

New records of truffle fungi (Basidiomycetes) from Turkey

Aziz TÜRKÖĞLU^{1*}, Michael Angelo CASTELLANO²

¹Biology Department, Faculty of Science, Muğla Sıtkı Koçman University, Muğla, Turkey

²Department of Agriculture, Forest Service, Northern Research Station, Forestry Sciences Laboratory, Corvallis, Oregon, USA

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Abstract: We report the first records of 5 truffle taxa in Turkey: *Gymnomyces xanthosporus* (Hawker) A.H.Sm., *Hymenogaster griseus* Vittad., *Hymenogaster olivaceous* Vittad., *Hymenogaster thwaitesii* Berk. & Broome, and *Hymenogaster vulgaris* Tul. & C.Tul. We also report a new locality within Turkey for *Melanogaster broomeanus* Berk.

Key words: Truffle, Basidiomycota, Hymenogastraceae, Paxilliaceae, Russulaceae

1. Introduction

Most truffle-like fungi form ectomycorrhizae with plant hosts, particularly in the families Betulaceae, Cistaceae, Fagaceae, Myrtaceae, Pinaceae, and Saliaceae. 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 14 basidiomycete truffle species have been reported from Turkey: *Chlorophyllum agaricoides* (Czern.) Vellinga, *Gautieria graveolens* Vittad., *Gautieria monticola* Harkn., *Hydnangium virescens* Quél., *Leucogaster liosporus* R.Hesse, *L. luteomaculatus* Zeller & C.W.Dodge, *L. nudus* (Hazsl.) Hollós, *Melanogaster broomeanus* Berk., *Phallogaster saccatus* Morgan, *Rhizopogon luteolus* Fr., *R. marchii* (Bres.) Zeller & C.W.Dodge, *R. ochraceorubens* A.H.Sm., *R. roseolus* (Corda) Th.Fr., and *Torrentia pulchella* Bres. (Solak et al., 2007; Kaya, 2009; Sesli and Castellano, 2009; Castellano and Türkoğlu, 2012; Sesli and Denchev, 2012; Türkoğlu and Yağız, 2012; Güngör et al., 2013). In our new efforts to identify and catalogue all the truffles from Turkey, we have examined all collections known from the country. Here we present 5 basidiomycetes (4 of *Hymenogaster* Vittad., 1 of *Gymnomyces* Masee & Rodway) identified as new records for Turkey. In addition, we present a new locality for the previously reported *Melanogaster broomeanus*.

2. Materials and methods

Field work was restricted to the Denizli, Muğla, and Samsun provinces of Turkey. These provinces are in

the Aegean, the Mediterranean, and the Black Sea phytogeographical regions. Some of the specimens were found with the help of a truffle dog. Macromorphological characteristics (size, fresh colour, bruising reactions, and odour) of specimens were recorded, after which each specimen was photographed in its natural habitat. Micromorphological characters were recorded after tissue sections were rehydrated in 3% KOH or Melzer's reagent. Spores and sterile tissues were photographed through a compound microscope. All collections are deposited in the herbaria of Muğla Sıtkı Koçman University and Oregon State University.

3. Results

In our study, 6 taxa belonging to 3 families were identified. These taxa are presented below with their localities, habitats, collection dates, and accession numbers.

Russulaceae

Gymnomyces xanthosporus (Hawker) A.H.Sm.

Macroscopic characters: Basidiocarp 0.5–2 cm in diameter, subglobose to slightly lobed (Figure 1), surface smooth, pale red-brown at first, red-brown when mature, some parts dark red-brown or even black. Gleba overall pale yellow but close examination reveals off-white tramal plates with abundant pale yellow to yellow-brown spores lining the irregular labyrinthine locules, locules 0.2–0.3 mm broad, empty. **Microscopic characters:** Peridium 115–140 µm thick, single-layered (Figure 1), uniform in structure, thin-walled (<0.5 µm), generally gelatinised, subparallel to somewhat interwoven hyphae, 3.5–5.5 µm broad, the outer portion pale yellow, inner portion off-

* Correspondence: turkoglu.aziz@gmail.com

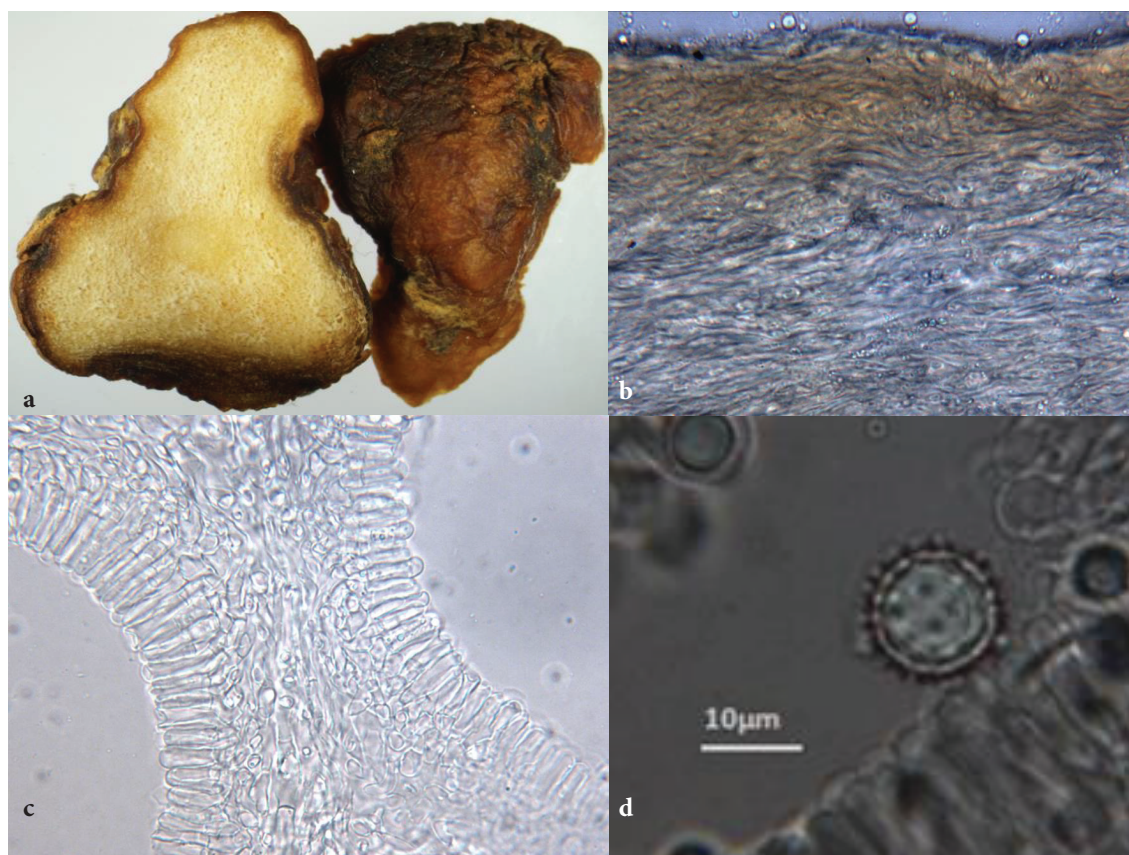


Figure 1. *Gymnomyces xanthosporus*: a- basidiocarp, b- peridium, c- trama, d- spore.

white. Dermatozystidia forming an irregular layer on surface of slender, hyaline, thin-walled ($<0.5\ \mu\text{m}$) hyphae, $2.5\text{--}3.5\ \mu\text{m}$ broad. Trama $10.5\text{--}35.5\ \mu\text{m}$ wide, of hyaline (Figure 1), walls $\pm 1\ \mu\text{m}$ thick, subgelatinised hyphae, $4.5\text{--}7.0\ \mu\text{m}$ broad, with areas of inflated cells, cells up to $6.5\text{--}9 \times 10.5\text{--}26.5\ \mu\text{m}$. Subhymenium of hyaline, thin-walled ($<0.5\ \mu\text{m}$) hyphae somewhat inflated up to $13.2\ \mu\text{m}$. Basidia $5.0\text{--}12.5 \times 21\text{--}37\ \mu\text{m}$, clavate, hyaline, walls $<0.5\ \mu\text{m}$, 2-spored, clamp connections present; sterigmata hyaline, up to $3.5\text{--}7 \times 1\text{--}2\ \mu\text{m}$. Spores $9\text{--}12.5 \times 9\text{--}13.5\ \mu\text{m}$ including ornamentation (Figure 1), mean $10.2 \times 12.3\ \mu\text{m}$, walls $\pm 1\ \mu\text{m}$ thick, subglobose, symmetrical, hyaline to pale yellow-brown, ornamentation partially amyloid, spiny and $1\text{--}2\ \mu\text{m}$ tall.

Locality. Denizli: Bozkurt, İnceler, under mixed *Pinus* spp. and *Quercus* spp., 15 June 2012, *Türkoğlu* AT-1435.

Strophariaceae

Hymenogaster griseus Vittad.

Macroscopic characters: Basidiocarp $0.5\text{--}2\ \text{cm}$ in diameter, subglobose to slightly lobate (Figure 2), surface glabrous, white at first, later yellow-brown, finally dark yellow-brown. Gleba overall dark brown but close examination reveals off-white to grey tramal plates with

abundant dark brown spores lining each locule, locules irregular, $0.1\text{--}0.2\ \text{mm}$ broad, empty. *Microscopic characters*: Peridium $60\text{--}130\ \mu\text{m}$ thick (Figure 2), off-white at first, later pale yellow, single-layered with a complex structure, a mixture of areas of inflated cells and interwoven hyphae, the outer and inner areas have hyaline, walls $<0.5\ \mu\text{m}$ thick, interwoven hyphae, $2\text{--}3.5\ \mu\text{m}$ thick, but middle area composed of hyaline, inflated cells, $9\text{--}11 \times 11\text{--}13\ \mu\text{m}$ with occasionally even larger cells, $26\text{--}33 \times 38\text{--}44\ \mu\text{m}$, walls $<0.5\ \mu\text{m}$ thick. Trama $22\text{--}40\ \mu\text{m}$ wide, of hyaline (Figure 2), subparallel to interwoven hyphae, $7\text{--}9\ \mu\text{m}$ broad, walls $<0.5\ \mu\text{m}$ thick, some cells becoming inflated to $11 \times 22\ \mu\text{m}$, clamp connections absent. Subhymenium of hyaline, hyphae somewhat inflated up to $10\ \mu\text{m}$ in diameter, walls $<0.5\ \mu\text{m}$ thick. Basidia reviving poorly, cylindrical-subclavate, hyaline, walls $<0.5\ \mu\text{m}$ thick, 2-spored; sterigmata not seen. Spores $21\text{--}24 \times 10.5\text{--}12.5\ \mu\text{m}$ including ornamentation (Figure 2), mean $22.5 \times 11.8\ \mu\text{m}$, walls $\pm 2\ \mu\text{m}$ thick, ellipsoid to broadly fusiform, symmetrical, pale yellow brown at first, soon deeper yellow-brown, finally dark yellow-brown, apex apiculated, base pedicellate, ornamentation densely rugose, rugosity contains patches and pits that are very irregular in appearance along most

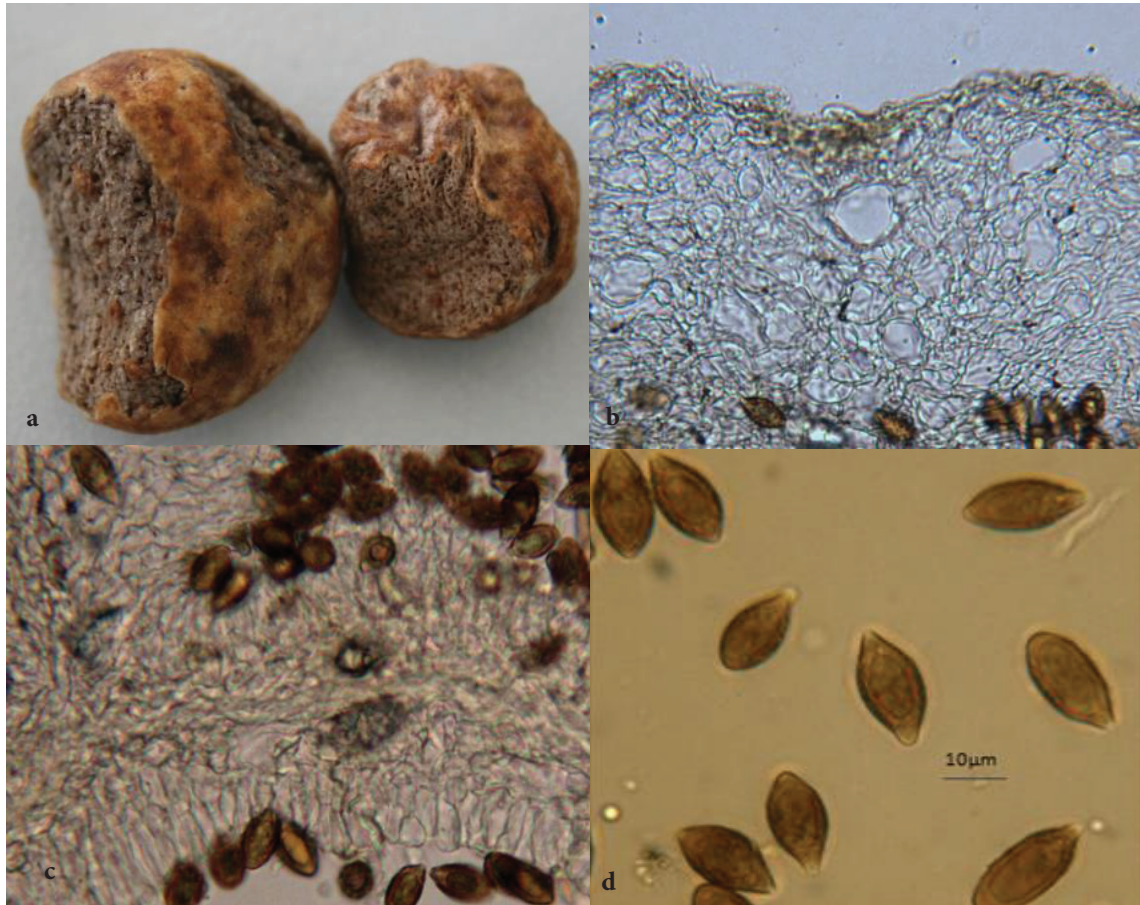


Figure 2. *Hymenogaster griseus*: a- basidiocarps, b- peridium, c- trama, d- spores.

of the spore except the unornamented apex, rugosity also includes some short lines and clumps but all more or less aligned along the length of spore. Pedicel hyaline, 2–3 μm long, 2–4 μm wide.

Locality. Muğla: Fethiye, Gökben village, in calcareous soils under *Quercus pubescens*, 15 March 2012, *Türkoğlu* AT-1422.

Hymenogaster olivaceus Vittad.

Macroscopic characters: Basidiocarp 1–4 cm in diameter, subglobose to irregular (Figure 3), surface smooth, off-white to pale brown at first, later becoming dark olivaceous-brown. Gleba of irregular labyrinthine locules, 0.1–0.3 mm broad, tramal plates off-white to grey, locules lined with dark yellow-brown spores. **Microscopic characters:** Peridium 105–145 μm thick, single-layered (Figure 3), of generally parallel to somewhat interwoven hyphae, mostly 2.5–4.5 μm broad but some hyphae inflated up to 5–7 × 8–10 μm and rarely 7–9 × 13–18 μm, walls <0.5 μm thick, the outer portion of the layer pale yellow, inner portion of the layer dark yellow. Trama 18–35 μm wide, of hyaline (Figure 3), gelatinised, interwoven hyphae,

3.5–9 μm broad, walls ±1 μm thick, clamp connections absent. Subhymenium of hyaline hyphae, 2.5–6.0 μm broad with some greatly inflated cells, 18–22 × 13–17 μm, walls <0.5 μm thick. Basidia elongate, 22–30 × 4–7 μm, hyaline, walls <0.5 μm thick, 2-spored; sterigmata hyaline, 3.5–6.5 × 13.5–22.0 μm. Spores 12.5–27.5 × 25.0–47.5 μm including ornamentation (Figure 3), mean 15.4 × 32.1 μm, walls ±2 μm thick, narrowly fusiform, spindle-like, symmetrical, pale yellow to dark yellow-brown, both ends spindle-shaped, apex elongated, 4.0–8 μm long and ±2 μm wide, base claw-like, 4.0–6.5 μm long, 3.0–4.0 μm wide, ornamentation densely rugose to ruminant except absent at base and apex.

Locality. Denizli: Çameli, in calcareous soils under mixed *Quercus* spp. and *Pinus* spp., 6 May 2010, *Türkoğlu* AT-1217.

Hymenogaster thwaitesii Berk. & Broome

Macroscopic characters: Basidiocarp 2–3 cm in diameter, subglobose to irregular (Figure 4), surface smooth, off-white at first, brown when dried. Gleba of irregular labyrinthine locules, 0.1–0.3 mm broad, tramal

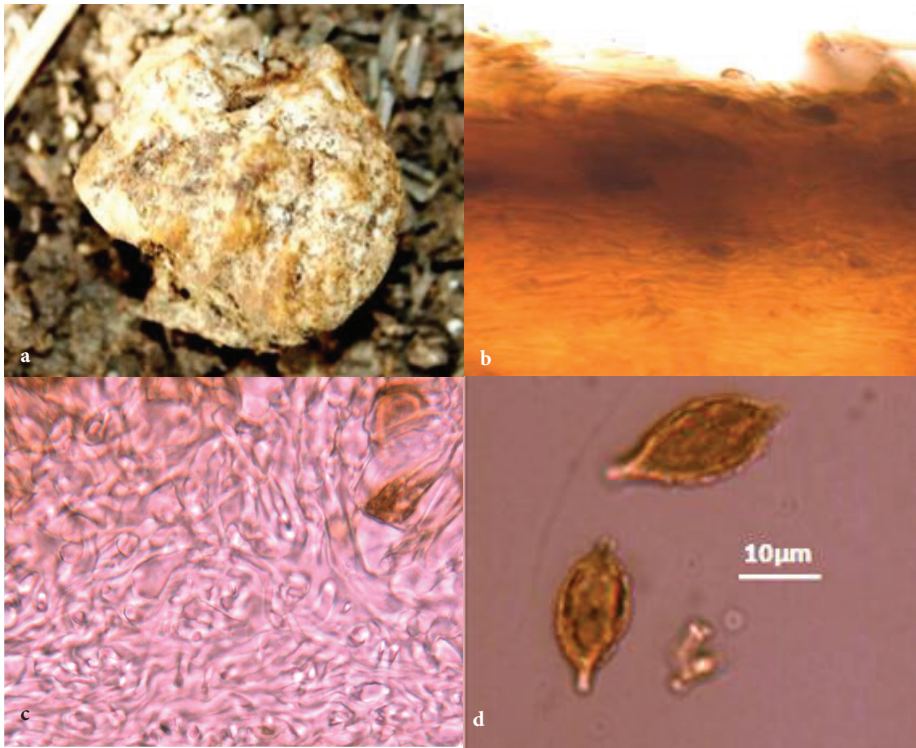


Figure 3. *Hymenogaster olivaceus*: a- basidiocarp, b- peridium, c- trama, d- spores.

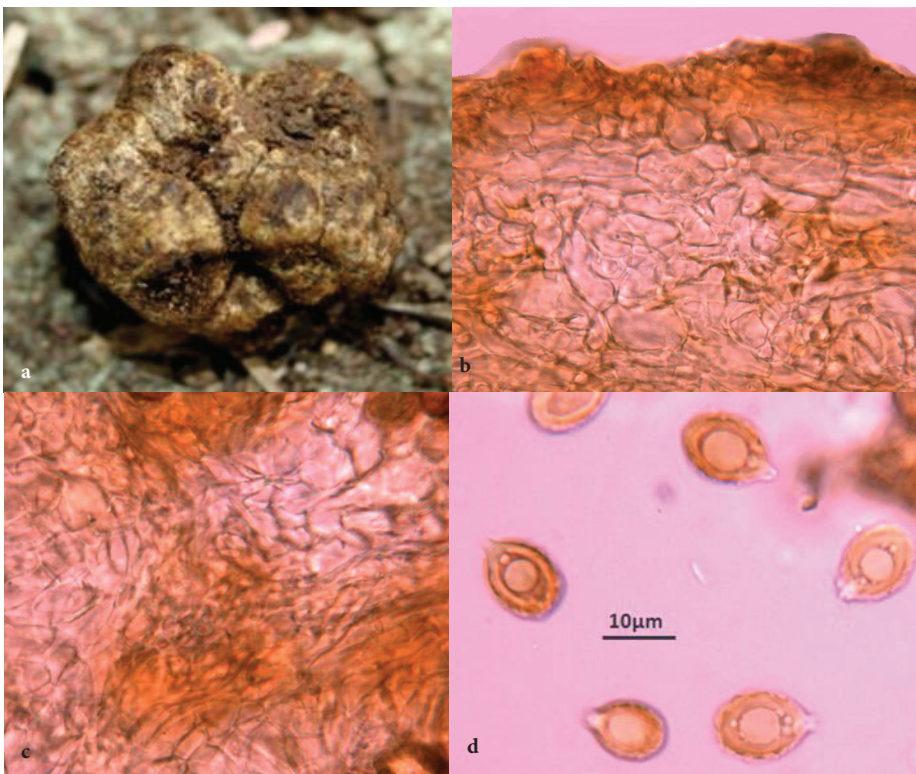


Figure 4. *Hymenogaster thwaitesii*: a- basidiocarp, b- peridium, c- trama, d- spores.

plates off-white to brown, locules lined with red-brown spores. *Microscopic characters*: Peridium 270–430 μm thick, single-layered of hyaline (Figure 4), generally parallel to somewhat interwoven hyphae, 3.5–12.5 μm broad, walls ± 1 μm thick, with some cells inflated up to 9–13.0 \times 13–26 μm , occasionally 26–29 \times 30–35 μm and rarely 26 \times 52 μm , the outer portion of layer yellow-brown, inner portion of layer pale yellow. Trama 18–35 μm wide, of hyaline, loosely interwoven hyphae (Figure 4), 2.5–6.0 μm broad, walls ± 1 μm thick. Subhymenium of hyaline hyphae somewhat inflated up to 6–9 \times 22–26 μm , walls ± 1 μm thick. Basidia 7–9 \times 18–31 μm , elongate, hyaline, walls < 0.5 μm thick, 2-spored; sterigmata hyaline, up to 1.5–4.5 \times 19.0–24.5 μm . Spores 10.0–17.5 \times 15.0–27.5 μm including ornamentation (Figure 4), mean 13.5 \times 21.5 μm , walls ± 1 μm thick, broadly ellipsoid, symmetrical, yellow-brown to dark red-brown, apex obtuse, base distinctly pedicellate, 2.5–4.5 μm long, 2.5–3.5 μm wide, ornamentation is densely rugose to ruminate.

Locality. Denizli: Çameli, in calcareous soils under mixed *Quercus* spp. and *Pinus* spp., 6 May 2010, *Türkoğlu* AT-1216.

Hymenogaster vulgaris Tul. & C.Tul.

Macroscopic characters: Basidiocarp 0.5–2 cm in diameter, subglobose to slightly lobed (Figure 5), surface smooth, off-white at first, later pale yellow-brown. Gleba dark brown, irregular labyrinthine locules, 0.2–0.3 mm broad. *Microscopic characters*:

Peridium 310–350 μm thick, pale yellow (Figure 5), single-layered but complex in structure, a mixture of areas of hyaline, subparallel to interwoven hyphae, 5–10 μm broad interspersed with some inflated cells 12–17 \times 20–26 μm , walls ± 1 μm thick. Trama 30–45 μm wide, of hyaline (Figure 5), subgelatinised, interwoven hyphae, 4.5–7.0 μm broad, some cells becoming inflated to 13–18 \times 22–53 μm , walls ± 1 μm thick. Subhymenium of hyaline hyphae somewhat inflated up to 22 μm , walls < 0.5 μm thick. Basidia cylindrical-clavate, 25–30 \times 5–8 μm , hyaline, walls < 0.5 μm thick, 2-spored; sterigmata not seen. Spores 9.5–12.5 \times 18.5–26.5 μm including ornamentation (Figure 5), mean 10.6 \times 20.7 μm , walls ± 2 μm thick, varying in form, typically narrowly fusiform to broadly fusiform, brown-yellow to dark brown-yellow, apex usually distinctly acute, base

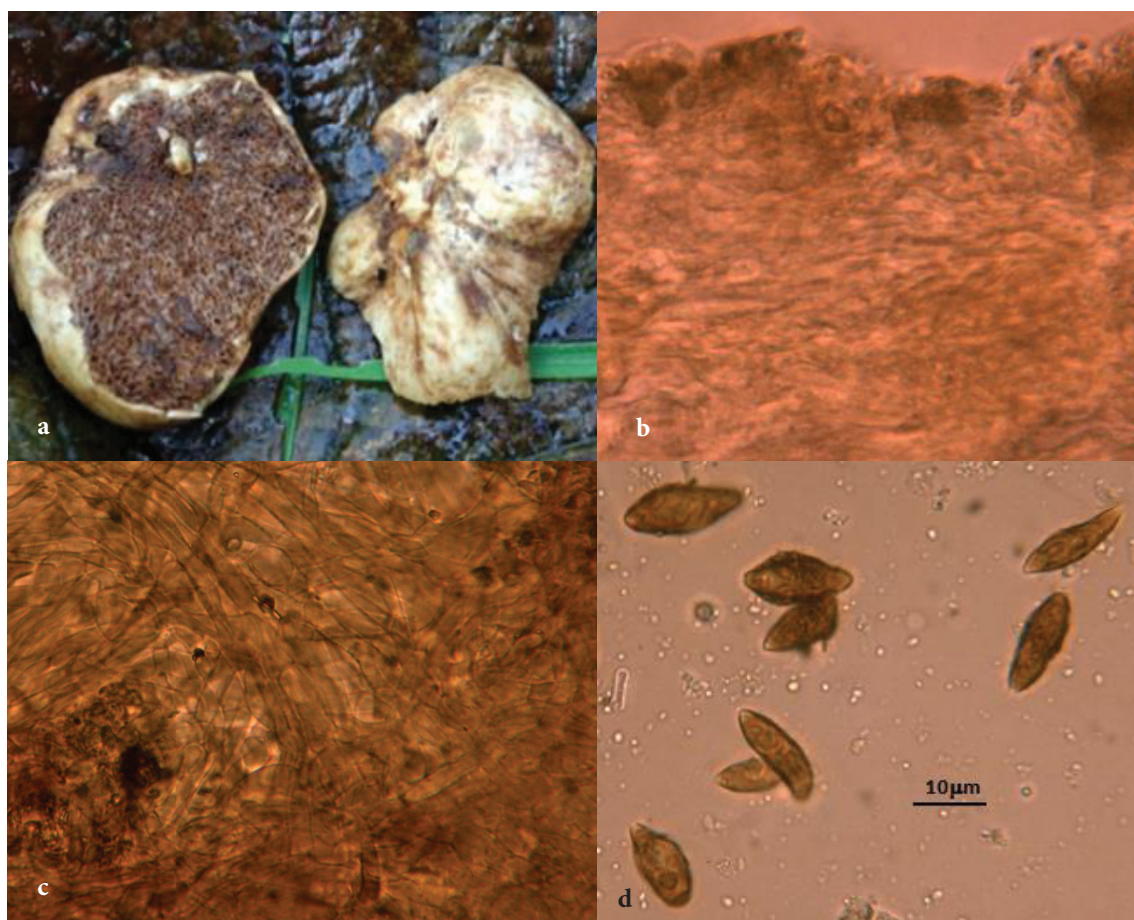


Figure 5. *Hymenogaster vulgaris*: a- basidiocarp, b- peridium, c- trama d- spores.

distinctly pedicellate, 2.5–4.5 μm long and 1.0–3.5 μm wide, ornamentation densely rugose to ruminant. While young spores are relatively large, pale, and smooth, mature spores are smaller and more ornamented.

Locality. Samsun: Çarşamba, under *Corylus* sp., 24 November 2010, *Türkoğlu* AT-1405.

Paxillaceae

Melanogaster broomeanus Berk.

Macroscopic characters: Basidiocarp 2–5 cm in diameter, subglobose to irregularly lobed or slightly flattened (Figure 6), with irregular grooves with patches and pits, surface finely tomentose, pale yellow-brown at first, later deep red-brown, bruising nearly black. Gleba overall black but close examination reveals thin, pale yellow tramal plates with fairly regular locules that are filled with a near black gelatinous matrix containing dark brown spores. *Microscopic characters:* Peridium 330–400 μm thick, single-layered (Figure 6), the outer portion red-

yellow with pigmented cells, inner portion pale yellow to off-white, of generally parallel to the surface but also somewhat interwoven hyphae, 3.5–9.0 μm broad, with some inflated cells up to 17–20 \times 62–44 μm , walls ± 1 μm thick, clamp connections present. Trama 40–50 μm wide, of hyaline (Figure 6), gelatinised, interwoven hyphae, 3.5–8.0 μm broad, walls ± 1 μm thick, clamp connections present. Subhymenium irregular structure of hyaline, gelatinised, loosely interwoven hyphae, 3.5–8.8 μm hyphae, with some cells inflated up to 8.8–15.8 \times 17.6–21.9 μm , walls ± 1 μm thick. Basidia poorly reviving. Spores 4.5–5.5 \times 7.0–10.5 μm (Figure 6), mean 5.1 \times 9.1 μm , walls ± 1 μm thick, ellipsoid to subcylindrical, apex obtuse, base broadly truncate, symmetrical, hyaline to pale dark-brown, walls nearly black in cross-section.

Locality. Denizli: Acıpayam under mixed *Pinus* spp. and *Quercus* spp., 10 May 2011, *Türkoğlu* AT-1418.

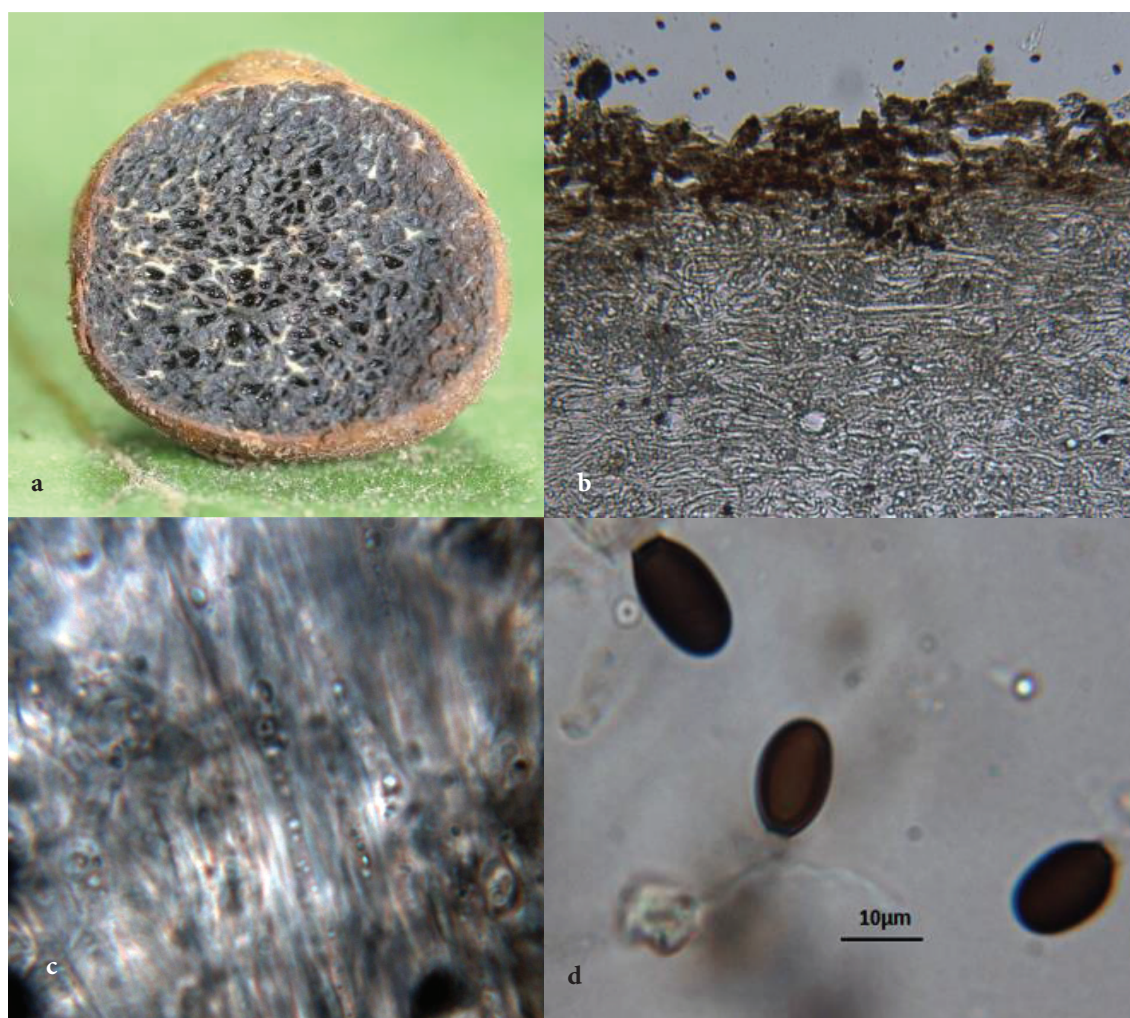


Figure 6. *Melanogaster broomeanus*: a- basidiocarp, b- peridium, c- trama, d- spores.

4. Discussion

In this study, we report 5 truffle taxa found in Turkey for the first time: *Gymnomyces xanthosporus* (Hawker) A.H.Sm., *Hymenogaster griseus* Vittad., *H. olivaceous* Vittad., *H. thwaitesii* Berk. & Broome, and *H. vulgaris* Tul. & C.Tul. We also report a new locality within Turkey for *Melanogaster broomeanus* Berk.

Gymnomyces xanthosporus is a rather uncommon species across Europe. Our material fits well that described by Pegler et al. (1993) and Montecchi and Sarasini (2000). Our concept of *Hymenogaster griseus* agrees well with that of Lange (1956), Pegler et al. (1993) and Montecchi and Sarasini (2000). It appears closely associated with *Quercus* spp. and *Fagus* spp. in West Europe as well as in Turkey. *Hymenogaster olivaceous* has distinct spindle-like spores as nicely illustrated by Pegler et al. (1993) and Montecchi and Sarasini (2000). It appears to also be closely associated with Fagaceae hosts. *Hymenogaster thwaitesii* has spores that lack an apiculus, making it easily differentiated

from the other species known from Turkey. It appears to be the most uncommon of the *Hymenogaster* species that we present. Our material of *Hymenogaster vulgaris* matches well the characters reported by Lange (1956) and Montecchi and Sarasini (2000) from the Netherlands and Italy, respectively. Pegler et al. (1993) reported the spores as being much larger than we accept, but that could be due to the immature spores being larger than mature spores, as we report measurements only of mature spores. *Melanogaster broomeanus* appears to be a common truffle found across Europe associated with Fagaceae hosts.

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