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New records and diversity of Agaricales in Mediterranean forest ecosystems of Morocco

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ABSTRACT

The order Agaricales represents one of the most diverse and ecologically significant groups of Basidiomycota, yet its diversity in North Africa remains poorly documented. In Morocco, forest ecosystems dominated by *Quercus suber* and *Cedrus atlantica* constitute potential reservoirs of ectomycorrhizal and saprotrophic fungi, but comprehensive taxonomic assessments are lacking. This study aimed to evaluate the diversity of selected Agaricales families (Entolomataceae, Hygrophoraceae, and Inocybaceae) across contrasting Mediterranean forest ecosystems, including Maâmora, the Oulmès plateau, the Rif, and the Middle Atlas. Specimens were subjected to detailed macro- and micromorphological analyses. Ten species were identified, including three taxa newly recorded for the Moroccan fungal flora: *Hygrocybe fornicata* (including a white morphotype) and *Hygrophorus agathosmus*. Additional regional first records included *Hygrocybe reae*, *Hygrophorus cossus, Inocybe lacera*, and *Inocybe geophylla var. lilacina.* The documented diversity of Agaricales in Morocco increased by three species newly recorded for the national fungal flora, together with several regional first record. The surveyed Mediterranean forests dominated by cork oak (*Quercus suber*) and Atlas cedar (*Cedrus atlantica*) yielded multiple taxa of Entolomataceae, Hygrophoraceae, and Inocybaceae.

Keywords: Agaricales; Entolomataceae; Hygrophoraceae; Inocybaceae; fungal diversity; Morocco.

INTRODUCTION

Agarics, or gilled mushrooms (Agaricomycetes, Basidiomycota), are one of the most visible and most studied groups of fungi (Royse, 2014). To date, they comprise eight suborders, 46 families and 482 genera, making them the largest order in the Fungi kingdom with approximately 40,000 species described (Vizzini et al., 2019; Kalichman et al., 2020; Mou and Bau, 2021; Bánki et al., 2022). Among these families, Entolomataceae Kolt. & Pouzar are among the most species-rich, with more than 2,200 known species worldwide (Kirk, 2019). These cosmopolitan fungi colonise a wide variety of habitats, ranging from arctic to tropical regions (Sulzbacher et al., 2020; Elliott et al., 2020; Dima et al., 2021; Reschke et al., 2022). While many species are saprotrophic on soil or litter, others develop ectomycorrhizal associations with conifers or angiosperms (Kondo et al., 2017; El Assfouri et al., 2024). Phylogenetically, Entolomataceae are divided into two large clades: and Rhodocybe-Clitopilus (Co-David et al., 2009; Baroni et al., 2011; Kluting et al., 2014), with the clade alone comprising approximately 2,000 taxa (Noordeloos et al., 2018). The highly diverse genus (Fr.) P. Kumm. is characterised by its pinkish-brown spore print and angular basidiospores with polyhedral facets (Noordeloos & Morozova, 2010; Noordeloos et al., 2021; Reschke et al., 2022). At the same time, the Hygrophoraceae Lotsy family, which includes 26 genera and approximately 690 species (Ainsworth et al., 2001; Kirk et al., 2020; Wasser et al., 1977), exhibits great ecological diversity. It includes ectomycorrhizal, bryophilic, litter or humus saprotrophic species, as well as lichenised fungi (Boertmann, 1995; Kovalenko, 1989; Lodge et al., 2013). For their part, the Inocybaceae Jülich form a diverse lineage of ectomycorrhizal fungi, estimated at more than 1,050 species (Matheny & Kudzma, 2019). Their palaeotropical origin dates back to the Cretaceous period, around 191 million years ago (Matheny et al., 2009), and they are thought to have first diversified in symbiotic association with angiosperms. This family is now recognised as one of the most taxonomically rich within the Agaricales (Matheny, 2009). Long considered a taxonomically unstable family, it has undergone a major revision over the last two decades thanks to advances in molecular phylogenetics. These approaches, which integrate morphological and genetic data (Matheny et al., 2002; Garnica et al., 2007) have profoundly reshaped its classification and enabled the description of a large number of new taxa (Bandini et al., 2018; Matheny et al., 2019). Between 2020 and 2021, no fewer than 59 new species were described in Europe alone (Bandini & Oertel, 2020; Bandini et al., 2020a, b, c, 2021a, b, c; Cervini et al., 2020; Mesic et al., 2021), bringing the number of known species on this continent to over 470 (Bandini et al., 2021a). Despite these advances, the diversity of Inocybaceae remains substantially underestimated, particularly in tropical regions such as Africa, where members of this family rank among the dominant ectomycorrhizal fungi in forest soils after Russulaceae (Meidl et al., 2021). In Morocco, Inocybaceae are poorly documented, and their species composition, ecological associations, and geographic distribution remain insufficiently resolved. Although Moroccan fungal diversity has benefited from pioneering contributions, notably those of Malençon and Bertault (1970, 1975), data concerning Entolomataceae and Hygrophoraceae remain fragmentary and have not been comprehensively updated (Bakkali Yakhlef et al., 2009; El Kholfy et al., 2011). Recent inventories have begun to document the ectomycorrhizal richness of cork oak forests (Larouz et al., 2016), yet Entolomataceae, Hygrophoraceae, and Inocybaceae remain underrepresented in national checklists compared to more extensively studied groups such as Russulaceae and Cortinariaceae. Furthermore, investigations conducted in the Maâmora forest revealed the occurrence of species with potential value as bioindicators of soil condition (El Assfouri et al., 2017), indicating that functionally relevant taxa may remain overlooked.

This lack of updated and systematic taxonomic assessments limits current understanding of the structure and ecological roles of Agaricales communities associated with *Quercus suber* and *Cedrus atlantica* forests, ecosystems that are increasingly exposed to anthropogenic disturbance and climate-driven stress. The present study aims to conduct a systematic survey of Entolomataceae, Hygrophoraceae, and Inocybaceae across selected Moroccan forest ecosystems in order to (i) reassess their species diversity, (ii) document their ecological distribution, and (iii) update their taxonomic records at the national scale. We test the hypotheses that: (1) the species richness of these families in Moroccan forest ecosystems is higher than currently reflected in published records; (2) cork oak- and Atlas cedar-dominated forests harbor distinct assemblages of ectomycorrhizal and saprotrophic Agaricales; and (3) targeted field surveys will reveal taxa previously unrecorded in Morocco or regionally overlooked. By addressing these hypotheses, this study seeks to reduce existing taxonomic gaps and provide a framework for future phylogenetic and biogeographic investigations of North African Agaricales.

Materials and Methods

Mycological surveys were conducted in northwestern and central Morocco across a broad ecological gradient, including coastal, plain, and montane ecosystems. The investigated sites comprised Khmiss-es-Sahel (northwestern coastal area), Jâaba Forest in the Rif and Middle Atlas massifs, and the Maâmora Forest (34°00′ N; 6°72′ W) located in the Gharb plain. The Maâmora Forest extends over approximately 132,000 ha on a Quaternary plateau (Boujraf et al., 2021, 2023; Kaddouri et al., 2025). Specimens were collected from different substrates, including sandy soils, leaf litter, and decaying wood, within forest stands dominated by *Quercus suber*, *Quercus faginea*, *Quercus pyrenaica*, *Cedrus atlantica*, and *Pinus pinea* (Kondo et al., 2017). Sampling was conducted to encompass both saprotrophic and ectomycorrhizal taxa associated with the dominant tree species (Sulzbacher et al., 2020; El Assfouri et al., 2024).

Field sampling

Basidiomata were collected from the selected study sites during peak fruiting periods, as defined

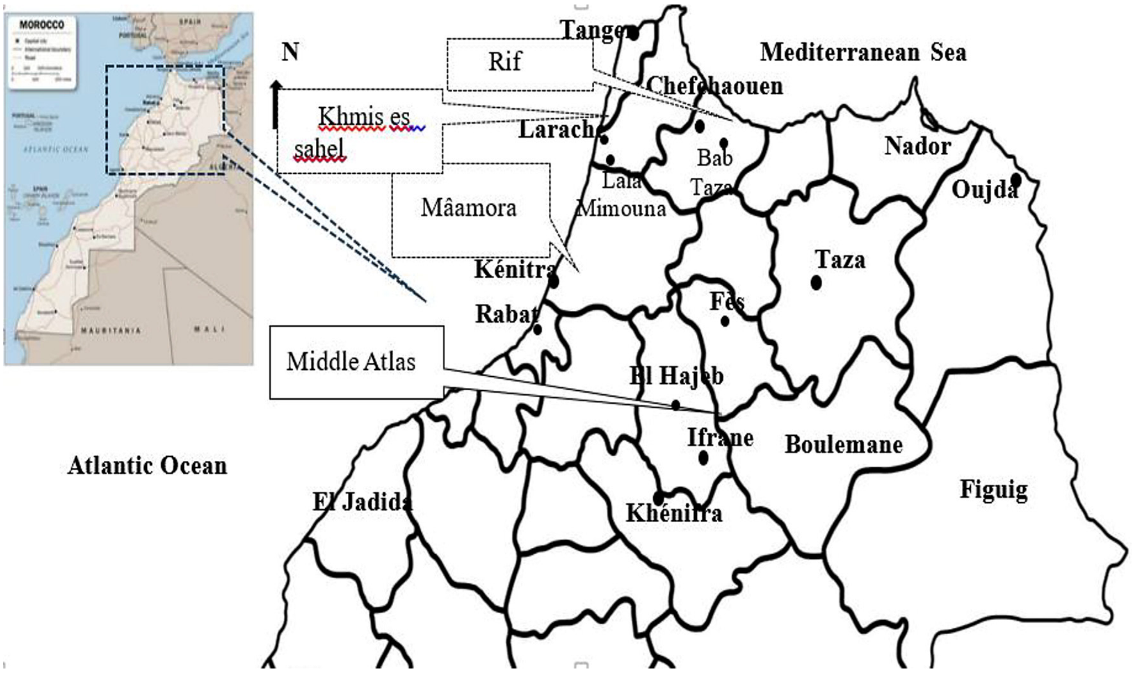

Figure. 1. Geographical location of the collection areas of the fungal species studied

for Mediterranean forest ecosystems (Ajana et al., 2020a, 2020b). Surveys were conducted using non-systematic exploratory sampling across multiple microhabitats within each site in order to capture specimens at different developmental stages (Nmichi et al., 2021; Id Elhakkar et al., 2026; Lotfi et al., 2019; El Kholfy et al., 2021a, 2021b; El Assfouri et al., 2024; Id Elhakkar et al., 2024).

For each specimen, ecological and habitat data were recorded in situ, including substrate type, associated vegetation, and geographic location. Fresh basidiomata were photographed prior to collection. Specimens were carefully excavated using a sterile metal blade to preserve basal structures and transported to the laboratory in ventilated containers to prevent degradation.

Macromorphological analyses

Macroscopic characters were examined on fresh material, supplemented when necessary by observations under a stereomicroscope. Descriptions followed standard taxonomic criteria (Simon, 1996b; Romagnesi, 1995; Lotfi et al., 2019, 2020; El Assfouri et al., 2026). The following features were recorded: pileus diameter, shape and surface characteristics; hymenophore type, attachment, spacing, and coloration; stipe dimensions, morphology, surface features, and presence or absence of annulus or volva; and context color, thickness, consistency, and odor. Spore prints were obtained from fresh caps deposited on white paper under controlled laboratory conditions, and spore print color was documented as a diagnostic character.

Micromorphological analyses

Microscopic examinations were performed on fresh material using a compound light microscope at 400× magnification. Preparations were mounted in tap water unless otherwise specified (El Assfouri et al., 2024; Bouchar et al., 2023). Basidiospores, basidia, and cystidia were measured using a calibrated ocular micrometer (10× wide-field eyepiece, 18 mm). For each specimen, measurements were taken from multiple mature structures to ensure representativeness. Spore dimensions, shape, ornamentation, and presence or absence of germ pore or apical appendage were recorded (El Assfouri et al., 2025a, 2025b; Bouchar et al., 2025). Thin sections of lamellae and pileipellis were prepared manually using a razor blade. Trama structure, pigmentation, clamp connections, and hymenial elements were examined following standard mycological terminology (Courtecuisse & Duhem, 2000). Basidia were characterized by size, morphology, and number of sterigmata (Id Elhakkar et al., 2025a, 2025b). Cheilocystidia and pleurocystidia were described based on shape, wall thickness, and content.

Taxonomic identification

Species identification was based on an integrative assessment of macro- and micromorphological characters and comparison with updated taxonomic keys and specialized literature (Malençon & Bertault, 1970, 1975; Courtecuisse & Duhem, 2000; Co-David et al., 2009; Noordeloos et al., 2022; Vesterholt, 2002; Esteve-Raventós et al., 2018).

RESULTS

The genus *Entoloma* (Fr.) P. Kumm

Entoloma (Fr.) P. Kumm. exhibits a broad geographical distribution, occurring from glacial regions to the tropics, and from alpine zones to lowland basins. Most species are saprotrophic, colonizing shaded, moist soils, mosses, or decaying wood within forest ecosystems (Horak, 1980; Noordeloos, 1981; Largent, 1994; Re-Schke et al., 2022b). To date, approximately 2,000 species of Entoloma have been described worldwide (Noordeloos et al., 2018; Kalichman et al., 2020). The genus is morphologically characterised by a pink to salmon-colored spore print and angular basidiospores (Noordeloos et al., 1981; Singer et al., 1886). Molecular phylogenetic analyses indicate that *Entoloma* forms a monophyletic clade, sister to the genera *Clitopilus* and *Clitocella* (Sato, 2023; Karstedt et al., 2029; Morgado et al., 2013).

Entoloma lividoalbum (Kühn. and Romagn.) Kubicka 1975: Rare and toxic species

Harvested on 20 March 2009 and April 2023, under *Quercus suber* in Mamora (Fig. 2).

The cap (3–10 cm) is domed, conical then irregularly convex-spreading and distinctly mamillate, dry to viscid when moist. It is smooth, glabrous to very finely hairy or finely rugulose at first and when cool, especially on the disc. When dry, it is satiny, shiny and non-hygrophane. The colour of the pileal surface is uniformly brown-grey, brown-yellow, sepia to beige-brown when moist and slightly paler at the disc or towards the margin. When dry, the surface becomes greyish-beige, greyish-ochre, pale sepia to yellowish ivory. The margin is initially rolled and inflected, then becomes straight or irregularly wavy. The gills are broadly adnate- emarginate or notched, broad, slightly bulbous and moderately crowded. They are initially white, then whitish and finally pink to brownish pink. The edge is the same colour as the gill faces. The flesh is fairly thick at the disc and thin towards the edges. It is fragile and whitish in colour. The stipe (3–10 × 0.8–3 cm) is evenly cylindrical or flattened. Sometimes it is widened under the blades and tapers towards the base. The stipe is initially solid, then becomes stuffed, dry, finely fibrillose-striated and sometimes flaky under the hymenophore. It is white, whitish to creamy yellow in colour and turns brownish towards its base. The spore print is pinkish brown. The smell and taste are mealy. The hymenium has clavate, looped basidia (35–50 × 10–14 µm) with two or four sterigmata. Cystidia are absent. The spores (7–13 × 6.5–12 µm, Q between 1 and 1.4) are polyhydric with five to seven angles, subglobular to broadly ellipsoid or subisodiametric. They are pink and non-amyloid.

Entoloma undatum (Fr.) M.M. Moser 1978

Collected on 25 January 2006, 5 March 2020 in a suburban environment, and on 3 March 2009 and 25 March 2023 in Quercus suber (la Mamora) clearings (Fig. 3).

The cap (3–5.5 cm) is initially convex, umbilicate, then concave to infundibuliform and deeply umbilicate, zoned and densely fibrillose. The fibrils are radially appressed and silvery-greyish, greyish to pale grey-brown or dark grey in colour. The margin is not striated and distinctly rolled at first, then becomes straight and raised with age. The hymenophore consists of uneven, spaced gills that are greyish to brown in colour. When mature, they turn pink. Initially, the gills are indented - adnate, then become decurrent. The edge is entire and the same colour as the gill faces. The stipe (3–5 × 0.4–0.6 cm) is even, central, cylindrical or flattened. It is the same colour as the cap and has a white bloom on its upper part. Sometimes the base of the stipe is enlarged or subbulbous. The flesh is thin and greyish to grey-brownish in colour. The spore print is brick red. The smell and taste are not distinctive. The hymenium consists of basidioliform bodies and basidia, but no cystidia. The basidia (42.5–50 × 10–15 µm) are clavate to cylindro-clavate, not looped and generally tetrasporic. Uni-, bi- or trisporic basidia also exist. The sterigmata are conical and 5 µm high. The blade margin is fertile. The blade texture is subparallel. The subhymenium consists of spherical cells 7.5 to 10 µm

Figure. 2. lividoalbum (Kühn. et Romagn.) Kubicka: Basidiocarps with a grayish and mammillate cap (a), young specimen with a slender, white stem and white gills (b); beige-brown cap, thin margin, and white stem (c); uneven gills, adnate-decurrent and pink (d); spores in water ×400 (e)

in diameter. The spores (7.5–10 × 7.5–8.75 (10) µm; Q = 1.0–1.67) are heterodiametric, angular, with 6–8 slightly rounded angles, pinkish in water and non-amyloid. The pigment of the hyphae is parietal and encrusting, yellow-brown in colour on the hyphae of the trama and pileipellis.

Hygrophoraceae Lotsy 1907

Hygrocybe (Fr.) P. Kumm. (1871), Hygrocybe fornicata (Fr.) Singer 1951: New species for Morocco

Harvest of February 6, 2006, January 28, 2022, and February 24, 2023, in the Mamora Forest (Fig. 4). The cap (3–8 cm) is initially conical, then convex with a nipple, and finally completely flattened, it is whitish-gray in color with a darker disk, with a dry coating and finely fibrillose-silky at the end. The margin is circular, straight, initially curved, then spreads out as the cap expands. The hymenophore consists of adnate, unequal, and interveined gills. They are white in color. The flesh (3–4 mm) is of an unchanging white color. It is compact in the cap and fibrous in the stem. The stipe (8–10 × 0.5–1.2 cm) is cylindrical, central, white, and has a rounded and brownish base. It is hollow and fibrous. The spore print is white. No particular odor or flavor is detectable. The basidia (30–45 × 6–8 um) are subcylindrical or clavate and often looped at the base. They are bisporic or tetrasporic. The spores (6.5–8.5) × (4.5–6 m) are hyaline, non-amyloid, smooth, and subglobose to elliptical. They are surrounded by a thin membrane and sometimes show a median depression on one side.

Hygrocybe reae (Maire) J. E. Lange 1923: New species for the Oulmes region. Harvested on January 11, 2009, January 5, 2022, and March 5, 2023 in the Oulmes region (1250 m altitude) among the undergrowth (Fig. 5).

The cap (15–20 mm) is hemispherical, convex, arched, and later becomes flat. It is orange-red in color, speckled with golden yellow toward the edges. When dry, it fades to pale yellow but does not turn black. The margin is fluted – striated. The gills, which are orange-yellow or pinkish-yellow in color, are swollen, spaced, adnate-uncinate, then decurrent. The flesh (1 to 2 mm) is pale yellow or orange-yellow in color. The stipe (15–40 × 1–3 mm) is slender, tortuous, equal and tapered at the base, hollow, and fissile. It is bright red in color and fades to a pale translucent yellow. The spore print is white. The hymenium consists of basidia (30–50 × 7.5–8.25 um) that are clavate with one, two, three, or four sterigmata of 5 to 7.5 um. The spores (6.5–7.5 × 4–6.25 m) are hyaline,

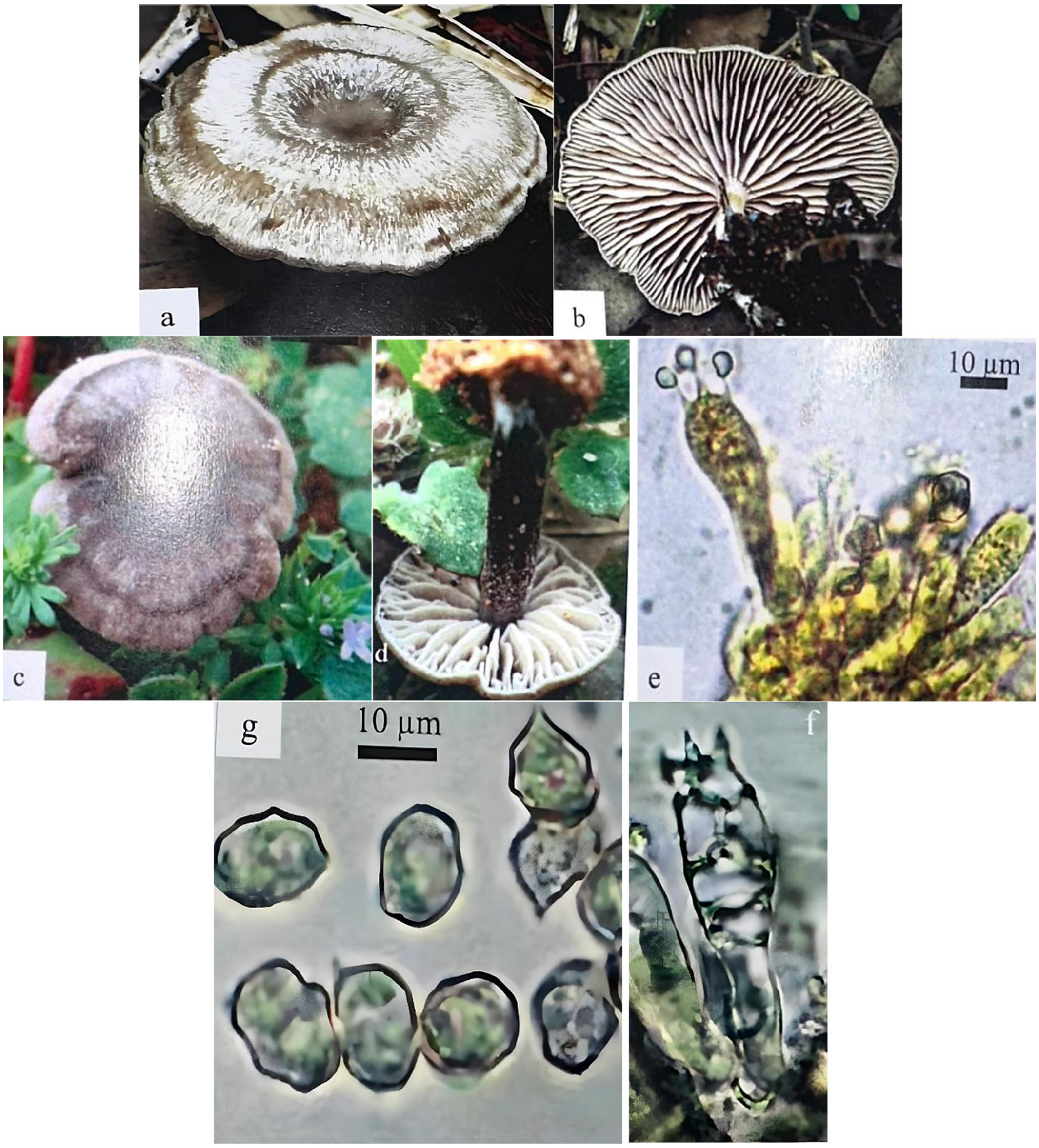

Figure. 3. *Entoloma undatum* (Fr.) M. M. Moser: Basidiocarp with a fibrillose-silky cap, concentrically zoned and umbilicate on fabric and rotten wood (a), hymenophore with adnate-subdecurrent gills of pinkish-gray color (b); zoned basidiocarp of lilac-gray color (c), pinkish-gray hymenophore and dark gray stipe with a bloom n its upper part (d); basidia of the gill edge (e); a tristigmatic basidium (e); polygonal basidiospores (g) (The microscopic observations were conducted in water ×600)

smooth, cylindro-ellipsoid with rounded ends, one side convex and the other concave. They are equipped with a rounded apicule.

Hygrophorus Fr. 1836

Hygrophorus agathosmus (Fr.) Fr. 1838 was recorded for the first time in the Middle Atlas and in Morocco. Specimens were collected on 15 November 2008 and 26 January 2023 under Quercus faginea in the Jâaba forest (Middle Atlas) (Fig. 6).

The pileus measured 3–5 cm in diameter, initially globose or kidney-shaped, hemispherical, then convex, without an umbo, sometimes exhibiting a slightly bumpy disc. Cap coloration ranged from gray to fawn-brown, with mottled gray, greenish-olive hues, and occasional yellowish traces. The margin was initially curved, becoming straight with age, and displayed a circular or lobed shape. The pileus surface was initially viscous and thick.

The hymenophore consisted of unequal, occasionally interveined gills that were adnate, moderately spaced, and creamy-white. The context was compact, white, tender, and exhibited a mild flavor. The stipe measured 10–12 cm ×

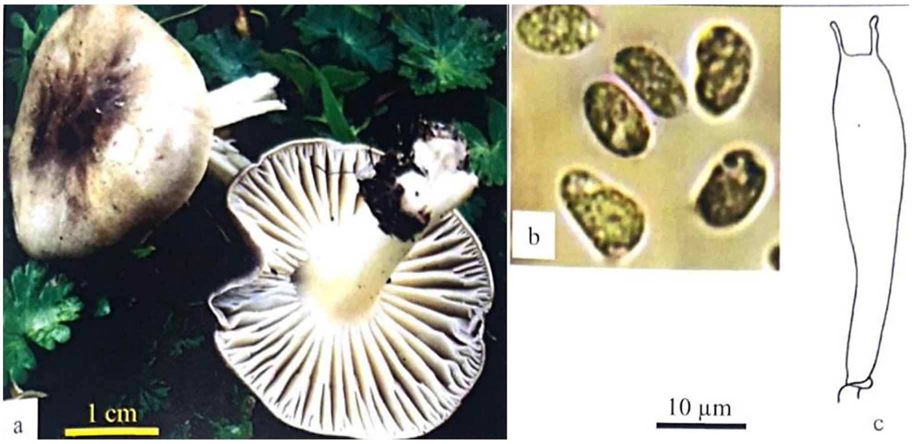

Figure. 4. *Hygrocybe fornicata* (Fr.) Singer: Basidiocarp with a tricholomatoid cap, flat, slightly mammillate, with a hymenophore consisting of adnate, unequal, thick, forked gills and a white, cylindrical, central stipe (a); smooth, elliptical spores (b) and a diagram of a cylindrical, bistigmate, and clamped basidium (c). (The microscopic observations were carried out in water ×400)

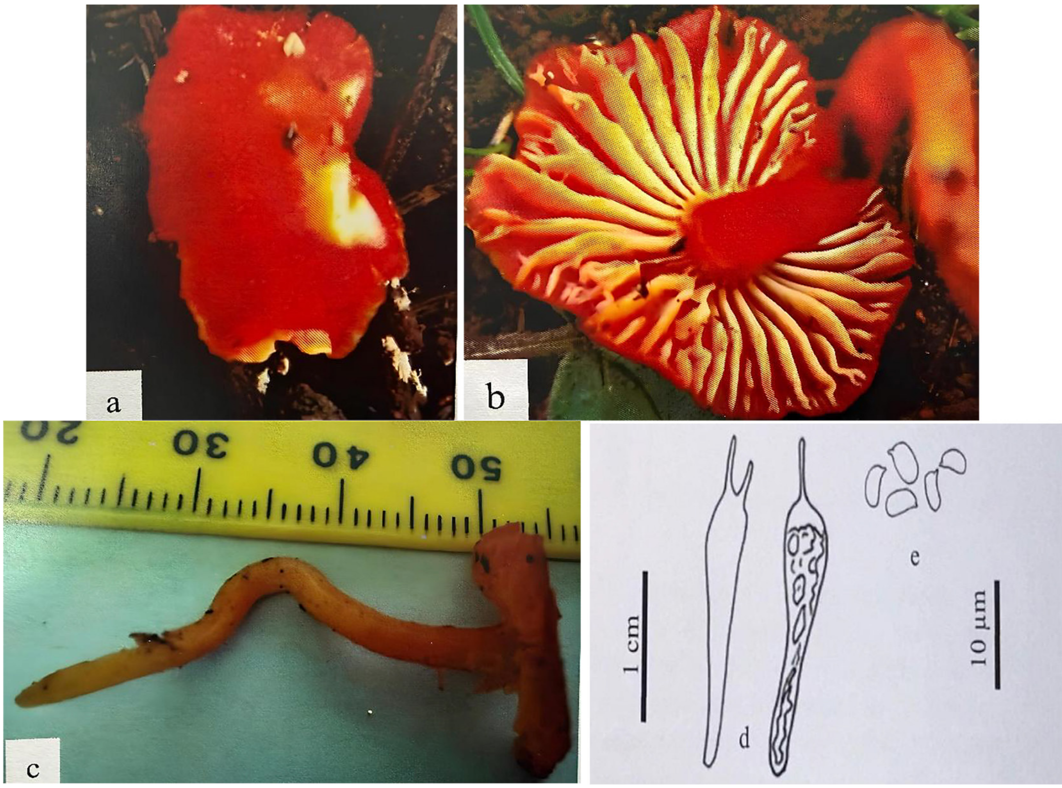

Figure. 5. *Hygrocybe reae* (*Fr.) Fr.* : Basidiocarp with a campanulate cap, bright red, yellow at the edges and with a fluted-striated margin (a), hymenophore made up of spaced gills of a pinkish-yellow color (b); red, reddish-yellow, tortuous stem with a tapered base (b and c); cylindrical basidia with two or one sterigmata (d) and smooth, cylindrical-ellipsoid basidiospores (e) (The microscopic observations were made in water and in iodized water ×400)

1–2.5 cm, slender, cylindrical, and often slightly tortuous, with a rounded or tapered base. Its surface was white with a membranous fuzz, producing a slightly mottled appearance toward the lower part. Odor and taste were mild and pleasant. Spore prints were white. Microscopic examination revealed basidia 45–50 × 6–9 µm, clavate, tightly packed, predominantly tetrasporic with 4–5 sterigmata, occasionally looped at the base. Basidiospores measured 8.25–11.25 × 4.5–6.25

Figure. 6. ***Hygrocybe agathosmus*** (Fr.) Fr. Basidiocarp with a campanulate cap, marbled brown with greenish hues and traces of yellow color (a), mycenoid basidiocarp with a grayish-brown color with an olive tint and a concolorous and mottled stem toward its base (b); hymenophore consisting of cream-white and adnate gills; white and tortuous stem; a cylindrical basidium, tetrasterigmate and clamped at its base, and smooth ovoid to elliptical spores (e). (The microscopic observations were conducted in water ×400)

μm, hyaline, ellipsoid, and smooth sometimes containing a central guttule, and possessing a prominent, rounded apiculus.

Hygrophorus cossus (Sowerby) Fr. 1838 = *H. quercetorum* P. D. Orton 1985: New species for Khmis-es-Sahel. Harvest of December 11, 2008, January 7, 2009, March 24, 2023 under Quercus suber in Khmiss-es-Sahel (Fig. 7).

The carpophores are clitocyboid in shape. The cap (6–8 cm) is initially globose, then becomes convex, flattened, and finally depressed and may have a low nipple. The color is white, initially, it is cream at the disk and then becomes completely cream with age. The coating is adnate and viscous. The margin is initially circular, non-striated, and curved, then it spreads out and becomes straight. The gills are uneven, white, moderately spaced, and slightly swollen and eroded. At first, the gills are adnate, then they become decurrent and cream-colored. The flesh (0.5–5 cm) is also white and then turns cream-colored. The stem (5–10 × 0.5–1.5 cm) is viscous when wet, central, cylindrical, equal, flexuous, and rounded at the base. It is fibrous, initially solid then hollow. The flavor is mild and the odor is quite pronounced. The spore print is white. KOH (10%) has no effect on the different parts of the basidiocarps. The hymenium consists of basidia (45–60 × 8–10 um) that are cylindrical and tetrasporic. The spores (6–8 × 4–5 m) are smooth, non-amyloid, and elliptical.

Figure. 7. *Hygrocybe cossus (Sowerby)* Fr. White and viscous basidiocarp (in situ), same basidiocarp with cream coloration (b), gills initially white then cream-colored (c and d); longitudinal section showing the cream coloration of the flesh and fistulous stipe (e); basidium and basidiospore in water ×400 (f)

Hygrophorus nigrescens (Quél.) Kühner 1926

Harvest of December 2010, March 2022, January 5, 2023 in the clearings of *Quercus suber* (la Mamora) (Fig. 8).

The cap (20–40 cm in diameter) is bell-shaped or broadly conical; it is often irregularly lobed, orange or scarlet red, and turns black with age. The flesh is yellow in the cap and whitish in the stem. Under exposure to air, the flesh turns black strongly. The stem (30–50 × 4–6 mm) is slender, straight, equal, and fibrous. It is scarlet yellow in color, flushed with a white base, and becomes streaked with black. The gills are ascending, free or subfree, then grayish yellow. The edge of the blades is initially smooth and whitish in color, then becomes eroded. The edge is very darkening. The spore print is white. The odor is non-distinctive and the flavor is mild. The basidia (45–50 × 8–2 um) are clavate or cylindrical and

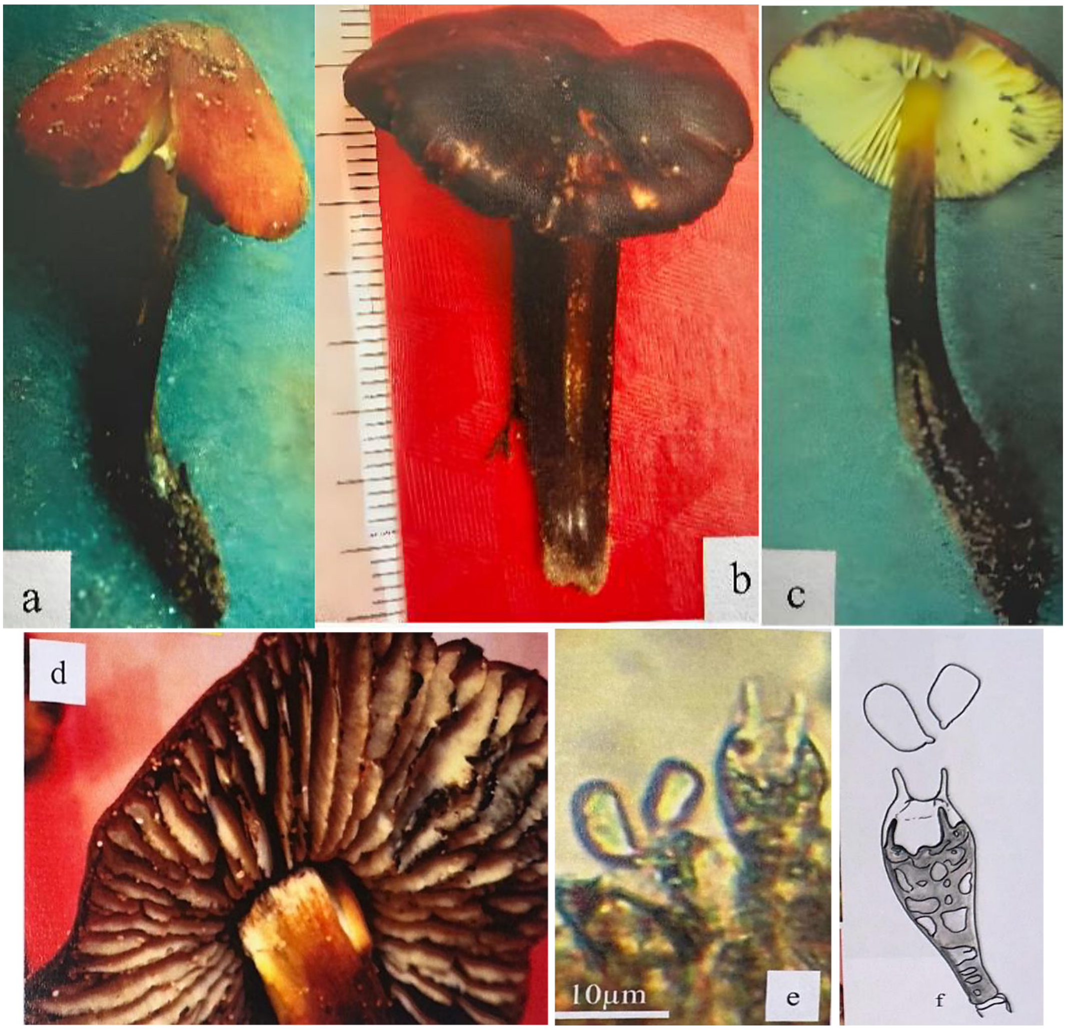

Figure. 8. Hygrocybe nigrescens (Quél.) Kühner: Basidiocarp with a conical cap that later becomes flat, reddish-yellowish in color, with a central stem that turns black (a and b); hymenophore consisting of ascending gills, first yellow then orange-gray, eroded with a blackened edge and the top of the stem turning white due to spores (c and d); tetrasterigmate basidium and basidiospores in iodized water ×400 (e); diagrams of a basidium and basidiospores (f)

four-spored. The spores (8–11 × 5–6 um) are hyaline, non-amyloid, and ellipsoid to subrectangular. They are rich in oily droplets.

Inocybaceae Jülich 1982

Inocybe (Fr.) Fr. 1863, Inocybe fastigiata Quél. 1872

Harvests from March 5, 2008, in Mamora, April 22, 2009, and March 26, 2023, in the Middle Atlas (Fig. 9)

The cap (2–10 cm) is initially conical, campanulate, then becomes almost flat with a blunt nipple. The pileus surface is fibrillose except at the center and of extremely variable color (from whitish, to pale ochre, straw yellow to orange-brown). The margin is often split. The blades are notched, adnate by a tooth or subfree, initially white in color then yellowish or grayish. The white flesh remains unchanged. The stem (2–15 × 6–15 cm) is whitish to pale ochre, the top of the stipe is often flaky. The specimens encountered in the Middle Atlas have basidia (25–45 × 10–15 um) that are clavate and bisporic, cheilocystidia (30–50 × 10–18 um) that are abundant, and spores (10–15 × 6–7.5 um) that are amygdaliform, brown, and double-walled.

Inocybe,lacera (Fr.) P. Kumm. 1871: New species for Mamora

Harvested on March 9, 2009, and March 25, 2023, in the sands of Mamora (Fig. 10) The specimens from this harvest are scattered in a sandy clearing within the cork oak forest of

Figure. 9. *Inocybe fastigiata* Quél. 1872: Macroscopic characteristics of basidiocarps encountered in the Middle Atlas (a) and in the Mamora (b); bisporic basidia (c); spores (d), (water mount ×400)

Mamora. The cap (3–7 cm) is flat, ochre-brown to rusty-brown, and not umbonate. The surface is covered with dense triangular wooly fibrils giving the cap a wooly appearance. The margin is circular, straight, and slightly overhanging. The hymenophore consists of unequal, moderately spaced gills, swollen toward the stipe, with fringed edges; the longest ones are adnate or emarginate. The flesh (0.6 cm) is creamy brownish. The stem (4–8 × 0.5–1.5 cm) is slender or stout, straight or sinuous, concolorous with the cap, but its upper part is covered with abundant and white tufts. The spore print is brown. The hymenium consists of basidia (30 × 8–10 um) that are tetrasporic and clavate. The

Figure. 10. Inocybe lacera (Fr.) P. Kumm.:.Specimens in situ on the sand in Mamora, the stipe can be short and thick or slender and sinuous (a); wooly cap (b); hymenophore with unequal, sinuous gills and the upper part of the stipe equipped with the remains of the partial veil, in the form of a white cortina (c); numerous and prominent cystidia, some of them mucronate (d); cylindrical spores (e), microscopic observations ×400

cystidia (60 - 100 um) are abundant, subcylindrical or pyriform with hyaline walls; the apex of some cystidia is surrounded by crystals. The spores (12–15 × 5–6 um) are cylindrical, smooth, with a conical apex and a medio-dorsal depression.

Inocybe geophylla var. lilacina Gillet 1876: New for Mamora

Harvest of February 7, 2009, and April 23, 2023, under Pinus pinea in Sidi Bouknadel (Mamora) (Fig. 11).

The specimens from this harvest are scattered in the Pinus reforestation. The cap (0.5–4 cm) is convex, mycenoid. The surface is finely scaly and lilac in color except for the nipple, which is ochre. This lilac coloration fades with age and becomes dull whitish. The margin is circular, straight, and slightly crenelated. The hymenophore consists of unequal, eroded, moderately spaced, emarginate, ventricose gills toward the stipe and is initially purplish in color, later becoming brownish.

The flesh of the cap (0.2 cm) is white, that of the stipe is lilac-white. The stem (2–5 × 0.3–0.7

cm) is cylindrical, central, straight, solid, concolorous with the cap, and scaly. The spore print is brown. The hymenium is made up of cystidia (60–80 × 15–20 um) that are subcylindrical with an obese base and surrounded at the top by crystals. The basidia (30 × 8–10 um) are tetrasporic. The spores (10–12 × 5–7 um) are elliptical or almond-shaped and topped with sterigmata of 4–5 um.

DISCUSSION

The genus *Entoloma* (Fr.) P. Kumm

Entoloma (Fr.) P. Kumm. has a very wide geographical distribution, ranging from glacial zones to the tropics, as well as from alpine regions to basins. The majority of species are saprotrophic, developing on shaded and humid soils, on mosses, or on decaying wood in forests (Horak, 1980; Noordeloos, 1981; Largent, 1994; Re-Schke et al., 2022b). To date, approximately 2000 known species have been recorded (Noordeloos et al., 2018; Kalichman et al., 2020). *Entoloma* is characterized by a pink to salmon spore print and angular basidiospores (Noordeloos et al., 1981; Singer et al., 1886). Molecular phylogenetic studies conducted by Sato (2023), Karstedt et al. (2029), and Morgado et al. (2013) have shown that Entoloma is a monophyletic group, sister to the genera *Clitopilus* and *Clitocella*. *Entoloma* (Fr.) P. Kumm. is one of the most diverse genera within the Agaricales, well characterized by spore prints ranging from pink to brownish and by angular basidiospores observable from all angles (Co-David et al., 2009). It has an extremely wide geographical distribution, ranging from cold areas to tropical regions, as well as from alpine environments to lowlands, with most of its representatives being saprophytic on shaded and humid soils, on mosses, or on decaying wood in forested areas (Horak, 1979; Noordeloos, 1981; Largent, 1994; Reschke et al., 2022b). Among these numerous species of the genus Entoloma, the following are mentioned: *Entoloma lividoalbum*, *Entoloma undatum*, which have been studied.

Figure. 11. *Inocybe geophylla* var. lilacina Gillet Basidiomes with a lilac cap, hymenophore with uneven, notched gills, tobacco brown in color, and a central, fibrous, cylindrical stalk (a), young specimen before the opening of the general veil (b); conical cap, lilac in color, rimose, and with a brownish umbo (c); notched gills and white flesh (d); hymenium with tetrasporic hooded cystidia (e) (×400) and brown spores with a convex dorsal face and a germ pore (f) (observations in water ×600)

Entoloma lividoalbum (Kühn. et Romagn.) Kubicka (Entolomataceae, Agaricales, Agaricomycetidae, Agaricomycetes, Agaricomycotina, Basidiomycota, Fungi) (Kirk et al., 2008) constitutes a taxon of particular interest due to its restricted distribution, variable ecological affinities, and potential toxicity (reference). It is found in a scattered or solitary manner on sandy soils and in the humus of deciduous or mixed forests (reference). According to Courtecuisse and Duhem (2000), *E. lividoalbum* is a rare species with a calcicolous tendency. In Morocco, it is observed in clearings under *Quercus suber* in the coastal forests from Ben Slimane to Tangier, under *Pinus* and *Quercus* in the Rif, and under *Quercus pyrenaica* in the Tazekka (Bertault and Malençon, 1970). However, the recurrent presence of the species on sandy soils under *Q. suber* in Mamora, Larache, and Tangier (Malençon and Bertault, 1970), confirmed by our own collections, calls into question its strictly calcicolous nature. In France, it is only reported in Haute-Savoie (Noordeloos and Polemis, 2008), and elsewhere in the Mediterranean, notably in Greece and Spain, in varied biotopes, highlighting a certain ecological plasticity. Moreover, this species is classified as toxic (Duffy, 2008). Beyond its potential toxicity, recent studies have highlighted remarkable biological properties in *E. lividoalbum*. Maity et al. (2015) isolated a water-soluble β-glucan (ELPS) with a branched structure, with a molecular weight of 2×10^5 Da, which proved capable of stimulating murine macrophages, splenocytes, and thymocytes in vitro, suggesting an immunomodulatory potential. This same compound also showed moderate antioxidant activity, demonstrated by its ability to trap hydroxyl and superoxide radicals, as well as its reducing power. These results add to a larger body of biological and pharmacological data related to this species naturally found in the Indian Himalayas (Das, 2010), *E. lividoalbum* is already recognized for its mineral richness and beneficial effects on human lymphocytes, as well as for its antimicrobial and antioxidant properties (Maity, Samanta, et al., 2015; Rai, Sen, & Acharya, 2013; Maity, Nandi, et al., 2014). The work of Acharya et al. (2017) confirms its pharmacological interest by revealing a high content of phenolic and flavonoid compounds in its methanolic extracts, responsible for moderate antioxidant activities and significant cytotoxicity against the A549 cell line. From a pharmacognostic point of view, these studies also highlight the importance of chromatographic profiles and physicochemical characteristics in the quality control of this species.

Entoloma undatum **(**Fr.) M.M. Moser 1978 (= Agaricus undatus Fr. 1838 = Agaricus undatus var. viarum Fr. 1874 = Claudopus sericeonitidus (P.D. Orton) P.D. Orton 1991 = Clitopilus undatus (Fr.) Gillet 1876 = Clitopilus undatus subsp. viarum (Fr.) Sacc. 1887 =Clitopilus viarum Fr. = Eccilia sericeonitida P.D. Orton 1960 = Eccilia undata (Fr.) Quél. 1880 = sericeonitidum (P.D. Orton) Arnolds 1982 (Entolomataceae) (Kirk et al., 2008) is a polymorphic species characterized by its clitocyboid stature, fibrillose-silky cap, slightly depressed at first then distinctly depressed. The cap is sometimes concentrically zoned and sometimes not zoned. The stem is short, the gills are adnate then arched-decurrent at maturity (Roux, 2006). Forms with an indistinct odor and others with a pronounced mealy odor exist. The habitat of *E. undatum* is also very diverse; it is found in deciduous or coniferous litter, on highly decomposed deadwood, on the ground, in open terrain, or in the lawn, in suburban environments (Noordeloos and Polemis, 2008). According to Malençon and Bertault (1975), *E. undatum* is common in the coastal plain, the Rif, the Middle Atlas, and the High Atlas. We encountered it on fabric waste mixed with rotten wood in the litter in a suburban environment in Kenitra and in the clearings of *Quercus suber* in the Mamora. *E. undatum* is a polymorphic species, its cap can even be zoned or not, and the coloration of the basidiomes can vary greatly. Roux, (2006). We think it is not useful to create a new form based on small variations in color or foot length. Indeed, the length of the foot may depend solely on the nature of the substrate. A deep substrate can lead to the elongation of the stem. The species close to *E. undatum* are essentially byssisedum (Pers. F) ; Donk, which has a pleurotoid habit, a hygrophanous cap, and a striated marginiceloi Nordel. presents cystidia and *E. albogriseum* (Peck) Redhead, which is characterized by a collybirde habit, non-decurrent gills at maturity, and a longer stipe (Roux, 2006; Noordeloos and Polemis, 2008). Malençon and Bertault (1970) reported that among their collections, one is characterized by its color and stature, which they did not specify. They assumed that when the specimens from this harvest become better known, they will lead to the creation of a new form (f. griseolilacina)

The Hygrophoraceae Losty family was revised by Lodge et al. (2014) thru an integrated approach combining molecular phylogeny, morphological analyzes, chemistry, pigment, and ecology. This revision led to the creation of three new subfamilies, eight tribes, eight subgenera, 26 sections, and 14 subsections within the family. Thus, the genus *Hygrocybe*, as defined by Lodge et al. (2013), includes terrestrial species characterized by a thin, tender, and sometimes striated pileus with a moist, lubricated, or viscous surface. The stipe is hollow or stuffed, splitting or fibrillous, generally smooth at the apex, with a moist or viscous surface. Recent research in Morocco has led to the identification of new species belonging to the genus *Hygrocybe*, such as *Hygrocybe* fornicata, *Hygrocybe* reae, *Hygrophorus agathosmus, Hygrophorus persoonii, Hygrophorus cossus, Hygrophorus nigrescens*

Hygrocybe fornicata (Fr.) Singer 1951 (Hygrophoraceae, Agaricales, Agaricomycetidae, Agaricomycetes, Basidiomycota, Fungi) (Kirk et al., 2008) is a rare species and considered calcicolous (Courtecuisse and Duhem, 2000). We encountered it among the grasses in the cork oak forest of Mamora. *H. fornicata* is a new species of Basidiomycetes in Morocco. The species *H. fornicata* enjoys strong ecological and conservation interest; however, there is a notable scarcity of publications focusing on it. This is often integrated into broader inventories of mycological diversity analyzes of the genus *Hygrocybe* (Sellier, 2014). In France, several ecological inventories and protected area management plans have shown that this species is considered an important indicator of the ecological quality of grasslands (Coteau du Mont de Quelmes, 2019-2023 Its presence generally indicates environments with low nitrogen and phosphorus enrichment, which highlights its ecological sensitivity to nutrient inputs related to intensive agricultural practices. This characteristic is shared by the entire *Hygrocybe* genus, whose members are widely recognized as relevant bioindicators in monitoring the naturalness of herbaceous habitats (Sellier, 2014). Several environmental monitoring programs have mentioned that *H. fornicata* is linked to environmental contamination, which shows its potential role as a bioindicator in ecotoxicological contexts (RENECOFOR project, France). The recognition of *H. fornicata* in ecological conservation projects underscores its heritage importance, despite the current lack of specific studies. It is essential to develop targeted work to ensure a better understanding of its ecology and vulnerability.

Hygrocybe reae (Maire) J. B. Lange = *Hygrocybe* mucronella (Pr.) P. Karst (Hygrophoraceae, Agaricales, Agaricomycetidae, Agaricomyceles, Basidiomycota, Fungi) (Kirk et al., 2008). It has been previously encountered in the *Quercus* clearings in Tangier, the Rif, the Middle Atlas (Malençon and Bertault, 1975). According to these authors, *Hygrocybe* reae is a species very similar to *H. miniata*, but it has a smooth, viscous cap, a striated margin, and bitter flesh. We first encountered it in the Oulmès region (Central Plateau). According to the Index Fungorum, *Hygrocybe* reae has a synonymous species called *Hygrocybe* mucronella, which has come to light thanks to recent work by Fuljer et al., 2024. These molecular and morphological studies have helped to clarify the complex taxonomic situation surrounding the group named *Hygrocybe* mucronella, resulting not only in the redefinition of this species, including a neotypification, but also in the description of two completely distinct species, *Hygrocybe* alpina and *Hygrocybe* amara. Thus, what was previously considered a single species known and widespread in various European habitats turns out to be a complex of cryptic species differentiated thru an integrative approach combining molecular phylogeny and ecology, in accordance with the recommendation of Lodge et al. (2013).

Hygrophorus agathosmus (Hygrophoraceae, Agaricales) is a species characterized by a non-umbonate cap, gray to olive-tinged color, and a distinct white stipe. According to Kirk et al. (2008), this species is also distinguished by its particular odor reminiscent of bitter almond. However, the precise identification of *H. agathosmus* proves to be delicate due to the high chromatic variability and the morphological similarity shared with several related species. Among these similar species, we notably find *Hygrophorus persoonii* Arnolds 1979 (synonym *H. dichrous* Kühner & Romagn. 1953), *H. marzuolus* (Fr.) Bres. 1893, as well as *H. odoratus* A.H.Sm. & Hesler 1954. The distinction between these taxa requires particular attention to morphological and ecological details. For example, H. persoonii is characterized by a larger and distinctly mammillate cap, as well as a stem whose lower part exhibits ridges or is sheathed in a glutinous bistre veil forming an upper ring. The thick and decurrent gills constitute another distinguishing criterion (Bertault and Malençon, 1975). On the other hand, *H. marzuolus* is recognized for its stocky stem and specific habitat in mountain cedar forests, where it fruits in the spring during the snowmelt (Malençon and Bertault, 1975; Courtecuisse and Duhem, 2000).

As for *H. odoratus*, this species shares the same characteristic odor as *H. agathosmus* but differs from it by a mycenoid or omphaloid habit and larger spores (Roux, 2006). Another related species, *H. latitabundus* (syn. *H. limacinus*), has a cap brown mammillate, viscous gills evolving toward a grayish-brown, as well as a swollen, fusiform, and subradicant stem (Malençon and Bertault, 1975).

The intra-specific variability of *H. agathosmus* is also notable, with several described forms and varieties, such as *H. agathosmus* f. albus Candusso, which retains a white cap at maturity, or *H. agathosmus* f. aureoloccosus, whose upper part of the stem is adorned with yellow flakes (Roux, 2006). The variety *H. agathosmus* var. hyacinthinus is notably distinguished by white gills when fresh, turning yellowish once dried, a white stem in the upper part and brown at the bottom, and a primarily muscinal habitat under conifers (Krieglsteiner, 2001).

In conclusion, the specimens collected in the Middle Atlas under Quercus faginea exhibit macroscopic and ecological characteristics compatible with those of *Hygrophorus agathosmus* var. *agathosmus*. The combination of morphological observations, comparison with neighboring species, as well as the biogeographical context, supports this taxonomic attribution.

Hygrophorus cossus (Sowerby) Fr. 1838 (Hygrophoraceae) (Kirk et al., 2008) is part of a group of species of the genus *Hygrophorus* that are white in color and difficult to distinguish from each other. *H. eburneus* (Bull. : Fr.), *H. discoxanthus* (Fr) Rea (= H. chrysaspis Métro.), *H. Piceae* Kühn., H. melizeus sensu Rea (1922) = *H. melizeus* Fr. 1838 et *H. cossus* . Indeed, these hygrophores are morphologically very similar. The distinction between these species is based on the relative yellowing with age of their basidiocarps, the odor, and the reaction to potash. According to Roux (2006); *H. eburneus* is white, its cap and stem are viscous, its gills are unchanging, and its odor is pleasantly aromatic. *H. cossus* is a species primarily found on oaks and is characterized by an unpleasant odor (a mix of bug odor and Jerusalem artichokes). *H. discoxanthus* is characterized by gills that turn reddish-brown at the edges.

According to Bertault and Malençon (1975*), H. piceae* Kühn. and *H. melizeus* sensu Rea (1922) = *H. melizeus* Fr. 1838 are not found in Morocco. The specimens we encountered in Khmiss-es-Sahel showed a cream to yellowish coloration on the basidiocarp disk. This coloration characterizes *H. cossus* (Malençon and Bertault, 1975; Courtecuisse and Duhem, 2000; Roux, 2006). According to Kirk et al. (2008), this species is synonymous with *H. discoxanthus* Rea 1909, and *H. chrysaspis* is synonymous with *H. discoxanthus* (Fr.) Rea. Thus, the species we have encountered would correspond according to morphological criteria to *H. cossus* (Sowerby) Fr.. *H. cossus* comes in two varieties: *H. cossus* var. cossus (Sowerby) Fr. 1838 and *H. cossus* var. quercetorum (P.D. Orton) Bon, Migl. and Cherubini 1989 (Kirk et al., 2008). *H. cossus* var. quercetorum is considered a species primarily associated with oaks. This is the species that Sowerby described in 1977 and to which he assigned the name Agaricus cossus Sowerby 1798 (Larsson and Jacobsson, 2004). In 2004, these two authors sequenced the DNA of the initial collection of *H. cossus* , which dates back to 1794. The comparison of the DNA of the type specimens with that of four other white Hygrophorus allowed the authors to conclude that *H. cossus* is a species associated with *Querecus*, and the two authors suggested retaining its old name *H. quercetorum*. P.D. Orton 1985. Malençon and Bertault (1975) did not provide precise information on the biotope and locality of the species they studied. These two authors reported that the three hygrophores present in North Africa (*H. cossus* , *H. chrysaspis*, and *H. eburneus*) are found either isolated or mixed, in the cork oak forests of the plains as well as in the oak or cedar forests of the mountains, with a predominance of *H. chrysaspis*, which, according to Kirk et al. (2008), is a synonym of H. discoxanthus (Fr.) Rea. However, due to the great physiognomic resemblance between these three species, they were unable to specify their exact locations. In this context, we believe that the species encountered in Khmiss-es-Sahel would correspond to *H. cossus* (Sowerby) Fr., equivalent to *H. quercetorum* (Sowerby: Fr) according to Larsson and Jacobsson (2004). This species could be considered new to Khmiss-es-Sahel, as Bertault and Malençon (1975) did not specify the stations of the similar white hygrophores they had reported. Moreover, among the species morphologically close to *H. cossus*, this one is of particular interest due to its strong macroscopic resemblance to *Hygrophorus glutiniceps*. However, a clear distinction can be established thru microscopic and ecological criteria. Indeed, *H. cossus* is characterized by significantly longer basidiospores (7–9.5 µm), which constitutes an important diagnostic trait (Candusso, 1997). Moreover, this species is typically observed in temperate zones, where it forms an ectomycorrhiza with species of the genus Quercus, unlike H. glutiniceps, which is associated with Castanopsis in subtropical to tropical forests of East Asia (Wang et al., 2020). These differences highlight the importance of adopting an approach that integrates both fine morphological data and ecological parameters to ensure precise species delineation within the genus Hygrophorus. Finally, morphologically, *H. cossus* is distinguished by its longer basidiospores (7–9.5 µm), while it is primarily associated with temperate forests, particularly with oaks (*Quercus*). On the other hand, *H. glutiniceps* is associated with subtropical to tropical forest formations dominated by Castanopsis (Wang et al., 2020; Candusso, 1997). The similarity between these species, particularly in their slimy appearance, once again highlights the importance of molecular support for precise species delineation. According to Malençon and Bertault (1975), *Hygrophorus nigrescens* (= *Hygrocybe* nigrescens (Quél.) Kühn. = *H. pseudoconica* Lange = *Hygrophorus nigrescens* (Quél.) Quél. Schwärzender Saftling, (Hygrophoraceae, Agaricales) (Kirk et al., 2008) is quite common in grassy clearings and oak groves in the coastal plain and in the mountains. It is more robust than *H. conicus* and also differs from it by its intense blackening and the presence of tetrasporic and rarely bisporic basidia (Malençon and Bertault, 1975).

According to Matheny and Kudzma, 2019, the genus Inocybe contains more than 1000 documented species worldwide. It turned out that the *Inocybe* species collected in tropical forests exhibit some particular characteristics of thin-walled cheilocystidia or thin-walled pleurocystidia (Horak, 1979; Pradeep et al., 2016; Latha and Manimohan, 2017; Gao et al., 2024).

Inocybe fastigiata Quél. 1872 (Inocybaceae, Agaricales) (Kirk et al., 2008) has been found in Mamora, the Middle Atlas, the Tangier region, and the Larache region. According to Malençon and Bertault (1970), L. *fastigiata* is found scattered in the forests from Casablanca to Tangier, in the Rif, and in the High Atlas. *Inocybe fastigiata* contains muscarine, it is a poisonous and deadly species (Hantson and Danell, 1999). It also forms mycorrhizal associations with several species of deciduous trees (Garbaye, 1990). The objective of the presentation of *I. fastigiata*, already described in previous works (Malençon and Bertault, 1970; El-Assfouri, 2006; Larouz, 2007), is notably to emphasize its extreme variability. Indeed, this species is among the most polymorphic. The coloration can vary from white, yellowish-white to reddish-brown. Similarly, its odor is also variable, ranging from a slight flour-like scent to a honeyed scent, and even a spermatic odor. The variability of *I. fastigiata* could be the reason for the use of several synonyms attributed to it, as well as the extremely high number of its forms and varieties. Indeed, consulting the Dictionary of the Fungi (Kirk et al., 2008) shows that *I. fastigiata* is known under twenty-two synonyms, the most commonly used being I. rimosa (Bull.) P. Kumm. 1871. Similarly, in the same dictionary, *I. fastigiata* is represented by thirteen forms, seven subspecies, and thirteen varieties. In Morocco, at less one form *I. fastigiata* f. argentata Kuhner 1956 and two varieties *I. fastigiata* var. cerina Malençon 1970 and *I. fastigiata* var. subcandida Malençon 1970 are represented (Malençon and Bertault, 1970). The high number of forms, varieties, subspecies, and synonyms undoubtedly complicates the identification of this poisonous species.

Inocybe lacera (Fr.) P. Kumm. (Inocybaceae, Agaricales) (Kirk et al., 2008) is found in groups under pine trees. In Sidi Bouknadel (la Mamora), the specimens found under Pinus pinea are of modest size (3 cm on average for the cap and 2–4 × 0.4–0.6 cm for the stipe). However, those found within the sands of the cork oak forest and described in this work are of larger dimensions. Note that in this last station, the terrain is clear. On the other hand, Malençon and Bertault (1970) reported that the *Inocybes* they encountered in Morocco sometimes exhibit an authentic character. Thus, a certain number (six) of species were described by these authors under a collection number without mentioning the name of the species.

The specimens of *Inocybe lacera* from the open area and those collected under the pines show quite significant morphological variations, particularly in the dimensions of the fruiting bodies. This is despite the similarity of the microscopic characteristics. Is it a variation due simply to the biotope (depth of the sands) or are they two different forms or varieties? Further studies will be essential to answer this question. *Inocybe lacera* is a new species for Mamora. Indeed, it was described by Malençon and Bertault in the Tangier region and in the Rif. *Inocybe lacera* grows in groups on sandy soils along roads, paths, near deciduous or coniferous trees. It is considered a poisonous species (Malençon and Bertault, 1970).

*Inocybe geophylla v*ar. lilacina (Inocybaceae, Agaricales) (Kirk et al., 2008) is found in groups under Pinus pinea at the end of winter and the beginning of spring. It was described in 1970 by Malençon and Bertault in the Tangier region, the Rif, and the Middle Atlas. It is a new species for Mamora. The hymenium consists of clavate and tetrasporic basidia (22–25 × 6–7 um) and cheilocystidia (50–60 × 6–7.5 um). The spores (6–8 × 4–5 um) are smooth, kidney-shaped, without a germ pore, and olive-brown in water and yellowish in iodine water.

According to the literature, the species *Inocybe geophylla* has historically presented a variety called *Inocybe lilacina*, a widely distributed species with smooth basidiospores. Indeed, the taxon *Agaricus geophyllus* var. lilacinus described by Peck in 1874 was subsequently transferred to the genus Inocybe as *I. geophylla* var. lilacina (Gillet, 1879). Phylogenetically, Matheny and Swenie (2018) showed that *Inocybe geophylla* and I. lilacina both belong to a monophyletic group called the *I. geophylla* group (or clade 1b according to Matheny, 2005). This group is characterized by smooth spores, a fibrillose-silky cap, a cortina, a spermatic odor, and thick-walled hymenial cystidia. However, although closely related, *I. geophylla* and *I. lilacina* are polyphyletic and each includes several genetically distinct lineages.

Inocybe geophylla is characterized by a generally whitish to pale yellowish cap, covered with a white velipellis, relatively small spores with a blunt apex, as well as hymenial cystidia averaging over 50 μm in length, sometimes equipped with a long pedicel. It is distinguished from several closely related species: *I. posterula* by its typically helmet-shaped cap and longer oblong spores, *I. miranda* by its shorter hymenial cystidia and more elongated spores, *I. sambucella* by its very long and narrow caulocystidia as well as its preference for acidic soils, and *I. bellidiana* by its cap becoming yellowish in the center and more fibrillose with age, as well as by its plumper spores (Atkinson, 1918; Bandini, Oertel & Eberhardt, 2021). Taxonomically, the examination of the original type of *Inocybe xantholeuca*, composed of two basidiomes, one of which belongs to a species with nodulose spores, led to the designation of the second basidiome as the lectotype. The description of the latter matches that of *I. geophylla*, and the molecular analysis (ITS sequences) of the epitype of *I. geophylla* and the lectotype of *I. xantholeuca* revealed a genetic identity. These elements justify the synonymization of the two taxa and confirm their conspecificity (Bandini et al., 2021).

CONCLUSIONS

This study significantly contributes to the current understanding of Agaricales diversity in Morocco through the documentation of ten species belonging to the families Entolomataceae, Hygrophoraceae, and Inocybaceae. Field investigations carried out in distinct forest ecosystems including Maâmora, the Middle Atlas, and the Rif led to the first national records of *Hygrocybe fornicata* (including its white morphotype) and *Hygrophorus agathosmus*. Moreover, several taxa exhibited noteworthy regional range extensions, notably Hygrocybe reae in the Oulmès plateau and *Hygrophorus cossus* in the Khmisses-Sahel area. The detailed morpho-anatomical analyses conducted in this study establish a reference framework for subsequent taxonomic, ecological, and biogeographic investigations. The results substantiate the hypothesis that species richness within these families in Moroccan forest ecosystems has been underestimated. They further demonstrate that forests dominated by cork oak and Atlas cedar sustain distinct assemblages of ectomycorrhizal and saprotrophic Agaricales. Importantly, the study highlights the effectiveness of targeted and systematic field surveys in revealing previously unrecorded or regionally overlooked taxa. In the context of escalating anthropogenic disturbances and climate-related pressures affecting Mediterranean forest ecosystems, sustained mycological inventories remain imperative. Future research integrating molecular phylogenetic approaches will be crucial to improve species delimitation, uncover cryptic diversity, and clarify the biogeographic patterns of North African Agaricales.

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