PART II

ECOLOGICAL STUDIES
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The boletes generally appear during the rainy season. Simla and adjoining areas, explored in the present studies for boletes, experience rains usually from June to September. An attempt was made to study the seasonal distribution of Boletaceae in this area over a period of five years (1975-79). The methods followed were of Slipp and Snell (1944); Binnyamini and Avizohar-Hershenzon (1973) and Kallio and Heikkilä (1978). For the purpose of observations, three forests with different topography and vegetation were selected. These forests are: Taradevi, Glen and Narkanda. Taradevi forest lies in the outer ranges of Simla, the Glen is in Simla proper whereas the Narkanda forest lies in the interior ranges.

These forests exhibit different floristic zones. In different zones, the flora of the climax association is fairly distinct. This feature has long been recognized with regard to the higher plants and it is one of the aims of this investigation to determine whether or not the boleti are similarly limited to specific plant associations. The species of fungi in these forests have been found to exhibit such a distributional pattern that many of them appear to be confined to a particular association. With the limited number of observations and collections, the element of chance cannot be ignored but observations in the Boletaceae are abundantly supplemented by similar sociological behaviour of local species of the Agaricaceae, the majority of which
likewise appear to be limited to single association.

**Procedure**

The observations on the appearance of boletes, in these forests were made every year during the rainy season continuously for five years, i.e. 1975-1979. The forests were visited almost every third day (except Narkanda, which was visited weekly/fortnightly) and observations were made considering the following parameters:

(i) In the first year, the specific sites were marked where fructifications of different species of boletes appeared. The same sites were visited subsequently for three rainy seasons to find out whether or not these species appeared again on these specific sites.

(ii) The observations were also made on the time and duration of appearance of the species and their distribution in particular forest-zone/s and also on their sequence of appearance or succession.

(iii) On the basis of frequency occurrence, the species were classified as abundant, frequent, common and rare (those observed only once).

(iv) Many boletes are known to form mycorrhizal associations with higher plants. The mycorrhizal associations of different boletes were demonstrated by tracing mycelial connections between fruiting bodies and associated trees (Young, 1936, 1940; Rayner, 1934; How, 1940, 1941, 1942; Zak, 1971, 1973 and others).
Observations and Zonations

A brief account of zonations and vegetation in these forests is given below following Champion and Seth (1968) and Collett (1902).

Taradevi Forest: The Taradevi forest has been divided into three altitudinal zones, each named after the dominating species in the climax association; the Pinus-zone (Pinus excelsa); the Quercus-zone (Quercus incana, Q. dilatata and Q. semicarpifolia) and the Quercus-Rhododendron-zone (Q. semicarpifolia and Rhododendron spp.). The first zone extends approximately from 1800 - 1900 m M.S.L. and occupies the lower exposed dry sites on the North-West slopes constituting a climax in which topography appears to be the controlling factor. The second zone (Quercus-zone) extends approximately from 1900 - 2100 m M.S.L. and occupies greater part of the forest area. The third zone (Quercus-Rhododendron) occupies higher ridges usually above 2100 m elevation and more open glades of this zone are filled with a few stunted bushes of Quercus semicarpifolia, Rhododendron lepidotum and R. arboreum.

Although, the three zones are altitudinal in their sequence yet their limits in terms of elevation above sea level overlap greatly. Frequently, isolated segments or elevations of Quercus-zone occur even as high as lower limits of the upper Quercus-Rhododendron-zone and also intergrade with the lower zone where the slope and exposure render the
site too severe to support *Quercus* spp. The distribution
pattern of boletes in each zone is given in the Table No.I.

<table>
<thead>
<tr>
<th>Abundant</th>
<th><em>S. granulatus</em></th>
<th><em>S. mollis</em></th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>G. castaneus</em></td>
<td><em>S. floccopus</em></td>
<td><em>Boletus</em> sp.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>B. queletii</em></td>
<td><em>Boletus</em> sp.29</td>
</tr>
</tbody>
</table>

| Frequent  | -               | *L. scabrum* | - |

<table>
<thead>
<tr>
<th>Common</th>
<th><em>B. pseudosulphureus</em></th>
<th><em>B. aestivalis</em></th>
<th><em>Boletus</em> sp.31</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>Boletus</em> sp.31</td>
<td><em>Boletus</em> sp.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>L. luteum</em></td>
<td><em>Boletus</em> sp.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>B. pseudosulphureus</em></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rare</th>
<th><em>L. scabrum</em></th>
<th><em>Boletus</em> sp.33</th>
<th><em>B. pseudosulphureus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>L. luteum</em></td>
<td><em>Boletus</em> sp.10</td>
<td></td>
</tr>
</tbody>
</table>

As indicated in the Table-I above, in the *Pinus* zone, *Suillus granulatus* and *Gyroporus castaneus* are most common. *S. granulatus* forms mycorrhizae with *Pinus wallichiana*. They appear after about 15 days of the first rains of the monsoon season. *L. luteum* and *L. scabrum* occurred rarely. *Boletus*
pseudosulphureus appears commonly.

The *Quercus* zone supports a luxuriant crop of boletes than the other two zones. In this zone, *S. mollis*, *S. floccopus* and *Boletus* species 34, 29 and *B. queletii* are abundant whereas *Leccinum scabrum* is frequent. *L. luteum* and *Boletus* sp. 31, *B. aestivalis*, *B. pseudosulphureus* are common whereas *Boletus* sp. 33 and *Boletus* sp. 10 are rare. In this zone *Boletus* sp. 34, *Boletus* sp. 29, *Boletus aestivalis*, *Boletus* sp. 31, *L. luteum* and *L. scabrum* are mycorrhizic with oaks and rhododendrons. In the *Quercus*–*Rhododendron*–zone only a few species of *Boletus* (*Boletus* sp. 33, *Boletus* sp. 31, *Boletus* sp. 10, *B. pseudosulphureus*) appear towards the end of the rainy season.

**Glen Forest**: The vegetation of this forest comprises of two distinct altitudinal zones: (*Quercus*–zone (1800–2000 m M.S.L.) *Q. incana*, *Q. semicarpifolia*, *Q. dilatata*) forming the lower belt and *Pinus–Quercus*–zone (2000–2150 m M.S.L., *Pinus wallichiana* and *Quercus incana*) occupying more exposed and dry elevations on North-West. The former zone extends into deep ravines forming a thick evergreen canopy under which luxuriant herbaceous growth is found during the rainy season. This forest by far yielded the largest number of boletes. The observations on various species are shown in Table II.
In the Pinus-Quercus-zone *G. castaneus* and *S. granulatus* appeared abundantly after the first showers of rainy season (middle of June). The former shows no association while the latter is mycorrhizic with *Pinus wallichiana*. The common species in this zone is *L. subleucophaeum* growing near *Betula* sp. appearing almost in the mid-season (middle of July). *Boletus pseudosulphureus* and *S. mollis* also grow commonly. *Boletus sp. 31* and *B. aestivalis* were recorded rarely.
In the Quercus-zone, *S. mollis*, *S. floccopus*, *B. queletii*, *Boletus* sp. 34 and *Boletus* sp. 29 were most abundant, mycorrhizic with oaks and were the first to appear after rains. *Boletus queletii* can be collected quite late in the season.

*Boletus* sp. 28, *Boletus* sp. 31, *B. subglabripes* and *B. aestivalis* were common but they maintained a characteristic periodicity and appeared only during alternate years despite almost the same environmental conditions. These species form mycorrhizae with *Quercus* and *Rhododendron* trees and generally appear in the middle of July. *Boletus* sp. 33 and *B. pseudosulphureus* were collected very rarely.

Narkanda Forest: The forest vegetation of this region comprises of *Abies Pindrow* and *Abies-Juniperus*-zones. The former occupies the greater and the lower part (2300-2600 m M.S.L.) of the region and the latter consists of *Abies Pindrow* and *Juniperus recurva* and is poorly represented. Both the zones support a luxuriant growth of herbaceous flora during the rainy season. The bolete flora of each zone of this forest is shown in Table III.

*Boletus* sp. 37 and *Boletus* sp. 23 are among the most common boletes appearing in the *Abies*-zone. None of these species has been found forming mycorrhizae. *B. holosericeus*, *B. erythropus* and *B. pseudosulphureus* are among the most common species found in the *Abies-Juniperus*-zone. None
forms mycorrhizae. *B. pseudosulphureus* is first to appear followed by *B. holoroseus, B. erythromus. Boletus sp. 23, Boletus sp. 20 and *S. mollis* appeared rarely.

Table - III Narkanda Forest

<table>
<thead>
<tr>
<th>Abundant</th>
<th>Abies Pindrow-zone</th>
<th>Abies-Juniperus-zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boletus sp. 37</td>
<td><em>B. holoroseus</em></td>
</tr>
<tr>
<td></td>
<td>Boletus sp. 23</td>
<td><em>B. erythromus</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>B. pseudosulphureus</em></td>
</tr>
<tr>
<td>Frequent</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Common</td>
<td><em>B. pseudosulphureus</em></td>
<td>Boletus sp. 23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boletus sp. 20</td>
</tr>
<tr>
<td>Rare</td>
<td>-</td>
<td><em>S. mollis</em></td>
</tr>
</tbody>
</table>

**DISCUSSION**

The vegetation of Taradevi and Glen forests have basically angiospermic elements while that of Narkanda forest has gymnospermic composition. In the angiospermic forests *Quercus* and *Rhododendron* are most common while *Abies* and *Juniperus* dominate the gymnospermic forest. It is clear from the observations that many species of boletes are characteristic to a particular forest zone while a few
intergrade in the different zones. Approximate temperature and rainfall in these forests is given in Table IV.

The Quercus-zones in Taradevi and Glen forests resemble greatly in the species of boletes. Smith and Thiers (1971) pointed out "Boletes are often abundant in relatively thin oakwoods on poor sandy soil and of course conifer plantations are an ideal place to hunt them during the fall season." The same holds true for these forests also. Both these zones have almost similar aspect, altitude and environment. So, in both these zones, S. mollis, S. floccopus, B. queletii, Boletus sp. 34 and Boletus sp. 29 are most abundant. Many of these species form mycorrhizal associations. Boletus sp. 34, B. queletii, Boletus sp. 29 and L. luteum are mycorrhizic with oaks while Boletus sp. 31 and B. aestivalis are found closer to Quercus and Rhododendron.

In the Pinus and Pinus-Quercus-zones of these forests, S. granulatus and S. castaneus are most common species. However, the species occurring rarely may differ. The uppermost zone of Taradevi forest (2100 m and above) supports a poor growth of these fungi. A few species like Boletus sp. 31, Boletus sp. 10 and Boletus sp. 33 appear in small populations. It shares with the Quercus-zone these three species. The two zones of Narkanda forest possess bolete species different from Taradevi and Glen forests. The only common element is B. pseudosulphureus.
Species differ in their temperature and humidity requirements and hence appear either during early or late season as is clear from Figs. 1 - 3. It has been observed that species like *E. pseudosulphureus*, *S. mollis*, *S. floccopus*, *G. castaneus*, etc., are among the earliest (middle of June) species when the temperature and humidity is higher while species like *Boletus* sp. 10, *Boletus* sp. 7, etc. appear late (end of July or in the beginning of August) when the temperature and humidity is lower.

It is interesting to note periodicity in the appearance of a few species, e.g. *B. aestivalis*, *Boletus* sp. 29, *Boletus* sp. 31, etc. were collected during the rainy season of 1975. Despite the abundant rains, not even a single specimen of these species could be collected during 1976. The same species, however, appeared during the rainy season of 1977. This observation suggests that these species of *Boletus* follow some periodicity in their appearance (Binnyamini, 1973). However, it could not be confirmed whether this periodicity was due to weather conditions or due to some other physiological reasons.

With regard to succession, the species of *Gyroporus* and *Strobilomyces* are the first to appear just after the first rains during middle of June. They are followed by species of *Suillus* and *Leccinum*, then by *Boletus* and *Tylopilus*. 
Many boletes grow specifically near certain angiospermic or gymnospermic plants. Most of the species, especially the mycorrhizal ones were found appearing on the same places and even on the same spots year after year. It is probably because their dormant rhizomorphs are activated on the advent of rains (Corner, 1935). A list of mycorrhizic species is given separately in Table V.

The environmental conditions appeared to effect the first appearance of boleti in any given area. As we travel from lower collecting sites (Taradevi, Glen, Mashobra, Kufri, etc.) to the higher ones (Narkanda, Hattoo Peak, Soja, etc.) it was observed that the species which appeared first at Taradevi, appeared later at higher altitudes. This is probably due to the differences in temperature and humidity conditions. For example, *B. pseudo sulphureus* and *S. mollis* were among the earliest appearing fungi at all collecting sites below/or at 2200 m M.S.L. and above or at 2500 m M.S.L. But it was observed that the same fungi appear by the end of May or in the first week of June at all the collecting sites below 2200 m M.S.L., but were found to appear by the middle of July or first week of August at the collecting sites at or above 2500 m M.S.L. It seems that temperature and humidity play a great role in the activation of rhizomorphs and thus in the first appearance of these fungi. It was further noticed that the species appearing below 2200 m have bigger size and occur more frequently while their frequency decreases considerably above 2500 m.
Table IV

Approximate average, maximum and minimum temperature and average rainfall in three forests

<table>
<thead>
<tr>
<th></th>
<th>Taradevi</th>
<th>Glen</th>
<th>Narikanda</th>
</tr>
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<tbody>
<tr>
<td>May</td>
<td><em>(22.1°C - 13°C)</em></td>
<td><em>(22.9°C - 14.3°C)</em></td>
<td><em>(20.1°C - 13.2°C)</em></td>
</tr>
<tr>
<td></td>
<td>66 mm</td>
<td>67 mm</td>
<td>70 mm</td>
</tr>
<tr>
<td>June</td>
<td><em>(22.2°C - 14°C)</em></td>
<td><em>(23.9°C - 15.6°C)</em></td>
<td><em>(20.2°C - 12°C)</em></td>
</tr>
<tr>
<td></td>
<td>172 mm</td>
<td>174 mm</td>
<td>180 mm</td>
</tr>
<tr>
<td>July</td>
<td><em>(17°C - 14°C)</em></td>
<td><em>(21.6°C - 15.1°C)</em></td>
<td><em>(18.2°C - 11°C)</em></td>
</tr>
<tr>
<td></td>
<td>420 mm</td>
<td>425 mm</td>
<td>455 mm</td>
</tr>
<tr>
<td>August</td>
<td><em>(16.1°C - 14°C)</em></td>
<td><em>(20.2°C - 14.1°C)</em></td>
<td><em>(16.3°C - 10.2°C)</em></td>
</tr>
<tr>
<td></td>
<td>425 mm</td>
<td>434 mm</td>
<td>410 mm</td>
</tr>
<tr>
<td>September</td>
<td><em>(15°C - 12.5°C)</em></td>
<td><em>(20.2°C - 13.2°C)</em></td>
<td><em>(15.2°C - 9.8°C)</em></td>
</tr>
<tr>
<td></td>
<td>160 mm</td>
<td>160 mm</td>
<td>120 mm</td>
</tr>
<tr>
<td>Table V</td>
<td></td>
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</table>

**ECOLOGICAL LIST OF MYCORRHIZAL FUNGI**

1) **Conifers**
   - *S. granulatus* close to *Pinus wallichiana*
   - *S. placidus* close to *Pinus wallichiana*

ii) **Quercus** spp.
   - *S. mollis*
   - *S. floccopus*
   - *Leccinum* sp. 1
   - *L. luteum*
   - *L. albêllum*
   - *L. griseonigrum*
   - *Boletus* sp. 31
   - *B. aestivalis*
   - *B. edulis-II*
   - *Boletus* sp. 28
   - *Boletus* sp. 29
   - *B. subglabripes*
   - *Boletus* sp. 34
   - *B. queletii*
   - *Boletus* sp. 16

iii) **Rhododendron** spp.
   - *Boletus* sp. 31
   - *B. aestivalis*

iv) **Betula** spp.
   - *L. subleuconphaeum*
SUCCESSION OF BOLETACEAE IN THREE FORESTS

Fig. 1. Taradevi Forest
1. *B. pseudosulphureus* 7. *S. granulatus*
2. *S. mollis* 8. *Boletus sp. 33*
3. *Boletus sp. 31* 9. *B. aestivalis*
4. *L. scabrum* 10. *L. luteum*
5. *T. rubrobrunneus* 11. *S. flocopus*
6. *Boletus sp. 10*

Fig. 2. Glen Forest
1. *B. pseudosulphureus* 7. *B. aestivalis*
2. *B. queletii* 8. *Boletus sp. 34*
3. *Boletus sp. 31* 9. *S. mollis*
4. *Boletus sp. 29* 10. *G. castaneus*
5. *Boletus sp. 31* 11. *S. granulatus*

Fig. 3. Narkanda Forest
1. *Boletus sp. 37* 4. *Boletus sp. 7*
2. *B. pseudosulphureus* 5. *Boletus sp. 20*
3. *B. boloroseus* 6. *Boletus sp. 23*
SUMMARY

The family Boletaceae (Agaricales) is represented by about 20 genera and 250 species, the world over. It has been extensively explored in Africa (Heinemann, 1951, 1961, 1964); U.S.A. (Coker and Beers, 1943; Snell and Dick, 1970; Smith and Thiers, 1964, 1971; Singer, 1945, 1947); Central Europe (Singer, 1967); Great Britain (Pearson, 1946; Watling, 1970); Newzealand (McNabb, 1967, 1968) and Malaysia (Corner, 1972). In India, the total number of boletes reported so far hardly exceeds twenty (Berkley, 1856; Bose, 1946; Lloyd, 1898-1925; Murrill, 1924; Singer and Singh, 1971). This number is the least representative of the vast forests, varied topography and climatic conditions of our country, especially the Himalayas. The present investigations envisage the following objectives:

(1) To explore the bolete flora of Simla and adjoining areas in the North Western Himalayas; (2) To record ecological data on forms collected; (3) To ascertain mycorrhizal associations of some species and (4) To bring on record those species of boletes which are consumed locally.

The thesis is divided into two parts. Part I deals with the Taxonomy and Part II with the Ecological studies. In "Taxonomy", the general part gives the topography, soil, climate and ecology of the areas explored, followed by an account of the previous explorations on this family in India. The general part is followed by "The Flora" which includes the methodology, characteristics of family Boletaceae and a key to the Indian genera of this family.

As a result of frequent field trips made during 1975-79 to various localities in the North Western Himalayas, about 500
specimens were collected. These collections comprise taxonomically of 69 species. These have been preserved dry as well as wet. All these species have been described fully. The descriptions have been supplemented with diagrams of various structures. Efforts were made to culture some species in the laboratory following Pantidou (1961, 1964) and Pantidou and Groves (1966). Chemical spot tests with various chemicals were performed on pileus cuticle and context. It was interesting to note that NH$_4$OH and KOH gave significant results in many species. Approximate growing period and period of maximum growth have also been recorded in some species. The description of each species is followed by a discussion on its relationships with its close allies and other related Indian populations. All the specimens have been deposited in the Herbarium, Department of Biosciences, H.P. University, Simla. The syntypes and paratypes of most of the species have been sent to Prof. A.H. Smith, the University of Michigan Herbarium and Department of Botany, University of Michigan, Ann Arbor; Prof. H.D. Thiers, Department of Ecology and Systematic Biology, San Francisco State University, San Francisco, California; Dr. E. Borak, Institut für Spezielle Botanik der ETH, Universitätsstrasse 2, CH 8092, Zürich; Dr. Roy Watling, Royal Botanic Garden, Edinburgh, Scotland and Prof. Tsugo Hongo, Department of Biology, Faculty of Education, Shiga University OTSU, 520 Japan.

All the 69 species described have been ascribed to 6 genera following recent trends in the generic delimitation. The results of the Part I are summarized below:

1) The genus *Boletus* is by far the largest with about 51 species. *Boletus glabellus* Reck, *B. subglabripes* Reck, *B. subaleutae*
Smith and Thiers, B. queletii Schulzer, B. alutaceus Morgan, B. rufoflavipes Corner, B. erythrophus (Fries) Krombhols, B. subvelutipes Peck, B. aestivalis Fries, B. pseudosulphureus Kallenbach, B. holoroosus Smith and Thiers and B. pulverulentus Opatowski are new records for India. About 37 species of Boletus did not fit into anyone of the earlier known species and hence appear to be new to science.

ii) In genus Gyroporus, only one species, i.e. G. castaneus(Fries) Quélet has been recorded. This is a new record for India.

iii) The genus Leccinum has about 7 species in this region (L. luteum Smith, Thiers and Watling, L. subleucophaeum Dick and Snell, L. albellum (Peck) Singer, L. erigeonigrum Smith and Thiers, L. seabrnum (Fries) Gray, L. rugoicems (Peck) Singer and Leccinum sp. 1). Out of these species 6 are new records and one appears to be a new species.

iv) In the genus Strobilomyces, out of the three species recorded, S. floccopus (Fries) Karsten and S. mollis Corner are new for India while Strobilomyces sp. 1 appears to be a new species.

v) The genus Suillus is represented by 4 species (S. sibiricus (Singer)Singer, S. placidus (Bonordon) Singer, S. granulatus (Fries) Kuntze and S. brunneescens Smith and Thiers). All have been recorded for the first time from this country.

vi) The genus Tylopilus is represented by 3 species (T. alboater (Schweinitz) Murrill, T. sordidus (Frost) Smith and Thiers and T. rubrobrunneus Mazzer and Smith). All are new records for India.
vii) There is a great paucity in the representation of species with rough walled spores. Only one genus (*Strobilomyces*) has reticulate spores while in species of all other genera, the spores were found to be smooth.

viii) The following species appear more frequently and abundantly than other species: *Coprorus castaneus*, *Strobilomyces floccopus*, *S. mollis*, *Boletus pulverulentus*, *B. pseudosulphureus*, *Boletus sp.* 34; *Suillus sibiricus*, *S. granulatus*, *Leccinum luteum*, *L. subleuconaeum* and *Tylopilus alboater*.

ix) All the species have been found growing on soil and no parasitic bolete has been collected. *Boletus* sp. 18 was cepitose in habit while all others were found growing either singly or in groups (gregarious).

x) Generally, the species of *Boletus* have a tendency to show a greenish or blue colour on bruising or injury. The species of *Leccinum* and *Suillus* turn olive brown to grayish brown; *Tylopilus* and *Strobilomyces* turn brown black to black or gray reddish black on bruising.

xi) Very few species have been found to show a distinctive taste, e.g. sweetish (*B. subpalustris*), sour (*L. albclum*) and acidic (*B. subglabripes*). In all other species, the taste and odour are usually pleasant and indistinct respectively.

xii) Veil has been observed in all species of *Strobilomyces* and rarely in *Suillus* and *Boletus*. A distinct annulus persists at maturity in *Strobilomyces floccopus* while in *S. sibiricus* and *S. placidus*, the annular zone may or may not be distinct at maturity.

xiii) Reticulate stem is typical of the genus *Boletus*, especially
subsection Boletus. In *Leccinum* and *Strobilomyces* the stipe may be reticulate only with floccose ornamentations. In *Suillus*, the stem is punctate with groups of caulocystidia. Punctate stem was also found sometime in sections *pseudoleccinum* and *pseudoboleti* of the genus *Boletus*. The stem in *Gyroporus* was unusual in being hollow and consisting of transverse hyphae.

xiv) The following species of this family have been confirmed to be ectomycorrhizic. The methods followed were of Young (1936, 1940); How (1940, 1941, 1942) and Zak (1971, 1973): *Suillus crenulatus* and *S. placidus* with *Pinus wallichiana*, *Strobilomyces mollis*, *S. floccopus*, *Leccinum luteum*, *Leccinum sp. 1*, *L. albellum*, *L. pruinosum*, *Boletus sp. 31*, *B. aestivalis*, *B. edulis II*, *Boletus sp. 28*, *Boletus sp. 29*, *B. subglaebipes*, *Boletus sp. 34*, *B. mueletii*, *Boletus sp. 16* with *Quercus* spp.; *Boletus sp. 31*, *B. aestivalis* with *Rhododendron* spp.; and *L. subleuconphaesum* with *Betula* sp.

Part II of the thesis deals with the ecological studies. The results of this part are summarized below:

1) The 3 forests selected for the ecological studies were Taradevi, Glen and Narkanda. These forests vary in topography aspect and vegetational zones. The species of boletes occurring in different zones of these forests have been found to vary with the composition of the particular zone. The forest-zones with similar altitude and vegetational elements intergrade in bolete flora also.

ii) In Taradevi forest, the species like *Boletus pseudosulphureus*, *Boletus sp. 31*, *Boletus sp. 10*, *Boletus sp. 33*, *B. aestivalis*, *Strobilomyces mollis*, *S. floccopus*, *Leccinum luteum*, *L. scabrum*,
Suillus granulatus and Tylopilus rubrobrunneus have been collected repeatedly.

iii) In Glen forest, Boletus pseudosulphureus, B. queletii, Boletus sp. 28, Boletus, sp. 29, Boletus sp. 31, B. subglabripes, B. estivalis, Boletus sp. 34, Strobilomyces mellis, Gyroporus castaneus, Suillus granulatus and L. subleucophaeum have been collected repeatedly.

iv) In Narkanda forest, the species like Boletus sp. 37, B. holoproseus, Boletus sp. 7, Boletus sp. 20 and Boletus sp. 23 have been found growing frequently.

v) Among the hardwoods, Quercus spp. Rhododendron spp. and Betula sp. were the most common associates while Pinus was a common associate among the conifers for boletes.

vi) There has been observed a sequence in the appearance of bolete species. Species of Gyroporus and Strobilomyces are the first to appear followed by Suillus, Leccinum and finally by Boletus and Tylopilus.

vii) The appearance of Boletes in the 3 distant forests seems to be controlled by temperature and relative humidity. The Taradevi, Glen and Narkanda forests lie respectively in the outer, middle and inner ranges of Himalayas. In Taradevi and Glen forests (at lower height) the species which appear during the early monsoon season appear during the late monsoon season in Narkanda forest (at higher height).
viii) *Boletus edulis*, *B. aestivalis* and *Boletus* sp. 31 are consumed locally and can be exploited commercially.

It is evident from the above results that there is a great need for extensive exploration of Indian boletes and other Agarics. Some of these species can provide better substitute for human consumption and also help in establishing better forests being mycorrhizic. A sizeable number of papers has appeared and is appearing from other countries on these fungi, but in our country, this still remains an untrodden field.