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Research Article

Mycobiology of ectomycorrhizas of *Amanita pakistanica* and *A. muscaria* var. *guessowii* with *Cedrus deodara* from Kashmir Himalayas, India

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Abstract
In the present manuscript, two lamellate agaric taxa namely *Amanita pakistanica* and *A. muscaria* var. *guessowii* were ectomycorrhizally described here on the basis of morpho-anatomy. The present study were undertaken to characterize ectomycorrhizae between *Cedrus deodara* and two gilled fungi of genus *Amanita* from Kashmir Himalayas. Each of these fungal taxa were depicted here with morphological and anatomical characteristics and illustrated with microphotographs to simplify ectomycorrhizal investigation. In the present study, ectomycorrhizal feeder roots are inhabited, distinct showing variability in configuration and colour of ectomycorrhizal organization. The morpho-anatomy of ECM feeder roots of *Cedrus deodara* organically associated with *Amanita pakistanica* and *A. muscaria* var. *guessowii* were described first ever from India.

Key words: *Cedrus deodara*, *Amanita* taxa, Ectomycorrhiza, Morpho-anatomy, Kashmir Himalayas.

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Introduction

The ectomycorrhizal (ECM) fungal communities take part in vital role in woodland habitats. These lamellate spore producing fungus create complementary association along feeder rootstock of higher plants to facilitate nutrient absorption and resilience of forest ecosystem (Bennett et al. 2017). Ectomycorrhizae (ECM) forms Collaborative interconnection allying plant rhizome along certain saprophytes typically of basidiomycetes and ascomycetes. This organic association is facilitated by soil – borne rhizomorphs enhancing nutrient and water uptake for both partners (Agerer, 2006). The symbiotic association of higher fungi with respect to fundamental prominence in tree development and existence. Such type of beneficial partnership occur in 85 percent trees globally (Kirk et al. 2008). Within continental and arctic forest ecosystems, approximately 95 percent of feeder tiny roots establish ectomycorrhizal (ECM) symbiosis (Smith and Read, 2008).

These beneficial associations are characterized by a mantle of interwoven hyphae on fine root tips plays a fundamental role in nutrient exchange (Smith and Read, 2008). The Hartig net is a mycorrhizal structure

characterized by a complex network based on extremely bifurcated mycelia that infiltrate these cella within epiblema or protective layer. This may be a complex structure formed by hyphae for bi-directional exchange of nutrients particularly minerals and water between a phytobiont and mycobiont (Smith and Read, 2008). Those intricate network regarding mycelium formed by saprophytes in top soil layer is considered as "wood wide web" for facilitation of communication and exchange (Shi et al. 2017).

Himalayan cedar is scientifically called as *Cedrus deodara* belonging to family Pinaceae which is the largest family comprising of approximately 230 taxa (Metreveli et al. 2020). It is naturally occurring in the huge Himalayan mountain ranges known as Western Himalayas such as zones of North-Central regions, North and North-West of Pakistan, Eastern Afghanistan, South-Western Tibet and Western Nepal and this evergreen conifer species flourish at altitudes ranging between 1500-3000 m (Ahmad et al. 2011). It is also mention within a non-profitable organization such as IUCN (International Union for Conservation of Nature) a detailed list of global species which are at menace of elimination and each part of *Cedrus deodara* tree has economic value such as wood, ornamental, oils, medicinal and soil conservation (Nishtha and Thakur, 2021).

The *Cedrus* genus consisting of four types of evergreen species of conifer trees and each individual species grows in unique geographical locations such as *Cedrus libani* var. *brevifolia* found in central Cyprus, *C. atlantica* growing confined to Algeria and Morocco, *C. libani* in Lebanon, Turkey, Syria and furthermore *C. deodara* found in India, Pakistan, Afghanistan, Tibet and Nepal (Panetsos et al. 1992). It is naturally grown and being cultivated in regions facing mild winters and it cannot tolerate temperature below -25^{0}C. The one of highly freezing resistant species exist in the regions belongs to Kashmir and Pakistan.

On the basis of earlier information regarding structure and composition of ectotrophic sheathing ectomycorrhizae (ECM) ecological assemblages associated with *Cedrus deodara*, out of fifty three mycota taxa, just 06 have been organically linked accompanied with *Cedrus deodara* (Zhang et al. 2021). Previously (Hanif et al. 2012) perform a study on the characterization of ectomycorrhizal (ECM) taxa associated with *Cedrus deodara* and identified some fungal species including *Peziza* species, *Russula livescens* and *Tomentella* species for the first time employing morpho-taxonomy and phylogeny from Pakistan. Prior to catalogue this diversification of ectomycorrhizal fungal taxa connected along with *Cedrus deodara* and *Pinus wallichiana* root proliferation of 04 provincially separated fungal roots viz. *Hebeloma theobromium*, *Boletus dryophilus*, *Scleroderma citrinum* and *Suillus luteus* and in addition their impression upon plantlets enlargement under nursery conditions were reported from Kashmir Himalayas (Itoo and Reshi, 2014). This phytobiont possesses an ability to host various ectomycorrhizal (ECM) fungi and particularly it forms organic associations with fungi like *Boletus edulis*, *B. hoarkii* and *Oetaviania densa* (Lakhanpal, 2000). Earlier, (Thakur et al. 2021) performed a study to investigate the mycorrhizal ability of *Rhizopogon himalayensis* escorted *Cedrus deodara* from Himachal Pradesh, India. Recently (Wen et al. 2023) conducted study on the ectomycorrhizal (ECM) community symbiotically integrated together with *Cedrus deodara* and investigated status of ectomycorrhizal expansion of 04 townified deodar plantation in Eastern China. Only a few species has been listed to form ectomycorrhizal (ECM) association accompanied with *Cedrus deodara* reporting from India and Pakistan (Lakhanpal, 2000; Deepika et al. 2011 and Niazi et al. 2008).

The Union territory of Jammu and Kashmir has only 14% of its area covered by forests. The forest cover consisting of cone-bearing, evergreen woodland that inhabited fourty one percent of the region and the remaining portion occupied by hardwood plantation and among the coniferophyta, the *Cedrus deodara* along with *Pinus wallichiana* are highlighted as economically significant trees (Itoo and Reshi, 2014).

In current analysis, assessment of the ectomycorrhizal diversity characterized to fine root tips of *Cedrus deodara* in organic association with ectomycorrhizal (ECM) lamellate fungi viz. *Amanita pakistanica* and *A. muscaria* var. *guessowii* have been morpho-anatomically described for the first time from India in the Kashmir Himalayas.

Review of Literature

The literature review in the present work focus at understanding the existing state of knowledge regarding ectomycorrhizal biology and ecology between *Cedrus deodara* and two gilled fungi of genus *Amanita* such as *Amanita pakistanica* and *A. muscaria* var. *guessowii* from Kashmir Himalayas.

Morpho-anatomical studies on Ectomycorrhiza:

The genus such as *Cedrus* possessing four types of evergreen species of conifer trees and each one individual species grow-up in distinctive geographical sites such as *Cedrus libani* var. *brevifolia* establish in central Cyprus, *C. atlantica* emerging restricted to Algeria and Morocco, *C. libani* in Lebanon, Turkey, Syria and furthermore *C. deodara* originate in India, Pakistan, Afghanistan, Tibet and Nepal (Panetsos et al. 1992). It is naturally grown-up and being sophisticatedly cultivated in regions facing placid winters and it cannot bear temperature lower than -25^{0}C. The one of extremely freezing resistant species survive in the regions fit in to Kashmir and Pakistan.

On the basis of former information concerning structure and composition of ectotrophic sheathing ectomycorrhizae (ECM) ecological assemblages allied with *Cedrus deodara*, out of fifty three mycota taxa, just 06 have been biologically linked accompanied with *Cedrus deodara* (Zhang et al. 2021). In the past (Hanif et al. 2012) carry out a study on the description of ectomycorrhizal (ECM) taxa connected with *Cedrus deodara* and acknowledged several fungal species including *Peziza* species, *Russula livescens* and

Tomentella species for the first time employ morpho-taxonomy and phylogeny from Pakistan. Earlier to index this diversification of ectomycorrhizal fungal taxa connected along with *Cedrus deodara* and *Pinus wallichiana* root proliferation of 04 provincially separated fungal roots viz. *Hebeloma theobromium*, *Boletus dryophilus*, *Scleroderma citrinum* and *Suillus luteus* and additionally their impression upon plantlets improvement under nursery conditions were reported from Kashmir Himalayas (Itoo and Reshi, 2014). This phytobiont possesses an capacity to host a range of ectomycorrhizal (ECM) fungi and predominantly it forms organic associations with fungi like *Boletus edulis*, *B. hoarkii* and *Oetaviania densa* (Lakhanpal, 2000). Pastly, (Thakur et al. 2021) execute a study to investigate the mycorrhizal ability of *Rhizopogon himalayensis* escort *Cedrus deodara* from Himachal Pradesh, India. Recently (Wen et al. 2023) accomplish study on the ectomycorrhizal (ECM) community symbiotically incorporated together with *Cedrus deodara* and investigated status of ectomycorrhizal extension of 04 townified deodar plantation in Eastern China. Only a few species has been listed to form ectomycorrhizal (ECM) association accompany with *Cedrus deodara* reporting from India and Pakistan (Lakhanpal, 2000; Deepika et al. 2011 and Niazi et al. 2008).

Tulloss et al. (2001) documented *Amanita pakistanica* growing lonely in association with *Abies pindrow* at an altitude of 2,400 m from Pakistan. Morpho-anatomical study of ectomycorrhizae of *Amanita pakistanica* in association with *Pinus wallichiana* has been investigated by (Niazi, 2008) from Pakistan. This species also give fruiting beneath Fir trees in the Northwest Frontier Province of Pakistan as reported by (Tulloss et al. 2001). These taxa were normally occurring in putative ectomycorrhizal relationship accompanied with *Abies pindrow* in Pakistan (Tulloss et al. 2001). This ectomycorrhizal species too occur under *Abies pindrow* at an altitude of 2,700 m in Himachal Pradesh, India (Kaur and Singh, 2014). The inclusive morphological description and nrLSU molecular taxonomy of *A. pakistanica* have been documented from India (Mehmood et al. 2021). According to Carboue and Lopez, 2021) this is a ectotrophic ectomycorrhizal mycota mushroom indigenous to glacial habitats of land hemisphere popularly known as Northern hemisphere. Characterization of non-native ectotrophic ECM lamellate mushroom succinctly found in mixed Eucalyptus woodlands, *A. muscaria* in a mixed Eucalyptus forest with *Nothofagus cunninghamii* were described from Victoria, Australia (Dunk et al. 2011). Itoo and Reshi (2014) conducted widespread field exploration in the Kashmir Himalayas, resulting in categorization of seventy six prospective mycorrhizal taxa linked to *Cedrus deodara* and *Pinus wallichiana*.

Importance of ectotrophic mutualistic fungus-root relationship of vegetation with a particular elusion to Kashmir Himalayas was reviewed (Rather and Nabi, 2017). Comparative studies were confirmed upon nutritive requirements as well as synthetic formation of ectotrophic mycorrhiza of *Cedrus deodara* with *Rhizopogon himlayensis* (Singh et al. 2020). An assessment of fungal taxa heterogeneity of above ground ectomycorrhizal mushrooms of the moderate natural habitat of western Himalayas concluded that all of these types of forests showing domination of ECM hosts with stubby tree species divergence (Pande et al. 2004). The *Trappeinda himalayensis* being structurally distinctive and ancestrally divergent taxa of genus *Rhizopogon* is ectomycorrhizally associated with *Cedrus deodara* and confirmed that *T. himalayensis* being a ectotrophic symbiotic allies of *Cedrus deodara* (Mujic et al. 2018). External morphological and internal anatomical characterization of *R. himalayensis* in consortium with *Cedrus deodara* mycorrhiza exposed that symbiotic interconnection joining *R. himalayensis* and *Cedrus deodara* underneath nursery environment being intimately ectomycorrhizal escorted by proficiently expanded mantle and Hartig net (Thakur et al. 2021). Ectomycorrhizas of *Rhizopogon himalayensis* on *Cedrus deodara* have been described by (Kumar et al. 2023). Ectomycorrhizal community associated with *Cedrus deodara* in four urban forests of Nantong in East China (Wen et al. 2023). Seedling ectomycorrhization is central to conifer forest restoration: a case study from Kashmir Himalaya has been postulated by (Assad et al. 2025). Does ectomycorrhizal fungal biodiversity affect tree growth have been described from Austria (Anthony, 2025).

Material and Methods

Area of investigation:

The region specified for current survey is the Kashmir Himalayas of North-western Himalayas. This region be exist in the North-Western Himalayan range and its dominance aided with temperate coniferous forests with gymnosperm cone bearing tree such as *Cedrus deodara* and *Pinus wallichiana*. Kashmir Himalayas having a latitude 33º20′-34º54′ N and longitude 73º55′-75º35′ E. The total area is 15,948 square kilometers, along a forestland of approximately 8,123 square kilometer. The elevation regarding most important Kashmir valley ranges between 1500-1800 meter (above mean sea level) and surrounding mountains with 3000-4000 meter (above mean sea level). The Kashmir Himalayas is like an oval saucer-shaped valley surrounded with western chain of lower Himalayas from the southern side and south-west side and bounded by Zanskar mountain ranges of higher Himalayas from northwards and northeast side. Three main forest groups of Kashmir Himalayas with altitudinal ranges viz. Temperate forests (1700-2900 m), Sub-alpine forests (3100-3500 m), Alpine forests (above 3500 m). The dominant tree species of conifer-dominated forests include *Cedrus deodara*, *Pinus wallichiana* and *Pinus gerardiana* escorted with patches of other species, such as *Picea smithiana*, *Abies pindrow*, *Abies spectabilis*, *Betula utilis*, *Taxus wallichiana* and *Rhododendron anthopogan*.

Sampling of biological material, Recognition and Characterization of Basidiocarps:

These sampling of above ground basidiocarps and ectomycorrhizal feeder mycotips from (ECM) groups in evergreen, cone-bearing forests of Kashmir Himalayas. The collection of basidiocarps near *Cedrus deodara* dominating forests at different altitudes (1592 m, $34^0$12'38"N – $74^0$48'28" E) and (2000 m, $34^0$16'17"N – $74^0$19'22" E) during June to September in 2024. The basidiocarps along with proliferated ectomycorrhizal mycotips have been sampled and besides detecting the mycelium connections uniting anchoring tree and basidiocarps. Documentation of comprehensive morphological characteristics of sampled basidiocarps by using identification index key (Atri et al. 2005). Basidiocarps have been dried up using hot air of temperature ranges between 45-50° celsius. A little electricity voltage (500 watt) heater was used for the drying process. A specially designed drier for mushroom collections was utilized (Atri et al. 2005). The desiccated specimens put in cellophane paper. Additionally, small number of solid crystals of para-dichlorobenzene or white Naphthalin balls for conservation in Herbarium. The categorizational identification involved both morphological and anatomical characteristics of the scrutinized taxa. The standard methodology outlined by Singer (1986) and Atri et al. (2017) were followed for the taxonomic work.

Ectomycorrhizal Studies:

Collection of ECM Material:

Carefully digging and extracting juvenile, well, healthy ectomycorrhizal mycotips beneath basidiocarps. This involves tracing hyphal connections and delicate rhizomorphs. Gathering the excavated roots and placing them in polythene bags for transportation to the laboratory. Choosing a *Cedrus deodara* tree as the phytobiont for sampling of ECM mycotips. Extracting soil pieces of 15 cm^3 along with root tips from the selected tree. These blocks are taken from a specific distance (15 centimeter to 1meter) from trunk of tree. Properly labeling plastic bags containing soil pieces with information such as collection number, locality and date. This ensures proper identification and tracking of the samples. Carrying the labeled samples to the laboratory for further examination. Storing the samples at 4°C until the subsequent steps of cleaning and sorting into different groups.

Cleaning of Roots:

The soil pieces has been submerged in water lasting for night to unwinding the attached soil particles. After soaking, the soil blocks were shifted to a 2 millimeter plastic mesh and put down under tap water. This step aimed to eliminate adhered soil and detritus waste preventing mislaying intricate mycotips. The ECM mycotips has been meticulously grouped into morphotypes underneath incandescent light based on morphological characters. Further, tightly connected soil pieces were detached using a fine brush under a Magnus MSZ-TR stereomicroscope for watchful analysis (Agerer, 1987-2012). Each ectomycorrhizal root tip was dissected individually for further examination.

Storage of ECM Roots:

The ectomycorrhizal mycotips being biologically preserved in formalin, glacial acetic acid, alcohol (FAA) [(5 ml formalin (37 percent) + 5 ml glacial acetic acid (100 percent) + 90 ml alcohol (50 percent)] for morpho–anatomical elucidation (Agerer, 1987-2012). The morphs retained in a specialized McCartney container in filtered and refined water for subsequent morphological evaluation (Jabeen et al. 2017).

Morphotyping of ECM Roots:

The external features has been distinguished underneath the stereomicroscope (Magnus MSZ-TR), electronically snapshoted and identify the distinctive features through meticulous examination in accordance with methodology specified by Agerer (1987-2012) and Agerer and Rambold (2004-2020). The mycotips has been noticed especially for taxonomic characters such as ectomycorrhizal network, ramification, form, dimensions, colour tones, appearance, presence or absence of mycelial cords and extralimitical hyphae (Emanating hyphae, Rhizomorphs, Cystidia, Sclerotia) following Agerer and Rambold (2004-2020).

Anatomical Studies of ECM Roots:

The preserved ectomycorrhizal mycotips has been subjected to anatomical characterization. This likely involves studying the internal structures and features of the roots. Ectomycorrhizal colonization was verified by meticulously inspecting cross-sections of the ectomycorrhizal mycotips. The roots were dissected free-handly for this purpose. The examination was performed beneath a biological microscope and documented through photomicrography using electronic microscope (Leica DM4000 B LED) in the laboratory. Surface insights of ectomycorrhiza were analyzed using peeling and squashing techniques (Harley and McCready, 1952). The colouring charts of Kornerup and Wanscher (1978) was followed.

Results

Illustration of Ectomycorrhizal association of Cedrus deodara root with Amanita pakistanica:

External characters:

Figure 1

Ectomycorrhizal organization irregularly pinnate to dichotomous like, having 0-1 ramification order, 6.0 - 10.0 millimeter long; main axes 0.5 - 2.0 millimeter in diameter. Unmodified ends straight, bent and sinuous, 2.0 - 6.0 millimeter long and 0.2 - 0.5 millimeter in radius. External covering of unmodified points rough, covered by dense soil bits, densely stringy; juvenile ectomycorrhizae grayish brown and older one deep black to brownish; surface of mantle non-transparent; cortical cells through mantle surface not visible; hydrophobicity of mantle absent; the colour of mycotips and whole ectomycorrhizae is same, grayish

brown to deep black, swollen, few tapering; carbonization present. Rhizomorphs hyphae or mycelia cords not found. Emanating hyphae not located. Cystidia absent.

Internal characters:

Mantle plectenchymatous/pseudoparenchymatous, Type 'F/K'. Mantle 71.4 - 91.3 µm thick, metamorphosed into outermost sheath layer and innermost sheath layer. Outermost sheath layer 51.5 - 64.7 µm, like plectenchymatous, provided with occasional nests of pseudoparenchymatous roundish cells; hyphal cells 5.0 - 8.3 µm in diameter, smooth, septate without clamps, unbranched; hyphal junction angle 45^0; ampullate protrusions present; pigmentation membranaceously dark brown, smooth, pseudoparenchymatous cells irregular, rounded to oval. Inner mantle layer 31.5 - 41.5 µm, pseudoparenchymatous, possessing irregularly arranged cells; hyphal cells measuring 5.8 - 13.3 µm tangentially and 4.2 - 6.6 µm radially, compactly arranged, smooth, few elongated, hyaline, irregularly arranged. Hartig net many cells deep, lobed type, protruding towards endodermis, made up of rectangular to cylindrical cells measuring 5.0 - 6.6 x 2.5 - 4.2 µm, tangentially and radially. Epidermal cells rectangular to elongated, measuring 31.5 - 43.2 µm tangentially and 12.5 - 20.0 µm radially, oval to elliptic or cylindrical. Tanin cells oval, elliptical or rod-like and orientate in aligned collaterally to the axis of root, calculating 23.5 -33.2 x 4.2 - 8.3 µm tangentially and radially. Emanating hyphae not found. Rhizomorphs not observed. Cystidia absent.

Collection Examined: Jammu and Kashmir: Ganderbal, village Goindub (1592 m) $34^0$12'38"N – $74^0$48'28" E, growing solitary in mixed coniferous forest, in ECM with *Cedrus deodara*, Hilal Ahmad Rather, June 12, 2024.

Figure 1

Ectomycorrhizal association of Cedrus deodara root with Amanita pakistanica



Note. (A) Sporophores growing in ECM association with *Cedrus deodara* root (B) Ectomycorrhizal system irregularly pinnate to dichotomous like, (C) Cross section of root showing plectenchymatous/pseudoparenchymatous outer mantle layer and inner mantle layer representing F/K arrangement and tannin cells oval, elliptical or cylindrical and oriented in parallel to the root axis (D) Hartig net many cells deep, lobed type, protruding towards endodermis, made up of rectangular to cylindrical cells. Scale bar a = 3cm, b = 1mm, c-d = 10µm.

Illustration of Ectomycorrhizal association of *Cedrus deodara* root with *Amanita muscaria* var. *guessowii*

Figure 2

External characters:

Ectomycorrhizal organization coralloid and dichotomously ramified, possessing 0 – 1 ramification order, 8.0 - 13.0 millimeter long; central axis 0.3 - 0.5 millimeter in radius. Unmodified ends undeviating, not swollen, rod-shaped, 0.6 – 2.5 millimeter long and 0.2 - 0.4 millimeter in radius, tops globular. External finish of unmodified ends grainy and rough, infrequently smooth; juvenile ectomycorrhizae chestnut colour like, older one dark hazel colour, mycotips show somewhat

different color. Rhizomorphs absent. Emanating hyphae not found.

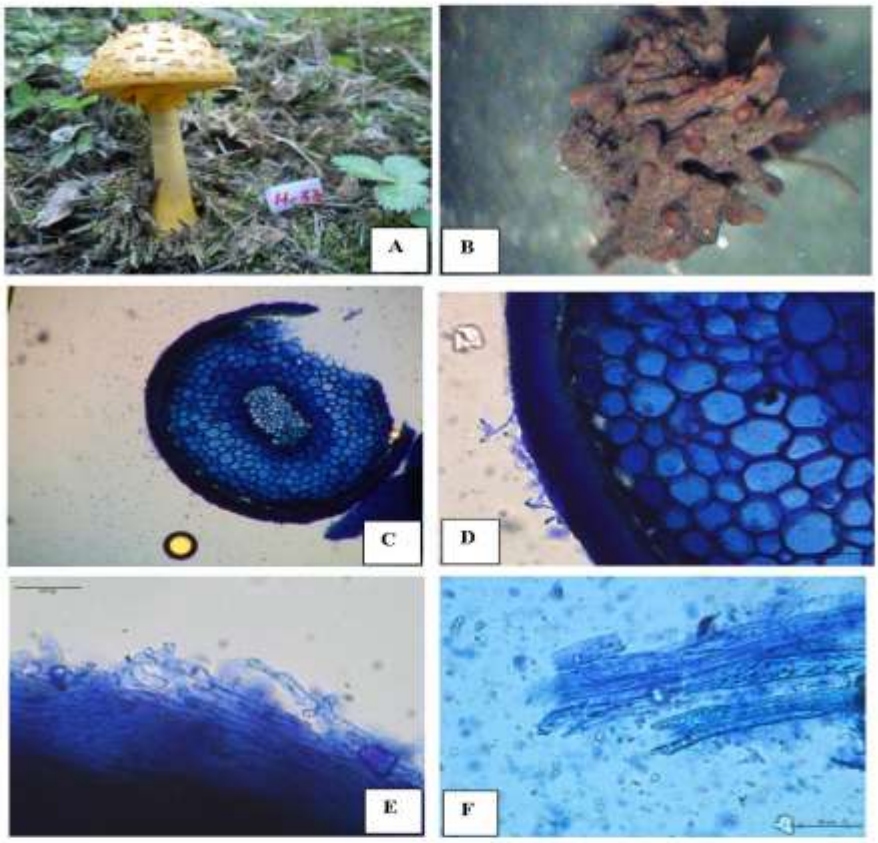
Internal characters:

Mantle plectenchymatous, Type 'F/H'. Mantle thickness 60.0 - 74.5 µm, divided into outermost sheath layer and innermost sheath layer. Outermost sheath layer 28.3 – 38.7 µm, plectenchymatous, arranged in condensed pattern with few nests of roundish cells; outer mantle hyphae 3.0 - 5.2 µm in diameter, cylindrical to subcylindrical, compactly organized, smooth, hyaline, septate, unbranched, clampless; outer mantle cells 5.2 - 12.0 µm tangentially and 4.5 - 6.7 µm radially. Inner mantle layer 29.8 - 35.7 µm, plectenchymatous, compactly arranged, a mesh of rough and asymmetrically formed hyphal strands; inner mantle hyphae 3.7-6.0 µm in 6.7 - 16.0 µm tangentially and 4.5 - 6.0 µm radially. Hartig net estimating 13.4 -24.0 µm peripherally and 6.0 - 13.5 µm concentrically. Cystidia lacking.

Collection Examined: Jammu and Kashmir: village Satrina, Baramulla (2,000 m), $34^0$16'17"N – $74^0$19'22" E, growing solitary in mixed coniferous forest in ectomycorrhizal association with *Cedrus deodara*, Hilal Ahmad Rather, September 17, 2024.

Figure 2

Ectomycorrhizal association of Cedrus deodara root with Amanita muscaria var. guessowii



Note. (A) Sporophore growing in ECM association with *Cedrus deodara* root (B) Ectomycorrhizal system coralloid to dichotomously ramified (C) Cross section of root showing mantle colonized by fungal hyphae (D) Hartig net measuring 13.4 –24.0 µm tangentially and 6.0—13.5 µm radially (E) Outer mantle layer plectenchymatous with few nests of roundish cells showing type F/H pattern (F) Hyphal cells measuring 6.7 - 16.0 µm tangentially and 4.5 - 6.0 µm radially. Scale bar a= 3cm; b = 1mm; c-f = 10µm.

Discussion

Tulloss et al. (2001) recorded *Amanita pakistanica* growing solitary in association with *Abies pindrow* at an altitude of 2,400 m from Pakistan. Morpho-anatomical study of ectomycorrhizae of *Amanita pakistanica* in association with *Pinus wallichiana* has been investigated by (Niazi, 2008) from Pakistan. This species also give fruiting under Fir trees in the Northwest Frontier Province of Pakistan as reported by (Tulloss et al. 2001). These taxa were generally occur in putative ectomycorrhizal relationship accompanied with *Abies pindrow* in Pakistan (Tulloss et al. 2001).

This ectomycorrhizal species also occur under *Abies pindrow* at an altitude of 2,700 m in Himachal Pradesh, India (Kaur and Singh, 2014). The comprehensive morphological description and nrLSU molecular taxonomy of *A. pakistanica* have been documented from India (Mehmood et al. 2021).

Morphological and anatomical detailing of the ectotrophic beneficial guildance between comprehensively elucidated and characterize first of all in the Argentina (Daniele et al. 2005). Tulloss (2013) listed *Amanita muscaria* var. *guessowii* Veselý, flourishing in clusters or gregariously in open woodlands of *Betula* and *Pinus strobes* in fields adjacent to *Picea glauca* forests of Canada. This species grows under *Picea abies* or *Pinus* or *Tsuga canadensis* in New Jersey, along roadside under *Picea engelmannii* in North Carolina and under *Pinus strobus* and *Pinus resinosa* in West Virginia (Tulloss, 2013). It is found to grow solitary, scattered to gregariously or sometimes in fairy rings in mycorrhizal association with conifers and hardwoods (Kuo, 2013). *Amanita muscaria* var. *guessowii* was found in mycorrhizal association with conifers and hardwood forests of Midust and in the North America (Kuo, 2013). According to Carboue and Lopez, 2021) this is a ectotrophic ectomycorrhizal mycota mushroom indigenous to polar habitats of land hemisphere popularly known as Northern hemisphere.

Characterization of non-native ectotrophic ECM lamellate mushroom concisely found in mixed Eucalyptus woodlands, *A. muscaria* in a mixed Eucalyptus forest with *Nothofagus cunninghamii* were described from Victoria, Australia (Dunk et al. 2011). An outline on decorative cone-bearing, evergreen tree *Cedrus deodara* (Himalayan Cedar) was reviewed as well as enunciate the overall importance regarding conventional usage, chemical substances extracted from Himalayan Cedar and curative, remedial uses of *Cedrus deodara* (Grover, 2021). Itoo and Reshi (2014) conducted extensive field exploration in the Kashmir Himalayas, resulting in categorization of seventy six prospective mycorrhizal taxa linked to *Cedrus deodara* and *Pinus wallichiana*. Naming and infusing of fungus varieties (strains) underneath *Cedrus deodara* soil zone (rhizosphere) involved in growth expansion and mitigate of elevated nitrogen pressure suggested such recently recognized mushroom strains manifest beneficial effect in use for growth and functions and processes of *Cedrus deodara* might be utilized for multiplication for economically efficient plants in Pakistan (Jamil et al. 2019).

Importance of ectotrophic mutualistic fungus-root relationship of vegetation with a particular ellusion to Kashmir Himalayas was reviewed (Rather and Nabi, 2017). Comparative studies were demonstrated upon nutritive requirements as well as artificial formation of ectotrophic mycorrhiza of *Cedrus deodara* with *Rhizopogon himlayensis* (Singh et al. 2020). An estimation of fungal taxa hetereogeneity of above ground ectomycorrhizal mushrooms of the temperate natural habitat of western Himalayas concluded that all of these types of forests showing supremacy of ECM hosts with stubby tree species divergency (Pande et al. 2004). The *Trappeinda himalayensis* being structurally distinctive and ancestrally dissimilar taxa of genus *Rhizopogon* is ectomycorrhizally associated with *Cedrus deodara* and confirmed that *T. himalayensis* being a ectotrophic symbiotic allies of *Cedrus deodara* (Mujic et al. 2018). External morphological and internal anatomical characterization of *R. himalayensis* in consortium with *Cedrus deodara* mycorrhiza revealed that symbiotic interconnection joining *R. himalayensis* and *Cedrus deodara* underneath nursery environment being closely ectomycorrhizal escorted by competently expanded mantle and Hartig net (Thakur et al. 2021). The morphological and anatomical study regarding presently examined ECM mycotips of *Cedrus deodara* mutually integrated accompanied with *A. pakistanica* and *A. muscaria* var. *guessowii* undergoes characterization and for the first time catalogued as ectomycorrhizal associates of *Cedrus deodara* from India.

Conclusion

This present investigation discloses that *Cedrus deodara* dominating forests of Kashmir Himalayas, India harbour diverse ectomycorrhizal fungal flora. During the studies, the documentation of two lamellate fungi forming ectomycorrhizal organic connections with the feeder roots of *Cedrus deodara* on the basis of morpho-anatomical details. The Himalayan cedar (*Cedrus deodara*) as phytobiont establish symbiotic association with two lamellate agaric taxa such as *A. pakistanica* and *A. muscaria* var. *guessowii* as mycobionts have been morpho-anatomically described for the first time from India in Kashmir Himalayas.

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