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Impact of anthropogenic disturbances on the plant diversity in a sub-tropical forest of Manipur, Northeast India

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ABSTRACT

We examined the impact of anthropogenic disturbances on the plant diversity in a sub-tropical forest of Langol hills, Manipur, Northeast India. Three sites representing various levels of anthropogenic disturbances along an elevational gradient (780-900 m) were earmarked in the forest on the basis of cut stumps analysis. Site I was located at the hill base and was a protected area, site II was located at the mid- hill and was mildly disturbed and site III was located at the top of the hill and was moderately disturbed. The forest vegetation was dominated by Lithocarpus fenestrata Roxb., Schima wallichii (DC) Korthals and Quercus serrata Thunb. A total of 282 species of plants were recorded from across the study sites, representing 210 genera and 82 families. The quantitative characteristics such as density and Importance value index of species varied between the study sites. Species richness in the tree layer was highest in the mildly disturbed forest site II (26 tree species) followed by the protected forest site I (25 tree species) and moderately disturbed forest Site III (18 tree species). In the shrub layer, species richness was highest in Site III (14) followed by Site I (13) and Site II (10) while in the herb layer, the maximum richness was recorded in Site III (21) followed by Site II (18) and Site I (16). The three sites exhibited high community co-efficient values for tree, shrub and herb layers. The Shannon and Wiener diversity index on basal cover basis for tree, shrub and herb layers varied between 2.37-3.77, 2.68-3.15 and 2.51-2.85 respectively. The distribution pattern of the species in each site followed in the order of contagious > random > regular. The concentration of dominance was low where species diversity was high in all the study sites. Beta diversity was found to decrease with the increase in altitude. Our study indicated that the present forest exhibited high species richness and also suggested that the mildly disturbed forest site favoured tree species diversity in the present forest compared to that of protected and moderately disturbed forest sites.

Keywords: *Anthropogenic disturbances, Beta diversity, Northeast India, Plant diversity, Shannon-Wiener diversity index, Species richness.*

1. INTRODUCTION

Tropical forests are repositories of much of the world's biodiversity and play a crucial role in the regulation of global climate. However, many tropical forests are under great anthropogenic pressure and require management interventions to maintain the overall biodiversity, productivity and sustainability. The loss of biodiversity is considered to be one of the most important of all the negative effects of degradation of tropical forests. Despite the increased awareness and energy invested in biodiversity conservation, the rate of biodiversity loss has not measurably reduced, the world has more poor people than ever and economic development is being achieved at the price of measurable climate change (Mianka *et al*. 2010).

One of the foundations for conservation of biological diversity in forest landscapes is understanding and managing the disturbance regimes of a landscape under past natural or semi-natural conditions (Spies and Turner 1999). Disturbance is widely believed to be one of the main factors structuring communities and influencing variation in species diversity. The intensity and frequency of disturbance are important determinants of plant diversity in a community. Anthropogenic disturbances of forests ecosystems are increasingly recognized as fundamental ecological processes with important long term implications for biogeochemical cycles and vegetation patterns (Gimmi *et al*. 2008). In most developing countries, including India even protected forests experience extensive anthropogenic disturbances due to grazing, extraction of fuel-wood and collection of non-wood forest products which contribute to the livelihood of forest dwelling populations (Sahu *et al*. 2008).

The state of Manipur in North-Eastern India is a part of Indo-Burma biodiversity hotspot which is one of the 34 biodiversity hotspots of the world (Mittermeier *et al.* 2005). The state is rich in diversity and endemism and harbours a unique flora. However, the genetic wealth of the state has been depleted considerably during the recent past, because the natural forests are being destroyed extensively by various anthropogenic activities such as collection of fuel wood and timber and including the age-old practice of shifting cultivation, causing serious threats to the rich diversity of the region. A number of studies have been reported on the structure and functioning of forest ecosystems in Manipur (Yadava and Singh 1988; Kikim and Yadava 1998, 2001; Devi and Yadava 2006). However, there is lack of information on the influence of biotic disturbances on the structure and plant diversity of the sub-tropical forest ecosystem of Manipur. Therefore, the present study was undertaken to examine the influence of anthropogenic disturbances on forest composition, diversity and structure in a reserve forest of Langol hills, Manipur, Northeast India and the study is intended to give important directions to conservation and management of natural resources including biodiversity for the present and future human requirements.

2. MATERIALS AND METHODS

2.1 Study area

The study site (24^{0}45'N latitude and 93^{0}55'E longitude) has an area of 50 hectares and is located within the Langol Reserved Forest at a distance of 12 kms from Imphal along NH 39 and at an altitude ranging from 780m-900m above mean sea level. Although the forest is protected, it is subjected to anthropogenic disturbances in the form of firewood extraction, removal of litter and selective cutting of trees for timber by the local people living around the forest. The Reserved forest harbours several timber yielding plants, which also have social and economic values. Three study sites based on different disturbance levels were earmarked for studying the impact of disturbances on the forest vegetation. Site I is located at the hill base and is a protected area, Site II is located at the mid- hill and is mildly disturbed and Site III is located at the top of the hill and is moderately disturbed. It has slope from moderate to steep. The forest sites were dominated by *Lithocarpus fenestrata*, *Schima wallichii* and *Quercus serrata*. According to Champion and Seth (1968), the present forest falls under East Himalayan sub-tropical wet hill forest type 8B/C1.

2.2 Climate

The climate of the area is monsoonic with warm moist summer, a distinct rainy season and cool dry winter. The mean maximum temperature varied from 22.1^{0}C (January) to 29.5^{0}C (August) and the mean minimum temperature varied from 5.4^{0}C (January) to 22.7^{0}C (August). The mean monthly rainfall ranged from 21.6mm (December) to 226.4mm (July). The total mean annual rainfall is 1379.80 mm. The average relative humidity of air varied between 59.7% (March) to 82.2% (July). Soil of the study area was reddish in colour, loamy-sand in texture and acidic in nature.

2.3 Methods

For the assessment of plant biodiversity of the forest sites, frequent visits were made and extensive floristic survey was carried out during the study period (2004-2006). Besides, for detailed investigation of plant biodiversity, whole area of the forest was divided roughly into five parts depending on topography and altitudes. Each part was sampled using 100m × 10m quadrat size plot and in which five quadrats of 10m × 10m size were laid down randomly. The specimens of trees, shrubs, herbs, climbers or lianas and ferns were collected and herbaria were prepared for the specimens. They were identified with the help of the Flora of British India (Hooker 1872-1897), Dicotyledonous and Monocotyledonous plants of Manipur (Deb 1961), Flora of Manipur (Chauhan *et al*. 2000) and the Herbaria of the Regional Botanical Survey of India, North Eastern Circle, Shillong were consulted for correct identification of plant specimens. The species richness and family divergence have been evaluated for the forest sites.

During 2004-2006, after a thorough reconnaissance of the study area, three study sites representing various levels of anthropogenic disturbances along an elevational gradient were earmarked within the forest site. The forest sites were classified on the basis of disturbance index calculated as the basal area of cut trees measured at ground level expressed as a fraction of total basal area of all trees, including felled ones (Rao *et al*. 1990). The disturbance index was 3.7% in the Protected site I, 20.1% in the mildly disturbed site II and 40.0% in the moderately disturbed site III. The vegetation analysis was carried out during September. The quantitative assessment of each forest site was done by laying 20 randomly selected quadrats each of size 10 × 10 m for trees, 5m × 5m for shrubs and 1m × 1m for herbs and care was taken to sample the most representative area for each position. The size of the quadrats and number of the samples followed are as per Saxena and Singh (1982). Circumference at breast height (cbh at 1.37m from the ground) of all the trees with ≥ 31.5cm cbh in each quadrat was measured and recorded individually per species. The species richness was simply the number of species per unit area (Whittaker 1972). The vegetation data was quantitatively analyzed for abundance, density and frequency following Curtis and Mc Intosh (1950). The relative values of frequency, density and dominance were determined following Phillips (1959). Importance Values Index (IVI) which is the integrated measure of relative frequency, relative density and relative dominance was computed for each species (Curtis 1959). The ratio of abundance to frequency for different species was determined for eliciting the distribution patterns (Whitford 1949). Community co-efficient or similarity index between pairs of stands was calculated following Jaccard (1912). The diversity index was computed using Shannon and Wiener information function ($\bar{H}$) (Shannon and Wiener 1963). Concentration of dominance (CD) was measured by Simpson's index (Simpson 1949). Beta diversity (β) was determined by Whittaker (1972) method.

3. RESULTS

3.1 Plant diversity and species richness within families

A total of 282 species (81 trees, 38 shrubs, 123 herbs, 25 climbers or lianas and 15 ferns) were recorded from across the study sites representing 210 genera and 82 families (Appendix 1).

Among families, Poaceae (26 species), Asteraceae (20 species), Rubiaceae (14 species) and Fabaceae (13 species) were most species diverse. Cyperaceae and Moraceae were represented by eight species each, Verbenaceae and Labiatae were represented by seven species each, Araceae, Euphorbiaceae and Vitaceae by six species each, Nine families by five species each, 11 families by four species each, five families by three species each, 12 families by two species each while the remaining 33 families were represented by one species each (Table 1).

3.2 Vegetation data of the three forest sites

3.2.1 Tree layer: In the protected forest site I, *L. fenestrata* exhibited absolute dominance in terms of frequency (100%), density (6.45 trees 100m^{-2}), basal cover (1196.41cm^{2}100m^{-2}) and IVI (101.54) followed by *S. wallichi* with density of 1.2 trees 100m^{-2} and IVI of 37.48 (Table 2). Most of the species were distributed contagiously but *S. cumini* and *C. zeylanicum* exhibited random distribution while *S. wallichi* exhibited regular distribution.

In the mildly disturbed forest site II, maximum values of density (4.6 trees 100 m^{-2}) and IVI (57.97) were recorded for *L. fenestrata* followed by *S. wallichi* with density of 2.95 trees 100 m^{-2} and IVI of 57.25 (Table 2). The maximum value of frequency (75%) and basal cover (1203.24 cm^{2} 100m^{-2}) was recorded for *S. wallichi.* Most of the species exhibited contagious distribution pattern while *S. cumini, S. personatum, L. polyantha, C. arborea, T. ciliata* and *S. jambos* were distributed randomly.

In the moderately disturbed forest site III, *Q. serrata* exhibited the maximum frequency (85%), density (3.35 trees 100m^{-2}), basal cover (1693.49 cm^{2} 100m^{-2}), and IVI (90.04) followed by *L. fenestrata* with frequency (80%), density of 2.75 trees 100m^{-2} and IVI of 53.25 (Table 2). *A. lebbeck, H. longifolia, L. fenestrata, Q. serrata, S. wallichi, S. personatum* and *W. grandis* were randomly distributed while the remaining species were distributed contagiously. Considering IVI as an indicator of dominance, *L. fenestrata* and *S. wallichi* were the dominant species in site I and site II whereas *Q. serrata* and *L. fenestrata* were dominant in site III.

3.2.2 Shrub layer: In site I, *Andidesma* sps. exhibited the maximum density (2.2 shrubs 25 m^{-2}) followed by *D. laxiflorum* (2.05 shrubs 25 m^{-2}) while the minimum value was recorded for *D. heterocarpon* (0.05 shrubs 25m^{-2}). The maximum value of basal cover (1.56 cm^{2} 100m^{-2}) and IVI (53.16) was recorded for *L. camara* (Table 3). The frequency percentage ranged from 5% to 60%. Most of the species exhibited contagious distribution pattern while *M. indica* was found to be randomly distributed.

In site II, *Andidesma* sps. exhibited the maximum frequency (75%), density (3.05 shrubs 25m^{-2}) and IVI (67.77) whereas the minimum value was recorded for *H. sanguinea* (5%, 0.05 shrubs 25m^{-2}, 2.65 respectively) (Table 3). The maximum basal cover was recorded for *O. stellata* (1.01 cm^{2} 25m^{-2}) whereas minimum value was recorded for *H. sanguinea* (0.025 cm^{2} 25m^{-2}). All the species were found to be distributed contagiously except *L. camara* which exhibited random distribution pattern.

In site III, the maximum density was recorded for *U. lobata* (3.25 shrubs 25m^{-2}) followed by *D. laxiflorum* (3.00 shrubs 25m^{-2}). The frequency varied from 5% to 95%. The maximum basal cover was shown by *E. odoratum* (1.07 cm^{2} 25m^{-2}) followed by *L. camara* (1.0 cm^{2} 25m^{-2}) while the maximum IVI was exhibited by *D. laxiflorum* (53.71) followed by *U. lobata* (46.15). The minimum value of density (0.05 shrubs 25m^{-2}), basal cover (0.01 cm^{2} 25m^{-2}) and IVI (1.58) was recorded in *M. glabra* (Table 3). Most of the species were found to be distributed contagiously whereas *D. laxiflorum, O. stellata, M.indica* and *F. hirta* were found to be distributed randomly.

3.2.3 Herb Layer: In site I, the maximum density and frequency was recorded for *E. nigra* (2.75 herbs m^{-2}, 100%) followed by *S. elata* (2.0 herbs m^{-2}, 40%) while the minimum density was recorded for *T. agrostis* (0.25 herbs m^{-2}). The maximum value of basal cover and IVI was recorded for *H. lucida* (1.31 cm^{2} m^{-2}, 50.13) and the basal cover was followed by *A. citratus* (1.00 cm^{2} m^{-2}) and IVI by *E. nigra* (47.04) (Table 4). The frequency ranged from 5% to 100% for different species. All the species exhibited contagious distribution pattern.

In site II, the maximum value of frequency (95%), density (4.65 herbs m^{-2}) and IVI (50.18) was exhibited by *E. nigra* while the minimum value of density (0.15 herbs m^{-2}) and IVI (2.11) was recorded for *G. hispida* (Table 4). *H. lucida* exhibited the maximum basal cover (0.73 cm^{2} m^{-2}) whereas the minimum value was recorded for *H. diffusa* (0.002 cm^{2} m^{-2}). All the species exhibited contagious distribution pattern.

In site III, *E. nigra* exhibited the maximum density (2.85 herbs m^{-2}) followed by *S. elata* (2.55 herbs m^{-2}) and minimum was recorded in *C. affinis* and *H. spicatum* (0.05 shrubs m^{-2}). *H. lucida* exhibited the maximum basal cover (1.67 cm^{2} m^{-2}) and IVI (54.92) while the minimum basal cover was shown by *H. diffusa* (0.002 cm^{2} m^{-2}) and IVI by *C. affinis* (1.25) (Table 4). The frequency ranged from 5% to 75%. Most of the species were found to be distributed contagiously whereas regular distribution was observed in *A. aromaticum* and *E. nigra* whereas *Habenaria lucida* exhibited random distribution.

4. SPECIES RICHNESS AND DIVERSITY WITHIN THE THREE FOREST SITES

A total of 81 trees (≥31.5 cm cbh), shrubs and herbs were recorded from the three forest sites, out of which 35 were tree species, 17 were shrub species and 29 were herb species. Species richness of the tree layer was highest in forest site II (26 tree species) followed by site I (25 tree species) and site III (18 tree species). In the shrub layer, species richness was highest in site III (14) followed by site I (13) and site II (10) whereas for the herb layer, the maximum richness was recorded for site III (21) followed by site II (18) and site I (16) (Table 5).

The tree, shrub, and herb layer composition were more or less similar among all the sites. The similarity coefficient values of tree, shrub and herb species for different forest sites were high i.e. >50%.

The variations in Shannon and Wiener diversity index as computed on density and basal cover basis are presented in Table 5. The diversity on density basis for trees ranged from 2.82 (site I) to 3.45 (site II). On the basis of basal cover also, the diversity was maximum in site II (3.77) however, diversity on basal cover basis was minimum in site III (2.37). The diversity for shrubs on density basis ranged from 2.72 (site II) to 3.36 (site III) whereas on basal cover basis, it varied from 2.68 (site II) to 3.15 (site III). Among the herbs, maximum diversity on density basis was exhibited by site III (3.75) and minimum by site II (3.53) while on basal cover basis, site II exhibited greater diversity (2.85) than site I (2.51) and site III (2.53).

The Concentration of dominance (CD) on density basis for the tree layer was highest in site I (0.30) and lowest in site II (0.16). In the shrub layer, the values ranged between 0.12 (site I) to 0.18 (site II) across the sites and for the herb layer, the value was maximum in site II (0.12) and minimum in site I and site III (0.09). The three sites showed variation in β-diversity ranging from 2.73 (site III) to 3.56 (site I) in the tree layer, 0.67 (site III) to 0.90 (site I) in the shrub layer and 1.11 (site II) to 1.89 (site I) in the herb layer (Table 5).

5. DISCUSSION

The sub-tropical forests of Manipur harbours over 2380 species belonging to 1052 different genera and over 205 families, out of which 282 species or 11.85% representing 82 families were recorded from the forest of Langol hills. The number of species reported in the present study was found to be higher than the number of species reported by several workers in different tropical forests (Nangendo *et al*. 2006 (121 species); Ruschel *et al*. 2007 (78 species); Sahu *et al*. 2008 (56 species); Page *et al*. 2010 (277 species); Uniyal *et al*. 2010 (182 species)) but lower than the values reported by Tchouto *et al*. (2006) (1112 species) from rain forest of Cameroon; Hemp (2006) (523 species) from forest of Kilimanjaro; Behera and Kushwaha (2007) (336 species) from Subabsiri district of Eastern Himalaya and Pereira *et al*. (2007) (730 species) from Atlantic Montane forest of S.E. Brazil. However, these comparisons convey limited meaning since the species richness of a given area would depend on the plot dimension and the sample area is variable across studies. According to Halpern and Spies (1995), interpolation or comparison of diversity among studies are problematic due to differences in sampling design, number or area of plots, indices used to express diversity or origin of the sere.

The high species richness of the families Poaceae and Asteraceae may be because many members of Poaceae and Asteraceae have evolved adaptations to the existing conditions, developed effective seed dispersal mechanisms (small seeds, wind dispersal, parachute like calyx or hooks), variability in flower form or phenology and high adaptive capability and these groups might have often speciated extensively in this region which may partly account for their success. The number of families reported in the present study is closer to the number reported by Heinrich and Hurka (2004) (77 families) from tropical dry forest of North-Western Costa Rica; Tchoucho *et al*. (2006) (97 families) from rain forest of Cameroon and Pereira *et al*. (2007) (86 families) from Montane forest of S.E. Brazil.

The three study sites showed variations in their species richness. The number of tree species was found to be higher in the mildly disturbed site II. It may be due to the positive role of mild disturbance in improving regeneration of forest by providing favourable environmental conditions which support seedling growth during the growing season whereas severe disturbance has deleterious effect. Canopy opening and disturbance of habitat may permit growth of less competitive species which would otherwise not grow in undisturbed old-growth forests (Sahu *et al*. 2008). Our findings are similar to other observations where more number of species is recorded in the mildly disturbed stand (Bhuyan *et al*. 2003; Mishra *et al*. 2004; Uniyal *et al*. 2010).

The moderately disturbed site III supported more shrubs and herbs than the other sites owing to more gaps in the forest canopy. Higher species richness for herbs and shrubs in the moderately disturbed site indicates that opening of canopies favours herb and shrub growth which gives overall stability to the forest (Uniyal *et al*. 2010). Similar results were also reported by many workers (Saxena and Singh 1982; Khera *et al*. 2001; Upadhaya *et al*. 2004; Lalfakawma *et al*. 2009; Raghubanshi and Tripathi 2009).

In the present study, the total density for tree species (11.55 trees $100m^{-2}$ - 14.4 trees $100m^{-2}$) were closer to the values reported from mixed-hardwood temperate forest of South Eastern Virginia, USA (14.4 trees $100m^{-2}$) by Dabel and Day (1977); mixed Sal forest of Kumaun Himalaya (11.2 trees $100m^{-2}$) by Agni *et al*. (2000); sub-tropical humid forests of Meghalaya, N.E. India (9.38-14.76 individuals $100m^{-2}$) by Upadhaya *et al*. (2004); Dipterocarpus forest of Charmandy, India (19.22 trees $100m^{-2}$) by Vasanthraj and Chandrashekar (2006) and forests of Garhwal Himalaya, India (8.45-12.57 trees $100m^{-2}$) by Uniyal *et al*. (2010).

Similarly, basal cover recorded in the present study (3892.0-5072.34 cm^2 $100m^{-2}$) were closer to the values reported from oak forest of Sattal, Central Himalaya (3598.60 cm^2 $100m^{-2}$) by Saxena and Singh (1982), wet temperate forest of Shiroy Hills, Manipur (3290.05-3454.0 cm^2 $100m^{-2}$) by Yadava and Singh (1988); evergreen forest at Kodayar, Western Ghats, India (6708 cm^2 $100m^{-2}$) by Sundarapandian and Swamy (1997); Rampara forest of Saurashtra, India (3326 cm^2 $100m^{-2}$) by Panchal and Pandey (2004); Dipterocarpus forest of Charmandy, India (5210 cm^2 $100m^{-2}$) by Vasanthraj and Chandrashekar (2006).

Contagious distribution of species as observed in majority of the cases in the present study may be related to seed dispersal mechanism of the species and gap formation. Armesto *et al*. (1986) concluded that clumping is characteristic of those forests in which formation of canopy gaps is the chief source of disturbances. On the whole, the distribution pattern of the species in each site followed the order of contagious > random > regular. The general preponderance of contagious distribution in natural vegetation has been reported by several workers (Visalakshi 1995; Panchal and Pandey 2004; Devi and Yadava 2006).

The similarity index between the three forest sites was high i.e.> 50%, thereby suggesting a fairly uniform floristic composition of the forest. High similarity values has also been reported by Ganesh *et al*. (1996) from fragmented Sholas forest of South India; Panchal and Pandey (2004) from Rampara forest of Saurashtra, India and Devi and Yadava (2006) from tropical semi evergreen forest of Manipur, N.E. India.

The values of Shannon and Wiener index of diversity for the trees on basal cover basis ranged from 2.37 (site I) - 3.77 (site II) for the tree layer. The maximum diversity of trees was maintained in the mildly disturbed forest Site II. It may be because few species are able to tolerate very intense disturbance regimes and few are able to compete successfully in habitats that experience little or no disturbance. It may also be because of the environmental heterogeneity resulting from exogenous disturbance which creates an internal mosaic involving spatial gradients of light, soil moisture, soil organic matter and temperature. The mild disturbance provides greater opportunity for species turnover, colonization and persistence of high species richness (Whittaker 1975). According to the intermediate disturbance hypothesis of Connell (1978) and Huston (1979), with no or little disturbance, only the competitive dominants can survive, while at sufficient high level of disturbance, only fugitive species can survive and therefore diversity is maximum at intermediate level of disturbance (Abugov 1982). The Shannon-Wiener index of the present forest (2.37-3.77) could be compared with Kalakad Reserve forests of Western Ghats, India (3.31-3.69) reported by Parthasarathy *et al*. (1992), Sub-tropical humid forest of Meghalaya (3.42-3.87) by Upadhaya *et al*. (2004), Rain forest of Philippine (2.2-3.9) by Langerberger *et al*. (2006); Deciduous Atlantic forest of Brazil (3.73) by Ruschel *et al*. (2007) and tropical semi-evergreen forest of North-East India (2.3-3.14) by Lalfakawma *et al*. (2009). Thus, the forest exhibited diversity values that lie within the range reported for other tropical forests.

The diversity index for the shrubs and herbs on basal cover basis ranged from 2.68 (site II) - 3.15 (site III) and 2.51 (site I) - 2.85 (site II) respectively. The greater absolute and relative numbers of shrub and herb species at higher elevation is probably a consequence of the more open canopy of forests which allows more light into the understorey and may permit understorey herbs and shrubs to exceed their ecological compensation point (Givnish 1988, Vazaquezg and Givnish 1998). The Shrub diversity was found to be lower in the site, which experience intermediate temperature and moisture condition (Saxena and Singh 1982). A greater diversity in the herb stratum in absence of a closed forest canopy has also been observed by other workers (Saxena and Singh 1982; Lalfakawma *et al*. 2009; Uniyal *et al*. 2010). The present values of diversity of the shrubs (2.68-3.15) and herbs (2.51-2.85) are closer to the values reported for mixed oak conifer forest of Central Himalaya (3.2-3.4) by Pandey (2003) and semi-deciduous rain forest of Southern Cameroon (2.45-3.10) by Bisseleua *et al*. (2008).

The concentration of dominance for tree, shrub and herb layer on density basis was in the range of (0.16-0.3), (0.12-0.18) and (0.09-0.12) respectively. Species diversity and concentration of dominance are inversely related to each other and are in agreement to Zobel *et al.* (1976). The present values of CD fall in the range reported by Risser and Rice (1971) for certain temperate vegetation (0.10-0.99) and Rikhari *et al.* (1991) from mixed-oak forest of Kumaun Himalaya (0.19- 0.59).

In the present study, the values of beta diversity for trees, shrubs and herbs varied from (2.73-3.56), (0.67-0.90) and (1.11-1.89) respectively. In general, β-diversity in the present study was found to decrease with increasing altitude. The decline in β-diversity indicates a decline in the proportional turn over of species composition. β-diversity values were lower in the shrub and herb layers compared to the tree layer. It shows that the rate of change of species composition was more rapid in the trees than the shrubs and the herbs. The value of β-diversity for trees in the present study (2.73-3.56) was higher than those reported from Saddle peak forest (Middle) of Andaman Island (1.54) by Tripathi *et al*. (2004) but well within the values reported from a range of vegetation in dry tropics of India (1.986-11.21) by Gupta and Narayan (2006) and forest fragments of Western Ghats, India (2.54-4.7) by Page *et al*. (2010).

6. CONCLUSION

Our study reveals that the sub-tropical forest of Langol hills, Manipur is characterized by high diversity of species and families with 282 species of plants and 82 families representing 81 tree species, 38 shrub species, 123 herb species, 25 climber species and 15 fern species. The analysis of vegetation indicates that disturbance and heterogeneity of the environment are important diversity promoting factors in the present forest. Canopy gaps created by mild disturbance and resulting spatial variability in understorey light conditions is of fundamental importance in the maintenance and promotion of high tree diversity. Nevertheless, this holds true only upto the level of disturbances of intermediate severity. The higher species richness of shrubs and herbs in the moderately disturbed site indicates that higher disturbances have positive impact in maintaining species richness in shrubs and herbaceous system which might have been due to the suppression of tree seedlings because of competition with the herbaceous species. We note that greater tree species diversity is maintained in the mildly disturbed forest site and our results are consistent with the generalization that predicts a peak in species diversity at intermediate disturbance intensity or frequency. Although the study site is a reserve forest which is protected by law, illegal logging of valuable species is still a problem as its boundaries have not been fully protected and it is suggested that a separate management strategy be developed to ensure full protection of the forest and its rich biodiversity. It can thus be concluded that if the present forest could be properly managed with a threshold level of extraction of resources then it can contribute significantly in the conservation and management of tropical forests, thereby helping in maintaining biodiversity.

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APPENDIX

Table 1. Plant families and number of species in mixed-oak forest, Langol hills, Manipur.

Family	No. of Species	Family	No. of Species
Poaceae	26	Fagaceae	4
Asteraceae	20	Malvaceae	4
Rubiaceae	14	Meliaceae	4
Papilionaceae	13	Myrtaceae	4
Cyperaceae	8	Orchidaceae	4
Moraceae	8	Scrophulariaceae	4
Labiatae	7	Urticaceae	4
Verbenaceae	7	Adiantaceae	3
Araceae	6	Begoniaceae	3
Euphorbiaceae	6	Flacourtiaceae	3
Rosaceae	6	Melastomaceae	3
Vitaceae	6	Umbelliferae	3
Anacardiaceae	5	Araliaceae	2
Acanthaceae	5	Bignoniaceae	2

Dioscoraceae	5	Clusiaceae	2
Lauraceae	5	Junglandaceae	2
Liliaceae	5	Lythraceae	2
Mimosaceae	5	Menispermaceae	2
Polypodiaceae	5	Polygonaceae	2
Rosaceae	5	Piperaceae	2
Zingiberaceae	5	Ranunculaceae	2
Amaranthaceae	4	Saurauiaceae	2
Commelinaceae	4	Theaceae	2
Caesalpinaceae	4	Tiliaceae	2
Dennsteadtiaceae	4	33 Families	1 each
		Total 82	282

Table 2. Importance value index (IVI) and density (D) of tree species in forest site I, II & III.

Name of species	Site-I		Site-II		Site-III	
	D ($100m^{-2}$)	IVI	D ($100m^{-2}$)	IVI	D ($100m^{-2}$)	IVI
Albizia lebbeck	0.25	8.93	0.15	4.77	0.20	6.77
Artocarpus heterophyllus	-	-	0.05	1.32	-	-
Bixa orellana	0.15	4.53	0.85	14.84	-	-
Bombax ceiba	0.05	2.53	0.10	4.21	-	-
Callicarpa arborea	0.05	2.53	0.20	5.33	-	-
Celtis australis	0.05	1.97	0.10	2.99	0.05	1.57
Cinnamomum zeylanicum	0.40	11.42	-	-	-	-
Derris robusta	0.15	3.78	-	-	1.25	23.34
Diospyros glandulosa			0.05	1.39	-	-
Engelhardtia spicata	0.35	10.43	0.10	2.00	0.10	3.20
Erythrina variegata	0.05	2.17	0.05	3.65		
Eurya nitida	-	-	-	-	0.10	2.08
Flacourtia jangomas	-	-	0.20	3.94	0.05	1.62
Ficus hispida	0.05	2.02	-	-	-	-
Gmelina arborea	-	-	0.60	16.11	0.05	1.86
Grevillea robusta	0.05	1.64	-	-	-	-
Heligarna longifolia	0.05	1.83	0.10	2.94	0.70	17.90
Lagerstroemia speciosa	-	-	0.10	5.12	-	-
Lannea grandis	-	-	-	-	0.10	2.21
Lithocarpus fenestrata	6.45	101.54	4.60	57.97	2.75	53.25
Litsaea polyantha	0.25	8.04	0.65	15.54	-	-
Litsaea sebifera	0.10	3.75	0.20	4.60	0.05	1.58
Magnolia hodgsonii	-	-	0.05	1.58	-	-
Pinus kesiya	0.40	26.09	0.30	10.97	0.85	41.49
Pyrus pashia	0.15	5.64	-	-	-	-
Quercus serrata	0.95	26.99	0.25	8.50	3.35	90.04
Sapium eugeniae folium	0.05	4.01	-	-	-	-
Schima wallichii	1.20	37.48	2.95	57.25	0.60	17.37
Stereospermum personatum	-	-	0.65	20.49	0.80	22.48
Symplocos crataegoides	0.10	2.24	-	-	-	-
Syzyginum cumini	0.50	15.22	0.60	13.23	0.05	1.57
Syzygium jambos	-	-	0.25	12.07	-	-
Toona ciliate	0.35	11.41	0.45	13.25	-	-
Wendlandia grandis	0.10	2.06	0.10	2.65	0.30	8.47
Xylosma longifolium	0.05	1.76	0.70	13.28	0.20	3.21

Table 3. Importance value index (IVI) and density (D) of shrub species in forest site I, II & III

Name of species	Site-I		Site-II		Site-III	
	D ($25m^{-2}$)	IVI	D ($25m^{-2}$)	IVI	D ($25m^{-2}$)	IVI
Adenosacme stipulata	0.45	12.46	0.10	3.49	-	-
Andidesma sps.	2.20	38.74	3.05	67.77	2.50	34.83
Crotalaria saltiana	1.20	25.05	0.40	13.04	0.95	16.44
Desmodium heterocarpon	0.05	2.32	-	-	0.30	5.20
Desmodium laxiflorum	2.05	43.07	1.65	45.86	3.00	53.71

Eupatrorium odoratum	0.95	32.21	0.35	10.42	0.75	29.54
Ficus hirta	-	-	-	-	0.25	4.40
Holmskioldia sanguinea	-	-	0.05	2.65	0.15	2.75
Lantana camara	1.80	53.16	0.95	44.86	1.30	35.05
Maesa indica	0.35	10.48	-	-	0.50	16.41
Mussaenda glabra		-	-	-	0.05	1.58
Osbeckia stellata	1.35	31.93	1.80	59.40	2.00	39.82
Sambucus javanica	0.15	3.27	-	-	-	-
Tournefortia argentea	0.10	3.13	-	-	-	-
Urena lobata	1.40	25.56	1.90	41.70	3.25	46.15
Urena sinuata	0.25	18.61	0.30	10.80	0.75	11.84
Vernonia subsessilis	-	-	-	-	0.15	2.29

Table 4. Importance value index (IVI) and density (D) of herb species in forest site I, II & III.

Name of species	Site-I		Site-II		Site-III	
	D (m^{-2})	IVI	D (m^{-2})	IVI	D (m^{-2})	IVI
Ageratum conyzoides	-	-	-	-	0.50	3.91
Amaranthus viridis	1.00	11.55	-	-	-	-
Amomum aromaticum	0.30	13.63	0.55	38.50	0.90	39.05
Andropogon citratus	0.50	36.57	-	-	1.45	26.32
Andropogon schoenanthus	0.65	12.59	0.30	6.56	1.15	16.46
Arisaema tortuosum	-	-	0.45	6.32	-	-
Axonopus compressus	1.20	10.70	0.55	7.12	-	-
Begonia acutifolia	-	-	-	-	0.10	1.71
Carex speciosa	-	-	-	-	0.15	1.75
Colocasia affinis	-	-	-	-	0.05	1.25
Commelina kurzii	1.15	21.47	0.50	11.03	0.70	8.28
Eragrostis nigra	2.75	47.04	4.65	50.18	2.85	27.26
Gomphrena hispida	-	-	0.15	2.11	0.35	5.36
Habenaria lucida	0.45	50.13	0.25	37.59	0.50	54.92
Hedychium spicatum	-	-	-	-	0.05	3.38
Hedyotis diffusa	-	-	0.35	4.14	0.50	9.38
Lindernia anagallis	-	-	-	-	0.30	4.35
Oplismenus compositus	1.25	14.40	3.35	32.91	2.25	25.41
Panicum montanum	-	-	-	-	0.80	14.47
Plectranthus macranthus	-	-	-	-	0.10	1.79
Paspalum notatum	1.00	11.86	0.85	10.67	-	-
Phyllanthus urinaria	0.30	4.80	1.35	19.23	-	-
Pogostemon elsholtzioides	0.35	3.83	1.30	15.62	0.70	9.16
Ranunculus diffuses	0.50	8.97	1.00	17.42	-	-
Rubia albicaulis	-	-	-	-	0.10	1.46
Ruellia prostrata	1.80	21.98	1.30	16.40	-	-
Scleria elata	2.00	25.34	1.15	13.25	2.55	28.96
Scutellaria discolor	-	-	0.35	4.23	1.35	15.38
Thysanolaena agrostis	0.25	5.16	0.25	6.74	-	-

Table 5. Species richness, species diversity ($\bar{H}$), concentration of dominance (CD) and beta diversity (β) in the three forest sites

Forest types	Species richness	Species diversity ($\bar{H}$)		Concentration of dominance (CD)		β diversity
		On density basis	On basal cover basis	On density basis	On basal cover Basis	
Trees						
Protected Site-I	25	2.82	3.35	0.30	0.15	3.56
Mildly disturbed Site-II	26	3.45	3.77	0.16	0.11	3.16
Moderately disturbed Site-III	18	3.05	2.37	0.17	0.28	2.73
Shrubs						
Protected Site-I	13	3.20	3.14	0.12	0.14	0.9
Mildly disturbed Site-II	10	2.72	2.68	0.18	0.19	0.81

Moderately disturbed Site-III	14	3.36	3.15	0.17	0.13	0.67
Herbs						
Protected Site-I	16	3.66	2.51	0.09	0.27	1.89
Mildly disturbed Site-II	18	3.53	2.85	0.12	0.21	1.11
Moderately disturbed Site-III	21	3.75	2.53	0.09	0.26	1.45

Appendix 1. Plant diversity of mixed oak forest, Langol Hills, Manipur.

Plant type	Family	Name of species
Trees	Alangiaceae	*Alangium Chinense* (Lour) Harms
	Anacardiaceae	*Heligarna longifolia* Buch-Ham ex. Roxb.
		Lannea grandis (Dennst)
		Mangifera indica L.
		Rhus semialata Murray
		Rhus succedanea. L
	Apiaceae	*Hydrocotyle nepalensis Hook.*
		Sanicula sps
	Aquifoliaceae	*Ilex excelsa* Wall
	Aquilariaceae	*Aquilaria agallocha* Roxb.
	Araliaceae	*Brassaiopsis palmata* Kurz
	Betulaceae	*Alnus nepalensis* D. Don
	Bignoniaceae	*Oroxylum indicum* (Linn.)
		Stereospermum personatum (Hassk)
	Bixaceae	*Bixa orellana* L.
	Bombaceae	*Bombax ceiba* L.
	Caesalpiniaceae	*Bauhinia purpurea* L
		Bauhinia variegata L.
		Cassia fistula L.
	Clusiaceae	*Garcinia pedunculata* Roxb. Ex. Buch-Ham
		Mesua ferrea L.
	Dilleniaceae	*Dillenia pentagyna* Roxb.
	Ebenaceae	*Diospyros glandulosa* Lace
	Euphorbiaceae	*Emblica officinalis* Gaertn
		Mallotus philippensis (Lamk) Muell-Arg.
		Sapium eugeniaefolium Buch-Ham
	Fagaceae	*Castanopsis tribuloides* A. DC.
		Lithocarpus dealbata (Hook)
		Lithocarpus fenestrata Roxb.
		Quercus serrrata Thunb.
	Flacourtiaceae	*Flacourtia jangomas* (Lour) Raeush.
		Hydnocarpus Kurzii (King) Warb.
		Xylosma longifolium Clos.
	Juglandaceae	*Engelhardtia spicata* Bl. Bijd
		Juglans regia Linn.
	Lauraceae	*Cinnamomum camphora* Linn.
		Cinnamomum zeylanicum Breyn.
		Litsaea polyantha Juss
		Litsaea sebifera Pers
		Phoebe hainsiana Brandis
	Lythraceae	*Lagerstroemia speciosa* (L.) Pers.
	Magnoliaceae	*Magnolia hodgsonii* (Hook.f & Thomson) Keng.
	Malvaceae	*Kydia calycina* Roxb.
	Meliaceae	*Aphanamixis polystachya* (Wallich) R.N. Parker
		Azadirachta indica A. Juss.
		Melia azedarach Linn.
		Toona ciliata M. Roem.
	Mimosaceae	*Albizia chinensis* (Osbeck) Merrill.
		Albizia lebbeck (L.) Benth.
		Albizia lucidior (Steudner) Nielson
		Albizia procera (Roxb.) Benth.
	Moraceae	*Artocarpus chaplasha* Roxb.
		Artocarpus heterophyllus Lamk.
		Ficus bengalensis Linn.
		Ficus cunea Buch-Ham ex Roxb.
		Ficus glomerata Roxb.

		Ficus hispida Linn.
		Ficus sps.
	Myrtaceae	*Eucalyptus maculata var citriodora* (Hook) Bailey
		Psidium guajava L
		Syzygium cumini (L) Skeels.
		Syzygium jambos (L) Alston.
	Papilionaceae	*Derris robusta* Roxb. ex. DC.
		Erythrina variegata L.
		Butea monosperma (Lamk) Toub.
	Pinaceae	*Pinus kesiya* Royle ex Gordon.
	Proteaceae	*Grevillea robusta* A. Cunn.
	Rhamnaceae	*Ziziphus mauritiana* Lam.
	Rosaceae	*Photinia notoniana* Wall.
		Pyrus pashia Buch-Ham.
	Rubiaceae	*Wendlandia grandis* (Hook.f) Cowan.
		Wedlandia wallichii Wight & Arn.
	Sapindaceae	*Sapindus emarginatus* Vahl, Symb.
	Saurauiaceae	*Saurauia punduana* Wallich.
		Saurauia roxburghii Wallich.
	Symplocaceae	*Symplocos crataegoides* Buch-Ham ex D. Don.
	Theaceae	*Eurya nitida* Korth.
		Schima wallichii (DC) Korthals.
	Urticaceae	*Celtis australis* Linn.
		Morus laevigata Wall.
	Verbenaceae	*Callicarpa arborea* Roxb.
		Gmelina arborea Roxb.
		Vitex glabrata R. Bor.
Shrubs	Araliaceae	*Heptapleurum venulosum* Seem.
	Asteraceae	*Blumea lanceolaria* (Roxb.) Druce.
		Eupatorium odoratum L.
		Eupatorium triplinerve Vahl, Symb.
		Vernonia subsessilis DC.
	Boraginaceae	*Tournefortia argentea* Linn.
	Caesalpiniaceae	*Cassia alata* L.
	Caprifoliaceae	*Sambucus javanica* Blume.
	Elaeagnaceae	*Elaeagnus latifolia* Linn.
	Euphorbiaceae	*Andidesma* sps.
		Kirganelia reticulata (Poir) Baill.
	Malvaceae	*Hibiscus rosa-sinensis* L.
		Urena lobata L.
		Urena sinuata L.
	Melastomaceae	*Osbeckia stellata* Don ex. C.B. Clarke.
	Mimosaceae	*Mimosa pudica* Linn.
	Moraceae	*Ficus hirta* Vahl Enum.
	Myrsinaceae	*Maesa indica* Wall.
	Papilionaceae	*Butea minor* Buch-Ham.
		Crotalaria saltiana Anders.
		Crotalaria sericea Retz.
		Desmodium heterocarpon (L.) DC.
		Desmodium laxiflorum DC.
		Desmodium sequex Wallich.
	Rosaceae	*Rubus hexagynus* Roxb.
		Rubus rugosus Smith.
	Rubiaceae	*Adenosacme stipulata* Hook. f
		Canthium angustifolium Roxb.
		Ixora coccinea Linn.
		Ixora lanceolaria Colebs.
		Mussaenda glabra Vahl, Symb.
		Pavetta indica L.
	Solanaceae	*Solanum torvum* Swartz.
	Tiliaceae	*Triumfetta tomentosa* Noronha
	Verbenaceae	*Clerodendron infortunatum* Gaertn.
		Clerodendrum serratum Spreng.
		Holmskioldia sanguinea Retz.
		Lantana camara Linn.

Herbs	Acanthaceae	*Hygrophila serphyllum* T. Anders.
		Justicia simplex Don.
		Lepidagathis ceylanica Nees.
		Ruellia prostrata Lamk.
	Alismaceae	*Sagittaria guayanensis* H.B & K.
	Amaranthaceae	*Achyranthes aspera* Linn.
		Achyranthes bidentata Bl.
		Amaranthus viridis Linn.
		Gomphrena hispida Linn.
	Araceae	*Arisaema consanguineum* Schott.
		Arisaema petiolulatum Hook. f.
		Arisaema tortuosum (Wall) Schott.
		Colocasia affinis Schott.
	Asteraceae	*Ageratum conyzoides* L.
		Bidens biternata (Lour) Merr & Sherff.
		Conyza japonica (Thunb.) Less.
		Dichrocephala integri folia (L.f.) O. Kuntze
		Eclipta prostrata L.
		Elephantopus scaber L.
		Galinsoga parviflora Cav., Ic, et. Descr.
		Gnaphalium polycaulon Pers.
		Siegesbeckia orientalis L.
		Sonchus arvensis Linn.
		Spilanthes acmella var *paniculata* (DC) C.B Clarke
		Spilanthes clava D.C.
		Tridax procumbens L.
		Vernonia cinerea (L). Less.
		Xanthium strumarium Linn.
	Balsaminaceae	*Impatiens balsamina* L.
	Begoniaceae	*Begonia acutifolia* Jacq.
		B. laciniata Roxb.
		B. picta Smith Exot.
	Commelinaceae	*Aneilema scaberrimum* Kunth.
		Commelina kurzii CB.Cl.
		Murdannia nudiflora (Linn) Brenan.
		Pollia secundiflora (Bl) Backer
	Euphorbiaceae	*Phyllanthus urinaria* Linn.
	Gentianaceae	*Swertia purpurascens* Wall. ex. C.B. Clarke.
	Haemodoraceae	*Peliosanthes teta* Anders.
	Lamiaceae	*Geniospermum coloratum* (Don) Kuntze Rev.
		Leucas aspera Spreng.
		Phryma leptortochya Linn.
		Plectranthus macranthus Hk. f.
		Pogostemon elsholtzioides Benth.
		Salvia coccinea Juss ex Murr.
		Scutellaria discolor Colebr.
	Liliaceae	*Polygonatum multiflorum* Allioni Fl. Pedem.
		Smilacina fusca Wall.
	Lobeliaceae	*Pratia begonifolia* Lindl.
	Lythraceae	*Ammannia rotundifolia* Ham.
	Melastomaceae	*Sonerila khasiana* CB.Cl.
		Sonerila maculata Roxb.
	Orchidaceae	*Arundina graminifolia* (D. Don) Hoehr.
		Habenaria acuminata Thwa.
		Habenaria lucida Wall.
		Zeuxine nervosa Benth.
	Oxalidaceae	*Oxalis acetosella* L.
	Papilionaceae	*Phaseolus calcaratus* Roxb.
		Phaseolus fuscus Wall.
	Piperaceae	*Peperomia heyneana* Miq. Syst. Pip.
		Piper sylvaticum Roxb.
	Plantaginaceae	*Plantago erosa* Wall.
	Polygalaceae	*Polygala chinensis* L.
	Polygonaceae	Fagopyrum cymosum *Meissn.*
		Polygonum rude Meissn
	Primulaceae	*Anagalis sps.*

	Ranunculaceae	*Ranunculus diffuses* DC.
		Ranunculus scleratus L.
	Rosaceae	*Fragaria indica* Andr.
	Rubiaceae	*Anotis calycina* Wall.
		Hedyotis corymbosa (L.) Lamk
		Hedyotis diffusa Willd.
		Knoxia sumatrensis (Retz) DC.
		Rubia albicaulis Boiss.
		Spermacoce ocymoides Burm.
	Scrophulariaceae	*Lindernia anagallis* var *grandiflora* (Spr)
		Lindernia cordifolia (Colsm) Merr Enum.
		Lindenbergia philippinensis Benth.
		Torenia vagans Roxb.
	Tiliaceae	*Triumfetta annua* L.
	Urticaceae	*Pilea hookeriana* Wedd.
		Pouzolzia hirta Hassk.
	Zingiberaceae	*Amomum aromaticum* Roxb.
		Globba charkii Baker.
		Globba multiflora Wall.
		Globba racemosa Smith.
		Hedychium spicatum Buch-Ham ex.Smith.
	Cyperaceae	Carex cruciata Wahlexb.
		Carex filicina Nees.
		Carex speciosa Kunth.
		Cyperus cephalotes Vahl.
		Cyperus corymbosus Roxb.
		Cyperus glomeratus Linn.
		Fimbristylis dichotoma (L.) Vahl.
		Scleria elata Thw.
	Poaceae	*Andropogon citratus* De.
		Andropogon schoenanthus Linn.
		Arundinella tuberculata Munro.
		Axonopus compressus (Swartz) Beauv.
		Brachiaria brizantha (A. Riech) Stapt.
		Brachiaria sps.
		Brachiaria villosa A. Camus
		Calamagrostis griffithiana Hk.f.
		Capillipedium assimile (Steud) A. Camus
		Cynodon dactylon (Linn.) Pers.
		Digitaria ciliaris (Retz) Koeler.
		Digitaria decumbens Steut.
		Eragrostis nigra Nees.
		Hordeum spontaneum C.Koch.
		Imperata cylindrical (Linn.) Beauv.
		Microstagium ciliatum (Trin.) A. Camus.
		Oplismenus busmanii Griff.
		Oplismenus compositus (Linn.) A. Beauv
		Panicum montanum Roxb. Ham.
		Panicum sps.
		Paspalum notatum Flugge.
		Pseudoechinolaena polystachya Stapf.
		Setaria palmifolia Stapf.
		Setaria glauca Beauv.
		Themeda triandra Forsk.
		Thysanolaena agrostis Nees.
Climbers and lianas	Acanthaceae	*Thunbergia coccinea* Wall.
	Apocynaceae	*Parameria pedunculosa* Benth.
	Araceae	*Rhaphidophora glauca* Schott.
		Rhaphidophora peepla (Roxb.) Schott.
	Asclepiadaceae	*Dregia volubilis* Benth ex. Hook. f.
	Asteraceae	*Mikania micrantha* Kunth.
	Dioscoreaceae	*Dioscorea alata* L.
		Dioscorea bulbifera Linn.
		Dioscorea deflexa Hook.f.
		Dioscorea hamiltonii Hook. f.
		Dioscorea spicata Roth.

	Liliaceae	*Smilax myrtillus* A. DC.
		Smilax parvifolia Wall.
		Smilax zeylanica Linn.
	Papilionaceae	*Derris cuncifolia* Benth.
		Dolichos lablab Linn.
	Passifloraceae	*Passiflora suberosa* Linn.
	Menispermaceae	*Tinospora cordifolia* (Willd) Miers.
		Stephania japonica (Thunb) Miers.
	Vitaceae	*Cissus adnata* Roxb.
		Cissus assamica (Law) Craib.
		Cissus discolor Bl. Bijdr.
		Vitis repanda Wight & Arn.
		Tetrastigma bracteolatum Planch.
		Tetrastigma serrulatum Planch.
Pteriophytes	Adiantaceae	*Adiantum lunulatum* (Burm)
		Adiantum venustum (Don) Bedd.
		Cheilanthes farinosa (Forst) Klf.
	Dennsteadtiaceae	*Blechnum orientale* Linn.
		Pteris eretica L.
		Pteris semipinnata L.
		Pteris vittata L.
	Gleicheniaceae	*Dieranopteris linearis* (Burm. f.)
	Polypodiaceae	*Ctenites sps.*
		Cyclosorus sps.
		Drynaria coronans (Wall) Bedd.
		Drynaria quercifolia (L.) Bedd.
		Pleopeltis rhycophyla (Hook). Bedd.
	Schizaceae	*Lygodium flexuosum* (L) SW.
	Selaginellaceae	*Selaginella bryopteris* Baker.

