

Description of the symptoms of *Biscogniauxia* on cork oak and identification of a fungal complex

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ABSTRACT

In this study, based on research conducted between 2023 and 2024 in the Mamora cork oak forest, various symptoms were observed and described in cork oak trees: defoliation and dieback of branch tips, abnormal discoloration of young shoots, twigs, and branches, alterations to the bark and wood, sap flow from branches and trunks, and bark peeling. The dieback was observed on old cork oak stumps and on young trees from reforestation projects. This study aimed to identify and study the fungal complex associated with the cankers visible on the trunks and branches of the cork oak. Samples taken from the cankers underwent two types of complementary analysis: (1) scraping of the canker patches and microscopic observation of the fungal spores present, and (2) incubation of the canker patches using the blotter test and transfer of the resulting spores onto a culture medium. The results revealed the presence of *Biscogniauxia mediterranea*, a fungus responsible for canker and cork oak dieback, accompanied by a diverse fungal complex including various genera: *Bipolaris*, *Alternaria*, *Pestalotia*, *Torula*, and *Fusarium*. These findings, which significantly improve our understanding of the health condition of the Mamora cork oak forest, constitute a preliminary but essential step toward future comprehensive studies aimed at developing effective prevention and protection strategies for cork oaks.

Keywords: *Biscogniauxia mediterranea*, coal, fungal complex, dieback, cork oak forests.

INTRODUCTION

Cork oak (*Quercus suber*), the main species of the Mamora forest, is one of the endemic species of the Mediterranean basin which extends over a total area of 19,640,000 ha (Dahmani et al., 2000; Santos Pereira et al., 2008), that of Morocco is 350,000 ha (16%). Moroccan cork oak forests extend in the northwestern part of the coastal plains to the Central Rif and the Middle Atlas: Western Rif, Central Rif, Tazekka, Rharb, Maamora, Central Plateau and hinterland, from Rabat to Casablanca (Bammi and Douira, 2004; Boujraf et al.,

2021, 2023). There are also many other small cork oak massifs or islets in the mountain ranges of the Eastern Rif (Jbel Karn), the Middle and High Atlas (Azilal, Guedrouz, Rheraia, Amizmiz, Amsittène, etc.) (Aafi, 2007).

The cork oak forest of the Maamora forest belongs to the private forest domain of the state, administratively managed by the forestry authorities of the provinces of Kenitra and Khémisset and the prefecture of Salé (Aafi, 2007). The forest is home to a very rich and varied flora and integrates a set of multifunctional ecosystems, notably for the production of wood, cork, fodder,

cytogenetic resources and the harvesting of non-timber forest products, such as lichens and edible mushrooms (Mhirit et al., 1996).

The Maamora forest, close to urban centers and agricultural lands, has unfortunately suffered for several decades from numerous natural and anthropogenic constraints that weigh heavily on its management system and which have very harmful repercussions on the natural regeneration of cork oak, and consequently on the dynamism and even the “health” of its ecosystem (Abourouh et al., 2005). It has become vulnerable to various types of air, soil and water pollution that have impacted the regeneration process and the production of quality cork (Hamidi et al., 2017), an important financial product in the region (Berkat, 2018). According to this author, the increasing concentration of pollutants, particularly due to human activities, leads to soil degradation and the reduction of their various forms. The forest also faces significant threats, including illegal logging, acorn collection, overgrazing (Laaribya, 2023), fragmentation linked to urbanization, conversion of land for agricultural purposes and climate change (Zine EL Abidine et al., 2020). Satellite image studies, carried out by Lahssini et al. (2015), revealed an increasing degradation of the Maamora forest. This deterioration has led to a decline of approximately 35% of the cork oak forest area over the past few decades. Similarly, the analysis of fire risk areas, established by Cherki (2012), highlighted a high vulnerability of the Mamora forest, especially during the summer (July and August), when temperatures increase and humidity decreases. The most affected vegetation cover is currently located, according to Lahssini et al. (2015), in the southern part of the Maamora forest, an area where agriculture has become intensive and the exploitation of the natural resources of the cork oak forests is particularly apparent.

The Maamora forest was also cleared by the water and forestry administration for the plantation of exotic species. In fact, the stunted trees were replaced by *Pinus pinaster* var. *atlantica* (14,100 ha), *Eucalyptus camaldulensis* (40,350 ha), or by *Acacia mollissima* (1,000 ha), to produce timber, paper pulp and tannin respectively (Dahmani, 2005). In addition to this decline in the area of cork oak, there is the threat of the disappearance of rare or endemic plant species (Benabid, 2000).

The cork oak areas are also declining considerably due to the successive declines they face, which weaken the ecosystems in question, reduce

their productivity and compromise the quality of the cork (Hamidi et al., 2014). According to Benabid (2000), It is difficult to satisfactorily explain and identify specific reasons behind this phenomenon. According to Chliyah et al. (2017), Rhimini et al. (2018 and 2020) and Msairi et al. (2023), the decline of the olive tree, from a mycological point of view, is due to a varied fungal complex. In general, the decline phenomenon, a complex phenomenon of both biotic and abiotic nature, must be approached in a multidisciplinary manner.

In Morocco, cork oak decline was first reported between 1918 and 1928 by Boudy (1948). Subsequently, other authors reported this type of complex cork oak symptom (Maghnia et al., 2017). According to Harrachi (2000), the Mamora forest is considered a typical example where cork oak decline is most apparent. The density of cork oak in this forest has decreased significantly (Belghazi et al., 2011).

The causes of cork oak decline are multiple, resulting from the combination of several factors, continuous disturbances of climatic factors, repetitive periods of drought (Lindner et al., 2010), aging of stands, fires, poorly carried out demascling, intense overgrazing (Belghazi et al., 2011), phytosanitary problems, diseases and insect pests (El-Badri and Abadie, 2000; El Ahmadi et al., 2023; Bendjebbar et al., 2023) and others. The fungal origin of cork oak decline is not yet well understood. Fungi associated with cork oak are numerous (El Assfour et al., 2011), but the specific contribution of each species to the degradation of different parts of the tree remains unknown. Soil-borne fungi that can induce cork oak dieback have never been isolated and studied in Morocco. However, some data relating to *Biscogniauxia mediterranea* (*Hypoxylon mediterraneum*), the causative agent of anthrax, are still fragmentary.

In Morocco, the decline of cork oak was first reported between 1918 and 1928 by Boudy (1948). Subsequently, other authors reported this type of complex symptom affecting cork oak (Maghnia et al., 2017). According to Harrachi (2000), The Mamora Forest is a very clear example of cork oak decline. The density of cork oak in this forest has decreased considerably (Belghazi et al., 2011).

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al., 2010), aging of stands, fires, poorly executed unmasking, intense overgrazing (Belghazi et al., 2011), phytosanitary problems, diseases and insect pests (El-Badri and Abadie, 2000; El Ahmadi et al., 2023; Bendjebbar et al., 2023) and others. The fungal origin of cork oak dieback is not yet well understood. Many fungi are associated with the cork oak trunk (El Assfour et al., 2011), but the specific contribution of each species to the degradation of different parts of the tree remains unknown. Soil fungi capable of causing cork oak dieback, such as species of the genera *Fusarium* and *Phytophthora*, are rarely reported in Morocco. However, some data relating to *Biscogniauxia mediterranea* (*Hypoxylon mediterraneum*), the causative agent of cork smut, are still fragmentary.

This study aimed to describe the various symptoms observed in cork oak and highlighted the presence of a fungal complex in the charcoal cankers, normally induced by *Biscogniauxia mediterranea*. We also isolated, using the blotter test, certain representatives of this fungal complex in pure cultures, the morphological, molecular, and pathological characteristics of which will be determined in further studies.

MATERIALS AND METHODS

Study area

The study was conducted in northern Morocco, specifically in the Maamora forest, located between latitudes 6° and 6° 45' west and longitudes 34° and 34° 20'. This forest in the northwest of Morocco extends from the Atlantic coast, between Rabat and Kenitra, to the interior of the country between Tiflet and Khemisset, over an area of approximately 132,000 ha (Aafi, 2007). According to Jbilou et al (2024), the Maamora forest has a diverse climate. It is sub-humid with warm winters in the west and semi-arid with temperate winters in the central and eastern regions of the forest. Climate analyses show that average annual rainfall is irregular, with Mamura Forest receiving between 350 and 650 mm of rain annually, gradually decreasing eastward to 100 mm per year (Shirki, 2013). This rainfall occurs primarily during November and December, the wettest months, while it is absent during the driest months of July and August. Regarding temperatures, the average monthly temperature is 12 °C during winter, with the lowest

temperatures reaching 3.5 °C (January). The average monthly temperature is 25 °C during summer, while the highest and warmest months reach 37 °C (July-August). According to Belghazi and Mounir (2016), the summer drought affecting the Maamora forest has recently extended to last for more than two months. Geologically, the forest's substrate consists of a layer of Miocene marl and clay, as well as Pliocene sand and sandstone, on which lie deposits of red Maamora clay. The soils are characterized by a sandy cover resting on an old sandy-clayey layer (Schoolenberg, 2011). The vegetation of the Mamora forest consists of cork oak stands, artificial stands of Eucalyptus, Acacia and Pine trees and empty land. The Maamora cork oak forest is characterized by the poverty of its undergrowth and its powerful deciduous herbaceous layer (Fennane and Rejdali, 2015).

Methods

Research were conducted between 2023 and 2024 in various locations within the Mamora forest to visualize the different symptoms developing on cork oak and to collect samples of trunks or branches exhibiting charcoal cankers. The surface of the symptoms (charcoal patches) was sterily scraped using a sterile metal spatula, the fragments obtained were suspended in sterile distilled water and then stirred for one minute (Figure 1). The spore suspension obtained was filtered using a muslin to remove debris and thus separate the spores from the fragments. Microscopic observations of the collected suspension were carried out first in distilled water and then in cotton blue and photographs were taken for the types of spores observed, at magnifications of 100, 400 and 600. The determination of the spores was facilitated by the use of different determination keys (Domsch et al., 1980; Champion, 1997). In this qualitative study, the isolation percentages of each fungal species were not calculated.

Isolation of fungi from the charred patches was also performed using the blotter test (Ouazani Touhami et al., 2000; Imrani et al., 2019; Berber et al., 2022). The fragments were incubated in a humid chamber under continuous fluorescent light at room temperature. After 10 days of incubation, the fragments were examined under binocular magnifiers or under an optical microscope (under aseptic conditions), at low magnification, to detect the presence or absence of fungal conidia. The transfer of conidia under the microscope

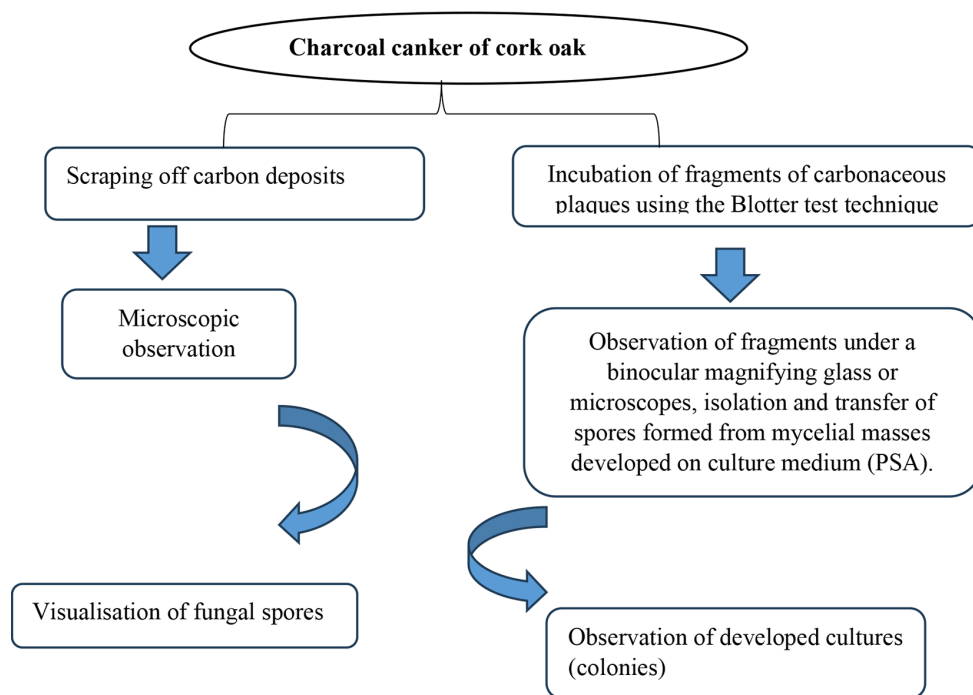


Figure 1. Diagram showing the process used to identify the fungal complex responsible for charcoal cankers in cork oak trees

was done using a drawn glass capillary previously sterilized with a flame and cooled in the culture medium (Benkirane et al., 1999, 2000; Bahous et al., 2003). The transferred conidia were deposited on the surface of the PSA culture medium (potato: 200 g; sucrose: 20 g; agar-agar: 15 g; distilled water: 1000 ml) (Serghat et al., 2005).

RESULTS

Description of symptoms observed in cork oak

The symptoms observed on cork oak in Marmora are numerous and concern all components of the tree: defoliation, drying and wilting of the tree tips, abnormal discoloration of young shoots, twigs and branches, bark and wood, oozing at the level of branches and trunks and detachment of the bark. Dieback was observed on old cork oak stumps and in young trees in reforestation plots. In the latter, cankers are sometimes observed from the base of the trunk to the tip of the tree.

Charcoal cankers observed on oak trunks are observed in old stumps and in young trees (Figures 2, 3, 4). In general, these symptoms are initially sub-cortical, become apparent as blackish plaques after the cork bursts and take on variable dimensions.

Observation of spores and isolation of fungi from charred patches

The blackish plaques of charcoal cankers visible on cork oak trunks, such as the one in Figure 5, were studied in the laboratory. The surface of the charcoal plaques was scraped with a sterile metal spatula, and the resulting fragments were placed in tubes containing sterile distilled water. After shaking, the resulting suspensions were filtered through muslin to remove debris. After this operation, microscopic preparations were made from the filtered suspensions to determine the fungal spores on the charcoal plaques. Microscopic observation of the suspension revealed the presence of various fungal structures for sexual reproduction (asci and ascospores) and asexual reproduction (multicellular spores, macroconidia), which were photographed using a camera attached to the microscope. These microphotographs are shown in Figures 6–8.

Figure 6 presents asci with eight ascospores, the sexually reproducing spores. These asci are cylindrical and measure $78\text{--}108 \times 7\text{--}9 \mu\text{m}$ (measurements taken with a micrometer). The ascospores are ellipsoid and brown to dark brown in color. They measure $13.4\text{--}20.9 \times 5.9\text{--}7.7 \mu\text{m}$. These descriptions are identical to those given by



Figure 2. Symptoms observed on cork oak growing in reforestation plots: total dieback or only parts of the tree, cankers observed along the trunk and discoloration of the wood (A and B), drying out of the branches, change in leaf color (C and D)



Figure 3. Symptoms observed on cork oak growing in reforestation plots: dieback, charcoal cankers, discoloration of the wood, lifting of the bark of the dry part of the tree, colonization of dead branches by foliose and crustose lichens, shoots developing at the base of a young tree showing total dieback of the entire aerial part

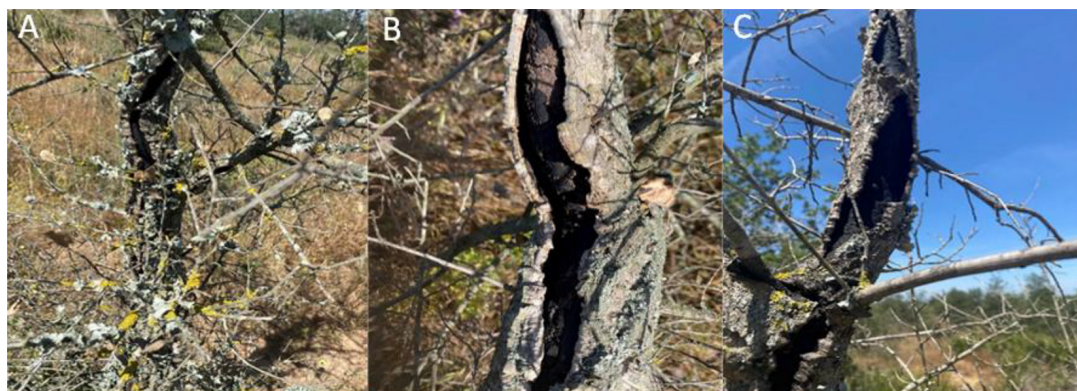


Figure 4. Cork oak trees showing total dieback and visible charcoal spots of varying sizes along the trunks

Samaneh et al. (2022) for *Biscogniauxia mediterranea*, the causative agent of charcoal cankers.

In other microscopic preparations made from the charcoal plates, asexual reproduction spores were observed in the presence of ascospores of *Biscogniauxia mediterranea* (Figures 7 and 8).

Torula spores are dark when mature, round to ovoid, and occur in characteristic chains. *Fusarium* spores are of three types, represented by multicellular macroconidia of variable shape, probably representative of three species. *Alternaria* spores are multicellular, with transverse



Figure 5. Hard, black crust visible in longitudinal cracks in cork oak bark, with brown discoloration of the tissues beneath the stroma. This crust dries out the cork, causing the bark to lift and the tree to die

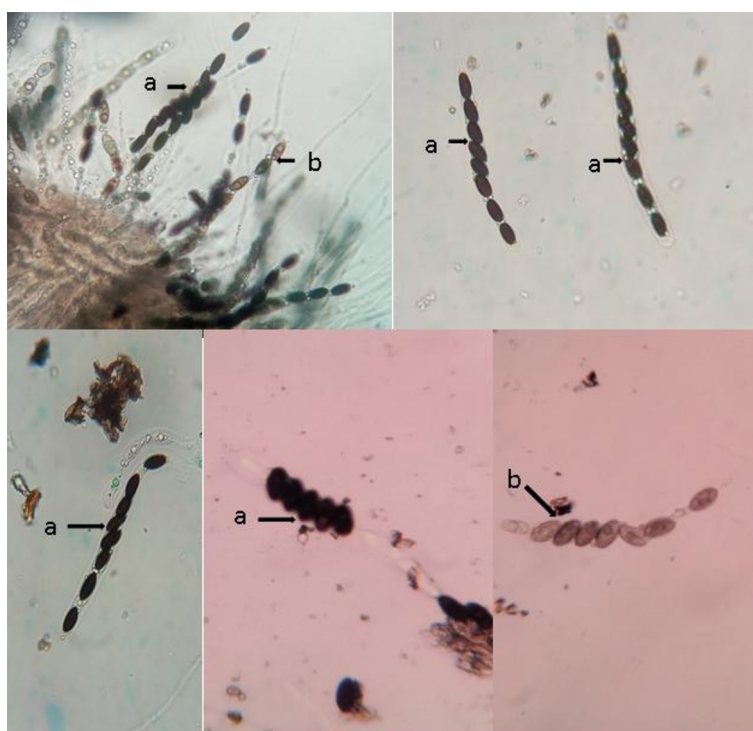


Figure 6. Observation of a microscopic preparation made from a carbonized plate (a): mature asci of *Biscogniauxia mediterranea*, with generally 8 ascospores, dark in color, per ascus, (b): asci with ascospores in the maturation phase; Observation in tap water, magnification ($\times 400$)

and longitudinal septa, while *Bipolaris* spores have only transverse septa. *Pestalotia* spores are flagellated, dark, with strongly pigmented central cells and lighter, pointed terminal cells.

Incubation of the fragments of the charcoal patches according to the 'Blotter test' technique and transfer of the spores formed onto culture medium made it possible to obtain pure cultures of different types of fungi: *Pestalotia* sp. and

Fusarium sp. (Figure 9), *Alternaria* sp. and *Bipolaris* sp. (Figure 10) and *Biscogniauxia mediterranea* (Figure 11).

These results show that the black stromata observed under the bark of cork oak trunks and branches are colonized by a varied fungal complex consisting of the main causal agent, *Biscogniauxia mediterranea*, and other fungi, such as *Alternaria*, *Torula*, *Fusarium*, *Bipolaris*

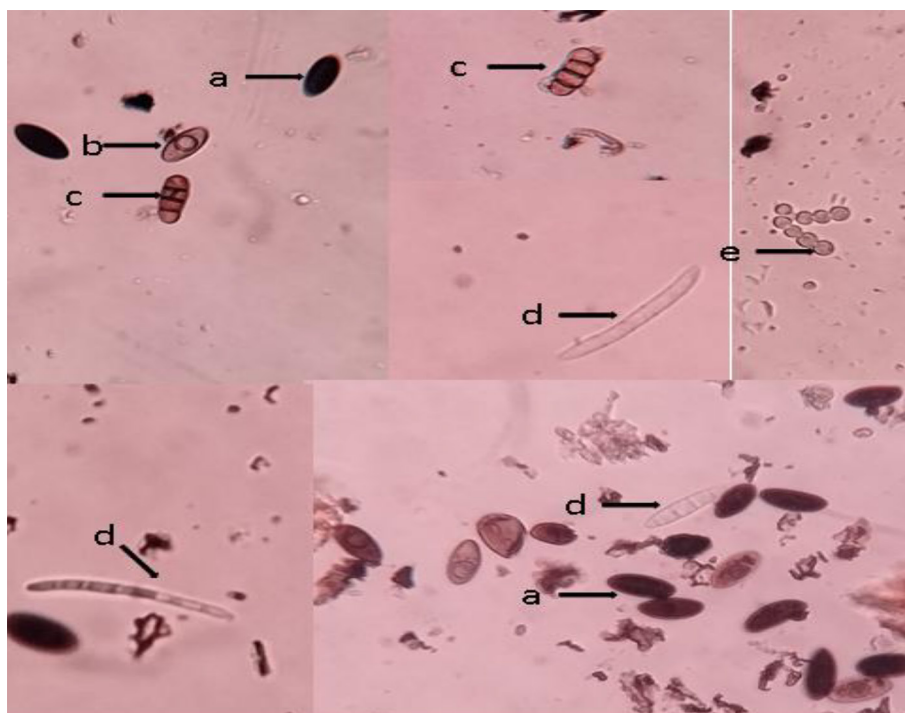


Figure 7. Microscopic observations of the structures of the fungal complex of carbonaceous plaques; (a) and (b): mature and immature ascospores of *Biscogniauxia mediterranea*; (c): spores of *Alternaria*, dictyospores, spores with longitudinal and transverse septa; (d): three types of spores (macroconidia) of *Fusarium*; (e): spores of *Torula*. Observation in tap water, magnification ($\times 400$)

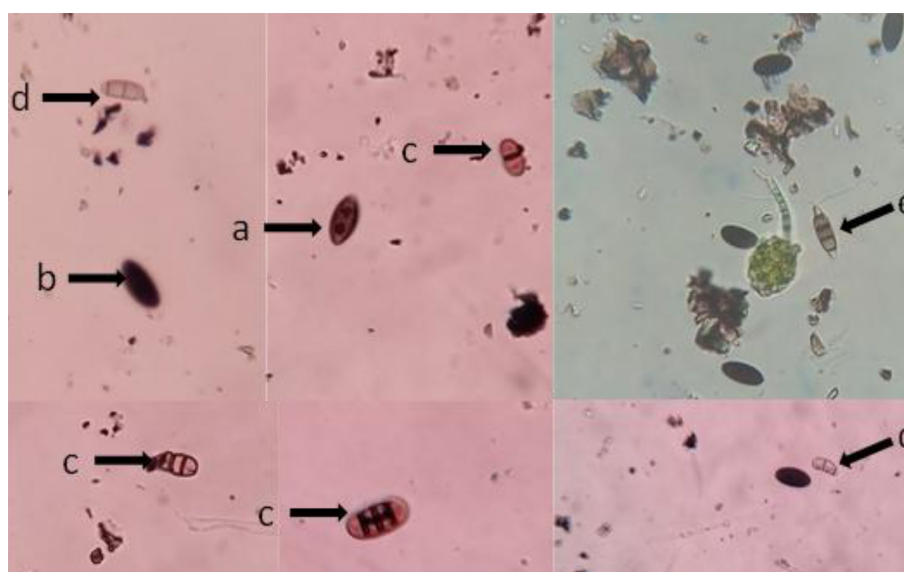


Figure 8. Microscopic observations of the structures of the fungal complex of carbonaceous plaques; (a) and (b): ascospores of *Biscogniauxia mediterranea*; (c): spores of *Alternaria*; (d): spores of *Bipolaris spicifera*; (e): spores of *Pestalotia* sp: observation in tap water, magnification ($\times 400$)

and *Pestalotia*. The isolation of all these fungi on culture media will facilitate their morphological and molecular identification. Similarly, it is advisable to know their pathogenic power towards cork oak plants

DISCUSSION

The present study describes *Biscogniauxia mediterranea* (syn. *Hypoxylon mediterraneum*), a pathogen of cork oak. The presence of *B.*

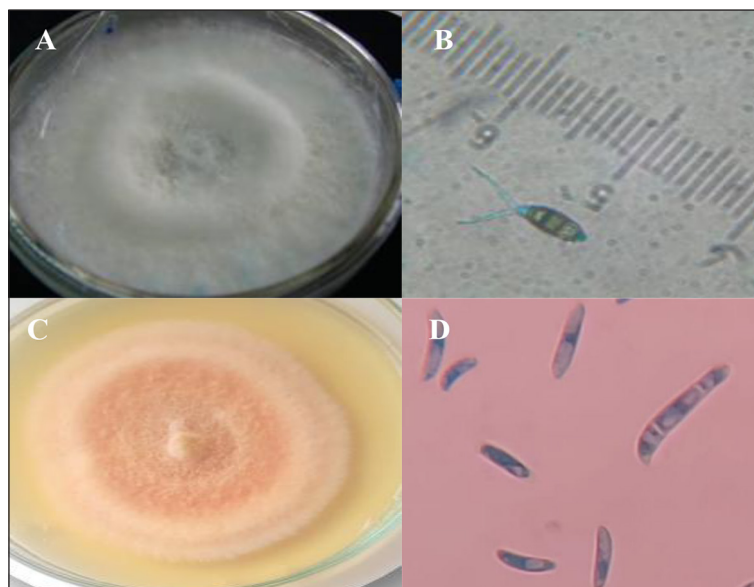


Figure 9. Colonies and conidia of fungi isolated from charcoal patches; (A) 14-day-old *Pistalotia* sp. colony; (B): *Pistalotia* sp. conidium; (C): 12-day-old *Fusarium* sp. colony; (D): *Fusarium* sp. conidia

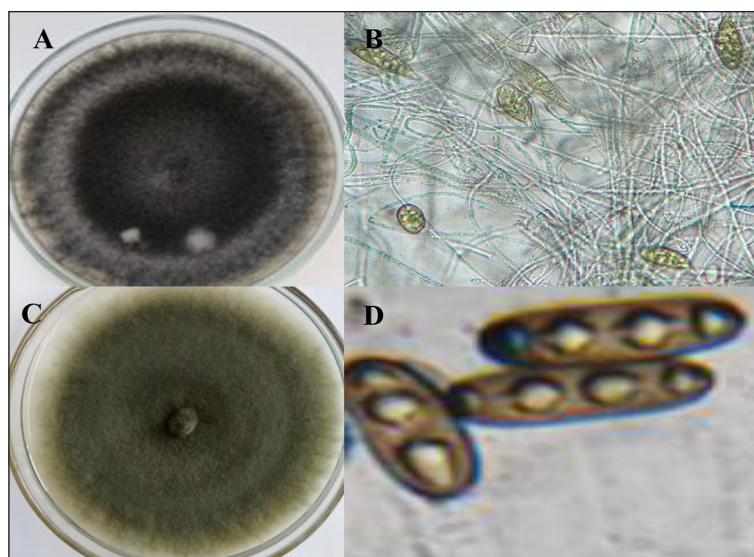


Figure 10. Colonies and conidia of fungi isolated from charcoal patches; (A) 16-day-old *Alternaria* sp. colony; (B): multicellular conidium of *Alternaria* sp; (C): 14-day-old *Bipolaris* sp. colony; (D): conidia of *Bipolaris* sp.

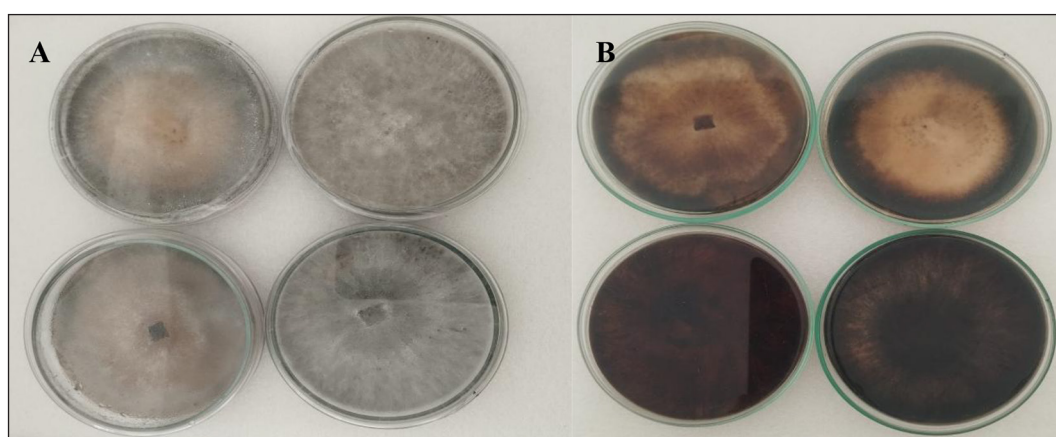


Figure 11. 7-day-old *Biscogniauxia mediterranea* colony on PDA (A), reverse side of the colony (B)

mediterranea, an endophytic fungus, is evident throughout the Maamora forest, manifested by carbonaceous cankers observed on old cork oak stumps as well as on young trees in reforested plots. Symptoms on young *Quercus suber* trees have also been reported in Portugal (Henriques, 2015). The type of symptoms induced by *B. mediterranea* is well described by Malençon and Marion (1951): carbonaceous plaques, initially subcortical, then erumpent, with an elliptical outline, longitudinally stretched of diverse dimensions. Afterwards, the cork layer splits open, revealing blackish plaques, with a charred appearance on the bast of the trees (Lanier, 1986), along the torn area. The pathogen also induces yellowing of the leaves followed by drying and defoliation (Lieutier et al., 1992). Drying also affects twigs, branches and trunks. The tree gradually declines due to lack of nutrition caused by cankers. According to Dehane et al. (2011), defoliation and dieback lead to a reduction in both the quality and quantity of cork produced. Linaldeddu et al. (2005) reported that *B. mediterranea* can infect all aerial organs of plants, including buds and, with limited frequency, roots. According to Santos (2003), the infection leads to the formation of carbonaceous stroma on the trunks and branches of affected hosts. Subsequently, the foliage discolors and dries up, and a dark exudation, accompanied by a strong tannin odor, may appear soon after plant colonization (Vannini and Valentini, 1994). In young trees, it is common to observe a brown powdery mass inside the trunks and branches, under the cracked cork.

The fungus induces discoloration of woody tissues (Henrique, 2015). The spread of *B. mediterranea* in the xylem was confirmed by microscopic observation of mycelia in the vessels by Vannini and Valentini (1994) who observed increased fungal growth in the xylem of seedlings in response to water stress.

On the surface of the stroma, small mature papilla-like outgrowths are observed and correspond to the necks of the perithecia. Within these perithecia, ascospores are produced, constituting the main propagation units of *B. mediterranea*. Ascospores and mycelium fragments also represent an effective inoculum for the dispersal of the fungus (Jimenez et al., 2005).

In general, inocula are transported to susceptible hosts by abiotic and biotic vectors: plant pathogens can be dispersed by air, rain, water or soil, and by vectors such as animals, pollen,

various microbes, people and machinery, as well as on infected plant material, including seeds (West, 2014).

The most important factor for the dispersal of *B. mediterranea* in the field is related to weather conditions, which influence both ascospore ejection and germination: ascospore ejection is associated with heavy rainfall or high relative humidity and is strongly reduced during dry periods (Vannini et al., 1996).

In Morocco, *Hypoxylon mediterraneum* is considered, according to Boudy (1950), as a very formidable fungal pathogen which, after its establishment, can, after a year, cause the death of the tree. It is difficult to accept this conclusion knowing that the incubation time, between the beginning of infection and the development of symptoms, in trees, in general, takes a long time and we must not neglect the part that comes from other biotic and abiotic constraints. A symptom, even specific, in the case of cork oak smut, to develop requires favorable conditions linked to the state of the tree and the climatic and edaphic conditions that prevail in the region. However, it is important to note that cork oak smut disease is well established in the Mamora forest.

According to Malençon and Marion (1951), *Biscogniauxia mediterranea* is a parasite of both injury and weakness, unable to attack vigorous trees, but which takes advantage of favorable circumstances for it to infect subjects weakened by poor demasking, injuries, insect attacks, fires, recurring droughts and poor soils (Smahi et al., 2014; Hamidi et al., 2014; Rouibah et al., 2018) to settle and develop. Attacks of cork oak by *B. mediterranea* cause considerable damage and a serious economic impact worldwide (Henriques et al., 2014).

Biscogniauxia mediterranea penetrates cork oak through wounds (Torres, 1985). After its establishment, the fungus forms ascospores. Rainfall participates in the release of ascospores, structures of sexual reproduction that ensure the dissemination of the fungus to other trees, via rain, wind, wood-eating insects and cork harvesting equipment (Henriques et al., 2014). According to these authors, aerial dispersal of ascospores in *Q. suber* stands is predominant, occurring after rainfall, and vertical contamination of plants is absent. According to Henriques (2015), infection of acorns by *B. mediterranea* does not mean that the fungus will be found in seedlings from these false fruits.

The degrees of attack on cork oak by *B. mediterranea* are variable and can lead to dieback, especially in young reforestation trees, with charcoal spots sometimes occupying the length of the tree trunks. The carbonaceous patches of cankers contain, in addition to *B. Mediterranea*, a diverse fungal complex, with representatives of the genera *Alternaria*, *Torula*, *Fusarium*. The pathogenicity of these representatives towards cork oak is still unknown and must be elucidated by inoculating them into cork oak plants. Indeed, representatives of these species can be considered as soil-borne fungi, in the case of *Fusarium*, or foliar fungi, in the case of *Alternaria* or *Bipolaris*. The presence of these fungi with *B. Mediterranea* could suggest several hypotheses. They can be considered as commensals living on the host metabolites without any apparent positive or negative effect on the plant's performance. They can behave as saprophytic species, as in the case of *Alternaria*, *Torula* and *Cladosporium* isolated from the root system of cannabis (Msairi et al., 2025). In the same sense, (Scortichini and Loreti, 2007) reported that some fungi can behave as latent pathogens, having harmful effects on the host plant only when growing conditions are optimal. Similarly, species of the genus *Fusarium* are soil-borne fungi capable of preserving and multiplying within the root system of plants, thus causing very serious diseases, root rot, wilting and dieback (El Haddadi et al., 2019, 2020, 2021b; El Hazzat et al., 2023, El Rhoch et al., 2025). Regarding species of the genus *Alternaria*, cork oak acorns can be attacked by these fungi (Jdaïdi et al., 2018). In the Mamora forest, *Alternaria tenuis* was isolated from the leaves and roots of *Eucalyptus gomphocephala* (Nounsi et al. (2016). Likewise, two species of the genus *Pestalotia*, case of *Pestalotia subcuticularis* (Yamni et al., 2006) and *Pestalotia cruenta* (Khey et al., 2013), isolated respectively from *Pyrus mamorensis* and *Chamaerops humilis*, two plant species which occur with the cork oak of the Mamora Forest.

The cork oak fungus, *Hypoxylon mediterraneum*, is not the only fungus that attacks cork oak in Morocco. Other fungi related to this plant species have been reported in the literature. Between 2001 and 2007, species of the genus *Gymnopilus* were studied in the Mamora forest, in the case of *Gymnopilus norfolkensis* Ress and Lepp, (2000), reported for the first time on *Quercus suber* (Haimed et al., 2001). Outcounit

et al. (2004) and Haimed et al. (2005) were able to follow the development of the carpophores of *Gymnopilus suberis* (Maire) Singer on wood fragments in the laboratory, and their macroscopic characteristics were described. *Gymnopilus luteifolius*, *Gymnopilus pampeanus* (Speg.) Singer (1951) and *Gymnopilus liqueritiae* (Pers.) P. Karsten (1879) were also reported on the cork oaks of Mamora (El-Assfour et al., 2006a, 2006b, 2007a, 2007 b; Ajana et al., 2020). These authors reported other lignicolous species on cork oak of Mamora: *Pluteus petasatus*, *Ossicaulis lignatilis*, *Meripilus giganteus*, *Fomes fomentarius*, *Schizophyllum commune*, *Bjerkandera adusta*, *Ochroporus ignarius* *Trichaptum abietinum*, *Auricularia auricula-judae*, *Stereum hirsutum*, *Pluteus cervinus*, *Volvariella bombycina*, *V. murinella* var. *umbonata*, *Gymnopilus spectabilis*, *G. spectabilis* var. *junonia*, *Armillaria mellea*, *Pleurotus ostreatus*, *P. ostreatus* f. *subalutaceus* et f. *suberis*, *P. pulmonarius*, *Pholiota limonella* et *Phyllotopsis nidulans*.

Khouader et al. (2018) also reported the symptoms of *Uredo quercus* on *Quercus suber* which are represented by uredosporiferous sori located on the upper surface of green and dried leaves.

Cork oak is also attacked by *Diplodia mutila*, which causes considerable damage in all lowland cork oak forests (Mhirit, 1999). This fungus has a higher pathogenicity than *Hypoxylon mediterraneum*. It is responsible for the formation of cankers and the drying out of the trunk and branches in cork oak with apparent regression of the crown and the appearance of tiny black fruiting bodies on all affected areas of the tree. Thus, *Diplodia mutila* appears to be a parasite with systemic endophytic development (El-Badri and Abadie, 2000). This fungus attacks other forest species such as *Acacia mollissima* and *Eucalyptus gomphocephella* (Sutton, 1980) as well as *Yucca filifera*, an ornamental plant in the towns of the Mamora forest (Kadri et al., 2014).

CONCLUSIONS

The degradation of Moroccan cork oak forests is a typical example of the weakening of forest ecosystems, where the decline of cork oak is particularly marked. The density of this emblematic species has decreased considerably, the result of a succession of declines attributed to climate change and the presence of a complex of diverse

phytopathogenic agents including in particular *Bipolaris*, *Alternaria*, *Pestalotia*, *Torula*, several species of *Fusarium* and dominated by *Biscogniauxia mediterranea*. This situation represents a real challenge for the preservation of cork oak. Furthermore, the worrying emergence of *Biscogniauxia mediterranea* is a warning signal requiring a rapid and concerted response. It is therefore imperative to put in place appropriate protection and conservation strategies in order to sustainably preserve these vulnerable ecosystems.

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