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Floristic diversity assessment and vegetation analysis of tropical semievergreen forest of Manipur, north east India

L. SUPRIYA DEVI & P.S. YADAVA*

Ecology Laboratory, Department of Life Sciences, Manipur University, Imphal 795 003, India

Abstract: The present paper aimed to study the floristic diversity of *Dipterocarpus tuberculatus* dominated forest of Manipur situated along the Indo-Myanmar Border, north-eastern India. A total of 123 species belonging to 48 families were recorded. The quantitative features such as density and importance value index of species varied greatly. In the present study the diversity index of shrubs and herbs were found to be higher than the tree species. The concentration of dominance was recorded highest in the tree species. The presence of low number of higher girth class of tree species and higher number of the saplings and seedlings indicates that the present forest is young exhibiting frequent regeneration.

Resumen: El presente estudio se enfocó en el estudio de la diversidad florística del bosque dominado por *Dipterocarpus tuberculatus* de Manipur, situado a lo largo de la frontera India-Myanmar, nordeste de la India. Se registró un total de 123 especies pertenecientes a 48 familias. Las características cuantitativas como la densidad y el índice de valor de importancia de las especies variaron considerablemente. El índice de diversidad de arbustos y hierbas fue más alto que el de las especies arbóreas. La mayor concentración de la dominancia fue registrada para las especies arbóreas. La presencia de un número bajo de especies arbóreas de las clases perimétricas más grandes, así como un mayor número de juveniles y plántulas, indican que el bosque actual es joven, mostrando una regeneración frecuente.

Resumo: O presente artigo tem por objectivo o estudo da diversidade florística da floresta de Manipur situada ao longo da fronteira Indo-Myanmar, Nordeste da Índia e dominada pela *Dipterocarpus tuberculatus*. Foram registadas um total de 123 espécies pertencendo a 48 famílias. Os dados mostraram que características quantitativas como a densidade, e o importante índice de valor das espécies eram bastante variáveis. Neste estudo encontrou-se que o índice de diversidade de arbustos e ervas era mais elevado do que os das espécies arbóreas. A concentração de dominância foi encontrada ser mais elevada nas espécies arbóreas. A presença de um pequeno número de espécies arbóreas de classes de perímetro elevadas e elevado número de germinantes e plântulas indica que esta floresta é jovem e exibindo regeneração frequente.

Key words: Concentration of dominance, deciduous, *Dipterocarpus* forests, floristic diversity, similarity index, species diversity.

* *Corresponding Author*; e-mail: yadavps1@sancharnet.in

Introduction

Tropical forests constitute the most diverse plant communities on earth. These forests are disappearing at alarming rates owing to deforestation for extraction of timber and other forests products. Especially in NE India shifting cultivation operation are most obvious causes of forests disturbances. The problem with the chronic form of forest disturbance is that plants or ecosystem often do not get time to recover adequately because the human onslaught never stops (Singh 1998).

An obvious approach to conserve plant biodiversity is to map distributional patterns and look for concentrations of diversity and endemism (Gentry 1992). Further, management of forest requires understanding of its composition in relation to other forests, the effects of past impacts on the present status and the present relationship of the forest with surrounding land uses (Geldenhuys & Murray 1993).

Across the world, 25 hot-spots have been identified on the basis of species endemism and degree of threat through habitat loss (Myers *et al.* 2000). Out of these, two are confined to India sub-continent (i.e. western ghat/SriLanka and Indo-Burma). The present study site falls within the Indo-Burma hot-spot.

In Manipur *Dipterocarpus* forests along Indo-Myanmar border occupy approximately 750 sq km area. This forms the part of Indo-Malaya forest formation of *Dipterocarpus* forests, which extends upto south east Asian countries. As such, *Dipterocarpus* forests occur in western ghat and northeastern India, especially in Assam (Champion & Seth 1968).

Floristic diversity and phytosociological study of *Dipterocarpus* forest in north east India is lacking. Therefore, the present study has been undertaken to assess the plant biodiversity and vegetation analysis of *Dipterocarpus* forest of Manipur, north east India.

Materials and methods

The study site (23°49´N and 24°28´N latitude and 93°45´E to 94°14´E longitude; altitude 300 to 360 m above the mean sea level) is located along the Indo-Myanmar border near Moreh town in the Chandel district of Manipur. It is 108 km away from Imphal, the capital of Manipur. Two forests sites were earmarked for the present study i.e. forest site I more or less plain topography on hilltop, whereas site II was situated on the southern hill slope facing Myanmar border. The forest is dominated by *Dipterocarpus tuberculatus* (locally known as Khangra) and represents preclimax state and maintain by burning and sparse felling of trees.

The climate of the area is monsoonic with warm moist summer and cool dry winter. The mean maximum temperature varied from 24.15°C (January) to 35.9°C (May) and the mean minimum temperature ranged from 4.5°C (January) to 23.1°C (August). The mean monthly rainfall ranged from 4.5 mm (January) to 196 mm (July). The mean annual rainfall is 1245 mm. The average relative humidity of air varied between 61.5% (February) to 82.8% (July). Soils of the study area were sandy in texture and acidic in nature. The study was conducted during the year 1999-2000.

For study of plant biodiversity the selected sites were divided roughly into five parts depending on topography and altitude. Each part was sampled using one 250 x 40 m transect containing five (10 x 10 m) randomly laid quadrats. From each quadrat sample species of trees, shrubs and herbs were collected and identified.

The vegetation analysis was conducted during October. A total of 20 (10 x 10 m) quadrats for trees, 5 x 5 m for shrubs and 1 x 1m for herbs were laid. Quadrat data were used for computation of analytical features such as density, frequency, abundance, A/F ratio, basal cover and importance value index (IVI), following standard phytosociological methods as given by Curtis & McIntosh (1950). Diameter at breast height (dbh at 1.37 m from the ground) of all the trees with >30 cm circumference in each quadrat was measured and recorded for each species. The importance value index (IVI) for the tree species was determined as the sum

of the relative density, relative frequency and relative dominance (Curtis 1959). The ratio of abundance to frequency for different species was determined for eliciting the distribution patterns (Curtis & Cottom 1956). The tree species diversity was determined by using Shannon-Wiener information function (H´) (Shannon & Wiener 1963). Concentration of dominance was measured by Simpson's index (Simpson 1949). Similarity index was determined by as per formula given by Sorenson (1948).

Results

Floristic diversity

A total of 123 species (17 trees, 36 shrubs, 70 herbs) belonging to 48 families were recorded (Appendix 1). Among families, Poaceae (19 species), Fabaceae (13 species), Euphorbiaceae (7 species) and Acanthaceae (6 species) were most species diverse. Rubiaceae, Asteraceae, Mimosaceae and Cyperaceae are represented by 5 species each, Verbenaceae by 4 species and Dipterocarpaceae by 3 species. 13 families have two species each and the remaining 25 families were monospecific (Table 1).

Table 1. Plant biodiversity in *Dipterocarpus* forests.

Name of the family	Number of species
Poaceae	19
Fabaceae	13
Euphorbiaceae	7
Acanthaceae	6
Rubiaceae	5
Asteraceae	5
Mimosaceae	5
Cyperaeceae	5
Verbenaceae	4
Dipterocarpaceae	3
Apocynaceae	2
Araceae	2
Brassicaceae	2
Commelinaceae	2
Dioscoreaceae	2
Lamiaceae	2
Lauraceae	2
Magnoliaceae	2
Moraceae	2
Rutaceae	2
Smilacaceae	2
Vitaceae	2
Zingeberaceae	2
Others (25)	1 each

Compositional features

Tree layer

In forest site I, only two species were recorded, of which highest density (675 ind ha^{-1}), frequency, abundance and IVI (272.6) was recorded for *Dipterocarpus tuberculatus* (Table 2).

On forest site II, of the four species *Dipterocarpus tuberculatus* exhibited maximum density (585 ind ha^{-1}) followed by *Ardisia peniculata*, (170 ind ha^{-1}), *Wendlandia wallichii* (45.0 ind ha^{-1}) and *Ficus cunia* (20 ind ha^{-1}). Frequency and abundance followed the trend of *Dipterocarpus tuberculatus* > *Ardisia peniculata* > *Wendlandia wallichii* > *Ficus cunia*. Considering IVI as an indicator of dominance, *Dipterocarpus tuberculatus* dominates the tree layer of both the sites.

Saplings and seedlings

In sapling stage, in site I, three species were recorded, of which *Dipterocarpus tuberculatus* exhibited maximum value of density and IVI and followed by *Ardisia peniculata* (Table 2). Minimum value of density and IVI recorded for *Wendlandia wallichii*. Saplings were represented for two species in site II, i.e. *Dipterocarpus tuberculatus* and *Ardisia peniculata* (Table 2). Considerably high seedling density is characteristic of both the sites. Site I showed maximum density of *Dipterocarpus tuberculatus* seedlings. Whereas, *Wendlandia wallichii* dominates the seedling layers of site II (Table 2).

Shrub layer

Albizia samman (1400 ind ha^{-1}) followed by *Quercus* species (380 ind ha^{-1}) exhibited high density in site I (Table 2). As such the density ranged from 80 to 1400 ind ha^{-1}. The highest frequency was recorded for *Albizia samman* (50%) followed by *Quercus* species (30%) and lowest was recorded for *Magnolia* species (5%). The frequency ranged from 15% to 50%. The maximum IVI was recorded for *Albizia samman*

and followed by *Machilus duthi* whereas, *Magnolia* species exhibited lowest value.

In site II, only four species of shrubs were recorded. Of these, *Machilus duthii* exhibited maximum density (1260 ind ha^{-1}) (Table 2). Maximum frequency for *Actephilla excelsa* (20%) and minimum was recorded for *Gynocardia odorata* (10%). *Quercus* species exhibited highest abundance value and lowest in for *Gynocardia odorata*. Maximum value of IVI was recorded for *Machilus duthii* (112.13) and lowest for *Gynocardia odorata* (30.33).

Herb layer

Table 2. Importance value index (IVI) and density of different species at different layers for both the forests sites. Density values are individuals ha^{-1} for tree and shrub layer and individuals m^{-2} for herb layer.

Name of the species	Site I		Site II	
	Density	IVI	Density	IVI
		TREE LAYER		
A. peniculata	10.00	27.36	170.00	60.72
D. tuberculatus	675.00	272.61	585.00	211.53
F. cunia	-	-	20.00	8.986
W. wallichii	-	-	45.00	18.726
SAPLINGS				
A. peniculata	115.00	62.47	15.00	59.51
D. tuberculatus	660.00	220.05	80.00	240.47
W. wallichii	20.00	17.44	-	-
SEEDLINGS				
A. peniculata	3300.00	70.88	1840.00	46.86
D. tuberculatus	9620.00	193.27	5460.00	154.09
W. wallichii	2580.00	38.80	10204.00	99.02
		SHRUBS		
Actephila excelsa	-	-	760.00	94.16
Albizia samman	1400.00	87.00	-	-
Desmodium pulchellum	80.00	18.71	-	-
Eleocarpus chinensis	200.00	15.81	-	-
Gynocardia odorata	220.00	22.32	60.00	30.33
Machilus duthii	220.00	57.03	1260.00	112.13
Magnolia species	220.00	10.03	-	-
Quercus species	380.00	31.34	260.00	63.33
Others (2)	340.00	57.30	-	-
		HERBS		
Andropogon species	-	-	0.7	15.44
Arundinella setosa	9.70	73.12	-	-
Axonopus compressus	-	-	0.70	15.49
Cardamine species	0.55	12.56	-	-
Carex spinosa	6.10	89.67	-	-
Eragrostis nigra	-	-	10.80	55.49
Eulalia fastigiata	1.10	10.17	-	-
Fimbristylis dichotoma	0.80	12.61	-	-
Heteropogon contortus	-	-	6.90	103.01
Imperata cylindrica	5.95	41.46	11.85	57.40
Justicia simplex	-	-	9.95	46.01
Kyllinga triceps	1.15	15.75	-	-
Leucas aspera	0.90	22.39	-	-
Scleria elata	0.15	3.40	-	-
Others (2 each)	0.90	18.68	1.75	17.55

In site I, the density ranged from 1500 to 97000 ind ha^{-1}. *Arundinella setosa* exhibited the maximum density, followed by *Carex spinosa* and *Imperata cylindrica*. Highest frequency was recorded for *Arundinella setosa* (70%) and lowest
for both *Scleria elata* (5%) and *Eulalia fastigiata* (5%). The highest IVI was recorded for *Carex spinosa* followed by *Arundinella setosa*.

In site II, maximum density was recorded for *Imperata cylindrica* (118500 ind ha^{-1}) and followed by *Eragrostis nigra* (108000 ind ha^{-1}) (Table 2). Highest frequency was recorded for *Heteropogon contortus* (45%) and minimum was for *Andropogon* species (5%). *Justicia simplex* exhibited maximum abundance and minimum was recorded for *Andropogon* species. IVI ranged from 15.44 (*Andropogon* species) to 103.01 (*Heteropogon contortus*).

Species diversity and concentration of dominance

The species diversity, concentration of dominance of different layer of the forest site are depicted (Table 3). The highest concentration of dominance was recorded for tree layer and followed by saplings, seedlings, shrubs and herbs in site I. Whereas in site II, highest concentration was recorded for saplings layers (0.7340) followed by trees, seedlings, shrubs and lowest for herbs (0.2259). The species diversity (H) was recorded highest for herbs (2.4985) and lowest for tree layers (0.1094) for site I and for site II maximum was recorded for herbs layer (2.2944) and minimum for saplings layers (0.6285). The similarity index between the two site is very high i.e. 50%.

Population structure

Relative proportion of individual of tree species in different age class have been depicted (Fig. 1). *D. tuberculatus* exhibited higher proportion of seedlings and low number of tree and sapling population in both the sites, though large size tree beyond 40-50 cm girth size were absent. In case of *A. peniculata* proportions of the number of tree and sapling are low even though large number of seedling population exists in both sites. Seedlings of the *W. wallichii* were in large number with a few tree and sapling and may establish in due course of time.

Discussion

The number of species (123) recorded in the present study was found to be higher than the number of species reported by several workers in the different tropical forests [Chowdhury *et al.* 2000 (85 species); Fox *et al.* 1997 (94 species); Kadavul & Parthasarathy 1999 (89 species); Khera *et al.* 2001 (92 species); Pande 1999 (52 species); Uma Shanker 2001 (87 species) and lower than the value reported by Mekail *et al.* 1997 (148 species)] in different forest types.

The stand density value (685-820 tree ha^{-1}) and basal area (18.9-19.58 m^{-2} ha^{-1}) of the study sites are closer to the value reported by Jha & Singh (1990) for dry tropical forest of Vindhyan region of India.

In the present forest 61.8 percent of the total species show contagious pattern of distribution which is the characteristic features of natural vegetation. Similar distribution pattern was reported in the forest vegetation by several workers (Kershaw 1973; Ralhan *et al.* 1982).

The value of diversity index in the present study ranged from 0.109 to 2.49. The diversity index is generally higher in tropical forests, which is reported as 5.06 and 5.40 for young and old stand respectively (Knight 1975), whereas for Indian forests it ranged between 0.83 to 4.1 (Parthasarathy *et al.* 1992; Singh *et al.* 1984; Visalakshi 1995) and between 1.16 to 3.40 for temperate forest (Braun 1950; Monk 1967; Pande *et al.* 1996; Singhal *et al.* 1986). The value of diversity index of the present study, therefore, lies within the range reported for tropical forests.

Table 3. Species diversity in different forest sites in different layers of plants communities. CD= Concentration of cominance, H = Shanon-Wiener Information Function.

	Site I		Site II	
	CD	H´	CD	H´
Trees	0.9712	0.1094	0.5554	1.1782
Saplings	0.7106	0.7595	0.7340	0.6285
Seedlings	0.4581	1.3323	0.4486	1.3180
Shrubs	0.2574	2.4544	0.3467	1.6432
Herbs	0.2304	2.4985	0.2259	2.2944

(Similarity index of the two site = 50%)

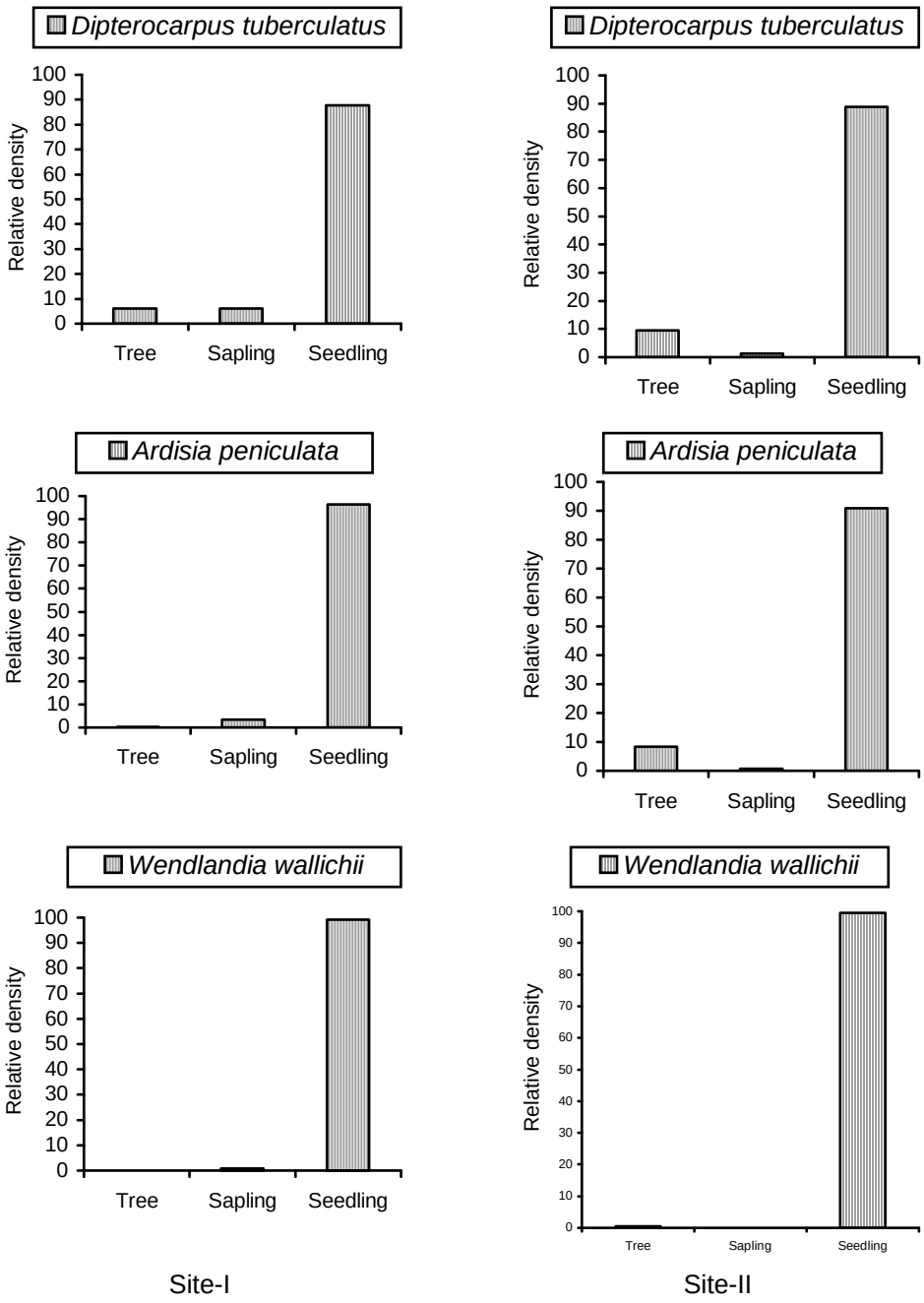

Fig. 1. Population structure of three tree species on forest Site I and Site II.

The concentration of dominance of the present study sites ranged from 0.225 to 0.971. According to Whittaker & Niering (1965); Risser & Rice (1971); Singhal *et al.* (1986) and Pande *et al.* (1996), the value of concentration of dominance (CD) for temperate forests falls within the range of 0.10 to 0.99, however, for tropical forests the average value is 0.06 as reported by Knight (1975). The range of CD reported for tropical forest of India varies from 0.21 to 0.92. The value reported in present study corresponds well with the reported range for tropical forest by several workers (Parthasarthy *et al.* 1992; Visalakshi 1995).

The similarity index between the two forest site is high, i.e. 50%, thereby suggesting that both
the forest sites are the parts of *Dipterocarpus* forest formation of the region.

The *Dipterocarpus* forest exhibits high level of species diversity and *D. tuberculatus* and *A. peniculata* exhibit high regenerating capacity, thus these forest showed fairly good regeneration
in comparison to many other semievergreen forests in India. *Dipterocarpus* forests are spread over 750 sq km near Myanmar border and extended to Myanmar and Malaya region. The present *Dipterocarpus* forest is gregarious in nature and maintains pre-climax stage of tropical evergreen type (climatic climax) owing to anthropogenic activities such as shifting cultivation and extraction of timber and cattle grazing. The prevention of cattle grazing and restricted extraction of wood may help in the conservation and management of these forest not only for maintaining the biodiversity but also to meet the basic needs of tribal population living around these forests.

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Appendix 1. Plant Biodiversity of *Dipterocarpus* forest of Manipur.

Name of the species	Family
Trees	
Actephila excelsa Muell.	Euphorbiaceae
Albizia gamblei Prain	Mimosaceae
Anthocepalus cadamba Mitz.	Rubiaceae
Ardisia peniculata Roxb.	Myrsinaceae
Croton oblongifolius Roxb.	Euphorbiaceae
Cryptocarya amygdalina Nees	Lauraceae
Dalbergia stipulata Wall.	Fabaceae
Dipterocarpus tuberculatus Roxb	Dipterocarpaceae
Dipterocarpus turbinatus Gaertn.F.	Dipterocarpaceae
Dysoxylum procernum Hiern	Meliaceae
Ficus cunia Ham.	Moraceae
Lagerstromia parviflora Roxb.	Lythraceae
Mallotus philippensis (Lam) Muell-Arg	Euphorbiaceae
Pithecolobium dulce Benth.	Mimosaceae
Shorea robusta Gaetrn.	Dipterocarpaceae
Tectona grandis Linn.	Verbenaceae
Wendlandia wallichii W&A	Rubiaceae
Shrubs	
Acaceia intsia Willd.	Mimosaceae
Albizia samman (Jacq). F.Muell	Mimosaceae
Antidesma diandrum Linn.	Euphorbiaceae
Baccaurea sapida Muel Arg.	Euphorbiaceae
Boeica filiformis CBC.	Gesneraceae
Buddlea asiatica Lour.	Longaniaceae
Canavalia ensiformis CD.	Fabaceae
Clerodendrum serratum Bl.	Verbenaceae
Congea tomentosa Roxb.	Verbenaceae
Derris elliptica Hk.f.	Fabaceae
Desmodium pulchellum Benth.	Fabaceae
Desmos dumosa Roxb.	Annonaceae
Dioscorea sativa Pr. & Burk.	Dioscoreaceae
Dioscorea wallichii Hk.F.	Dioscoreaceae

Contd...

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Appendix 1. continued.

Name of the species	Family
Elaeocarpus chinensis Linn.	Elaeocarpaceae
Erythroxylon kuntiasia Hk.f	Erythroxyloceae
Ficus drupacea Thunb.	Moraceae
Flemingia congesta Roxb.	Fabaceae
Glycomis cyanocarpa Spring.	Rutaceae
Gynocardia odorata R.Br.	Bixaceae
Jasminum coarctatum Roxb.	Oleaceae
Machilus duthii Roxb.	Lauraceae
Magnolia species	Magnoliaceae
Manglietia insignis (Wall)Bl.	Magnoliaceae
Meliosma simplicifolia Bl.	Sabiaceae
Murraya koenigii Spreng.	Rutaceae
Phlogacanthus tubiflorus Nees.	Acanthaceae
Pithecolobium montatum Benth.	Mimosaceae
Psychotria curviflora Thew.	Rubiaceae
Pueraria thunbergiana Benth.	Fabaceae
Quercus species	Fagaceae
Randia malabarica Wall.	Rubiaceae
Smilax roxburghinia Benth.	Smilacaceae
Trewia mudiflora Linn.	Euphorbiaceae
Vitex crispa Bl.	Vitaceae
Vitex peduncularis Wall.	Vitaceae
Herbs	
Alocasia acuminata Scott.	Araceae
Alocasia farnicata Roxb.Scott.	Araceae
Alternenthera sessilis Roxb.	Amaranthaceae
Andrographis paniculata Nus.	Acanthaceae
Andrographis wightiana Arn.	Acanthaceae
Andropogon species	Poaceae
Arundinella mutica Nus.ex. Stued	Poaceae
Arundinella setosa Trin..	Poaceae
Axonopus compressus (Sw.)P. Beauv.	Poaceae
Bambusa affinis Munro	Poaceae
Biophytum sensitivum (L) D.C.	Oxalidaceae
Calanthe wallichii Hook.f.	Orchidaceae
Cardamine species	Brassicaceae
Carex spinosa Linn.	Cyperaceae
Clerodendrum nutans Wall.	Verbenaceae
Costus speciosus Smith.	Zingeberaceae
Crotalaria incana Linn.	Fabaceae
Cyanotis barbata Linn.	Commelinaceae
Cyperus distans Linn.	Cyperaceae
Desmodium concanum DC	Fabaceae

Appendix 1. continued.

Name of the species	Family
Eulalia fastigiata Hainis	Poaceae
Eupatorium odoratum Linn.	Asteraceae
Euphorbia hirta Linn.	Euphorbiaceae
Fimbristylis dichotoma (L) Valh.	Cyperaceae
Flemingia involucrata Benth.	Fabaceae
Flemingia strobilifera R.Br.	Fabaceae
Globba orixensis Roxb.	Zingeberaceae
Heteropogon contortus (L) P. Beauv ex.Roem & Schult.	Poaceae
Holboellia latifolia Wall.	Lardizabalaceae
Imperata cylindrica (Linn) Beauv.	Poaceae
Inula cappa DC	Asteraceae
Iodes ovalis Bl.	Icacinaceae
Ipomea linifolia Wall.	Convolvulaceae
Justicia simplex Don.	Acanthaceae
Knoxia lanciolata Benth.	Rubiaceae
Kyllinga triceps Rottb.	Cyperaceae
Leucas aspera Wall.	Lamiaceae
Melodinus khasianus Hk.f.	Apocynaceae
Melodinus monogynus Roxb.	Apocynaceae
Mikania scandens Willd.	Asteraceae
Mucuna pruriens DC	Fabaceae
Murdania simplex Vohl.	Commelinaceae
Ophiopogon griffithii W.A	Haemodaraceae
Oplismenus compositus (L)	Poaceae
Panicum brevifolium Linn.	Poaceae
Paraya macrocarpa Br.	Brassicaceae
Paspallum chinensis Hk.f.	Poaceae
Pavetta indica Gaertn.	Poaceae
Phragmites karka Trin.	Poaceae
Polygala leptolia DC	Polygalaceae
Polygonum chinensis Linn.	Polygonaceae
Rungia racemosa Linn.	Acanthaceae
Scleria elata Thw.	Cyperaceae
Scoparia dulcis Linn.	Scorphulariaceae
Scutellaria bicolour Linn.	Lamiaceae
Seigesbeckia orientalis Linn.	Asteraceae
Sesamum indicum DC	Pedaliaceae
Setaria compacta Schur.	Poaceae
Smilax smilacina Hk.f.	Smilacaceae
Smithia sensitiva Ait.	Fabaceae
Sporobulus indicus Br.	Poaceae
Stellaria vagans Linn.	Caryophyllaceae
Themeda gigantea Cav.	Poaceae
Thladiantha calcarta C.B.C	Cucurbitaceae
Thysanolaena maxima (Rox) Kuntze.	Poaceae
Vernonia cinerea Less.	Asteraceae