such as the Western Ghats, which is consid-
ered to be a hotspot of biodiversity.


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Diversity in ectomycorrhizal fungi of a dipterocarp forest in Western Ghats

According to Gadgil\(^1\), biological diversity in the Western Ghats faces threats due to the exploitation of its habitat. Inventorying and monitoring of the biological diversity of the Western Ghats is therefore an important challenge before the community of systematists, biogeographers and ecologists in India. Fieldwork, which forms the basis of this correspondence, was carried out largely in the Uppangala Reserve Forest, Western Ghats region, Karnataka, India. The Uppangala forest is situated in Kadamakkal Reserve Forest (Kodagu district) in the foothills of the Ghats and lies at 12°30’N, 75°39’W at an altitude of 500–600 m amsl. Floristically, it belongs to the low elevation *Dipterocarpus indicus* – *Kingiodendron pinnatum* – *Humboldtia brunonis* type of wet evergreen forests. One of the main plots where extensive collections have been made during two seasons (June 2001 to May–June, 2002) consists mainly of trees belonging to the family Dipterocarpaceae, viz. *D. indicus* and *Vateria indica*. In the surrounding areas, other dipterocarp trees such as *Hopea parviflora* and *Hopea pongo* are dominant.

Genera belonging to the Dipterocarpaceae are predominantly ectomycorrhizal. Dipterocarps were thought to dominate extensively throughout South East Asia. Watling and Lee\(^2\) have reported over 20 different agrics and boleti, four earth balls and a new species of *Pisolithus*, which were found associated with dipterocarps in Malaysia. The dominant fungi were species of *Amanita*, *Boletus* and *Russula*, with members of Russulaceae being most numerous. Species belonging to the genus *Amanita* and the families Russulaceae, Boletaceae and Sclerodermataceae have also been reported as mycorrhizal associates of dipterocarps in Malaysia\(^3\)–\(^5\). The same genera were also found to be associated with dipterocarps in Indonesia\(^6\)–\(^7\). Similarly, many ectomycorrhizal fungal species associated with dipterocarps have been reported from Philippines\(^8\), Thailand\(^9\), Sri Lanka\(^10\) and Indonesia\(^11\). Recently Thomas et al.\(^11\) have reported a new genus *Anamika*, with the species *A. indica* under *Hopea* sp. in Wayanad District, India.

In the present study, many ectomycorrhizal fungal species were found to be associated with the dominant tree species in the Uppangala area, such as *D. indicus*, *V. indica* and *H. parviflora* (Table 1).

It is seen from Table 1 that majority of fungi collected in the present study were found to be associated with *V. indica* followed by *D. indicus*. Only two species were found to be associated with *H. parviflora*. As in the other South East Asian countries, species of *Amanita* and *Russula* were found to be dominant, with members of the Russulaceae being numerous. The genus *Russula* is represented by twelve species and the genus *Amanita* by five species (Figure 1).

Since this is mainly a study on fungal biodiversity, no attempt has been made to collect root samples with a view to study the ectomycorrhizal types in the above-mentioned tree species. In earlier studies in India\(^12\)–\(^13\), the ectomycorrhizal types in the roots of *Shorea robusta*, *D. indicus*, *H. parviflora* and *V. indica* had been investigated. However, the fungi involved in these roots are not known. In an extensive study on the ectomycorrhizas of *Shorea leprosula* occurring in Malaysia in FRIM, Kepong in the state of Selanangor, Lee et al.\(^15\) have reported 24 ectomycorrhizal types from seedlings and 20-year-old trees. The dominant ectomycorrhizal type was formed by the members of Russulaceae. They have also collected fungal fruting bodies under adult *S. leprosula* in various parts of peninsular Malaysia over a period of three years. Among the 28 species of putative ectomycorrhizal fungi collected, fifteen were members of Russulaceae. It

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*Note: The text contains references and a table that are not transcribed here.*

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Figure 1. a, A. antillana; b, Amanita tax sp.; c, A. cinerea; d, A. vaginata; e, A. hemibapha var. cystidiosa; f, Suillus tax sp. 1; g, Suillus tax sp. 2; h, Russula variegatula; i, R. rosea; j, R. azurea; k, R. xericeis; l, R. amoena; m, R. pseudodelica; n, R. albomarga; o, R. pectinata; p, R. pectinatoides; q, R. emeticella; r, R. subfoetens; s, R. delica var. puta; t, Laccaria bicolor; u, L. tetraspora var. aberrans; v, Strobilomyces mollis; w, Anamika indica; x, Cortinarius caniculus; y, Pisolithus indicus.
Table 1. Ectomycorrhizal fungal species associated with dominant tree species in Uppangala forest

<table>
<thead>
<tr>
<th>Vateria indica</th>
<th>Diplocarpos indicus Bedd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricholomataceae</td>
<td>Amanitaceae</td>
</tr>
<tr>
<td>Laccaria bicolor</td>
<td>Amanita cinerea</td>
</tr>
<tr>
<td>L. tetraspora var. aberrans</td>
<td>A. vaginata</td>
</tr>
<tr>
<td>Amanitaceae</td>
<td>Amanita tax. sp.</td>
</tr>
<tr>
<td>Amanita hemibapha var. cystidiosa</td>
<td>Cortinariaceae</td>
</tr>
<tr>
<td>A. antillana</td>
<td>Astrosporina calospora</td>
</tr>
<tr>
<td>Boletaceae</td>
<td>A. avellana</td>
</tr>
<tr>
<td>Suillus tax. sp 1</td>
<td>A. amygdalina</td>
</tr>
<tr>
<td>Suillus tax. sp 2</td>
<td>Boletaceae</td>
</tr>
<tr>
<td>Russulaceae</td>
<td>Stroblomycetes mollis</td>
</tr>
<tr>
<td>Russula pectinatoides</td>
<td>Russulaceae</td>
</tr>
<tr>
<td>R. amoena</td>
<td>R. rosea</td>
</tr>
<tr>
<td>R. delica var. puta</td>
<td>R. variegatula</td>
</tr>
<tr>
<td>R. subfoetens</td>
<td>R. pseudodelica</td>
</tr>
<tr>
<td>R. pectinata</td>
<td>Hopea parviflora Bedd</td>
</tr>
<tr>
<td>R. emeticella</td>
<td>Cortinariaceae</td>
</tr>
<tr>
<td>R. albongriva</td>
<td>Anamika indica</td>
</tr>
<tr>
<td>R. azurea</td>
<td>Cortinarius causticus</td>
</tr>
<tr>
<td>R. senecis</td>
<td>Sclerodermaeaceae</td>
</tr>
<tr>
<td>Pisolithus indicus</td>
<td></td>
</tr>
</tbody>
</table>

is also interesting to find that most of the Russula species identified belonged to the section Foetentinae, Heterophylinae, Ingratae and Nigricaninae, as found in the Uppangala collections. Species like R. senecis and R. pectinata were found in Uppangala as in Malaysia. The biodiversity of putative ectomycorrhizal fungi associated with dipterocarps occurring in the Uppangala forest in the Western Ghats, Karnataka differs considerably with that of the fungi associated with Pinus patula plantations in the Nilgiris hills of the Western Ghats. Natarajan et al.6 have shown that there is a distinct flora of limited number of fungi occurring in these plantations. They also found that there is a distinct pattern of succession of fungi in the young (3–7 years) and old plantations (11–17 years). The genera and species of fungi were quite different from those that occur in Uppangala. Compared to the P. patula plantations, members of species of fungi that occur in the Uppangala forest are different, with species of Russula and Amanita being more dominant. Several new species belonging to the genera Amanita, Suillus and Pisolithus have been collected in the present study. The discovery of a new species of Pisolithus, viz. P. indicus is noteworthy since species of the genus associated with dipterocarps in other South East Asian countries are different from those occurring in Uppangala. Further studies on ectomycorrhizal fungal types in dipterocarp roots and culturing of the various species of fungi will aid in identifying suitable ectomycorrhizal fungi for inoculating dipterocarp seedlings for outplanting.


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