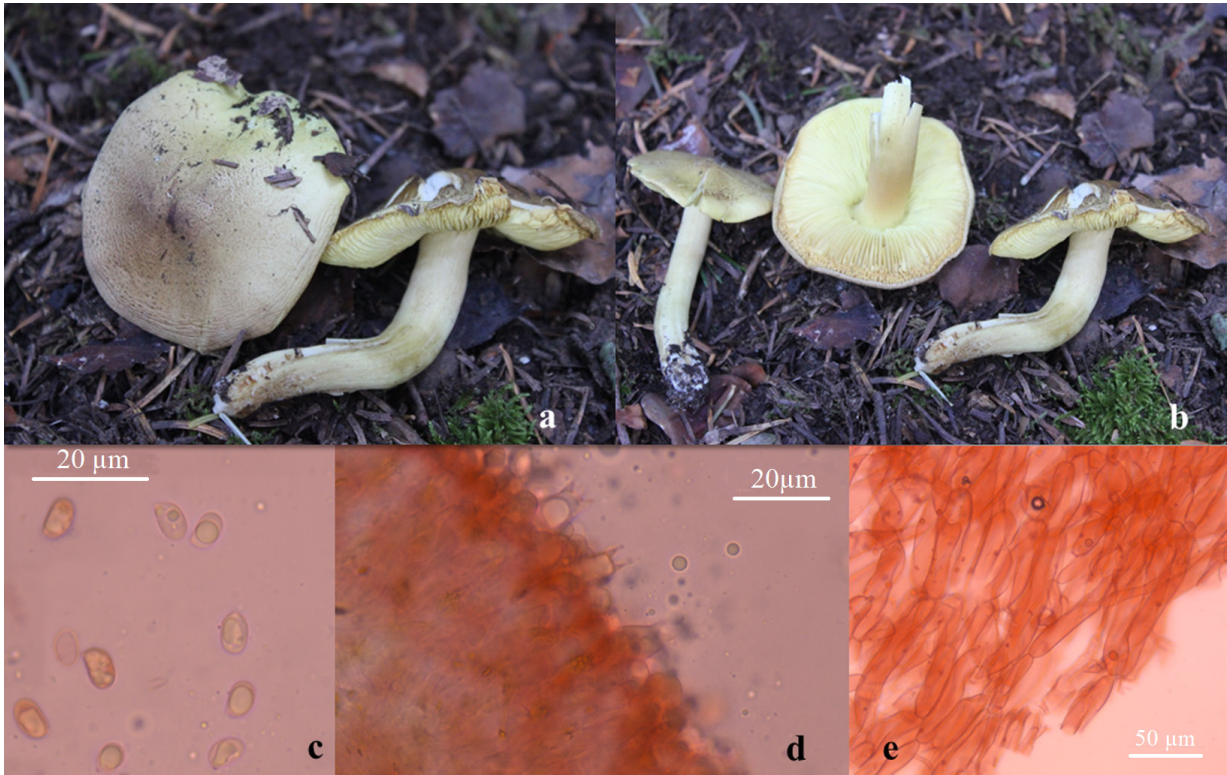


Figure 3. *Tricholoma frondosae*: a-b. basidiocarp, c. basidiospore, d. basidia, e. pileipellis.

3.1.20. *Tricholoma quercetorum* Contu (Figure 4)

Cap 50–90 mm, first hemispherical, later convex to plane, somewhat irregular, generally lobed with broad umbo, dry and shiny, slightly viscid in wet weather, reddish brown to chestnut brown, darker at the center and paler towards the margin, sometimes margin ribbed. Gills emarginate, irregularly arranged, whitish at first, later yellowish cream and brown spots when old. Stipe 55–90 × 15–20 mm, cylindrical, generally slightly widened and curved at the base, whitish or pale cream, often brownish at the base, reddish brown fibrillose, rarely yellowish scaly at the base. Flesh whitish, slightly cream or brownish at the stipe base when cut. Odor and taste farinaceous.

Spore 5.35–6.10 × 3–3.85 µm, ellipsoid (Q value: 1.45–1.64), hyaline. Basidia 25–35 × 7–8 µm, 4-spored. Pileipellis cutis to trichoderm, 4–8 µm wide, with incrustated pigment. Clamp connection absent.

This species is associated with *Quercus*.

Specimen examined: Afyonkarahisar, Sinanpaşa, Yörükmezarı village, *Quercus* sp., *Juniperus* sp., *Pinus nigra* mixed forest (Loc. 1c3), 20.10.2014, Şen 961.

3.1.21. *Tricholoma rufenum* P. Donati (Figure 5)

Cap 30–70 mm, first bell-shaped, then convex, finally plane, broadly umbonate, smooth and shiny, dry but greasy in moist weather, longitudinally fibrillose, anthracite,

blackish-gray or purple violet, generally paler towards margin, wavy margin with often darker drop-like spots. Gills emarginate, white with yellowish tinge, pinkish when old. Stipe 50–80 × 10–15 mm, cylindrical, rarely widened towards base, white, silky, indistinctly brown fibrillose at the base. Flesh white, slightly pinkish at stipe base when cut. Odor farinaceous, sometimes with ripe fruity odor. Taste farinaceous, then slightly bitter. Spore 5.70–6.90 × 4.10–4.80 µm, ellipsoid (Q value: 1.38–1.56), hyaline. Basidia 34.45–41 × 6.70–8.55 µm, 4 spored. Pileipellis cutis, hyphae 5–10 µm wide, with weakly incrustated pigment. Clamp connections absent.

This species is associated with *Quercus*.

Specimen examined: Balıkesir, Edremit, Kazdağı National Park entrance gate, *Pinus nigra*, *Quercus* sp. mixed forest (Loc. 3a1), 09.11.2014, Şen 1316.

3.1.22. *Tricholoma saponaceum* (Fr.) P. Kumm.

Specimens examined: Loc. 3a3, 25.10.2014, Şen 1043; Loc. 3a2, 25.10.2014, Şen 1079; Loc. 3a2, 26.10.2014, Şen 1115; Loc. 8b1, 05.11.2014, Şen 1178; Loc. 3a2, 08.11.2014, Şen 1224; Loc. 3a1, 09.11.2014, Şen 1319; Loc. 4a3, 02.12.2014, Şen 1449; Loc. 4a5, 02.12.2014, Şen 1459; Loc. 8d3, 12.12.2014, Şen 1475.

3.1.23. *Tricholoma sculpturatum* (Fr.) Quél.

Specimens examined: Loc. 8c1, 12.01.2014, Şen 603; Loc.



Figure 4. *Tricholoma quercetorum*: a-b. basidiocarp, c. basidiospores, d. basidia, e. pileipellis.

6d1, 10.05.2015, Şen 751; Loc. 1c2, 19.05.2014, Şen 846; Loc. 1c3, 19.05.2014, Şen 850; Loc. 6a1, 28.10.2014, Şen 864; Loc. 1d1, 19.10.2014, Şen 921, 922, 924; Loc. 1c2, 20.10.2014, Şen 952; Loc. 1c3, 20.10.2014, Şen 956; Loc. 3a1, 26.10.2014, Şen 1098.

3.1.24. *Tricholoma sejunctum* (Sowerby) Quél.

Specimens examined: Loc. 3a1, 09.11.2014, Şen 1313; Loc. 5a1, 13.12.2014, Şen 1484.

3.1.25. *Tricholoma squarrulosum* Bres.

Specimen examined: Loc. 3a1, 14.12.2014, Şen 1491.

3.1.26. *Tricholoma stans* (Fr.) Sacc.

Specimens examined: Loc. 8d4, 05.11.2014, Şen 1162; Loc. 8b1, 16.11.2014, Şen 1341; Loc. 6b2, 22.11.2014, Şen 1395; Loc. 6b1, 22.11.2014, Şen 1401; Loc. 8b3, 01.12.2014, Şen 1429; Loc. 8b4, 01.12.2014, Şen 1438; Loc. 8a1, 21.12.2014, Şen 1517.

3.1.27. *Tricholoma sudum* (Fr.) Quél. (Figure 6)

Syn: *Agaricus sudus* Fr., *Gyrophila suda* (Fr.) Quél.

Cap 40–90 mm, first bell-shaped, then convex to plane, generally umbonate, smooth, rarely fibrillose, felty

or marbled when old, gray buff to gray brown, uniformly colored, often darker at the center with whitish margin, sometimes with dark grayish brown drop-like spots. Gills adnate to emarginate, white, gray or whitish chrome, pink or cinnamon when old or bruised. Stipe 40–80 × 10–20 mm, cylindrical or tapering downwards and rooting in soil, smooth, white to pale gray buff. Flesh white or pale gray and slowly turns pink when bruised. Odor faint, slightly farinaceous or rancid, but distinctly farinaceous when cut. Taste slightly bitter-farinaceous.

Spore 5.25–7.45 × 3.35–4.60 µm, ellipsoid (Q value: 1.46–1.60), hyaline. Basidia 28.75–35 × 6.34–8.11 µm, clavate, 4-spored. Pileipellis cutis, 3–8 µm wide. Clamp connections abundant.

This species is associated with *Pinus*.

Specimens examined: Muğla, Kavaklıdere, Gökçukur area, *Pinus nigra* forest (Loc. 8b1), 05.12.2014, Şen 1175, 1179; Balıkesir, Edremit, *Pinus nigra* forest (Loc. 3a3), 09.12.2014, Şen 1294.

3.1.28. *Tricholoma sulphurescens* Bres.

Specimen examined: Loc. 1c1, 20.10.2014, Şen 948.

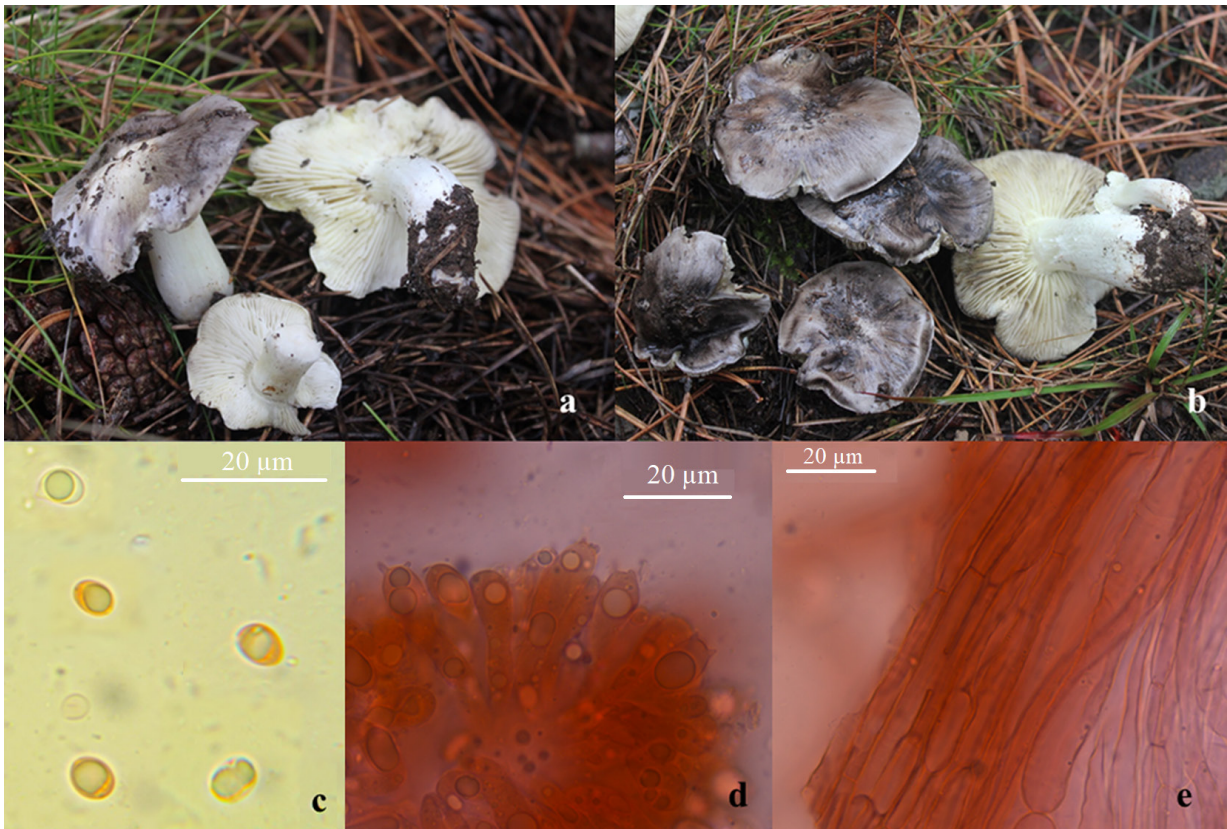


Figure 5. *Tricholoma rufenum*: a-b. basidiocarp, c. basidiospores, d. basidia, e. pileipellis.

3.1.29. *Tricholoma terreum* (Schaeff.) P. Kumm.

Specimens examined: Loc. 5a1, 03.11.2013, Şen 266; Loc. 7b1, 04.11.2013, Şen 275; Loc. 7b2, 04.11.2013, Şen 277; Loc. 8d5, 20.11.2013, Şen 296; Loc. 2a3, 22.11.2013, Şen 324; Loc. 7a3, 23.11.2013, Şen 349, 351; Loc. 7a1, 23.11.2013; Şen 356; Loc. 6d2, 24.11.2013, Şen 382; Loc. 6b3, 25.11.2013, Şen 416; Loc. 2b1, 29.11.2013, Şen 436, 437; Loc. 2d1, 29.11.2013, Şen 441; Loc. 2c1, 30.11.2013, Şen 454; Loc. 5d1, 30.11.2013, Şen 473; Loc. 5b2, 30.11.2013, Şen 480, 481; Loc. 7c1, 31.11.2013, Şen 485; Loc. 7c6, 31.11.2013, Şen 491, 496; Loc. 7c4, 31.11.2013, Şen 507, 508; Loc. 8f2, 02.12.2013, Şen 524; Loc. 8d1, 08.12.2013, Şen 537; Loc. 8d6, 08.12.2013, Şen 539, 540; Loc. 8b3, 08.12.2013, Şen 555; Loc. 8e1, 11.01.2014, Şen 585; Loc. 8e2, 11.01.2014, Şen 589, 590; Loc. 8d3, 12.01.2014, Şen 593; Loc. 5c2, 09.05.2014, Şen 734; Loc. 1b1, 11.05.2014, Şen 777, 778; Loc. 4c1, 12.05.2014, Şen 813; Loc. 6a1, 19.05.2014, Şen 838; Loc. 6d2, 25.05.2014, Şen 861; Loc. 6e1, 25.05.2014, Şen 863, 872; Loc. 4c1, 18.10.2014, Şen 894; Loc. 1a1, 19.10.2014, Şen 937, 938; Loc. 1b1, 20.10.2014, Şen 946; Loc. 1c3, 20.10.2014, Şen 962, 963; Loc. 3a3, 25.10.2014, Şen 1078; Loc. 3a2,

26.10.2014, Şen 1133; Loc. 8b1, 05.11.2014, Şen 1184; Loc. 3a3, 08.11.2014, Şen 1263; Loc. 7c3, 10.11.2014, Şen 1328; Loc. 5c2, 21.11.2014, Şen 1360, 1362; Loc. 9a1, 23.11.2014, Şen 1402, 1405, 1409; Loc. 4c1, 23.11.2014, Şen 1414; Loc. 4d1, 23.11.2014, Şen 1425, 1418; Loc. 8b4, 01.12.2014, Şen 1433; Loc. 2a1, 01.12.2014, Şen 1440; Loc. 2a4, 01.12.2014, Şen 1441; Loc. 4a4, 02.12.2014, Şen 1463; Loc. 8d5, 10.12.2014, Şen 1471; Loc. 5a2, 13.12.2014, Şen 1481, 1482; Loc. 5a3, 13.12.2014, Şen 1488; Loc. 3a1, 14.12.2014, Şen 1490, 1494; Loc. 7c3, 15.12.2014, Şen 1503; Loc. 8a1, 21.12.2014, Şen 1515.

3.1.30. *Tricholoma triste* (Scop.) Quél.

Specimens examined: Loc. 7c3, 10.11.2014, Şen 1324; Loc. 5c2, 21.11.2014, Şen 1357; Loc. 8d5, 10.12.2014, Şen 1472, Loc. 7c3, 15.12.2014, Şen 1507.

3.1.31. *Tricholoma ustaloides* Romagn.

Specimens examined: Loc. 8b5, 08.12.2013, Şen 546; Loc. 6d2, 08.10.2014, Şen 867; Loc. 8d2, 02.12.2014, Şen 1442.

3.2. Keys to *Tricholoma* species in the Aegean region

The identification keys of *Tricholoma* have been constructed by researchers in accordance with field and laboratory experiences and literature data. In these keys,

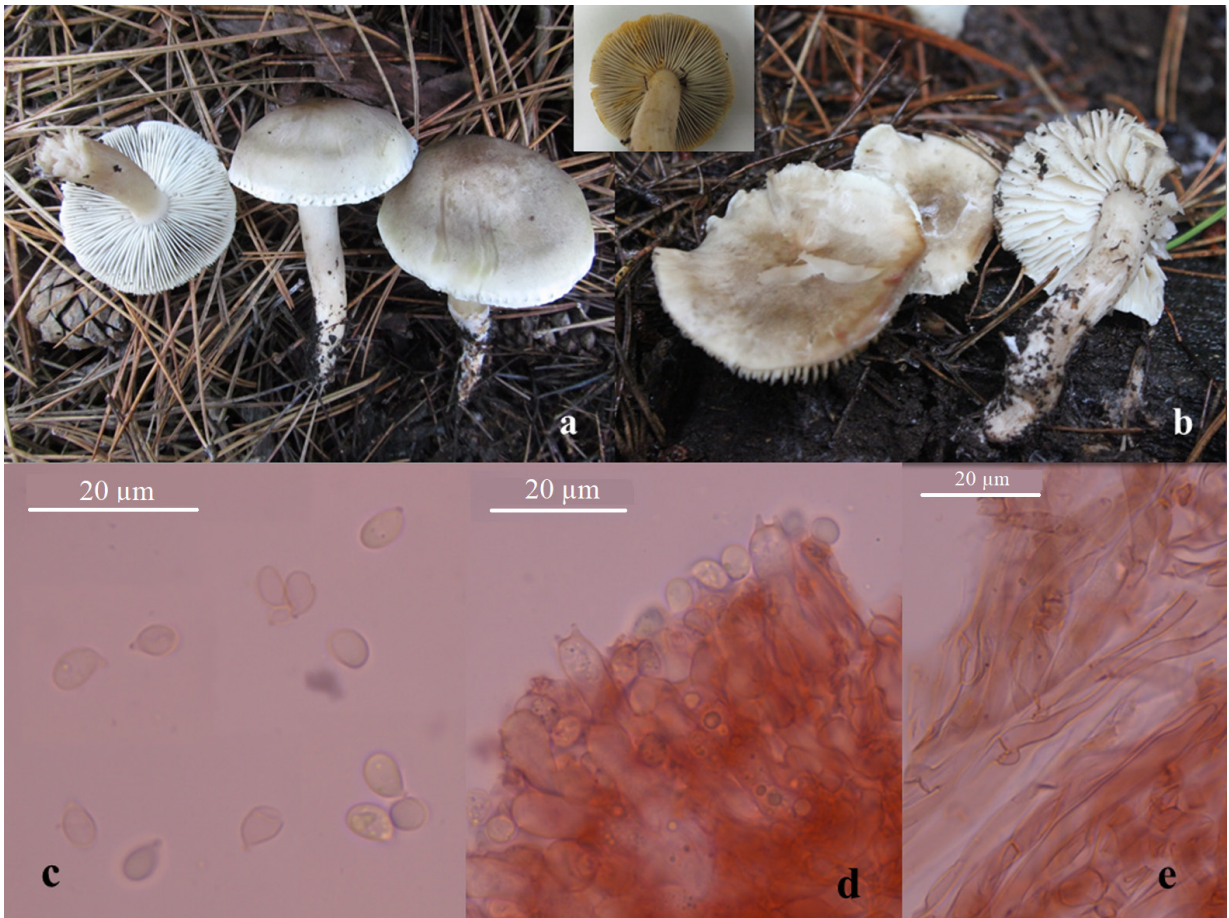


Figure 6. *Tricholoma sudum*: a-b. basidiocarp, c. basidiospores, d. basidia, e. pileipellis.

31 *Tricholoma* species, collected from study area, are presented.

Main key

- 1. Stem with a distinct, woolly or permanent ring Key A
- 1. Stem without ring or ring membranous or cortina like 2
- 2. Cap yellow to yellowish brown; if almost white, yellowing when old or damaged Key B
- 2. Cap not yellowish tinge and not yellowing 3
- 3. Cap smooth or cracked at the center, grayish, olivaceous, or greenish Key C
- 3. Cap not smooth, gray, black, red, or brown 4
- 4. Cap densely fibrillose, scaly or felty, gray to black Key D
- 4. Cap smooth, fibrillose or rarely scaly, cream, red to reddish brown Key E
- Key A.** Stem with a distinct, woolly or permanent ring
- 1. Odor flower-like, especially narcissus-like *T. caligatum*

- 1. Odor farinaceous, sometimes cucumber-like or rancid *T. focale*
- Key B.** Cap yellow to yellowish brown; if almost white, yellowing when old or damaged
- 1. Basidiocarp entirely white, and strongly yellowing when touched or old *T. sulphurescens*
- 1. Basidiocarp not entirely white and color not changing or slowly yellowing 2
- 2. Gills white or rarely yellowing when old *T. sejunctum*
- 2. Gills entirely yellow 3
- 3. Stipe coarsely fibrillose or scaly *T. chrysophyllum*
- 3. Stipe smooth to finely fibrillose 4
- 4. In *Pinus* forest *T. equestre*
- 4. In *Populus* or *Picea* forest *T. frondosae*
- Key C.** Cap smooth, grayish, olivaceous or greenish
- 1. Odor farinaceous or slightly rancid *T. sudum*
- 1. Odor unscented soap-like *T. saponaceum*
- Key D.** Cap densely fibrillose, scaly or felty, gray to black
- 1. Clamp connection present 2

1. Clamp connection absent 3
2. Cap dark gray scaly and showing strong contrast with whitish, silky fibrillose background, spore length $>8.5 \mu\text{m}$ *T. pardinum*
2. Cap radially fibrillose, gray to olivaceous buff and coarsely scaly when old with little contrast of scales and background, spore length $<8.5 \mu\text{m}$ *T. filamentosum*
3. Cap viscid and sticky, or greasy when wet, radially or longitudinally rillose 4
3. Cap dry, felty, squamulose or scaly 5
4. In *Quercus* forest; cap blackish-gray, purple violet or anthracite and generally with black dots at margin *T. rufenum*
4. In conifer forest; cap grayish and without black dots at the *T. portentosum*
5. Odor distinctly farinaceous; gills yellowing with age; spores averagely $<6 \mu\text{m}$ long *T. scalpturatum*
5. Odor indistinct or spicy; gills not yellowing or reddening or bluish; spores averagely $>6 \mu\text{m}$ long 6
6. Odor indistinct; gills and flesh color not changing; cap surface fibrillose to elty 7
6. Odor spicy; gills and flesh color reddening or bluish; cap surface distinctly fibrillose or scaly, rarely felty 9
7. Stipe white to grayish; Q value <1.75 *T. terreum*
7. Stipe gray to blackish fibrillose; Q value >1.75 8
8. Cap edge distinctly woolly white *T. triste*
8. Cap edge not woolly white *T. bonii*
9. Stipe white and shiny with black fibrils; odor sweetish or honey-like 10
9. Stipe whitish to gray with dark fibrils or scales; odor spicy 11
10. Stipe base grayish blue when cut or bruised; basal mycelium sulfur yellow *T. orirubens*
10. Stipe color not changing; basal mycelium white *T. atosquamosum*
11. Cap tomentose to squarroluse, dark grayish brown to almost black at center, margin white woolly *T. squarrolusum*
11. Cap felty at first, later distinct fuscous to black recurved scales on pale cream to buff background, margin smooth or felty, but not woolly *T. basirubens*
- Key E.** Cap smooth, fibrillose or rarely scaly, cream, red to reddish brown
1. Stem with membranous annulus or pseudoannular zone *T. batschii*
1. Stem without annular zone, but sometimes with a clearly white delimited zone at apex 2
2. Cap cream to pale cinnamon buff *T. acerbum*
2. Cap reddish brown to dark brown 3
3. Cap felty to scaly or suede-like *T. imbricatum*
3. Cap smooth or fibrillose 4
4. In deciduous forests 5
4. In coniferous forests 7
5. With *Populus* *T. populinum*
5. With other deciduous trees 6
6. Cap margin lobed or ribbed; stipe without sharply delimited white zone at the top *T. quercetorum*
6. Cap margin not lobed or ribbed; stipe with sharply delimited white zone at the top *T. ustaloides*
7. Cap radially fibrillose; stem with clearly delimited white zone at apex *T. albo brunneum*
7. Cap not radially fibrillose; stem without white zone at the top 8
8. With *Cedrus* *T. cedretorum*
8. With *Pinus*, rarely with *Picea* and *Abies* 9
9. Cap usually with drop-like spots and margin not ribbed *T. pessundatum*
9. Cap without drop-like spots and margin ribbed *T. stans*

3. Discussion

Turkey has suitable ecological conditions to enable macrofungi biodiversity and more than 2200 macrofungi species have been reported (Sesli and Denchev, 2008; Doğan and Kurt, 2016; Taşkın et al., 2016; Allı et al., 2017; Akata et al., 2018; Doğan et al., 2018; Sesli and Liimatainen, 2018). Among the rich macrofungi biodiversity, 54 *Tricholoma* taxa (except for *T. ilkkæ*) were reported from Turkey to date and 14 of them are distributed in the Aegean region (Sesli and Denchev, 2008; Şen et al., 2018). In this study, we reported 31 *Tricholoma* taxa from the study area. The numbers of the taxa are significantly increased when compared to older literature. This rise might be due to the lack of direct studies on *Tricholoma* taxonomy in Turkey until today. Also, 5 taxa (*T. filamentosum*, *T. frondosae*, *T. quercetorum*, *T. rufenum*, and *T. sudum*) are reported as new records for Turkish Mycota with this study and the number of *Tricholoma* taxa distributed in Turkey is updated to comprise 59 taxa.

Although 14 *Tricholoma* taxa were reported from the study area in older literature (Sesli and Denchev, 2008), we could not find 4 of them: *T. argyraceum* (Bull.) Gillet, *T. arvernense* Bon, *T. sulphureum* (Bull.) P. Kumm., and *T. ustale* (Fr.) P. Kumm. These taxa were reported from the inner part of the study area and the weather during the study periods in the inner parts was colder than in previous years, and there was frost in the area where these taxa were found. Thus, it might be possible that unsuitable weather conditions affect these taxa.

In the study area, the most common species were *Tricholoma terreum* and *T. batschii* with 70 and 33 specimens, respectively. However, it has been seen that most of the other species revealed fewer than 10 samples and locations during the research periods. As was mentioned above, this study aims to create a background for determining *Tricholoma* species across the whole of

Turkey so that the IUCN criteria and conservation status of the genus in Turkey could be determined in the future.

Three national parks are located in the study area, and among them, Kazdağı National Park (also known as Ida Mountain) in the northern parts of the Aegean region is one of the richest areas for macrofungi biodiversity. Recently, the macrofungi biodiversity of Kazdağı National Park was published, and 9 *Tricholoma* (among 207 species) were reported (Altuntaş et al., 2017). Besides this, we collected four of the new records reported in this study (*T. filamentosum*, *T. frondosae*, *T. rufenum*, and *T. sudum*) from Kazdağı National Park.

Tricholoma filamentosum is characterized by radially fibrillose cap, coarsely scaly when old, with little contrast of scales and background, gray to olivaceous buff colored and abundant clamp connections (Christensen and Heilmann-Clausen, 2013). According to Kibby (2012), the scales and background contrast of this species is very distinct. The specimen reported in this study was old, and its scales and background contrast were somewhat distinct and darker at the center (Figure 2a). *Tricholoma filamentosum* and *T. pardinum* have similar morphological characters and it was first described as a variety of *T. pardinum* (Alessio, 1983), and then as a separate species (Alessio, 1988). Although *T. filamentosum* is associated with deciduous trees, especially *Quercus*, *Fagus*, and *Carpinus*, it was also reported under conifers by Kibby (2012). We collected *T. filamentosum* in mixed forest of *Quercus* and *Pinus nigra* from the entrance of Kazdağı National Park. Similarly, *T. pardinum* was collected from mixed forest of *Abies nordmanniana* subsp. *equi-trojani* and *Pinus nigra* in Kazdağı National Park. These specimens could easily be distinguished by different habitat and spore sizes.

Tricholoma frondosae is characterized by bright yellow to olivaceous, appressed squamulose cap, yellow gills, and farinaceous odor (Christensen and Heilmann-Clausen, 2013). This species belongs to a controversial group, the “*equestre*” complex, in the genus. In this complex, *T. equestre* and its allies (these species have relatively yellow fruiting body and mild farinaceous taste) have been discussed for a long time by several researchers. Recently, Kalamees (2001) evaluated the specimens collected from Nordic countries morphologically and ecologically, and it was reported that this complex is distinguished as three different taxa: *T. equestre*, *T. frondosae*, and *T. ulvinenii* Kalamees. Beside this, *T. flavovirens* (Pers.) S. Lundell and *T. auratum* Gillet were reported as synonyms of *T. equestre*. To date, only *T. equestre* (including *T. auratum* and *T. flavovirens*) has been reported in Turkey (Sesli and Denchev, 2008).

Tricholoma frondosae differs from *T. equestre* by yellow to olivaceous colors, distinctive squamulose pileus, and different ecological properties. Although *T. equestre* is

associated with *Pinus* forests, *T. frondosae* prefers *Picea*, *Populus*, and possibly *Abies* forests (Christensen and Heilmann-Clausen, 2013). We found *T. frondosae* in *Abies nordmanniana* subsp. *equi-trojani* (this is an endemic species of Turkey and is known as Kazdağı fir), *Pinus nigra*, and *Populus* mixed forest. Thus, *T. frondosae* is distinguished from *T. equestre* by its different ecological and morphological differences.

Tricholoma rufenum is characterized by anthracite, greasy cap in wet conditions and dark spots on the cap. This South European species has much closer morphological characters with *T. portentosum* and differs in cap features and broader spores. Additionally, they grow in different habitats. In this study, we collected *T. portentosum* and *T. rufenum* in the different habitat of Kazdağı National Park. *Tricholoma rufenum* was observed in *Quercus* and *Pinus nigra* mixed forest, and distinct cap morphology helped to distinguish it from *T. portentosum*. Also, *T. portentosum* was collected from *A. nordmanniana* subsp. *equi-trojani* and *P. nigra* mixed forest.

Another new record collected from Kazdağı National Park is *Tricholoma sudum*, and we also collected this species from a different location of the study area (Loc. 8b1). This species belongs to section *Contexticutis*. Four members of the section have been reported recently (Heilmann-Clausen et al., 2017) and they are easily distinguished from other *Tricholoma* species by abundant clamp connections, olive colors, and meaty taste. Although the members of this section are easily identified in the field, more than 10 varieties of *T. saponaceum* have been described by several researchers because of its variable morphological characters (Riva, 1988; Riva, 2003; Galli, 2005; Kibby, 2012). Recently, *Tricholoma sudum* and *T. boudieri* Barla are considered as separate species (Christensen and Heilmann-Clausen, 2013; Heilmann-Clausen et al., 2017). *Tricholoma sudum* differs from *T. saponaceum* by its farinaceous odor, olive green color, and larger spores. Also, *Tricholoma sudum* grows in conifers while *T. saponaceum* and *T. boudieri* are associated with deciduous trees (Heilmann-Clausen et al., 2017). We collected some specimens belonging to this section. The odors of two of them are farinaceous and matched with *T. sudum*, and it has been recorded for the first time in Turkey.

Tricholoma quercetorum was collected from the Yörükmezari village of Afyonkarahisar (Loc. 1c3) in the inner part of the research area. *Tricholoma quercetorum* is characterized by reddish brown to chestnut brown basidiocarp, ribbed pileus margin, and association with *Quercus* (Contu, 2003). *Tricholoma quercetorum* differs from *T. ustale* by narrower spores, ribbed pileus margin and sulfur yellow tinges towards stipe base (Christensen and Heilmann-Clausen, 2013). Another species similar to *T. quercetorum* is *T. ustaloides* and this species was also

collected in this study. *Tricholoma ustaloides* grows in the same habitat as *T. quercetorum* and is distinguished by the lack of a ribbed cap margin, sharply delimited white zone at the stipe, and bitter taste of the pileipellis (Christensen and Heilmann-Clausen, 2013). In Turkey, most of the forests comprise different kinds of trees, which make them mixed forests. In particular, *Quercus coccifera* grows in *Pinus* forests of the Mediterranean basin. Thus, these species might be confused in these forests.

In this study, we have tried to create a general perspective on the Turkish *Tricholoma*. It is shown that the biodiversity of the genus *Tricholoma* in the Aegean

region of Turkey is relatively abundant. The biodiversity of the genus *Tricholoma* distributed throughout the whole of Turkey might be determined and reported in the future. Moreover, the identification key of the determined species will help in future studies to compare European and Turkish species.

Acknowledgment

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