Contribution to the smut fungi of Greece

Authors: Teodor T. Denchev, and Cvetomir M. Denchev

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Introduction

Greece is home to an unusually high diversity of vascular plants, ranking among the highest in Europe and the Mediterranean area with 5752 species, and one of the most important centres of endemism with 1278 endemic species (22.2% of the total number of species) (Dinopoulous & al. 2013). This is a prerequisite for a high species richness of parasitic fungi on plants. However, the diversity of the smut fungi in Greece (Ustilaginomycotina and Microbotryales) is not intensively studied. No regional monographic study has been carried out yet. To date, only 66 species on 77 vascular plant species have been reported, making 86 smut-host combinations (Hohenbühel 1868; Bornmüller 1894, 1928; Magnus 1894; Maire 1905, 1917; Sarejanni 1935, 1939; Sydow 1935; Săvulescu 1937; Konstantinia-Sulidu 1939; Maire & Politis 1940; Petrak 1943, 1944, 1956; Apostolidis 1952; Cripopoulos 1953; Demetriades & Zachos 1962; Durrieu 1968; Brandenburger 1969; Pyrowolakis & Weltzien 1970; Vánky 1980, 1985a, 1986, 1989, 1990a, b, 1991, 1992, 1996, 1998, 2003a, b, 2008, 2011; Scholz & Scholz 1988; Scheuer 1992, 2010; Vánky & Oberwinkler 1994; Denchev 1997; Triebel 1998, 1999; Vánky & Scholz 2001; Vánky & Berner 2003; Kashefi & Vánky 2004; Vánky & al. 2005; Denchev & Minter 2008, 2011a, b; Braun 2013; Denchev & al. 2013; Savchenko & al. 2014).

In the present article, eight species of smut fungi (indicated by * in the text) are reported for the first time from Greece: Microbotryum dianthorum, Sporisorium pulverulentum, Tilletia fusca, T. lolii, Urocystis dactylidina, U. johansonii, U. ornithogali and U. ulei. Four fungus-host combinations are recorded for the first time: Microbotryum dianthorum on Dianthus viscidus, Tranzscheliella williamsii on Stipa isoldeae, Urocystis dactylidina on Dactylis glomerata subsp. hackelii and Urocystis ulei on Festuca jeanpertii. Two plant species are reported as new hosts of smut fungi already known from Greece: Stipa isoldeae for Tranzscheliella williamsii, and Lygeum spartum for T. hypodytes. All ten species of smut fungi are illustrated. A description is also provided for Urocystis agropyri, recorded in Greece on Thinopyrum junceum.

Key words: Dactylis glomerata subsp. hackelii, Dianthus viscidus, Festuca jeanpertii, Greece, Microbotryum, smut fungi, Sporisorium, taxonomy, Stipa isoldeae, Tilletia, Tranzscheliella, Urocystis
**Material and methods**

Dried specimens from the herbarium of B (herbarium code according to Thiers 2016+) were examined under a light microscope (LM) and a scanning electron microscope (SEM). For LM observations and measurements, spores were mounted in lactoglycerol solution (w : la : gl = 1 : 1.2) on glass slides, gently heated to boiling point to rehydrate the spores, and then cooled. The measurements of spores are given as min-max (mean ± 1 standard deviation). For SEM, spores were attached to specimen holders by double-sided adhesive tape and coated with platinum-palladium in an ion sputter. The surface structure of the spores was observed and photographed at 5 kV accelerating voltage using a JEOL JSM-7600F scanning electron microscope (Naturalis Biodiversity Center, Leiden, The Netherlands). The descriptions below are based entirely on the specimens examined. The description of spore ornamentation is in accordance with Denchev & al. (2013). The height of the wall ornamentation (warts and spines) was measured with SEM. Lists of shapes of sterile cells or spores are arranged in descending order of frequency.

**New records of smut fungi for Greece**

*Microbotryum dianthorum* (Liro) H. Scholz & I. Scholz in Englera 8: 206. 1988, s. lat. – Fig. 1A–C.

*Sori* in anthers (some flowers may be unaffected). Spore mass dark reddish brown. *Sporides* globose, subglobose, broadly ellipsoidal, ellipsoidal or ovoid, (5.5–)6–8.5(–9.5) × (5–)5.5–7.5(–8) (7.2 ± 0.6 × 6.4 ± 0.5) μm (n = 100), pale vinchaceous; spore wall reticulate, 1–1.5 μm thick; meshes (5–)6–9 per spore diameter, polygonal or rounded, 0.4–1.1(–1.8) μm wide; muri 0.5–0.9 μm high; interspaces in SEM smooth or rugulose.


*Note* — *Dianthus viscidus* is a new host for *Microbotryum dianthorum*.

*Sporisporium pulvulentum* (Cooke & Massee) Vánky in Symb. Bot. Upsal. 24(2): 120. 1985. – Fig. 1D–F.

*Sori* in all spikelets of inflorescence, elongate to cylindric, c. 1.5 × 0.7 mm, partially concealed by glumes, covered by a thick yellow-brown to rusty brown peridium that ruptures irregularly (usually at apex) exposing a single, stout, tapering, sometimes slightly branched columella with shallow, longitudinal furrows. Columella to 5 mm long, surrounded by powdery, blackish brown mass of spores and sterile cells. Sterile cells in irregular groups (single sterile cells not seen), subglobose, broadly ellipsoidal or irregular, often collapsed, (7–)8.5–16.5(–18.5) μm long, hyaline; cell wall 0.6–1.2 μm thick. Spores subglobose, broadly ellipsoidal, slightly irregular or ovoid, sometimes ellipsoidal, (9.5–)10–13.5(–15) × (8.5–)9.5–12(–13) (12.0 ± 0.8 × 10.8 ± 0.8) μm (n = 100), medium yellow-brown; spore wall ± evenly thickened, 0.6–0.8(–1) μm thick, often with one or two paler, rounded areas of 2.5–4 μm in diam., minutely verruculose, spore profile not affected or slightly affected, in SEM minutely echinulate; spines to 0.2 μm high, spore surface densely punctate between spines.

*Specimen examined* — On *Saccorhiza strictum* (Host) Spreng. – GREECE: Rodos island, c. 1 km E of Archangeios, 23 Oct 2003, M. Ristow (B 70 0015526).

*Note* — *Sporisorium pulvulentum* is a rare species known only from S Europe and S and SE Asia (India, Malaysia and Indonesia) (Vánky 2011; Chalkley 2015). In Europe, it has previously been recorded only from Serbia (Mt Fruska Gora near Novi Sad; Vánky 1985a, b).

*Tilletia fusca* Ellis & Everh. in J. Mycol. 3: 55. 1887. – Fig. 2A–C.

*Sori* in ovaries of most spikelets of infected plant, ovoid, 1.5–2.2 mm long, partially concealed by floral envelopes, initially covered by thin, dark brown pericarp that later ruptures exposing powdery, dark reddish brown mass of spores and sterile cells. Sterile cells subglobose or broadly ellipsoidal, sometimes slightly irregular, (9.5–)10.5–14.5(–15.5) × (9–)10–13.5(–14.5) μm, hyaline; cell wall 0.9–1.6 μm thick, in SEM smooth. Spores globose, subglobose or broadly ellipsoidal, (16.5–)17.5–20.5(–21.5) × (16–)17–19.5(–20.5) (19.1 ± 1.0 × 18.2 ± 1.0) μm (n = 100), light to medium yellow-brown, completely reticulate; spore wall 3–3.8 μm thick (including reticulum and hardly visible, 0.5–0.7 μm-thick inner layer); meshes (5–)6–8(–9) per spore diameter, usually polyhedral, sometimes rounded, (0.9–1.2–3.5(–4) μm wide; muri 21–29 on equatorial circumference, in optical median view subacute or blunt, (1.2–)1.4–1.8(–2.2) μm high, in SEM some meshes with a low hemispherical protuberance on bottom.

*Specimen examined* — On *Vulpia ciliosa* Dumort. – GREECE: Crete, Agia Triada, 27 Mar 1979, R. Böcker (B 70 0015527).
Fig. 1. A–C: Microbotryum dianthorum on Dianthus viscidus (B 70 0007639); A: habit; B, C: spores in LM and SEM, respectively. – D–F: Sporisorium pulverulentum on Saccharum strictum (B 70 0015526); D: habit; E, F: spores in LM and SEM, respectively. – Scale bars: A = 0.5 cm, B = 10 µm, C = 1 µm, D = 0.2 cm, E = 10 µm, F = 5 µm.
Fig. 2. A–C: *Tilletia fusca* on *Vulpia ciliata* (B 70 0015527); A: habit; B: spores in LM; C: spores and a sterile cell in SEM. – D–F: *Tilletia lolii* on *Lolium temulentum* (B 70 0015546); D: habit; E: spores in LM; F: spores and a sterile cell in SEM. – Scale bars: A = 0.2 cm, B = 10 µm, C = 5 µm, D = 0.2 cm, E = 10 µm, F = 5 µm.
Sori in all ovaries of infected plant, ovoid, 3–4 × 1.2–1.8 mm, partially concealed by floral envelopes, initially covered by thin, purplish brown pericarp that later ruptures exposing powdery, cinnamon-brown mass of spores and sterile cells. Sterile cells subglobose, broadly ellipsoidal or slightly irregular, (11.5–)12.5–15.5(–18) × (10.5–11.5–14.5(–16.5) μm, subhyaline; cell wall (0.9–)1.2–1.8(–2.3) μm thick, smooth. Spores globose, broadly ellipsoid or subglobose, (18–)18.5–21.5(–23) × (17.5–)18–20(–21) (19.9 ± 0.7 × 19.0 ± 0.6) μm (n = 100), light yellow-brown, completely reticulate; spore wall 2.9–4 μm thick (including reticulum and 0.5–0.8 μm-thick inner layer), covered by a hyaline sheath 0.3–0.6 μm thick; meshes (5–)6–7(–8) per spore diameter, usually polyhedral, sometimes rounded, 0.7–3.8(–4.3) μm wide; muri 25–33 on equatorial circumference, in optical median view acute or subacute, 1.3–2.2(–2.5) μm high, in SEM single meshes with a low hemispherical or conical protuberance on bottom.

Specimen examined — On Lolium temulentum L. – GREECE: Crete, Prov. Rethymno, between the mountain peaks TsiliVidakas and Xilis Korifi near Kali Sikia village, 720 m, 30 May 1983, Greuter & Matthäus (B 70 0015546).

Tranzscheliella hypodytes (Schldtl.) Vánky & McKenzie, Smut Fungi New Zealand: 156, 2002, s. lat. – Fig. 3A–C.

Sori around upper internode or around branches of aborted inflorescence, initially covered by upper leaf sheaths or spatheole, respectively, later exposed; peridium absent. Spore mass powdery, blackish brown. Infection systemic. Spores slightly flattened, in plane view suborbicular, orbicular or broadly elliptic, sometimes slightly irregular, in plane view (5.5–)6–9(–9.5) × (5–)5.5–7.5(–8) (7.4 ± 0.8 × 6.8 ± 0.5) μm (n = 100), medium olivaceous brown; spore wall 0.6–1 μm thick, smooth; exospore often cracked, bearing 2 persistent appendages on flattened sides, in SEM with low, flattened, densely packed ornamentations connected in small groups and short rows or forming labyrinthinform pattern.


Notes — From Greece, Tranzscheliella williamsii has been previously recorded only once, as T. otophora Lavrov, on Stipa sp. (Petrak 1956). The relevant specimen is kept at the Mycological Collection of the Natural History Museum, Vienna (W): Epirus, Distr. Ioannina, Montes Pindus, in monte Tsuka Rossa ditionis pagi V ourinos massif, 1600–1980 m, in pinetis, substr. serpent., 1–2 Aug 1956, K. H. Rechinger, Iter Graecum VIII, 1956; W 1976-04903) (Fig. 3D). This specimen was re-examined by us and its identification was confirmed.

Stipa isoldeae is endemic to Greece. This grass is reported here as a new host of Tranzscheliella williamsii.


Sori in leaves, sheaths and culms as long striae, initially covered by epidermis that later ruptures disclosing semi-agglutinated, blackish brown mass of spore balls. Spore balls irregular, subglobose, broadly ellipsoidal, ellipsoidal or ovoid, composed of 1–4 (or 5) central spores (1 = 26.5 %, 2 = 43.4 %, 3 = 20.3 %, 4 = 7.3 %, 5 = 2.4 %; n = 875), surrounded by a continuous or almost continuous layer of sterile cells, (16.5–)18–26(–28.5) × (14.5–)16–20(–21.5) μm [with 1 spore], (20.5–)22.5–29(–33) × (17.5–)19–24.5(–26.5) μm [with 2 spores], (24–)25.5–33(–36) × (19–)21–26.5(–28.5) μm [with 3 spores], (27.5–)29–40(–44.5) × (22.5–)24–29 (–31.5) μm [with 4 spores], Sterile cells elliptic, irregular, suborbicular, broadly elliptic, elongate or ovate in outline, collapsed, 4.5–12(–13) μm long, light yellow-brown; cell wall on side distal to spores 0.6–1.1 μm thick,
Fig. 3. A–C: *Tranzscheliella hypodytes* on *Lygeum spartum* (B); A: habit; B, C: spores in LM and SEM, respectively. – D: Habit of *Tranzscheliella williamsii* on *Stipa* sp. (W). – E, F: *Tranzscheliella williamsii* on *Stipa isoldeae* (B); E: habit; F: spores in LM. – Scale bars: A = 1 cm, B = 10 µm, C = 1 µm, D = 1 cm, E = 0.2 cm, F = 10 µm.
Fig. 4. A: Spores of *Tranzscheliella williamsii* on *Stipa isoldeae* (B) in SEM. – B, C: *Urocystis dactylidina* on *Dactylis glomerata* subsp. *hackellii* (B); B: spore balls in LM; C: spore ball in SEM. – D–F: *Urocystis johansonii* on *Juncus bufonius* (B); D: habit; E, F: spore balls in LM and SEM, respectively. – Scale bars: A = 1 µm, B = 10 µm, C = 5 µm, D = 0.5 cm, E = 10 µm, F = 5 µm.
on side proximal to spores thicker, smooth, in SEM punctate; projections irregularly arranged, often fused. Spores broadly ellipsoidal, subpolyhedral, subglobose, ellipsoidal or ovoid, sometimes cuneate or elongate, often slightly flattened on a few places, (11.5–)12.5–17.5(–19.5) × (10–)10.5–14.5(–16) (15.8 ± 1.4 × 12.8 ± 1.2) μm (n = 100), medium reddish brown; spore wall slightly uneven, 0.7–1.1 μm thick.


Note — In some websites, Urocystis agropyri is reported from Greece as collected on wheat. In fact, the correct identity of all collections, seen by him, was suspected to be wrongly identified. For this reason, U. dactildina needs a purposeful investigation. Dactylos glomerata subsp. hackelii, reported here, is a new host of U. dactildina.

*S. dactildina* (Lavrov) Zundel in Contri. Dept. Bot. School Agric. Pennsylvania State Coll. 176: 314. 1953. – Fig. 4B, C.

*S. dactildina* in leaves and sheaths as long striae, initially covered by epidermis that later ruptures disclosing powdery, blackish brown mass of spore balls. *Spore balls* irregular, broadly ellipsoidal, subglobose or ovoid, composed of 1–3(or 4) central spores (1 = 42.5 %, 2 = 45.3 %, 3 = 9.7 %, 4 = 2.5 %; n = 746), surrounded by a continuous or almost continuous layer of sterile cells, (18–)20–29(–32) × (16–)17–24(–28) μm [with 1 spore], (24–)26–34(–37) × (18–)20–28(–32) μm [with 2 spores], (29–)31–38(–42) × (23.5–)25–33(–37) μm [with 3 spores]. *Sterile cells* subcubical, broadly ellipsoidal, irregular, elliptic or ovate in outline, often collapsed, (4.5–)5.5–14(–17) μm long, medium yellow-brown; cell wall irregularly thickened, on side distal to spores 0.7–2.3(–2.6) μm thick, on side proximal to spores thicker, smooth, in SEM punctate; projections sometimes connected, forming fine, irregular pattern. *Spores* subpolyhedral, broadly ellipsoidal, subglobose or ovoid, sometimes ellipsoidai or cuneate, sometimes slightly flattened on a few places, (11.5–)12.5–18.5(–20) × (10–)11–15.5(–16.5) (15.3 ± 1.5 × 13.1 ± 1.2) μm (n = 100), medium reddish brown; spore wall slightly uneven, 0.8–1.2(–1.4) μm thick.


Note — Urocystis dactildina is a rare species collected only a few times in C Europe (Czech Republic, Switzerland, ?Poland) and Asia (W and E Siberia) (Vánky 1985a, 1994, 2011; Azbukina & Karatygin 1995; Karatygin 2012). Vánky (2011) noted that the host plant identity of all collections, seen by him, was suspected to be wrongly identified. For this reason, U. dactildina needs a purposeful investigation. Dactylos glomerata subsp. hackelii, reported here, is a new host of U. dactildina.

*S. johnsonii* (Lagerh.) Magnus in Verh. Bot. Vereins Prov. Brandenburg 37: 94. 1896. – Fig. 4D–F.

*S. johnsonii* at basal part of leaves as bulb-like swellings, initially covered by epidermis that later ruptures disclosing powdery, blackish brown mass of spore balls. *Spore balls* subglobose, irregular, broadly ellipsoidal, ovoid or ellipsoidal, composed of 1–5(–9) central spores (1 = 6 %, 2 = 29.6 %, 3 = 35.2 %, 4 = 15.6 %, 5 = 8.8 %, 6 = 2.8 %, 7 = 1 %, 8 = 0.7 %, 9 = 0.3 %; n = 609), surrounded by a continuous layer of sterile cells, (13.5–)14.5–20(–21) × (12.5–)13.5–17.5(–18.5) μm [with 1 spore], (18–)20–26–(29) × (14–)16–20(–22) μm [with 2 spores], (21–)22–30–(31.5) × (18–)19–23–(24.5) μm [with 3 spores], (23.5–)25–33(–35) × (19.5–)21–26(–28.5) μm [with 4 spores], (27–)29–41(–45) × (20–)22–31(–33) μm [with 5 spores]. *Sterile cells* irregular, subcubical, broadly elliptical or ovate in outline, collapsed, 3.5–13(–15) μm long, light or medium yellow-brown; cell wall on side distal to spores 0.5–0.8 μm thick, on side proximal to spores thicker, smooth, in SEM smooth. *Spores* subglobose, broadly ellipsoidal, slightly irregular, ellipsoidal or ovoid, sometimes slightly flattened on a few places, 10.5–15(–16) × (8–)9–12(–13) (13.0 ± 1.0 × 10.7 ± 0.8) μm (n = 100), dark reddish brown; spore wall slightly uneven, 0.9–1.4(–1.6) μm thick.


*S. ornithogali* Körn. ex A. A. Fisch. Waldh., Aperçu Syst. Ustilag.: 41. 1877. – Fig. 5A–C.
Fig. 5. A–C: **Urocystis ornithogali** on *Ornithogalum* sp. (B); A: habit; B, C: spore balls in LM and SEM, respectively. – D–F: **Urocystis ulei** on *Festuca jeanpertii* (B); D: habit; E, F: spore balls in LM and SEM, respectively. – Scale bars: A = 0.5 cm, B, C = 10 µm, D = 0.5 cm, E, F = 10 µm.
Sori in leaves and stems as small to large pustules, initially covered by epidermis that later ruptures disclosing powdery, blackish brown mass of spore balls. Spore balls irregular, broadly ellipsoidal, subglobose or ovoid, composed of 1–3(–5) central spores (1 = 31 %, \(2 = 41.7\) %, \(3 = 21.1\) %, \(4 = 5.3\) %, \(5 = 0.9\) %; \(n = 546\)), surrounded by a continuous layer of sterile cells, (18–)20–26(–28) × (16.5–)18–23(–25.5) \(\mu\)m [with 1 spore], (22–)25–33(–35) × (19.5–)21–26(–28) \(\mu\)m [with 2 spores], (24.5–)27–40(–44) × (22.5–)25–32(–35) \(\mu\)m [with 3 spores]. Sterile cells irregular, suborbicular, orbicular or ovate in outline, collapsed, 5–13(–15) \(\mu\)m long, light or medium yellow-brown; cell wall on side distal to spores 0.4–0.8 \(\mu\)m thick, on side proximal to spores thicker, smooth, in SEM smooth to sparcely punctate. Spores subglobohydral, broadly ellipsoidal, subglobose or cuneate, sometimes slightly flattened on a few places, (13–)14.5–20.5(–22.5) × (10.5–)11.5–16(–17) (17.3 ± 1.4 × 14.2 ± 1.0) \(\mu\)m (\(n = 100\)), medium reddish brown; spore wall slightly uneven, 0.7–1 \(\mu\)m thick.


*Urocystis ulei* Magnus in Rabenhorst, Fungi Europ. exsicc. 17: no. 2390. 1878. – Fig. 5D–F.

Sori in leaves and sheaths (infected plants usually sterile) as long, slightly swollen striae, initially covered by epidermis that later ruptures disclosing powdery, blackish brown mass of spore balls. Spore balls subglobose, broadly ellipsoidal, irregular, ellipsoidal or ovoid, composed of 1 or 2(–4) central spores (1 = 78.4 %, \(2 = 16.6\) %, \(3 = 4.2\) %, \(4 = 0.8\) %; \(n = 529\)), surrounded by a continuous or almost continuous layer of sterile cells, (14.5–)16–27(–29) × (12–)13.5–22(–23.5) \(\mu\)m [with 1 spore], (17.5–)20–34(–38) × (14.5–)16–25(–27) \(\mu\)m [with 2 spores], (27–)29–37(–40) × (22–)24–32(–35) \(\mu\)m [with 3 spores]. Sterile cells suborbicular, orbicular, irregular, broadly elliptic, elliptic or ovate in outline, collapsed, (5–)6–13(–15) \(\mu\)m long, light or medium yellow-brown; cell wall on side distal to spores 0.5–0.7 \(\mu\)m thick, on side proximal to spores thicker, smooth, in SEM punctate. Spores subglobose, broadly ellipsoidal, subglobose, slightly irregular, ellipsoidal or ovoid, sometimes elongate, sometimes slightly flattened on a few places, (11.5–)13–17(–19.5) × (10–)11–14.5(–15.5) (14.8 ± 1.4 × 12.7 ± 1.2) \(\mu\)m (\(n = 100\)), medium reddish brown; spore wall slightly uneven, 0.8–1.5 \(\mu\)m thick.


Note — *Festuca jeanpertii* is a new host for *Urocystis ulei*.

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References


