

New records of some Ascomycete truffle fungi from Turkey

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Abstract: We report the first records of 6 Ascomycete truffle taxa in Turkey: *Genea verrucosa* Vittad., *Genea klotzschii* Berk. & Broome, *Stephensia bombycina* (Vittad.) Tul. & C.Tul., *Terfezia olbiensis* Tul. & C.Tul., *Tuber excavatum* Vittad., and *Tuber rufum* Pico. We also report new localities within Turkey for *Picoa juniperi* Vittad., *Terfezia leptoderma* Tul. & C.Tul., *Choiromyces meandriformis* Vittad., *Tuber brumale* Vittad., *Tuber nitidum* Vittad., and *Tuber mesentericum* Vittad.

Key words: Truffle, hypogeous fungi, Ascomycota, Pyronemataceae, Terfeziaceae, Tuberaceae

1. Introduction

Most truffle fungi form an ectomycorrhizal association with various trees and shrubs. Many truffle species form this ectomycorrhizal association with specific tree genera. The positioning of Turkey at the convergence of the European flora and the Asian flora predicates a high potential for interesting ectomycorrhizal fungal partners. Little is known about the truffle diversity in Turkey. To date, only 17 Ascomycete truffle species have been reported from Turkey: *Choiromyces meandriformis* Vittad., *Geopora arenicola* (Lév.), *G. arenosa* (Fuckel) S.Ahmad, *G. cooperi* Harkn., *G. sumneriana* (Cooke) M.Torre, *Picoa juniperi* Vittad., *P. lefebvrei* (Pat.) Maire, *Sarcosphaera eximia* (Durieu & Lév.) Maire, *Terfezia arenaria* (Moris) Trappe, *T. boudieri* Chatin, *T. leptoderma* Tul., *Tirmania pinoyi* (Maire) Malençon, *Tuber aestivum* Vittad., *T. borchii* Vittad., *T. brumale* Vittad., *T. mesentericum* Vittad., and *T. nitidum* Vittad. (İşiloğlu and Öder, 1995; Afyon, 1996; Öztürk et al., 1997; Solak et al., 1999; Doğan and Öztürk, 2006; Solak et al., 2007; Kaya, 2009; Gücin et al., 2010; Castellano and Türkoğlu, 2012; Sesli and Denchev, 2012; Güngör et al., 2013; Türkoğlu and Castellano, 2013).

During our recent efforts to identify and catalogue all truffle species from Turkey, we examined all truffle collections known from the country. Here we present 6 Ascomycete truffle taxa identified as new records for Turkey. In addition, we present new localities for the previously reported *Choiromyces meandriformis*, *Picoa juniperi*, *Terfezia leptoderma*, *Tuber brumale*, *Tuber nitidum*, and *Tuber mesentericum*.

2. Materials and methods

Field work was restricted to the Muğla, Antalya, Burdur, Osmaniye, Denizli, Uşak, Samsun, Kastamonu, Bolu, Nevşehir, Konya, and Elazığ provinces in Turkey. These provinces are in the Aegean, the Mediterranean, the Black Sea, the Central Anatolia, and the East Anatolia regions. Some of the specimens were found with the help of a truffle dog, but most truffle specimens were discovered by raking in appropriate habitats. Macromorphological characteristics (size, fresh colour, bruising reactions, and odour) of specimens were recorded, after which each was photographed. Micromorphological characters were recorded from tissue sections rehydrated in water, 3% KOH, or Melzer's reagent. Spores and sterile tissues were photographed using a light microscope. Each collection was split and a representative specimen was deposited in the herbaria of Muğla Sıtkı Koçman University and the herbarium of Oregon State University.

3. Results

In our study, 12 taxa belonging to 4 families were identified. Brief descriptions of new records are presented along with geographic and phenological information. Author names are given according to Kirk et al. (2008) and fungal names according to Index Fungorum and MycoBank.

3.1. Helvellaceae Fries

3.1.1. *Picoa juniperi* Vittad

Ascocarp 1–3 cm broad, globose to subglobose; surface blackish or blackish brown, covered regularly with obtuse

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or flat warts (Figure 1a). Gleba off-white to pale yellow, marbled with irregular, pale yellowish veins. Peridium 350–450 μm thick, off-white to yellowish brown, of angular cells 25–50 $\times$ 20–25 μm with walls 2 μm thick, surface cells reddish yellow, pigmented cells with walls up to 7 μm thick, sometimes with emergent, septate hairs 25–100 $\times$ 3.5–6.5 μm (Figure 1b). Gleba of hyaline, parallel hyphae 4.5–5.5 μm broad with walls $\pm$ 1 μm thick. Asci randomly dispersed in the gleba, 120 $\times$ 80 μm , subglobose with a stem of up to 100 μm long, the walls $\pm$ 1 μm thick, 8-spored (Figure 1c). Ascospores 20–27 $\times$ 20–22 μm , mean = 24.3 $\times$ 21.6 μm , with walls $\pm$ 1 μm thick, broadly ellipsoid, hyaline and smooth at first, pale yellowish to pale green and minutely verrucose when mature (Figure 1d).

Specimens examined: Uşak (Türkoğlu and Yağız, 2012); Denizli: Bozkurt, İnceler, 24 April 2009, *Türkoğlu* AT-1175; Denizli: Bozkurt, İnceler, 10 July 2010, *Türkoğlu* AT-1282; Nevşehir: Gülşehir, 15 May 2011, *Türkoğlu* AT-1419; Konya: Çumra, 29 March 2013, *Türkoğlu* AT-1901; Elazığ: Baskil, Karakaş village, 13 April 2013, *Nihat GÜLDAŞ* AT-1962; Afyon: Evciler, Borçka village, 19 April 2013, *Mehmet Cirit* AT-1999; Konya: Ereğli, 24 April 2013, *Türkoğlu* AT-2037; Antalya: Korkuteli, 26 April 2013, *Mustafa Turunçoğlu* AT-2042; Denizli: Bozkurt, 14 May 2013, *Türkoğlu* AT-2105; Elazığ: Baskil, Karakaş village, 3 June 2013, *Nihat GÜLDAŞ* AT-2116.

3.2. Pyronemataceae Corda

3.2.1. *Genea verrucosa* Vittad.

Syn.: *Genea papillosa* Berk.

Ascocarp 5–10 mm broad, very irregular in form; surface dark brown to black, with pyramidal warts (Figure 2a). Gleba with a single, much folded, convoluted, glebal chamber opening to the outside, and with irregular short ridges intruding into the chamber, lined with black warts and glabrous epithecium similar to the ascocarp surface. Peridium 200–250 μm thick with 3 layers: outer layer 40–90 μm thick, of dark reddish brown, angular cells, 35–90 $\times$ 20–30 μm , with walls 6–11 μm thick; middle layer 110–180 μm thick, hyaline, of hyaline, angular cells, 15–30 $\times$ 5–20 μm , with walls 2 μm thick; inner layer 40–70 μm thick, of hyaline, interwoven hyphae, 4.5–6.5 μm broad, with walls 2 μm thick; epithecium structure similar to that of the peridium (Figure 2b). Asci in a hymenial palisade embedded under the epithecium, (170–)190–225 $\times$ 26–30 μm , cylindrical, broadly rounded at the apex, abruptly narrowed at the base as a short stalk, with walls 2 μm thick, 8-spored (Figure 2c). Ascospores 21–26(–28) $\times$ 19–22 μm , mean = 23.3 $\times$ 20 μm , excluding ornamentation, broadly ellipsoid, hyaline at first, pale yellow when mature, ornamented with irregular, conical warts, 2 μm tall $\times$ 1.5–4.5 μm wide (Figure 2c). Paraphyses hyaline, cylindrical, guttulate, 2–7 μm broad, with walls $\pm$ 0.5 μm thick (Figure 2d).

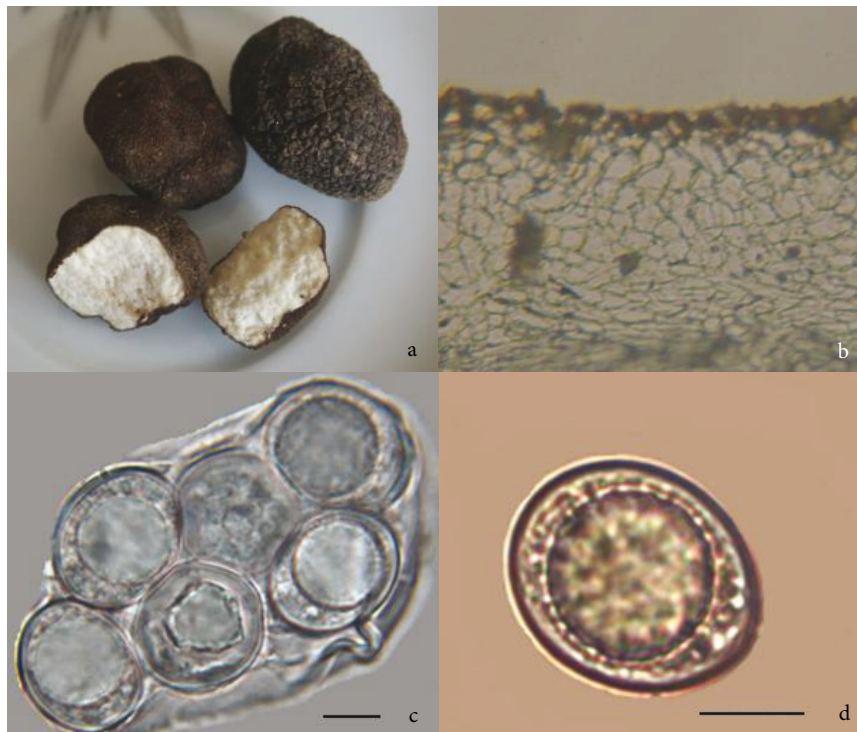


Figure 1. Macroscopic and microscopic appearance of *Picoa juniperi*: a- ascocarp, b- peridium, c- ascus, d- ascospore. Scale bars: c and d =10 μm .

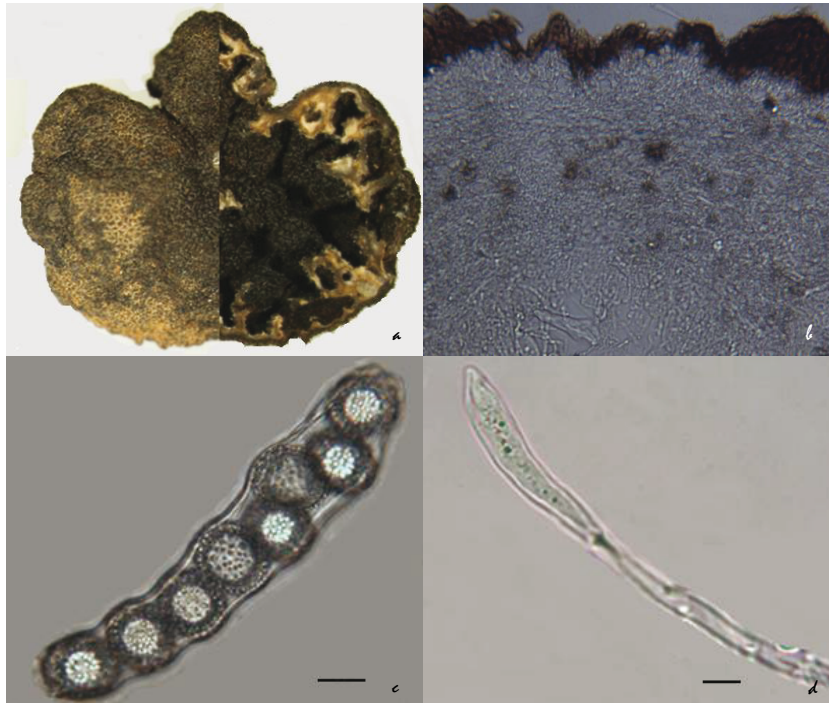


Figure 2. Macroscopic and microscopic appearance of *Genea verrucosa*: a- ascocarp, b- peridium, c-ascus and ascospores, d- paraphysis. Scale bars: c and d = 10 μ m.

Specimen examined: Muğla: Fethiye, Gökben village, in calcareous soils under *Quercus pubescens*, 29 April 2012, *Türkoğlu* AT-1429.

3.2.2. *Genea klotzschii* Berk. & Broome

Syn.: *Genea verrucosa* Klotzsch

Ascocarp 0.4–0.8 mm broad, globose to subglobose, surface blackish brown, with pyramidal warts (Figure 3a). Gleba with a simple, infolded chamber opening to the outside, lined with a black epithecium similar to the ascocarp surface. Peridium 220–250 μ m thick with 3 layers: outer layer 40–60 μ m thick, dark reddish brown, of angular cells, 30–70 $\times$ 20–30 μ m, with walls of up to 9 μ m thick; middle layer 90–120 μ m thick, of hyaline, angular cells, 20–30 $\times$ 5–20 μ m, with walls 2 μ m thick; inner layer 90–100 μ m thick, of hyaline, interwoven hyphae, 2.5–9 μ m broad, with walls $\pm$ 0.5 μ m thick, with scattered inflated cells, 10–20 $\times$ 5–10 μ m (Figure 3b); epithecium structure similar to that of the peridium. Asci in a hymenial palisade embedded under the epithecium, (180–)210–260 $\times$ 22–25 μ m, hyaline, cylindrical, broadly rounded at the apex, abruptly narrowed at the base as a short stalk, with walls 2 μ m thick, 8-spored (Figure 3c). Ascospores 24–26(–30) $\times$ (15–)18–22 μ m, mean = 25.7 $\times$ 18.7 μ m, excluding ornamentation, ellipsoid, hyaline at first, pale yellow when mature, ornamented with irregular, generally flask-shaped or sometimes forked or cone-shaped warts, 3.5–4.5 $\times$ 2.5–3.5 μ m, with many scattered smaller, irregular warts

1–2 μ m broad (Figure 3c). Paraphyses hyaline, cylindrical, guttulate, 2–7 μ m broad, with walls $\pm$ 0.5 μ m thick (Figure 3d).

Specimen examined: Samsun: Çarşamba, under *Corylus* sp., 24 November 2010, *Türkoğlu* AT-1406.

3.2.3. *Stephensia bombycina* (Vittad.) Tul. & C.Tul.

Syn.: *Genea bombycina* Vittad.

Ascocarp 8–10 cm broad, subglobose to irregular with a basal opening, surface pale brown to reddish brown (Figure 4a). Gleba off-white at first, with yellowish veins when mature. Peridium 750–900 μ m thick with 2 layers: outer layer 260–350 μ m thick, of hyaline to pale brown, angular, sometimes elongated cells, 20–40 $\times$ 10–20 μ m, with walls 2 μ m thick, but the outermost hyphae darker reddish brown, 8–9 μ m broad, with walls 2 μ m thick, sometimes with emergent, branched, and septate hairs; inner layer 300–400 μ m thick, of hyaline, interwoven to parallel hyphae, 8.5–10.5 μ m broad, with walls $\pm$ 1 μ m thick (Figure 4b). Gleba of hyaline, interwoven hyphae 6–7 μ m broad with walls $\pm$ 1 μ m thick. Asci in a hymenial palisade in the glebal veins, 180–240 $\times$ 22–26 μ m, cylindrical-clavate, rounded at the apex, narrowed at the base, with walls $\pm$ 2 μ m thick, 8-spored (Figure 4c). Ascospores 22–26 $\times$ 21–26 μ m, mean = 24.3 $\times$ 23.7 μ m, smooth, globose, hyaline, slightly yellowish contents, walls $\pm$ 1 μ m thick (Figure 4d).

Specimen examined: Samsun: Çarşamba, under *Corylus* sp., 24 November 2010, *Türkoğlu* AT-1404.

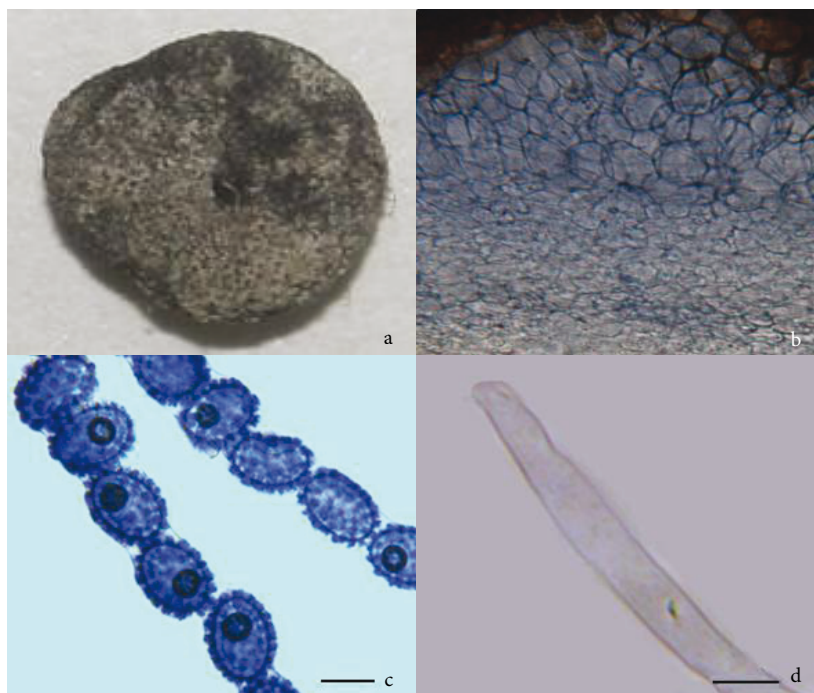


Figure 3. Macroscopic and microscopic appearance of *Genea klotzschii*: a- ascocarp, b- peridium, c- ascus and ascospores, d- paraphysis. Scale bars: c and d = 10 μ m.

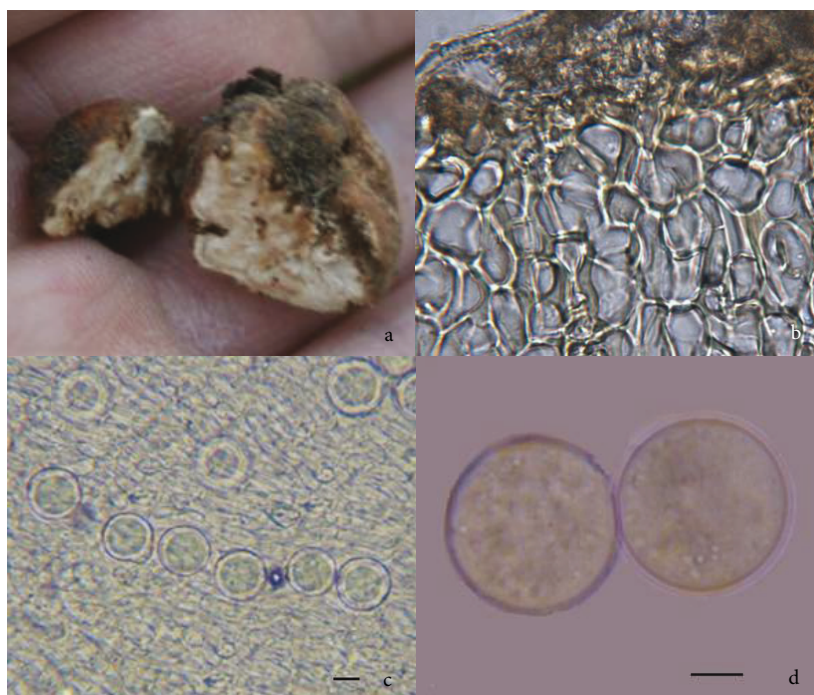


Figure 4. Macroscopic and microscopic appearance of *Stephensia bombycina*: a- ascocarp, b- peridium, c- ascus, d- ascospores. Scale bars: c and d = 10 μ m.

3.3. *Pezizaceae* Dumort.

3.3.1. *Terfezia leptoderma* Tulasne & C.Tulasne

Ascocarps 2–4 cm broad, globose to subglobose; surface off-white then rose-lilac, yellowish and finally yellowish

brown (Figure 5a). Gleba greyish at first, becoming rosy and bruising lilac when exposed to air, grey-green to olive-green with age, with very broad, off-white sterile veins. Peridium 220–600 μ m thick, separable, greyish or

olive-green to pale yellow with a narrow brown zone at the surface; of angular cells, sometimes with inflated cells, $35\text{--}90 \times 20\text{--}45\text{ }\mu\text{m}$ broad, with walls up to $\pm 4\text{ }\mu\text{m}$ thick (Figure 5b). Gleba of hyaline, interwoven to parallel hyphae, $9\text{--}11\text{ }\mu\text{m}$ broad, with walls $\pm 1\text{ }\mu\text{m}$ thick. Asci randomly dispersed in the gleba, $70\text{--}90 \times 65\text{--}80\text{ }\mu\text{m}$, subglobose to ellipsoid, with walls $\pm 2\text{ }\mu\text{m}$ thick, 8-spored (Figure 5c). Ascospores $17\text{--}21 \times 17\text{--}21\text{ }\mu\text{m}$, mean = $18.9 \times 18.7\text{ }\mu\text{m}$, excluding ornamentation, globose, ornamentation of subcylindrical, truncate to round-tipped spines, $1.8\text{--}2.6\text{ }\mu\text{m}$ thick at the base and $3.5\text{--}4.5\text{ }\mu\text{m}$ tall, yellowish brown but spore wall darker brown than spines (Figure 5d).

Specimens examined: Uşak (Castellano and Türkoğlu, 2012). Denizli: Bozkurt, 29 April 2012, *Türkoğlu* AT-1430; Uşak: Eşme, 28 April 2013, *Türkoğlu* AT-2100.

3.3.2. *Terfezia olbiensis* Tulasne & C.Tulasne

Ascocarps $2\text{--}4\text{ cm}$ broad, globose to subglobose; surface off-white to pale rose at first, later reddish brown and much wrinkled when mature (Figure 6a). Gleba grey-rose at first, later grey-green to olive-green with sterile veins. Peridium $420\text{--}600\text{ }\mu\text{m}$ thick, separable, greyish or olive-green to pale yellow with a narrow, brown zone at the surface; of angular cells, sometimes with inflated cells $40\text{--}130 \times 25\text{--}60\text{ }\mu\text{m}$ broad, with walls $\pm 1\text{ }\mu\text{m}$ thick (Figure 6b). Gleba of hyaline, interwoven to parallel hyphae, $9\text{--}11\text{ }\mu\text{m}$ broad, with walls $\pm 1\text{ }\mu\text{m}$ thick. Asci randomly dispersed in the gleba, $60\text{--}90 \times 60\text{--}80\text{ }\mu\text{m}$, subglobose to ellipsoid,

with walls $\pm 2\text{ }\mu\text{m}$ thick, 8-spored (Figure 6c). Ascospores (Figure 6c) $15\text{--}19 \times 15\text{--}18\text{ }\mu\text{m}$, mean = $17.3\text{--}16.8\text{ }\mu\text{m}$, excluding ornamentation, globose, ornamentation with narrow to broad, truncate cones, $2.5\text{--}3.5\text{ }\mu\text{m}$ thick at base and $2.6\text{--}4.3\text{ }\mu\text{m}$ tall, yellowish brown (Figure 6d).

Specimens examined: Uşak: Eşme, 24 April 2009, *Türkoğlu* AT-1117; Uşak: Eşme, 4 April 2013, *Türkoğlu* AT-1905; Konya: Akşehir, 24 April 2013, *Türkoğlu* AT-2005; Nevşehir: Gülşehir, 26 April 2013, *Türkoğlu* AT-2089; Uşak: Eşme, 28 April 2013, *Türkoğlu* AT-2097.

3.4. *Tuberaceae* Dumort.

3.4.1. *Choiromyces meandriformis* Vittad.

Ascocarp $2\text{--}8\text{ cm}$ broad, subglobose to irregular, sometimes lobed; surface pale yellow to yellowish brown, much wrinkled when dried (Figure 7a). Gleba off-white to pale yellow, marbled with irregular, greyish to yellowish veins. Peridium $500\text{--}600\text{ }\mu\text{m}$ thick with 2 layers: outer layer $50\text{--}100\text{ }\mu\text{m}$ thick, yellowish brown to reddish yellowish brown, of parallel hyphae, $4\text{--}7\text{ }\mu\text{m}$ broad, with walls $1\text{ }\mu\text{m}$ thick; inner layer $500\text{--}550\text{ }\mu\text{m}$ thick, pale yellowish to brownish, of angular cells, sometimes inflated to $30\text{--}70 \times 20\text{--}30\text{ }\mu\text{m}$, with walls $2\text{ }\mu\text{m}$ thick, with scattered parallel hyphae, $9.5\text{--}13\text{ }\mu\text{m}$ broad, with walls $2\text{ }\mu\text{m}$ thick (Figure 7b). Gleba of hyaline, interwoven hyphae, $9\text{--}13\text{ }\mu\text{m}$ broad, with walls $\pm 2\text{ }\mu\text{m}$ thick. Asci $70\text{--}120 \times 45\text{--}80\text{ }\mu\text{m}$, clavate to saccate, with walls $\pm 2\text{ }\mu\text{m}$ thick, 8-spored. (Figure 7c). Ascospores $15\text{--}18 \times 15\text{--}18\text{ }\mu\text{m}$, mean = 14.6×14.6

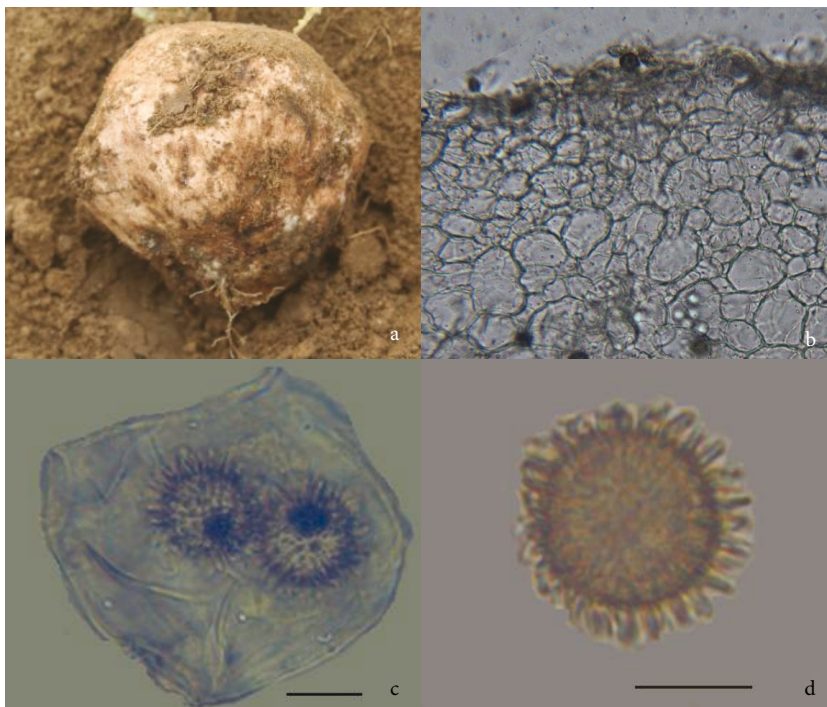


Figure 5. Macroscopic and microscopic appearance of *Terfezia leptoderma*: a- ascocarp, b- peridium, c- ascus, d- ascospores. Scale bars: c and d = $10\text{ }\mu\text{m}$.

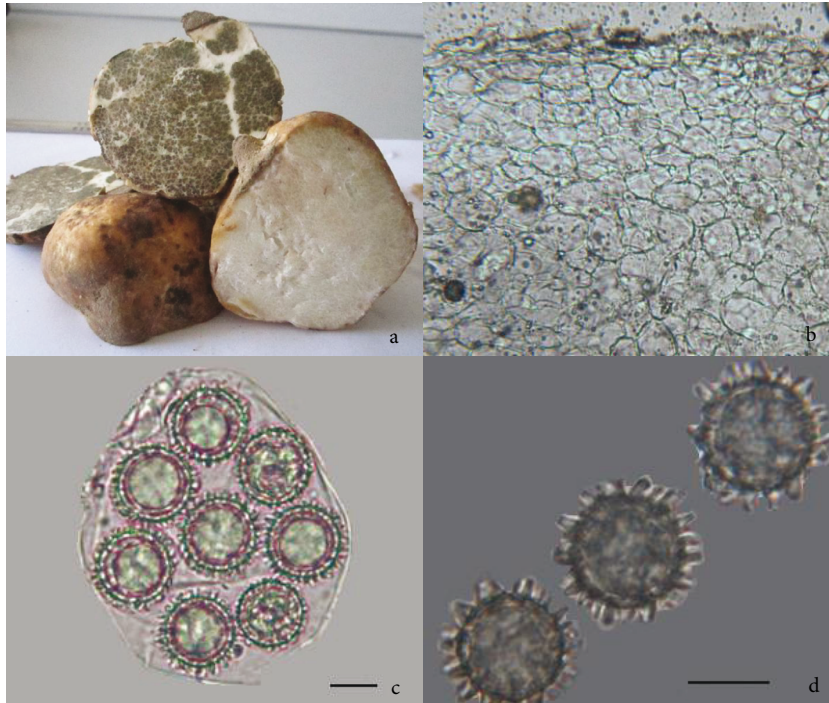


Figure 6. Macroscopic and microscopic appearance of *Terfezia olbiensis*: a- ascocarp, b- peridium, c- ascus, d- ascospores. Scale bars: c and d = 10 μ m.

μ m, excluding ornamentation, globose, pale yellowish to yellowish brown, ornamentation of cylindrical rods, with indented tips, $\pm 2 \mu$ m thick at the base and 3.5–4.5 μ m tall (Figure 7d).

Specimens examined: İzmir (Solak et al., 1999); Uşak: Eşme, 18 April 2009, *Türkoğlu* AT-1087; Bolu: 9 September 2012, *Türkoğlu* AT-1438; Samsun: Çarşamba, 13 November 2012, *Türkoğlu* AT-1613.

3.4.2. *Tuber brumale* Vittad.

Ascocarps 3–5 cm broad, subglobose or irregular, often with slight depressions, surface blackish brown to black with angular, pyramidal to irregularly polygonal or somewhat hexagonal warts, 1–2 mm broad that are depressed at the centre and usually with tiny grooves radiating from the centre (Figure 8a). Gleba initially off-white to grey, later bluish grey, then blackish brown when mature, marbled with off-white veins. Peridium 220–330 μ m thick, with 3 layers: outer layer 20–60 μ m thick, reddish yellow to deep reddish brown, of hyaline, inflated, irregular cells, 20–35 $\times$ 10–15 μ m, with walls $\pm 2 \mu$ m thick; middle layer 90–130 μ m thick, off-white to yellowish brown, of hyaline, inflated irregular cells, 10–35 $\times$ 5–10 μ m, with walls $\pm 2 \mu$ m thick; inner layer off-white to yellowish brown, of hyaline, interwoven hyphae, 3.5–4.5 μ m broad, with walls $\pm 2 \mu$ m thick (Figure 8b). Gleba of hyaline, interwoven hyphae, 4.5–6 μ m broad, with walls $\pm 1 \mu$ m thick. Asci (60–)90–130 $\times$ (35–)50–110 μ m, broadly ellipsoid to sometimes subglobose, sessile, with walls $\pm 2 \mu$ m thick, 1–4-spored

(Figure 8c). Ascospores (19–)22–31(–36) $\times$ 15–19(–21) μ m, mean = 26.0 $\times$ 16.8 μ m, excluding ornamentation, in 1-spored asci 26–31 $\times$ 15–18 μ m, 2-spored 23–27 $\times$ 15–21 μ m, 3-spored 19–26 $\times$ 13–18 μ m, 4-spored 24–28 $\times$ 16–19 μ m, ellipsoid, yellowish-brown, ornamented with cyanophilic, acutely pointed, spines 6.2–7.0 μ m tall (Figure 8d).

Specimens examined: Niğde (Öztürk, 1997); Samsun: Çarşamba, under *Corylus* sp., 24 November 2010, *Türkoğlu* AT-1361; Samsun: Çarşamba, under *Corylus* sp., 25 October 2012, *Türkoğlu* AT-1439; Samsun: Çarşamba, Uluköy, under *Corylus* sp., 25 October 2012, *Türkoğlu* AT-1507; Samsun: Çarşamba, Köklü village, under *Corylus* sp., 13 November 2012, *Türkoğlu* AT-1614; Osmaniye: Zorkun plateau, under *Pinus brutia*, 23 January 2013, *Türkoğlu* AT-1874.

3.4.3. *Tuber excavatum* Vittad.

Ascocarp 1–2 cm broad, globose to subglobose or irregular, with a distinct cavity; surface finely papillate to somewhat coarsely warted, pale yellowish brown to yellowish brown at first, reddish brown when mature (Figure 9a). Gleba off-white to pale yellow at first, later yellowish brown to deep yellowish brown, finally reddish brown, marbled with off-white to pale yellow veins originating from the base of the cavity and branching towards the ascocarp surface. Peridium 260–320 μ m thick, off-white to pale yellow with 2 layers: outer layer of inflated, irregular cells, 10–15 $\times$

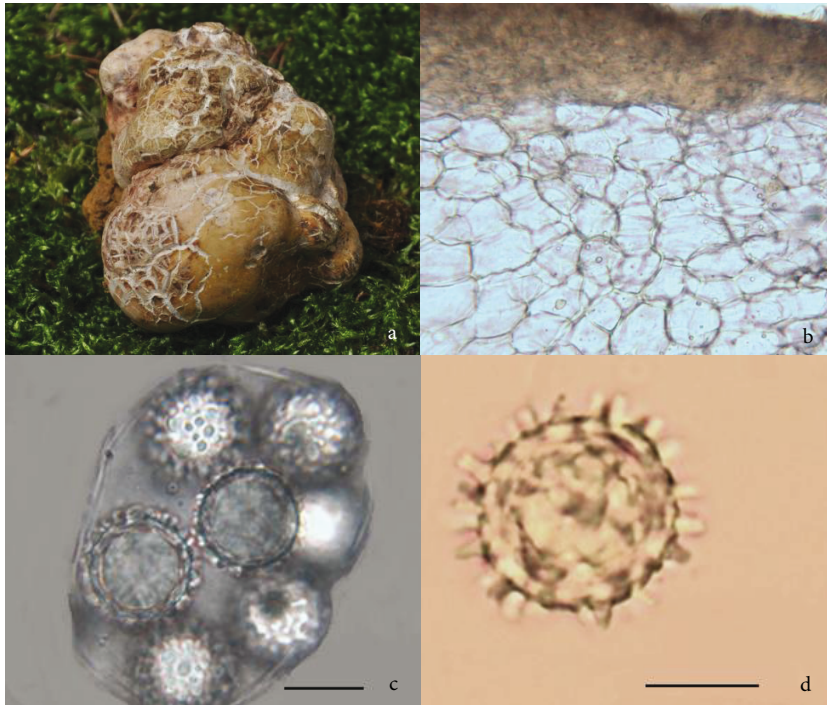


Figure 7. Macroscopic and microscopic appearance of *Choiromyces meandriformis*: a- ascocarp, b- peridium, c- ascus, d- ascospore. Scale bars: c and d = 10 μ m.

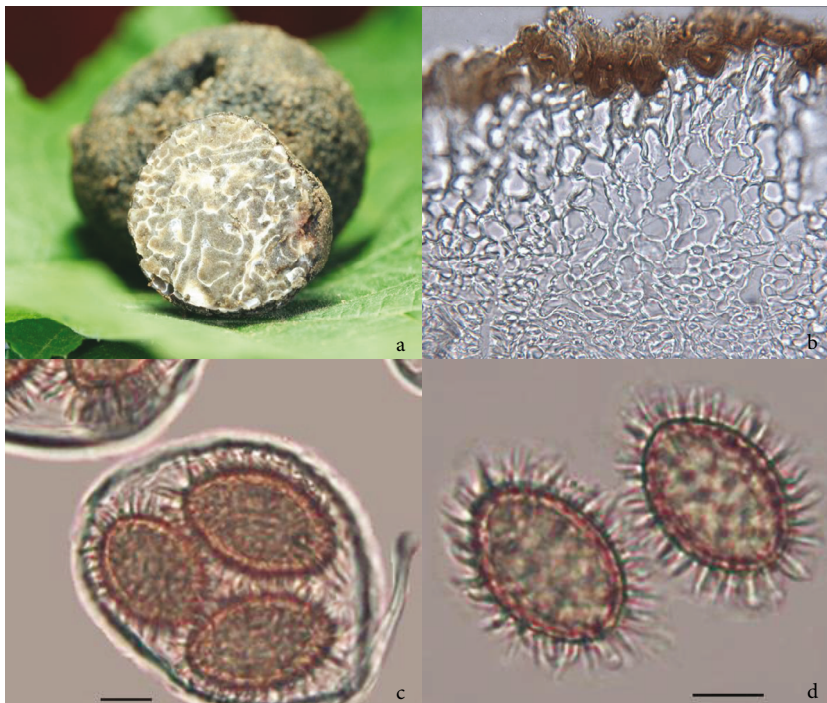


Figure 8. Macroscopic and microscopic appearance of *Tuber brumale*: a- ascocarp, b- peridium, c- ascus, d- ascospores. Scale bars: c and d = 10 μ m.

5–10 μ m, with walls ± 2 μ m thick; inner layer of hyaline, interwoven hyphae, 2.5–3.5 μ m broad, with walls ± 2 μ m thick (Figure 9b). Gleba of hyaline, interwoven hyphae,

3.5–5 μ m broad, with walls ± 1 μ m thick. Asci 60–100 $\times$ 40–75 μ m, subglobose to ellipsoid, short-stalked, with walls 2–4 μ m thick, 1–4-spored (Figure 9c). Ascospores

(25–)30–46 × (20–)22–33(–44) μm , mean = 32.1 × 28.4 μm , excluding ornamentation, in 1-spored asci 44–48 × 38–42 μm , 2-spored 31–35 × 31–33 μm , 3-spored 31–32 × 31–33 μm , 4-spored 26–29 × 21–26 μm , ellipsoid, yellowish-brown, ornamented with a regular reticulum, 3.5–7.0 μm tall with 3–4 meshes across the spore (Figure 9d).

Specimen examined: Denizli: Bozkurt, İnceler, under mixed *Quercus* spp. and *Pinus* spp., 15 June 2012, *Niyazi Uluçoban* AT-1436.

3.4.4. *Tuber nitidum* Vittad.

Ascocarp 1–3 cm broad, globose to subglobose, the surface generally glabrous even at maturity, somewhat coarsely warted, off-white to pale yellow, rarely with reddish yellow patches (Figure 10a). Gleba white at first, later off-white to pale yellow, marbled with distinct, broad white veins. Peridium 250–550 μm thick with 2 layers: outer layer 50–60 μm thick, pale yellow, of isodiametric to irregular, pigmented cells, 10–20 × 4–10 μm , with walls ± 2 μm thick; inner layer 200–500 μm thick, off-white to grey, of hyaline, interwoven to parallel hyphae, 3.5–5.5 μm broad, with walls ± 2 μm thick (Figure 10b). Gleba of hyaline, parallel hyphae, 5.5–7 μm broad, with some inflated cells, 10–20 × 5–10 μm , with walls ± 1 μm thick. Asci 70–100 × 40–60 μm excluding stalk, broadly clavate, stalk up to 26 μm long, the walls ± 2 μm thick, 1–4-spored (Figure 10c). Ascospores 21–33(–39) × (13–)16–27(–29) μm , mean = 28.5 × 21. μm ,

excluding ornamentation, in 1-spored asci 30–39 × 26–27 μm , 2-spored (26–)31–32 × 18–22(–29) μm , 3-spored 21–27 × 18–22 μm , 4-spored 22–26 × (13–)16–18 μm , ellipsoid, yellowish brown to reddish brown, ornamented with pointed spines 3.5–4.5 μm tall (Figure 10d).

Specimens examined: Denizli (Castellano and Türkoğlu, 2012); Osmaniye: Zorkun plateau, under mixed *Quercus* spp. and *Pinus* spp., 12 April 2012, *Türkoğlu* AT-1428;

Kastamonu: Küre, Yarılgöz district, under *Abies nordmanniana* and *Pinus sylvestris*, 26 May 2013, *Michael Castellano* 36244; Osmaniye: Zorkun plateau, under mixed *Quercus* spp. and *Pinus* spp., 31 May 2013, *Michael Castellano* and *Fatih Kaya* 36268-36271-36274; Burdur: Bucak, 15 July 2013, *Osman Çoban* AT-2167.

3.4.5. *Tuber rufum* Pico

Syn.: *Oogaster rufus* (Pico) Corda

Ascocarp 1–3 cm broad, subglobose to irregular, the surface finely papillate to somewhat warty, yellowish brown to reddish brown, sometimes mottled nearly black (Figure 11a). Gleba white at first, becoming pale reddish-brown to deep reddish brown, marbled with distinct, broad, reddish brown to off-white veins. Peridium 350–480 μm thick with 2 layers: outer layer pale yellow to yellowish brown, of hyaline, isodiametric or irregular, pigmented cells, 10–15 × 7–10 μm , with walls ± 2 μm thick; inner layer off-white, of hyaline, mostly interwoven, somewhat parallel hyphae,

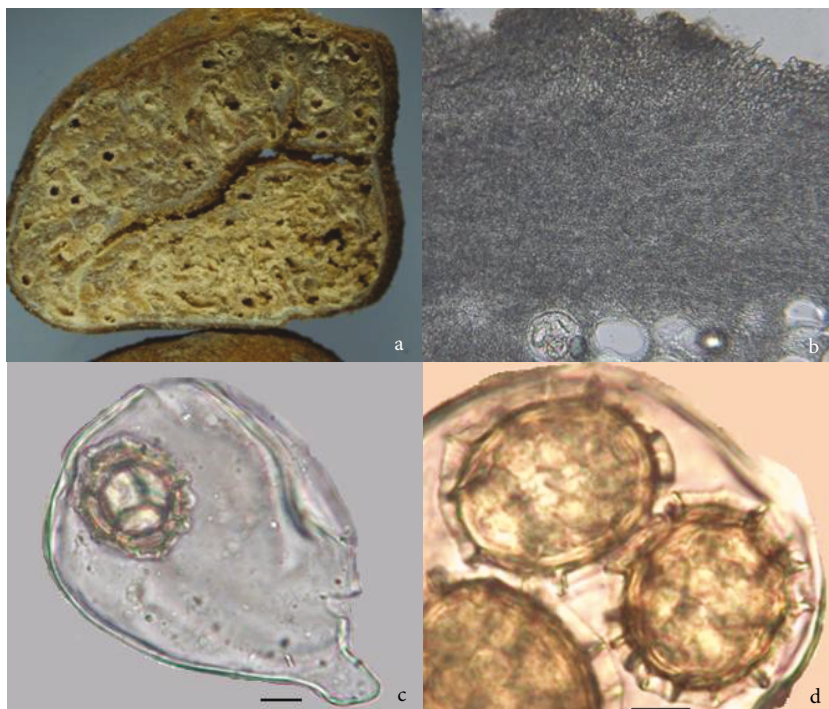


Figure 9. Macroscopic and microscopic appearance of *Tuber excavatum*: a- ascocarp, b- peridium, c- ascus, d- ascospores. Scale bars: c and d = 10 μm .

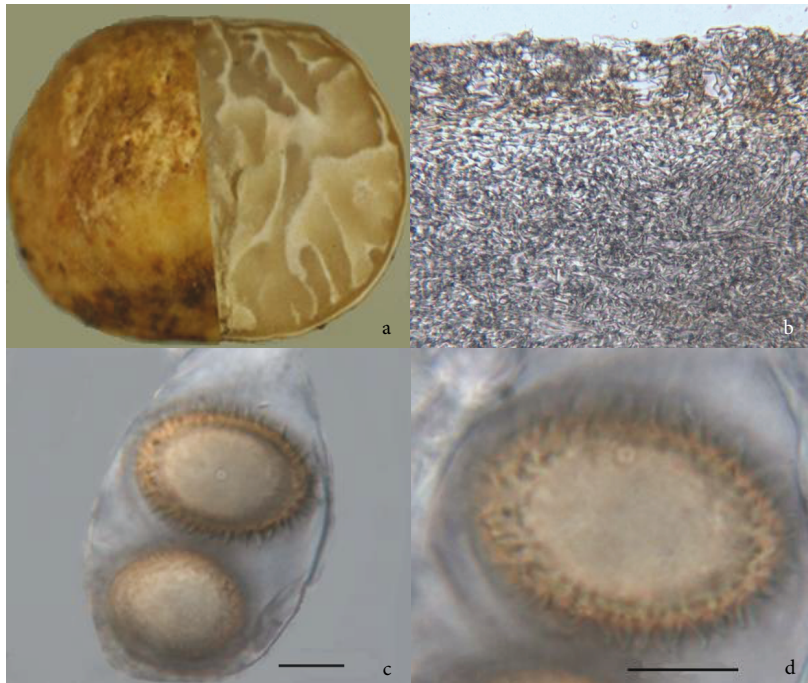


Figure 10. Macroscopic and microscopic appearance of *Tuber nitidum*: a- ascomarp, b- peridium, c- ascus, d- ascospore. Scale bars: c and d = 10 μ m.

3.5–4.5 μ m broad, with walls ± 2 μ m thick (Figure 11b). Gleba of hyaline, interwoven to parallel hyphae, 3.5–7.0 μ m broad, with walls ± 1 μ m thick. Asci 50–90 $\times$ 40–50 μ m excluding stalk, clavate, stalk of up to 30 μ m long, walls 2–3.5 μ m thick, 1–5-spored (Figure 11c). Ascospores (22–)26–33(–36) $\times$ 17.5–22 μ m, mean = 27 $\times$ 19 μ m, excluding ornamentation, in 1-spored asci 20–37 $\times$ 17–20 μ m, 2-spored 26–32 $\times$ 18–22 μ m, 3-spored 23–33 $\times$ 17–18 μ m, ellipsoid, yellowish brown, ornamented with pointed spines, 3.5–5.4 μ m tall (Figure 11d).

Specimens examined: Denizli: Honaz, 6 May 2009, *Türkoğlu* AT-1181; Denizli: Honaz, 6 May 2010, *Türkoğlu* AT-1213; Denizli: Çal, 15 October 2011, *Türkoğlu* AT-1417; Muğla: Fethiye, Gökben village, 19 April 2013, *Türkoğlu* AT-1964; Konya: Akşehir, 19 April 2013, *Türkoğlu* AT-1996; Denizli: Bozkurt, Yukarıdağdere village, 14 May 2013, *Türkoğlu* AT-2107; Kastamonu: Küre, 11 June 2013, *Serkan Sevinç* AT-2130; Antalya: Korkuteli, 20 June 2013, *Mustafa Turunçoğlu* AT-2147.

3.4.6. *Tuber mesentericum* Vittad.

Ascomarps 2–4 cm broad, subglobose or irregular, with a cavity; surface blackish brown to black with a acutely pyramidal warts, warts irregularly polygonal, 4–6-sided, 2–4 mm broad, usually with tiny grooves radiating from the centre (Figure 12a). Gleba initially off-white, later brown, marbled with off-white and brown veins. Peridium 220–550 μ m thick, with 3 layers: outer layer 50–150 μ m thick, blackish brown, of hyaline, inflated, angular cells,

10–20 $\times$ 5–10 μ m, with walls ± 2 μ m thick; inner layer 150–400 μ m thick, off-white, of hyaline, interwoven hyphae, 3.5–6 μ m broad, with walls ± 2 μ m thick (Figure 12b). Gleba of hyaline, interwoven hyphae, 3.5–7 μ m broad, with walls ± 1 μ m thick. Asci 55–75 $\times$ 40–60 μ m, saccate to shortly pedicellate, with walls ± 2 μ m thick, 1–4-spored (Figure 12c). Ascospores (22–)26–35(–38) $\times$ 21–30(–36) μ m, mean = 29.6 $\times$ 26.2 μ m, excluding ornamentation (Figure 12c), in 1-spored asci (27–)30–33(–38) $\times$ (23–)27–36 μ m, 2-spored 26–35 $\times$ 23–28(–36) μ m, 3-spored (26–)28–33 $\times$ (23–)26–30 μ m, 4-spored 22–29 $\times$ 21–25 μ m, rarely globose but generally ellipsoid to broadly ellipsoid, yellowish-brown, ornamented with a very reticulate-alveolate, up to 5.5 μ m tall, 3–5 meshes across the spore (Figure 12d).

Specimen examined: Denizli (Castellano and *Türkoğlu*, 2012); Denizli: Bozkurt, 15 June 2012 *Türkoğlu* AT-1437.

4. Discussion

We report 6 Ascomycete truffle taxa found in Turkey for the first time: *Genea klotzschii*, *Genea verrucosa*, *Stephensia bombycina*, *Terfezia olbiensis*, *Tuber excavatum*, and *Tuber rufum*. We also report new localities within Turkey for *Choiromyces meandriformis*, *Picoa juniperi*, *Terfezia leptoderma*, *Tuber brumale*, *Tuber nitidum*, and *Tuber mesentericum*.

We report the genera *Genea* and *Stephensia* from Turkey for the first time. *Genea klotzschii* has fairly long

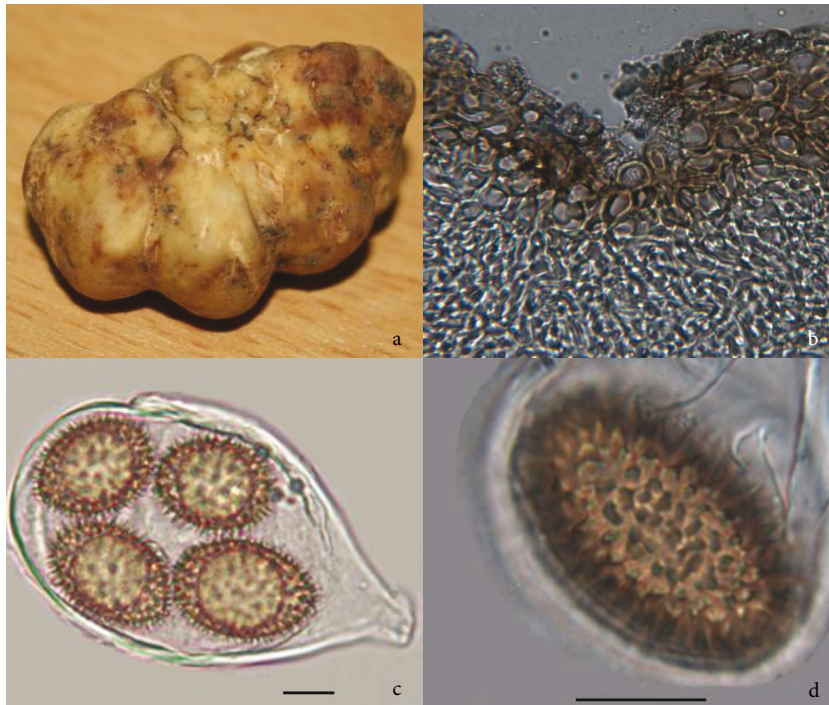


Figure 11. Macroscopic and microscopic appearance of *Tuber rufum*: a- ascocarp, b- peridium, c- ascus, d- ascospore. Scale bars: c and d = 10 μ m.

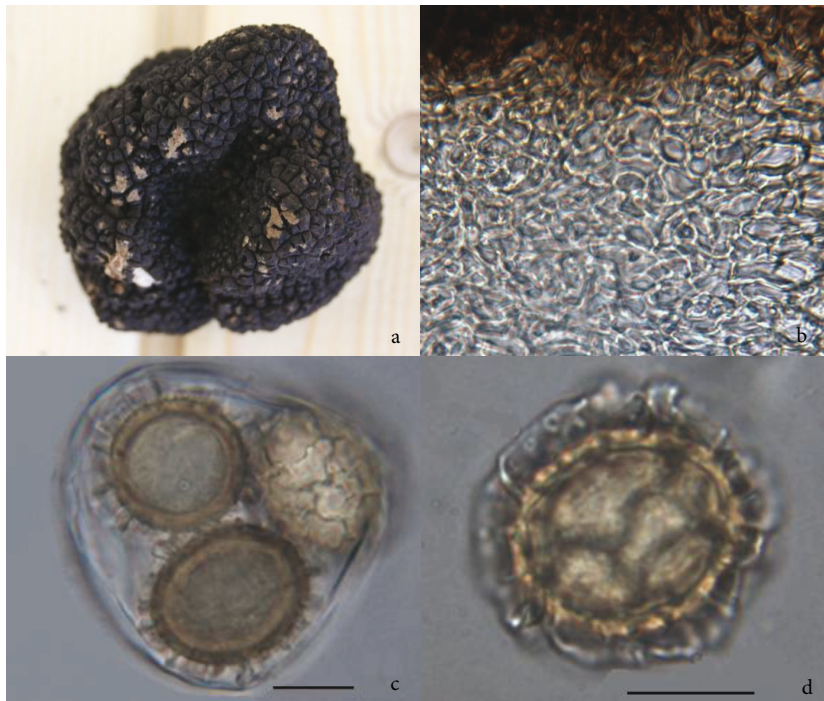


Figure 12. Macroscopic and microscopic appearance of *Tuber mesentericum*: a- ascocarp, b- peridium, c- ascus, d- ascospore. Scale bars: c and d = 10 μ m.

asci and spores ornamented with irregular, flask-shaped or fork-shaped warts while *Genea verrucosa* has mostly shorter asci and spores ornamented with irregularly

conical warts. *G. verrucosa* occurs in calcareous soils under *Quercus pubescens* in the Mediterranean region while *Genea klotzschii* occurs in acidic soils under *Corylus*

sp., in the Black Sea region. *Stephensia bombycina* has characteristic smooth, globose spores. Montecchi and Sarasini (2000) reported *S. bombycina* from under *Tilia* but our collections were from acidic soils under *Corylus* sp., in the Black Sea region. *Terfezia olbiensis* has small ascocarps with pale colours and also fairly short spores ornamented with narrow to broadly truncate cones. It appears to be the most uncommon of the *Terfezia* species found in Turkey. Montecchi and Sarasini (2000) reported *T. olbiensis* from under *Quercus* or *Pinus* spp., but our collections occurred in sandy soils associated with *Helianthemum* spp. The combination of a fine to coarsely warted peridium and distinct basal cavity in *Tuber excavatum* easily separates this species from all others in the genus. *T. excavatum* is collected in calcareous soils under mixed *Quercus* spp. and *Pinus* spp. It appears to be closely associated with coniferous trees throughout Europe as well as in Turkey. The spiny spores of *Tuber rufum* are distinctive among

the palely coloured *Tuber* species. *T. rufum* occurs in calcareous soils under mixed *Quercus* spp. and *Pinus* spp. It appears to be closely associated with coniferous trees. *G. klotzschii*, *G. verrucosa*, and *S. bombycina* are not desirable edible fungi due to texture or small size. *T. olbiensis*, *T. excavatum*, and *T. rufum* are edible and have economic value, but only *T. olbiensis* is well known, eaten, and sold in local village bazaars.

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References

- Afyon A (1996). Isparta yöresinde belirlenen bazı makroskobik mantarlar. *Turk J Bot* 20: 161–164 (in Turkish).
- Castellano MA, Türkoğlu A (2012). New records of truffle taxa in *Tuber* and *Terfezia* from Turkey. *Turk J Bot* 36: 295–298.
- Doğan HH, Öztürk C (2006). Macrofungi and their distribution in Karaman province, Turkey. *Turk J Bot* 30: 193–207.
- Gücin F, Kaya A, Soylu MK (2010). *Picoa* Vittad., a new truffle genus record for Turkey. *BioDiCon* 3: 23–25.
- Güngör H, Allı H, Işıloğlu M (2013). Three new macrofungi records for Turkey. *Turk J Bot* 37: 411–413
- Işıloğlu M, Öder N (1995). Malatya yöresinin makrofungusları. *Turk J Bot* 19: 321–324 (in Turkish).
- Kaya A (2009). Macromycetes of Kahramanmaraş Province (Turkey). *Mycotaxon* 108: 31–38.
- Kirk PM, Cannon PF, Minter DW, Stalfers JA (2008). Authors of Fungal Names [Index to Fungi Supplement]. Wallingford, UK: CABI Bioscience.
- Lange M (1956). Danish Hypogeous Macromycetes. Copenhagen, Denmark: Dansk Botanisk Arkiv.
- Montecchi A, Sarasini M (2000). Fungi ipogei d'Europa. Trento, Italy: Associazione Micologica Bresadola (in Italian).
- Öztürk C, Kaşık G, Toprak E (1997). Ascomycetes makrofunguslarından Türkiye için iki yeni kayıt. *Ot Sistematik Botanik Dergisi* 4: 53–56 (in Turkish).
- Pegler DN, Spooner BM, Young TWK (1993). British Truffles: A Revision of British Hypogeous Fungi. Kew, UK: Royal Botanic Gardens.
- Sesli E, Denchev CM (2012). Checklist of the myxomycetes, larger ascomycetes, and larger basidiomycetes in Turkey. *Mycotaxon* 106: 95–68.
- Solak MH, Işıloğlu M, Gücin F, Gökler I (1999). Macrofungi of İzmir Province. *Turk J Bot* 23: 383–390.
- Solak MH, Işıloğlu M, Kalmış E, Allı H (2007). Macrofungi of Turkey Checklist. İzmir, Turkey: Üniversiteler Ofset (in Turkish).
- Türkoğlu A, Castellano MA (2013). New records of truffle fungi (Basidiomycetes) from Turkey. *Turk J Bot* 37: 970–976.