
Ectomycorrhizal fungi of *Shorea robusta* G.f. from West Bengal

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Twelve ectomycorrhizal fungi of *Shorea robusta* G.f., namely, *Russula delica*, *R. cyanoxantha*, *R. vesca*, *R. lepida*, *R. albonigra*, *R. pectinata*, *Lactarius subdulcis*, *Amanitopsis vaginata*, *Prophyrellus malaccensis*, *Boletus piperatus*, *Pulveroboletus shoreae*, and *Astreaus hygrometricus* were described. Of these six are new reports from India and nine are new reports from West Bengal.

Key words : Ectomycorrhizal fungi, *Shorea robusta*, Jhargram forest, West Bengal

INTRODUCTION

It was recognised long ago by different authors that mycorrhiza which occur in symbiotic association between roots of higher plants and fungi, plays a beneficial role in the forest soil. From the available reports it is known that a large number of fungi exist in association with a variety of higher plants as ectotrophic mycorrhiza. The members of the hard wood family Abietaceae, Betulaceae, Fagaceae, Salicaceae, Juglandaceae, Myrtaceae, Caesalpinae, Ericaceae and Pinaceae are very common among them (Trappe, 1962; Harley and Harley, 1987). Among the fungal symbionts a great majority of ectomycorrhiza forming fungi belongs to the Basidiomycetes.

Singh (1966) has reported ectomycorrhizal association in members of Dipterocarpaceae and Fagaceae. Hung (1979) and Becker (1983) have also described some Dipterocarpaceous mycorrhizal association from Malaysia.

Some of these popularly edible mushrooms (viz., *Russula heterophylla*, *R. albonigra*, *R. parazurea*, *R. sanguinea*, *Amanita vaginata*, *A. hemibapha*, *Astreaus hygrometricus*, *Lactarius rufus*) have been found to form mycorrhiza with sal roots. Bakshi (1974) has also reported from Dehra Dun (Uttar Pradesh), that *Russula delica*, *Astreaus hygrometricus*, *Lactarius scrobiculatus*, *Pulveroboletus shoreae*, etc. have formed mycorrhiza with *Shorea robusta*. But unfortunately, there is no scientific account of these edible as well as mycorrhizal species in the district of Midnapore, West Bengal; upto now. As such the present study has been taken in 1981 to prepare a detailed account including ecological conditions of mycorrhizal mushrooms occurring in this district to facilitate the exploitation of these fungi as an efficient tool for afforestation programme and food substitution as well.

In India, Bakshi (1974) has reviewed about the work done on ectomycorrhizal association in forests of India. But this work clearly shows that a lot of work remains to be done on this line in India. As such in present investigation an attempt has been made to survey the ectomycorrhizal fungi of *Shorea robusta* G.f., an important timber yielding crop of eastern India.

MATERIALS AND METHODS

The district Midnapore is situated in western side of West Bengal between $21^{\circ}36'35''$ and $22^{\circ}57'10''$ in Northern hemisphere and its western most part is situated at $86^{\circ}33'50''$ longitude. The soil type is mainly lateritic and comprises loam and sandy loam of reddish brown colour. Its climate is characterised by oppressive hot summer, high relative humidity and well distributed rain-fall during the monsoon. The average rain-fall is 1525.5 mm and monsoon season extends from June to September with an average temperature of 35°C .

West Midnapore comprises mainly of sal forests (*Shorea robusta* G.f.) and contributes 63.52 lakhs rupee annually to the total forest resources of West Bengal.

Due to these above mentioned climatic conditions mushrooms grow abundantly in the forests of West Midnapore during rainy season. Most of which are in mycorrhizal association with the roots of sal trees (*Shorea robusta* G.f.).

The basidiocarps of different mushrooms which were growing in mycorrhizal association in *Shorea robusta* were collected from different areas of the forest of West Midnapore during the months of July to September, 1981-84. During collection all the necessary field records were noted along with photographs. The collected specimens were then brought to laboratory for necessary preparation of spore print and other chemical tests. The colour of the basidiocarps were determined according to the colour identification chart published by Her Majesty's Stationary Office, Edinburgh.

Morphological and anatomical descriptions of all the fungi were done following the standard scientific procedures.

The mycorrhizal roots were cut into thin cross section and stained in cotton blue in lactophenol. The stained sections were observed under microscope for determining the types of mycorrhizal association in each case. The hyphal structures and other peculiarities were also noted.

The identification of the mycorrhizal mushrooms was made following the method proposed by Singer (1975). All the species with requisite field notes are kept in the herbarium of Mushroom Research Centre, Mycology Laboratory Department of Botany, University College of Science, Calcutta and duplicate sets of the same were sent to the Kew Herbarium, Royal Botanic Garden, Surrey, England and National Herbarium, I.A.R.I., New Delhi for species identification.

All these fungal species described here are considered as mycorrhizal on the basis of circumstantial evidences like, (i) the proximity and connection of carpophores with collected mycorrhizae, and (ii) the structural resemblance of the mycorrhizae and carpophore mycelium.

The fungal tissues are treated with the following chemicals for microchemical reactions :

10% aq. ferrous sulphate solution, 30% aq. sodium hydroxide solution, 20% aq. potassium hydroxide, 40% aq. ammonium hydroxide, concentrated sulphuric acid, nitric acid and hydrochloric acid, 2% aq. phenol solution, aniline water (1:1) solution, Melzer's reagent.

ENUMERATION OF SPECIES

Russula delica Fr.

Bres. Fung. Trid t. 201, Bakshi. Project Report, P.L. 480

(Fig.1)

Pileus - 4.0-9.0 cm, umbilicate, fresh white, glabrous, non-hygrophanous, brittle; *Cuticle* - dry, smooth, easily separable, without any scales; *Margin* - entire, smooth and inrolled; *Gills* - slightly decurrent, moderately crowded, distinctly formed easily separable from the pileus, not interveined, consistency brittle to pliable, branched, 0.3-0.6 cm width at the middle, margin smooth, latex absent; *Stipe* - 4.0-6.0 x 0.5-1.0 cm; tapering towards the base, white, consistency fleshy to brittle, surface smooth and dry, solid, exannulate, evolvate; *Flesh* - fresh white, 0.3-0.5 cm thick at the middle; *Spore print* - white.

Basidiospores - 5.14-8.0 μ m, white, hyaline in water under microscope, spherical, slightly thick-walled, finely echinulate, non-apiculate, amyloid; *Basidia* - clavate to tubular, 28.0-36.4 x 8.0-13.0 μ m, tetrasterigmate (sterigmata 3.9 μ m), mature basidia hyaline, thin-walled and subhymenial origin; *Pileal trama* - made up of spherical and angular thin-walled cells, oliferous hyphae frequently present; *Gill trama* - heteromerous, intermixed to irregular in arrangement, sphaerocyst present, hyphae 3.2-4.2 μ m in diameter; *Pileus surface* - made up of narrow and thin-walled hyphae; *Cheilocystidia* - thin-walled with acute apex, 52.0-7.8 μ m.

All tissues reacted with conc. H₂SO₄ and turned into grey colour; in HNO₃ turned into yellow colour, in phenol changed into risset-vinaceous but in HCl, NaOH, KOH, Anniline, FeSO₄ and Melzer's reagent have negative response upon the tissues.

Mycorrhiza

Simple, white, rough; *mantle* - pseudoparenchymatous, 6-8 celled and upto 25.0 μ m thick; *Hyphae* - thin-walled, upto 3.8 μ m diameter with simple septa.

Locality - Gidhni, Kankrajhore and Jhargram sal forest; *Altitude* - 125' m.s.l. (approx); *Soil type* - red laterite to black loamy forest soil having pH 5.5-6.0 (approx); *Vegetational community* - solitary, associated with sal roots.

June-August, 1981; M.H. No. M-26.

Russula cyanoxantha (Schaeffl) Fr. Cke.

Illus No. 1007 t. 1076; Kew Bull, 30 : 619

(Fig. 2)

Pileus - 7.0-10.0 cm in diameter, depressed at the centre, umbilicate, livid vinaceous in colour, glabrous, brittle, not hygrophanous, not polished; *Cuticle* - peels easily, dry, livid, vinaceous, changing at maturity; *Margin* - entire, enrolled, broken at maturity;; *Gills* -

adnate, 0.8 cm width, 4 cm long, easily separable, number of length 9, white, not interveined, pliable, dichotomously branched, edge entire; *Stipe* - 4.0-6.0 x 1.5-2.0 cm, central, equal with slightly bulbous base, glabrous, exannulate, evolvate, solid (mites make it hollow), fleshy, brittle; *Flesh* - white 0.4-0.6 cm, thick at the middle; *Spore-print* - white. *Basidiospores* - globose, finely echinulate, 6.0-8.0 μ m, nonapiculate, amyloid in nature, *Holobasidium* - clavate, tetrasterigmate, 36.4-52 x 10.0-13.0 μ m, *sterigmata* 7.8 μ m; *Cystidia* - 56.7 x 13 μ m, hyaline, acute tipped; *Gill trama* - irregular in arrangement, oliferous hyphae present, hyphae diameter 2.6- 3.8 μ m; sphaerocysts present.

In HNO_3 (conc). all the tissues turned greenish yellow colour and in H_2SO_4 - Hazel colour, in KOH and NH_4OH context tissue turned sepia colour but gill tissues showed no change, in aniline-water all tissues fulvus in colour and in phenol rusty tawny but in HCl, FeSO_4 and Melzer's reagent no colour change observed.

Mycorrhiza

Simple, racemosely borne, chocolate brown colour; *mantle* - pseudoparenchymatous and 3-6 cell layered (24-26 μ m) thick, consists of thin walled branched hyphae with simple septa.

Locality - Gindhni; *Altitude* - 125' m.s.l.; *Soil type* - red laterite soil, pH 5.6; *Vegetational community* - solitary, associated with *Shorea robusta* roots.

July-August, 1982; M.H. No. M/41.

Russula vesca Fr. (= *R. rosea* Schaeff Quel.)

Sverig atl. Svamp. t. 63; Butler & Bisby Imp. Coun. Agric. Res. India Sci. Monogr. I

(Fig. 3)

Pileus - 3.0-7.0 cm, convex, sometimes depressed at the centre, red to deep vinaceous, intermingled with white patches, glabrous slightly viscid; *Cuticle* - peels easily, thin; *Margin* - entire and inrolled; *Gills* - equal, cream colour, moderately formed, brittle, adnate, edge entire, latex absent, easily separable from pileus; *Stipe* - 3.0-4.5 x 0.6-0.8 cm, central, equal, solid, brittle, white, smooth; *Flesh* - white, 0.2-0.4 cm thick; *Spore print* - white.

Basidiospores - subglobose, echinulate, apiculate, 6.4-7.2 μ m in diameter, hyaline and amyloid in nature; *Basidia* - subclavate to tubular, 24.0-26.3 μ m x 8.4-9.2 μ m, tetrasterigmate, holobasidia, sterigmata 3.2 μ m; *Cystidia* - 39.2-45.3 x 6.4-9.9 μ m, fusiform hyaline and thin-walled. *Gill trama* - heteromerous, sphaerocysts present, hyphae 4.2-6.3 μ m in diameter, simple septate, branched, oiliferous hyphae present, 1.5 to 2.2 μ m in diameter.

In H_2SO_4 all tissues turned into Hazel colour; in HNO_3 and HCl no change observed; in NaOH, KOH and NH_4OH - no change observed; in FeSO_4 only stipe tissue changed to Sienna colour; all tissues turned dark brick colour in phenol; in aniline water - pileal context changed to Sienna colour and in Melzer's reagent all tissues taken reagent colour.

Mycorrhiza

Simple, racemose, brown to grey in colour; *mantle* - brown with tufts of hyphae; pseudoparenchymatous 5-8 cell layered, consists of branched, thin-walled hyphae with simple septa, 4.2-5.2 μ m in diameter.

Locality - Balibhasa, Gidhni and Kankrajhore; *Altitude* - 125' m.s.l.; *Soil type* - red laterite soil, pH 5.5;; *Vegetational community* - solitary, associated with *Shorea robusta* roots.

June, 1982 and 1983, M.H. No. M/19.

Russula lepida Fr.

Bres Fung Trid t. 204; J Madras Univ. B, 22 : 25

(= *Russula lepida* Fr. var. *pulcherima* Gillet.)

(Fig. 4)

Pileus - 5.0-10.0 cm, convex to flat and slightly depressed at the centre, blood red to rust colour having fade yellowish spots here and there or somewhat tanned leather colour, cracks with age, slightly squamulose and slightly viscid; *Cuticle* - moist, peels easily; *Margin* - cracked with age, slightly incurved; *Gills* - white to creamish white close or slightly crowded, branched towards the margin, brittle; *Stipe* - 4.0-5.6 x 1.0-1.5 cm, central, tapering towards the base, white firm but brittle, solid, exannulate, evolvate; *Flesh* - white; *Spore-print* - creamish white.

Basidiospores - hyaline, globose, 8.0-10.2 μ m, echinulate, amyloid, non-apiculate; *Basidia* - 28.2-36.3 μ m clavate, tetrasterigmate, holobasidium, thin-walled and hyaline; *Cheilocystidia* - 66.0-78.0 μ m long, cylindrical and thin-walled; *Gill trama* - heteromerous, subregular to irregular in arrangement, with shaerocysts, hyphae 4.2-5.2 μ m in diameter and thin-walled.

All tissues from different parts turned vinaceous buff in phenol; pink in H₂SO₄ and red in Melzer's reagent, buff in F₂SO₄; the others have no colour reaction.

Mycorrhiza

Simple, borne racemosely; *Mantle* - pseudoparenchymatous, 3-4 cells layered, 18.0-22.0 μ m in thickness, hyphae with simple septa, hyaline, thin-walled and branched.

Locality - Gidhni, Jhargram; *Altitude* - 125' m.s.l. (approx.); *Soil type* - red laterite to sandy loam, pH 6.0; *Vegetational community* - solitary, associated with sal roots.

June-August, 1982, M.H. No. M/31.

Russula albonigra (Krombh) Fr.,

Kew Bull. 20 : 226, Ind. J. Mycol. Res., 18(2) : 76-87

(Fig. 5)

Pileus - umbilicate, 4-7 cm in diameter, white - buff, becomes dark in age, glabrous, not hygrophanous, dry, very brittle; *Cuticle* - Not easy to separate, dry; *Margin* - regular, inrolled; *Gills* - 0.3 cm width, adnate, crowded, distinctly formed, not easy to separate, pliable, white at first but blackened at maturiry number of gills many, withour latex; *Stipe* - 3.0-4.0 x 0.8-1.0 cm, central, cylindrical, creamish white colour changed to black, solid, brittle, evolvate, exannulate; *Flesh* - white, blackened on cutting; *Spore-print* - white.

Basidiospores - globose, echinulate, apiculate, amyloid, 2.0-3.5 μ m in diameter; *Basidia* - clavate, tetrasterigmate, 22.3-25.4 μ m x 4.5-6.2 μ m thin-walled, hyaline; *Gill trama* -

heteromerous, hyphae without clamp connexion, irregular, upto 6.2 μm in diameter; *Pileus trama* - heteromerous with sphaerocyst, hyphae without clamp connexion; *Cystidia* - pleurocystidia lecythiform, thin-walled, hyaline, 25-35 μm long.

In FeSO_4 pink colour taken by all tissues; in H_2SO_4 grey colour taken by all tissues; in Melzer's reagent bluish tincture taken by pileus tissue only and all other chemicals showed negative reaction.

Mycorrhiza

Simple, borne racemosely; *mantle* - pseudoparenchymatous, yellowish, 6-7 cell layered, 24-28 μm thick, made up of branched thin-walled, unclamped hyphae.

Locality - Gidhni; *Altitude* 125' m.s.l.; *Soil type* - red laterite soil, pH 5.5; *Vegetational community* - solitary, associated with sal roots.

July 1982, M.H. No. M/43.

Russula pectinata (Bull) Fr.

(Fig. 6)

(= *R. consobrina* Fr. var. *sororia*) (Larb) Cke illus. No. 1024, t. 1101

Pileus - convex to reflexed at maturity, 5-8 cm diameter, yellowish white, glabrous, without scale, fleshy; *Cuticle* - peels easily, striate at the margin, dry; *Margin* - entire to slightly serrated; *Gills* - 2-4 cm long, 0.8 cm width at the middle, easily separable, latex absent, adnate, edge distinctly serrated, brittle, white to creamish white in colour; *Stipe* - 4.0-5.0 $\times$ 1.8-3.0 cm thick, equal, solid (mites make it hollow), white, central to slightly eccentric, exannulate, evolvate, brittle; *Flesh* - white, 0.5 cm thick; *Spore-print* - white.

All tissues turned in HNO_3 to lemon yellow colour, vinaceous buff in H_2SO_4 , rusty tawny in phenol and in Melzer's reagent red colour, other chemicals showed no reaction.

Basidiospore - globose to slightly subglobose, thick-walled, non-apiculate, echinulate, 7.9-8.0 μm in diameter, amyloid; *Basidia* - clavate, holobasidium, tetrasterigmate, 52.6 $\times$ 13.5 μm , sterigmata 3.0 μm ; *Cystidia* - 65.7 $\times$ 15.2 μm hyaline, thin-walled, notched neck and acute tipped; *Gill trama* - irregular, cell diameter 4.7-5.2 μm ; *Pileal trama* - oliferous hyphae present, pseudoparenchymatous, tissues surface made up of pigmented and slightly thick-walled cells.

Mycorrhiza

Simple, racemose; *mantle* - with tufts of loose hypha, clamp connexion not found, hypha branched, thin-walled, sometimes incrustated walled, 3.2-3.8 μm in diameter.

Locality - Gidhni; *Altitude* 125' m.s.l.; *Soil type* - red laterite soil, pH 5.5; *Vegetational community* - solitary, associated with sal roots.

July - August 1982, M.H. No. M/45.

Lactarius subdulcis (Pers. ex Fr.)

S. F. Gray; Kew Bull. 30; 617

(Fig. 7.)

Pileus - 3.5-5.0 cm diameter, convex, umbilicate depressed at the centre, rusty in immature, apricot at medium and orange to clay pink at maturity, cartilaginous, dry; *Cuticle* - dry, peels easily, smooth;; *Margin* - regular, entire, inrolled; *Gills* - adnate to subdecurrent, crowded, distinctly formed, separable, not interveined, brittle, 0.4 mm thick, 1.5-2.5 mm width, cream at first but salmon colour at maturity, edge entire, milky latex present, number of gill lengths 3; *Stipe* - 4.0 x 0.6 cm, central, cylindrical, hollow, cartilaginous, concolorous with pileus or light colour, dry, smooth, evolvate, exannulate, milky latex present; *Flesh* - 1.5 mm thick, cream in colour; *Spore-print* - white or creamish white.

In conc. HCl and HNO₃ no change observed; in H₂SO₄ context tissue becomes date brown; in KOH, Aniline water and FeSO₄ no change observed; in NH₄OH gill tissue showed no change but stipe and context tissue changed to smoke grey in colour; in phenol stipes context and gill tissue and gill tissue changed to chestnut in colour. All tissues react in Melzer's reagent and changed to red in colour.

Basidiospores - colour in mass white to cream, under microscope the spores are hyaline, spherical 8.2-9.3 μ m in diameter, slightly thick-walled, echinulate, apiculate and amyloid in nature; *Basidia* - tubular to subclavate, 24.4-26.0 μ m x 2.6-4.2 μ m, thin-walled, subhymenial origin, tetrasterigmate, sterigmata 3.9-5.2 μ m long; *Cystidia* - hyaline, thin-walled 62.0-68.0 μ m long; *Gill trama* - subregular to regular, more or less parallel type, mediastratum broad, consists of spherical to angular thin-walled cells, lateral stratum consists of thin-walled hyaline tubular cells upto 5.2 μ m diameter and simple septate, no sphaerocyst seen; *Pileus trama* - loosely arranged, consists of both spherical and tubular cells, hyaline, oliferous hyphae present, 4.2 - 6.3 μ m wide, sphaerocysts present.

Mycorrhiza

Simple, racemose, pale brown in colour; *Mantle* - broad, 47.2-52.0 μ m, sometimes tufts of hyphae present outside the epiblema, hyphae with simple septa, 4.0-5.2 μ m in diameter.

Locality - Jhargram; *Altitude* - 120' m.s.l.; *Soil type* - red laterite soil, pH 5.6; *Vegetational community* - gregarious or solitary, associated with *Shorea robusta* root.

July-August, 1982; M.H. No. M/40.

Amanitopsis vaginata (Bull.ex Fr.) Vitt.

Kew Bull. 16 (1) 65-73, Ind. Phytopath. 17 : 317-322, (= *Amanita vaginata*) Ind. J. Mycol. Res. 17(2) : 65-69, Botanique, 3 : 53-59.

(Fig. 8)

Pileus - 3.0-4.0 cm, umbilicate to flat, at maturity, white greyish at middle, without scale, smooth, polished, hygrophanous; *Cuticle* - peels easily, smooth, polished, moist; *Margin*-entire, regular and striated; *Gills* - lengths three, free, 1.8 cm long and 0.4 cm width, easily separable, not interveined, moderately formed, latex absent, white, edge entire, brittle; *Stipe* - 7.0-9.0 cm x 0.4-0.6 cm, white, central, equal with short bulbous base, moist, smooth solid, exannulate, volvate (volva deeply situated in the soil and very fragile); *Flesh*-white, 0.1 cm thick at the middle context; *Spore-print* - white.

Pileus - 3.0-4.0 cm, umbilicate to flat, at maturity, white greyish at middle, without scale,

smooth, polished, hygrophanous; *Cuticle* - peels easily, smooth, polished, moist; *Margin*-entire, regular and striated; *Gills* - lengths three, free, 1.8 cm long and 0.4 cm width, easily separable, not interveined, moderately formed, latex absent, white, edge entire, brittle; *Stipe* - 7.0-9.0 cm x 0.4-0.6 cm, white, central, equal with short bulbous base, moist, smooth solid, exannulate, volvate (volva deeply situated in the soil and very fragile); *Flesh*-white, 0.1 cm thick at the middle context; *Spore-print* - white.

Basidiospores - 7.0-9.2 μm , spherical to ovoid, thin and smooth walled, apiculate, hyaline inamyloid; *Basidia* - 25.0-28.0 μm x 7.0-9.0 μm , clavate to tubular, thin-walled, tetrasterigmate, sterigmata 3.2 μm long, holobasidia.

All tissues turned sulphur yellow colour in HCl; in Melzer's reagent all tissues except gill showed colour reaction; all tissues changed colour in FeSO_4 to olivaceous buff and in phenol to rust colour.

Mycorrhiza

Simple, borne racemosely, light brown in colour; *mantle*-pseudoparenchymatous, upto 26.0 μm thick, 5-6 cell layered, with seta-like structure present outside the mantle, tufts of loose hyphae also seen, hyphae thin-walled, septa simple 3.0-3.5 μm wide.

Locality - Jhargram, Gidhni and Kankrajhore; *Altitude* - 125' m.s.l. (approx.); *Soil type* - red laterite, pH 5.5; *Vegetational community* - solitary, associated with *Shorea robusta* roots.

July-August, 1981-84; M.H. No. M/34.

Porphyrellus malaccensis (Pat. & Baker) Singer.

Ind. J. Mycol. Res. 17(2) : 65-69 and 22(1) : 63-64.

(Fig. 9)

Pileus - 5.0-7.0 cm, aplanate to flat, grey to drab or olivaceous grey in colour, glabrous, fleshy to slightly leathery, slightly viscid; *Cuticle* - glabrous, easily separable, without scale; *Margin* - entire and regular; *Gills* - polyporaceous, sulphur yellow, buff to deep yellowish brown, pores large, angular-hexagonal, 0.3-0.5 cm in diameter, 1-1.5 cm width, easily separable; *Stipe* - 3.5-4.5 x 0.6 cm, central to slightly eccentric, concolorous with the pileus, solid, longitudinal ridges present, glabrous, base slightly bulbous, leathery, exannulate, evolvate; *Flesh* - dull yellow or cream white, 0.5 cm thick at the middle, become black on exposure; *Spore-print*-rusty tawny. *Basidiospores* - thick-walled, elliptical, 9.3-10.8 x 3.4-4.21 μm , smooth-walled, apiculate, inamyloid; *Basidia* - clavate to obclavate, 26.2-33.8 x 7.2-8.2 μm , tetrasterigmate, holobasidia, thin-walled; *Pleurocystidia* - hyaline, thin-walled, 66-72 μm long; *Pileal trama* - loosely arranged and consisted of branched hyaline, thin-walled hyphae, 4.2-5.8 μm in diameter; oliferous hyphae present; *Gill trama* - bilateral in arrangement.

In HNO_3 gill tissue turned brown colour, context and stipe tissue turned yellow colour; all tissues turned pink in NaOH and KOH and black in phenol and grey in FeSO_4 but context tissue only taken red colour in Melzer's reagent.

Mycorrhiza

Simple, racemosely borne; *mantle* - with loose tufts of hyphae; 3-5 cell layered and 15-18 μm thick and consisted of thin-walled, hyaline, simple septate hyphae of 3.3-4.2 μm in diameter.

Locality - Gidhni; *Altitude* - 125' m.s.l.; *Soil type* - red laterite soil, pH 5.5; *Vegetational community* - caespitose, associated with sal roots

July 1981, M.H. No. M/38.

Boletus piperatus (Bull. ex Fr.) Kuntze.

Rev. Gen. Pl. 3(2) : 535 (1898) (= *Suillus piperatus* [Bull. ex Fr.] Kuntze).

Kew Bull. 30 : 613.

(Fig. 10)

Pileus - convex to flat, sometimes depressed at the centre, 3.0-5.0 cm, sepia to hazel in colour, glabrous and polished, viscid when wet; *Cuticle* - peels easily, moist; *Margin* - entire and inrolled; *Hymenophore* - tubes yellow or buff to deep luteus, colour changes with maturity, subdecurrent, easily separable, pores unequal, angular mouthed, openings 0.2-0.5 mm and 3.0-5.0 mm long; *Stipe* - 3.0-5.0 cm x 0.5-0.8 cm, light yellow to fulvus colour with fine scales (brown), dry, cartilaginous, solid and slightly attenuated at the base; *Flesh* - lemon chrome, 1.5-2.5 mm thick; *Spore print* - brown. *Basidiospores* - brown, smooth and slightly thick-walled, elliptical, large, 8.2-10.0 x 3.2-4.2 μm , inamyloid, apiculate; *Basidia* - clavate, 22.0-39.0 x 8.0-9.2 μm , hyaline, thin-walled, tetrasterigmate, holobasidium; *Gill trama* - bilateral type; hyphae - 4.2-5.3 μm broad with simple septa.

All tissues turned to pink colour in Melzer's reagent; in H_2SO_4 all tissues turned to apricot colour; in phenol only gill tissue changed to pink colour, in other chemicals no colour reaction have been observed.

Mycorrhiza

Simple, racemose, brown, tufts of loose hyphae present outside the mantle; *mantle* - brown, pseudoparenchymatous, 6-9 cell layered and 25.0-36.9 μm in thickness; *Hyphae* - thin-walled, hyaline, branched with simple septa and 3.3-4.2 μm in diameter.

Locality - Balibhasa sal forest; *Altitude* - 120' m.s.l.; *Soil type* - black loamy, pH 6.0; *Vegetational community* - solitary and associated with *Shorea robusta* roots. July, 1982; M.H. No. M/37.

Pulveroboletus shoreae Sing and Singh

Bakshi - Project Report P.L. 480; Indian Forester, 92 : 512-13

(Fig. 11)

Pileus - 4.0-6.0 cm in diameter, convex to flat, fleshy, glabrous, reticulately pitted date brown to yellowish orange in colour; *Cuticle* - viscid when wet and peels easily; *Margin* - inrolled and entire; *Hymenophore* lemon-chrome to light yellow or Sienna colour, 3-4 mm

long, free, easily separable, 0.4-0.5 mm in diameter; *Stipe* - 4.0-6.0 x 0.6-0.8 cm, brown - yellowish brown to orange rufus, minutely scaly, dry, solid, slightly eccentric, subequal, cartilaginous; *Flesh* - lemon chrome, changed into dark colour on exposure, 0.5 cm thick; *Spore-print* - brown.

In NaOH, KOH and NH₄OH gill, context and stipe tissues changed to deep brown colour, other chemicals showed no colour change.

Basidiospore - 7.8-8.3 x 4.2-5.3 μ m, thick, smooth-walled, fusiform, inamyloid non-apiculate; *Basidia* - clavate, 18.2-25.3 x 7.8-8.3 μ m, tetrasterigmate, thin-walled, holobasidia; *Cystidia* - 28.2-39.4 x 8.3-9.2 μ m, fusiform; *Gill trama* - bilateral type, hyphae thin-walled with simple septa, 2.2-4.2 μ m broad.

Mycorrhiza

Simple, racemose, brown; *mantle* - brown, pseudoparenchymatous, sometimes tufts of hyphae present, 5-7 cell layered, 18-22.2 μ m thick, hyphae thin-walled and branched with simple septa, 2.5-4.2 μ m in diameter.

Locality - Balibhasa; *Altitude* - 120' m.s.l.; *Soil type* - black loamy soil, pH 6.0; *Vegetational community* - solitary, associated with *Shorea robusta* roots.

July-August, 1981; M.H. No. M/39.

Astraeus hygrometricus (Pers.) Morg.

Jour. Cinn. Nat. Hist., 1219 : 1889-1890.

= *Geaster hygrometricus* Ind. J. Mycol. Res. 14(1 & 2) : 19-29.

(Fig. 12)

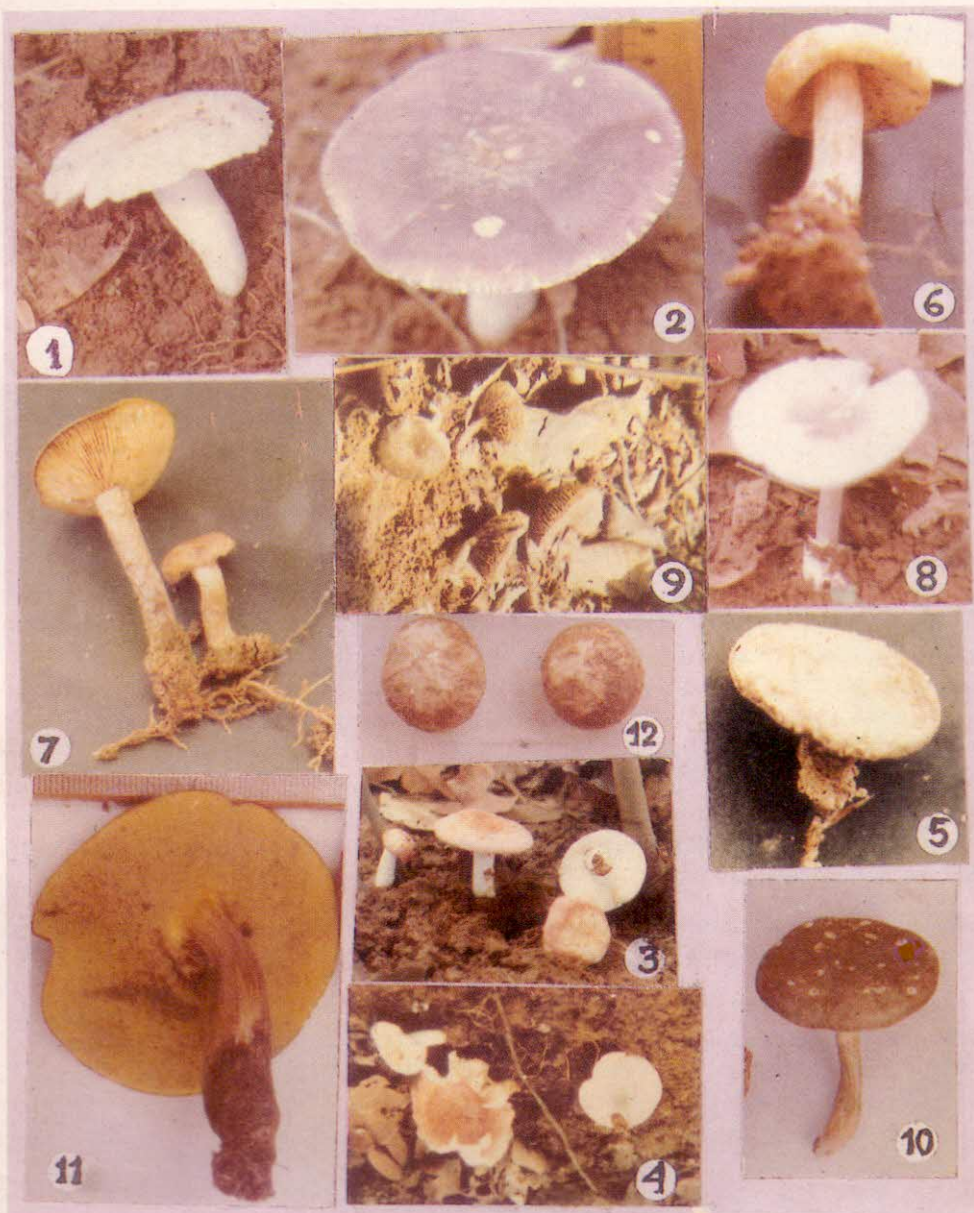
Sporophores - sessile, subglobose to tuberiform, hard, 1.0-2.0 cm in diameter; *Peridium*-white, 1.5-2.0 mm thick on side and 3.5 mm at the base, three layered, hard and hygroscopic, splits into 6-9 radiating arms; *Gleba* - sessile, white when young, dark brown at maturity, globose, 1.8 cm in diameter, dehiscence by irregular apical slit; *Rhizomorph* - hyphae thick-walled, clamped, branched 3.8-4.2 mm wide; *Basidiospores* - yellowish brown to brown, spherical to slightly ovoid, thick-walled, highly echinulate, inamyloid, 8.3-9.8 μ m in diameter; *Basidia* - clavate, 17.25 - 33.81 x 10.32 - 11.43 μ m; *Hyphae* - hyaline, yellowish in microscope, thick-walled, branched, septa with distinct clamp connexions, 3.8-4.2 μ m broad;

Mycorrhiza

Simple, racemosely borne, smooth; *mantle* - buff colour, pseudoparenchymatous, 8-10 celled; 25-33 μ m thick; *Hyphae* - slightly thick-walled, branched, clamped, 2.2-4.2 μ m in diameter.

Locality - Gidhni, Jhargram and Balibhasa sal forest; *Altitude* - 120' m.s.l. (approx.); *Soil type* - red laterite to sandy loam, pH 5.5 to 6.0; *Vegetational community* - solitary, rhizomorph associated with *Shorea robusta* roots.

August, 1981; M.H. No. A43.



Figs. 1-12. Photographs of the ectomycorrhizal fungi of *S. robusta* : Fig. 1. *Russula delica* (x0.8) ; Fig. 2. *R. cyanoxantha* (x0.4) ; Fig. 3. *R. vesca* (x0.15) ; Fig. 4. *R. lepida* (x0.3) ; Fig. 5. *R. albonigra* (x0.5) ; Fig. 6. *R. pectinata* (x0.8) ; Fig. 7. *Lactarius subdulcis* (x0.8) ; Fig. 8. *Amanitopsis vaginata* (x0.4) ; Fig. 9. *Porphyrellus malaccensis* (x0.2) ; Fig. 10. *Boletus piperatus* (x0.8) ; Fig. 11. *Pulveroboletus shoreae* (x0.8) ; Fig. 12. *Astraeus hygrometricus* (x1).

DISCUSSION

In this study of ectomycorrhizal mushrooms of West Midnapore (West Bengal), some characteristic features have been found.

The predominant genera among the common mycorrhiza forming fungi of sal forests of West Midnapore division are *Russula*, *Lactarius*, *Amanita*, *Boletus* etc. The species of *Russula* appear from the very beginning of the rainy season (June) and flourished till September. *Russula lepida* appears at the first shower, then *R. pectinata* and *R. delica* on the subsequent rains. *R. cyanoxantha* occurs only when continuous rain is prevailing and low temperature persists for a few days. The genus *Russula* of the family Russulaceae have 275 fully known species (Singer, 1975) which are distributed throughout the world. Uptil-nopw only 12 species have been recorded in India. These are *Russula delica* Fr. (Bakshi, 1974), *R. alutacea* Fr. (Berkely, 1876; Saccardo, 1887), *R. cinnabarina* Hook.f. (Mundkar, 1938), *R. emetica* (Saccardo, 1887; Berkely, 1844-1856), *R. furcata* (Berkely, 1844-1856; Saccardo, 1887), *R. lepida* Fr. (Ramkrishnan and Subramaniam., 1951), *R. rosacea* Fr. (Butler and Bisby, 1931), *R. foetens* (Pess) Fr. (Saini and Atri, 1881), *R. heterophylla* (Fr.) Fr. (Roy, 1981), *R. albonigra* (Krombh) Fr. *R. heterophylla* (Fr.) Fr. (Roy, 1981), *R. albonigra* (Krombh) Fr. (Roy and Samajpati, 1980), *R. parazuera* J. Schoeff (Roy and Samajpati, 1980), *R. sanguinea* (Roy and Samajpati, 1974). The most species of *Russula* form mycorrhiza with conifers and sal (Bakshi, 1974). Most of the species of *Russula* are used as food by local people of Midnapore and named as "Murgi Chhatu". It is also evident from the present study that *Russula vesca*, *R. cyanoxantha* and *R. pectinata* are taxonomically new report from India.

Lactarius belongs to the same family Russulaceae and consisting of 86 species (Singer, 1975) distributed throughout the world. In India, 7 species of *Lactarius* is reported uptil-now. *Lactarius scrobiculatus* (Scop-ex-Fr.) is reported as mycorrhiza forming species with Spruce and Fur (Bakshi, 1974). *L. deliciosus* (L. ex. Fr.) S. F. Gray was recorded to form mycorrhiza with *Pinus* by Dennis (1964). *L. stramineus* Berk. (Berkely, 1844-1856), *L. princeps* Berk. (Saccardo, 1856; Berkely, 1844-1856), *L. subdulcis* (Bull.) Fr. (Saccardo, 1856), *L. vallereus* (Saccardo, 1887, Berkely, 1844-1856), are more common among the Indian reported species. *Lactarius subdulcis* is a new report from Bengal. It is important to note that it grows at an early shower with *Russula lepida* and only found when there is continuous and prolonged rain.

Amanitopsis vaginata is locally called as "Rakhal Chhatu". *Amanitopsis vaginata* was found to grow at the first shower and very common in occurrence.

The genus *Boletus* of the family Boletaceae, generally occurs in very late shower and due to slow growth it persists for a long time. Among the Indian reported species, four species of *Boletus* have been found to form mycorrhiza with sal (Bakshi, 1974). *B. piperatus* (= *Suillus piperatus*) (Bull. ex Fr.) Kruntz. was found to form mycorrhiza with *Pinus* roots. *B. piperatus* is a new report from India both taxonomically and as a mycorrhiza forming fungus on sal.

Porphyrellus, a genus under Strobilomycetaceae consists of 17 species (Singer, 1975). The only species *Porphyrellus malaccensis* (Pat and Beker) Singer was taxonomically described and reported from India for the first time by Roy and Samajpati (1979). It is described here as a mycorrhiza forming fungus with sal roots and found to grow along with

Boletus during the month of August-September. One of the species described here as mycorrhiza.

Pulveroboletus shoreae Sing and Singh was reported as a mycorrhizal fungus on sal roots by Bakshi (1974) also found in this district very rarely in a specific conditions.

Astraeus belongs to the family *Astreaceae* has popularly named by the local people as "Bhuin Chhatu" flourished generally in the month of August and September profusely. *Astraeus hygrometricus* is highly edible and strictly mycorrhizal fungus. This fungus was taxonomically reported from Bengal by Roy and Samajpati (1976). Here the mycorrhiza type with sal roots is discussed.

The above findings clearly reaffirms the ectotrophic mycorrhizal association type of *Shorea robusta* G.f. as previously observed by Becker (1983), Bakshi (1974), Hung (1979), and it leads to a conclusion that *Shorea robusta* like *Eucalyptus*, *Pinus* and other conifers, also possess a wide range of fungi with which the host species enter into the mycorrhizal symbiosis. It also appears from the above study that there is a definite sequence of occurring of different species of mushrooms on forest beds. This might be due to different optimum temperature, humidity and pH of the substratum required for cropping of the individual species. As such rain plays an important role in this regard as it could manipulate all the three factors.

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(Accepted for publication 6 May 1995)