Diversity and Distribution of *Russula* in India with Reference to Central Indian species

R.K. Verma¹, Vimal Pandro¹* and Abhishek Pyasi²

¹Forest Pathology Discipline, Forest Protection Division, Tropical Forest Research Institute, Jabalpur - 482 021, Madhya Pradesh, India
²Dayanand Anglo Vedic Public School, Burhar–484110, Shahdol, Madhya Pradesh, India

*Corresponding author

**A B S T R A C T**

An account of mushrooms belonging to genus *Russula* reported from different part of India is given. Total 124 species of the genus were compiled from literature with their records of habitat, distribution and references. *Russula* species were recorded from 13 states of India. Uttarakhand represent the maximum diversity of *Russula* species (57) followed by Kerala (17), Himachal Pradesh (13), West Bengal (13), Jammu and Kashmir and Sikkim 10 species each, Madhya Pradesh (6) and Nagaland (6). Other states from where species recorded include Meghalaya (3), Punjab (2) while Maharashtram and Tamil Nadu are represented by only one species each. Six species of *Russula* namely: *R. adusta, R. cinerella, R. congoana, R. delicula, R. leelavathyi* and *R. michiganensis* were recorded and described for the first time from Sal forest of central India (Madhya Pradesh and Chhattisgarh). These fungi are known to form ectomycorrhizal association with sal trees. Among them some species are edible and sold in the local market during rainy season.

**Keywords**

Agaricomycetes, Distribution, Ectomycorrhiza, *Russula*, Sal forest

**Introduction**

Members of the *Russula ceae* are characterized by their fleshy and often brightly coloured fruiting bodies with prominent lamellae, a heteromorous context traversed by conducting hyphae, warted, light-colored amyloid basidiospores which exhibit various types of ornamentations. *Russula ceae* was established by Roze in 1876 and it is one of the largest ectomycorrhizal families. The members of this family form ectomycorrhizal association in different angiosperm and gymnosperm trees like *Abies, Acer, Betula, Diospyros, Hopea, Larix, Myristica, Rhododendron, Shorea, Tsuga, Vateria*, etc. The genus is represented by about 130 taxa from India (Das et al., 2014). North-western sub tropical and temperate forests of Himalayan region of Uttarakhand state are represented most *Russula* species. There is a large gap that exists with respect to knowledge diversity of macro-fungi in India. For proper planning and management of forests and the conservation of their biodiversity, characterization, systematics and ecology of these macro-fungi is essential. Many *Russula* species for example, *R. crustosa, R. lutea, R. olivacea, R. parvovirescens, R. senecis, R. virescens* are edible (Atri et al., 2010; Das et
al., 2002; Bhatt and Lakhanpal, 1988a, b; Kalita et al., 2016; Khatua et al., 2015; Semwal et al., 2014). The present paper provides a comprehensive database of diversity of *Russula* species in India. Six species of *Russula* from central India are also described. Edible species are also listed.

Materials and Methods

Specimens of mushrooms were collected from Madhya Pradesh and Chhattisgarh during rainy seasons. Some parts of collected samples were preserved in 70% alcohol just after collection for microscopic study. The fruit bodies of fungi were dried under the sun or in the wooden box lighted with 100W electric bulb. Microscopic slides were prepared by using stain, mountant, clearing and softening chemicals. Slides were observed under advanced research microscope (Leica, Germany) using 5x, 10x, 20x, 40x objectives and 10x and 15x eyepieces. Observations under phase contrast and dark field were also made whenever required. Photomicrography was done with the help of a digital camera (make, Leica) attached to the advanced microscope. Identification of fungi has been done with the help of published literature, monographs, books, keys, etc. (Abraham et al., 1980; Atri and Kour, 2003; Atri and Saini, 1986, 1990a, 1990b, 1990c; Atri et al., 1992, 1997, 2016; Berkeley, 1851, 1856, 1876; Bhatt et al., 1995, 2007; Buyck and Atri, 2011; Chaudhary and Tripathy, 2016; Crouset al., 2016; Das, 2013; Das and Sharma, 2001, 2003, 2005b; Das et al., 2002c; 2005a, 2006, 2008; 2010; 2013a, b; 2014; 2017; Dhanochalia, 2011; Dutta et al., 2015; Farook et al., 2013; Ghosh and Das, 2017; Hedawoo, 2010; Joshi et al., 2012; Kauret al., 2011; Kumar et al., 2014; Manimohanand Deepn, 2011; Mohanan, 2011, 2014; Natarajanand Raman, 1983; Pavithra et al., 2017; Pradeep and Vrinda, 2007, 2010; Rawla, 2001; Rawla and Sarwal, 1983; Romagnesi, 1945; Saini et al., 2010; Saini and Atri, 1981, 1984, 1989a, b; Saini et al., 1988, 1989; Sarwal, 1984; Sathe et al., 1980; Shaffer, 1962; Shajahan and Samajpati, 1995; Sharma and Das, 2002; Varghese et al., 2010; Vishwakarma et al., 2012; Vrinda et al., Vrinda 1997a, b; Watling and Gregory, 1980).

Results and Discussion

Taxonomic description

*Russula adusta* (Pers.) Fr. (Figures 1-4) = *Agaricus adustus* Pers. = *Omphalia adusta* Pers.

Basidiome medium to large sized. Pileus 5-8 cm diam, with a deep depression at centre at maturity; margin in rolled when young, becoming uplifted when fully expanded; surface dull white becoming grayish white then dark brown and finally black on handling or aging, non-striate. Lamella adnate, white turning black on handling, more or less crowded with lamellulae of different lengths, sometimes bifurcated close to the stipe; edge smooth, entire. Stipe 4-6 x 1-2 cm, central equal, solid; surface chalky white, immediately turning black when handled, odour not distinctive. Context white discoloring blackish on exposure, heteromorphous with nests of sphaerocytes. Spores 6-8 x 5-7 µm globose to broadly ovoid, strongly amyloid with an ornamentation of prominently verrucose and connective forming a partial reticulum; supra-hilarplageinamyloid. Basidia clavate 31-46 x 7-8 µm, tetrasporate. Lamella-edge sterile with crowded macrocystidia 59-80 x 6-8 µm, clavate, mucronate with oleaginous refractive contents discoloring black, pleurocystidia similar. Hyphomorphoraltrema heteromorphous with sphaerocytes. Pileipellis an exocutis devoid of dermatocystidia. Caulocystidia, 30-45 x 5-7 µm.
**Collection examined**

Mycorrhizal on sal (*Shorea robusta*), Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh, 24/07/2012, Mycology Herbarium, Tropical Forest Research Institute, Jabalpur TF 2789.

**Russula cinerella** Pat. (Figures 5-7)

Basidiomes are small to medium sized, pileus 4-7 cm diam, convex to planate, depressed at the centre, surface light grey to brownish orange, silky, dry smooth, margin undulate and incurved. Lamellae adnate, white becoming pale yellowish brown on exposure. Context up to 5 mm thick, white becoming pinkish brown on exposure. Spore print pale cream. Spores 5-8 x 5-7.5 µm, subglobose to ovoid, hyaline, ornamented with very fine, amyloid. Besidia 34-40 x 8-10 µm, clavate, bearing 4 sterigmata. Lamella-edge heteromorphous. Cheilocystidia 27-35 x 10-12 µm, cylindric to fusoid, often apically constricted or capitates, hyaline, with numerous refractive contents. Pleurocystida 31-41 x 8-9 µm, sinuous, lanceolate-fusoid, often constricted or mucronate, with abundant granular contents. Hymenophoral trama irregular and intermixed. Pileal surface a disrupted trichodermium subtended by a broad hypodermium. Trichodermium of more or less erect hyphae, 2-3.5 µm diam., sometimes agglutinated into fascicles; dermatocystidia absent. Hypodermium 110-130 µm thick, of tightly interwoven hyphae, slightly agglutinated.

**Collection examined**

Mycorrhizal on sal, Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh, 24/07/2012. Mycology Herbarium, Tropical Forest Research Institute, Jabalpur TF 2788.

**Russula congoana** Pat. (Figures 8-11)

Basidiome small to medium sized. Pileus 4-5.5 cm diam, at first convex then expanded with slight central depression; surface uniformly pastel red to red, smooth finely striate at the margin, sticky. Lamellae adnate, white to pale cream exceeding the gills, up to 5 mm wide, close; edge entire, concolourous to the sides. Context thin white. Stipe 2.5-3.5 cm x 7-12 mm, central cylindrical equal or slightly broader at the base, solid becoming stuffed and hollow surface creamy white with a pinkish tint at the base, smooth. Odour pleasant, test met distinctive. Spores 4-6 x 3-5 µm, subglobose ellipsoid to oblong, densely ornamented with coarse, amylloid, verrucose interconnected by a reticulate system. Basidia clavate, 29-39 x 10-14 µm, 4-spored. Macro cystidia scattered on both edges and sides of the lamellae, 33-51 x 9-12 µm, clavate to fusiform, frequently mucronate, thin walled. Subpellis slightly gelatinized. Suprapellis composed of erect, shortly cylindrical element, 3-5 diam. Pileocystidia numerous, intermixed with hyphae, 33-200 x 4-8 µm, cylindrical clavate to fusiform, obtuse or slightly constricted to fusiform, obtuse or slightly constricted at large apex. Clamp connection absent.

**Collection examined**

Mycorrhizal with sal, Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh, 24/07/2012. Mycology Herbarium, Tropical Forest Research Institute, Jabalpur, TF 2790.

**Russula delicula** Romagn. (Figures 12-14)

Basidiome small to medium sized. Pileus 4.5-5.5 cm diam, convex becoming uplifted and infundibula form at maturity margin inrolled when young, becoming uplifted when fully expanded; surface yellowish grey with grayish
orange tints, viscid when wet, otherwise dry, non-striate. Lamellae subdecurrent, white, up to 4mm broad, often forked at or near the stipe, interveinose, white to pale buff, close, without lamellulae; edge smooth, entire. Context white. Stipe 15-32 x 1.2-2 mm; central, equal or slightly attenuated below, solid; surface white, smooth, annulus absent.

Odour not distinctive Spores 5.0-8.75 x 5.0-7.5µm, globose to broadly avoid strongly amyloid with an ornamentation of moderately large verrucose& thin connectives forming a partial to complete reticulam. Basidia 36-41 x 4-7µm, clavate, tetrasporate. Cystidia scattered both on edges & sides of the lamellae, 78-112 X 15-26µm clavate-fusoid sometimes with a long, attenuated neck bearing a small bulk apically, filled with oleaginous refractive contents. Subhymenium pseudoparenchymatous. Hymenophoraltrama heteromorphous pileipellis with horizontally arranged non-gelatinized hyphre, devoid of dermatocystidia.

**Collection examioned**

Mycorrhizal on sal, Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh, 24/07/2012, Mycology Herbarium, Tropical Forest Research Institute, Jabalpur, TF 2792.

**Russula leelavathyi** K.B. Vrinda, C.K. Pradeep & T.K. Abraham (Figures 15-17)

Basidiome small to medium sized pilus 3-5cm diam., fleshy, convex than expanded with a central depression; surface uniformely ivory to grayish white, areolately cracked forming patches of ivory squamules on a off white ground, entire at the disk; margin radially plicato-striate for two third of radium from the margin and cracking along radial striae to expose underlying white context below, gelatinized under wet weather. Lamellae adnexed to subdecurrent, white up to 3mm white, heteromorous with thin walled hyaline hyphae 2-6mm wide intermixed with sphaerocytes 17-23µm. Stipe 3-5cm x 5-13mm, central, cylindical, equal, solid, becoming stuffed; surface white, smooth. Basidiopores 7.5-6.25 x 7.5-7.5µm, subglobose to broadly ovoid, hyaline with an ornamentation of coarse, amyloid, verrucose and scattered fine connectives forming a pilus reticulum. Basidioclavate 45-56 x 7-9 µm, tetraspored.

Lamella edge sterile, cheilocystidia 33-35 x 9-10µm, clavate, fusoid, lageniform often with actually pointed or mucronate apex. Macrocytisia 73-87 x 4.7-6.5µm, ventricose, fusoid to acuminate, thin-walled, with granular contents, numerous both on sides and edges of the lamellae. Hymenophoraltrama heteromerous composed of thin–walled, hyaline hyphae, intermixed with sphaerocytes. Piliepellis distinctly two layered an upper epithelial layer and a lower loosely interwoven gelatinized layer. Stipitipellis with abundant caulocystedia 20-40 x 7-12µm similar to cheilocystedia. The furcated lamellae together with lack of lamellulae are characteristic feature of this species.

**Collection examined**

Mycorrhizal on sal, Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh, 24/07/2012, Mycology Herbarium, Tropical Forest Research Institute, Jabalpur, TF 2793.

**Russula michiganensis** Shaffer (Figures 18-20)

Sporocarp small to medium sized. Pileus up to 2.5-6cm diam, convex to broadly convex with a central depression becoming uplifted in older ones; surface grayish brown becoming black on aging, non-striate.
| S. N. | Name of fungus | Habit | Distribution | Reference |
|------|----------------|-------|--------------|-----------|
| 1.   | *Russula abbotensis* K. Das & J.R. Sharma | - | From Abbot Mount, Champawat, Uttarakhand | Das and Sharma (2005a) |
| 2.   | *Russula aciculocystis* Kauffman ex Bills & O.K. Mill. | - | Thiruvananthapuram, Kerala | Pradeep and Vrinda (2010); Mohanan (2011, 2014) |
| 3.   | *Russula adusta* (Pers.) Fr. in leaf litter and ectomycorrhizal with *Vateria indica* | From Kailana, Chakrata, Mayawati, Jageshwar, Uttarakhand; Malappuram and Thiruvananthapuram, Kerala and Mangalore, Karnataka | Saini and Atri (1984); Atri and Saini (1990b); Das and Sharma (2005b); Pradeep and Vrinda, (2010); Mohanan (2011, 2014); (Pavithra et al., 2017) |
| 4.   | *Russula aeruginea* Lindblad:-Fr. | - | Puliebzie, Zakhama and Pherma forest ranges, Nagaland | Kumar et al., (2014) |
| 5.   | *Russula alachuana* Murrill | - | Kailana, Chakrata, Uttarakhand | (Atri, Saini, 1986). |
| 6.   | *Russula albida* Peck | - | Nagdev-Jhandidhar Forest, Punjab and Khirsu Forest, Uttarakhand | Bhatt et al., (1995) |
| 7.   | *Russula albonigra* (Krombh.) Fr. Ectomycorrhizal on sal in sal forest | Deoban, Chakrata, Uttarakhand, Gidhani and Jhargram, West Bengal | Saini and Atri (1984); Atri and Saini (1986, 1990a); Shajahan and Samajpati (1995) |
| 8.   | *Russula alnetorum* Romagnesi in leaf litter in the forest range | Mankoi and Chungtia, Nagaland | Kumar et al., (2014) |
| 9.   | *Russula alutacea* (Fr.) on wood | Gulmarg, Jammu | Berkeley |
| Fr. ≡ Agaricus alutaceus Fr., and Kashmir (1876) |
|-----------------|-----------------|-----------------|
| 10. Russula amoena Quél. | - | Palakkad, Kollam, Wayanad, and Thiruvananthapuram, Kerala | Vrinda et al., (1997c); Pradeep and Vrinda (2010; Mohanan (2011)) |
| 11. Russula amoenicolor Romagn. | - | JabbarKhet, Mussoorie, Uttarakhand | Rawla and Sarwal (1983). |
| 12. Russula amoenicolor var. Ramgarhensis K. Das, J.R. Sharma & R.P. Bhatt | - | Ramgarh, Nainital, Uttarakhand | Das et al., (2005a). |
| 13. Russula amoenolens Romagn. | From Nagdev-Jhandidhar Forest | Khirsu, Uttarakhand | Bhatt et al., (1995) |
| 14. Russula anatine Romagn. | | DafiaDhura, Pithoragarh; Dhakuri, Bageshwar, Uttarakhand | Das and Sharma (2003) |
| 15. Russula appendiculata K. Das, S.L. Mill. & J.R. Sharma | Associated with Pinus Gagar, Nainital, Uttarakhand | Das et al., (2006a) |
| 16. Russula arunii S. Paloi, A.K. Dutta & K. Acharya | On the base of Pterigotaalata (Stercaliaeae) | West Bengal, (Botanical Garden of the Ballygunge Science College campus, Kolkata) | in Crous et al., (2017) |
| 17. Russula atropurpurea (Krombh.) Britzelm. | In leaf litter and ectomycorrhizal with Vateriaindica | Charkara, Uttarakhand; Malappuram and Nilambur, Kerala and Mangalore, Karnataka | Atri, Saini 1986; Saini, Atri (1989b); Pavithra et al., (2017); Mohanan (2011, 2014) |
| 18. Russula atropurpurea Peck. | From conifer dominated forest under pine | Gulmarg, Jammu and Kashmir | Dar et al., (2010) |
| 19. Russula aurata Fr. | - | Deoban, Chakrata, Uttarakhand | Atri & Saini, (1986); Saini and Atri(1989b); Saini et al., (1989) |
|   | **Species**                  | Location/Environment                                                                 | Location/Region               | Reference                           |
|---|-----------------------------|-------------------------------------------------------------------------------------|--------------------------------|-------------------------------------|
| 20. | *Russula aurea* Pers.       | From conifer dominated forest                                                        | Gulmarg, Jammu and Kashmir    | Dar *et al.*, (2010)                |
| 21. | *Russula aureorubra* K.     | In temperate broadleaf forest associated with *Lithocarpus*                          | Sikkim                        | in *Das et al.*, (2017)             |
|    |   | Das, A. Ghosh, Baghela&Buyck |                                                                               |                                   |                                     |
| 22. | *Russula aurora* (Krombh.) Bres. |                                                                                   | Chakrata, Mussoorie, Uttarakhand | *Saini et al.*, (1989)              |
| 23. | *Russula azurea* Bres.      | Growing solitary on humicolous soil under *Juniperus recurva*                        | Churdhar, Himachal Pradesh     | *Saini et al.*, (2010)              |
| 24. | *Russula brevipes* Peck     | In forest areas                                                                     | Jageshwar, Mayawat, Uttarakhand; Nagaland (Puliebzie, Zakhama, Chungtia) and Namcha forest ranges and Jammu and Kashmir | Das and Sharma (2005b); *Kumar et al.*, (2014); Watling and Gregory (1980) |
|    | = *Russula brevipes* var.   |                                                                                   |                                |                                     |
|    |   | *acrior* Shaffer             |                                                                               |                                   |                                     |
| 25. | *Russula brevipes* var.     | -                                                                                  | Lohaghat, Mayawati, Champawat; Sandev, Pithoragarh, Uttarakhand                | Das and Sharma (2005b)             |
|    |   | *acrior* Shaffer             |                                                                               |                                |                                     |
| 26. | *Russula brunneoviolacea*   | Growing solitary on humicolous soil in *Abiesprintrow* forest                        | Narkanda, Himachal Pradesh     | *Kaur et al.*, (2011)               |
|    | Crawshay var. *macrospora*  |                                                                                   |                                |                                     |
|    | Kaur, NS Atri, S. Sharma & Y. Singh |                                                |                                |                                     |
| 27. | *Russula buycikii* K.       | Growing under *Castanopsis* sp., among mosses                                       | Darjeeling, West Bengal        | *Paloi et al.*, (2016)              |
|    | Acharya, S. Paloi & A.K.    |                                                                                   |                                |                                     |
|    | Dutta                       |                                                                               |                                |                                     |
| 28. | *Russula brunneoviolaceavarrube* hogrisea Romang, | Growing solitary on humicolous soil in a broad leaved forest | Hattu Peak, Himachal Pradesh | *Kaur et al.*, (2011)               |
| 29. | *Russula californiensis*    | Growing on hard ground in August                                                    | Kasauli, Himachal Pradesh      | Chaudhary, Tripathy (2016)          |
|    | Burl                        |                                                                                   |                                |                                     |
| 30. | *Russula cinerella* Pat.    | -                                                                                  | Wayanad, Kerala                | Mohanan (2011, 2014)                |
| 31. | *Russula cinnabarina* Berk. | On clay bank                                                                       | Darjeeling, West Bengal        | Berkeley (1851)                     |
| 32. | *Russula claroflava*        | -                                                                                  | Amravati, Hedawoo              |                                     |
|   | Species                       | Locality                                      | Note                                                                 |
|---|-------------------------------|-----------------------------------------------|----------------------------------------------------------------------|
| 33. | *Russula compacta* Frost     | -                                             | Grove, Maharashtra, Abbot Mt., Sandev, DafiaDhura, Uttarakhand        |
| 34. | *Russula congoana* Pat.      | -                                             | Maharashtra, Mussoorie, Uttarakhand, Ernakulam, Kollam, Malappuram, Wayanad and Thiruvananthapuram, Kerala |
| 35. | *Russula consobrina* (Fr.) Fr. | -                                             | Das and Sharma (2005b)                                               |
| 36. | *Russula cremeoavellanea* Singer | -                                             | Sarwal (1984); Pradeep and Vrinda (2010); Varghese et al., (2010); Mohanan (2011) |
| 37. | *Russula crustosa* Peck.     | Solitary-scattered under *Piseasmithiana*, *Pinuswalitiana*, *Quercusincana* and *Rhododendron arboretum* | Sharma et al., (2016)                                               |
| 38. | *Russula cyanoxantha* (Schaeff.) Fr. | Ectomycorrhizal on sal | Shajahan and Samajpati (1995); Atri and Saini (1986, 1990c); Das and Sharma (2005b). |
| 39. | *Russula dafianus* K. Das & J.R. Sharma | -                                             | Das and Sharma (2005b)                                               |
| 40. | *Russula decipiens* (Singer) Bon | -                                             | Das and Sharma (2005b)                                               |
| 41. | *Russula decolorans* (Fr.) Fr. | -                                             | Das and Sharma (2005b)                                               |
| No. | Species | Location Details | Reference |
|-----|---------|------------------|-----------|
| 42. | *Russula delica* Fr. | Ectomycorrhizal on sal Gidhani and Jhargram, West Bengal and Chakrata, Deoban and Nainapeak Uttarakhand | Shajahan and Samajpati (1995); Atri and Saini (1986) |
| 43. | *Russula delicula* Romagn. | - | Thiruvananthapuram and Wayanad, Kerala | Pradeep and Vrinda (2010); Mohanan (2011, 2014) |
| 44. | *Russula densifolia* Secr. ex Gillet | - | Jammu and Kashmir | Watling and Gregory (1980) |
| 45. | *Russula dhakuriiana* K. Das, J.R. Sharma & S.L. Mills | Associated with *Rhododendron* | Dhakuri, Bageshwar, Uttarakhand, Himalaya | Das *et al.*, (2006a) |
| 46. | *Russula dissimulans* Shaffer | - | Adwani Forest, Uttarakhand | Bhatt *et al.*, (1995) |
| 47. | *Russula dubdiana* K. Das, Atri & Buyck | On ground under *Castanopsis hystrix* in subtropical to temperate broad-leaved forest | Sikkim | Das *et al.*, (2013) |
| 48. | *Russula emetica* (Schaeff.) Pers. = *Agaricus emeticus* Schaeff. | - | Khasi Hills, Meghalaya and clay banks, Darjeeling, West Bengal | Berkeley (1856) |
| 49. | *Russula farinipes* Romell | Growing in the mixed forest dominated by *Pinus wallichiana* and *Quercus incana* | Himachal Pradesh | Saini and Atri (1989) |
| 50. | *Russula firmula* Jul. Schäff. | - | Jammu and Kashmir | Watling, Gregory (1980) |
| 51. | *Russula flavidavar. Dhakurianus* K. Das, J.R. Sharma & R.P. Bhatt | - | Dhakuri, Bageshwar, Uttarakhand | Das and Sharma (2005a) |
| 52. | *Russula flocculosa* Burl. | - | Chobattakhal, Phaedkhal, Pauri Garhwal, Uttarakhand | Bhatt *et al.*, (2007) |
| No. | Species | Habitat/Location | Authors | References |
|-----|---------|------------------|---------|------------|
| 53. | *Russula foetens* Pers. | On humicolous soil, under *Quercus incana*, Joshimath, Nainital, Chakrata, Deoban, Jamnotri, Uttarakhand; Summer Hills, Simla, Himachal Pradesh | Saini and Atri (1984); Saini and Atri (1981) |
| 54. | *Russula fragrantissima* Romagn | - | Nongkham, Namcha and Tigit forest range, Nagaland and Jammu and Kashmir | Watling and Gregory (1980) |
| 55. | *Russula furcata* Pers. | Clay banks | Sinchal, Sikkim, Himalayas | Berkeley (1856) |
| 56. | *Russula grata* Britzelm. = *Russula laurocerasi* Melzer | Growing solitary on humicolous soil under *Quercus incana* | Thiruvananthapuram, Kerala and Himachal Pradesh | Pradeep and Vrinda (2010); Saini and Atri (1989) |
| 57. | *Russula griseocarnosa* X.H. Wang, Zhu L. Yang & Knudsen | - | Sikkim | in Das et al., (2010) |
| 58. | *Russula grossa* Berk. | on earth and mossy bank | Darjeeling, West Bengal | Berkeley (1851) |
| 59. | *Russula himalayana* Rawal & Sarwal | On humus under *Aesculus* and *Acer* | JabbarKhet, Mussoorie, Uttarakhand | Rawla and Sarwal (1983) |
| 60. | *Russula hookeri* S. Paloi, A.K. Dutta & K. Acharya | Growing solitary - group of two, under Castanopsis sp. among the mosses | Darjeeling, West Bengal | Paloi et al., (2015) |
| 61. | *Russula hygrophytica* Pegler | - | Ernakulam, Perumbavoorand Thiruvananthapuram, Kerala | Mohanan (2011, 2014) |
| 62. | *Russula indica* Sathe & J.T. Daniel | - | Idukki, Kerala | in Sathe et al., (1980); Florence (2004) |
| 63. | *Russula indoarmeniaca* A. Ghosh, K. Das & R.P. Bhatt | From broadleaf forest | Baniyakund, Rudraprayag, Uttarakhand | Ghosh et al., (2016) |
| 64. | *Russula intervenosa* Paloi, A.K. Dutta & K. Acharya | Associated with *Shorearobusta* | Lodhasuli forest, PaschimMidnapur, West Bengal | in Crous et al., (2016) |
| 65. | *Russula kanadii* A.K. | Growing solitary under | Gurguripal forest, | Dutta et al., |
| No. | Species                          | Habitat/Associated Plants | Location/Notes                                                                 |
|-----|----------------------------------|-----------------------------|-------------------------------------------------------------------------------|
| 66. | *Russula khanchanjungae*          | in mixed forest with *Abies densa, Betula utilis* and *Rhododendron barbatum* | Sikkim in *Das et al.*, (2010)                                                |
| 67. | *Russula leelavathi* K.B. Vrinda, C.K. Pradeep & T.K. Abraham | On sandy soil, associated with *Hopea parviflora* | *Vrinda et al.*, (1997a); Pradeep and Vrinda (2007, 2010); Mohanan (2011, 2014) |
| 68. | *Russula lepida* Fr.             | ectomycorrhizal on sal; on clay bank, Darjeeling, WB; reported edible from Tapovan, Dehradun, Uttarakhand | *Shajahan and Samajpati* (1995); (Berkeley 1851); *Semwal et al.*, (2014) |
| 69. | *Russula lepidicolor* Romagnesi  | growing scattered on humicolous soil in *Cedrus deodara* forest | *Nagar Forest, Manali, Himachal Pradesh* in *Saini et al.*, (2010) |
| 70. | *Russula lutea*, Bhatt *et al.*, 1988a, b | Solitary-scattered, associated with *Cedrus deodara, Picea smithiana, Pinus walitiana, Quercus ciusciana and Rhododendron arboreum* and humicolous soil in sal forests | *Shimla, Himachal Pradesh and lower Shiwalik Hills of Uttarakhand* in *Bhatt and Lakhanpal* (1988b); *Semwal et al.*, (2014) |
| 71. | *Russula luteotacta* Rea          | -                           | *Thiruvananthapuram, Ernakulam and Perumbavoor, Kerala* in *Pradeep and Vrinda* (2010); Mohanan (2011, 2014) |
| 72. | *Russula mariae* Peck             | On soil under *Hopea ponga*, *H. parviflora, Vateria indica, Diospyros mala barica* forming ectomycorrhiza | *Shenkily, Kulathupuzha, Wayanad, Kerala* in *Mohanan* (2014) |
| 73. | *Russula martinica* Pegler       | On soil under *Hopea parviflora* | *Malappuram, Nilambur, Kerala* in *Mohanan* (2011, 2014) |
| 74. | *Russula mayawatiana* K. Das, S.L. Mill. & J.R. Sharma | Associated with *Quercus* and *Rhododendron* | *Champawat, Mayawati, Uttarakhand* in *Das K et al.*, (2006a) |
| No. | Species | Location Details | Collection Details |
|-----|---------|------------------|--------------------|
| 75. | *Russula michiganensis* Shaffer | Under *Hopeaponga, H. parviflora, Vateria indica* and *Diospyros malabarica* | from Wayanad and Ernakulam, Kerala | Mohanan (2011, 2014) |
| 76. | *Russula minutulavar.* *Minutula* Velen. | - | Kailana, Dhabighat, Alumandi, Mussoorie, Joshimath, Uttarakhand | Saini and Atri (1984); Saini *et al.*, (1989) |
| 77. | *Russula mukteshwarica* K. Das, S.L. Mill., J.R. Sharma & R.P. Bhatt | In close association with *Myrica, Quercus* and *Rhododendron* | Uttarakhand, Himalayas | Das *et al.*, (2005) |
| 78. | *Russula mussooriensis* Rawla & Sarwal | - | from JabbarKhet, Mussoorie, Uttarakhand | Rawla and Sarwal (1983) |
| 79. | *Russula mustelina* Fr., Oli Forest | - | Chakrata, Kailana, Uttarakhand | Saini and Atri (1984); Atri and Saini (1986, 1990c) |
| 80. | *Russula natarjani* K. Das, J.R. Sharma & Atri | Associated with *Quercus* species in moist, temperate, deciduous/mixed forests | Dhakuri, Bageshwar, Uttarakhand | Das *et al.*, (2006b) |
| 81. | *Russula nauseosa* (Pers.) Fr. | On ground amongst pine litter | Gulmatg, Jammu and Kashmir | Abraham *et al.*, (1980); Watling and Gregory (1980) |
| 82. | *Russula nigricans* Fr. | - | Chakrata, Uttarakhand | Saini and Atri (1984); Saini *et al.*, (1988) |
| 83. | *Russula nobilis* Velen | In forest | Pherma and Mankoi, Nagaland | Kumar *et al.*, (2014) |
| 84. | *Russula obscuricolor* K. Das, A. Ghosh & Buyck | On soil in mixed broad leaf forest associated with *Castanopsis* | Sikkim | (in Das *et al.*, (2017) |
| 85. | *Russula ochroleuca* (Pers.) FrGray. | In forest ranges | Lahorijan, Puliebzie, Zakhama, Nagaland | Kumar *et al.*, (2014) |
| 86. | *Russula ochroleuca* (Pers.) Fr. | - | Chakrata, Uttarakhand | Saini *et al.*, (1989) |
| 87. | *Russula odorata* Romagn. | - | JabbarKhet, Mussoorie, | Rawla and Sarwal |
| No. | Species                     | Collected Location                                                                 | Habitat                                                                 | Location and Reference                          |
|-----|-----------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------|
| 88  | Russula olivacea (Schaeff.) Fr. | Uttarakhand (1983)                                                                | In dense clusters, around trunks, in pine forest                       | Shyrwat, Shillong, Meghalaya                     |
| 89  | Russula parazurea Jul. Schäff. | -                                                                                 | Chennai, Tamil Nadu                                                     | Natarajan and Raman (1983c)                      |
| 90  | Russula parvovirescens Buyck, D. Mitch. & Parrent | Shyrwat, Shillong, Meghalaya                                                      | Solitary, on ground, in Pine forest                                   | Kalita et al., (2016)                           |
| 91  | Russula pauriensis A. Ghosh, K. Das & Buyck | Uttarakhand (2017)                                                               | On soil in mixed broadleaf forest associated with Quercus             | in Das et al., (2017)                            |
| 92  | Russula peckii Singer        | Shyrwat, Shillong, Meghalaya                                                      | from North West Himalayas, Himachal Pradesh                           | Sharma et al., (2016)                           |
| 93  | Russula pectinata (Bull.) Fr. | Jabbar Khet, Mussoorie, Uttarakhand                                              | On soil in mixed broadleaf forest associated with Quercus             | Rawla and Sarwal (1983)                         |
| 94  | Russula pectinata Fr.        | Chakrata, Uttarakhand and Gidhanisal forest, West Bengal                           | On hemicolous soil under Quercusincana, mycorrhizal with sal          | (Saini SS, Atri NS, 1989); (Shajahan M and Samajpati N, 1995) |
| 95  | Russula periglypta Berk. & Broome | Thiruvananthapura m, Nilambur and Malappuram, Kerala                             | On soil under Vateria indica, Hopeaparviflora and Diospyrosmalabarica | Pradeep and Vrinda (2010); Manimohan, Deepna (2011); Mohanan (2011, 2014) |
| 96  | Russula persicina Krombh.     | Jammu and Kashmir                                                                  | -                                                                      | Watling and Gregory (1980)                      |
| 97  | Russula petersenii A. Ghosh & K. Das | Uttarakhand                                                                         | On the soil under Rhododendron                                        | Ghosh and Das (2017)                             |
| 98  | Russula praetervisa Sarnari   | Dhakuri, Bageshwar, Mayawati and Mornoula, Champawat, Uttarakhand                 | -                                                                      | Sharma et al., (2005)                            |
| 99  | Russula Phedkhal, Bhatt et al., | Phedkhal, Shyllong, Meghalaya                                                      | -                                                                      |                                                 |
| No. | Species                          | Location Details                                                                 | Reports                                           |
|-----|---------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------|
| 100 | *Russula pseudolepida*          | Solitary on humicolous soil among *Fragaria* sp., under *Cedrus deodara*         | Singer et al. (2007)                              |
| 101 | *Russula puellarisvarpuellaria* Fr. | associated with *Quercus* and *Rhododendron*                                 | Kaur et al., (2011)                              |
| 102 | *Russula puellaris* atrii K. Das, S.L. Mill. & J. R Sharma | -                                                                                 | Das et al., (2006a)                              |
| 103 | *Russula pulverulenta* Peck     | -                                                                                | Pradeep and Vrinda (2010); Manimohan and Deepna (2011) |
| 104 | *Russula rajendrae* A. Ghosh & K. Das | On the soil under *Quercus*                                                    | Ghosh and Das (2017)                             |
| 105 | *Russula raoultii* Quél.        | -                                                                                | Das and Sharma (2003)                            |
| 106 | *Russula rhodomelanea* Sarnari  | -                                                                                | Das and Sharma (2001b)                           |
| 107 | *Russula romagnesiana* Schaffer | -                                                                                | Pradeep and Vrinda (2010)                         |
| 108 | *Russula rubra* (Lam.) Fr. = *Russula rubra var. hymenocystidiata* Atri & Kour | In pine wood; on the ground                                                     | Atri and Kour (2003)                             |
| 109 | *Russula sanguinaria* (Schumach. ) Rauschert = *Russula rosacea* (Pers.) Gray ≡ *Agaricus roseus* Schaeff. | In pine wood; on the ground                                                     | Berkeley (1851a); Mundkur (1938)                  |
| 110 | *Russula sarnarii* A. Ghosh, K. Das & R.P. Bhatt | Growing under *Pinus* forest                                                   | Ghosh et al., (2017)                             |
| 111 | *Russula sanguinea* Fr.         | -                                                                                | from Jammu and                                   |
| No. | Species                                      | Habitat                                                                 | Location                                      | Reference                                |
|-----|---------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------|------------------------------------------|
| 112 | *Russula sanguineus* Bull.                  |                                                                         | Kashmir                                       | Gregory (1980)                           |
| 113 | *Russula schaefferina* Rawla & Sarwal       |                                                                         | Mussoorie, Uttarakhand                        | Rawla and Sarwal (1983)                  |
| 114 | *Russula senecis* S. Imai                   | In association with *Vateria indica*, dipterocarp forests, and under *Lithocarpus* and *Castenopsis* | Western Ghats Sikkim West Bengal              | Natarajan *et al.*, (2005); Das (2009); Das *et al.*, (2010); Khatua *et al.*, (2015) |
| 115 | *Russula sharmae* K. Das, Atri & Buyck       | On ground under *Lithocarpus pachyphyllus* in mixed forest             | Sikkim                                        | Das *et al.*, (2013)                      |
| 116 | *Russula shingbaensis* K. Das & S.L. Mill.  | On ground, sub-alpine forest, under *Abies densa*, *Shingba Rhododendron* wildlife sanctuary | North district, Sikkim                        | Das *et al.*, (2014).                    |
| 117 | *Russula sikkimensis* K. Das, Atri & Buyck  | On ground in *Abies densa* sub-alpine mixed forest                      | Sikkim                                        | Das *et al.*, (2013)                      |
| 118 | *Russula silvicola* Shaffer, Beih., Khirsu   | -                                                                       | PauriGrahwal, Uttarakhand                     | Bhatt *et al.*, (2007)                    |
| 119 | *Russula subfoetens* W.G. Sm.               | Solitary on humidicolous soil under *Cedrus deodara* and *Quercus incana* | Chakrata, Uttarakhand                        | Atri and Saini (1986); Saini and Atri (1989a) |
| 120 | *Russula thindii* K. Das & S.L. Mill.       | On ground, coniferous forest, *Abies densa*, *Shingba Rhododendron* wildlife sanctuary, | North district, Sikkim                      | Das *et al.*, (2014)                      |
| 121 | *Russula tsokae* K. Das, Van de Putte & Buyck | Under *Tsuga dumosa* forest                                             | Sikkim                                        | in Das *et al.*, (2010)                   |
| 122 | *Russula vaurasiana* K. Das & J.R. Sharma   | Associated with *Quercus* in temperate mixed forest                     | Uttarakhand                                   | Das and Sharma (2005b)                   |
| 123 | *Russula velenovskyi* Melzer & Zvára        | In Oli Forest                                                           | Joshimath, Uttarakhand                        | Atri and Saini (1986); Saini and Atri (1989b) |
| 124 | *Russula vesca* Fr.                         | Ectomycorrhizal on sal,                                                 | Gidhani and Balibhasasal forest, West Bengal  | Shajahan and Samajpati (1995)            |
| 125 | *Russula virescens* (Schaeff.) Fr.          |                                                                         | Dhobighat, Mussoorie;                         | Saini *et al.*, (1988)                   |
### Table 2: Distribution of 124 species of *Russula* in different states of India

| S. No. | State                  | Number of species | Percentage (%) |
|--------|------------------------|-------------------|----------------|
| 1.     | Himachal Pradesh       | 13                | 9.2            |
| 2.     | Jammu and Kashmir      | 10                | 7.1            |
| 3.     | Karnataka              | 2                 | 1.4            |
| 4.     | Kerala                 | 17                | 12.1           |
| 5.     | Madhya Pradesh         | 6                 | 4.3            |
| 6.     | Maharashtra            | 1                 | 0.7            |
| 7.     | Meghalaya              | 3                 | 2.1            |
| 8.     | Nagaland               | 6                 | 4.3            |
| 9.     | Punjab                 | 2                 | 1.4            |
| 10.    | Sikkim                 | 10                | 7.1            |
| 11.    | Tamil Nadu             | 1                 | 0.7            |
| 12.    | Uttarakhand            | 57                | 40.4           |
| 13.    | West Bengal            | 13                | 9.2            |
| **Total** |                      | **141**          | **100**        |

### Table 3: Edible species of *Russula*

| S. No. | Name of species       | Place                  | Reference |
|--------|-----------------------|------------------------|-----------|
| 1.     | *Russula crustosa*    | Himachal Pradesh       | Bhatt and Lakhanpal (1988a, b) |
| 2.     | *Russula lepida*      | Tapovan, Dehradun, Uttarakhand | Semwal *et al.*, (2014) |
| 3.     | *Russula lutea*       | Himachal Pradesh and Uttarakhand | Bhatt and Lakhanpal (1988b); Semwal *et al.*, (2014) |
| 4.     | *Russula olivacea*    | Meghalaya              | Kalita *et al.*, (2016) |
| 5.     | *Russula parvovirescens* | Meghalaya         | Kalita *et al.*, (2016) |
| 6.     | *Russula senecis*     | West Bengal            | Khatua *et al.*, (2015) |
| 7.     | *Russula virescens*   | Uttarakhand            | Saini *et al.*, (1988) |
Fig. 1-4 *Russula adusta*, 1 basidiocarps, 2 basidia, 3 basiospores (100x).

Fig. 5-7 *Russula cinerella*, 4 basidiocarp, 6 basidia and 6 basiospores
Fig.8-11 *Russula congoana*, 8-9 basidiocarp habit, 10 basidia and 11 basidiospores
**Fig.12-14** *Russula delicula*, 12 basidiocarp, 13 basidia, 14 basidiospores

**Fig.15-17** *Russula leelavathyi*, 15-16 basidiocarp, 17 basidia and basidiospores
Fig.18-20 *Russula michiganensis*, 18 basidiocarps different developing stages, 19 tetrasporatebasidia with developing basidiospores, 20 basidiospores

Fig.21 Tribal women selling *Russula* species in local market at Bajag in Dindori, Madhya Pradesh along with other mushroom (*Astraeus hygrometricus*)
Lamellaeadnate, white turning grayish black to black on handling, more or less crowded with lamellulae of different lengths, with plenty of bifurcations; edge smooth, entire. Context white up to 5mm thick. Discolouring blackish on exposure, heteromerous with nests of sphaerocytes. Stipe 3-6-5cm x 9-17mm central, equal, solid; surface chalky white, turning black when handled. Annulus absent. Odour not distinctive. Spores 5-8 x 3-5 µm, subglobose to broadly ovoid ornamentation hardly up to 0.4 µm high small to medium sized warts and thick and fine ridges are connected to form a partial reticulum; Suprahilar phage inamyloid. Basidioclavate, 24-26 x 4-6µm, tetrasporate. Lamella-edge sterile with macrocystidia and leptocystidia. Macrocystidia 26-29 x 5-10µm, cylindric, thin-walled with refractive contents, concentrated near tip. Pleurocystidia abundant 27-55 x 4-7µm subcylindric with capitate apices or round with 2 or 3 sub-apical constrictions, at times curved with scarcely visible contents, projecting prominently beyond the hymenium, very abundant. Subhymenium pseudoparenchymatous, hymenophoral trama heteromorphous with sphaerocytes.

**Collection examined**

Mycorrhizal on sal, Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh, 24/07/2012, Mycology Herbarium, Tropical Forest Research Institute, Jabalpur, TF 2787.

**Russula** mushrooms distributd in different states of India are presented in Table 1. Total 124 species were recorded from 13 states. States-wise status of species is presented in Table 2. Edible species are presented in Table 3.

**Russula adusta**formed mycorrhizal association with sal (*Shorearobusta Gaertn.*). Its ectomycorrhizal association were reported in trees like, *Hopeaponga, H. parviflora, Myristicamalabarica, Vateriaindica, and Diospyrosmalabarica.* The species is distributed at different places in India: Kailana, Chakrata, Lohaghat, Mayawati, Jageshwar and Champawatin Uttarakhand (Saini and Atri 1984; Atri and Saini 1990b); Malappuram, Thiruvananthapuram in Kerala (Pradeep and Vrinda, 2010; Mohanan, 2011, 2014) and Mangalore in Karnataka (Pavithra et al., 2017). In the present study it is being reported from Amarkantak-Achanakmar Biosphere Reserve in Madhya Pradesh and Chhattisgarh, India.

**Russula cinerella** is being reported mycorrhizal with sal from Amarkantak-Achanakmar Biosphere Reserve, Madhya Pradesh and Chhattisgarh. It was also reported from Wayanad, Kerala growing solitary or scattered in large groups on soil under *Hopeaparviflora, Vateriaindica, and Diospyrosmalabarica* (Mohanan, 2011; 2014). The species is also reported to be distributed in Madagascar (Patouillard, 1924).

**Russula congoana** and **R. delicula** form ectomycorrhizal asocoiarion with sal (*Shorearobusta Gaertn.*). **R. congoana** has worldwide distribution. It was earlier recorded from moist deciduous forests of India from Mussoorie, Uttarakhand (Sarwal 1984) and Ernakulam, Kollam, Malappuram, Wayanad and Thiruvananthapuram, Kerala. It is also distributed in moist-deciduous to evergreen forests and occurs solitary or scattered on soil under *Hopeaponga, H. parviflora, Myristica malabarica, Vateriaindica, and Diospyrosmalabarica* forming an ectomycorrhizal association. The species can be easily recognized by distinct pastel red pileus and the heavy ornamented the spores. It is an edible species (Pradeep and Vrinda 2010; Varghese et al., 2010;
Mohanan 2011, 2014). *R. deliculais* widely distributed in moist deciduous forests of India and reported from Thiruvananthapuram and Wayanad, Kerala (Pradeep and Vrinda 2010; Mohanan 2011, 2014). *Russula leelavathyi* has worldwide distribution in North America, Europe and moist deciduous forests of India it was reported growing on sandy soil and was associated with *Hopeaparviflora* from Thiruvananthapuram, Malappuram and Wayanad, Kerala (Pradeep and Vrinda 2007, 2010; Mohanan 2011, 2014). In the present study it was also recorded from Amarkantaka-Achanakmarsal forest of Chhattisgarh and Madhya Pradesh.

*Russula michiganensis* is recorded on sal forest from Amarkantaka-Achanakmarsal forest of Chhattisgarh and Madhya Pradesh. Earlier the species was recorded from moist deciduous forests of India forming ectomycorrhizal association with *Hopea ponga*, *H. parviflora*, *Vateria indica* and *Diospyros malabarica* in Wayanad and Ernakulam, Kerala (Mohanan 2014). This mushroom has worldwide distribution. *Russula senecis*, an edible mushroom grows in association with *Vateria indica* plants among the dipterocarp forests of Western Ghats (Natarajan et al., 2005), and in mixed forests in Sikkim (Das, 2009; Das et al., 2010) is collected from forests and sold in West Bengal (Khatua et al., 2015)

Many of *Russula* species are edible. *Russula crustosais* an edible mushroom reported from Shimla, Himachal Pradesh (Bhatt and Lakhanpal 1988a). *R. luteais* another edible mushroom growing in association with *Cedrus deodara*, *Picea smithiana*, *Pinus walitiana*, *Quercus cinoxifera* and *Rhododendron arboreum* in Shimla and lower Shiwalik Hills of Uttarakhand (Bhatt and Lakhanpal 1988b), another edible mushroom, *R. lepida* was recorded on humicoolous soil from sal forests (Semwal et al., 2014). Other edible species include *R. olivacea* and *R. parvovirescens* growing in pine forest at Shillong in Meghalaya (Kalita et al., 2016). *R. senecis* collected by tribes in West Bengal (Khatua et al., 2015).

In the present study out of six species reported some species for example, *R. congoana* collected from sal forest of Chhattisgarh and Madhya Pradesh are also edible, these mushrooms were collected by the local tribal people and sold in local market (Figure 21).

Mushrooms belong to genus *Russula* are widely distributed in India. 124 species of the genus are listed from 13 states. Uttarakhand represent the maximum diversity of *Russula* species and over 40% species recorded from this state only. Six species namely: *Russula adusta*, *R. cinerella*, *R. congoana*, *R. delicula*, *R. leelavathyi* and *R. michiganensis* are described occurring in sal forest of central India. These fungi form ectomycorrhizal association with sal trees and some edible species are also collected by the local people and sold in the local market.

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