

THE GENUS *LACTARIUS* IN INDIA

KANAD DAS AND J.R. SHARMA

Botanical Survey of India, 192 Kaulagarh Road, Dehradun - 248 195

A B S T R A C T

The genus *Lactarius* (family Russulaceae) is presently known by 56 species and 12 varieties from India. Based on a thorough survey of Himalayan forests and the reports by earlier workers, a detailed distribution, associated trees and the colour of the latex both before and after the exposure is presented for all the Indian taxa.

INTRODUCTION

The genus *Lactarius* Pers. ex S.F. Gray belongs to the family Russulaceae which encompasses the most beautiful agaric flora almost in all climatic zones in India. Besides *Lactarius*, the family is represented only by the genus *Russula* Pers. ex S.F. Gray. The present genus, characterized by soft chalky brittle non fibrous basidiocarps, heteromerous pilear trama with sphaerocysts, clampless hyphae and whitish spore print, is separated in the field from the genus *Russula* by the presence of latex. Ecologically the genus can be categorized into 3 broad groups, viz. (a) Ectomycorrhizal : growing symbiotically with forest trees. More than 90% of *Lactarius* species belong to this group; (b) Lignicolous : growing on dead rotten woods; (c) Soil-saprophytic : growing on the organic matters of the soil.

Some species like *L. deliciosus*, *L. subdulcis*, *L. sanguifluus*, *L. hygrophoroides*, *L. volemus* are edible all over the world, while a few like *L. piperatus*, *L. helvus*, *L. torminus* are poisonous.

REVIEW OF LITERATURE

History of the genus *Lactarius* dates back to 1797, with the establishment of the genus *Lactaria* (orthographic variant of current *Lactarius*) by Persoon and was followed by the publication of "Systema Mycologicum", Vol.-1 by E. Fries in 1821 (the same year when S.F. Gray published *Lactarius* as a genus). Some other remarkable contributions on

the genus *Lactarius* were given by Peck (1872, 1885); Burlingham (1908, 1910a & b); Coker (1918); Murrill (1948); Hesler & Smith (1960 a & b) and Singer (1962). Recently, a detailed systematic analysis of the present taxon has been done by Hesler and Smith (1979); Verbeken (1996, 1998 a & b, 2000); Verbeken & *al.* (2000) and Heilmann-Clausen & *al.* (1998).

In India, Berkeley (1851, 1854) reported a number of Agarics including 5 species of *Lactarius* collected particularly from Eastern Himalayas by Hooker and Thomson during their expedition to Sikkim and Khassya mountains (1849-1850). His work was followed by Sharma & *al.* (1978); Kumar & *al.* (1979); Watling and Gregory (1980); Abraham & *al.* (1980, 1981); Abraham and Kaul (1985); Saini and Atri (1982, 1984, 1990); Rawla and Sarwal (1983); Atri and Saini (1986, 1988); Lakhanpal & *al.* (1987); Bhatt and Lakhanpal (1990); Atri & *al.* (1991 a & b, 1993); Rawla (1994); Bhatt & *al.* (1999, 2000); Sharma and Das (2001, 2002) and Das and Sharma (2001).

METHODOLOGY

Specimens were collected following Læssøe and Conte (1996) during surveys, each of 15-25 days duration to different forests types in Himalaya. Field notes, chemical tests and collection of spore prints were completed with fresh specimens in the field (Largent & *al.* 1977). All the possible mycorrhizal hosts for each species were recorded by establishing the link between the basidiocarps and the roots of host trees. The frequency of occurrence of individual species in major forest communities like deciduous, coniferous and mixed forests was also recorded.

Specimens were preserved in wet (alcohol-formalin) as well as in dry condition. Microscopic characterization was carried out using 3% KOH, Lactophenol-cotton blue, Carbol Fuchsin, Ferrous sulphate, and Melzer's reagent. Identifications were based on Hesler and Smith (1979) and Heilmann-Clausen & *al.* (1998). Specimens were submitted to the Cryptogamic Herbarium, Botanical Survey of India, Northern Circle (BSD), Herbarium of Laboratory of Plant Systematics, State University of Gent, Belgium (GENT).

Distribution of all the known species of *Lactarius* is given below (Table - I). Species marked with '*' are collected and studied thoroughly by the authors themselves and those with '**' are reported by the authors for the first time from India. The characters of five



Plate - I. (a-f) : Basidiocarps : a. *Lactarius zonarius* var. *zonarius*; b. *L. subvellereus* var. *subdistans*; c. *L. hygrophoroides* var. *odoratus*; d. *L. zonarius* var. *riparius*; e. *L. volemus* var. *flavus*; f. *L. corrugis*.

Distribution of the Reported Species of LACTARIUS from India

Name	Distribution	Associated trees	Latex
<i>Lactarius allardii</i> Coker	Chamba, Himachal Pradesh (H.P.) [5-6500 ft]	<i>Quercus leucotrichophora</i> A. Camus	White, unchanging.
<i>L. alnicola</i> var. <i>alnicola</i> A.H. Smith	Dehradun, Uttaranchal (U.C.) [6-7000 ft]	<i>Quercus semecarpifolia</i> Sm.	White, turning brilliant yellow on exposure.
<i>L. angustifolius</i>	Batote, Jammu & Kashmir (J & K) [4500-7000 ft]	<i>Cedrus deodara</i> Loud, <i>Pinus wallichiana</i> Jack.	White, unchanging.
<i>L. aurantiacus</i> Fr.	Solan (H.P.) [4-5000 ft]	<i>Quercus</i> sp.	White, unchanging.
<i>L. aurantiovirens</i> Bhatt & Lakhanpal	Shimla (H.P.) [7-7500 ft]	<i>Q. leucotrichophora</i> , <i>Rhododendron arboreum</i> Sm.	White, turning brown- orange on exposure.
<i>L. barrowsii</i> Hesler & Smith	Kullu (H.P.) [4-5000 ft]	Not known	Dark red, unchanging.
* <i>L. camphoratus</i> (Bull. ex Fr.) Fr.	Shimla (H.P.); Chamoli, Bageswar (U.C.) [6-9500 ft]	<i>Q. leucotrichophora</i> , <i>Q. semecarpifolia</i> , <i>P. wallichiana</i> , <i>C. deodara</i> , <i>R. arboreum</i> Sm.	White, unchanging.
<i>L. cillicioides</i> Fr.	Delhi	On grassy ground.	White, turning lilac.
<i>L. controversus</i> (Fr. ex Fr.) Fr.	Kashmir (J & K) [7-10000 ft]	<i>Salix alba</i> Linn.	White, unchanging.
* <i>L. corrugis</i> Peck	Tehri, Pauri, Pithoragarh (U.C.); Shimla, (H.P.) [5-7000 ft]	<i>Q. leucotrichophora</i> , <i>R. arboreum</i>	White, unchanging.
<i>L. deliciosus</i> var. <i>areolatus</i> A.H. Smith	Chamba (H.P.) [5-6500 ft]	Open grassy lawn.	Carrot orange, unchanging.
* <i>L. deliciosus</i> var. <i>deliciosus</i> (Fr.) S.F. Gray	Pauri, Dehradun (U.C.); North Sikkim [5500-9000 ft]	<i>Q. semecarpifolia</i> , <i>Abies pindrow</i> Spach., <i>Picea smithiana</i> (Wall.) Boiss	Deep orange, turning greenish on exposure.

Name	Distribution	Associated trees	Latex
<i>L. deliciosus</i> var. <i>indica</i> Atri et al.	Chamba (H.P.) [5-6500 ft]	<i>C. deodara</i>	Carrot orange, unchanging.
<i>L. deliciosus</i> var. <i>olivaceosordidus</i> Hesler & Smith	Chamba (H.P.) [5-6500 ft]	<i>P. smithiana</i> , <i>C. deodara</i> , <i>Q. leucotrichophora</i>	Carrot orange, unchanging.
* <i>L. deterrimus</i> Gröger	Gulmarg (J & K); Bageswar (U.C.) [8-10000 ft]	<i>P. smithiana</i> , <i>Q. semecarpifolia</i> Sm., Lignicolous with <i>Q. semecarpifolia</i>	Reddish orange, unchanging.
<i>L. fuliginosus</i> (Fr.) Fr.	Shimla (H.P.); Pauri (U.C.) and Gulmarg (J & K) [5500-9000 ft]	<i>Q. leucotrichophora</i> , <i>P. smithiana</i>	White, turning pink.
<i>L. fumosus</i> var. <i>fumosus</i> Peck	Kullu (H.P.) [4-5000 ft]	Not known	White, unchanging.
** <i>L. gerardii</i> Peck var. <i>surubescens</i> (Smith & Hesler) Hesler & Smith	Pithoragarh (U.C.) [7-8500 ft]	<i>Q. leucotrichophora</i>	White, turning slowly light greenish to brilliant yellow.
<i>L. himalayana</i> Rawla & Sarwal	Mussoorie (U.C.) [6-7000 ft]	<i>Q. leucotrichophora</i>	Transparent
<i>L. hygrophoroides</i> var. <i>hygrophoroides</i> Berk. & Curt.	Chamoli, Pauri, Pithoragarh (U.C.) Shimla (H.P.) [5500-7000 ft]	<i>Q. leucotrichophora</i> , <i>R. arboreum</i>	White, unchanging.
* <i>L. hygrophoroides</i> var. <i>lavendulaceus</i> Hesler & Smith	Bageswar, Pithoragarh, Tehri, Pauri, (U.C.) [5-7000 ft]	<i>Q. leucotrichophora</i> , <i>R. arboreum</i>	White, unchanging.
* <i>L. hygrophoroides</i> var. <i>odoratus</i> Hesler & Smith	Pithoragarh, Pauri, (U.C.) [5-7000 ft]	<i>Q. leucotrichophora</i> , <i>Q. semecarpifolia</i>	White, unchanging.
<i>L. hygrophoroides</i> var. <i>rugatus</i> Hesler & Smith	Pauri (U.C.) [5-7000 ft]	<i>P. wallichiana</i> , <i>Q. leucotrichophora</i>	White, unchanging.

Name	Distribution	Associated trees	Latex
<i>L. indica</i> Bhatt & Lakhanpal	Shimla (H.P.) [6500-8000 ft]	<i>Q. leucotrichophora</i> , <i>P. wallichiana</i>	White, unchanging.
** <i>L. indigo</i> var. <i>indigo</i> (Schw.) Fr.	Pauri, Tehri, (U.C.) [5500-7000 ft]	<i>Q. leucotrichophora</i> , <i>R. arboreum</i> , <i>Myrica esculenta</i> Buch.-Ham. ex D. Don	Deep indigo blue, turning dark greenish.
<i>L. insulsus</i> Fr.	Solan (H.P.) [5000 ft]	<i>Quercus</i> sp.	White, unchanging.
<i>L. lignyotellus</i> Smith & Hesler	Shimla (H.P.) [6-7000 ft]	Not known.	White, unchanging.
<i>L. lutescens</i> Bhatt & Lakhanpal	Shimla (H.P.) [6-7000 ft]	<i>Q. leucotrichophora</i> , <i>P. roxburghii</i>	White, turning pale red on exposure.
<i>L. pallidus</i> Fr.	Solan (H.P.) [5000 ft]	Coniferous trees	White, turning cream colour.
<i>L. paradoxus</i>	Dehradun (U.C.) [6-7500 ft]	<i>P. smithiana</i> , <i>A. pindrow</i> and <i>Q. semecarpifolia</i>	Dark vinaceous-brown ("sorghum brown"), unchanging.
<i>L. peglerius</i> Rawla	Dehradun (U.C.) [6500-8000 ft]	Not known.	White, turning ochereous on exposure.
** <i>L. picinus</i> Fr.	Almora (U.C.) [5000-6500 ft]	<i>Q. leucotrichophora</i>	White, unchanging.
* <i>L. piperatus</i> var. <i>glaucescens</i> (Crossl.) Hesler & Smith	Almora, Pithoragarh (U.C.) [5-6500 ft]	<i>Q. leucotrichophora</i> , <i>P. roxburghii</i> Sargent	White, turning pale green.
* <i>L. piperatus</i> var. <i>piperatus</i> (Fr.) S.F. Gray	Pauri, Dehradun, Pithoragarh (U.C.); Shimla (H.P.) [5-7000 ft]	<i>C. deodara</i> , <i>Q. leucotrichophora</i> , <i>R. arboreum</i> , <i>Q. dilatata</i> Lindl., <i>P. smithiana</i>	White, turning yellow.
<i>L. princeps</i> Berk.	Khassya Hills, (Meghalaya) [5-6000 ft]	<i>Quercus</i> sp.	White, unchanging.

Name	Distribution	Associated trees	Latex
<i>L. proximellus</i> Beards. & Burl.	Chamba (H.P.) [5500-6500 ft]	<i>Q. leucotrichophora</i>	White, unchanging.
<i>L. pseudoaspideus</i> Hesler & Smith	Dehradun (U.C.) [6-7000 ft]	<i>Q. leucotrichophora</i> , <i>R. arboreum</i>	White, unchanging.
<i>L. pubescens</i> Fr.	Gulmarg (J & K) [8-9000 ft]	<i>Betula</i> sp.	White, unchanging.
<i>L. pudicus</i> Bhatt & Lakhanpal	Shimla (H.P.) [7-8000 ft]	<i>C. deodara</i> , <i>P. roxburghii</i>	White, unchanging.
** <i>L. rubrifluus</i> Gillet	Tehri (U.C.) [5-5500 ft]	<i>P. wallichiana</i>	Dark to deep red, unchanging.
<i>L. rufus</i> (Scop. ex Fr.) Fr.	Bankura, (West Bengal)	<i>Shorea robusta</i> Roxb. ex Gaertn.f.	White, unchanging.
<i>L. sanguifluus</i> Fr.	Shimla (H.P.) [4-5500 ft]	Mixed coniferous forest, under the fern <i>Onychium contiguum</i>	Deep red to purplish red, unchanging.
<i>L. sanmiguelensis</i> Hesler & Smith	Sirmour, (H.P.) [4-5000 ft]	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	White, unchanging.
<i>L. scrobiculatus</i> var. <i>canadensis</i> (Smith) Hesler & Smith	Gulmarg, Pahalgam (J&K) [6500-10000 ft]	<i>A. pindrow</i> , <i>P. smithiana</i>	White, turning yellowish on exposure.
<i>L. scrobiculatus</i> var. <i>scrobiculatus</i>	Gulmarg, (J&K) [6500-8000 ft]	<i>P. smithiana</i> , <i>P. wallichiana</i>	White, sulphur- yellow on exposure.
<i>L. serifluus</i> (Fr.) Fr.	Sirmour (H.P.); Chamoli (U.C.) [8-9000 ft]	<i>Q. leucotrichophora</i>	Watery, unchanging.
<i>L. stramineus</i> Berk.	Khasya Hills, (Meghalaya) [5-6000 ft]	<i>Pinus</i> sp.	White, unchanging.
<i>L. subdulcis</i> (Fr.) S.F. Gray	Pauri, (U.C.); Sikkim [5-7000 ft]	<i>M. esculenta</i> , <i>Q. leucotrichophora</i> , <i>R. arboreum</i>	White, unchanging.

Name	Distribution	Associated trees	Latex
<i>L. subgerardii</i> Hesler & Smith	Chamba (H.P.) [5-7000 ft]	Not known.	White, unchanging.
<i>L. subisabellinus</i> var. <i>murrillianus</i> (Smith & Hesler) Hesler & Smith	Chamba (H.P.); Dehradun, Nainital (U.C.) [5-7500 ft]	<i>Q. leucotrichophora</i> , <i>Q. semecarpifolia</i> , <i>R. arboreum</i> ,	White, unchanging.
<i>L. subisabellinus</i> var. <i>subisabellinus</i> Murrill	Sirmour (H.P.) [4-5000 ft]	<i>Q. incana</i>	White, unchanging.
<i>L. subpiperatus</i> Hongo	Chamba (H.P.) [5-7000 ft]	Not known.	White, unchanging.
<i>L. subpurpureus</i> Peck	Gulmarg, Phalgam, (J & K); Dehradun (U.C.) [6500-10000 ft]	<i>P. smithiana</i> , <i>P. wallichiana</i> , <i>C. deodara</i> , <i>A. pindrow</i>	Violet brown, unchanging.
** <i>L. subvellerus</i> Peck var. <i>subdistans</i> Hesler & Smith	Pithoragarh (U.C.) [5-6000 ft]	<i>Q. leucotrichophora</i>	White, turning slowly light greenish to brilliant yellow.
<i>L. subvernalis</i> var. <i>albo-ochraceus</i> (Hesler & Smith) Hesler & Smith	Chamba (H.P.) [5-6500 ft]	<i>Q. leucotrichophora</i>	White, turning pink on exposure.
<i>L. subvernalis</i> Hesler & Smith var. <i>himalayensis</i> Atri & al.	Shimla (H.P.) [8-10000 ft]	<i>P. wallichiana</i>	White, turns quickly to carrot red on exposure.
<i>L. uvidus</i> (Fr. ex (Fr.) Fr.	Kashmir (J & K) [5000-6500 ft]	<i>S. alba</i>	Whey colour, turning violet.
<i>L. vellerus</i> Fr.: Fr.) Fr.	Sikkim; Khassya Hills (Meghalaya) [5-6500 ft]	<i>Abies</i> sp.	White, unchanging.
* <i>L. volemus</i> var. <i>flavus</i> Hesler & Smith	Pithoragarh, Bageswar, Dehradun Pauri (U.C.) [4-7000 ft]	<i>P. roxburghii</i> , <i>Q. leucotrichophora</i>	White, unchanging.

Name	Distribution	Associated trees	Latex
* <i>L. volemus</i> var. <i>volemus</i> (Fr.) Fr.	Shimla (H.P.); Pithoragarh, Pauri (U.C.) [5-7500 ft]	<i>Q. leucotrichophora</i> , <i>C. deodara</i>	White, unchanging.
<i>L. yazooensis</i> Hesler & Smith	Dehradun [6-7000 ft]	<i>Q. leucotrichophora</i>	White, unchanging.
* <i>L. zonarius</i> var. <i>riparius</i> Hesler & Smith	Pauri (U.C.) [5-7000 ft]	<i>Lyonia ovalifolia</i> (Wallich) Drude, <i>M. esculenta</i> , <i>Q. leucotrichophora</i> , <i>R. arboreum</i>	White, unchanging.
<i>L. zonarius</i> var. <i>zonarius</i> (Bull. ex St-Amans) Fr.	Shimla, Chamba (H.P.); Pauri (U.C.) [5-7000 ft]	<i>Q. leucotrichophora</i>	White, unchanging.
* <i>Lactarius</i> sp.1. (KD1065)	Bageswar (U.C.) [9-10000 ft]	<i>Q. semecarpifolia</i>	White, unchanging.
* <i>Lactarius</i> sp.2. (KD4030)	Pithoragarh (U.C.) [5-6000 ft]	<i>Q. leucotrichophora</i>	White, turning lemmon yellow.
* <i>Lactarius</i> sp.3. (KD612)	Pauri (U.C.) [5-6000 ft]	<i>Q. leucotrichophora</i>	White, turning lemmon yellow.
* <i>Lactarius</i> sp.4. (KD2021)	Chamoli (U.C.) [5-7000 ft]	<i>Q. leucotrichophora</i>	White, turning lemmon yellow.
* <i>Lactarius</i> sp.5. (KD3081, 4001)	Tehri, Pithoragarh (U.C.) [5-6000 ft]	<i>C. deodara</i>	White, unchanging.

species mentioned at the end do not match with any known species of the genus reported till date. These species are treated here provisionally and are under investigation.

DISCUSSION

Different types of Himalayan forests covering the full range of habitats were investigated for the past few years to estimate the Russulacean wealth particularly the genus *Lactarius*. It has been observed that the present genus strongly dominate the mycoflora and usually appears 10-15 days after the first shower of the monsoon rains and grow up to pre winter season.

However, the best growing period is June to October. Most of the species prefer to form the ectomycorrhizal associations with species of *Quercus*, *Pinus*, *Cedrus*, *Picea*, *Abies*, *Rhododendron*, *Lyonia*, *Salix* and *Myrica*.

Based on the observations made by authors in the field coupled with the reports by the earlier workers, it appears that *L. camphorates*, *L. piperatus*, *L. volemus*, *L. hygrophoroides* strongly dominate whereas *L. picinus*, *L. gerardii*, *L. deterrimus* are rare. Out of a total of 68 taxa (56 species and 12 varieties so far known from India, 34 prefer deciduous, 13 prefer coniferous and only 13 grow in both types of forests, while only 2 grow in grassy grounds. In the tropics this genus is much reduced. In contrast to tropical areas, Himalayan temperate forests were found to have more variations probably because of the presence of oaks being the well known mycorrhizal hosts.

Keeping in view of the vast area of Indian subcontinent, presence of plenty of mycorrhizal hosts, favourable ecological conditions, the reported numbers of *Lactarius* species appear to be quite less. Further, many of the reported species have not been thoroughly worked out and their taxonomic circumscription is still not known completely. In spite of being ecologically and economically important, there is no good consolidated systematic account available on the Indian *Lactarius*. A continuous survey and study only can fill these gap areas. Further, like *Russula* (Singh & Lakhanpal 2000), *Lactarius* should be introduced in mycorrhizal biotechnology in the forest nurseries to get the significant growth and development of seedlings of important forest trees.

ACKNOWLEDGEMENTS

Authors are thankful to the Director, Botanical Survey of India, Kolkata and Joint Director, Northern Circle for providing facilities. Financial help by BSI to one of the authors (KD) is gratefully acknowledged. Thanks are also due to Prof. A. Verbeken, University of Gent, Belgium for supplying valuable literature and providing identification help.

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