

## **Hypogeous fungi in Liguria (Italy): distribution and ecology**

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**Abstract** – The paper presents an *update* list of hypogeous fungi observed in Liguria (Italy) during the last three years. The list also includes the species recorded by several mycologists in early 20<sup>th</sup> century. The species collected were geographically mapped by means of a GIS; the habitats where the fungi were found are described in detail. As concerns Ligurian mycoflora, 10 new taxa were observed, among these two species are very rare and interesting: *Alpova rubescens* and *Rhizopogon rocabrunae*.

### **Hypogeous fungi/Distribution**

**Résumé** – Nous avons rédigé une liste des toutes les espèces des champignons hypogés qu'ont été signalés et décrits dans la région italienne Ligurie jusqu'aujourd'hui. Cette liste comprend aussi les espèces signalées à partir des mycologues du vingtième siècle, les données GPS et la description de l'environnement de croissance. Les espèces nouvelles pour la flore de la Ligurie sont 10, dont deux particulièrement rare et intéressantes : *Alpova rubescens* et *Rhizopogon rocabrunae*.

### **Champignons hypogés/Distribution**

## **INTRODUCTION**

Liguria (Fig. 29) is a Northwestern Italian region characterized by a very high level of mycodiversity (Zotti *et* Orsino, 2001; Zotti *et al*, 2008). Numerous species grow in the different environments, which characterize the territory. The issue of mycodiversity has been faced in a number of papers from different perspectives (Orsino, 1991, 1993; Zotti, 2002; Zotti & Zappatore, 2006). In spite

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of this, little attention has been paid to hypogeous macrofungi although several species, very relevant for commercial purpose, has been always collected and the presence of white truffle has been kept almost secret. The most important area for truffle production is Bormida Valley, a North – Midwestern area bordering with Piedmont “Langhe”.

In other words, there is a lack of information about this wide group of fungi and their ecology. This paper aims at integrating the list of hypogeous fungi observed in Liguria (data by Montecchi & Sarasini 2000 included) taking into account not only the recent surveys, but also information derived from the studies carried out by a number of mycologists in the past. As concerns data previously recorded, it is worth mentioning Pollacci (1897), who attempts to organize data previously collected by Barla, De Notaris and Panizzi. Pollacci reports only five species and affirms that *Tuber magnatum* Pico is a species imported from Piedmont. No other information is available in the literature, till Mattiolo described further 19 and 9 hypogeous taxa in 1911 and 1933, respectively (Mattiolo, 1911, 1933).

The present study mainly focuses on some specific areas belonging to Bormida Valley (Fig. 29), and reports the results of surveys performed through the last three years. The goal was to: i) increase the knowledge on the Ligurian hypogeous fungi; ii) check the previous lists by Mattiolo and Pollacci, and iii) map the distributions of this kind of fungi.

## MATERIALS AND METHODS

With the purpose to get a global vision on a different forest habitat, a number of areas was sampled at different altitudes and with different vegetations.

The samplings were performed during the period from August 2007 to April 2009 with the help from professional harvesters and trained dogs.

The sporomata collected were photographed and the following data were recorded: station code, WGS-84 Global Position System (GPS) coordinates in decimal degrees, altitude and vegetation type.

Macroscopic and microscopic characters were described from fresh specimens using a stereo microscope (Leica M 205 C) and a compound microscope (Axioscope, Zeiss), respectively. The observations of microscopic characters are based on material mounted in distilled water, in lactic acid plus acid fuchsine, in 5% potassium hydroxide and in Melzer's reagent. For spores and other structures at least 30 individuals were measured.

For taxa identification we exploited the works of Montecchi & Sarasini (2000), Chevalier *et al.* (2001), Ceruti *et al.* (2003) and Gori (2005). Family, order and class names follow Vizzini (2004), Hibbett *et al.* (2007) and Kirk *et al.* (2008). Authors names are abbreviated according to Brummit & Powell (1992) and IPNI (2008).

All examined material is deposited and kept at GDOR (Herbarium of the Museo Civico di Storia Naturale Giacomo Doria, Mycologia section, Genova, Italy). Herbarium abbreviations follow Holmgren & Holmgren (1998).

The geographical data were mapped on the Official Map of Italian State (I.G.M.I) by means of a GIS software (MapInfo 7.0). The data were also inserted in a database where all Ligurian macrofungi species are recorded.

The results reported in this paper include both the records by Mattiolo (1911, 1933), Montecchi & Sarasini (2000) and the ones derived from our surveys.

## RESULTS

Altogether, 61 taxa have been recorded till now in Liguria. During our surveys, 10 new taxa were observed. Specifically, 5 Ascomycota, 4 Basidiomycota and 1 Glomeromycota were collected. Moreover, 11 out of 28 species recorded by Mattiolo were observed again.

The following list is arranged in taxonomic order. The details of old records by Mattiolo were omitted in order to highlight the new species observed. Each new taxonomic entry provides Latin name, authority, geographical location (altitude and WGS-84 GPS coordinates, if not available the whole area of municipality was marked), survey date and collection site habitat.

## LIST OF FUNGI

### ASCOMYCOTA

#### EUROTIOMYCETES

##### *Eurotiales*

##### *Elaphomycetaceae*

Genus *Elaphomyces* Nees

*Elaphomyces anthracinus* Vittad. - Mattiolo (1933).

*Elaphomyces asperulus* Vittad. - Mattiolo (1933).

*Elaphomyces caelatus* Vittad. - Mattiolo (1911).

*Elaphomyces echinatus* Vittad. - Mattiolo (1911).

*Elaphomyces granulatus* Fr. - Zotti & Orsino (2001).

*Elaphomyces hirtus* Tul. & C. Tul. - Mattiolo (1911).

*Elaphomyces leveillei* Tul. & C. Tul. - Mattiolo (1933).

*Elaphomyces muricatus* Fr. - Cairo Montenotte (SV) 16/02/2009, under mixed wood (Fig. 1).

#### PEZIZOMYCETES

##### *Pezizales*

##### *Helvellaceae*

Genus *Balsamia* Vittad.

*Balsamia polysperma* Vittad. - Montecchi & Sarasini (2000).

*Balsamia vulgaris* Vittad. - Mattiolo (1911); Zotti & Orsino (2001); Cairo Montenotte (SV) 09/02/2009, under broadleaves trees (Fig. 2).

##### *Pyronemataceae*

Genus *Genea* Vittad.

*Genea fragrans* (Wallr.) Sacc. - Zotti *et al.* (2008); Cairo Montenotte (SV) 02/10/2008, under *Quercus pubescens* Willd., *Ostrya carpinifolia* Scop. and *Corylus avellana* L.; Cairo Montenotte (SV) 25/10/2008, broadleaves trees (Fig. 3); Ventimiglia (IM) long. 7.541772°, lat.

43.80168°, 445 m s.l.m., 28/02/2009, under *Ostrya carpinifolia*, *Corylus avellana* and *Castanea sativa* Mill. (Fig. 4)

***Genea hispidula*** Berk. ex Tul. & C. Tul. - Zotti & Orsino (2001).

***Genea klotzschii*** Berk. & Broome - Mattiolo (1911); Zotti & Orsino (2001).

***Genea lespiaultii*** Corda - Mattiolo (1911).

***Genea sphaerica*** Tul. & C. Tul. - Mattiolo (1933).

***Genea verrucosa*** Vittad. - Mattiolo (1911); Zotti & Orsino (2001); Zotti *et al.* (2008); Spotorno (SV) long. 8.394441°, lat. 44.24219°, 354 m s.l.m., 04/04/2008, under *Quercus sp.*; Spotorno (SV) long. 8.397025°, lat. 44.240538°, 389 m s.l.m., 04/04/2008, under *Quercus sp.*; Spotorno (SV) long. 8.397599°, lat. 44.23956°, 293 m s.l.m., 04/04/2008, under *Quercus sp.*; Spotorno (SV) long. 8.397268°, lat. 44.238856°, 384 m s.l.m., 04/04/2008, under *Quercus sp.* (Fig. 5); Ventimiglia (IM) long. 7.555038°, lat. 43.781491°, 10 m s.l.m., 28/02/2009 under mixed wood (Fig. 6).

Genus *Hydnocystis* Tul.

***Hydnocystis piligera*** Tul. - Cairo Montenotte (SV) 02/10/2008, under *Quercus pubescens* Willd., *Ostrya carpinifolia*, and *Corylus avellana* (Fig. 7).

Genus *Stephensia* Tul.

***Stephensia bombycina*** (Vittad.) Tul. - Zotti & Orsino (2001); Piana Crixia (SV) long. 8.27583333° lat. 44.48166667°, 09/11/2008, under *Quercus pubescens* and *Ostrya carpinifolia* (Fig. 8).

#### Tuberaceae

Genus *Choiromyces* Vittad.

***Choiromyces meandriformis*** Vittad. - Mattiolo (1911); Zotti & Orsino (2001); Zotti *et al.* (2008).

Genus *Reddellomyces* Trappe, Castellano & Malajczuk

***Reddellomyces donkii*** (Malençon) Trappe, Castellano & Malajczuk (= *Labyrinthomyces donkii* Malençon) - Villa Hanbury Ventimiglia (IM), 28/02/2009, under *Eucalyptus sp.* (Fig. 9).

Genus *Tuber* Micheli ex Wiggers

***Tuber aestivum*** Vittad. - Mattiolo (1911); Zotti *et al.* (2008).

***Tuber borchii*** Vittad. - Mattiolo (1911); Zotti *et al.* (2008); Spotorno (SV) long. 8.394441° lat. 44.24219°, 293 m s.l.m., 04/04/2008, under *Quercus sp.* (Fig. 10).

***Tuber brumale*** Vittad. - Mattiolo (1911); Zotti & Orsino (2001); Zotti *et al.* (2008); Ventimiglia (IM) long. 7.541485°, lat. 43.801739°, 445 m s.l.m., 28/02/2009, under *Ostrya carpinifolia*, *Quercus ilex* L. and *Quercus sp.* (Fig. 11).

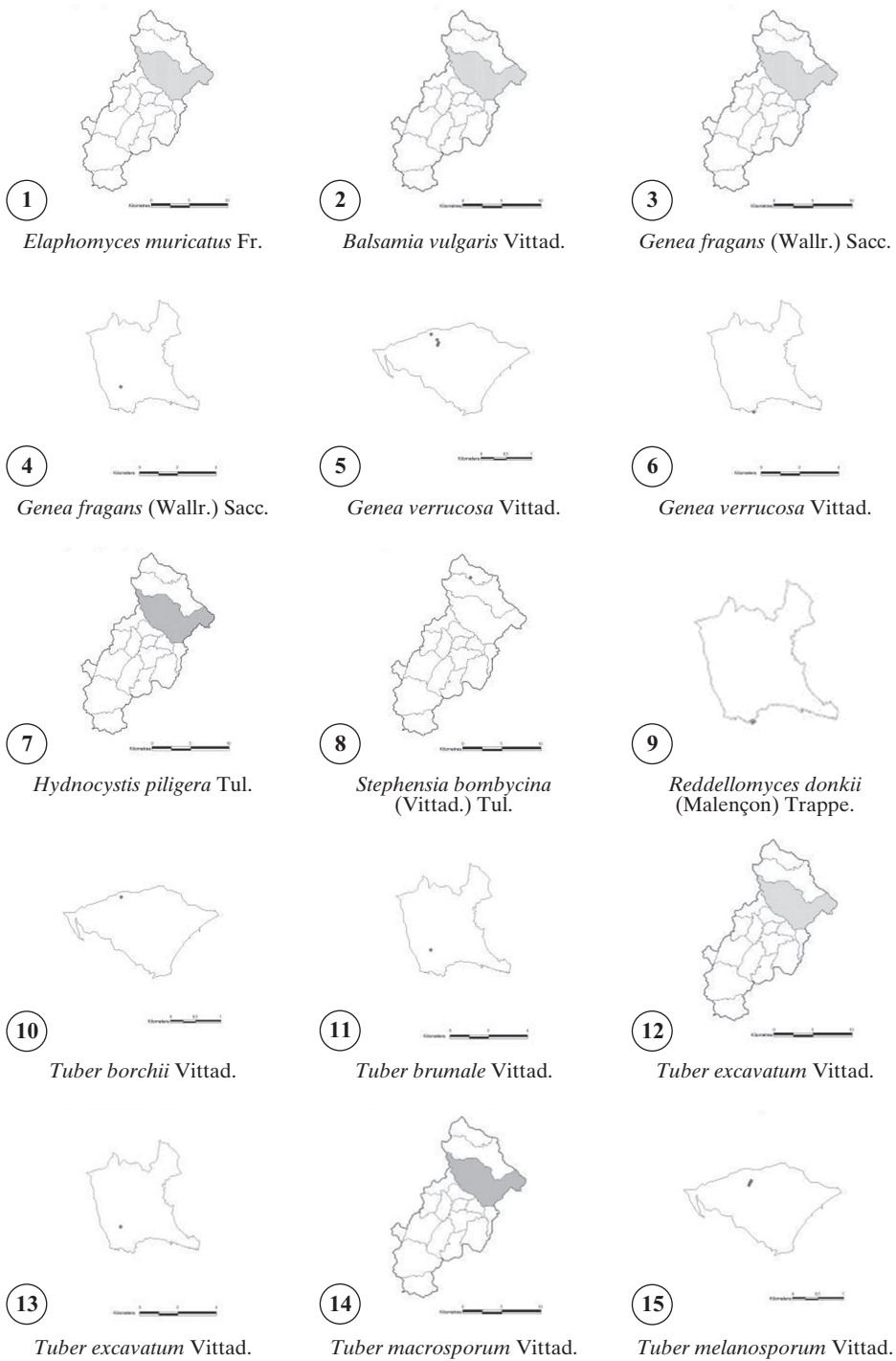
***Tuber excavatum*** Vittad. - Mattiolo (1911), Zotti & Orsino (2001); Cairo Montenotte (SV) 02/10/2008, under *Quercus pubescens*, *Ostrya carpinifolia*, and *Corylus avellana*; Cairo Montenotte (SV) 25/10/2008, under *Quercus sp.* (Fig. 12); Ventimiglia (IM) long. 7.541485°, lat. 43.801739°, 354 m s.l.m., 28/02/2009, under *Ostrya carpinifolia*, *Quercus ilex* and *Quercus sp.* (Fig. 13).

***Tuber foetidum*** Vittad. - Montecchi & Sarasini (2000).

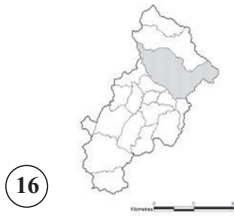
***Tuber gibbosum*** Harkn. - Zotti & Orsino (2001).

***Tuber macrosporum*** Vittad. - Zotti *et al.* (2008); Cairo Montenotte (SV) 25/10/2008, under *Quercus sp.* (Fig. 14).

***Tuber magnatum*** Pico. - Zotti *et al.* (2008).



Figs 1-28. Different hypogeous species distribution.



16

*Tuber mesentericum* Vittad.

17

*Tuber oligospermum*  
(Tulasne & C. Tulasne) Trappe

18

*Tuber rufum* Pico f. *ferrugineum*  
(Vittad.) Montecchi & Lazzari.

19

*Tuber rufum* Pico f. *lucidum*  
(Bonnet) Montecchi & Lazzari.

20

*Tuber rufum* Pico f. *nitidum*  
(Vittad.) Montecchi & Lazzari.

21

*Hymenogaster bulliardii* Vittad.

22

*Hymenogaster luteus* Vittad.

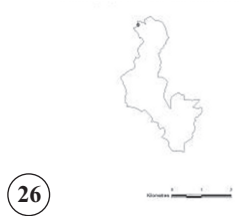
23

*Melanogaster variegatus*  
(Vittad.) Tul. & C. Tul.

24

*Octaviania asterosperma* Vittad.

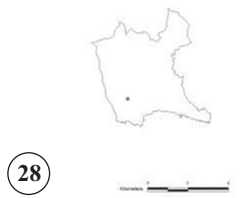
25

*Alpova rubescens* (Vittad.)  
Trappe.

26

*Rhizopogon rocabrunae*  
M.P. Martin.

27

*Gautieria morchelliformis*  
Vittad.

28

*Glomus microcarpum*  
Tul & C. Tul.

Figs 1-28. Different hypogeous species distribution.

- Tuber melanosporum*** Vittad. - Mattiolo (1911); Zotti *et al* (2008); Spotorno (SV) long. 8.398143° lat. 44.240202°, long. 8.397599° lat. 44.23956°, long. 8.397268° lat. 44.238856°, 04/04/2008, under *Quercus sp* (Fig. 15).
- Tuber mesentericum*** Vittad. - Mattiolo (1911); Zotti & Orsino (2001); Cairo Montenotte (SV) 07/02/2008, under broadleaved woods (Fig. 16).
- Tuber oligospermum*** (Tulasne & C. Tuasne) Trappe - Passeggiata mare Finale Ligure Marina (SV), 10/04/2009 under *Pinus pinaster* Aiton (Fig. 17).
- Tuber panniferum*** Tul. - Mattiolo (1911).
- Tuber puberulum*** Berk. & Broome - Zotti *et al* (2008).
- Tuber rufum var. rufum*** Pico - Mattiolo (1911); Zotti *et al* (2008).
- Tuber rufum var. nigrum*** Mattiolo - Mattiolo (1933).
- Tuber rufum* Pico f. *ferrugineum*** (Vittad.) Montecchi & Lazzari - Mattiolo (1933); Zotti & Orsino (2001); Cairo Montenotte (SV), 25/10/2008, under *Quercus sp* (Fig. 18).
- Tuber rufum* Pico f. *lucidum*** (Bonnet) Montecchi & Lazzari - Cairo Montenotte (SV), 25/10/2008, *Quercus sp* (Fig. 19).
- Tuber rufum* Pico f. *nitidum*** (Vittad.) Montecchi & Lazzari - Mattiolo (1911); Cairo Montenotte (SV), 25/10/2008, *Quercus sp* (Fig. 20).

## BASIDIOMYCOTA

### AGARICOMYCETES

#### Agaricales

##### Hydnangiaceae

Genus *Hydnangium* Wallr.

***Hydnangium carneum*** Wallr. - Mattiolo (1911).

##### Strophariaceae

Genus *Hymenogaster* Vittad.

***Hymenogaster bulliardii*** Vittad. - Mattiolo (1933); Santa Margherita Ligure (GE), 13/04/2009, under *Quercus ilex* (Fig. 21).

***Hymenogaster hessei*** Soehner. - Zotti & Orsino (2001).

***Hymenogaster luteus*** Vittad. - Cairo Montenotte (SV), 07/02/2008, under broadleaves trees (Fig. 22).

***Hymenogaster muticus*** Berk. & Brum. - Mattiolo (1911).

***Hymenogaster vulgaris*** Tul. & C. Tul. - Mattiolo (1933).

#### Boletales

##### Paxillaceae

Genus *Alpova* C.W. Dodge

***Alpova rubescens*** (Vittad.) Trappe - Cascinassa Cairo Montenotte (SV), long. 8.399363° lat. 44.393336°, 02/10/2008, *Fagus sylvatica* L. (Fig. 25).

Genus *Melanogaster* Corda

***Melanogaster ambiguus*** (Vittad.) Tul. & C. Tul. - Zotti & Orsino (2001).

***Melanogaster broomeanus*** Berk. - Zotti & Orsino (2001).

***Melanogaster macroscopus*** Velenovsky - Montecchi & Sarasini (2000)

***Melanogaster variegatus*** (Vittad.) Tul. & C. Tul. - Mattiolo (1911); Zotti & Orsino (2001); Cairo Montenotte (SV), 25/10/2008 (Fig. 23).

##### Octavianaceae

Genus *Octaviania* Vittad.

***Octaviania asterosperma*** Vittad. - Zotti & Orsino (2001); Cairo Montenotte (SV), 02/10/2008, under *Quercus pubescens*, *Ostrya carpinifolia* and *Corylus avellana* (Fig. 24).

Genus *Wakefieldia* Corner & Hawker

***Wakefieldia macrospora*** Hawker - Montecchi & Sarasini (2000).

*Rhizopogonaceae*

Genus *Rhizopogon* Fr.

***Rhizopogon luteolus*** Fr. & Nordholm - Zotti & Orsino (2001).

***Rhizopogon occidentalis*** Zeller & Dodge - Montecchi & Sarasini (2000).

***Rhizopogon rocabrunae*** M.P. Martín - Testa d'Alpe (IM) long. 7.569798° lat. 43.946087°, 16/06/2008, under *Abies alba* Mill. (Fig. 26).

***Rhizopogon roseolus*** (Corda) Th. Fr. - Mattiolo (1911, as *R. provincialis* Tul. and *R. rubescens* Tul.); Zotti & Orsino (2001).

***Rhizopogon villosulus*** Zeller - Zotti & Orsino (2001).

***Rhizopogon vulgaris*** (Vittad.) M. Lange - Zotti & Orsino (2001).

**Phallales**

*Hysterangiaceae*

Genus *Hysterangium* Vittad.

***Hysterangium clathroides*** Vittad. - Montecchi & Sarasini (2000).

***Hysterangium stoloniferum*** Tul. & C. Tul. - Montecchi & Sarasini (2000).

**Gomphales**

*Ramariaceae*

Genus *Gautieria* Vittad.

***Gautieria morchellaeformis*** Vittad. - Ventimiglia (IM) long. 7.540702°, lat. 43.801225°, 354 m s.l.m., 28/02/2009, under *Corylus avellana* (Fig. 27).

**GLOMEROMYCOTA**

**Glomerales**

*Glomeraceae*

Genus *Glomus* Tul. & C. Tul.

***Glomus microcarpum*** Tul. & C. Tul. - Ventimiglia (IM) long. 7.541485°, lat. 43.801739°, 354 m s.l.m., 28/02/2009, under *Ostrya carpinifolia* Scop., *Quercus ilex* L. and *Quercus* sp. (Fig. 28).

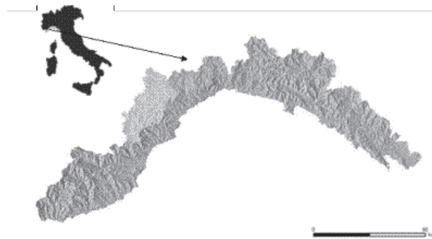
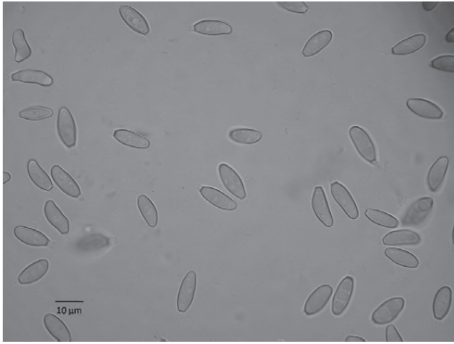
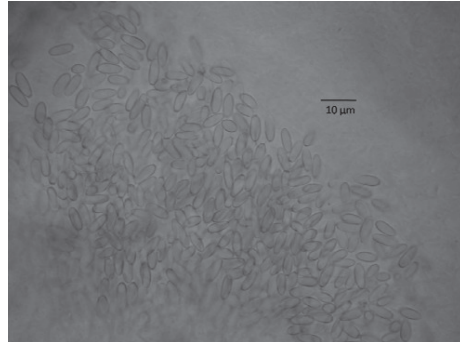


Fig. 29. Map of Italy, Liguria, and Bormida Valley.



Fig. 30. Sporomata of *Alpova rubescens*.Fig. 31. Sporoma of *Rhizopogon rocabrunae*.Fig. 32. Spores of *Alpova rubescens*.Fig. 33. Spores of *Rhizopogon rocabrunae*.

## DISCUSSION

Among the recently collected species, two are remarkable for their rarity: *Alpova rubescens* (Fig. 30) and *Rhizopogon rocabrunae* (Fig. 31). The former is characterized by its strict association with *Fagaceae* (*Fagus sylvatica*, *Quercus* spp., *Castanea sativa*), by very thick tramal plates, a gelatinous gleba that turns reddish-brown when exposed to air, and smooth, thin-walled, over 10 micron long on average, ellipsoid to oblong spores (Fig. 32). It was observed in Northern and Central Italy (Trappe, 1975; Ruini, 1995; Montecchi & Sarasini, 2000; Gori, 2005), Spain (Calonge & Pasabán, 1993; Rubio *et al.*, 2006) and Croatia (Tkalčec *et al.*, 2005). Ligurian specimens differ from those previously cited in the literature because of the abundance of clamp connections in the peridium and the strongly alliaceous odour, persistent and reminiscent of *Tuber magnatum* Pico.

The later, *Rhizopogon rocabrunae*, is a poorly recorded species known from a restricted area: originally described on the basis of a single collection from Spain (Martín, 1996) and then found once in France (Cavet & Lopez, 2004) and Italy (Montecchi & Sarasini, 2000), it is well circumscribed within the genus on the basis of its brown-orange peridium covered by minute squamules (it looks like an *Elaphomyces*), and truncate spores (Fig. 33). It seems strictly associated to *Abies alba* as also supported by the Ligurian collection.

It is worth noting that in three years a limited number of surveys has permitted to record 10 new taxa thus confirming how this kind of fungi was not sufficiently investigated and that a number of potential sites where this fungi should grow is almost unexplored. This fact encourages us to increment the surveys and to enlarge the areas of investigation.

Finally, the richness of hypogeous species agrees with the already proved high level of mycodiversity measured in Liguria (Zotti & Orsino, 2001; Zotti *et al.*, 2008).

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