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**Original article**

# Plant diversity and community structure in tropical moist deciduous sal (*Shorea robusta* Gaertn.) forest of Assam, northeast India

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Diversity, Doboka reserve forest, Herb, Sal, Shrub, Tree

**Abstract:**

The present study was conducted for quantitative analysis of plant diversity and community structure of tropical moist deciduous sal ((*Shorea robusta* Gaertn.) forest of Assam, northeast India. The study was carried out in Doboka reserve forest (longitude $92^0$46′0″- $92^0$57′0″ E and latitude $26^0$6′0″- $26^0$13′0″ N) located towards the South of Nagaon district of Assam. A total of 89 plant species (34 tree, 15 shrubs, 25 herbs and 15 climbers) belonging to 77 genera and 45 families were recorded. The *Shorea robusta* had highest IVI (125.3) followed by *Dillenia pentagyna* (27.24) and *Careya arborea* (23.12). The stand density and basal area of tree species recorded 422 individual $ha^{-1}$ and 88.87 $m^2ha^{-1}$ respectively. Tree density in lower girth class i.e. 30-60 cm was found to be higher. Shannon-Wiener index of diversity ranges from 2.02 to 2.43. The study indicates that the tropical moist deciduous sal forest of Assam is a species diverse forest ecosystem.

## 1. INTRODUCTION

Study on plant species diversity and community structure of tropical forest is ecologically significant because of their richness in medicinal and economically important plants. On a global basis, 52% of the total forests are tropical forests having rich species diversity (Pitchairamu *et al.* 2008; Sagar and Singh 2005; Kadavul and Parthasarathy 1999; Kumar 1989). Sal (*Shorea robusta* Gaertn.) is one of the most dominant tree species in tropical moist deciduous forest (Kushwaha and Nandy 2012) and in tropical India sal forests are widely distributed and cover approximately 13.30% of the total forest area of the country. Geographically, the sal occupies two main regions, the northern and central Indian regions and in the northern region, there is almost a continuous belt of sal stretching along the sub-Himalayan tract from Punjab to Assam (Pandey and Shukla 2003). Sal belonging to the family Dipterocarpaceae is one of the most important timber trees in India. Sal is also a good source of 'aromatic gum' which is known to have medicinal properties (Deka *et al.* 2012). Because of its high timber value, socio-economic importance for fodder, fuel-wood, leaf litter and for minor forest product sal forests are considered one among the most disturbed types of forest in Southeast Asia (Sapkota *et al.* 2009). The governments saw sal forests more as a timber source rather than for other forest products and government attempted to manage sal forests for commercial timber production in order to increase revenue (Gautam and Devoe 2006).

Understanding of forest structure is a pre-requisite to describe various ecological processes of forest (Eluard *et al.* 1997). Species diversity of forest has functional consequences, because the number and kinds of species present in any area determine the organisamal traits, which influence the ecosystem processes (Rana and Gairola 2009). The biodiversity of sal forests is very wide and interesting both from ecological and conservation point of view (Rahman *et al.* 2010). Various workers have studied Indian sal forest to understand the community composition (Shankar 2001; Pandey and Shukla 2001; Pande

1999; Singh *et al.* 1995; Gupta and Shukla 1991). Pandey and Shukla (2003) studied the plant diversity in managed sal forests of Gorakhpur, India. Singh and Kuswaha (2005) studied the phenology of sal forests. Recently Kushwaha and Nandy (2012) studied the diversity and community structure in two climatically distinct sal forest and reported high species richness in the moist sal forest then the dry sal forest of West Bengal, India.

The state of Assam falls in the tropical climate belt in the northeastern region of India (Srivastava *et al.* 2002) and maximum forest area of the state included under tropical moist deciduous type (Agarwala 1990). Studies on plant diversity and community structure of sal forest in the state of Assam of northeast India have not received much attention, except a study on community structure of secondary sal forest of Kamrup district (Deka *et al.* 2012) and studies on development and history of sal forests of Goalpara district in Assam (Dixit and Bera 2011). In Doboka reserve forest, no phytosociological study has been carried out so far. Therefore, the present study was undertaken to investigate the plant diversity and its composition, which would able to understand various characters of community structure of tropical moist deciduous sal forest of Assam. The hypothesis of the study is that the species diversity and density is high and comparable with the other sal forests of the country.

## 2. MATERIALS AND METHODS

### *2.1 Study site*

The study was conducted in Doboka reserve forest, located in the Nagaon district in Assam, Northeast India. In Nagaon district distribution of *Shorea robusta* restricted only in two reserve forests and Doboka reserve forest is one among them. The forest is tropical moist deciduous type and is located between $92^0$46′0″- $92^0$57′0″ E longitude and $26^0$6′0″- $26^0$13′0″ N latitudes (Fig 1). The area of Doboka reserve forest is 12,251.23 ha at an elevation of 106 m amsl. Topography of Doboka Reserve Forest is flat to hilly.

### *2.2 Sampling design and data collection*

The study was carried out during 2009-2010 by lying quadrat. Trees were sampled by lying 10 × 10 m quadrat, placed randomly covering an area of 0.5 ha. Girths of trees (≥30 cm) were measured at 1.3 m height from the base. Depending on girth size the recorded individuals were divided into ten girth classes e.g. 30-60, >60-90, >90-120, >120-150, >150-180, >180-210, >210-240, >240-270, >270-300 and >300-330 cm. The shrubs were sampled through 5 × 5 m quadrat, herbs and climbers were sampled by lying 1 × 1 m quadrat within the quadrats for trees. In aggregate 50 quadrats for trees, 50 quadrats for shrubs and 100 quadrats for herbs and climbers were sampled. The size of the quadrat for sampling of tree, shrub and herb were determined by following Muller-Dombois and Ellenberg (1974). Basal area, density and Importance Value Index (IVI) for plant species were calculated according to the formulae of Cottam and Curtis (1956). Statistical analysis was carried out using the software Origin 6.1. Shannon-Wiener diversity index (H′) was calculated using the formula given by Shannon and Wiener (1963):

$$H' = -\sum_{i=1}^{s} \text{pilnpi}$$

Where $p_i$ represents the proportional abundance of the $i^{th}$ species in the community.

Simpson's index of dominance ($C_D$) was measured by formula given by Simpson (1949):

$$C_D = \sum_{i=1}^{s} (\text{pi})^2$$

Where $p_i$ is the same as for the Shannon-Wiener diversity index.

Evenness index (e) was calculated using formula given by Pielou (1966):

$$e = H'/\log S$$

Where H′ is the number derived from the Shannon-diversity Index and S is the total number of species.

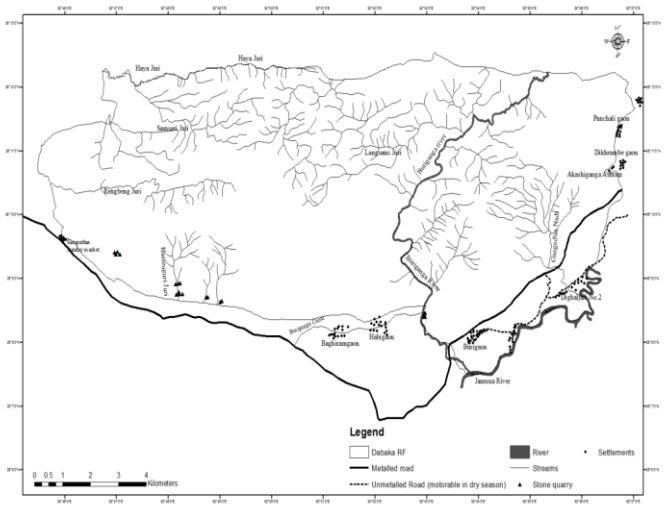


**Fig 1.** Map of Doboka reserve forest

## 3. RESULTS AND DISCUSSION

### *3.1 Diversity and Species richness*

In total, 89 plant species (34 tree species, 15 shrubs, 25 herbs and 15 climber) belonging to 77 genera and 45 families were recorded during this study in Doboka reserve forest (Table 1).

The 34 tree species found in the forest belonging to 31 genera and 27 families and 25 species of herb representing 21 genera and 12 families. Total 15 climber belonging to 13 genera and 11 families were recorded in the forest. Overall Poaceae (8 species) was the dominant family, followed by Asteraceae (5 species) and Euphorbiaceae (5 species). Among the tree, Caesalpinaceae, Combretaceae, Lythraceae, Moraceae, Rubiaceae, Sterculiaceae and Verbenaceae had two species in each. Among the shrubs, the dominant families were Euphorbiaceae (3 species) and Verbenaceae (3 species). Poaceae (8 species) and Asteraceae (3 species) were found to be the dominant families among herbs. Menispermaceae with three species, recorded as a dominant family among climbers. Shannon-Wiener index of diversity ranges from 2.02 to 2.43 (Table 2). In Doboka reserve forest herb diversity was found to be higher than trees and shrubs. Simpson's index indicate that the dominance of trees was higher than shrub and herb but herb species were more evenly distributed than shrub and tree species.

### *3.2 Density, basal area and importance value index*

The stand density and basal area of tree species recorded 422 individual $ha^{-1}$ and 88.87 $m^2ha^{-1}$ respectively. Tree density in lower girth class i.e. 30-60 cm was found to be higher whereas basal area was found to be highest (18.06 $m^2ha^{-1}$) in higher girth class i.e. >240-270 cm (Fig 2). The *Shorea robusta* had highest IVI (125.3) followed by *Dillenia pentagyna* (27.24), *Careya arborea* (23.12), *Lagerstroemia flosreginae* (15.73), *Bauhinia variegate* (14.16), *Terminalia belerica* (12.01) and *Sterculia colorata* (11.71). *Chromolaena odorata* (99.68), *Bridelia verrucosa* (58.07), *Clerodendron colebrookianum* (37.27) and *Vitex negundo* (25.89) were the dominant shrub species in Doboka reserve forest. Among the herbs, *Costus speciosus* (55.04), *Ophiuros megaphyllus* (43.52), *Curcuma amada* (34.27), *Maranta arundinacea* (32.58), *Commelina benghalensis* (28.42), *Cyperus rotundus* (24.82), *Oplismenus burmanni* (20.8) and *Panicum repens* (17.69) were found to be the dominant species.

The overall species richness in Doboka reserve forest is greater than the Alluvial plain Kamrup sal forest of Assam (Deka *et al.* 2012), but lower than the sal forest in Eastern Himalaya (Shankar 2001) and sal forests of west Bengal (Kushwaha and Nandy 2012). The number of tree species (≥30 cm) in Doboka reserve forest found to be more than the sal forests in Central Himalaya (Pande 1999; Pandey and Shukla 1999; Singh *et al.* 1995) and sal forests in Central India (Prasad and Pandey 1992). Shannon-Wiener index value of 2.43 for trees was slightly lower than the sal dominated forests (3.59) in Eastern Himalaya (Shankar 2001), in West Bengal moist sal forest (Kushwaha and Nandy 2012) but higher than the dry sal forest (0.62) of West Bengal and Alluvial plain Kamrup sal forest (1.43) of Assam. Moist sal forests are generally characterized by the presence of more tree species (Kushwaha and Nandy 2012).

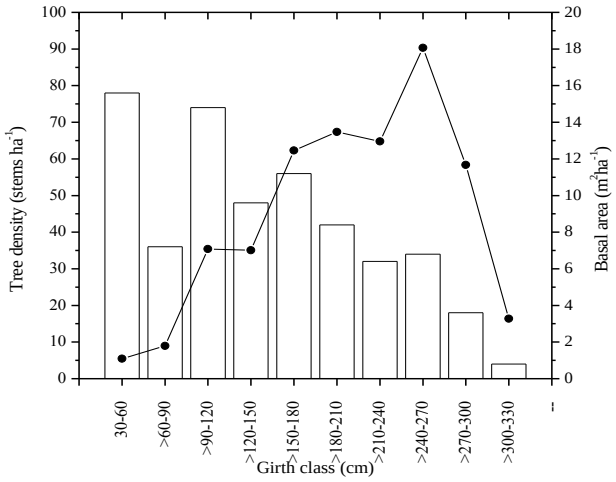


**Fig 2. Density and basal area of trees in different girth classes in Doboka reserve forest**

Information on species richness and diversity as a baseline information is required for proper management of protected area. High species richness means greater diversity and which leads to a higher community stability (MacArthur 1955). In the present study, Poaceae was found to be the dominant family like Sunabeda wildlife sanctuary in Odisha, where sal is one of a predominant species (Kandi *et al.* 2011). Except Poaceae, Asteraceae and Euphorbiaceae recorded as dominant family which are common in West Bengal sal forest (Kushwaha and Nandy 2012), Eastern Himalaya sal forest (Shankar 2001), Gorakhpur sal forest (Pandey and Shukla 2003), sal forest of Kamrup district of Assam (Deka *et al*. 2011).

Tree density 422 individual $ha^{-1}$ was observed to be higher in Doboka reserve forest than managed sal forest of Gorakhpur (404 individual $ha^{-1}$) (Pandey and Shukla 2003) and close to 438 individual $ha^{-1}$ recorded for moist sal foresi in West Bengal (Kushwaha and Nandy 2012), 484 individual $ha^{-1}$ recorded for Himalayan lowland sal forest (Shankar 2001). Basal area of 88.87 $m^2ha^{-1}$ in Doboka reserve forest is higher than the sal forests of West Bengal (Kushwaha and Nandy 2012), Alluvial plain Kamrup sal forest of Assam (Deka *et al.* 2011), sal dominated forest in Eastern Himalaya (Shankar 2001), in Central Himalaya (Pande 1999; Pande and Shukla 1999), in Central India (Jha and Singh 1990; Prasad and Pandey 1992). High tree density in lower girth class could because of to the repeated disturbance (Whitmore 1975). The high basal area in present study site resulted from the presence of some very large trees in girth size >240-270 cm in which the highest basal area recorded. Overall, large mature trees (>150-180 to >270-300)

mainly contribute to increase the value of basal area. Associated species of sal in present study like, *Dillenia pentagyna*, *Terminalia balerica*, *Careya arborea*, *Chromolaena odorata*, *Oplismenus burmanni* were recorded as common associated species in other sal dominated forest ecosystem (Kushwaha and Nandy 2012; Rahman *et al.* 2009; Shankar 2001).

The present study can serve as a baseline for tropical moist deciduous sal forest of Assam. Moreover, species richness and community structure of the forest can contribute to understand the tropical moist deciduous sal forest ecosystem. Burning, grazing, browsing, timber harvesting, fodder, fuel-wood extraction are common in different sal forests (Pande 1999; Pandey and Shukla 2001; Sagar *et al.* 2003; Webb and Sah 2003; Timilsina *et al.* 2007; Sapkota *et al.* 2009) which are also common scene in Doboka reserve forest. The threats from the disturbances are needs to be investigated in future for proper management of this species rich sal forest.

Table2. Summary of species inventory in Doboka reserve forest

| Variable | Tree | Shrub | Herb | Climber and lianas |
|---|---|---|---|---|
| Species richness (No. of species) | 34 | 15 | 25 | 15 |
| Number of genera | 31 | 14 | 21 | 13 |
| Number of families | 27 | 9 | 12 | 11 |
| Stand density (individual ha-1) (SD) | 422 (27.11) | 3426 (409.67) | 108500 (6039.4) | 29500 (2823.03) |
| Basal area (m2ha-1) (SD) | 88.87 (9.45) | 0.82 (0.08) | 1.73 (0.13) | 0.39 (0.07) |
| Shannon-Wiener index | 2.43 | 2.02 | 2.51 | - |
| Simpson's index | 0.19 | 0.18 | 0.11 | - |
| Evenness index | 0.69 | 0.75 | 0.78 | - |

Table1. IVI, density $ha^{-1}$ and basal area $m^2ha^{-1}$ of plant species recorded in Doboka reserve forest

| Species Name | Family | IVI | Density $ha^{-1}$ | Basal area $m^2ha^{-1}$ |
|---|---|---|---|---|
| Tree | | | | |
| *Ailanthus grandis* Prain. | Simaroubaceae | 1.67 | 2 | 0.392 |
| *Albizzia lucida* Benth. | Mimosaceae | 2.02 | 2 | 0.702 |
| *Bauhinia variegata* L. | Caesalpinaceae | 14.2 | 26 | 2.397 |
| *Bombax ceiba* L. | Malvaceae | 1.62 | 2 | 0.344 |
| *Careya arborea* Roxb. | Lacythidaceae | 23.1 | 36 | 3.54 |
| *Cassia fistula* L. | Caesalpinaceae | 4.06 | 6 | 0.327 |
| *Chukrasia tabularis* A. Juss. | Meliaceae | 1.56 | 2 | 0.29 |
| *Dillenia pentagyna* Roxb. | Dilleniaceae | 27.2 | 38 | 8.131 |
| *Duabanga grandiflora* Walp. | Sonneratiaceae | 2.29 | 2 | 0.94 |
| *Ficus glomerata* Roxb. | Moraceae | 1.27 | 2 | 0.035 |
| *Gmelina arborea* Roxb. | Verbenaceae | 3.57 | 6 | 0.561 |
| *Garuga pinnata* Roxb. | Burseraceae | 2.81 | 4 | 0.306 |
| *Holarrhena antidysenterica* Wall. | Apocynaceae | 2.5 | 4 | 0.032 |
| *Ilex godajam* Coleb. | Aquifoliaceae | 3.35 | 4 | 0.785 |
| *Lagerstroemia flosreginae* Retz. | Lythraceae | 15.7 | 36 | 2.361 |
| *Lagerstroemia parviflora* Roxb. | Lythraceae | 3.47 | 4 | 0.895 |
| *Linnea grandis* A. Rish. | Anacardiaceae | 3.73 | 4 | 1.796 |
| *Litchi longana* (Camb.) Sonner | Sapindaceae | 2.78 | 4 | 0.951 |
| *Machilus globosa* A. Das | Lauraceae | 1.25 | 2 | 0.014 |
| *Mitragyna rotundifolia* Kuntze | Rubiaceae | 5.45 | 8 | 0.464 |
| *Palaquium obovatum* Engl. | Sapotaceae | 1.53 | 2 | 0.269 |
| *Sapium baccatum* Roxb. | Euphorbiaceae | 3.15 | 4 | 0.611 |
| *Schima wallichii* Choisy | Theaceae | 2.89 | 4 | 0.378 |
| *Shorea robusta* Gaertn | Dipterocarpaceae | 125 | 154 | 55.35 |
| *Sterculia colorata* Roxb. | Sterculiaceae | 11.7 | 14 | 3.416 |
| *Sterculia villosa* Roxb. | Sterculiaceae | 5.3 | 10 | 0.584 |
| *Strablus asper* Lour. | Moraceae | 2.07 | 2 | 0.742 |
| *Syzygium cumini* (L.) Skeels | Myrtaceae | 1.38 | 2 | 0.129 |
| *Terminalia bellerica* Roxb. | combretaceae | 12 | 20 | 1.072 |
| *Terminalia chebula* Retz. | combretaceae | 1.26 | 2 | 0.027 |
| *Trema amboinensis* Blume | Ulmaceae | 2.83 | 4 | 0.323 |
| *Vangueria spinosa* Roxb. | Rubiaceae | 1.25 | 2 | 0.014 |
| *Vitex altissima* L. | Verbenaceae | 4.45 | 6 | 0.672 |
| *Ziziphus jujuba* Lam. | Rhamnaceae | 1.25 | 2 | 0.016 |
| Shrub | | | | |
| *Adhatoda vasica* Nees. | Acanthaceae | 0.96 | 8 | 0.0001 |
| *Berchemia floribunda* Wall. | Rhamnaceae | 2.92 | 24 | 0.007 |

| | | | | |
|---|---|---|---|---|
| *Bridelia verrucosa* Haines. | Euphorbiaceae | 58.1 | 504 | 0.192 |
| *Callicarpa arborea* Roxb. | Verbenaceae | 1.3 | 16 | 0.001 |
| *Cephalanthus occidentalis* L. | Rubiaceae | 2.36 | 4 | 0.004 |
| *Chromolaena odorata* (L.)R.M. Kingand H.Rob. | Asteraceae | 99.7 | 1488 | 0.294 |
| *Clerodendron colebrookianum* Walp. | Lamiaceae | 37.3 | 760 | 0.043 |
| *Clerodendron viscosum* Vent. | Lamiaceae | 14.8 | 224 | 0.007 |
| *Desmodium cephalotes* Wall. | Papilionaceae | 1.01 | 8 | 0.0006 |
| *Holmskioldia sanguinea* Retz. | Verbenaceae | 2.93 | 8 | 0.016 |
| *Lantana camara* L. | Euphorbiaceae | 7.55 | 56 | 0.026 |
| *Mezoneurum cucullatum* W and A. | Caesalpiniaceae | 6.76 | 26 | 0.009 |
| *Phlogacanthus thyrsiflorus* Nees. | *Acanthaceae* | 18.5 | 128 | 0.1 |
| *Phyllanthus multiflorus* Willd. | Euphorbiaceae | 19.9 | 96 | 0.088 |
| *Vitex negundo* L. | Verbenaceae | 25.9 | 76 | 0.032 |
| Herb | | | | |
| *Achyranthes aspera* L. | Amarantaceae | 1.52 | 300 | 0.003 |
| *Aerva lanata* (L.) Schult. | Amarantaceae | 6.55 | 900 | 0.074 |
| *Ageratum conyzoides* L. | Asteraceae | 1.11 | 500 | 0.005 |
| *Chrysopogn aciculatus* | Poaceae | 1.27 | 600 | 0.006 |
| *Commelina benghalensis* L. | Commelinaceae | 28.4 | 9000 | 0.085 |
| *Costus speciosus* (Koen) Smith. | Costaceae | 55 | 11600 | 0.536 |
| *Curcuma amada* Roxb. | Zingiberaceae | 34.3 | 6700 | 0.311 |
| *Curcuma aromatica* Salisb. | Zingiberaceae | 2.75 | 300 | 0.03 |
| *Cynodon dactylon* L. | Poaceae | 3.18 | 2100 | 0.003 |
| *Cyperus rotundus* L. | Poaceae | 24.8 | 5900 | 0.185 |
| *Dicliptera retusa* | Acanthaceae | 1.19 | 600 | 0.005 |
| *Dicliptera roxburghiana* Nees. | Acanthaceae | 2.19 | 800 | 0.006 |
| *Lygodium japonicum* (Thunb.) Sw. | Lygodiaceae | 5.23 | 2100 | 0.013 |
| *Lygodium microphyllum* (Cav.) R. Br. | Lygodiaceae | 6.9 | 2600 | 0.009 |
| *Maranta arundinacea* L. | Marantaceae | 32.6 | 9000 | 0.295 |
| *Ophiuros megaphyllus* Stapf. | Poaceae | 43.5 | 24000 | 0.088 |
| *Oplismenus burmannii* (Retz.) P. Beauv. | Poaceae | 20.8 | 13900 | 0.032 |
| *Oplismenus compositus* L. | Poaceae | 0.74 | 400 | 0.0001 |
| *Panicum repens* L. | Poaceae | 17.7 | 13400 | 0.011 |
| *Phyllanthus fraternus* G. L.Webster | Euphorbiaceae | 1.2 | 500 | 0.0003 |
| *Pollinia ciliata* Trin. | Poaceae | 1.45 | 600 | 0.003 |
| *Proniphricum nudatum* | Thlipteridaceae | 1.64 | 1000 | 0.006 |
| *Urena lobata* L. | Malvaceae | 2.86 | 500 | 0.017 |
| *Vernonia cinera* Less. | Asteraceae | 2.45 | 1000 | 0.008 |
| *Xanthium strumarium* L. | Asteraceae | 0.61 | 200 | 0.001 |
| Climber and lianus | | | | |
| *Butea parviflora* Roxb. | Papilionaceae | 2.85 | 100 | 0.007 |
| *Butea superba* Roxb. | Papilionaceae | 126 | 7100 | 0.269 |
| *Cissampelos pareira* L. | Menispermaceae | 4.37 | 400 | 0.007 |
| *Dioscorea alata* L. | Dioscoreaceae | 58.7 | 9500 | 0.024 |
| *Ichnocarpus frutescens* (L.) R. Br. | Apocynaceae | 10.1 | 1400 | 0.008 |
| *Mikania micrantha* Kunth | Asteraceae | 23.4 | 3000 | 0.011 |
| *Merremia vitifolia* (Burm.f.) Hallier.f. | Convolvulaceae | 1.19 | 100 | 0.0008 |
| *Paederia foetida* L. | Rubiaceae | 15.4 | 1900 | 0.007 |
| *Piper longum* L. | Piperaceae | 1.45 | 100 | 0.002 |
| *Smilax macrophylla* Willd. | Smilaceae | 31 | 3100 | 0.032 |
| *Stephania japonica* (Thunb.)Miers | Menispermaceae | 16 | 2100 | 0.004 |
| *Tinospora chinensis* (Lour.) Merr. | Menispermaceae | 2.85 | 100 | 0.007 |
| *Vitis planicaulis* Hook. | Vitaceae | 1.81 | 100 | 0.003 |
| *Vitis latifolia* Roxb. | Vitaceae | 1.74 | 200 | 0.002 |
| *Combretum roxburghii* Spreng | Combretaceae | 3.58 | 300 | 0.002 |

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