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## Ectomycorrhizal mushrooms of Central India-I. *Russula*

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The paper dealt with the description of 24 ectomycorrhizal mushroom species of Central India, belonging to *Russula* found to be ectomycorrhizal with sal (*Shorea robusta*). Their morphological and anatomical characters were described from the fresh materials.

**Key words :** Ectomycorrhizal mushrooms, Central India, *Russula*

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### INTRODUCTION

The genus *Russula* (Russulaceae) is a large group of colorful gilled mushrooms including some very beautiful and interesting species, some good edibles, and a lot of hard-to-distinguish species. About 20 or 30 species can be identified fairly easily but there are perhaps 750 species worldwide. *Russula* is a brittle-fleshed, gilled mushroom with a central stem, without a universal veil and, except in a few tropical species, without a partial veil. The spore color varies from pure white to yellow to a deep salmon or ochre. The stipe is most commonly white, but may have a surface tint of red or purple in some species, or may stain yellowish or brownish on handling, and may turn shay gray or black in others. The flesh is normally white, but in some species discolors to red, brown or black when injured or aged.

It has been reported that *Russula* forms ectomycorrhizal associations with several host tree species including *Shorea*, *Pinus*, *Vateria* and *Dipterocarpus* (Lee *et al.*, 1997; Riviere *et al.*, 2007) but fewer reports from India. This may be a reflection of the lack of collectors, although where studies have been carried out, the genus appears to be widespread. Within India, *Russula* is predominantly found in dipterocarp forests particularly in Eastern Himalayas, Western Ghats and Central India (Rajak *et al.* 2002; Rahi, 2001; Shukla, 2001; Natarajan *et al.*, 2005; Natarajan and Ravindran, 2003; Pande *et al.*, 2004). It is considered to be culinary delicacy

and has a high market value in local tribla markets. The lack of a current revision of *Russula* species, coupled with their ability to form ectomycorrhizal associations and their importance as a source of food for local people, initiated the present study.

### MATERIALS AND METHODS

Specimens of ectomycorrhizal mushroom *Russula* were collected from various districts of Madhya Pradesh and Chhattisgarh and brought to the local laboratory for processing, Microscopic examinations were made on lactophenol cotton blue mounts of gills using Nikon Eclipse E800 microscope at varying magnifications and microphotographs were taken with Nikon H-II camera attached to the microscope. Descriptions recorded were organized in worksheets, or computer formats for field descriptions. After macroscopic and microscopic studies, the edible ECM specimens were keyed out to their respective families, genera and species level. Air dried samples were deposited in Mycological Research Laboratory, Department of Biological Sciences, R. D. University, Jabalpur, Authoritative monographs, papers and books were consulted/referred for correct identification. Literature consulted includes: Singer, (1986); Purkayasha and Chandra, (1985); Wilkinson and Buczaki, (1982); Findlay, (1977); Fluck, (2002); Jordan, (1999); Rayner, (1979); Mancinelli and Mancinelli, (1974); Lincoff, (1981) and Keizer, (1998). Literature reviewed showed 3 new reports for India (Bilgrami *et al.* 1991 Jamaluddin *et al.* 2003).

## OBSERVATIONS

The taxonomy of ectomycorrhizal mushrooms of *Russula* that were encountered during this investigation are as under :

***Russula aeruginea* Fr.**

*Pileus* globose but soon plane 4-5 cm in diameter when young and extends up to 10 cm at maturity, depressed in the centre, olive green-gray to greenish with yellowish to brownish tinge; centre brownish, faded in the margin, sometimes speckled with rusty spots, margin irregular radially veined, cuticle smooth, slightly viscid separable almost up to the centre fleshy, fragile. *Stipe* sometimes somewhat thick and unequal, white then spotted with brown, starting from base 5-10.5 cm long and 2.5-4 cm thick firm, equal, central *Flesh* white, tending to become cinerous, fragile. *Gills* first close and then somewhat apart, bifid slightly decurrent, cream- yellowish with few brownish spots, *Spores* globose-subglobose broadly elliptical, deep cream- yellowish with few brownish spots. *Spores* globose-subglobose broadly elliptical, deep cream colored in mass, shortly warty, spiny 7.5-8×6 µm. *Basidia* 36-40×16-20 µm, clavate, 4-spored, sterigmata up to 3-5 µm, long. *Cystidia* 42-60×14-16 µm, sub clavate, hyaline. *Hyphae* septate, interwoven, hyaline. *Hymenophoral trama* tetramerous hypha intermixed with nests of sphaecocyst. *Habit & Habitat*: terrestrial, solitary. *Ecology*: grow under sal forest, *Edibility*: locally edible. *Accession Number*: FGCCR 2001. *Place of collection*: Chada, Jagatpur, *Distribution*: New report from India, (Fig: 1a).

***Russula brevipes* Peck., 43<sup>rd</sup> Rep. N. Y. Mus. p.20, (1890)**

*Pileus* up to 15 cm broad at first depressed at the centre, then broadly infundibuliform, white or buff, sometimes clay coloured, brownish with age, surface dry, margin incurved, not striate. *Gills* close, sometimes crowded with lamellae of different lengths, decurrent narrow, occasionally forked towards the stipe, white to yellow at first often with clay coloured spots. *Stipe* up to 8.0 cm long, even or tapering downwards whitish or brownish, round, solid, sometimes hollow. *Flesh* white sometimes brown, hard, brittle. *Hymenophoral Trama* heteromerous made of

septate and branched hyphae mixed with sphaerocysts. *Basidia* 4-spored, claviform, fusiform. *Spores* broadly elliptical, sometimes ovate or sub globose. *Pleurocystidia* varying in shape, clavate, fusiform or clavate, sometimes rounded or somewhat acute, straight or curved. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 1001. *Place of collection*: Achanakmar, Amarkantak, Jagatpur, Karanjia. *Distribution*: Garhwal, U.P. (Bhatt *et al.* 1995), Gulmarg Forest, Jammu and Kashmir (Abraham *et al.*, 1980; Watling and Gregory, 1980), Dalhousie, Himachal Pradesh (Atri *et al.* 1991), Bastar, Chhattisgarh (Rajak *et al.*, 2003), (Fig. 1b).

***Russula cyanoxantha* (Schaeff. Schew) Fr., Hyman. Eur. ed. 2, p. 446, (1871)**

*Pileus* 5 cm when young and extend up to 10 cm on full maturity, initially globose then convex and finally depressed in the centre, margin regular to slightly incised, fleshy, firm, viscid when wet, surface covered with radial and anastomosing veins, flesh white, cuticle not easily peeling. *Gills* white, equal, adnate to sub-decurrent, close with entire edges, flexible, crowded. *Stipe* 2-10 cm long and 3 cm thick, central, usually white with a purplish hue, firm at first, solid, then spongy and hollow. *Flesh* usually white, pink just beneath the cuticle, solid, granular. *Spores* 7-8.5×7 µm, white broadly ellipsoidal to sub-globose, warty. *Basidia* 50-46×8-10 µm, 4-spored, clavate, sterigmata, up to 6.0 µm long. *Dermatocystidia* present, narrow and short, 25-46×4-6 µm, clavate, hyaline. *Pileus trama* heteromerous, hyphae interwoven. *Hymenophoral trama* heteromerous, hyphae interwoven, hyaline, hyphae 4-6 µm, hyphae with clamp connections. *Habit & Habitat*: terrestrial, solitary or in groups. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 1001. *Place of collection*: Mawai, Chada, Mandha, Achanakmar, *Distribution*: Shimla, Himachal Pradesh (Saini and Atri, 1984), Joshimath, Uttar Pradesh (Atri and Saini, 1990), Dalhousie, West Bengal (Atri *et al.*, 1991), Chakrata, Uttar Pradesh (Atri and Saini, 1986, 1990), Narkanda, Himachal Pradesh (Saini *et al.*, 1993), Jagdalpur and Bastar-Chhattisgarh, Mandla-Madhya Pradesh, (Rajak *et al.*, 2003), Fig.1c.



Fig. 1 : Sporocarps of ECM Mushrooms-Russula  
a. *Russula aeruginea*, b. *R. brevipes*, c. *R. Cyanoxantha*,  
d. *R. decolorans*, e. *R. delica*, f. *R. densifolia*.

***Russula decolorans*** Fr., *Epicr. Syst. Mycol.* p. 361, (1838)

*Pileus* 2-6 cm in diam, convex-plane or slightly depressed, surface smooth, viscid when moist, red or pink mixed with cream, margin striate, flesh white, *Gills* adnate- adnexed, soft, edges entire, close, creamy, white to yellowish. *Stipe* 3-6 cm long, 1.0-1.5 cm wide, equal to clavate, solid, firm, creamish white to yellowish. *Stipe* 3-6 cm long, 1.0-1.5 cm wide, equal to clavate, solid, firm, creamish white or cream. *Spores* 6-8×4-6 µm, ellipsoid to globose, whitish, warty, *Basidia* 35-45×8-10 µm, cylindrical, tapering downwards, 4- shaped, sterigmata, up to 4 µm, hyaline. *Pleurocystidia* 40-45×8-10 µm, clavate, hyaline. *Hymenophoral Trama* heteromerous, hyaline, consists of nests of sphaerocysts, septate, 4-6 µm, thick, hyaline. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 1003

*Place of collection*: Motinala, Pandutala, Mawai. *Distribution* : Bastar, Chhattisgarh (Rajak *et al.* 2003), Fig. 1.d.

***Russula delica*** Fr., *Epicr. Syst. Mycol.* p. 350, (1838)

*Pileus* extends up to 12 cm on full maturity, convex, cyathiform, sometimes infundibuliform, dull white, surface dry, sometimes with rust coloured patches, dry with unchanging white flesh, margin inrolled, not striated, cuticle not separable. *Odour* agreeable. *Gills* whitish, short, decurrent, some are forked with intermixed lamellulae, edges entire. *Stipe* 5-6 cm long, 0.7-1.0 cm wide, central, dry, cylindrical sometimes attenuated at the base, surface glabrous or slightly hairy. *Flesh* white, firm, no change on injury, having a distinct smell of fish of meat. *Spores* 8-12×7-9 µm, covered with conical warts, whitish. *Basidia* 35-40 x 8-10 µm, subcylindrical, tapering downwards, 4-spored, sterigmata up to 4µm, hyaline. *Cystidia* 30-35×5-7 µm, clavate to cylindrical with broad base, hyaline. *Hyphae* thick, septate, 4-6µm, hyaline. *Habit & Habitat* : terrestrial, solitary to scattered. *Ecology* : ECM with *Shorea robusta* (sal). *Edibility* : edible, very popular among tribals. *Accession Number* : FGCCR 3001. *Place of collection*: Chada, Mandha,

Amarkantak. *Distribution*: Solan, Himachal Pradesh (Kumar *et al.*, 1979). Sonamarg, Jammu and Kashmir (Saini *et al.*, 1988), Raigarh, Madhya Pradesh (Rajak *et al.*, 2003), Fig. 1e.

***Russula densifolia*** (Secr.) Gillet, *Champ Fr.* 1:231, (1874)

*Pileus* 3-5 cm when young and up to 10 cm in diameter on full maturity, at first convex, then depressed at the centre, cyathiform or sometimes infundibuliform whitish with dull brown centre, occasionally dull brown throughout or blackish, fleshy, surface moist and viscid margin non-striated, incurved, and irregular with yellowish- cream to dull white flesh, firm, soft, smooth, cuticle separable. *Gills* whitish or creamish; sub-decurrent to decurrent, crowded, smooth, margin entire, dull colour on bruising, more or less narrow. *Stipe* 5-6 cm long, and 1.5-3 cm broad, central, solid, glabrous, dry, white, becomes red or dark, grey or grey on cut. *Spores* 8-10×6-7 µm, obvate, covered with warts, apiculate, spore print whitish. *Basidia* 35-40×10-12 µm, clavate, 4-spored, sterigmata, up to 3-4 µm, long. *Cystidia* 45-60×12-15 µm, clavate to cylindrical. *Hyphae* hyaline, septate, up to 4-6 µm, thick. *Hymenophoral trama* with heteromerous hyphae, intermixed, septate hyphae, 4-6 µm thick. *Habit & Habitat*: terrestrial, solitary or in groups. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 2002. *Place of collection*: Mawai, Chada, Baiyar. *Distribution*: Ambikapur, Chhattisgarh (Rajak *et al.*, 2003), Fig.: 1f.

***Russula emetica*** (Schaeff. ex Fr.) S. F. Gray, *Epicr. Syst. Mycol.* p. 357 (1838)

*Pileus* 3-4 cm when young and upto 11 cm on full maturity, red, yellowish or whitish, convex to campanulate when young, then expanded depressed when old with radial grooves in the older specimens, surface smooth and shining, slightly sticky when young, margins marked with streaks, cuticle easily peeled off. *Gills* equal, white, broad, thick, sparse in some forms and closer in other forms, free or almost free from the stem or adnate or adnexed, white, often with yellowish shades. *Stipe* thick, hard, central, smooth, white, cylindrical, narrowed near the top, 4.0-5.0×1.0-2.0 cm, thick, solid, becoming

somewhat hollow. *Flesh* brittle, usually white, slightly reddish beneath the cuticle. *Spores* white, echinulate, 7.5-10.0  $\mu\text{m}$ , globose. *Basidia* 40-45 $\times$ 10-12  $\mu\text{m}$ , clavate, sterigmata up to 1-2  $\mu\text{m}$ , long. *Cystidia* 40-45 $\times$ 12-14  $\mu\text{m}$ , clavate, tapering towards base. *Hymenophoral trama* heteromerous, hyphae septate, hyaline. *Habit & Habitat*: terrestrial, solitary. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 3002. *Place of collection*: Chada, Mandha, Mawai, Jagatpur, Pandutala, Motinala, Chilpi, Achanakmar, Baiyar. *Distribution*: Chakrata, Uttar Pradesh (Saini and Atri, 1989a), Darjeeling, West Bengal (Berkeley, 1856), Solan, Himachal Pradesh (Kumar *et al.*, 1979), Mandla, Madhya Pradesh (Rajak *et al.*, 2003), Fig.: 2a.

***Russula foetens*** (Pers. ex Fr.) Fr. *Epicr. Syst. Mycol.* p. 359, (1838)

*Pileus* 2-3 cm when young and upto 5 cm across, dull brownish ochre to honey-colored, globose at first, later convex and depressed at the centre of flesh, thick, firm, fleshy, surface smooth, slimy or glutinous when moist, margins furrowed and warty, later absent. *Stipe* 5-8 $\times$ 1-1.5 cm wide, central, glabrous, whitish to buff marked with brownish starting at base, cylindrical or swollen in the middle, solid containing irregular cavities, hard and rigid but easily breaking. *Flesh* whitish turning brown when exposed to air. *Gills* white, then cream-colored with reddish brown markings, unequal large some forked, young specimens produce watery droplets in damp weather, sub-decurrent-decurrent, crowded, margin wavy. *Basidia* 30-4 $\times$ 8-12  $\mu\text{m}$ , clavate, hyaline, 4-spored. *Sterigmata* 1-2  $\mu\text{m}$ , long. *Cystidia* 35-60 $\times$ 8-10  $\mu\text{m}$  cylindrical, narrow at the tip. *Hymenophoral trama* heteromerous, hyphae septate, intermixed with nests of spæocysts. *Hyphae* hyaline septate, 4-6  $\mu\text{m}$ , thick. *Dermatocystidia* frequently present, cylindrical, appendiculate. *Spores* pale cream-colored, ovoid, sub-globose to globose, thick, conical or oblate warty, 7.5-10 $\times$ 6-9  $\mu\text{m}$ . *Habitat*: in groups on wet grounds. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: inedible because of flavour. *Accession Number*: FGCCR 2003. *Place of collection*: Mawai, Sijhaura. *Distribution*: Shimla, Himachal Pradesh (Saini and Atri, 1989a), Raipur, Chhattisgarh (Rajak *et al.*, 2003), Fig.: 2b.

***Russula fragilis*** (Pers.) Fr.

*Pileus* 2-6 cm in diameter, usually pinkish, purplish or violet tinted, small, delicate and fragile as if faded pink colour, cuticle, moist, separable, sunken initially then depressed, margin radially sulcate, inrolled. *Stipe* 2.5-6.0 $\times$ 0.5-1.5 cm., white, tends to be yellowish without any trace of red, more or less cylindrical to slightly club-shaped. *Gills* white to very pale cream, close then sparse, thin, fragile. *Spores* white, sub-globose, ornamented, 8.0-10.0 $\times$ 6.5-8.5  $\mu\text{m}$ . *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: form ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 3003. *Place of collection*: Mandha, Chada, Gopalpur. *Distribution*: Shimla, Himachal Pradesh (Saini and Atri, 1989), Fig.: 2c.

***Russula integra*** (L.) Fr.

*Pileus* 5-15 cm in diameter, smooth, soon concave with sulcate and undulate margin, cuticle separable, viscid in humid weather, color basically brown but tendency to yellowish, amaranth, violet, or purple, never red or orange. *Stipe* long thick, white, smooth, 3-5 $\times$ 1-1.5 cm cylindrical solid, Glabrous. *Gills* yellow, close, broad, thick sometimes bifurcate not always adhering to the stem, white then yellowish. *Flesh* firm, soft, white then yellowish. *Spores* echinulate, globose to subglobose. *Basidia* clavate, hyaline, 4-spored, sterigmata upto 3-4.5  $\mu\text{m}$ . *Cystidia* cylindrical-clavate, hyaline. *Hyphae* interwoven, hyaline, septate, 4-6  $\mu\text{m}$ , thick. *Habit & Habitat*: terrestrial, gregarious / scattered. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible only by tribals. *Accession Number*: FGCCR 3004. *Place of collection*: Motinala, Pandutala, Chilpi Ghati. *Distribution*: New report for India, Fig.: 2d.

***Russula lepida*** Fr., *Epicrisis Syst. Mycol.* p. 355, (1851)

*Pileus* 2-3 cm when young extend up to 10 cm on full maturity, firm soft, smooth, flesh white, red to pale red, margin inrolled, margin incised or cracked. *Gills* white to cream, sub-decurrent; to free, unequal, soft edges smooth, close to crowded. *Stipes* 6-8 cm long, 1-1.5 cm wide, cylindrical, glabrous, white with abrupt base. *Spores* 6-8  $\mu\text{m}$ , subglobose-globose, apiculate, warty. *Basidia* 36-



Fig. 2 : Sporocarps of ECM Mushrooms-Russula.  
a. *Russula emetica*, b. *R. foetens*, c. *R. Fragilis*,  
d. *R. integra*, e. *R. lepida*, f. *R. lutea*.

38×6-8 µm, 4-spored, clavate. *Pleurocystidia* not observed. *Hyphae* septate, 3.5-4 µm thick. *Hymenophoral trama* heteromerous, regular, hyphae septate, hyaline, hyphae parallelly arranged 3.5-4 µm thick. *Dermatocystidia* present, cylindrical, fusiiform or often clavate. *Habit & Habitat*: terrestrial, solitary or in groups. *Ecology*: ECM with *Shorea robusta* (sal), *Edibility*: edible only among tribals. *Accession Number*: FGCCR 2004. *Place of collection*: Gorakhpur, Gopalpur, Chada. *Distribution*: Darjeeling, West Bengal (Berkeley, 1856), Kodaikanal, Tamil Nadu (Ramakrishnan *et al.*, 1952), Shimla, Himachal Pradesh (Kumar *et al.*, 1979), Seoni, Madhya Pradesh (Rajak *et al.*, 2003), Fig.: 2e.

***Russula lutea*** (Huds. : Fr.) Fr.

*Pileus* globular, then convex finally plane 4-9 cm or also depressed, margin thin, almost always with radial striate and thin with knotty grooves, cuticle viscid not easily separable from the cap, uniformly ochre more or less intense. Stem-generally thick, pallid, and then yellowish, then starting from the base, it becomes ochraceous. *Flesh* cream, then ocher. *Gills* close also in the ripe mushroom, thin pointed towards the stem, rounded towards the cap's margin, with some dewy droplets hanging from the edges, white then acquiring slowly the colour of the cap. *Spores* white or tending to cream. *Habit & Habitat*: solitary or gregarious. *Ecology*: ECM with Sal. *Edibility*: non edible, *Accession Number*: FGCCR 1004. *Place of collection*: Karanjia, Jagatpur, Saraigaun. *Distribution*: New report for India, Fig.: 2f.

***Russula nigricans*** (Bull : Fr.) Fr.

*Pileus* 10-20 cm across, dirty white becoming brown and finally black developing deep depression and funnel shaped, dry, margin incurved at first, margin thick, smooth. *Gills* straw to olive, grayish rose on bruishing, eventually turning black, adnate, very thick and widely spaced remaining white longer than the rest of cap cuticle, dry slightly velvety in dry weather. *Stipe* 3-8 cm × 1-4 cm at first white then dull brown and finally black, hard. *Flesh* white becoming graying rose on exposure to air and finally grey to black. *Spores* white 6-8×6-7 µm, ornamentation. *Habit & Habitat*: solitary or gregarious. *Ecology*: grows under Sal. *Edibility*: non edible, *Accession Number*: FGCCR 3005, *Place of collection*: Chada, Bajak,

Gopalpur, *Distribution*: Jammu and Kashmir (Saini *et al.*, 1988), Fig.: 3a.

***Russula nigriinitiales*** Rahi, Shukla, Rajak and Pandey, *Indian J. Mush.* XXI (1&2): 29-31.

*Pileus* upto 10 cm at maturity and 2-3 cm when young; depressed in centre, flesh soft, smooth, dry, margin entire, black-dark black, flesh gray-blackish. *Gills* adnate to decurrent, creamish-grayish-blackish, soft, edges entire, crowded. *Stipe* 6×1.5 cm, solid, cylindrical-clavate, tapering downwards, central, glabrous, Grayish-black. *Spores* whitish, 6-8×4-6 µm, spherical, apiculate, *Basidia* granulate, hyaline, clavate, 4-spored, sterigmata up to 4 µm long. *Pleurocystidia* cylindrical-subclavate. *Cheilocystidia* ventricose-sylindrical. *Hymenophoral trama* heteromerous, hyphae intermixed with spherocyst. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: grows under Sal. *Edibility*: edible. *Accession Number*: FGCCR 1005, *Place of collection*: Chada, Mawai, Pandutala. *Distribution*: Mandla-Madhya Pradesh, Bastar-Chhattisgarh (Rajak *et al.* 2003), Fig.: 3b.

***Russula romelli*** Maire

*Pileus* 7-20 cm diam., it reaches a large size of 20 cm, red, tending to violet along the margin and greenish yellow towards the centre, margin striate and then sulcate, cuticle smooth, viscid in humid weather, easily separable underneath surface clear white, brittle leathery usually cracks from middle. *Gills* broad, brittle bifurcate, white then yellowish. *Stipe* long, thick, white, smooth, then slightly rugose and with brownish shades 5-10×2.5-4 µm thick firm, equal central. *Spores* 8-10×6-10 µm, whitish globose to subglobose, some elliptical warted. *Cystidia* subclavate, hyaline. *Hyphae* septate, interwoven. *Habit & Habitat*: terrestrial, scattered, gregarious. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible only among tribals. *Accession Number*: FGCCR 3006. *Place of collection*: Mandla. *Distribution*: Chakrata, Uttar Pradesh (Saini and Atri, 1989a), Fig.: 3c.

***Russula rosea*** Quel., *Ench. Fung.* p. 184, (1886)

*Pileus* 8-10 cm in diameter, first convex then sunken in the centre, pink to pale dark red, surface smooth, moist with incurved margin, at maturity it is funnel



**Fig. 3 :** Sporocarps of ECM Mushrooms-Russula.  
a. *Russula nigricans*, b. *R. nigritiales*, c. *R. romelli*,  
d. *R. rosea*, e. *R. rubescens*, f. *R. sanguinea*.



shaped, flesh reddish under cuticle. *Stipe* 7-8×1.0-1.5 cm wide, cylindrical, solid, central, glabrous, white to cream, sub-globular base. *Gills* adnexed to adnate, creamy white to yellowish white, unchanging when bruised, edges entire. *Spores* 6-7×4-5 μm, short, ellipsoid, yellowish white, warty, apiculate. *Basidia* 30-34×7-9 μm, clavate, 4-spored, sterigmata 3-6 μm long. *Pleurocystidia* 36-38×6-9 μm, clavate or sub-cylindric. *Hymenophoral Trama* heteromerous, septate hyphae. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal.) *Edibility*: Edible, very popular among tribals. *Accession Number*: FGCCR 1006. *Place of collection*: Chada, Mawai, Gopalpur, *Distribution*: Jagdalpur, Chhattisgarh (Rajak et al., 2003), Fig.: 3d.

#### ***Russula rubescens*** Beardslee

*Pileus* 2-5 cm in diam, when young and extend upto 10 cm on full maturity, firm red, paler towards margin, fading with age, flesh white, slightly depressed, margin striate surface smooth, *Gills* adnate, close, white, forked, edges entire, close. *Stipe* 3-5×1-1.5 cm, glabrous, white, cylindrical. *Spore* 8-10×6-8 μm, whitish globose, verrucose to echinulate. *Basidia* 38-46×10-12 μm, clavate, hyaline, 4-spored, sterigmata upto 4.5 μm, long. *Cystidia* 40-55×10-12 μm, cylindrical to clavate, hyaline. *Hyphae* interwoven, hyaline septate, 4-6 μm, thick. *Hymenophoral trama* heteromerous, hyphae Septate hyaline 4-6 μm, thick. *Habit & Habitat*: terrestrial, solitary or in groups. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible only among tribals. *Accession Number*: FGCCR 3007. *Place of collection*: Amarkantak, Kabir chauraha. *Distribution*: Mandla, Madhya Pradesh (Rajak et al., 2003), Fig.: 3e.

#### ***Russula sanguinea*** (Bull. ex. St. Amans) Fr., *Epicr. Syst. Mycol.* p. 351, (1838)

*Pileus* convex, then plane, 4-10 cm or also slightly depressed in the centre, margin even, only tardily radially striate, cuticle not separable from cap, deep red or tomato red or rosy; viscid and glossy only in humid weather, flesh white. *Gills* white but also cream narrow, almost decurrent on the stem unequal, edges entire. *Stipe* thick tall, white, hollow, reddish spots becoming yellowish, whitish, cylindrical, wrinkled or striated. *Spores* creamy-

white, warted or spiny, 7-8×6-8 μm, oval to globose. *Basidia* 35-38×10-12 μm, 4-spored, clavate, sterigmata up to 3 μm. *Hymenophoral trama* heteromerous, intermixed with sphaerocysts, hyphae septate. *Habit & Habitat*: terrestrial, solitary. *Ecology*: ECM with *Shorea robusta* (sal), *Edibility*: edible very popular among tribals. *Accession Number*: FGCCR 2005. *Place of collection*: Mawai, Amarkantak, Jagatpur. *Distribution*: Mandla, Madhya Pradesh (Rajak et al., 2003), Fig.: 3f.

#### ***Russula sororia*** Fr., *Epicr. Syst. Mycol.* 355, (1838)

*Pileus* 5-7cm in diameter, convex then flattened or depressed surface viscid when moist yellowish brown in the centre, date brown, grayish brown, usually pale grayish brown, smooth, slimy when moist, margin entire straight, inrolled. *Stipe* up to 5 cm long and 1-1.5cm wide, pale, soft becoming interruptedly hollow, white starting from base tinged with brownish gray and slightly flesh-coloured reddish brown, flesh whitish then slightly grayish, brownish in hollow of stipe, thick and rigid. *Gills* whitish, often with brown or grayish markings, crowded than distant unequal and thin. *Spores* pale, cream-coloured, ovoid with conical warts, 6.5-8.5×5-7 μm. 45-47×6-8 μm, clavate, hyaline, 4-spored, sterigmata up to 5 μm long. *Cystidia* 46-50 μm×6-8 μm, clavate, cylindrical, hyaline. *Hymenophoral trama* heteromerous hyphae intermixed with nests of sphaerocysts. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal), *Edibility*: non-edible. *Accession Number*: FGCCR 3008. *Place of collection*: Mawai, Pandutala, Motinala. *Distribution*: Mandla, Madhya Pradesh (Rajak et al., 2003), Fig.: 4a.

#### ***Russula subfoetens*** Smith, *Journ. Bot.* p. 337, (1873)

*Pileus* 3-4 cm in diameter at young and extends up to 7 cm on full maturity, umbilicate, planoconvex and depressed at maturity, buff to yellowish, fleshy, flesh white, smooth, dry, surface viscid when moist. *Gills* adnexed to sub-decurrent, dark yellowish to yellowish, white, close, smooth, thick, brittle, lamellulae present. *Stipe* 3-5 cm long and 1-1.5 cm broad, cylindrical solid then hollow, centrally attached to pileus, glabrous yellowish cream to brown, basal part abrupt. *Spore* 8-10×6-8 μm, globose to subglobose, warty, reticulate. *Basidia* 35-



Fig. 4 : Sporocarps of ECM Mushrooms-Russula  
 a. *Russula sororia*, b. *R. subfoetens*, c. *R. vesca*,  
 d. *Russula* sp. 1, e. *Russula* sp. 2, f. *Russula* sp. 3.

60×8-10 µm, clavate, 4-spored, sterigmata upto 3 µm, long. *Cystidia* 40-65×8-10 µm, cylindrical to clavate. *Hyphae* 4-6 µm, thick interwoven, septate, hyaline. *Habit & Habitat*: terrestrial, solitary or in groups. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 1007. *Place of collection*: Chada, Mandha. *Distribution*: Chakrata, Uttar Pradesh (Saini and Atri, 1989b), Bastar, Chhattisgarh (Rajak *et al.*, 2003), Fig.: 4b.

#### ***Russula vesca* Fr.**

*Pileus* first convex, then more or less depressed, 5-11 cm, cuticle slightly rugose, often extreme end of the gill is uncovered, margin smooth or slightly striate in the direction of the gills, cap colour ochraceous brown or amaranth brown, deeper in the centre or paler in the centre and with rozy zones along the margin. *Stipe* cylindrical, often pointed at the base, white then yellowish, brownish at the base, firm, stuffed, rather hard, 3-10×1.5-2.5 cm. *Flesh* thick, firm, when healthy, white, then with yellowish shades tending to develop rust-coloured or dirty yellow markings. *Gills* close, almost decurrent, white, then slightly cream, crowded, equal. *Spores* white, echinulate, small isolated warts, 6-8×4.5-6.0 µm, globose to sub-globose. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 2006. *Place of collection*: Chada. *Distribution*: New report for India, Fig.: 4c.

#### ***Russula* sp. 1**

*Pileus* hemispheric, then expanded 7-10 cm also depressed, red with olivaceous or yellowish spots or olivaceous yellow, tends to fade, cuticle is viscid and separable from the cap, margin radially marked by striae and then by grooves. *Stipe* more or less, extensively rosy or reddish on white background. *Flesh* white. *Gills* not too close, rather thick and broad, sometimes with the edges reddish near the margin of the cap. *Spores* ocher. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 3009. *Place of collection*: Mandha, Fig.: 4d.

#### ***Russula* sp.2**

*Pileus* 5-6 cm in diam., fragile, of more varied colours, yellow, pink, or cherry red, often yellowish in the center, and pink, along the margins. *Gills* somewhat apart, yellow. *Stipe* 3-4×1.0 cm, white, cylindrical, tapering at base. *Flesh* white. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal.) *Edibility*: edible, very popular among tribals. *Accession Number*: FGCC 3010. *Place of collection*: Chada, Fig.: 4e.

#### ***Russula* sp. 3**

*Pileus* hemispheric, 1-1.5 cm in diam., somewhat knobby, cuticle not easily separable. *Stipe* thin, fragile, marked by veins. *Flesh* firm, whitish or slightly yellowish. *Gills* close, thin, rather unequal, often bifid, fragile, first whitish, then cream coloured. *Spores* pale ocher. *Habit & Habitat*: terrestrial, solitary or scattered. *Ecology*: ECM with *Shorea robusta* (sal). *Edibility*: edible, very popular among tribals. *Accession Number*: FGCCR 2007. *Place of collection*: Mandha, Fig.: 4f.

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