



Proceeding Paper

# Desert Truffles and Truffles in Morocco: Biodiversity of Promising Fungi to Combat Desertification †

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**Abstract:** The desert truffle (*Terfezia*) and other truffles (*Tuber*) have a significant economic and ecological value and are considered as important fungi in Morocco. Desert truffles are important to combat desertification and enhance soil fertility. As these fungi form a mycorrhizal symbiosis with several specific desert shrubs, it protects the soil from degradation and assists plant growth in the semi- arid and desert areas. The aim of this short paper is to present the different species of desert truffle that exist in Morocco and identify their macroscopic and microscopic characteristics and their host plants as well as their areas of distribution. There are strong analogies between the species found in Morocco with those previously discovered in other countries. *Terfezia arenaria*, *T. leptoderma* and *Delastria rosea* were mainly available in Mamora forest and *T. boudieri* in Oualidia. Otherwise, the species *Picoa juniperi*, *Terfezia claveryi*, *Tirmania pinoyi* and *T. nivea* were present in the Oriental regions of Morocco.

**Keywords:** desert truffles; truffles; morphology; microscopy



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## 1. Introduction

In Morocco, truffles and desert truffles (Terfess) are important fungi with economic and ecological value. These are edible species and are considered important seasonal and local trade in the country. Generally, Moroccan truffles grow in the sand and are harvested in the vicinity of herbaceous plants such as *Helianthemum*, *Cistus*, or *Pinus* tree in a mycorrhizal association [1–4]. The most common method of identification for harvesting is by the “mark” produced by the fungi (the soil is often swollen and cracked on the surface at the base of the host plant) [4].

Terfess has a considerable ecological interest, especially in arid and semi-arid areas. Its cultivation using biotechnological methods, in particular the controlled mycorrhization with their native host or non-host plants, would be interesting to utilize infertile lands, conserve these fungal species, and promote the social and economic activities in the region [5]. Moreover, the host plants of these fungi are xerothermophile species and their planting can help to preserve the land against desertification and degradation. The fungi act as extensions of the plant root and are capable of capturing water where the plant cannot. The aim of the study was to characterize the different species of desert truffles “Terfess” and other Moroccan truffles (*Tuber*), to identify the areas for harvest as well as areas of their distribution.

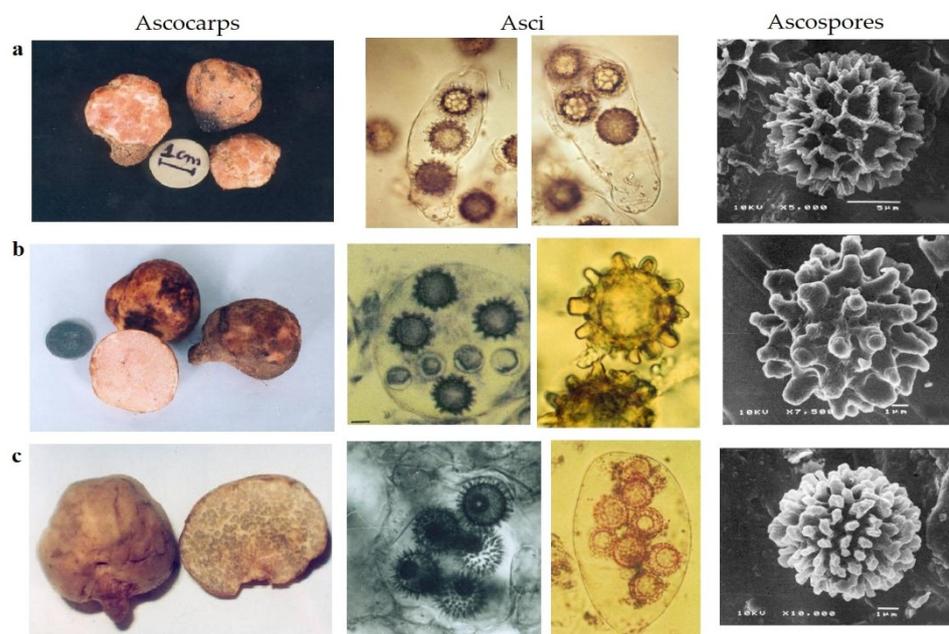
## 2. Materials and Methods

A survey was carried out to collect truffles from several regions of Morocco, with different climatic and edaphic conditions. The morphological observations of the collected

samples were realized visually or using a stereomicroscope. The microscopic studies were performed using crushed ascocarp fragments in water. The scanning electron microscopy studies were preceded through two methods: progressive dehydration with acetone (25%, 50%, 75%, 95% and 100%) and acetolysis according to the Erdtman method [6].

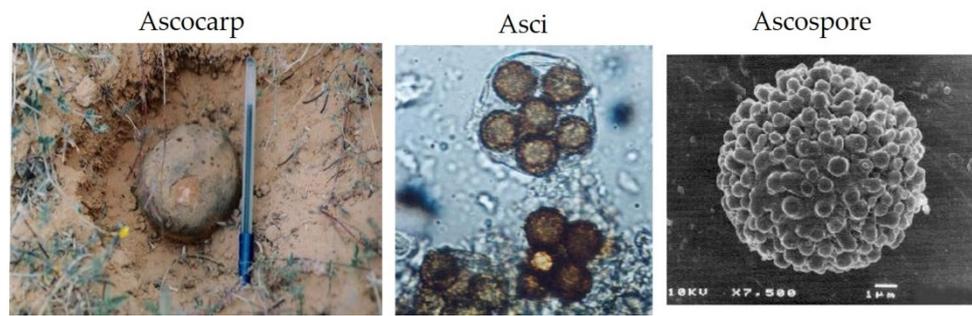
### 3. Results

The distinction of truffle species was classically based on both the ascocarps morphology and the ascospore ornamentation. Eight desert-truffle species were identified. Three species were collected from Mamora Forest, located in the Rabat region (34°15'52" N, 6°39'27" W). The first species was *Delasria rosea* (= *Terfezia rosea*), locally called 'Bitter Terfess of Taida' and collected under the pine (*Pinus pinaster* var. *atlantica* and *Pinus halepensis*). The ascocarps were sub-globose or turbinate, more or less bumpy, 3 to 5 cm in diameter. The ascocarp color was white to pinkish or white blackened. Each elongated asci (140–176 × 56–64 μm) contained two to four globose ascospores, orange to yellow and ornamented with an alveoli network surmounted by short spines (Figure 1a). The second species was *Terfezia arenaria*, the most popular edible mushroom in this region, commonly called 'Pink Terfess of Mamora'. It was harvested on acid soil, in a semi-arid climate. *Terfezia arenaria* established mycorrhizal symbiosis with *Helianthemum guttatum*, and it was detected by the 'mark' method. The ascocarps examined were from 2 to 10 cm in diameter and weighed between 4 and 200 g with variable shape (sub-globose, cordiform, bumpy). The asci were ovoid or sub-globose (80–96 × 71–79 μm). They contained eight ascospores, spherical (22–26 μm diameter) and covered with truncated cylindrical warts characteristic of the species (Figure 1b). *Terfezia leptoderma* was collected on acid soil under *Helianthemum guttatum*. The ascocarps were 2 to 5 cm in diameter, generally globose ovoid or pyriform and humped. Asci were octospores, globose, and sessile at maturity; they measured 54–70 × 62–80 μm. The ascospores were black at maturity, spherical and 20–24 μm in diameter. They were covered with spines truncated at the ends (Figure 1c).



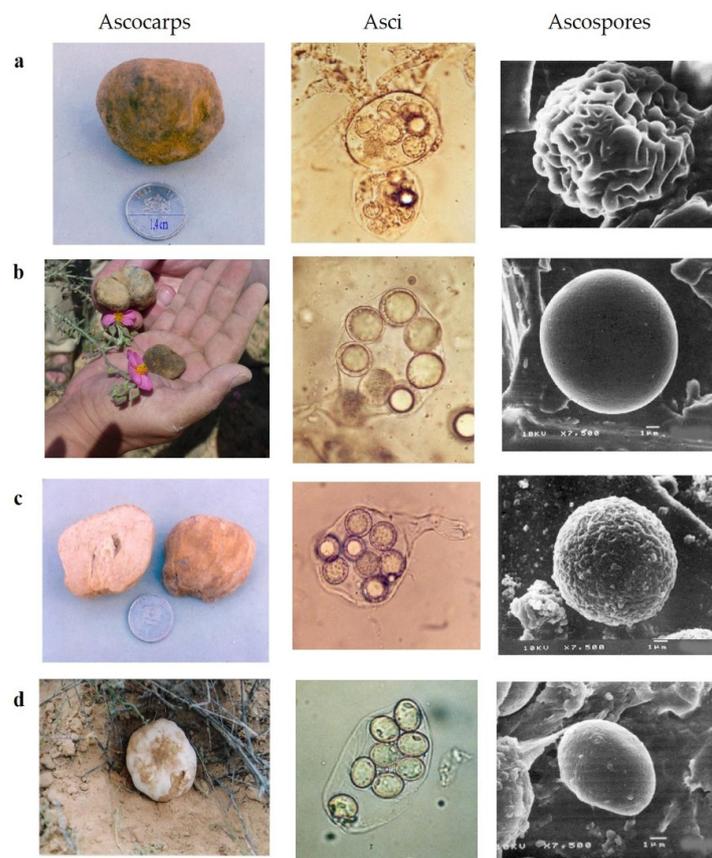
**Figure 1.** Ascocarps, asci and ascospores of Mamora truffles (Leg. Khabar). (a) *Delasria rosea*; (b) *Terfezia arenaria*; (c) *Terfezia leptoderma*.

Another species, *Terfezia boudieri*, was collected from Had Hrara in the region of Oualidia (32°43'53" N, 9°2'3" W), on limestone soil. The ascocarp weight was 30 to 100 g and diameter size of 3 to 8 cm, sub-globose, turbinate or fusiform. The sub-globose asci (66–80 × 56–60 μm) contained six globose ascospores 26 to 30 μm in diameter and yellow to brown in color at maturity (Figure 2).



**Figure 2.** Ascocarps, asci and ascospores of *Terfezia boudieri* (Leg. Khabar).

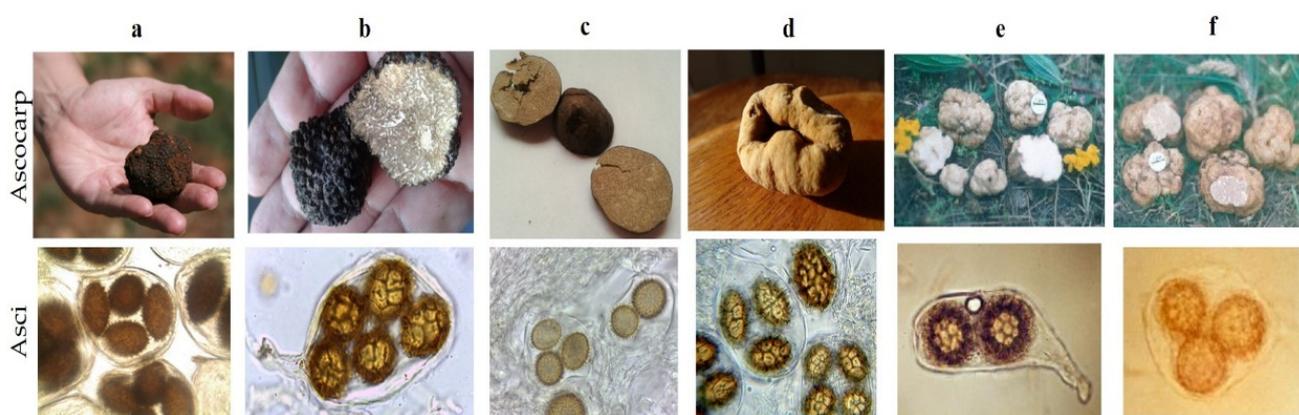
In the oriental region of Morocco, other promising species were detected, such as *Terfezia claveryi*, *Picoa juniperi*, and *Tirmania* sp. *Terfezia claveryi*, which were collected close to *Helianthemum lippii* in the Arfoud region (31°26'20" N, 4°14'37" W) in the southeast of Morocco, called 'Red Terfess of Tafilalt'. The examined ascocarps had various shapes (cordate, ovoid, and rounded), measuring from 3 to 5 cm in diameter with a weight of 17 to 50 g. The asci were numerous and ovoid (64–68 × 72–84 µm). The ascospores were hyaline to grayish with a spherical shape (18–21 µm in diameter) (Figure 3a). *Picoa juniper* is a very rare species found in Ten Drara of Figuig province (33°03' N, 2°00' W). The ascocarps were very light and characterized by a modest size (3 to 6 cm). The asci were sessile and globose, 60 to 100 µm in diameter, containing eight smooth and slightly elliptical ascospores (24–28 × 28–30 µm) (Figure 3b). Otherwise, *Tirmania* sp., locally known as 'White Terfess of Tafilalt', was very abundant in the southeast, in arid and sub-Saharan climates. *Tirmania pinoyi* was collected in Bni Guil whilst *Tirmania nivea* was located in Bouarfa, both under *Helianthemum hirtum*.



**Figure 3.** Ascocarps, asci and ascospores of Morocco Oriental truffles (Leg. Khabar). (a) *Terfezia claveryi*; (b) *Picoa juniperi*; (c) *Tirmania pinoyi*; (d) *Tirmania nivea*.

The ascocarps size of *Tirmania pinoyi* was from 3 to 8.5 cm in diameter. The asci were about  $70\text{--}100 \times 40\text{--}55 \mu\text{m}$ . The ascospores were globose and  $16\text{--}24 \mu\text{m}$  in diameter (Figure 3c). The ascocarp size of *Tirmania nivea* was 3–12 cm in diameter and the asci were  $60\text{--}80 \times 30\text{--}50 \mu\text{m}$ . The ascospores were elliptical and  $60\text{--}20 \times 12\text{--}15 \mu\text{m}$  (Figure 3d).

Regarding tuber species in Morocco, five truffles were identified including *Tuber uncinatum/aestivum*, *Tuber brumal*, *Tuber excavatum*, *Tuber rufum* and *Tuber melanosporum*. This species was particularly found in mountainous regions, with pedoclimatic conditions similar to those of Europe. *Tuber melanosporum* (Figure 4) was found in the plateau of Debdou and in Immozer of Moyen Atlas. *Tuber uncinatum/aestivum*, *Tuber brumal*, *Tuber excavatum* and *Tuber rufum* (Figure 4) were collected in the middle Atlas under *Quercus ilex* and *Quercus faginea*. Finally, two other species were collected in semi-arid climates and in acidic sandy loam soil of Mamora forest, such as *Tuber asa* near *Helianthemum guttatum* and *Tuber oligospermum* under *Pinus pinaster* and *Pinus halepensis*.



**Figure 4.** Ascocarps and asci of *Tuber* sp. (Leg. Khabar). (a) *Tuber melanosporum*; (b) *Tuber uncinatum/aestivum*; (c) *Tuber rufum*; (d) *Tuber excavatum*; (e) *Tuber asa*; (f) *Tuber oligospermum*.

#### 4. Discussion

The species found in Morocco, such as *Terfezia arenaria*, *Terfezia leptoderma* and *Delastria rosea*, were also found in the south of Spain, the south of France and the south of Italy [7], and these species were in all countries of North Africa [4]. On the other hand, the species *Picoa juniperi*, *Terfezia claveryi*, *T. boudieri*, *Tirmania pinoyi*, and *T. nivea* collected in the Oriental regions of Morocco were also discovered in the deserts of Algeria [8] and Tunisia [9,10], whereas the black truffles collected in Moyen Atlas of Morocco were found in similar conditions of Europe truffles [7].

#### 5. Conclusions

There are strong analogies between the species found/available in the Mediterranean countries. Still, the survey of Moroccan truffles is in progress, and further exploration will be performed in the southern and Saharan region of Morocco. We propose to develop methods of mycorrhization by several desert truffles to enhance the culture and rural development. We thought that desert truffles with their host plants would be an excellent alternative for recovering degraded soils.

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