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Tree Stands and Liana Community in Royal Belum State Park, Malaysia

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ABSTRACT

The diversity of lianas and trees were studied in five study sites of 100 x 20 m within the Royal Belum State Park, Malaysia with a view to provide baseline information on their incidence, taxonomy and ecological distributions. The sites include Sungai Kejar, Sungai Papan, Sungai Papan 2, Teluk Gopal and Sungai Kooi with at least 1000 m apart. These plots were further sub-divided into five sub-plots of 20 x 20 m each. Lianas with a diameter at breast height (dbh) ≥ 1 cm and trees with dbh ≥ 10 cm were identified and frequencies of occurrence were determined. Lianas comprising 92 species from 23 families while trees comprising 221 species and 48 families were enumerated. Annonaceae was the richest family of lianas and trees (19 species and 23 species respectively). *Connarus* (Connaraceae) and *Spatholobus* (Fabaceae) had the highest number of lianas (six species) whilst *Syzygium* (Myrtaceae) had the highest number of trees (11 species). There are significant differences in all the diversity indices among the study sites, except between Sungai Papan and Teluk Gopal which were the richest and most diverse in liana species. These two sites also showed high similarity index in liana species (0.50) followed by Sungai Kejar and Sungai Papan 2 (0.37). Sungai Kejar was however observed to have the highest tree species richness. These study sites could be described as very rich with a high diversity of lianas and trees. Although, it is richer in trees than lianas which means that the level of disturbance of the park is very low.

Keywords: Annonaceae, *Connarus*, forests, lianas diversity, Perak, *Syzygium*

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INTRODUCTION

Tropical forests are important carbon pools, comprising approximately 40% of terrestrial carbon storage (Dixon *et al.*, 1994). None of that matters because deforestation still going rampant and the quality of habitable spaces turned plummet (Potter, 1999). Wildlife creatures especially, are threatened by the scenario and have always been in great jeopardy. The intact forest, Royal Belum State Park, is recognizable for the pristine jungle, hosting innumerable floras and faunas. The excessive beauty of the forest gives protection to wild animals like tigers, elephants etc. (Khairil *et al.*, 2012). Moreover, a sparse canopy covers wholly shade everything beneath as promoting a nature of complexity and essential for wildlife interaction.

Lianas are woody climber species that are very abundant in tropical forests forming about 45% of the total woody plants population in such forests (Addo-Fordjour *et al.*, 2008; Schnitzer & Bongers, 2011). Liana and tree exhibit mutual relationship, in which liana benefiting more than its counterpart. This invariably means that lianas are trees competitors which disrupt their regeneration processes (Tobin *et al.*, 2012). Over the decades, the studies on trees are ubiquitous and researchers mainly pinpointed tree behavior in terms of ecology, functions and benefits. On the contrary, the ecology of lianas and their distribution in tropical forests are scantily perceived and became a lesser known subject amongst researchers (Addo-Fordjour *et al.*, 2016). Unknowingly, lianas are branded as a plant habit that only contribute nuisance to the forest ecosystem. Though they are very useful in the proper functioning of tropical ecosystems, their abundance in such forests is disastrous to native trees (Schnitzer *et al.*, 2000; Pérez-salicrup, 2001; Ingwell *et al.*, 2010; Putz, 2012). The misconception, however, weighed our team

to uplift the information on the occurrence of lianas alongside trees and to list important and endangered species in Royal Belum State Park. This will provide an inventory of species that will be useful for future researchers.

MATERIALS AND METHODS

Study Site

This study was carried out at the Royal Belum State Park, Perak, Malaysia (Figure 1). This is a UNESCO World heritage site covering an area of 117,500 ha and straddling the northern, undisturbed and pristine lowland dipterocarp, hill dipterocarp and lower montane forests (up to about 1,533 m above sea level) of northern Peninsular Malaysia. This forms the northern and strategic component of the Central Forest Spine (CFS). It is considered as one of the oldest protected park that is undisturbed in Peninsular Malaysia. This park has been referred to as the biodiversity hotspot in Malaysia hosting diverse ecosystems and habitats for several flora and fauna species in which many of them are endemic, rare, vulnerable or otherwise threatened in Malaysia and the region.

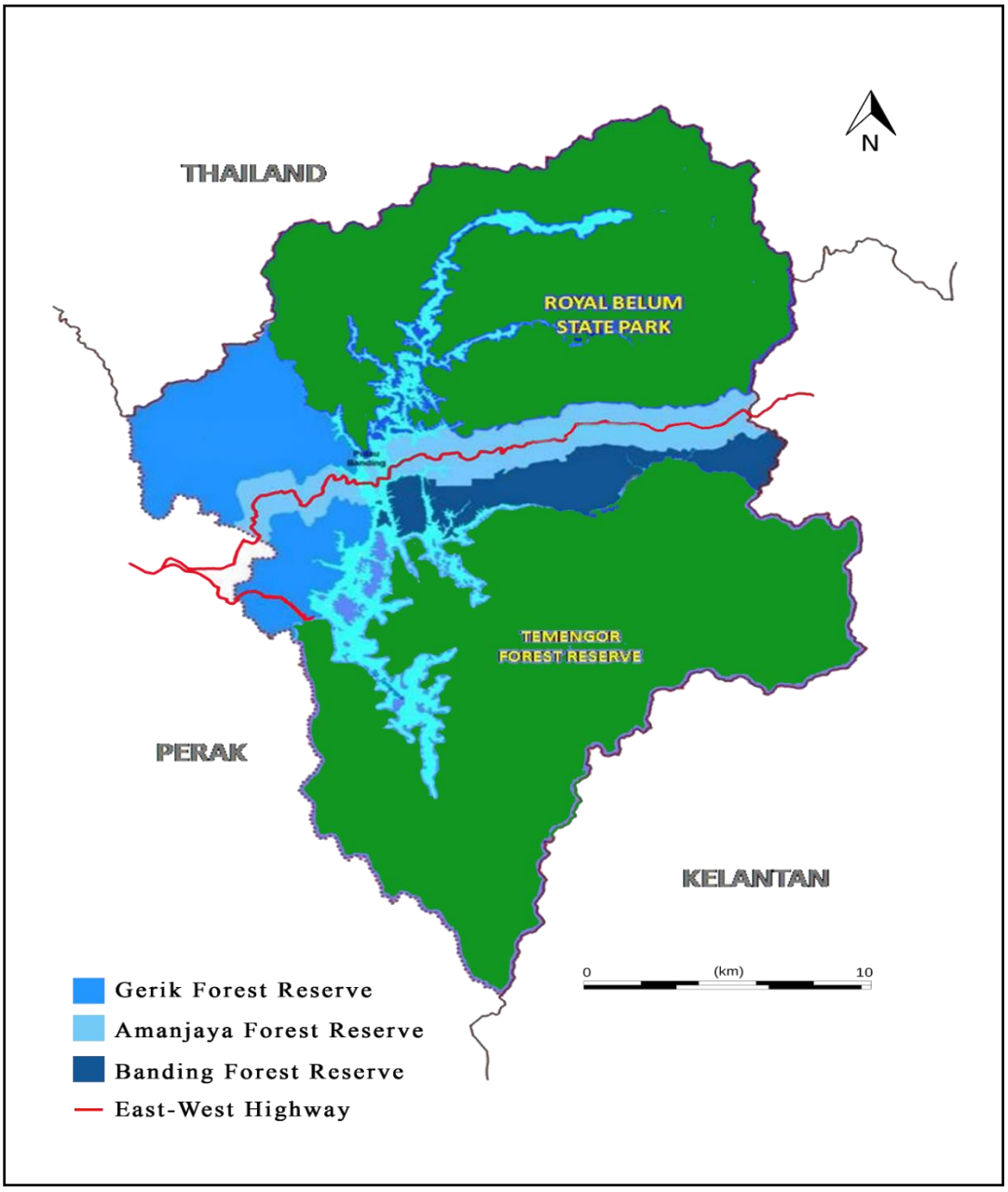

Figure 1. The map of Belum-Temengor Forest Complex (Redrawn from: https://mnshornbillvolunteerprogramme.wordpress.com/about/).

Sampling Procedure

The occurrence of liana and trees were enumerated in five study sites within the park, namely; Sungai Kejar, Sungai Papan, Sungai Papan 2, Teluk Gopal and Sungai Kooi (Table 1). For each site, plots were randomly established with the size of 100 x 20 m (0.2 ha). Subsequently, these plots were further divided into five subplots (20 m x 20 m). Within the subplots, lianas with dbh ≥ 1 cm and trees with dbh ≥ 10 cm were identified. All processed specimens were kept in the Herbarium of Universiti Sains Malaysia, Pulau Pinang for further reference. Unidentified species were recorded by physical appearances such as leaf, flowers and fruits for further recognition by referring to the books and forest manual provided (Ng, 1978, 1989; Whitmore,1983a,b; Kiew *et al*., 2010, 2011, 2012).

Table 1. Geographical coordinate of sampling sites.

Location	Latitude (N)	Longitude (E)	Elevation (m)
Sungai Kooi	05° 37' 40.6"	101° 26' 40.8"	540
Sungai Papan	05° 37' 40.6"	101° 24' 10.3"	290
Sungai Papan 2	05° 37' 23.8"	101° 24' 39.0"	405
Sungai Kejar	05° 48' 06.2"	101° 25' 33.4"	514
Teluk Gopal	05° 36' 37.7"	101° 23' 28.4"	360

Statistical Analysis

The lianas and trees diversity indices such as Shannon index, Simpson index and Evenness index were quantified for each study site using PAST software (Rahmad & Akomolafe, 2018). Incidence-based rarefaction-extrapolation analysis, which is a non-asymptotic species richness evaluator, was carried out to estimate the species richness of lianas and trees species in the study sites using the twenty-five sample size.

A significant difference in species richness between the study sites was determined using confidence intervals, constructed by 100 bootstrap replicates (Addo-Fordjour *et al.*, 2016). Software called iNEXT (online version) was used for this (Chao *et al.*, 2016). If the confidence intervals of the curves do not overlap, estimates of species richness are regarded as significantly different. However, if the confidence intervals of the curves overlap, then the estimates of species richness are not significantly different.

Analysis of similarity is a non-dependent analysis of the sample size as the indication of the presence/absence data for species in a community are particularly used (Krebs, 1989). Range of similarity commences from 0.0 (least similar) to 1.0 (highly similar). Modified Morisita's Similarity was preferably used due to its independence on the sample size. Hence, the unweighted pair-group method using arithmetic averages (UPGMA) was performed as the clustering method (Romesburg, 1984). Multivariate Statistical Package (MVSP) version 3.22, Kovach Computing Services coordinated the analysis.

RESULTS

Diversity, Richness and Similarities of Liana Species Among Study Sites

In all study sites, 92 species of lianas belonging to 23 families were identified (S1). The largest liana family was Annonaceae (19 species) followed by Connaraceae (11 species) and Fabaceae (11 species). Annonaceae, which was the largest family, was composed of nine genera followed by Apocynaceae with four genera and Connaraceae with three genera (S1). In terms of a number of species, the richest genera are *Connarus* (six species), *Spatholobus* (six species) and *Strychnos* (five species). For each study site, Sungai Papan has the highest recorded species (39 species) followed by Teluk Gopal (38 species) and Sungai Kejar (37 species). Sungai Papan and Teluk Gopal also have the highest diversity indices compared with others (Table 2). There was overlap in the confidence intervals of the rarefied and extrapolated species richness curves of all the sites. Sungai Papan and Teluk Gopal had the highest species richness which was not significantly different (Figure 2).

Table 2. Diversity indices of liana species in the study sites.

Diversity Indices	Sungai Kejar	Sungai Papan	Sungai Papan 2	Teluk Gopal	Sungai Kooi
Simpson Index	0.9667	0.9671	0.9603	0.9698	0.9615
Shannon Index	3.493	3.526	3.297	3.571	3.326
Evenness Index	0.889	0.872	0.901	0.912	0.898
Fisher alpha	22.5	24.72	16.69	20.49	15.27
Rarefied and extrapolated species richness	36	39	29	39	30

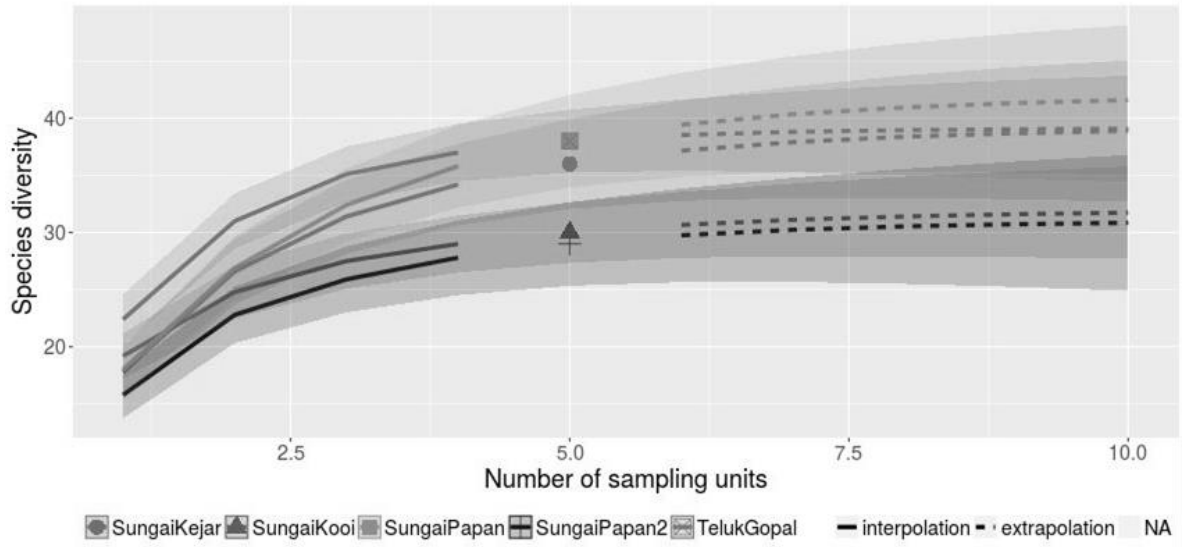

Figure 2. Incidence based rarefaction and extrapolation curves for species richness (including confidence intervals) of liana species. Solid lines represent rarefaction curves while dashed lines represent extrapolation curves. Each dot stands for the estimated species richness. The shadow of each curve represents the confidence interval.

Analysis of species similarity displays the cluster analysis of liana community in different sites (Figure 3). The highest value was indicated between Sungai Papan and Teluk Gopal (0.50) which implies the highest species similarity in both study sites, followed by Sungai Kejar and Sungai Papan 2 (0.37). Whilst, the comparison between Node 1 (consisting of Teluk Gopal and Sungai Papan) and Sungai Kooi read the second highest at 0.34. Notwithstanding, the lowest value was denoted between Node 2 (consisting of Sungai Kooi, Teluk Gopal and Sungai Papan) and Node 3 (consisting of Sungai Papan 2 and Sungai Kejar) at 0.36, which suggests the lowest species similarity recorded between them.

Diversity, Richness and Similarities of Tree Species Between Study Sites

Results showed that 221 trees species belonging to 48 families were identified in all the sites (S2). The families with the high number of species include Annonaceae (23 species, 16 genera) followed by Euphorbiaceae (22 species, 12 genera) and Meliaceae (18 species, eight genera). The richest genus was *Syzygium* (11 species) followed by *Dacryodes* (seven species) and *Shorea* (six species). Sungai Kejar was observed to have the highest tree species richness and diversity while Sungai Kooi had the lowest (Table 3). However, all the study sites had the same even distribution of tree species.

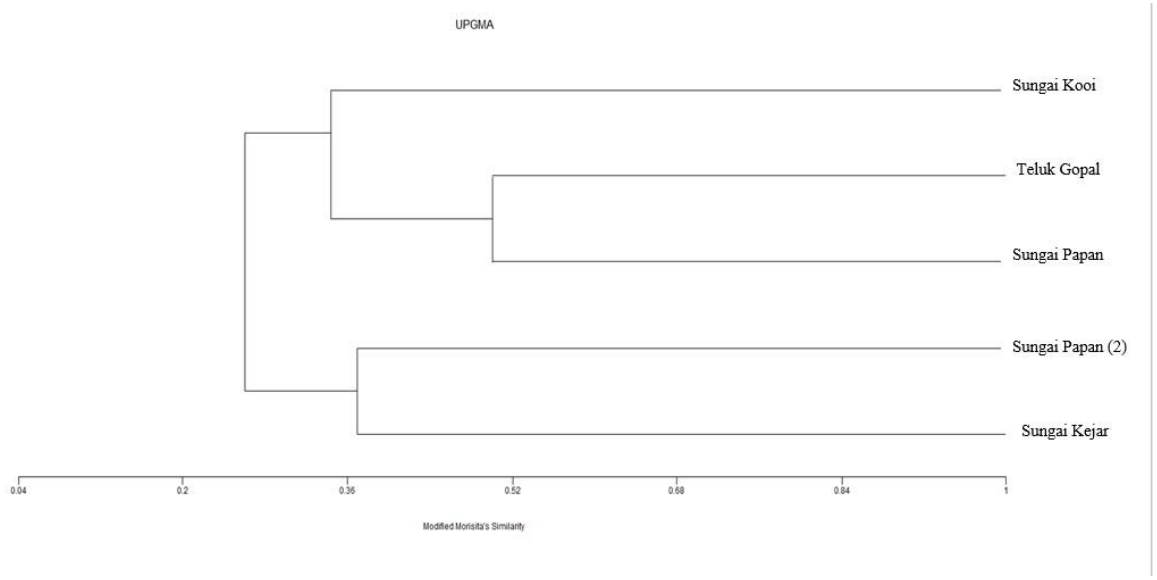

Figure 3. Tree diagram of clustering method (UPGMA) on liana community in the study sites of Royal Belum State Park.

The rarefied and extrapolated analysis of species richness showed an overlap in the confidence intervals of all the sites which indicated no significant difference between them (Figure 4). However, rarefied-extrapolated curves did not reach asymptote for all the sites, meaning that the sampling size was not adequate. The cluster analysis revealed the similarity of censuses trees species (Figure 5). The highest value was observed between Sungai Kooi and Teluk Gopal (0.27) followed by Sungai Papan and Sungai Papan 2 (0.23). Whilst, the comparison between Node 2 (consisting of Teluk Gopal and Sungai Kooi) and Node 1 (consisting of Sungai Papan and Sungai Papan 2) recorded the second highest at 0.20. Notwithstanding, the lowest value was denoted between Sungai Kejar and Node 3 (consisting of four study sites) at 0.14, which suggests the lowest species similarity recorded between them.

IUCN Conservation Status of Lianas and Trees

The assessment of the IUCN status of the lianas showed six species as Least Concern while the others have Deficient Data (Table 4). However, the IUCN conservation status of the trees showed that two are Critically Endangered, three are Endangered, 11 are Vulnerable, eight are Near Threatened, 31 are Least Concern while the remaining 166 are Data Deficient (Table 5).

Table 3. Diversity indices of tree species in the study sites.

Diversity Indices	Sungai Kejar	Sungai Papan	Sungai Papan 2	Teluk Gopal	Sungai Kooi
Simpson Index	0.9809	0.9819	0.9788	0.9816	0.9730
Shannon Index	4.089	4.088	3.95	4.072	3.754
Evenness Index	0.865	0.904	0.880	0.903	0.821
Fisher alpha	49.13	42.59	37.86	42.99	33.14
Rarefied and extrapolated species richness	68	65	58	64	50

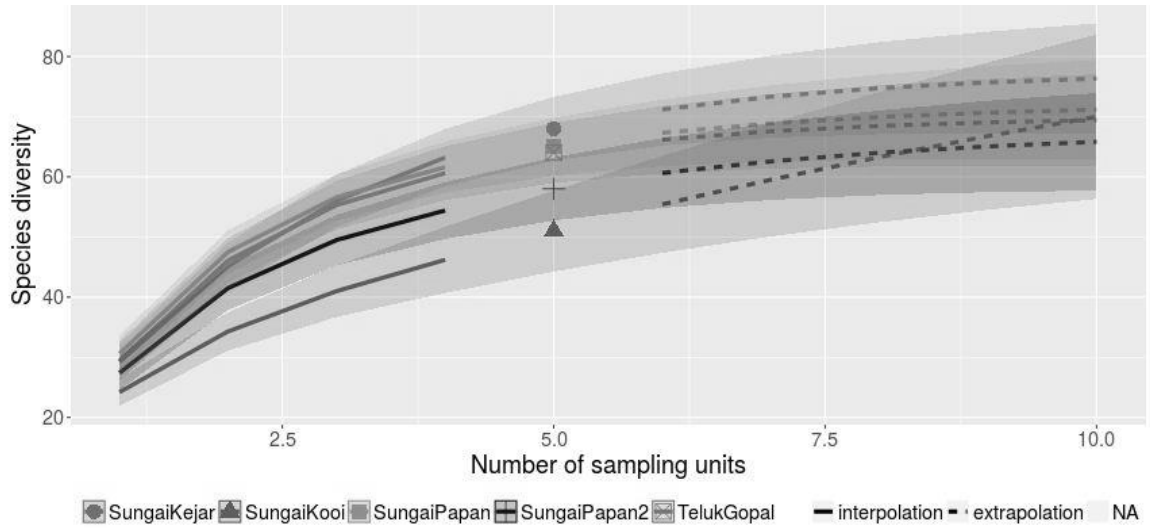

Figure 4. Incidence based rarefaction and extrapolation curves for species richness (including confidence intervals) of tree species. Solid lines represent rarefaction curves while dashed lines represent extrapolation curves. Each dot stands for the estimated species richness. The shadow of each curve represents the confidence interval.

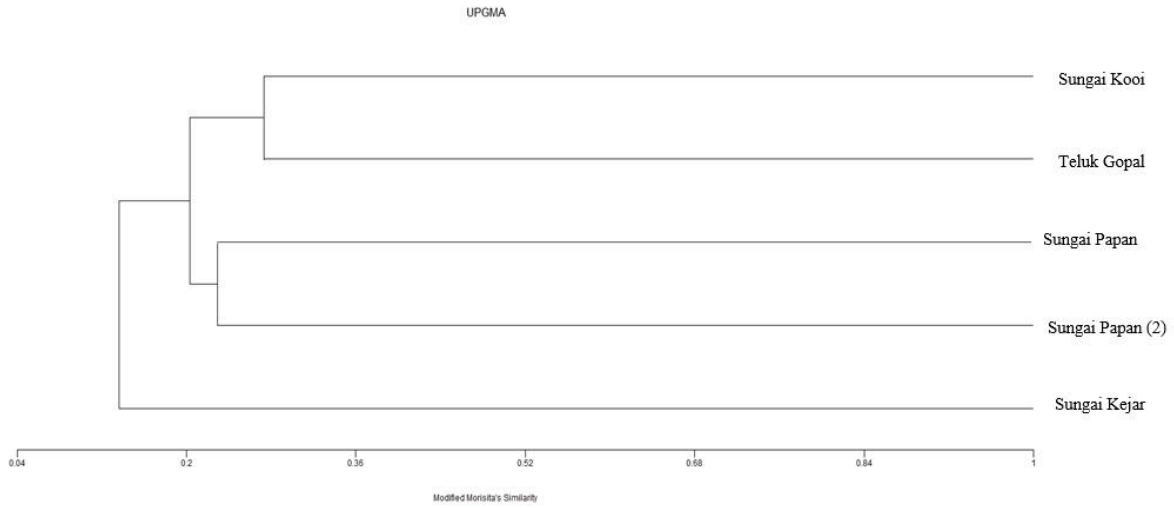

Figure 5. Tree diagram of clustering method (UPGMA) on liana community in the study sites of Royal Belum State Park.

Table 4. IUCN conservation status of lianas in the study sites.

IUCN Red List Status	Number of Species	Name of Species
Extinct (EX)	0	Nil
Extinct in the Wild (EW)	0	Nil
Regionally Extinct (RE)	0	Nil
Critically Endangered (CR)	0	Nil
Endangered (EN)	0	Nil
Vulnerable (VU)	0	Nil
Near Threatened (NT)	0	Nil
Least Concern (LC)	6	*Bauhinia acuminata, Spatholobus gyrocarpus, Gnetum gnemonoides, Gnetum latifolium, Gnetum macrostachyum, Gnetum microcarpum*
Data Deficient (DD)	86	Others

Table 5. IUCN conservation status of trees in the study sites.

IUCN Red List Status	Number of Species	Name of Species
Extinct (EX)	0	0
Extinct in the Wild (EW)	0	0
Regionally Extinct (RE)	0	0
Critically Endangered (CR)	2	*Dipterocarpus kunstleri, Shorea lepidota*
Endangered (EN)	3	*Parashorea densiflora, Shorea parvifolia, Shorea pauciflora*
Vulnerable (VU)	11	*Dipterocarpus gracilis, Hopea sangal, Hopea sublanceolata, Parashorea stellate, Vatica pauciflora, Beilschmiedia dictyoneura, Endocomia canarioides, Horsfieldia polyspherula, Horsfieldia sucosa, Pentace perakensis, Schoutenia kunstleri*
Near Threatened (NT)	8	*Shorea leprosula, Castanopsis curtisii, Aglaia leucophylla, Aglaia oligophylla, Aglaia palembanica, Aglaia rubiginosa, Aglaia squamulosa, Palaquium hexandrum*
Least Concern (LC)	31	*Anisophyllea corneri, Alphonsea maingayi, Endiandra maingayi, Tabernaemontana corymbosa, Canarium littorale, Canarium patentinervium, Dacryodes laxa, Dacryodes costata, Dacryodes puberula, Dacryodes rostrata, Dacryodes rugosa, Santiria apiculata, Santiria tomentosa, Santiria laevigata, Shorea multiflora, Diospyros ridleyi, Diospyros singaporensis, Paracroton pendulus, Ormosia macrodisca, Irvingia malayana, Beilschmiedia insignis, Chisocheton tomentosus, Sandoricum koetjape, Xylocarpus moluccensis, Knema conferta, Myristica iners, Prunus arborea, Prunus grisea, Payena maingayi, Celtis rigescens, Rinorea horneri*
Data Deficient (DD)	1	Others

DISCUSSION

The composition, abundance and diversity of lianas in some tropical forests has been directly influenced by the intensity of human disturbances (Schnitzer & Bongers, 2011; Addo-Fordjour & Rahmad, 2015). In these disturbed tropical forests, lianas became over-populated and exerted limiting effects on neighbouring plants, especially trees (Paul & Yavitt, 2011). This could mean that Sungai Papan and Teluk Gopak have undergone little human disturbances over the years. Favourable environmental conditions such as increased CO_2 level, sunlight availability and enough space for growth have been reported as promoters of liana diversity and abundance in disturbed tropical forests (Gerwing & Farias, 2000). The presence of tree species of Annonaceae, Euphorbiaceae and Meliaceae could mean that these dominated plant families and genera are typical trees of tropical rain forests (Francoso *et al.,* 2016). The variations observed in the spread of these trees in all the sites in such a way that the abundant species in one site while less-abundant in the others and vice versa might just be as a result of delimitation in the geographical areas and time, not necessarily by physiological differences (Oliveira & Amaral, 2004).

This inventory and diversity assessments of trees in these study sites have been able to provide the understanding of the current richness status of the trees which could serve as a guide for driving the future conservation plans of these

forests (Jayakumar *et al.,* 2011; Francoso *et al.,* 2016). Researches have shown that the abundance of lianas in tropical forests usually reduced trees regeneration and interfered with ecosystem processes that tend to enhance trees richness and diversity (Garcia *et al.,* 2018). This means that abundance of lianas will directly reduce the abundance and diversity of trees in a forest community. Lianas are able to achieve this by competing with trees for water, soil nutrients and light (Perez-Salicrup *et al.,* 2001; Schnitzer *et al.,* 2005). The high tree species composition, richness and diversity recorded in our study revealed that these study areas have not been so much infested by liana species. The most important indicator of disturbances in a forest ecosystem is the high density of lianas compared to trees in such forests (Villagra *et al.,* 2013; Oliveira *et al.,* 2014). Invariably, most forests inside the Royal Belum State Park have not experienced a high level of disturbance over the years. According to the IUCN conservation status of the lianas and trees, it can be deduced that the most important tree species in this forest which are categorized as Endangered and Critically Endangered are *Parashorea densiflora, Shorea parvifolia, Shorea pauciflora Dipterocarpus kunstleri* and *Shorea lepidota.* None of the lianas can be described as important species for conservation. Also, lack of adequate data and assessment of the conservation status of most of these plants should be a serious concern to conservationists.

CONCLUSION

Royal Belum State Park encapsulates a mesmerizing diversity of lianas and trees together with the hospitable environmental condition. The similarity of species is considerably low suggesting high species richness. Both plant habits are important forest structure and are beneficial to animals, especially for protection. Therefore, it is reasonable to ensure the conservation of these forest resources. It is hereby suggested that the forest management should pay close attention to the most important tree species highlighted in this study, which stand the risk of going into extinction if not conserved immediately.

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