#### **Research Article**

# Forest structure, plant diversity and local endemism in a highly varied New Guinea landscape

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#### **Abstract**

The Island of New Guinea is renowned for its high biodiversity, which arises in part from its complex geology and topographical variability. The island is, however, relatively understudied. We surveyed forest plant communities in the poorly studied Naoro-Brown catchment of the West Koiari region of Papua New Guinea. We identified four forest types—riverine successional forest, lower montane forest, hill forest, and riverine mixed forest—along a 13-km transect, and examined forest structure (tree height, stand density, and biomass) and tree species diversity (species richness, Shannon-Wiener diversity index, and composition) in these forest types. We also assessed the effect of local topography on floristic patterns. Forest structure and species diversity varied greatly among the forest types, with topography strongly affecting species assemblages. These results suggest that highly varied landscapes may contain high *beta* diversity via intense segregation and establishment of varied vegetation communities. *Beta* diversity in New Guinea may be higher than expected as such highly varied landscapes are common, yet poorly studied. To effectively conserve biodiversity in New Guinea's forests, protection must include forested landscapes that best represent the topographical variability throughout the island to account for locally endemic species restricted to specific ecological niches.

**Key words:** *Beta* diversity, Biodiversity conservation, Forest structure, Local endemism, Species diversity, Topographic variation.

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#### Introduction

The island of New Guinea is estimated to contain 5-7% of total global biodiversity, making it one of the richest tropical biomes in the world [1-2]. There are at least two likely explanations for this. First, because of its geographic location, New Guinea is the confluence point for biodiversity from both Australasia and Southeast Asia [3]. Second, high habitat heterogeneity generated by the geological processes (tectonic uplift and volcanism) from which the island originated, have also enhanced diversity [4]. A classic example of this is the exceptionally high biodiversity found on Mount Bosavi, an extinct Pleistocene volcano in the Southern Highlands of Papua New Guinea [5]. In this area, topographical barriers have restricted species migration, promoting a radiation of new plant and animal species, many of which are locally endemic [5].

Much of the biodiversity in New Guinea is still undescribed scientifically, as evidenced by continued discoveries of new species in remote areas [e.g. 5-8]. Furthermore, information on species occurrences and the structural dynamics of biodiversity in multiple forest types is still far from adequate [9]. The only known published studies of the structural dynamics of biodiversity in New Guinea focused on insect herbivory and trophic interactions between food webs [e.g. 10-12]. In addition, recent publications provide novel information on diversity patterns of forest succession in New Guinea lowland forests [e.g. 57, 58]. Despite the biological advances in New Guinea, information on the diversity and composition of plant communities is still scarce.

Previous plant surveys in New Guinea mainly focused on *alpha* diversity, which is the species richness within a localised area [13-14]. These surveys reported tree richness ranging from 98 to 178 species per hectare [e.g. 15-19], with the highest published estimate of tree and liana diversity (≥ 10cm diameter-at-breast height [DBH]) reaching 228 species per hectare in the Crater Mountain Wildlife Management Area [16]. However, *beta* diversity, the variation in species composition through space [13-14], remains virtually unstudied in New Guinea. Understanding patterns of *beta* diversity is crucial for guiding conservation efforts in rich tropical biomes such as New Guinea that are being rapidly altered by deforestation and forest degradation [2, 14].

The relative lack of biodiversity surveys in New Guinea have been attributed to financial constraints, limited availability of experts, and the difficulty of accessing many areas due to highly rugged terrain [18, 20-22]. However, increasing human encroachment into old-growth forests is leading to increasing numbers of environmental impact assessments, which often involve rapid plant surveys. Such surveys could improve the spatial resolution of plant compositional data and thereby allow *beta* diversity to be better estimated in New Guinea [e.g. 23].

Here we present a study of forest structure and floristics in a rugged New Guinea landscape from such a rapid plant survey. Specifically, we ask: (1) Do forest types within the Naoro-Brown River catchment vary considerably in structure and plant richness? (2) How does *beta* diversity vary among the major forest types? (3) Does local topography influence plant endemism within this catchment?

#### Methods

Study Location

Our study was conducted in July 2010 along a 13-km transect within the Naoro-Brown catchment area in the West Koiari district (S 9° 12.46′ E 147° 34.45′ and S 9° 10.35′ E 147° 27.93′), on the south-eastern region of Papua New Guinea (Fig 1). This rapid assessment was conducted over six days as part of an Environmental Impact Assessment for a proposed mini-dam and hydro-power station [24]. The study area extends over highly forested riverine plains and foothills to lower montane forests. Rainfall is

seasonal, ranging between  $1,550 - 2,000 \text{ mm yr}^{-1}$  and increases with elevation [20, 25]. Pristine vegetation dominates most of the study area, although it also includes patches of successional regrowth in old village and garden sites abandoned more than three decades ago.

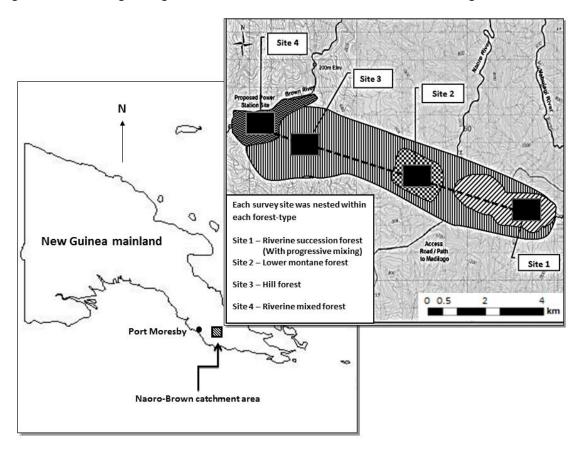


Fig. 1. Orientation of the study sites showing the four forest types along a 13-km transect. The study area is dominated by small-crown hill forest with tracts of riverine mixed forests and lower montane forests associated with waterways and low mountain peaks, respectively.

#### Study design

We identified four forest types along the transect, using forest classifications for Papua New Guinea [20]. These were riverine mixed forest (~173 m above sea level [a.s.l]), hill forest (~665 m a.s.l), lower montane forest (~1,174 m a.s.l), and riverine succession forest (~874 m a.s.l). Riverine mixed forest generally extends from riverbanks, through ravines, and along the ascending ridges where it merges with hill forest. Hill forest covers most of the study area (Fig. 1), extending along the ascending ridge crest of low mountains where it meets patches of lower montane forest covering the highest crests within the area. Unlike these three forest types, which are currently intact, riverine succession forests are patches of post-disturbance regrowth in abandoned human settlements along the Naoro-Brown river.

The topographical aspects defining each forest type were fairly distinctive.

Four 50 x 20 m (0.1 ha) plots were randomly established >0.1 km apart in each forest type. Topography within each plot was measured by elevation, linear distance between plots, and slope, as these have shown to be ecologically meaningful in complex landscapes [26-28]. Elevation above sea level and the

distance between each pair of plots were measured in the centre of each plot using a Garmin GPSmap 76Cx. Slope of each plot was estimated using a clinometer by averaging five slope measurements at randomly selected points along the direction of the greatest slope [29].

#### Forest structure survey

Forest structure was measured by tree height, stand density, and biomass. For each plot tree height was measured using a Haglöf ECII Electronic Clino / Height Meter. We measured and recorded all living trees ≥10 cm DBH, according to Pearson et al. [30], and enumerated all measured stems to determine the tree-stand density. Tree biomass was estimated using a generic allometric equation for tropical forests adapted from Chave et al. [31], and plot-level biomass was generated by summing values for all trees in each plot. Forest height was the average maximum tree height recorded at five random points within each plot.

#### Plant survey

Plant diversity was estimated via plant species richness and the Shannon-Wiener diversity index [32]. Compositional similarity among forest types was used as a proxy for *beta* diversity [14]. We collected voucher specimens of all tree morphospecies and tagged each tree for identification purposes. Voucher specimens were also collected for non-tree species (herbs, shrubs, climbers, creepers, and ferns) and treelets in each plot. All non-tree plants were sampled using twenty 1 x 1 m quadrats randomly placed within each plot (after Katovai et al. [33]). Flowers and fruiting bodies were collected where possible to assist with identification. Vouchers were taken to Pacific Adventist University, Port Moresby, for further taxonomical sorting and then to the National Herbarium at the Forest Research Institute in Lae for expert verification. All voucher specimens were keyed to genus and to species level where possible. A species list for each plot was then generated (Appendix A) and used to compare species compositional similarity among forest types. Saplings were excluded from the survey due to challenges in taxonomical sorting.

#### Statistical Analysis

A one-way analysis of variance (ANOVA) was used to test whether forest structure and species diversity variables differed among forest types, followed by Tukey's HSD tests to assess pair-wise differences. All analyses were run in SPSS [34].

We ran an analysis of similarity (ANOSIM) based on Bray–Curtis similarity matrices of species occurrence to determine how plant community composition varied among forest types [35-36]. We then used non-metric multi-dimensional scaling (NMDS) to identify major gradients in species composition. These analyses were carried out using PRIMER V6 [36].

To examine the effect of topography on plant endemism in the forest types, we categorised all species found in each plot into tree and non-tree categories. Using these categories, we estimated local endemism, the proportions of trees and non-trees occurring uniquely in a single forest type. Pearson correlations were used to test for associations among the arcsine-transformed endemism levels and log-transformed values of slope and elevation. Based on the correlation outputs, we selected highly associated predictor-response combinations (r>0.70), and used linear regressions to examine how topography influenced variation in local plant endemism within the Naoro-Brown landscape.

#### **Results**

In total, we sampled 1.6 ha in the Naoro-Brown catchment area and identified 163 species (87 non-tree and 76 tree species) from 60 families, of which 93 were identified to species level (Appendix A). We also counted 754 trees with DBH  $\geq$ 10 cm across the forest types. The estimated mean ( $\pm$ SD) of tree biomass for the entire area was 537 $\pm$  356 tonnes/ha.

#### Forest structure and diversity

Forest structure differed among forest types, although results varied among response variables (Table 1). For example, while there were overall significant differences in mean tree height ( $F_{3, 12} = 68.8$ , p < 0.0001), tree stand density ( $F_{3, 12} = 43$ , p < 0.0001), and tree biomass ( $F_{3, 12} = 110$ , p < 0.0001), Tukey's tests showed different groupings of forest types associated with each measure (Table 1). Tree height, for instance, showed two homogenous groups. One group consisted of riverine mixed forest ( $31.6\pm1.4$  m) and hill forest ( $25.9\pm0.7$ m), and the other consisted of riverine succession ( $22.8\pm0.6$  m) and lower montane forest ( $21.2\pm1.4$  m). Mean tree density in riverine succession forest was significantly higher than in the three primary forests (Table 1). Riverine mixed forest had the highest mean biomass ( $1,113\pm141$  tonnes), followed by homogenous groups hill forest ( $442\pm32$  tonnes) and lower montane forest ( $315\pm24$  tonnes). Mean biomass of riverine succession forests was lowest ( $277\pm27$  tonnes), and differed significantly from all others (Table 1).

Table 1.Details of landscape, floristics and forest structure variables across forest types in the Naoro-Brown catchment. Mean values ±SD of four 0.1ha plots per forest type are given for each variable. Superscript letters beside mean numbers of variables indicate significant pair-wise differences across forest types and elevation bands using Tukey's HSD tests. Means with different superscript letters are significantly different. Forest type acronyms explained: RSF = Riverine succession forest, LMF = Lower montane forest, HF = Hill forest and RMF = Riverine mixed forest.

Forest-type	Mean Species richness	Shannon Index	Est.Forest height (m)	Tree stand density	Est. Mean biomass (t)
RSF	31±2.2 <sup>D</sup>	2.60±0.09 <sup>B</sup>	22.8±0.6 <sup>c</sup>	62.3±4.6 <sup>A</sup>	277.4±26.8 <sup>c</sup>
LMF	44.8±1.0 <sup>C</sup>	2.73±0.15 <sup>B</sup>	21.2±1.4 <sup>c</sup>	41.3±1.5 <sup>B</sup>	314.9±24.3 <sup>BC</sup>
HF	50.3±2.6 <sup>B</sup>	3.07±0.04 <sup>A</sup>	25.9±0.7 <sup>B</sup>	47±1.8 <sup>B</sup>	441.5±31.9 <sup>B</sup>
RMF	55.3±1.9 <sup>A</sup>	3.24±0.09 <sup>A</sup>	31.6±1.4 <sup>A</sup>	41.5±3.1 <sup>B</sup>	1113.2±141 <sup>A</sup>

Plant diversity also differed among forest types (Table 1). Mean species richness differed significantly among forest types ( $F_{3, 12} = 69.3$ , p < 0.0001), with all pairwise comparisons being considerably different (Table 1). Riverine mixed forest had the highest mean richness (55.3±1.9 species), followed by hill (50.3±2.6 species), lower montane (44±1.0 species), and riverine succession forests (31±2.1 species). Shannon diversity indices also differed significantly among the forest types ( $F_{3, 12} = 38.1$ , p < 0.000), with Tukey's tests revealing two homogeneous subsets: riverine mixed forests (3.24±0.09) and hill forests (3.07±0.04); and lower montane forests (2.73±0.15) and riverine succession forests (2.60±0.09).

#### Beta diversity

ANOSIM and pairwise comparisons revealed that species composition differed significantly among forest types P < 0.001; Fig 2). As expected, species compositional similarity was highest between hill forest and riverine mixed forest, albeit still with a relatively low similarity of 17.86%. Compositional similarity was lowest between riverine mixed forest and lower montane forest, with 3.70% similarity (Fig 2).

#### Topography and local endemism

Tree species endemism was strongly negatively associated with slope (r = -0.82, p < 0.001), but its association with elevation was non-significant (r = 0.20, p > 0.05). In contrast, non-tree endemism was highly negatively associated with elevation (r = -0.87, p < 0.001) but not with slope (r = -0.15, p > 0.05; all Pearson correlations).

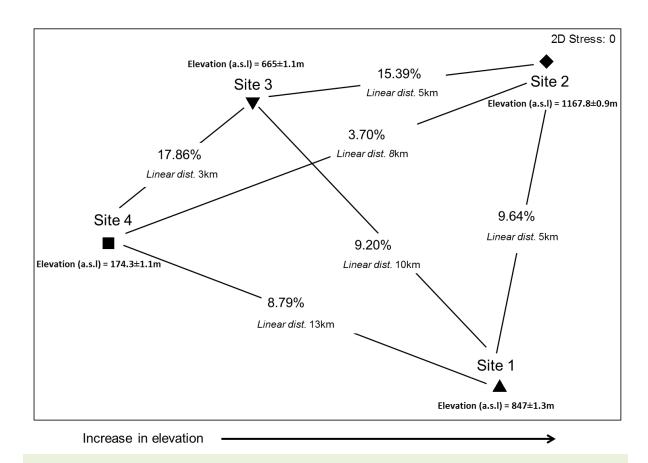


Fig. 2. Multidimensional Scaling (MDS) for similarity in species composition between Riverine successional forest (♠), Lower montane forest (♠), Hill forest (▼) and Riverine mixed forest (■). MDS is based on Bray–Curtis similarity indices. Also displayed are the species compositional similarity percentage and linear geographic distance (in km) between each forest type. The elevation gradient along the horizontal axis shows how forest types are positioned with respect to topographical elevation within the landscape.

Linear regressions showed that elevation was a good predictor of local endemism for non-tree species ( $F_{1,14}$  = 102.7, p < 0.001), explaining 87% of the variability in non-tree endemism among forest types (Fig 3c). Local endemism in trees was predicted by slope ( $F_{1,14}$  = 28.92, p < 0.001), explaining 65% of the total variation among forest types (Fig 3b).

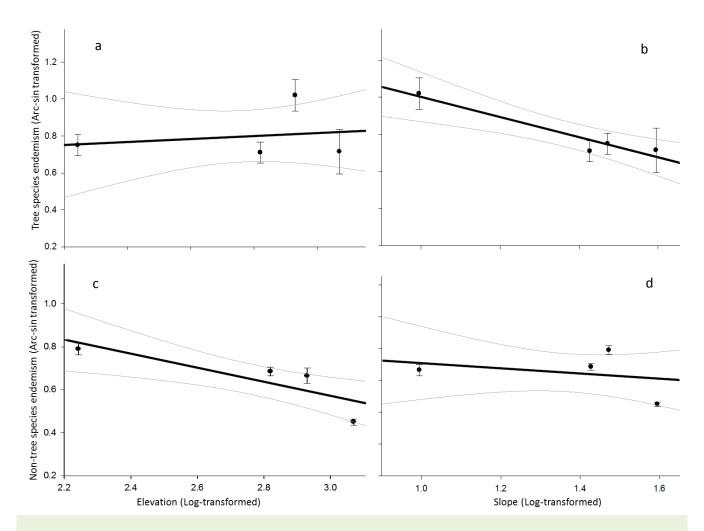


Fig. 3. The regression plots (with 95% Confidence Intervals – in grey) display relationships between tree and non-tree local endemism across elevation and slope in the Naoro-Brown catchment area. Solid lines in b and c indicate the strong effects of elevation and slope on non-tree species and tree species endemism respectively. In contrast, solid lines in a and d indicate insignificant relation between the compared variables.

#### **Discussion**

#### Forest structure and diversity across forest types

Forest structure and plant diversity were highly variable in our study transect (Table 1, Fig. 2). Such high spatial variation could result from both local environmental factors, such as varying precipitation, temperature, and topographical features [29, 37], as well as from different dynamics and disturbance histories throughout the study area [38]. Below we consider key attributes of each of these four major forest types.

#### Riverine mixed forest

In riverine mixed forest, canopy trees are relatively uniform in height, averaging 31 m. This forest has large tree crowns that significantly reduce the amount of light penetrating into the understory and forest floor. Common trees are mainly from the genera *Syzigium*, *Llitsea*, *Aglaia*, *Harpullia* (Tulipwood), and *Acalypha* (Copperleaf), with no evidence of single-species dominance. The dense canopy cover and leaf litter on the forest floor help to maintain surface moisture [39], which supports moss growth covering the base of trees and a high abundance of herbaceous forms. Large woody vines throughout the forest column are also apparent, which may indicate a mature forest system [40-42].

We observed a low density of treefall gaps in this forest type, which suggests only sporadic disturbance from wind or tree death. Treefall gaps displayed a range of seral stages, augmenting plant species diversity [43-44]. Perhaps a more substantial form of disturbance is triggered by huge volumes of runoff channelled through ravines that flood the forest floor during monsoonal rains between October and January. These ravines develop micro-topographical formations on the forest floor that could help diversify microhabitats within the forest [15, 45].

#### Hill forest

Hill forests mainly contain small-crowned deciduous trees, thus having a relatively open canopy with tree heights rarely exceeding 28 m. Understory trees are abundant because understory light levels are relatively high [44]. Common deciduous trees include *Bombax ceiba* (Bombax), *Gordonia papuana* (Gordiana), *Pterocarpus spp*.(Makua or Nara) and *Terminalia spp* (Terminalia). The shrub layer is dominated by scrambled bamboo, *Maniltoa psilogyne*, and a variety of lianas and palm species that may be maintained by relatively high light and semi-dry conditions of the understory [46-47]. The rarity of herbaceous forms may also be related to such dry environmental conditions.

#### Lower montane forest

In lower montane forests the trees exhibit smaller crowns than those at lower elevations. Mean canopy tree height was ~21 m with a few scattered *Syzygium trees* over 25 m high. Due to the small crowns and high variance in canopy height, light penetration into the understory and forest floor is irregular, creating large variability in the structure of the undergrowth. Trees dominating the canopy and sub-canopy mostly belong to the genera *Garcinia*, *Harpullia* (Tulipwood),, *Cryptocarya*, *Macaranga* (Euphorbs), and *Syzygium*. The understory mainly includes a few genera of palms (*Calamus*, *Caryota*, *Hydriastile*), pandanas (*Freycinetia*) and a number of ground orchids in the genera *Tropidia* and *Bulbophylum*.

#### Riverine successional forest

After fallow decades, riverine successional forest mainly exhibited a high abundance of thin trees dominated by *Terminalia*, *Glochidion*, *Cryptocarya*, and a few *Ficus* species. Also present were multiphase successional trees (*Litsea timoriana*, *Annesijoa novoguineensis*, *Dysoxylum* [Rose Mahogany],

*Xylopia papuana*), ferns, herbaceous creepers and shade-tolerant understory species, such as epiphytes and non-woody climbers. These varied groups indicate a mixing of plant life forms and successional stages in this forest.

#### Beta diversity and endemism

The low species compositional similarity among these forests suggests high *beta* diversity in the Naoro-Brown catchment area (Fig 2). However, other tropical studies at comparable geographical distance (0-13km) reported lower species turnover of ~50% [e.g. 27-28, 48-50]. The high *beta* diversity in our study area may have been overestimated due to limited sampling, restricted to trees ≥10 cm DBH only. The large gradient in elevation along our transect (~1,000 m) would likely have enhanced *beta* diversity relative to the aforementioned studies, which were conducted over topographically less variable areas.

Our results also suggest that topography strongly influences local endemism of plant species. Such responses are generally regulated by microclimate and soil attributes along topographical gradients [e.g. 51-53]. However, consistent trends of plant endemism have been reported on larger spatial scales. For example, studies on oceanic islands have revealed a unimodal response to elevation whereby endemism peaks at mid-elevation and then gradually decreases at high elevations [58-59]. Relatively low diversification and speciation at high elevations on recently uplifted mountains may have caused in these patterns [59]. Our results cannot account for this because of the relatively small spatial extent of our study and its location. We suggest that the ecological mechanisms driving shifts in plant endemism vary at any given time and space due to complex interactions among environmental variables throughout the studied landscape [54-55].

### Implications for conservation

Our findings suggest that to conserve biological and functional diversity in New Guinea, protected areas must at least include landscapes that best represent the topographical variability throughout the island [2, 21, 33]. Immediate efforts should focus on forests that are most vulnerable to deforestation and degradation (see [2, 22]). Rapid plant surveys can be used opportunistically to document vital information on spatial vegetation patterns of uncharted landscapes in New Guinea. In the absence of such information, a focus on maximizing the conservation of gradients spanning topographic, geological, and climatic gradients should be a priority. For an island rich in locally endemic species that is being rapidly altered by a range of human land uses, such simple surrogate variables can help to guide near-term conservation efforts.

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Appendix A. Identified plant taxa collected in the study area.

1       Actinidiaceae       Saurauia       sp.         2       Actinidiaceae       Saurauia       sp.         3       Amaryllidaceae       Crimun       asiatica         4       Anacardiaceae       Semecarpus       sp.         5       Annonaceae       Cyathocalyx       petiolatus         6       Annonaceae       Cyathocalyx       sp.         7       Annonaceae       Polyalthia       glanca         8       Annonaceae       Xylopia       papuana         9       Apocynaceae       Allamanda       sp.         10       Apocynaceae       Papuechites       sp.         11       Araceae       Homalomena       cordata         12       Araceae       Pothos       hellwigii         13       Araceae       Rhaphidophora       peekelii         14       Araceae       Rhaphidophora       sp.         15       Araliaceae       Polyscias       sp.         16       Araliaceae       Schefflera       sp.         17       Arecaceae       Calmus       hollrungii         18       Arecaceae       Heterospath       sp.         20       Arecaceae       Hydria	Sp. NO.	Family	Genera	Species
3AmaryllidaceaeCrimunasiatica4AnacardiaceaeSemecarpussp.5AnnonaceaeCyathocalyxpetiolatus6AnnonaceaeCyathocalyxsp.7AnnonaceaePolyalthiaglanca8AnnonaceaeXylopiapapuana9ApocynaceaeAllamandasp.10ApocynaceaePapuechitessp.11AraceaeHomalomenacordata12AraceaePothoshellwigii13AraceaeRhaphidophorapeekelii14AraceaeRhaphidophorasp.15AraliaceaePolysciassp.16AraliaceaeSchefflerasp.17ArecaceaeCalamushollrungii18ArecaceaeCaryotarumphiana19ArecaceaeHeterospathsp.20ArecaceaeHydriastelecostata21ArecaceaeHydriastelesp.122ArecaceaeHydriastelesp.223AsclepiadaceaeHoyasp.224AsclepiadaceaeHoyasp.225AspleniaceaeVittariasp.26AspleniaceaeVittariasp.27AsteraceaeElaphantopusscaber28BombacaceaeBombaxceiba29BurseraceaeCanariumacutifolium30ClusiaceaeGarciniasp.131ClusiaceaeG	1	Actinidiaceae	Saurauia	conferta
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27AsteraceaeElaphantopusscaber28BombacaceaeBombaxceiba29BurseraceaeCanariumacutifolium30ClusiaceaeGarciniasp.131ClusiaceaeGarciniasp.232CombretaceaeTerminaliasp.33CyperaceaeCyperusrotundus34CyperaceaeFimbristylisdichotoma	25	Aspleniaceae	Asplenium	nidus
28BombacaceaeBombaxceiba29BurseraceaeCanariumacutifolium30ClusiaceaeGarciniasp.131ClusiaceaeGarciniasp.232CombretaceaeTerminaliasp.33CyperaceaeCyperusrotundus34CyperaceaeFimbristylisdichotoma	26	Aspleniaceae	Vittaria	sp.
29BurseraceaeCanariumacutifolium30ClusiaceaeGarciniasp.131ClusiaceaeGarciniasp.232CombretaceaeTerminaliasp.33CyperaceaeCyperusrotundus34CyperaceaeFimbristylisdichotoma	27	Asteraceae	Elaphantopus	scaber
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31 Clusiaceae Garcinia sp.2 32 Combretaceae Terminalia sp. 33 Cyperaceae Cyperus rotundus 34 Cyperaceae Fimbristylis dichotoma	29	Burseraceae	Canarium	acutifolium
32 Combretaceae Terminalia sp. 33 Cyperaceae Cyperus rotundus 34 Cyperaceae Fimbristylis dichotoma	30	Clusiaceae	Garcinia	sp.1
33 Cyperaceae Cyperus rotundus 34 Cyperaceae Fimbristylis dichotoma	31	Clusiaceae	Garcinia	sp.2
34 Cyperaceae Fimbristylis dichotoma	32	Combretaceae	Terminalia	sp.
	33	Cyperaceae	Cyperus	rotundus
35 Davalliaceae Drynaria sp.	34	Cyperaceae	Fimbristylis	dichotoma
	35	Davalliaceae	Drynaria	sp.

36	Davalliaceae	Lindsaea	sp.
37	Davalliaceae	Nephrolepis	hirsutula
38	Dioscoreaceae	Dioscorea	alata
39	Dracaenaceae	Dracaena	angustifolia
40	Ebenaceae	Diospyros	sp.
41	Ebenaceae	Diospyros	sogerensis
42	Ericaceae	Dimorphanthera	dekokii
43	Euphorbiaceae	Acalypha	sogerensis
44	Euphorbiaceae	Antidesma	sp.
45	Euphorbiaceae	Codiaeum	variegatum
46	Euphorbiaceae	Drapetes	bordenii
47	Euphorbiaceae	Glochidion	cf. ferdinandi
48	Euphorbiaceae	Glochidion	phillipicum
49	Euphorbiaceae	Macaranga	punchata
50	Euphorbiaceae	Phyllanthus	sp.
51	Euphorbiaceae	Pimelodendron	amboinicum
52	Fabaceae	Archidendron	glabrum
53	Fabaceae	Desmodium	sp.
54	Fabaceae	Gigasiphon	schlecterii
55	Fabaceae	Maniltoa	psylogyne
56	Fabaceae	Maniltoa	sp.
57	Fabaceae	Milletia	pinnata
58	Fagaceae	Lithocarpus	celebicus
59	Flacourtiaceae	Casearia	sp.
60	Flagellariaceae	Flagellaria	indica
61	Gesneriaceae	Cyrtandra	erectiloba
62	Gleicheniaceae	Dicranopteris	linearis
63	Hypoxidaceae	Curculigo	recurvata
64	Lauraceae	Cryptocarya	sp.
65	Lauraceae	Endiardra	sp.1
66	Lauraceae	Endiardra	sp.2
67	Lauraceae	Litsea	timoriana
68	Lauraceae	Litsea	sp.1
69	Lauraceae	Litsea	sp.2
70	Liliaceae	Dianella	sp.
71	Liliaceae	Dianella	ensifolia
72	Loganiaceae	Strychnos	minor
73	Lycopodiaceae	Lycopodium	cernuum

74	Melastomataceae	Medinilla	crassinervia
75	Meliaceae	Aglaia	sp.
76	Meliaceae	Chisocheton	sp.
77	Meliaceae	Dysoxylum	sp.1
78	Meliaceae	Dysoxylum	sp.2
79	Menispermaceae	Tinospora	sp.
80	Monimiaceae	Kibara	fugax
81	Monimiaceae	Palmeria	sp.
82	Monimiaceae	Palmeria	brassii
83	Moraceae	Artocarpus	communis
84	Moraceae	Ficus	sp.1
85	Moraceae	Ficus	sp.2
86	Moraceae	Ficus	sp.3
87	Moraceae	Ficus	sp.4
88	Moraceae	Ficus	molior
89	Myristicaceae	Gymnacranthera	paniculata var. zippelliana
90	Myrsinaceae	Maesa	haplobotrys
91	Myrsinaceae	Rapanea	leucantha
92	Myrtaceae	Syzygium	plumeum
93	Myrtaceae	Syzygium	acuminatissima
94	Myrtaceae	Syzygium	malaccense
95	Myrtaceae	Syzygium	longipes
96	Myrtaceae	Syzygium	claviflorum
97	Oleaceae	Chionanthus	brassii
98	Oleaceae	Chionanthus	sessiliflorum
99	Orchidaceae	Bulbophylum	sp.
100	Orchidaceae	Dendrobium	sp.
101	Orchidaceae	Glossoryncha	sp.
102	Orchidaceae	Tropidia	disticha
103	Pandanaceae	Freycinetia	linearis
104	Pandanaceae	Freycinetia	sp.1
105	Pandanaceae	Freycinetia	sp.2
106	Piperaceae	Piper	macropiper
107	Piperaceae	Piper	sp.
108	Pittosporaceae	Pittosporum	sp.
109	Poaceae	Arundo	sp.
110	Poaceae	Bambusa	sp.
111	Poaceae	Coix	lachyma-jobi

112	Poaceae	Eriachne	sp.
113	Poaceae	Imperata	cylindrica
114	Poaceae	Paspalum	conjugatum
115	Poaceae	Setaria	sp.
116	Polypodiaceae	Christella	arida (Don)
117	Polypodiaceae	Diplazium	sp.
118	Polypodiaceae	Drynaria	sp.
119	Polypodiaceae	Humata	pectinata (J.J.Sm)
120	Polypodiaceae	Lindsaea	repens (Bory)
121	Polypodiaceae	Microsorium	sp.3
122	Polypodiaceae	Microsorium	sp.1
123	Polypodiaceae	Microsorium	sp.2
124	Polypodiaceae	Nephrolepis	sp.
125	Polypodiaceae	Polypodium	sp.
126	Polypodiaceae	Pteris	cretica
127	Polypodiaceae	Pteris	sp.
128	Polypodiaceae	Sphaerostephanos	sp.1
129	Polypodiaceae	Sphaerostephanos	sp.2
130	Polypodiaceae	Sphaerostephanos	unitus
131	Polypodiaceae	Tectaria	siifolia (Wild)
132	Polypodiaceae	Tectaria	semibipinnata (Wall)
133	Polypodiaceae	Tectaria	sp.
134	Proteaceae	Helicia	sp.
135	Rhamnaceae	Ziziphus	angustifolius
136	Rhizophoraceae	Gynotroches	axillaris
137	Rosaceae	Prunus	gazel-peninsulae
138	Rubiaceae	Guettadella	sp.
139	Rubiaceae	Guettadella	sp.1
140	Rubiaceae	Lasianthus	sp.
141	Rubiaceae	Mussaenda	sp.
142	Rubiaceae	Psychotria	sp.1
143	Rubiaceae	Psychotria	sp.2
144	Sapindaceae	Cupaniopsis	sp.
145	Sapindaceae	Guioa	sp.
146	Sapindaceae	Guioa	crassinervia
147	Sapindaceae	Harpullia	sp.
148	Sapindaceae	Harpullia	longipetala
149	Sapotacaea	Palaquium	warburgianum

150	Sapotaceae	Manilkara	sp.
151	Schizaeaceae	Schizaea	dichotoma
152	Selaginellaceae	Selaginella	aspericaulis
153	Smilacaceae	Smilax	australis
154	Sterculiaceae	Sterculia	schumanniana
155	Sterculiaceae	Sterculia	papuana
156	Theaceae	Gordonia	papuana
157	Theaceae	Gordonia	sp.
158	Urticaceae	Elatostema	novoguiniense
159	Vitaceae	Leea	indica
160	Zingiberaceae	Alpinia	sp.
161	Zingiberaceae	Amomum	aculeatum
162	Zingiberaceae	Curcuma	longa
163	Zingiberaceae	Hornstedtia	scottiana