Turkish truffles I: 18 new records for Turkey

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1. Introduction
Turkey has a potentially rich diversity of truffle taxa due to its unique phytogeographical location, climate and soil variability, and vegetation diversity. More than 2000 fungal species have been recorded from Turkey (Solak et al., 2007; Sesli and Denchev 2014); nearly all of them are epigeous. In Turkey, truffle fungi have received less attention than epigeous fungi. To date only 42 truffle species have been reported from Turkey (Solak et al., 2007; Afyon, 1996; Demirel, 1998; Solak et al., 2003; Doğan and Öztürk, 2006; Kaya, 2009; Sesli and Castellano, 2009; Castellano and Türkoglu, 2012; Türkoglu and Castellano, 2013, 2014). We have begun a concerted effort to collect truffle fungi across all regions of Turkey and herein present our results to date for truffle taxa previously described. In the course of our collecting we have encountered a number of new truffle fungal species that will be presented in subsequent papers.

2. Materials and methods
Truffle fungal specimens were collected in most regions of Turkey except Eastern Anatolia during the period of 2008–2014. Some specimens were found with the help of a truffle dog, but most were discovered by traditional truffle raking in appropriate habitats (Castellano et al., 2004). Macromorphological characteristics (size, fresh color, bruising reactions, and odor) of specimens were recorded and photographed. Micromorphological characters were recorded from tissue sections rehydrated in water, 3% KOH, or Melzer’s reagent. Spores and sterile tissues were photographed by use of a light microscope. Each collection was split and representative specimens are deposited in the herbaria of Muğla Sıtkı Koçman University and Oregon State University (OSC). Authority names are given according to Kirk et al. (2008) and fungal names according to Index Fungorum (2014) and Mycobank (2014).

3. Results
Here we present 18 truffle species determined to be new records for Turkey: 3 species in the Ascomycota (Genea 1, Elaphomyces 2), 15 in the Basidiomycota (Leucogaster 1, Octaviania 1, Hysterangium 4, Gautieria 3, Hymenogaster 4, Alpova 1, and Protoglossum 1). Additional date and locality data are given for Picoa juniperi, P. lefebvrei, Geopora cooperi, Terfezia arenaria, T. claveryi, and Tuber aestivum in the Ascomycota; and Leucogaster nudiust, Hymenogaster thwaitesii, H. vulgaris, and Melanogaster broomeanus in the Basidiomycota.

3.1. Elaphomyctaceae Tul. ex Paol.
3.1.1. Elaphomyces leucocarpus Vittad.
Ascocarp 2–3 cm broad, enclosed in a husk of mycorrhizae and fine roots, irregularly flattened to subglobose, surface brown to yellow-brown, covered by crowded, pyramidal, or irregular, yellow-brown warts 80–200 µm tall, partially embedded in a brown matrix. Inner layer leathery,
homogeneous, white (Figure 1a). Gleba rose-brown and cottony in youth, becoming a black, powdery spore mass at maturity. Peridium 1000–1300 µm thick, 2-layered: outer layer 180–200 µm thick, of mottled yellow to yellow-brown, conical warts, partially embedded in a brown matrix of hyaline, parallel, distinctly septate hyphae, 3.5–4.5 µm broad, walls ±1 µm thick, of sepal, hyaline, interwoven hyphae, 3.5–4.5 µm broad, walls ±1 µm thick. Gleba a black powdery spore mass containing scattered, off-white, fragile dissepiments of hyaline, septate hyphae, 3.5–4.5 µm broad, walls ±1 µm thick. Asci not seen. Ascospores globose, (21–) 24–33 µm, mean = 29.3 µm, excluding ornamentation of brown spines and short ridges, up to 3.5 µm tall (Figure 1b).

Comments: Elaphomyces leucocarpus has often been confused with E. granulatus Fr. That species, however, has a rose to rose-brown inner peridium in cross-section in contrast to the white inner peridium of E. leucocarpus.


3.1.2. Elaphomyces muricatus Fr.
Syn: Ceraunium muricatum (Fr.) Wallr.
Elaphomyces variegatus Vittad.
Lycoperdastrum variegatum (Vittad.) Kuntze
Ascocarp 1–2 cm broad, enclosed in a husk of mycorrhizae and fine roots, subglobose to slightly flattened or irregular, the surface covered by yellow-brown to dark red-brown, polygonal, pointed, tall warts (Figure 2a). Inner layer leathery, grayish brown to dark blackish brown, marbled with pallid veins. Gleba with pale rose to gray-rose veins at first, later becoming filled with a very dark brown, powdery spore mass. Peridium 900–1100 µm thick, 2-layered: outer layer 150–200 µm thick, of yellow-brown to red-brown tissue that forms the warts partially embedded in a brown matrix of hyaline, parallel, agglutinated hyphae, 3.5–7 µm broad, walls 2 µm thick; inner layer 800–900 µm thick, of sepal, hyaline, interwoven hyphae, 6–8 µm broad, walls ±1 µm thick. Gleba of cottony, septate hyphae, 2–3 µm broad, walls ≤1 µm thick, filled with spores at maturity. Asci 50–65 µm broad, subglobose to irregular. Ascospores globose, 24–32 µm (mean = 27.6 µm), excluding ornamentation of dark red-brown, slightly curved rods or spines up to 2.6 µm tall (Figure 2b).


3.2. Helvellaceae Fries
3.2.1. Picoa juniperi Vittad.
This species was previously presented by Türkoglu and Castellano (2013).

Specimens examined: Kayseri: Bünryan, 6 June 2014, Mustafa Demir AT-2392.

3.2.2. Picoa lefebvrei (Pat.) Maire
Syn: Phaeangium lefebvrei Pat.
Ascocarp 2–4 cm broad, globose to subglobose; surface pale yellow-brown to yellow-brown, nearly smooth to covered with scattered to numerous, irregular warts, 0.5–2 mm broad and 0.5–1 mm tall, subtomentose (Figure 3a).

Figure 1. Macroscopic and microscopic appearance of Elaphomyces leucocarpus: a- ascocarp, b- ascospores. Scale bar: b =10 µm.
Gleba off-white to pale yellow, marbled with irregular, pale yellow veins. Peridium 440–580 µm thick, 2-layered: outer layer 100–130 µm thick, off-white to yellow-brown, of angular cells, 25–30 × 15–20 µm, walls 2 µm thick, surface cells red-brown, sometimes towards the outside bearing prominent, septate, yellow-brown, smooth or granulated hairs, 90–150 µm tall, up to 12 µm broad, walls 2 µm thick; inner layer 340–450 µm thick, of hyaline, parallel to interwoven hyphae, 5.5–12.5 µm broad, walls 2 µm thick. Gleba of hyaline, parallel hyphae, 7–11.5 µm broad, walls ±1 µm thick. ASCI formed in fertile pockets in the gleba, 130 × 90 µm, subglobose with a stem up to 30 µm long, walls 2 µm thick, 8-spored. Ascospores broadly ellipsoid to globose, 21–24 × 22–27 µm, mean = 21.9 × 24.2 µm, walls ±1 µm thick, hyaline at first, then pale olive, with a large guttule filling entire spore, ornamentation of minute, rounded warts (Figure 3b).

Specimens examined: Elazığ, Urfa (Gücin et al., 2010); Denizli: Bozkurt, İnceler, 08 April 2013, Türkoğlu AT-1915; Konya: Akşehir, 24 April 2013, Murat Kılıç AT-2024; Aksaray: 26 April 2013, Seyyit Ahmet Akay AT-2076.

Comments: Our specimens closely match the description by Alsheikh and Trappe (1983).

3.3. Pyronemataceae Corda
3.3.1. Geopora cooperi Harkn.
Geopora gilkeyae (Burds.) Guevara, Göker & Stielow
Ascoscarps 2–5 cm broad, irregularly subglobose, surface tomentose, brown to dark brown (Figure 4a). Gleba off-white, of infolded and convoluted tramal veins with a hymenial palisade on exposed surfaces. Peridium 360–500 µm thick, 3-layered: outer layer 100–130 µm thick, of yellow-brown to red-brown, mycelial hyphae, 11–13 µm

Figure 2. Macroscopic and microscopic appearance of *Elaphomyces muricatus*: a- ascocarp, b- ascospores. Scale bar: b =10 µm.

Figure 3. Macroscopic and microscopic appearance of *Picoa lefebvrei*: a- ascocarp, b- ascospores within an ascus. Scale bar: b =10 µm.
broad, walls ±2 µm thick, encrusted and incorporating substrate particles; middle layer 130–180 µm thick, of hyaline, subglobose or angular cells, 15–25 × 20–50 µm, walls ±2 µm thick; inner layer 130–180 µm thick, of hyaline, parallel hyphae, 2.5–4 µm broad, sometimes inflated up 11 µm, walls 1 µm thick. Asci in a hymenial palisade, 160–190 µm long × 15–22 µm broad, cylindrical, operculate, walls 2 µm thick, 8-spored. Paraphyses hyaline, septate, cylindrical, 4.5–11 µm broad, walls ±1 µm thick. Ascospores broadly ellipsoid, 10–13 × 20–26 µm, mean = 11.7 × 21.5 µm, hyaline, rounded at the apex (Figure 4b).

Specimens examined: İzmir (Solak et al., 2003); Bolu: Kartalkaya, 11 November 2012, Türkoğlu AT-1597; Denizli, Serinhisar, Kefe Plateau, 14 May 2013, Niyazi Uluçoban AT-2102; Burdur: Bucak, Beşkonak village, 12 November 2013, Türkoğlu AT-2199; Burdur: Bucak, Beşkonak village, 21 April 2014, Türkoğlu AT-2305; Muğla: Ula, 30 April 2014, Türkoğlu AT-2305; Denizli: Çivril, 21 May 2014, Niyazi Uluçoban AT-2358.

3.3.2. *Genea sphaerica* Tul. & C. Tul.
Syn: *Genea sphaerica* f. lobulata Mor.-Arr., J. Gómez & Calonge
*Genea sphaerica* Tul. & C. Tul. f. sphaerica
*Genea sphaerica* var. lazzarii G. Gross
*Genea sphaerica* Tul. & C. Tul. var. sphaerica
Ascocarp 10–15 mm broad, globose, very regular in form; surface glabrous, black-brown, with pyramidal to angular warts (Figure 5a). Gleba chamber much folded and convoluted, lined with an epithecium similar to the ascocarp surface. Peridium 300–450 µm thick, 3-layered: outer layer 150–200 µm thick, of dark red-brown, angular cells, 20–50 × 40–70 µm, walls 2.2–6.5 µm thick; middle layer 80–100 µm thick, off-white, of angular cells, 10–20 × 20–45 µm, walls 2 µm thick; inner layer 100–150 µm thick, off-white, of interwoven hyphae, 2.5–6.5 µm broad, walls ±1 µm thick; epithecium structure similar to that of the peridium. Asci in a hymenial palisade embedded beneath the epithecium, 190–220 µm long × 17–30 µm.

Figure 4. Macroscopic and microscopic appearance of *Geopora cooperi*: a- ascocarp, b- ascospores within an ascus. Scale bar: b =10 µm.

Figure 5. Macroscopic and microscopic appearance of *Genea sphaerica*: a- ascocarp, b- ascospores. Scale bar: b =10 µm.
broad, cylindrical, broadly rounded at the apex, abruptly narrowed at the base as a short stalk, walls 2 µm thick, 8-spored. Paraphyses hyaline, cylindrical, 2.5–9 µm broad, walls 1 µm thick. Ascospores ellipsoid, 17–22 × 22–32 µm, mean = 19.2 × 27.9 µm, excluding ornamentation of hyaline at first, pale yellowish when mature, rounded-hemispheric to sometimes flask-shaped warts, 2.5–3.5 µm broad (Figure 5b).

Specimens examined: İzmir: under mixed stand of *Pinus nigra* and *Quercus cerris*, 15 June 2013, Zülal Totan, AT-2131.

3.4. Terfeziaceae Dumort.

3.4.1. *Terfezia arenaria* (Moris) Trappe

Syn: *Tuber arenaria* Moris

Ascocarps 3–6 cm broad, globose to subglobe, surface off-white at first, later yellow-brown, finally dark brown (Figure 6a). Gleba off-white at first, later with grayish pockets of fertile tissue separated by irregular, off-white, sterile veins. Peridium 400–450 µm thick, of hyaline, parallel hyphae, 6.5–11 µm broad, walls 1 µm thick, mixed with subglobe or elongate cells, inflated up to 50 µm broad, walls 4 µm thick. Gleba of hyaline, parallel hyphae, 6.5–11 µm broad, walls ±1 µm thick. Asci randomly dispersed in the gleba, 75–90 µm long × 65–80 µm broad, globose to ellipsoid, walls ±2 µm thick, 8-spored. Ascospores globose, 16–18 × 16–19 µm, mean = 17.3–17.4 µm, excluding ornamentation of truncate-conical or rounded warts, 4.5–6 × 5.5–6 µm, pale brown or yellow-brown to dark brown, (Figure 6b).

Specimens examined: Konya (Öder, 1988; Kaşık et al., 1998); Malatya (İşloğlu and Öder, 1995); Isparta (Afyon, 1996); Aydın: Çine, Güney, under *Asphodelus aestivus*, 04 May 2008, Mehmet Halil Solak, AT-2084.

3.4.2. *Terfezia claveryi* Chatin

Ascocarps 4–6 cm broad, globose to subglobe, surface off-white at first, later red-brown, finally dark red-brown or black-brown, much wrinkled when mature (Figure 7a). Gleba off-white at first, later pale yellow with distinct sterile veins. Peridium 450–600 µm thick, off-white to pale yellow with a narrow brown zone at the surface; surface hyphae with pale brown walls, 13–17 µm broad, mixed with cells inflated up to 50 µm broad, walls ±1 µm thick. Gleba of hyaline, parallel hyphae, 7–12 µm broad, walls ±1 µm thick. Asci randomly dispersed in the gleba, 60–80 × 50–70 µm, globose-ellipsoid, walls ±2 µm thick, 8-spored. Ascospores globose, 16–18 × 16–19 µm, mean = 17.3–17.4 µm, excluding ornamentation of hyaline to pale brown, irregular reticulation, walls 3 µm tall and 2 µm thick (Figure 7b).


3.5. Tuberaceae Dumort.

3.5.1. *Tuber aestivum* Vittad.

Ascocarps 2–8 cm broad, globose to subglobe, the surface black-brown, with 4–6-sided, polygonal warts, 1–2 mm broad, usually with tiny grooves radiating from center (Figure 8a). Gleba initially off-white, by maturity brown marbled with off-white to brownish veins. Peridium 220–530 µm thick, with 2 layers: outer layer 100–150 µm thick, of hyaline, angular cells, 20–30 × 5–10 µm, walls ±2 µm thick; inner layer 110–480 µm thick, of hyaline to pale yellow, interwoven hyphae, 2.5–6 µm broad, walls ±1 µm thick. Gleba of hyaline, interwoven hyphae 2.5–4.5 µm

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**Figure 6.** Macroscopic and microscopic appearance of *Terfezia arenaria*: a- ascocarp, b- ascospores within an ascus. Scale bar: b =10 µm.
broad, walls ±1 µm thick. Ascii 60–90 µm long × 50–70 µm broad, saccate to short-pedicellate, walls ±3 µm thick, 1–6-spored. Ascospores ellipsoid to broadly ellipsoid, (15–) 18–20 (–25) × (22–) 24–31 (–48) µm, mean = 20.5 × 29.3 µm, excluding ornamentation, yellowish-brown, in 1-spored ascii 20–25 × 26–29 µm, 2-spored 22–25 × 31–40 (–44) µm, 3-spored 20–23 × 22–28 µm, 4-spored (15–) 18–20 × 26–28 (–48) µm, 5-spored 18–20 × 26–31 µm, 6-spored 18–20 × 24–26 µm, ornamentation of a coarse reticulum, up to 3–5 µm tall, with 3–5 irregular, polygonal meshes along the spore axis (Figure 8b).

3.5.2. *Tuber rufum* Pico.

Syn: *Oogaster rufus* (Picco) Corda

This species was previously presented by Türkoğlu and Castellano (2013).


3.5.3. *Tuber nitidum* Vittad

Syn: *Oogaster nitidus* (Vittad.) Corda

This species was previously presented by Türkoğlu and Castellano (2013).

Specimens examined: Çankırı: Ilgaz Mountain (Pilát 1937); Kastamonu: Kure, under *Abies nordmannia* var. *bornmulleriana* and *Fagus orientalis*, 15 June 2013, Serkan Sevinç AT-2129.

3.6. *Albatrellaceae* Nuss

3.6.1. *Leucogaster nudus* (Hazsl.) Hollós

Syn: *Hydnangium nudum* Hazsl.

*Leucogaster floccosus* R. Hesse

Basidiocarp 1.5–3 cm broad, subglobose to irregularly lobed, surface pubescent, off-white at first with yellow patches, later developing red-brown stains (Figure 9a). Gleba off-white to pale olive-brown with globose to angular, locules empty, 0.5–1.5 mm broad. Peridium 220–520 µm thick, 2-layered: outer layer 60–80 µm thick, of brown to yellow-brown, periclinal hyphae, 4.5–6.5 µm broad, walls 2 µm thick, with adhering crystalline structures; inner layer 160–440 µm thick, of hyaline, parallel to interwoven hyphae 2.5–7 µm broad, walls ±1 µm thick. Trama 50–90 µm wide, of white to pale, subparallel to interwoven hyphae, 2.5–4.5 µm broad, walls ±1 µm thick. Basidia not rehydrating. Spores enclosed in a hyaline, smooth, thin-walled episporal membrane, globose to subglobose, 13.2–15.8 × 13.2–17.5 µm, mean 14.1 × 14.9 µm, hyaline to pale yellow, ornamentation a reticulum, 1 µm tall (Figure 9b).

Specimens examined: Çankırı: Ilgaz Mountain (Pilát 1937); Kastamonu: Kure, under *Abies nordmannia* var. *bornmulleriana* and *Fagus orientalis*, 15 June 2013, Serkan Sevinç AT-2129.

3.6.2. *Leucogaster tozzianus* (Cavara & Sacc.) Mattir. ex Zeller & C.W. Dodge

Syn: *Endogone tozziana* Cavara & Sacc.

Basidiocarp 0.5–1 cm broad, subglobose, surface off-white with some yellow tones in patches or streaks and scattered black thin and short fibrils (Figure 10a). Gleba very pale yellow with white tramal walls, locules empty, 0.5–1 mm broad, globose to angular. Peridium 150–220 µm thick, 2-layered: outer layer 60–100 µm thick, of yellow-brown to orange, periclinal hyphae, 4.5–7 µm broad, walls 2 µm thick, with adhering crystalline structures; inner layer 90–200 µm thick, of hyaline, parallel to interwoven hyphae, 3.5–4.5 µm broad, walls ±1 µm thick. Trama 40–80 µm wide, of hyaline, gelatinized, interwoven hyphae 2.5–3 µm broad, walls ±1 µm thick. Basidia not rehydrating. Spores enclosed in a hyaline, smooth, thin-walled episporal membrane, globose to subglobose, 13.2–15.8 × 13.2–17.5 µm, mean 14.1 × 14.9 µm, hyaline to pale yellow, ornamentation a reticulum, 1 µm tall (Figure 9b).

Specimens examined: Çankırı: Ilgaz Mountain (Pilát 1937); Kastamonu: Kure, under *Abies nordmannia* var. *bornmulleriana* and *Fagus orientalis*, 15 June 2013, Serkan Sevinç AT-2129.

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Figure 9. Macroscopic and microscopic appearance of *Leucogaster nudus*: a- basidiocarp, b- basidiospores. Scale bar: b =10 µm.
enclosed in a hyaline, smooth, thin-walled, episporal membrane, globose, 9.7–11.4 × 9.7–11.4 µm, mean 10.1 × 10.4 µm, excluding reticulate ornamentation, 1–2 µm tall, walls 2 µm thick (Figure 10b).

Specimens examined: Kastamonu: Daday, Ballıdağ, under *Abies nordmannia* var. *bornmulleriana*, *Pinus sylvestris*, and *Fagus orientalis*, 26 May 2013, Michael Castellano T36239; Trabzon: Sürmene, Region 245, under *Fagus orientalis*, *Picea orientalis*, *Castanea sativa*, and *Rhododendron ponticum*, 28 May 2013, Michael Castellano T36255, T36256; Veysel Kodalak T3658.

### 3.7. Boletaceae Chevall.

#### 3.7.1. *Octaviania asterosperma* Vittad.

Syn: *Arcangeliella asterosperma* (Vittad.) Zeller & C.W. Dodge

Basidiocarp 0.6–1.5 cm broad, subglobose to oblong or lobate, surface finely felty, off-white at first, then staining dark violet to black when handled, with a cluster of small concolorous rhizomorphs at the base (Figure 11a). Gleba with pale brown locules, 0.5–1 mm broad, irregularly shaped, filled with spores, separated by white tramal veins. Peridium 100–200 µm thick, 2-layered: outer layer 30–60 µm thick, of yellow-brown, loosely interwoven, granulated hyphae, 4.5–11 µm broad, walls 2 µm thick; inner layer 70–140 µm thick, of hyaline, parallel hyphae, 2.5–9 µm broad, inflated up to 22 µm, walls ±1 µm thick. Trama 40–60 µm wide, of parallel to interwoven hyphae, 3.5–9 µm broad, walls ±1 µm thick. Basidia hyaline, clavate, 5–10 × 20–40 µm, with 2 sterigmata and 5 µm tall. Spores globose to subglobose, (8.8–) 10.5–11.4 × 10.5–11.4 (12.3) µm; mean 10.5 × 11.1 µm, excluding ornamentation of pale yellow to yellow-brown, pyramidal-conical warts, 2–3.5 µm long and 2.5–3.5 µm wide (Figure 11b).

Specimens examined: Ordu: Ünye, Çaybaşı, under pure *Fagus orientalis*, 27 May 2013, Michael Castellano
3.8. Cortinariaceae R. Heim
3.8.1. Protoglossum aromaticum (Velen.) J.M. Vidal
Syn: Hymenogaster aromaticus Velen., České Houby
Basidiocarp 1–2.5 cm broad, subglobose to ellipsoid, surface silky to felt-fibrillose, with various mixtures of lilac and pale yellow to yellow-brown with some brown stains in age, with a distinct base (Figure 12a). Gleba at maturity cinnamon, locules irregular, empty; columella lacking. Peridium 300–400 µm thick, off-white to pale yellow, 1-layered, of hyaline, subparallel to interwoven hyphae, 3.5–7 µm broad, walls ±1 µm thick. Trama 60–90 µm wide, of hyaline, subparallel to interwoven hyphae, 3.5–7 µm broad, walls ±1 µm thick. Trama 60–90 µm wide, of hyaline, interwoven hyphae, 5.5–7 µm broad, walls ±1 µm thick, with some inflated cells 8–10 × 13–20 µm. Basidia 5–8 × 20–25 µm, clavate, hyaline, walls 1 µm thick, 2-spored; sterigmata hyaline, 4–5 µm tall. Spores ellipsoid, 5.2–7.8 × 9–12 µm, mean 6.8 × 10.2 µm, including ornamentation of small, brown warts, with a hyaline pedicel, 1–2 µm long (Figure 12b).


3.9. Hysterangiaceae E. Fisch.
3.9.1. Hysterangium clathroides Vittad.
Basidiocarp 0.6–1 cm broad, subglobose, indented at base, surface pubescent, red-brown to brown (Figure 13a). Gleba olive to gray-green; locules elongate, filled. Peridium 180–260 µm thick, 2-layered: outer layer 140–200 µm thick, of hyaline to golden-yellow, incrusted, filamentous hyphae, somewhat parallel to surface, 2.5–6.5 µm broad, walls ±1 µm thick, with adhering crystalline particles on outer layer; inner layer 50–70 µm thick, of hyaline, interwoven and subparallel hyphae, 4.5–9 µm broad, walls 1 µm thick. Trama 90–200 (–300) µm wide, of hyaline, interwoven hyphae in gelatinized matrix, 2–4.5 µm broad, walls ±1 µm thick. Basidia hyaline, cylindrical to clavate, 8–11 × 25–35 µm, 2-spored. Spores ellipsoid-fusiform, (4.4–) 5.3–7 (–7.9) × 16.7–23.7 µm, mean 6.0 × 18.8 µm, walls ±1 µm thick, green-brown, verrucose, apex slightly papillate, sterigmal appendix 2.5 µm long and 2.5 µm wide (Figure 13b).

Specimens examined: Kütahya: Dörtyol District, under Fagus orientalis and Pinus sylvestris, 9 June 2013, Michael Castellano T36279; Trabzon: Sürmene, Aksu village, under Fagus orientalis, Picea orientalis, Castanea sativa, and Rhododendron ponticum, 27 October 2013, Türkoğlu AT-2180a.
3.9.2. *Hysterangium epiroticum* Pacioni
Basidiocarp 0.4–0.6 cm broad, subglobose, surface pubescent, off-white at first, later red-brown (Figure 14a). Gleba gray-green to dark green, locules elongate, empty. Peridium 220–260 µm thick, 3-layered: outer layer 65–80 µm thick, of brown to yellow-brown, interwoven hyphae, 4.5–8.5 µm broad, walls ±1 µm thick, hyphae generally erect and forming as a encrusted structure; middle layer 110–150 µm thick, of hyaline to pale brown, subglobose and somewhat broadly ellipsoid cells, 10–45 µm broad; inner layer 45–60 µm thick, of pale brown, subparallel hyphae, 2–4.5 µm broad, walls 1 µm thick. Trama 100–150 µm wide, of hyaline, interwoven hyphae in gelatinized matrix, 1–2.5 µm broad, walls ±1 µm thick. Basidia not rehydrating well, hyaline, 2- or 4-spored. Spores ellipsoid-fusiform, 5.3–6.1 × 17.5–21.9 (~24.6) µm, mean 5.9 × 21.0 µm, wall ±1 µm thick, olive-green, verrucose, apex acuminate, sterigmal appendix 2.5–3 µm long and 1.5–2.5 µm wide (Figure 14b).

Specimens examined: Kastamonu: Çatalzeytin, under pure *Fagus orientalis*, 26 May 2013, Michael Castellano T36246.

3.9.3. *Hysterangium fragile* Vittad.
Basidiocarp 1.5–2.5 cm broad, subglobose, indented at base with single small concolorous rhizomorph at the base, surface pubescent, off-white and pale yellow to pale yellow-brown with handing, KOH on surface yellow (Figure 15a). Gleba olive-gray, columella dendroid, 2 mm broad at the base. Peridium 450–600 µm thick, of hyaline, 2-layered: outer layer 400–520 µm thick, of subglobose cells, 20–30 × 45–60 µm broad, walls 2 µm thick; inner layer 30–80 µm thick, of hyaline, interwoven hyphae, 4.5–11 µm broad, walls ±1 µm thick. Trama 100–150 µm wide, of hyaline, gelatinized, interwoven hyphae 2.5–5.5 µm broad, walls ±1

![Figure 13](image13.jpg)  ![Figure 13](image13.jpg)

**Figure 13.** Macroscopic and microscopic appearance of *Hysterangium clathroides*: a- basidiocarp, b- basidiospores. Scale bar: b =10 µm.

![Figure 14](image14.jpg)  ![Figure 14](image14.jpg)

**Figure 14.** Macroscopic and microscopic appearance of *Hysterangium epiroticum*: a- basidiocarp, b- basidiospores. Scale bar: b =10 µm.
µm thick. Basidia hyaline, cylindrical to subclavate, 7–10 × 25–45 µm, 1-2-3-spored. Spores ellipsoid-fusiform, 6.1–7.0 (−8.8) × (17.5–) 18.4–24.0 µm, mean 6.9 × 21.2 µm, wall ±1 µm thick, hyaline to pale green, smooth, sterigmal appendix 1.5–2.5 µm long and 2.5 µm wide (Figure 15b).


3.9.4. *Hysterangium nephriticum* Berk.
Basidiocarp 0.8–1 cm broad, subglobose, surface off-white, staining yellow-brown in areas, somewhat filamentous. Gleba olive-gray, locules irregular, filled. Peridium 250–400 µm thick, 2-layered: outer layer 160–300 µm thick, of hyaline, periclinal hyphae, 3–6.5 µm broad, walls 1 µm thick, with abundant crystalline particles; inner layer 80–100 µm thick, of hyaline, of subglobose to irregular cells 10–20 µm, walls 1 µm thick (Figure 16a). Trama 50–130 µm wide, of hyaline, gelatinized, interwoven hyphae, 2–4.5 µm broad, walls ±1 µm thick. Basidia hyaline, cylindrical, 8–10 × 30–50 µm, 2-spored. Spores ellipsoid-fusiform, 5.3–6.1 × 15.8–18 µm, excluding sterigmal appendix, mean 5.8 × 17.5 µm, wall ≤0.5 µm thick, hyaline to pale brown, smooth, sterigmal appendix 2.5 µm long and 1.5 µm wide, perisporium wrinkled, up to 1 µm at maturity (Figure 16b).
Specimens examined: Sakarya: Sapanca, İstanbul dere mevkii, under pure Fagus orientalis, 23 May 2013, Michael Castellano T36282.

3.10. Gomphaceae Donk

3.10.1. Gautieria otthii Trog
Syn: Gautieria graveolens var. otthii (Trog) Zeller & C.W. Dodge
Basidiocarp 1–3 cm broad, subglobose to lobate or irregular, surface smooth, off-white with pale yellow patches (Figure 17a). Gleba off-white, abundant yellow-brown spores lining each locule, locules elongate to labyrinthiform, empty. Columella dendroid and gelatinized. Peridium 130–200 µm thick, of hyaline, gelatinized, parallel hyphae, 4.5–7 µm broad, walls 1 µm thick. Trama 60–100 µm wide, of hyaline, gelatinized, parallel hyphae, 2.5–3.5 µm broad, walls 1 µm thick. Subhymenium of hyaline hyphae, somewhat inflated up to 20 µm, walls 1 µm thick. Basidia 7–14 × 25–60 µm, clavate, hyaline, walls 1 µm thick, 2-spored; sterigmata 4–8 µm tall. Spores ellipsoid, 7–9.5 × 12.5–17.5 µm including ornamentation, mean 7.9 × 14.9 µm, pale yellow, ornamentation of 8–10 longitudinal ribs, rarely with warts, pedicel hyaline, 2–2.5 µm long and 1.5–2.5 µm wide (Figure 17b).

Specimens examined: Bolu: Gerede, Seviller, 9 November 2012, Türkoğlu AT-1591.

3.10.2. Gautieria retirugosa Th. Fr.
Basidiocarp 1–2 cm broad, subglobose or irregular lobate, with basally attached, thin, mycelia cords, surface smooth, off-white at first, later pale yellow (Figure 18a). Gleba off-white, abundant yellow-brown spores lining each locule, locules labyrinthiform, empty. Peridium 220–300 µm thick, 2-layered: outer layer 90–130 µm thick, pale yellow to yellow-brown, interwoven hyphae, 4.5–6.5 µm broad, walls 1 µm thick, sometimes with inflated cells, 20–30 × 30–40 µm; inner layer 130–170 µm thick, of hyaline, parallel hyphae, 2.5–4.5 µm broad, walls 1 µm thick. Trama 70–130 µm wide, of hyaline, gelatinized, parallel hyphae, 2.5–3.5 µm broad, walls <0.5 µm thick. Subhymenium of hyaline hyphae, somewhat inflated up to 10 µm, walls <0.5 µm thick. Basidia 5–10 × 35–40 µm, clavate, hyaline, walls <0.5 µm thick, 2-spored; sterigmata 3–4 µm long. Spores ovoid to ellipsoid, 9–12 × 15–21 µm including ornamentation, mean 10.5 × 17.7 µm, pale yellow, ornamentation of 9–10 longitudinal ribs, pedicel hyaline, 2–3 µm long and 1–2 µm wide (Figure 18b).

Specimens examined: Bolu: Gerede, Seviller, 9 November 2012, Türkoğlu AT-1591.

3.10.3. Gautieria trabutii (Chatin) Pat.
Syn: Hymenogaster trabutii Chatin
Basidiocarp 2–4 cm broad, subglobose to irregularly lobed, surface smooth, off-white at first, later pale yellow (Figure 19a). Gleba off-white, abundant yellow-brown spores lining each locule, locules elongate, 2–3 mm broad, empty. Peridium 220–440 µm thick, 2-layered: outer layer 70–90 µm thick, pale yellow to yellow, interwoven hyphae, 4.5–9 µm broad, walls 1 µm thick; inner layer 150–350 µm thick, of hyaline, loosely interwoven to parallel hyphae, 3.5–6 µm broad, walls 1 µm thick. Trama 90–180 µm wide, of hyaline, gelatinized parallel hyphae, 3.5–5.5 µm broad, walls 1 µm thick. Basidia 7–10 × 35–40 µm, clavate, hyaline, walls <0.5 µm thick, 2-spored; sterigmata 4–5 µm tall. Spores ellipsoid, 8–11 (–12.5) × 15–18 (–19.7) µm including ornamentation, mean 11.2 × 17.9 µm, yellow to yellow-brown, ornamentation of 8–10 longitudinal ribs.

Figure 17. Macroscopic and microscopic appearance of Gautieria otthii: a- basidiocarp, b- basidiospores. Scale bar: b =10 µm.
with several hemispherical nubs, pedicel hyaline, 2–3 µm long and 1–2 µm wide (Figure 19b).

Specimens examined: Burdur: Bucak, 15 July 2013, Osman Çoban AT-2154; Muğla: Dalaman, Darıyeri village, 31 May 2014, Türkoğlu AT-2375.

3.11. Strophariaceae Singer & A.H. Sm.
3.11.1. Hymenogaster citrinus Vittad.
Syn: Gautieria citrina (Vittad.) Bougher & Castellano Basidiocarp 1–1.5 cm broad, irregularly globose, surface smooth, pale yellow at first, later yellow-brown with some dark brown patches, finally red-brown (Figure 20a). Gleba firm, pale brown at first, later red-brown, finally dark brown, locules irregular, nearly full. Peridium 150–180 µm thick, pale yellow to yellow-brown, 2-layered: outer layer 90–100 µm thick, of hyaline, parallel hyphae, 2.5–3.5 µm broad, walls 1 µm thick. Trama 20–40 µm wide, of hyaline, parallel hyphae, 2.5–5 µm broad, walls <1 µm thick. Basidia 7–9 × 25–30 µm, cylindrical-clavate, hyaline, walls <0.5 µm thick, 2- or 4-spored. Spores citriform to elongate-fusoid, 11–20 × 25–32.5 (–40) µm, including ornamentation, mean 16.6 × 31.5 µm, hyaline at first without ornamentation, later with pale yellow to yellow ornamentation, with a smooth papilla, ornamentation of longitudinal folds, appearing somewhat ribbed, pedicel hyaline, 5 µm long and 4–5 µm wide (Figure 20b).

Specimens examined: Samsun: Çarşamba, Köklü village, under Corylus sp., 12 November 2013, Türkoğlu AT-1606.

3.11.2. Hymenogaster hessei Soehner
Hymenogaster hessei Soehner f. hessei
Basidiocarp 1–2 cm broad, irregularly globose to lobed, surface wrinkled and tomentose, off-white to grayish with some brown mottling (Figure 21a). Gleba dark brown at first, later black, locules irregular, nearly full. Peridium 60–90 µm thick, pale yellow to yellow-brown, 2-layered: outer layer 45–65 µm thick, of hyaline, interwoven to subparallel hyphae, 9–11 µm broad, walls 1 µm thick, sometimes inflated to 10–20 × 30–45; inner layer 15–25 µm thick, of hyaline, parallel hyphae, 2.5–3.5 µm broad, walls 1 µm thick. Trama 45–65 µm wide, of hyaline, parallel hyphae, 3.5–7 µm broad, walls <0.5 µm thick. Subhymenium of hyaline hyphae, sometimes inflated up to 10 µm, walls 1 µm thick. Basidia 5–9 × 20–35 µm, cylindrical-clavate, hyaline, walls <0.5 µm thick, 2-spored. Spores ellipsoid or ellipsoid-fusoid, 12.5–17.5 × 19–27 µm, including ornamentation, mean 14.2 × 22.9 µm, pale yellow with brown or red-brown ornamentation, with or without an acute, ornamentation of longitudinal folds, appearing nearly ribbed, pedicel hyaline, 1–2 µm long and 3–4 µm wide (Figure 21b).

Specimens examined: Kastamonu: Bozkurt, Şeyh Şaban, Orta Sökün District, under Fagus orientalis, Rhododendron sp., Ilex sp., 26 May 2013, Michael Castellano T36245; Kastamonu: Daday, Ballıdağ, Soğucakova mevkii, under Abies nordmannia var. bornmulleriana, 29 May 2013, Michael Castellano T36237.

3.11.3. Hymenogaster luteus Vittad.
Syn: Hysterogaster luteus (Vittad.) C.W. Dodge
Basidiocarp 0.1 cm broad, subglobose to ellipsoid, regular

Figure 20. Macroscopic and microscopic appearance of Hymenogaster citrinus: a- basidiocarp, b- basidiospores. Scale bar: b =10 µm.

Figure 21. Macroscopic and microscopic appearance of Hymenogaster hessei: a- basidiocarp, b- basidiospores. Scale bar: b =10 µm.
in shape, surface wrinkled and tomentose, off-white or gray to pale yellow (Figure 22a). Gleba green to pale yellow, dark brown, abundant pale yellow spores lining each irregularly shaped locule. Peridium 90–180 µm thick, pale yellow to yellow-brown, 1-layered, of hyaline, interwoven to parallel hyphae, 2.5–6 µm broad, walls 1 µm thick. Trama 25–45 µm wide, of hyaline, parallel hyphae, 2.5–4.5 µm broad, walls <0.5 µm thick. Trama 25–45 µm wide, of hyaline, parallel hyphae, 2.5–4.5 µm broad, walls <0.5 µm thick. 

Basidium 8–10 × 20–30 µm, clavate, hyaline, walls <0.5 µm thick, 2-spored. Spores elongate-ellipsoid, 9.5–13.5 × 15.5–22 µm, including ornamentation, mean 11.1 × 18.4 µm, sometimes papillate or with rounded apex, dark brown, perisporum wrinkled, with short small folds, pedicel hyaline, 2–3 µm long and 4–5 µm wide (Figure 23b).

Specimens examined: Isparta: Eğirdir, Yukarı Gökdere, Kasnak Meşesi Koruma Alanı, under Quercus volcanica, 1 June 2013, Michael Castellano T36275-2.

3.11.5. Hymenogaster thwaitesii Berk. & Broome

This species was previously presented by Türkoğlu and Castellano (2013).

Specimens examined: Muğla (Türkoğlu and Castellano, 2013); Osmaniye: Zorkun plateau, under mixed stand of Quercus cerris, Pinus nigra, and Pinus brutia, 13 January 2013, Türkoğlu AT-1870; Muğla: Fethiye, Gökben village, 2 January 2014, Türkoğlu AT-2226; Denizli: Çivril, under Quercus spp., 21 May 2014, Niyazi Uluçoğlan AT-2369:


Syn: Hymenogaster vulgaris var. hessei Soehner Hymenogaster vulgaris var. madeirensis Torrend Hymenogaster vulgaris Tul. & C. Tul. var. vulgaris Rhizopogon albus Berk.

This species was previously presented by Türkoğlu and Castellano (2013).

Specimens examined: Muğla (Türkoğlu and Castellano, 2013); Tecirday: Saray, Ergene District, under mixed stand of Pinus nigra, Quercus sp., and Carpinus betulus, 22 November 2013, Türkoğlu AT-2204.
3.12. Paxillaceae Lotsy

Basidiocarp 1.8–2.2 cm broad, irregular to subglobose or irregularly lobed, surface finely pubescent, off-white to pale flesh or pale pink-brown, with handling darker in areas, with some dark brown rhizomorphs scattered on peridium (Figure 24a). Gleba pale yellow-brown, with off-white trama at first, later dark brown. Peridium 550–700 µm thick, 1-layered: of pale yellow to dark red brown, interwoven hyphae, 4.5–11 µm broad, walls 2 µm thick, sometimes inflated up to 20 µm broad and mixed with subglobose cells 40 × 60 µm. Trama 40–60 µm wide, of white to yellowish white, parallel to interwoven hyphae, 4.5–8 µm broad, walls ±2 µm thick. Basidia not rehydrating. Spores ellipsoid, 1.8–2.6 × (3.5–) 5.3–6.1 µm, mean 2.4 × 5.5 µm, hyaline to pale greenish, smooth (Figure 24b).


Syn: *Melanogaster broomeanus* Berk. var. *broomeanus* *Melanogaster broomeanus* var. *pseudorubescens* Svrček
This species was previously presented by Türkoğlu and Castellano (2013).

Specimens examined: Artvin (Demirel 1998); Denizli (Türkoğlu and Castellano 2013); Samsun: Çarşamba, Köklü village, under *Corylus* sp., 12 November 2012, Türkoğlu AT-1599, AT-1601, AT-1605, AT-1607; Samsun: Çarşamba, Zümrut village, under *Corylus* sp., 13 November 2012, Türkoğlu AT-1611; Kastamonu, Çatalzeytin, 26 May 2013, Michael Castellano T36247.
4. Discussion and conclusion

We report 3 Ascomycete and 15 Basidiomycete truffle taxa found in Turkey for the first time: Alpova coricus, Elaphomyces leucocarpus, E. muricatus, Gautieria otthii, G. retirugosa, G. trabutii, Gea phaerica, Hymenogaster citrinus, H. hessei, H. luteus, H. lycoperdineus, Hysterangium clathroides, H. epiroticum, H. fragile, H. nephriticum, Leucogaster nudus, Melanogaster broomeanus, Picoa juniperi, T. claveryi, Tuber aestivum, T. nihidum, and T. rufum. We report the genera Alpova, Elaphomyces, Geopora, Octaviania, and Protoglossum for the first time from Turkey.

Elaphomyces leucocarpus has a brown to yellow-brown peridial surface with pyramidal or irregularly warts and brown ascospores, while Elaphomyces muricatus has a yellow-brown to dark red-brown peridial surface with fairly distinct, polygonal pointed, tall warts and dark red-brown ascospores. Elaphomyces leucocarpus and E. muricatus both occur under Alnus glutinosa, Salix caprea, Rhododendron ponticum, and Fagus orientalis in the Black Sea region. Picoa lefebvrei has a pale yellow-brown to yellow-brown peridial surface with scattered to numerous, irregular warts, while Picoa juniperi has a brown-black to black peridial surface with regularly arranged and uniformly distributed warts. Our material of Geopora cooperi has a brown to dark brown, tomentose peridial surface and matches well the descriptions reported by Montecchi and Sarasini (2000). Genea phaerica has globose, slightly lobed ascosporas while G. verrucosa has irregular and very lobed-folded ascosporas. Genea phaerica has spores ornamented with rounded-hemispheric warts while G. klotzschii and G. verrucosa have spores with either flask-shaped and fork-shaped warts or irregularly conical warts.

Terfezia claveryi and T. arenaria both have an off-white peridial surface at first but later T. arenaria has a yellow-brown, finally dark brown peridial surface while T. claveryi has a red-brown, finally dark red-brown or black-brown peridial surface. Terfezia arenaria has a gleba with grayish zones of fertile tissue separated by whitish veins while T. claveryi has a pale yellow gleba with distinct sterile veins. Terfezia claveryi has spores ornamented with a prominently irregular reticulation with irregular alveolae, while spores of T. arenaria have ornamentation consisting of verrucae that are truncate-conical or rounded. Montecchi and Sarasini (2000) reported T. arenaria from under Helianthemum guttatium, Quercus ilex, and Q. suber but our collections occurred under Asphodelus aestivalis. Leucogaster nudus has a peridial surface with yellow patches at first, later staining red-brown while Leucogaster tozzianus has an off-white peridial surface with some yellow spots or streaks with scattered black thin and short fibrils. Leucogaster nudus has a gleba with pale olive-brown, empty locules while L. tozzianus has a very pale yellow gleba with white tramal walls. Leucogaster nudus and L. tozzianus have similarly shaped spores but L. nudus has larger spores than L. tozzianus. Octaviania asterosperma and Protoglossum aromaticum fit well the descriptions by Montecchi and Sarasini (2000). Hysterangium clathroides and H. epiroticum have reddish brown to brown peridial surfaces and verrucose spores while H. fragile and H. nephriticum have off-white and yellowish brown peridial surfaces and smooth spores. Hysterangium clathroides and H. nephriticum have glebae with filled locules while H. epiroticum has empty locules. The gleba of H. fragile has a dendroid columella. Hysterangium epiroticum has a 3-layered peridium while H. clathroides, H. fragile, and H. nephriticum have 2-layered peridia. Gautieria otthii has a 1-layered peridium and small spores while Gautieria retirugosa and G. trabutii have 2-layered peridia and larger spores. Gautieria species have ornamented spores with longitudinal ribs. Spores of G. otthii have smooth ribs while the ribs of G. trabutii have verrucae giving a knotted aspect. Gautieria retirugosa has reticulated ribs at the base. Hymenogaster citrinus and H. lycoperdineus have a smooth peridial surface while H. hessei and H. luteus have a wrinkled and tomentose surface. Hymenogaster citrinus and H. hessei have 2-layered peridia while H. luteus and H. lycoperdineus have 1-layered peridia. Hymenogaster luteus has pale yellow, smooth spores while H. hessei, H. citrinus, and H. lycoperdineus have a distinct enveloping perisporium. Hymenogaster citrinus has large, citriform spores up to 40 µm long while the others have smaller and ellipsoid spores. The spores of H. hessei have a rib-like ornamentation while H. lycoperdineus has distinctly papillated spores.

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