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Bioecology of desert truffles in the province of Figuig in Eastern Morocco

Bioecología de las trufas del desierto en la provincia de Figuig en Marruecos Oriental

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SUMMARY

Background: The phytosociology, host plant and diversity of desert truffles in northeastern Morocco are very little known worldwide.

Objective: To evaluate some general and specific parameters of phytosociology, host plant and diversity of desert truffles in eastern Morocco.

Methods: Ten pilot productive sites located in the province of Figuig, Morocco were evaluated. Soil characteristics were evaluated and host plants and species of truffles were identified under field conditions.

Results and conclusion: Phytosociological results revealed the abundance of the herbaceous *Helianthemum ledifolium* as dominant host plant in eight sites in Abbou Lakhel and Bni Guil. Meanwhile, the perennial *Helianthemum lippii* dominated two sites in the Northwestern part of the study area. The truffles *Tirmania nivea*, *Tirmania pinoyi*, *Terfezia claveryi*, *Terfezia boudieri* and *Picoa juniperi* were identified in the studied areas. Species of the genus *Tirmania* were abundant in Bni Guil and those belonging to the genus *Terfezia* dominated in Abou Lakhel. The genus *Picoa* was identified only in one site. This work shows that the host plants and the climatic conditions influence the distribution of desert truffles in eastern Morocco.

Keywords: Desert climate, Desert truffles, *Helianthemum ledifolium*, *Helianthemum lippii*, *Terfezia*, *Tirmania*, *Picoa*.

RESUMEN

Antecedentes: La fitosociología, y diversidad de plantas hospederas y de trufas del desierto en el noreste de Marruecos ha sido escasamente estudiada a nivel mundial.

Objetivo: Evaluar algunos parámetros generales y específicos de la fitosociología, y la diversidad de las plantas hospederas y la diversidad de trufas del desierto en el noreste de Marruecos.

Métodos: Se evaluaron diez sitios productivos piloto ubicados en la provincia de Figuig, en Marruecos. Se evaluaron las características del suelo y se identificaron las plantas hospederas y la diversidad de trufas en condiciones de campo.

Resultados y conclusión: Los resultados fitosociológicos revelaron la abundancia de la planta herbácea *Helianthemum ledifolium* como planta huésped dominante en ocho sitios en Abbou Lakhel y Bni Guil. Mientras tanto, la planta perenne *Helianthemum lippii* dominó dos sitios en la parte noroeste del área de estudio. Las trufas del desierto *Tirmania nivea*, *Tirmania pinoyi*, *Terfezia claveryi*, *Terfezia boudieri* y *Picoa juniperi* fueron identificadas en las áreas estudiadas. Las especies del género *Tirmania* fueron abundantes en Bni Guil y las pertenecientes al género *Terfezia* dominaron en Abou Lakhel. El género *Picoa* fue identificado solo en un sitio. Este trabajo muestra que las plantas hospederas y las condiciones climáticas influyen en la distribución de las trufas del desierto en el este de Marruecos.

Palabras clave: Clima desértico, trufas del desierto, *Helianthemum ledifolium*, *Helianthemum lippii*, *Terfezia*, *Tirmania*, *Picoa*.

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INTRODUCTION

Desert truffles “Terfass” are mycorrhizal fungi that grow almost exclusively in semi-arid and arid zones. Mycorrhizas are worldwide symbiotic associations established between certain soil fungi and most vascular plants and are fundamental in optimizing plant fitness and soil quality. Mycorrhizal symbioses improve the resilience of plant communities against environment stresses, including nutrient deficiency drought and soil disturbance (Barea *et al.*, 2011).

The desert truffles “Terfass” grow in the sand, under herbaceous angiosperms, under *Cistus* and *Helianthemum* (Alsheikh, 1984), the most common host plants of “Terfass” being generally herbaceous or perennial *Helianthemum* species (Awameh and Alsheikh, 1980; Khabar *et al.*, 1994; 1999; 2001; 2014; Fortas and Chevalier, 1990, Roth-Bejerano *et al.*, 1990; Morte and Honrubia, 1997).

Generally, “Terfass” occur in semiarid and arid areas with hot climates in almost all the Mediterranean basin especially in North Africa and Middle East countries. Diez *et al.* (2002) grouped them based on climatic and soil characteristics of the area of origin and they found that *Helianthemum* hosts have a wide edaphic tolerance which explains the occurrence of several truffle species hosted by *Helianthemum* in both acid and basic soil. The formation of truffles depends on several factors such as the rainy season (including length and amount of precipitation), the soil types and some abiotic characteristics as water availability and climatic conditions.

Desert truffles grow in arid desert climate characterized by very hot summers with high humidity and relatively cooler winters (Mandeel and Al-Laith, 2007). In Algeria the productive area of desert truffles are characterized by its aridity and high average temperatures (Bradai *et al.*, 2013). A factor of paramount importance in the formation of desert truffles are the autumnal rains (Bradai *et al.*, 2013). Khabar *et al.* (2001; 2016) and Zambonelli *et al.* (2014) described the area localized in the East and South eastern Morocco in arid and subdesert climate and calcareous soil and they identified five species of desert truffles belonging to three genera: *Tirmania pinoyi*, *Tirmania nivea*, *Terfezia boudieri*, *Terfezia claveryi* and *Picoa juniperi* associated to *Helianthemum lippii* as perennial host plant and

other species of herbaceous *Helianthemum*. *H. lippii* hosted all the desert truffles species in arid climate including *T. boudieri* and *T. claveryi* in the Arab Peninsula (Alsheikh, 1994); *T. boudieri*, *T. claveryi*, *Tirmania pinoyi*, *T. nivea* and *Picoa juniperi* in the Moroccan High plateaus (Khabar *et al.*, 2005) and Médenine in Tunisia (Slama *et al.*, 2010); and *Terfezia boudieri* in Negev desert (Sitrit *et al.*, 2014).

This work aims to study some biological (phytosociology, host plants and presence of shrubs) and abiotic ecological parameters (climate and soil) which influence the distribution of the desert truffles in pilot productive Moroccan areas in order to identify its general characteristics and particularities.

MATERIAL AND METHODS

Study areas

The study area is administratively located in the province of Figuig, in the eastern part of the rural commune of Bni Guil, which is a rural commune placed in the southeastern part of Morocco. The study area (Figure 1) is naturally limited by a range of mountains (mountain in Arabic = *Jebel*) into the chain of the high Atlas of the southern side by the most important summit, the biological and ecological interest site of Jebel Grouz (1920 m a.s.l.) representing a natural territorial limit between Morocco and Algeria.

The choice of the studied sites was based on the investigation of the nomad population, seasonal collectors, and truffle production data of 2013 by kg per a three-month season in various production sites. These data were obtained from the Provincial Department of Agriculture of Figuig. No data were recorded recently due to the great production fluctuation and low harvests.

Ecology

Desert truffles “Terfass” soil of 13 productive site, six in east and seven in the western part of the study area were analyzed (Table 1) (PDPEO, 2005). Rainfall and temperature data were obtained from climate-data.org. For Bni Guil we used Bouarfa city climate data station, the urban center of Bni Guil (Table 2).

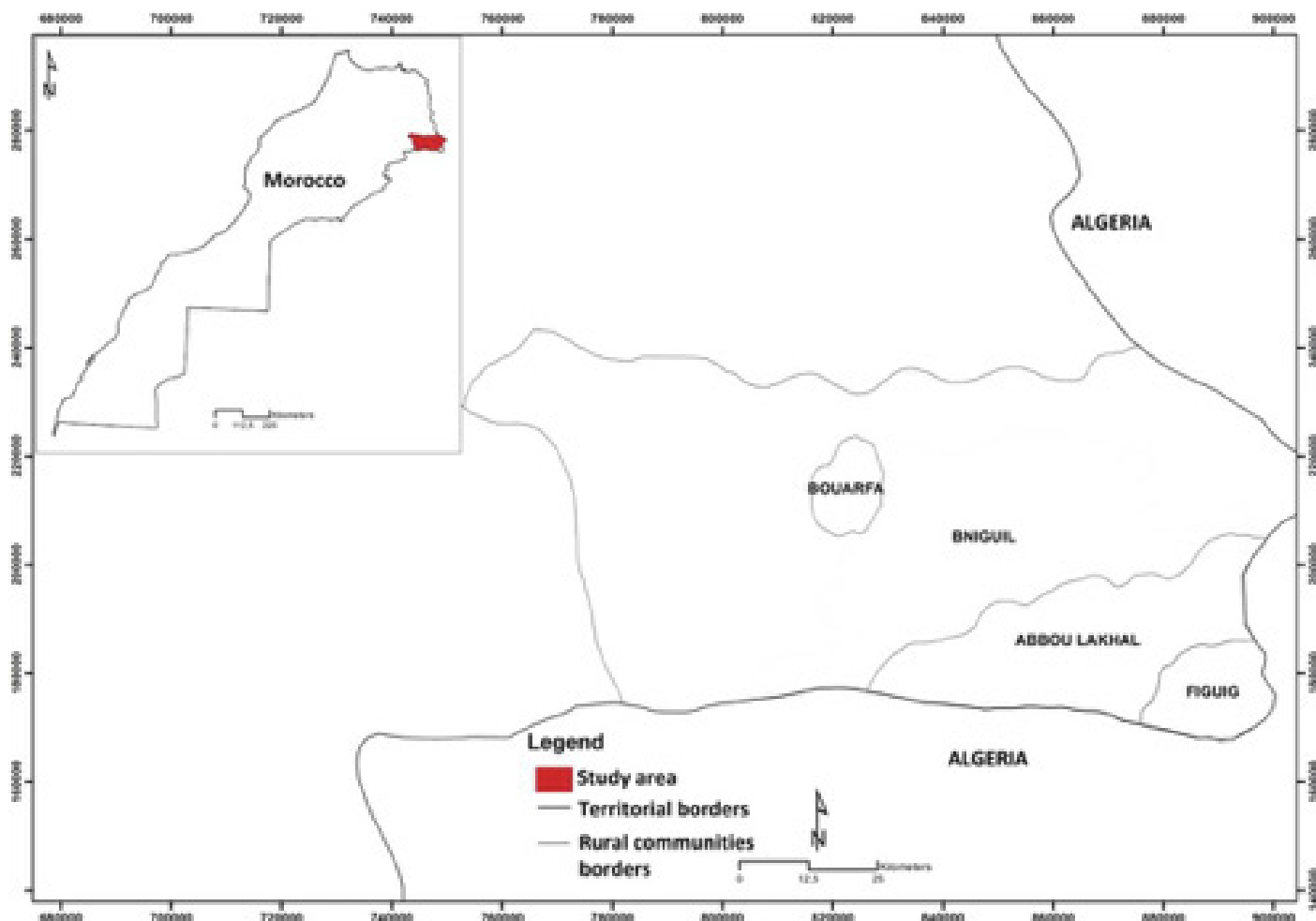


Figure 1. Study area located in the borders of Morocco and Algeria.

Table 1. Average soil parameters of the study area

Texture (%)	
Clay	17.5
Silt	7.5
Sand	44.5
pH	8.25
Chemical composition	
Organic matter %	0.9
K ₂ O (mg.kg ⁻¹)	389.86
P ₂ O ₅ (mg.kg ⁻¹)	12.825
N-NH ₄ (mg.kg ⁻¹)	0.35
N-NO ₃ (mg.kg ⁻¹)	15.65
MgO (mg.kg ⁻¹)	272.585
CaO (mg.kg ⁻¹)	2913.815

Mycological and phytosociological study

Mycological and phytosociological surveys were conducted according to the method defined by Braun-Blanquet (1952), in an area of 100 m² of a representative and homogeneous harvest point. Knowing that every productive site can contain several harvest points. These areas included the dominant perennials and herbaceous strata identified directly on the field. The distinction among truffle species is typically based on both macromorphology and micromorphological characters (Malençon, 1973). In the laboratory, small fragments were taken from the gleba, crushed and mounted in KOH 5%. The observation by light microscopy allowed the observation of ascospores and to specify their sizes, shapes, color, and the degree of maturity of the truffles by using the Key of Tuberals of Morocco (Khabar, 2002).

RESULTS AND DISCUSSION

Abiotic conditions

The study area is relatively mountainous. Every site nomenclature refers to a relief; there is the lowland, the Jebel foothills (*Jebel*=Mountain), (*Dayet* =Lake), (*Maader* =Lowland where there is an intersection). It is therefore a very clear contrast. Nine productive sites were selected for this study, knowing that, each site could contain from one to several harvest points, the surface of a homogenous site varied, and therefore was linked to another close site if there was no orographic barrier between them.

(i) Climate and soil: Climatic parameters are among the most important abiotic factors that effectively control the occurrence of desert truffles (Trappe *et al.*, 2008 a, b). In eastern Moroccan steppes, vegetation is affected by climate; its intensity seems more amplified in the presence of the most pressing anthropic factors on pastoral resources (Bechchari *et al.*, 2014). The climate in our study area was desert with moderate rainfall in both winter and summer, with average temperatures of 17.9 °C in Bni Guil (k: dry and cold) and 18.6 °C in Abbou Lakhhal (h: dry and hot). The average annual rainfall was 170 mm, with June and July as the driest months with 1.5 mm of average rainfall. On average, 57% of the rain fell before the end of March and nearly 92% by the end of April (PDPEO, 2005). Usually good annual rainfall from October to March makes a good harvesting season desert truffles in Algeria (Bradai *et al.*, 2014). Autumnal precipitation was higher, 21 mm in October for Abou lakhal and 25 mm in November for Bni Guil, which is called *Choula* by local and nomad population. Meteorologically, heavy rain showers during mild to warm weather (25–30 °C) coupled with heavy evening or early morning dewfalls and thunder and lightning has been considered an essential requirement for truffle formation (Al-Rahmah, 2001).

(ii) Soils analysis. This showed a sandy structure, very low contents of organic matter, alkaline pH and very low levels of nitrogen and phosphorus. Corresponding to the fact that soils with the low P availability is highly correlated to a low organic matter, from 10 to 20 mg/kg (Bonifacio and Morte, 2014). On the other hand, the potassium and calcium contents were high. According to Morte *et al.* (2009) variations in the content of carbonate and pH affect the presence of truffle species.

Phytosociology and mycological diversity

Phytosociology: *The dominant species were Anabasis aretoides, Hammada scoparium, and Helianthemum appenninum. The host plants Helianthemum lippii* (Figure 2) called locally “Gurish” and *Helianthemum ledifolium* called locally “Tegsis” were included into an *Anabasis aretoides* Bugen steppe studied in Oriental Morocco (Guinet, 1954). Dominance of *A. aretoides* is used by harvesters as an important parameter to identify a desert truffle area. The formation characterized the rocky soils vegetation and covers quite large areas between Bouarfa and Figuig under a Desert bioclimate (Ben El Moustapha *et al.*, 2001).

No desert truffles were collected under the perennial *Helianthemum appenninum* and no other host plant was signaled by nomads and seasonal harvesters. Ninety percent of native people in Algeria do their truffle searching where host plants *Helianthemum* spp. are abundant (Bradai *et al.*, 2014). Plants from the genus *Helianthemum* were the only host plants and sometimes desert truffles were linked to their roots. In Mader Msarin and Hammourzag, *Tirmania* and *Terfezia* species were identified under *Helianthemum lippii* when *Helianthemum ledifolium* was totally absent. On the other hand, and despite the presence of the perennial *Helianthemum lippii* in Mdaouer site no desert truffles were recorded, whereas *Helianthemum ledifolium* was dominant (Table 3).



Figure 2. *Helianthemum lippii* host plant of desert truffles growing under field conditions.



Table 3. Floristic and mycological information of the studied areas

Station	Kharouaa	Jbel Maiz	Bou Rmouana	Jbel Araitha	Mâder Zoulay	Dayet Chaoui	Bliaza	Mdaouer	Mâder Msarir	Hammourzag
Latitude N	32° 14' 49.2"	32° 13' 48.4"	32° 9' 36"	32° 13' 55.1"	32° 17' 5.1"	32° 20' 33.9"	32° 29' 17.2"	32° 29' 33.3"	32° 29' 33.3"	32° 38' 5.1"
Longitude W	1° 53' 13.7"	1° 23' 28.5"	1° 33'	1° 38' 47.7"	1° 39' 11.3"	1° 37' 30.0"	1° 38' 21"	1° 53' 13.7"	1° 53' 13.7"	2° 15' 53.7"
Commune	Abou Lathal		Bni Guil							
Plants										
% Total Rec/										
100m ²	20%	15%	15%	15%	15%	12%	15%	15%	15%	12%
Dominant species 1	<i>H.scoparium</i>	<i>A.aretioides</i>	<i>A.aretioides</i>	<i>A.aretioides</i>	<i>H.scoparium</i>	<i>A.aretioides</i>	<i>H.scoparium</i>	<i>H.scoparium</i>	<i>A.aretioides</i>	<i>H.scoparium</i>
Dominant sp. 2	<i>A.aretioides</i>	<i>H.scoparium</i>	<i>H.scoparium</i>	<i>N.mucronata</i>	<i>H.apenninum</i>	<i>N.mucronata</i>	<i>H.apenninum</i>	<i>H.apenninum</i>	<i>H.lippii</i>	<i>N.mucronata</i>
Dominant sp. 3	<i>H.apenninum</i>	<i>H.apenninum</i>	<i>H.apenninum</i>	<i>H.apenninum</i>	<i>A.aretioides</i>	<i>H.apenninum</i>	<i>Lycium.sp</i>	<i>H.lippii</i>	<i>cronata</i>	<i>H.lippii</i>
Herbaceous layer	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Ferula communis,</i>	<i>Atractilys serratulooides</i>
Host plant	<i>Ferula com-munis</i>	<i>Lobularia maritima</i>	<i>Lobularia maritima</i>	<i>Lobularia maritima</i>	<i>Lobularia maritima</i>	<i>Lobularia maritima</i>	<i>Lobularia maritima</i>	<i>Lobularia maritima</i>	<i>Atractilys serratulooides</i>	<i>Ferula com-munis</i>
Truffles	<i>Helianthemm ledifolium</i>	<i>Helianthemm ledifolium</i>	<i>Helianthemm ledifolium</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Helianthemm ledifolium,</i>	<i>Ferula</i>	<i>Atractilys serratulooides</i>
Dominant genera 1	<i>Terfezia,</i>	<i>Picoa,</i>	<i>Terfezia,</i>	<i>Terfezia</i>	<i>Terfezia</i>	<i>Terfezia,</i>	<i>Tirmania</i>	<i>Tirmania</i>	<i>Tirmania</i>	<i>Tirmania</i>
Dominant genera 2	<i>Tirmania</i>	<i>Terfezia</i>	<i>Tirmania</i>	<i>Tirmania</i>	<i>Tirmania</i>	<i>Tirmania</i>	<i>Terfezia,</i>	<i>Terfezia,</i>	None	<i>Terfezia</i>
Average number of truffle /100m ² harvest point	4	4	3	3	2	4	5	3	1	3
Harvest points / Site	12	3	18	7	9	11	14	6	1	10

Mycological diversity: There was a big variation in the number of desert truffles collected and the dominant species collected. We had some particularities in the site of Jbel Maiz characterized by the presence of *Picoa juniper* (Figure 3). The mycological study showed variability in the number of harvest point's number per site and the number of desert truffles collected per harvest point. A dominance of ascomata belonging to the genus *Terfezia* (Figure 4) in Abbou Lakhel and dominance of the genus *Tirmania* (Figures 5 and 6) were recorded in Bni Guil.

A particular presence of *Picoa* genus represented in Morocco by one species *Picoa juniperi* by (Khabar *et al.*, 2001) was identified in Jbel Maiz site. This has been considered as an infrequent species by Calogne (1982).

The average number of desert truffles collected in harvesting points of 10m²x10m² ranged from 1 to 4. In the same site it was possible to find a variation of ascomata from a harvest point to another (Table 3).

In addition to that, soil and climate factors were favorable for the development of other non-mycorrhizal fungi as *Pleurotus eryngii* an edible mushroom hosted by *Ferula communis* consumed locally but having a moderate economic interest compared to "Terfass".



Figure 3. *Picoa juniper* showing its small size.



Figure 4. *Terfezia boudieri* growing under natural conditions.



Figure 5. *Tirmania nivea* growing under natural conditions.



Figure 6. *Tirmania nivea* showing the big size that can reach.



CONCLUSION

Climatic and edaphic conditions favor the mycorrhization and development of the following desert truffles: *Tirmania nivea*, *T. pinoyi*, *Terfezia claveryi*, *T. boudieri* and *Picoa juniperi* in the study area. In our study area we have a Desert climate with an average annual rainfall of 170 mm and some rainfall in October and November. Phytosociological and mycological surveys showed a dominance and presence of only one host plant *Helianthemum ledifolium* in Abbou Lakhhal conditioned by microclimate created by orographic reliefs. Meanwhile, mycological surveys showed a dominance of *Terfezia* then *Tirmania* species and the presence of a rare species of *Picoa* in one site. We can conclude that our study highlight the importance of biotic and abiotic factors in the distribution of desert truffles in eastern Morocco.

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