

Biodiversity of Hypogeous Fungi in Basilicata

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Abstract During the last two decades, systematic studies were carried out on biodiversity of hypogeous fungi in forestry territories of the two Basilicata (southern Italy) provinces, Matera and Potenza. Identification of fungus taxa found in the region was commonly accomplished on the basis of macro- and microscopic features, and only in a few instances, molecular analyses were utilized. Thanks to these investigations, Basilicata now occupies, among Italian regions, the first and fourth positions for number of *Tuber* species, varieties or forms and total number of hypogeous fungi (*Ascomycota*, *Basidiomycota* and *Zygomycota*) naturally growing in its woodlands and Mediterranean maquis areas. In fact, the last up-to-date acquisitions on the topic bring up to 29 and 53 the number of *Tuber* taxa and that of the other hypogeous and semi-hypogeous (only three entities) fungi present in the region, respectively. In this chapter, the essential information regarding these fungi is given, so updating to 2014 the relative available knowledge. Among the *Fungi*, object of this review, the *Ascomycota* *Pachyphloeus conglomeratus* and *Tuber malençonii*, the *Basidiomycota* *Hymenogaster decorus*, *H. hessey*, *H. rehsteineri*, *Schenella pityophilus* and *Myriostoma coliforme* as well as the *Zygomycota* *Youngiomyces multiplex* deserve a particular mention because of their rarity.

1 Introduction

In the last two decades, several researches have been carried out on biodiversity of hypogeous fungi of Basilicata, an Italian region characterized by a very heterogeneous territory for cenotic diversity deriving from its great geomorphologic complexity. The first studies accomplished on the topic by Cerone et al. (1994) and by the Potenza group of *Associazione Micologica G. Bresadola (Trento)* (Tagliavini 1999) showed that all the commercial species, varieties and forms of truffles were present in the region along with some unmarketable taxa, *i.e.* *Tuber excavatum* Vittad., *T. fulgens* Quél., *T. rufum* Pico: Fr. var. *rufum*, *T. rufum* var. *nitidum*

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(Vittad.) Montecchi & Lazzari, *T. gibbosum* Harkn., *T. maculatum* Vittad., *Choiromyces meandriformis* Vittad. and *Balsamia vulgaris* Vittad. The Institute of Plant and Forestry Pathology of the Agriculture Faculty of University of Basilicata [now School of Agricultural, Forestry, Food and Environmental Sciences (SAFE)] subsequently carried out systematic investigations on these fungi. Initially, with the graduation thesis entitled “Il tartufo in Basilicata” (Marino 1999), additional documented information was given on the above taxa, and presence of another hypogeous fungus, belonging to *Basidiomycota*, *Hymenogaster popouletorum* Tul. & C. Tul., was reported in Potenza province. Further studies (Cerone et al. 2000, 2002; Marino et al. 2003) allowed to bring up to 16 and six the numbers of Lucanian hypogeous fungi belonging to *Ascomycota Pezizales* and to *Basidiomycota*, respectively. Thanks to successive investigations (Marino et al. 2005; Rana et al. 2008, 2010, 2011, 2013a, and unpublished data), the number of hypogeous fungi naturally growing in Basilicata, including only three semi-hypogeous taxa, grew up to 82 entities as shown in Table 1. Although all fungi, object of the article, are well-known species, varieties or forms, *exsiccatae* of almost all specimens found in Basilicata were deposited in *Herbarium Lucanum (HLUC)* of SAFE. In this chapter, the essential information on these fungi is briefly reported. For those here mentioned for the first time, the main macro- and microscopic features along with the relative *exsiccata* number, date and site of finding are mentioned. For details about the great majority of Lucanian taxa, the available specific literature and truffle treatises by Montecchi and Sarasini (2000), Rioussset et al. (2001), Gori (2005), and Granetti et al. (2005) should be consulted. The nomenclature and taxonomic classification adopted for fungi object of the article are those reported on the MycoBank website (Crous et al. 2004; Robert et al. 2005).

2 Lucanian Hypogeous and Semi-hypogeous Fungi

2.1 *Ascomycota*

2.1.1 *Pezizomycotina, Eurotiomycetes, Eurotiomycetidae, Elaphomycetales, Elaphomycetaceae (Tul. & C. Tul.) Paol.*

The following three species of *Elaphomyces* grow in nature in the region: *E. leveillei* Tul. & C. Tul., *E. asperulus* Vittad. and *E. muricatus* Fries. The first one was found in a mixed wood of Pignola (PZ) communal territory (Cerone et al. 2000); the second and the third ones were collected under oak and beech plants in Terranova di Pollino (PZ) area (Rana et al. 2008).

Table 1 Hypogeous and semi-hypogeous fungi found in Basilicata between 1994 and 2014, listed in the taxonomical order reported in the article

Division	Family	Species/Var/Form
<i>Ascomycota</i>	<i>Elaphomycetaceae</i>	<i>Elaphomyces leveillei</i> , <i>E. asperulus</i> and <i>E. muricatus</i>
	<i>Helvellaceae</i>	<i>Balsamia vulgaris</i> , <i>Choiromyces meandriiformis</i> , <i>Fisherula macrospora</i> , <i>Leucangium chartusianum</i> and <i>Picoa lefebvrei</i>
	<i>Pezizaceae</i>	<i>Pachyphloeus citrinus</i> , <i>P. ligericus</i> , <i>P. conglomeratus</i> and <i>Sarcosphaera coronaria</i> var. <i>coronaria</i>
	<i>Pyronemataceae</i>	<i>Genea fragrans</i> , <i>G. hispidula</i> , <i>G. lespialtiii</i> , <i>G. sphaerica</i> , <i>G. verrucosa</i> , <i>G. papillosa</i> , <i>Geopora clausa</i> , <i>G. sumneriana</i> and <i>Stephensia bombycina</i>
	<i>Terfeziaceae</i>	<i>Terfezia arenaria</i> and <i>T. olbiensis</i>
	<i>Tuberaceae</i>	<i>Reddellomyces donkii</i> , <i>T. aestivum</i> , <i>T. aestivum</i> var. <i>uncinatum</i> , <i>T. asa-foetida</i> , <i>T. bellonae</i> , <i>T. borchii</i> , <i>T. brumale</i> , <i>T. brumale</i> var. <i>moschatum</i> , <i>T. dryophilum</i> , <i>T. excavatum</i> , <i>T. foetidum</i> , <i>T. fulgens</i> , <i>T. gibbosum</i> , <i>T. hiemalbum</i> , <i>T. macrosporum</i> , <i>T. maculatum</i> , <i>T. malençonii</i> , <i>T. magnatum</i> , <i>T. magnatum</i> var. <i>Vittadiniii</i> , <i>T. melanosporum</i> , <i>T. mesentericum</i> , <i>T. oligospermum</i> , <i>T. panniferum</i> , <i>T. puberulum</i> , <i>T. regianum</i> , <i>T. rufum</i> var. <i>apiculatum</i> , <i>T. rufum</i> fo. <i>ferrugineum</i> , <i>T. rufum</i> fo. <i>lucidum</i> , <i>T. rufum</i> fo. <i>nitidum</i> and <i>T. rufum</i> var. <i>rufum</i>
<i>Basidiomycota</i>	<i>Strophariaceae</i>	<i>H. aromaticus</i> , <i>H. bulliardii</i> , <i>H. decorus</i> , <i>H. hessei</i> , <i>H. luteus</i> var. <i>luteus</i> , <i>H. luteus</i> var. <i>subfuscus</i> , <i>H. lycoperdineus</i> , <i>H. olivaceus</i> , <i>H. populetorum</i> , <i>H. rehsteineri</i> and <i>H. vulgaris</i>
	<i>Melanogastraceae</i>	<i>Melanogaster ambiguus</i> var. <i>ambiguus</i> , <i>M. broomeanus</i> , <i>M. tuberiformis</i> , <i>M. umbrinogleba</i> and <i>M. variegatus</i>
	<i>Octavianiaceae</i>	<i>Octavianina asterosperma</i>
	<i>Rhizopogonaceae</i>	<i>Rhizopogon vulgaris</i>
	<i>Geastraceae</i>	<i>Geastrum fimbriatum</i> , <i>G. triplex</i> , <i>Myriostoma coliforme</i> and <i>Schenella pityophilus</i>
	<i>Gomphaceae</i>	<i>Gautieria graveolens</i> var. <i>graveolens</i> , <i>G. graveolens</i> var. <i>othii</i> and <i>G. morchellaeformis</i>
	<i>Hysterangiaceae</i>	<i>Hysterangium inflatum</i> , <i>H. nephriticum</i> and <i>H. stoloniferum</i>
	<i>Zygomycota</i>	
	<i>Endogonaceae</i>	<i>Youngiomyces multiplex</i>

2.1.2 *Pezizomycotina*, *Pezizomycetes*, *Pezizomycetidae*, *Pezizales*, *Helvellaceae* Fries

Balsamia vulgaris seems able to grow quite commonly in the region under *Quercus* spp. or in mixed woods (Cerone et al. 1994; Marino et al. 2005; Rana et al. 2011). It has been re-found in “Mantenera-Malcanale” mixed wood (Tricarico, MT) in 2014

(Rana et al. unpublished data). *B. polysperma* Vittad. was so far never found in Basilicata and appears limited to northern Italian regions (Montecchi and Sarasini 2000). *C. meandriformis* is enough distributed in Basilicata. It was at first found by Cerone et al. under *Quercus pubescens* Willd. (*s.l.*) and *Fagus sylvatica* L. (1994 and 2000) and repeatedly discovered in mixed woods of Tricarico (MT), Abriola and Brindisi di montagna (PZ) in successive years (Rana unpublished data). Findings of *Fischerula macrospora* Mattirollo, a taxon apparently limited to Italy (Montecchi and Sarasini 2000), occurred in territories of Tricarico (MT) in 2006 and Abriola (PZ) in 2011 (Rana et al. 2008, 2011) under *Q. pubescens* (*s.l.*) and *F. sylvatica*, respectively. *Picoa carthusiana* Tul. & C. Tul. [= *Leucangium carthusianum* (Tul. & C. Tul.) Paol.] and *P. lefebvrei* (Pat.) Maire were both only once reported in the communal mixed wood of Tricarico (PZ) (Rana et al. 2008, 2010).

2.1.3 *Pezizomycotina, Pezizomycetes, Pezizomycetidae, Pezizales, Pezizaceae Dumortier*

The hypogeous fungus genera naturally growing in Basilicata and belonging to this family are *Pachyphloeus* Tul. & C. Tul. and *Sarcosphaera* Auersw.

Two species of *Pachyphloeus* were discovered under oaks in Basilicata in 2002 and 2003, *P. citrinus* Berk. & Br. and *P. ligericus* Tul. & C. Tul., respectively (Marino et al. 2005) Another species, *Pachyphloeus conglomeratus* (Berk. & Br.) Doweld (*exsicc.* n. 88), has been recently discovered in the region. More in detail, five ascomata were complexively found: two of them under *Salix elaeagnos* Scop. and *Populus alba* L. in Roccanova territory (PZ) in October 2013 and the remaining three in the “Montecarusò” mixed wood of Filiano (PZ) in November of the same year. The macro- and microscopic features (see Fig. 1a, b, c) of the fungus were very like if not identical to those already described for the *Pezizaceae* (Montecchi and Sarasini 2000). The poisonous *Sarcosphaera coronaria* var. *coronaria* (Jacq.) J. Schröt [= *S. crassa* (Santi: Strudel) Pouzar] is quite common under pine woods in Basilicata (Tagliavini and Tagliavini 2011) at the end of winter or in spring. Its last documented finding occurred under *Pinus halepensis* Mill. in “Mantenera-Malcanale” wood (Tricarico, MT) 4 years ago. DNA extracted from a Lucanian ascoma of the fungus, subjected to PCR with primers ITS4 and ITS5 (White et al. 1990), gave an amplification product of about 562 bp. The same sequence was deposited in EMBL database under accession code FR827862 and matched at 89 % ($E = 0$) two sequences, DQ200843 and DQ200844, of the same *Pezizaceae* (Rana et al. 2011).

2.1.4 *Pezizomycotina, Pezizomycetes, Pezizomycetidae, Pezizales, Pyronemataceae Schröter*

The hypogeous fungi of this family found in Basilicata belong to genera *Genea* Vittad., *Geopora* Harkn., *Hydnocystis* Tul. & C. Tul. and *Stephensia* Tul. & C. Tul.

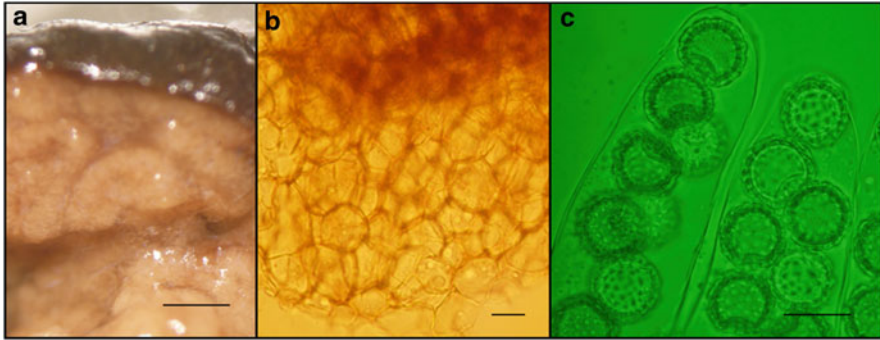


Fig. 1 Gleba cross section (a), pseudoparenchymatic structure of peridium (b), asci and spores (c) of a Lucanian ascoma of *Pachyphloeus conglomeratus*. Bars: (a) 15 mm, (b) 10 μ m and (c) 20 μ m

Findings of *Genea* species present in Basilicata are reported by Cerone et al. (2000) and Marino et al. (2002) for *G. verrucosa* Vittad. and *G. lespiaultii* Corda, Marino et al. (2005) for *G. fragrans* (Wallroth) Paol. and *G. hispidula* Berk. & Br. and, finally, Rana et al. (2011, unpublished data) for *G. sphaerica* Tul. & C. Tul. and *G. papillosa* Vittad., the last of which is thought to be a bay-brown form of *G. verrucosa* (Montecchi and Sarasini 2000).

Two species of *Geopora*, *G. sumneriana* (Cooke) Kers and *G. clausa* (Tul. & C. Tul.) Burds., and one of *Stephensia* (Tul. & C. Tul.), *S. bombycina* (Vittad.) Tul., result in inhabitation of some areas of the region. Tagliavini and Tagliavini (2011), about the first species of *Geopora*, wrote that “it is rare but abundant in the sites where it grows”. *G. clausa* (Tul. & C. Tul.) Burds. [= *Hydnocystis clausa* (Tul. & C. Tul.) Ceruti] is present in Bernalda (MT) area and exactly in the “Biogenetic Natural Reserve of Metapontum and Marinella—Stornara” (BNR) (Rana et al. 2011). *Hydnocystis piligera* Tul. & C. Tul., that has been reported in the extended Apulian portion (1,456 ha) of BNR, was so far never encountered in Basilicata.

Finally, *S. bombycina* (Vittad.) Tul. & C. Tul. was firstly reported under *Quercus cerris* L. in Corleto Perticara (PZ) territory in 2006 (Rana et al. 2010) and subsequently refound for two–three times in Filiano (Rana et al. 2011) and Rionero in Vulture (PZ) territories (Rana et al. unpublished data).

2.1.5 *Peizomycotina*, *Peizomycetes*, *Peizomycetidae*, *Peiziales*, *Terfeziaceae* Fischer

The species of *Terfezia* Tul. & C. Tul. so far found in Basilicata are *T. arenaria* (Moris) Trappe (= *T. leonis* Tul. & C. Tul), sniffed by a well-trained Lagotto dog under *Quercus* spp. in the inland Lucan territory of Brindisi di montagna town (PZ) in June 2013 (Rana et al. unpublished data), and *T. olbiensis* Tul & C. Tul.

which grew close to *P. halepensis* and *Cistus salvifolius* L. in the before mentioned “Mantenera-Malcanale” wood.

It is conceivable to hypothesize that two other *Terfezia* species, i.e. *T. leptoderma* Tul. and *T. boudieri* Chatin, present in the close region Apulia, the first, between Torre dell’ Orso and Melendugno towns (LE) and, the second, in the Apulian BNR surface (Rana et al. 2010), could also grow in the Lucanian part (45 ha) of the same reserve.

2.1.6 *Peizomycotina, Peizomycetes, Peizomycetidae, Peizales, Tuberaceae Dumortier*

Tuber aestivum and *T. aestivum* fo. *uncinatum* are the most common black truffles of Basilicata; their natural beds are located in broad-leaved and coniferous woods of 93 and 37 Lucanian communes, respectively (*Bollettino Ufficiale Regione Basilicata-BURBas* 2004). Prudential estimates indicate that a single professional truffle hunter can pick up two–three q/year of their ascomata. Both truffles can be successfully cultivated in the region and ascomata weighting 400–700 g are not rarely produced. In nature, an exceptional Lucanian ascoma weighting 1,006 g was collected under oaks in Rieti (PZ) area during October 2006 (Rana and Marino 2007).

The other truffles, which are marketable according to the national and regional laws n. 752 of June 20th 1985 and n. 35 of March 27th 1995, are, in decreasing order for quantity and economical importance, *T. borchii* Vittad. (including all truffles of *T. puberulum* Berk. et Br. group as well as *T. gibbosum* Harkness), *T. magnatum* Pico, *T. brumale* Vittad. and its fo. *moschatum* (Ferry) Montecchi & Lazzari, *T. macrosporum* Vittad., *T. bellonae* Quél., *T. hiemalbum* Chatin, *T. melanosporum* Vittad. and *T. mesentericum* Vittad. (complex species which probably comprehends more than three taxa) (Leonardi et al., manuscript sent to Fungal Biology). The last *Tuber* species and, more specifically *T. mesentericum* (*s. s.*), although abundant in beech wood of Basilicata at 1,000–1,300 m a.s.l. and appreciated in Campania, is scarcely used in kitchen in the Lucanian region. *T. borchii* grows either in coastal pine woods or under oaks on the Basilicata mountains in more than 20 natural sites (*BURBas* 2004).

The tasty *T. melanosporum* was found growing in small natural beds of Fardella, Marsicovetere, Muro Lucano, Teana and Rotonda (PZ) (*BUR-Bas* 2004).

The precious *T. magnatum* grows in loamy-sandy, calcareous soil along the banks of more or less large torrents and streams located between Agri and Sinni rivers as well as along Basentum in territories of about 20 Lucanian towns (*BURBas* 2004). Cerone et al. (2002) described the ecological characteristics of a natural bed of this *Tuber* species existing in Chiaromonte (PZ) territory where *Populus canescens* (Aiton.) Sm. predominantly grows. A realized niche of the species, located in upper Sinni river area, was recently studied using GIS, direct in situ survey and genetic diversity at DNA marker loci (Figliuolo et al. 2013).

Furthermore, 89 ascomata of *T. aestivum*, *T. borchii*, *T. brumale*, *T. magnatum* and *T. mesentericum* from 41 different Basilicata sites were object of a biodiversity study (Pomarico et al. 2007) employing molecular tools.

T. macrosporum grows in limited areas of oak and beech woods in a few communal territories of the region (Marino et al. 2002; BURBas 2004; Rana unpublished data).

Among the numerous unmarketable Lucanian truffles, *T. excavatum* Vittad. and *T. rufum* var. *rufum* are very abundant; *T. malençonii* Donadini, Rioussset et Chevalier is, on the contrary, very rare (Rana et al. 2013a) whereas *T. regianum* Montecchi and Lazzari, *T. maculatum* Vittad., *T. foetidum* Vittad., and *T. dryophyllum* Tul. et C. Tul. can be rarely encountered (Rana et al. 2011, 2013a, unpublished data).

Tuber gibbosum Harkness was only found under *Pseudotsuga menziesii* (Mirbel.) Franco in territories of Abriola, Campomaggiore and Teana (PZ), *T. oligospermum* (Tul. & C. Tul.) Trappe and *T. asa-foetida* Tul. & C. Tul. in pine woods of the Lucanian Jonian coast (Marino et al. 2003) and *T. panniferum* under *Q. ilex* L. in Tursi and Marsicovetere areas (Cerone et al. 2000) and, on July 9th, 2012 and June 22th, 2014, in Calciano (MT) area and in the “Mantenera-Malcanale” mixed wood, respectively (Rana et al. unpublished data).

Finally, *Reddellomyces donkii* (Malençon) Trappe was found in the BNR surface of Basilicata under *P. halepensis* in 2007 and 2008 (Rana et al. 2010).

2.2 Basidiomycota

2.2.1 *Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales Strophariaceae* Singer & A. H. Sm.

The species of *Hymenogaster* Vittad. so far reported in Lucanian territories are listed hereafter: *H. populetorum* Tul. & C. Tul., *H. luteus* Vittad. var. *luteus* and *H. vulgaris* Tul. & C. Tul. that were found in territories of Trivigno, Marsicovetere, Pignola, Vaglio di Basilicata, Campomaggiore, Corleto Perticara and Anzi (PZ) in the first years of research (Cerone et al. 2000); *H. aromaticus* Velenovski. [= *Protoglossum aromaticum* (Velen.) J.M. Vidal.] presence of which in the region (Cerone et al. 2002) needs to be confirmed, because some of the original *exsiccata* resulted to be *H. populetorum*; *H. lycoperdineus* Vittad., collected under *Quercus* spp., *F. sylvatica* L. and *Ilex aquifolium* L. in Gorgoglione (PZ) and Tricarico (MT) territories from 2002 to 2004 (Marino et al. 2005); *H. bulliardii* Vittad. and *H. luteus* var. *subfuscus* Soehner, found in the “Mantenera-Malcanale” wood and Pignola area (PZ) (Rana et al. 2008); *H. olivaceus* Vittad. collected in a cultivated truffle ground planted in Ruoti (PZ) territory (Rana et al. 2011).

Furtherly, presence of the following other *Hymenogaster* species is here reported for the first time: *H. decorus* Tul. & C. Tul. (*exsicc.* n. 89), collected under oaks at about 1,000 m a.s.l. in Rionero in Vulture (PZ) area on February 2013 and identified thanks to the spore morphology and average dimensions (20–25 × 12–15 μm), the loose and markedly knotted perisporium and the typical two-spored basidia (Montecchi and Sarasini 2000) (see Fig. 2a), *H. hessey* Soehner (*exsicc.* n. 90),

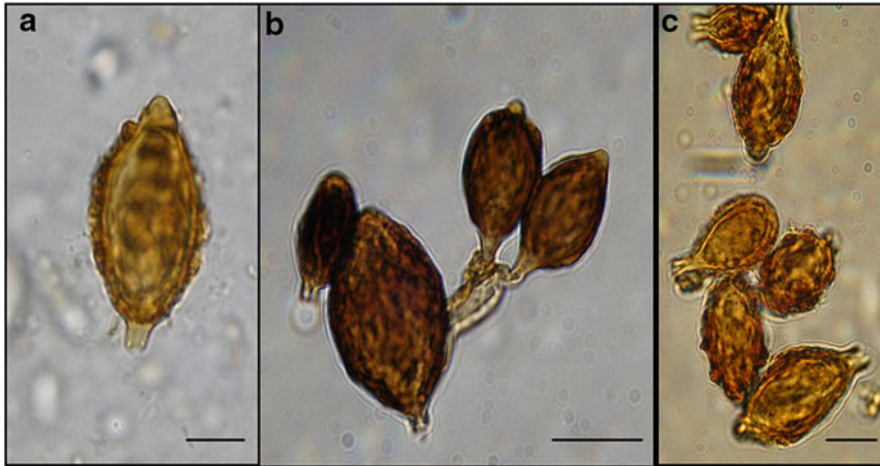


Fig. 2 Basidiospores of *Hymenogaster decorus* (a), *H. hessei* (b) and *H. rehsteineri* (c). Bars: (a) and (c) 10 μ m, (b) 15 μ m

found in the same regional zone and date and recognized on the base of sour and pungent scent of its basidiomata, gold-yellow colour of its unripe spores and average dimensions of the mature ones (21–24 \times 15–16 μ m) which were morphologically much variable (see Fig. 2b) and, finally, *H. rehsteineri* Bucholtz (*exsicc.* n. 91) (see Fig. 2c), found under *P. canescens* in Chiaromonte (PZ) territory at about 300 m a.s.l. at the end of October 2014. Useful for identification of the last species were the variable scent of its basidiomata and spore morphology that matched almost perfectly that described by Montecchi and Sarasini (2000).

Some recent findings of *H. albus* (Klotzsch) Berk. & Br. and *H. niveus* Vittad. under *Eucalyptus camaldulensis* Dehnh. and oaks, respectively (Rana unpublished data), still request to be confirmed.

2.2.2 *Agaricomycotina*, *Agaricomycetes*, *Agaricomycetidae*, *Boletales*, *Melanogastraceae* Fischer

Five out of the ten known *Melanogaster* Corda species result present in Basilicata:

M. ambiguus var. *ambiguus* (Vittad.) Tul. & C. Tul. and *M. umbrinogleba* Trappe & Guzmàn found under *Q. cerris* in Filiano (PZ) territory and under *P. halepensis* in the above-mentioned “Mantenera-Malcanale” wood in 2011 and 2009, respectively (Rana et al. 2011); *M. tuberiformis* Corda under *Q. cerris* in Corleto Perticara (PZ) area in 2006 (Rana et al. 2008); *M. variegatus* (Vittad.) Tul. & C. Tul., that is the most common *Melanogaster* species in the region, and *M. broomeanus* Berk. apud Tul. & C. Tul. in Brienza and Pietragalla (PZ) mixed woods (Cerone et al. 2000; D’Auria et al. 2014; Rana et al. unpublished data).

2.2.3 *Agaricomycotina, Agaricomycetes, Agaricomycetidae, Boletales, Octavianiaceae* Loquin ex Pegler & Young

The genus *Octavianina* Kuntze is known in Europe for the presence of a single species, *O. asterosperma* (Vittad.) Kuntze that has been found in Basilicata under *Q. cerris* and *F. sylvatica* on Volturino mountain in Marsicovetere (PZ) territory in spring–summer 2001 (Marino et al. 2003). Basidiomata of the same fungus were often refound in region [e.g. in a mixed wood of Tricarico territory on July 2011 and June 2012 as well as under oak in a zone between Satriano di Lucania and Brienza (PZ) during June 2013] (Rana et al. 2011 and unpublished results).

2.2.4 *Agaricomycotina, Agaricomycetes, Agaricomycetidae, Boletale, Rhizopogonaceae* Gäumann & Dodge

Rhizopogon vulgaris (Vittad.) M. Lange is the only species of the genus *Rhizopogon* Fries so far discovered in Basilicata. After its first finding in the region under *Pinus pinaster* Ait. in Policoro (MT) territory in 2001, it was again encountered under *E. camaldulensis* and *P. halepensis* in BNR (Bernalda, MT) in April 2011 (Rana et al. 2011).

2.2.5 *Agaricomycotina, Agaricomycetes, Phallomycetidae, Geastrales, Geastraceae* Corda

Geastrum fimbriatum Fries and *G. triplex* fo. *triplex* Jungh. have been often found in Basilicata (Tagliavini and Tagliavini 2011; Rana et al. 2013b, unpublished data). The last findings are referred to the “Mantenera-Malcanale” wood and, for the close Apulia, to BNR and Corigliano d’Otranto (LE) territories. Another hypogeous fungus, belonging to this family and found under *P. halepensis* in the region (Rana et al. 2011), is *Schenella pityophilus* (Malençon and Rioussat) Estrada & Lado. It was previously considered rare in Europe, but it seems common enough along the Adriatic and Ionic coasts of Apulia and Basilicata, respectively (Signore et al. 2008). It was again encountered in “Mantenera-Malcanale” mixed wood in the region in February 2014 (Rana unpublished data). Molecular analysis, accomplished as before summarized on one of its basidiomata, gave an ITS gene amplicon of 625 bp. Its sequence resulted very like (similarity coefficient = 91 %) that present in GenBank under accession number GU184106 for *S. pityophilus*. The sequence obtained from the Lucanian sample of *S. pityophilus* was deposited into the EMBL database under FR821766 accession number (Rana et al. 2011). *Myriostoma coliforme* (Dicks.) Corda, a rare, semi-hypogeous *Geastraceae*, was found in two localities of the region, “Villa Caivano” (Picerno, PZ) and “Manferrara” (Pomarico, MT), at 700 and 400 m a.s.l. in autumn of 2008 and 2009, respectively (Rana et al. 2013b).

2.2.6 *Agaricomycotina, Agaricomycetes, Phallomycetidae, Gomphales, Gomphaceae* Donk

Three varieties of *Gautieria graveolens* Vittad. were so far found in Basilicata:

G. graveolens var *graveolens* Vittad., *G. graveolens morchellaeformis* var. *morchellaeformis* Vittad. and *G. graveolens* var. *otthii* (Trog) Zeller & Dodge. A single basidioma of the second variety was firstly found in Brienza (PZ) territory during February 2006. Presence of the third and the first varieties was reported under *Q. pubescens* (s.l.) in Corleto Perticara (PZ) area (Rana et al. 2010) and in a mixed wood of *Q. cerris* and *Carpinus betulus* L. in Gorgoglione (PZ) territory in 2009 (Rana et al. 2011). Although molecular analyses were carried out, identification of the first variety was based mainly on basidiospore morphology and dimensions. A 775 bp ITS gene DNA sequence of a Lucanian specimen of the same *G. graveolens* variety was deposited in NCBI database under accession code FN666413 (Rana et al. 2011).

2.2.7 *Agaricomycotina, Agaricomycetes, Phallomycetidae, Hysterangiales, Hysterangiaceae* Fischer

Three species of *Hysterangium* Vittad. were so far found in Basilicata: *H. stoloniferum* Tul. & C. Tul. under *Q. cerris* in Corleto Perticara (PZ) area (Rana et al. 2008), *H. inflatum* Rod. under *Eucalyptus* spp. in BNR in 2007 (Rana et al. 2010) and *H. nephriticum* Berk. under oak in “Mantenera-Malcanale” forest (Tricarico, PZ) in 2012 (Rana et al. 2013a).

2.3 *Zygomycota*

2.3.1 *Mucoromycotina, Endogonales, Endogonaceae* Paoletti

Only one species of *Youngiomyces*, *Y. multiplex* (Taxter) Yao (= *Endogone multiplex* Taxt.), has been reported in the region under *P. pinaster* in winter 2000. Its identification was mainly achieved considering spore morphology and dimensions (Marino et al. 2003).

3 Concluding Remarks

On the basis of the up-to-date information available for hypogeous and semi-hypogeous fungi naturally growing in Basilicata, a reckoning of 82 taxa comes out as shown in Table 1. The fungal entities so far found belong to 14, nine and one genera of *Ascomycota*, *Basidiomycota* and *Zygomycota*, respectively. Among

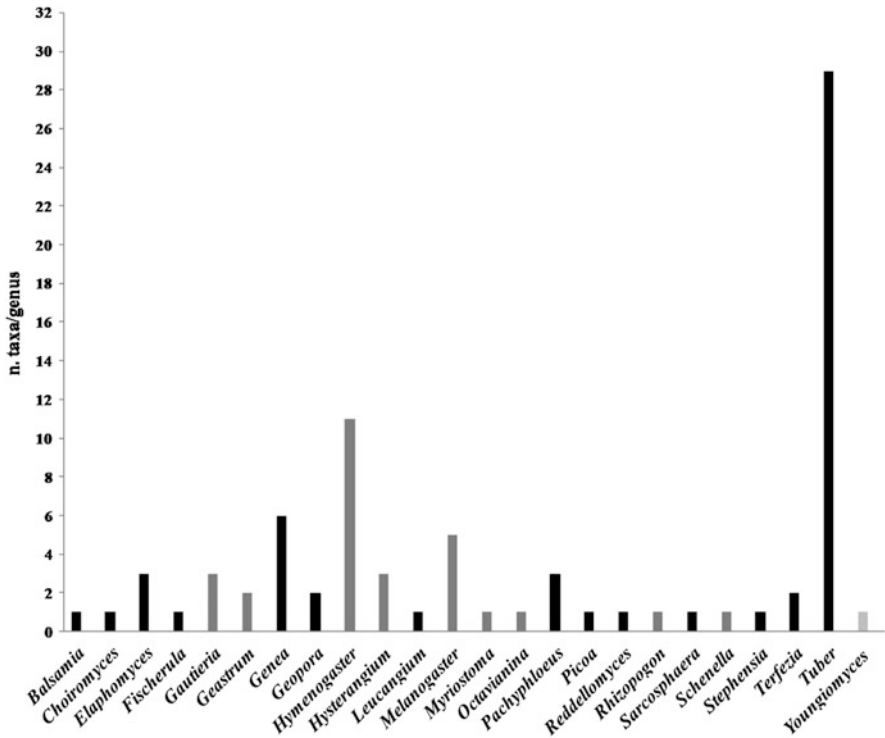


Fig. 3 Number of taxa/genus of hypo- and semi-hypogeous *Ascomycota* (black), *Basidiomycota* (grey) and *Zygomycota* (light grey) growing in nature in Basilicata

Ascomycetes, the most numerous genus is *Tuber* Micheli: Wiggers which includes, except for *T. gennadii* (Chatin) Patouillard (= *Terfezia gennadii* Chatin), all the taxa described by Montecchi and Sarasini (2000) and Rioussset et al. (2001) as well as the hypothetical variety *vittadinii* of *T. magnatum* (Daprati 2007) for a total of 29 taxa.

A more restrictive estimate, considering that *T. aestivum* is identical to *T. aestivum* var *uncinatum*, i.e. *T. uncinatum* Chatin, either morphologically (Tanfulli and Di Massimo 2002) or molecularly (Wedén et al. 2005), *T. brumale* to its var. *moschatum* (Gandeboeuf et al. 1997) and *T. hiemalbum* to *T. melanosporum* (Dupré et al. unpublished data, as reported by Rioussset et al. 2001), would reduce the above number to 25 (see Fig. 3). Anyway, Basilicata, 4 years after a previous review (Venturella et al. 2011), for the number of *Tuber* taxa which can grow in its territory, confirms its first position among Italian regions.

Other genera enough represented in the region are *Hymenogaster* (11 taxa), *Genea* (6), *Melanogaster* (5), *Gautieria*, *Elaphomyces*, *Pachyphloeus* and *Hysterangium* (3).

The region has an enviable biodiversity of hypogeous and semi-hypogeous fungi. Some of them, as the marketable *Tuber* species, play an important

economical role for human beings. The other *Tuber* species and *taxa* belonging to the various *Ascomycota* and *Basidiomycota* mentioned certainly are precious for some components of wild fauna as squirrels (Venturella et al. 2011), field-mouse, mole, fox, etc.

Despite of the high number of hypogeous fungus *taxa* already identified in the region, some zones (e.g. Italian State's and Basilicata Region's properties and protected areas) still remain unexplored in this respect and numerous semi-hypogeous and hypogeous fungi are waiting to be discovered.

The drawback is that the natural *Tuber* production showed a progressive marked decrease in Italy and other main truffle producing European countries (France, Spain) in the last 20 years (Hall et al. 2007). This negative trend occurred also in Basilicata due to the massive presence of wild boars on its woody areas and the excessive and the often illegal exploiting of its natural truffières.

This situation renders necessary and pressing the widespread diffusion of the available know-how to extend truffle cultivation in the region and to preserve, through *in situ* conservation programmes, the survival of some hypogeous fungi which risk extinction before being known. In this mode, the future generations will inherit this fascinating and incommensurable patrimony of the Nature.

Acknowledgements The authors are grateful to Dr. Mariano Annarita (Basilicata Region, PZ) who provided basidiomata of *Hymenogaster decorus*, *H. hessey* and *H. rehsteineri* and to Cerroni Andrea and Cerroni Nazzareno (Pignola, PZ) who found sporophores of *Pachyphloeus conglomeratus*, *Terfezia arenaria* and *Melanogaster broomeanus*.

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