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Effect of Altitude on the Species Composition, Diversity and Biomass of Trees in Mann Reserve, Magway Region, Minbu District, Myanmar

Kyi Kyi Khaing, Assistant Research Officer
Aye Nyein Chan, Research Assistant 2
Mu Mu Aung (Ph.D), Deputy Director
Forest Research Institute

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A Study on the Effect of Gradients on Tree Species Composition, Diversity and Biomass in Mann Reserved Forest, Minbu District, Magway Region, Myanmar

Kyi Kyi Khaing, Assistant Research Officer
Forest Depatment

Abstract

This study was conducted in the lower mixed deciduous forests, upper mixed deciduous forests, and hill evergreen forests of Mann Reserved Forest (Compartment 34 (9348 acre, 35(2346 acre, 38 (3915 acre, 39 (2515 acre), Ngape Township, Minbu District in Magway Region. In this study, four experimental plots at each level of three different elevations were taken, and each plot 100 long and 5 m wide and a total of (12) plots were investigated along elevation transects on the mountains in Mann Reserve. The elevation patterns of tree species composition, diversity and biomass were explored. Trees with a diameter of the trunk (DBH ≥ 5 cm and above) were measured and studied. A total of 452 trees from 71 species of 26 families were observed in all of the three elevations of the study area. The study area of Mann Reserve is dominated by Dipterocarp trees. Only one tree is represented for each of the other 26 species in the transect line of study area. The percentage of tree species is more or less very low in the community except some members of the family Dipterocarpaceae, Anacardiaceae, Combretaceae, and Fabaceae. A small percentage of tree species richness might be a strong indicator of reduced ecosystem resilience and a high likelihood of environmental degradation. Among the three different layers of elevation, the lower layer is the highest bio-diversified zone and densely populated, representing a rich lowland tropical forest with high species turnover and complexity. In the middle layer, biodiversity is found to be the lowest. The upper layer represents a distinct forest community with a few species of hill or montane forest flora such as Fagaceae and Theaceae. But it has a low tree density and a more even spread of species across many families, suggesting it may be more susceptible to disturbances of ecosystem. In abundance of number of individuals, a clear decline is observed from Lower layer to middle to upper ones. Both of Shannon-Winer index and Simpson's diversity index of the study area also show the highest value of species diversity in Lower layer or Level I. The highest value of biomass is also found to be in the same layer.

Keywords: *Elevation, species composition, diversity, biomass*

မကွေးတိုင်းဒေသကြီး၊ မင်းဘူးခရိုင်၊ မန်းကြိုးဝိုင်းအတွင်း ပင်လယ်ရေမျက်နှာပြင် အမြင့်ပေ အလိုက် သစ်မျိုးများ၏ မျိုးစိတ်ပါဝင်မှု၊ ကွဲပြားမှုနှင့် ဇီဝဒြပ်ထုဖြစ်တည်မှုကို လေ့လာခြင်း

ကြည်ကြည်ခိုင်၊ လက်ထောက်သုတေသနအရာရှိ

စာတမ်းအကျဉ်း

ဤသုတေသနကို မကွေးတိုင်းဒေသကြီး၊ မင်းဘူးခရိုင်၊ ငဖဲမြို့နယ် မန်းကြိုးဝိုင်း (အကွက်အမှတ် ၃၄(၉၃၄၈ ကေ)၊ ၃၅(၂၃၄၆ ကေ)၊ ၃၈(၃၉၁၅ ကေ)၊ ၃၉(၂၅၁၅ ကေ) အတွင်းရှိ ရွက်ပြတ်ရောနှောတော၊ တောင်ပေါ်အမြဲစိမ်းတောများတွင် ဆောင်ရွက်ခဲ့ပါသည်။ ပင်လယ်ရေမျက်နှာပြင် အထက်အမြင့်ပေ ကွဲပြားသော နေရာ(၃) နေရာတွင် စမ်းသပ်ကွက်တစ်ကွက်လျှင် ၁၀၀× ၅ မီတာဖြင့် (၄)ကွက်စီ စုစုပေါင်း (၁၂)ကွက်တွင် သစ်ပင်မျိုးစိတ် ဖွဲ့စည်း မှု၊ ကွဲပြားမှုနှင့် ဇီဝဒြပ်ထုဖြစ်တည်မှုများကို စူးစမ်းလေ့လာခဲ့သည်။ သစ်ပင်တစ်ပင် ချင်းစီ၏ အချင်း(ရင်စို့လုံးပတ်အချင်း (၅)စင်တီမီတာ နှင့်အထက်) ရှိသည့်သစ်မျိုးများကို တိုင်းတာလေ့လာခဲ့ပါသည်။ သုတေသနပြုလေ့လာသည့် ဧရိယာအတွင်း မျိုးရင်း(၂၆)၊ မျိုးစိတ်(၇၁)တို့ ၏ အပင်အရေအတွက် စုစုပေါင်း (၄၅၂) ပင်ကို လေ့လာခဲ့ရာ အင်၊ ကညင် မျိုးရင်းဝင်အပင်များ လွှမ်းမိုးနေသည်ကိုတွေ့ရသည်။ မျိုးစိတ်(၂၆)ခုတွင်အပင်အရေအတွက်တစ်ခုသာပါရှိသည်။ ဤ သစ်တောအပင်အုပ်စုတွင် Dipterocarpaceae၊ Anacardiaceae၊ Combretaceae နှင့် Fabaceae မျိုးရင်းများမှလွဲ၍ သစ်ပင်မျိုးစိတ်ရာခိုင်နှုန်း ပါဝင်မှုနည်းသည်ကိုတွေ့ရသည်။ သစ်ပင်မျိုးစိတ်များ ပေါက်ရောက်မှု ရာခိုင်နှုန်းနည်း ခြင်းသည် ဂေဟစနစ်လျော့ကျစေခြင်းကို ခံနိုင်အားနှင့် ပတ်ဝန်းကျင်ပျက်စီးယိုယွင်းမှု ဖြစ်နိုင်ခြေ မြင့်မားသည့် ထင်ရှားသည့် လက္ခဏာ တစ်ရပ်ဖြစ်နိုင်သည်။ အလွှာ၃လွှာတွင် ဇီဝမျိုးစိတ် ကြွယ်ဝမှု အမြင့်မားဆုံးအလွှာသည် အောက်ဆုံးအလွှာဖြစ်ပြီး၊ သစ်ပင်ဦးရေများပြားထူထပ်သည်။ သစ်ပင်မျိုးစိတ်ပါဝင်မှု များပြားပြီး၊ ပါဝင်မှု ပြောင်းလဲနှုန်းမြင့်ပြီး အပင်များ ကြွယ်ဝသည့် မြေနိမ့်ဒေသအပူပိုင်း သစ်တောကို ကိုယ်စားပြုသည်။ အလယ်လွှာသည် ဇီဝမျိုးစိတ်ကြွယ်ဝမှု အနည်းဆုံးဖြစ်သည်။ အပေါ်ပိုင်း အလွှာသည် Fagaceae မျိုးရင်းဝင် ဝက်သစ်ချမျိုးနှင့် Theaceae မျိုးရင်းဝင်လောက်ယားပင်မျိုးများပါဝင်သည့် တောင်ပေါ်ဒေသမျိုးစိတ်အနည်းငယ်ရောပြွမ်းနေသည့်ထင်ရှားသော သစ်ပင် အုပ်စုမျိုးဖြစ်သည်။ သို့ရာတွင် ထိုအလွှာသည် မျိုးရင်းများစွာတို့မှ မျိုးစိတ်များစွာ ပျံ့နှံ့ပါဝင် သော်လည်း၊ မျိုးစိတ်တစ်ခုစီတွင် သစ်ပင်ပါဝင်မှု အရေအတွက်နည်းသည်။ ဤ အချင်းအရာ သည်ဂေဟစနစ် နှောက်ယှက်မှုကို ခံနိုင်ရည်ပိုနည်းသည့်သဘောဖြစ်သည်။ မျိုးစိတ် တစ်မျိုးစီရှိ အပင်အရေအတွက် များများ ပါဝင်ခြင်းတွင် အောက်ဆုံးအလွှာ၌ များပြီး အထက်သို့ ရောက်လေလေ ထင်ထင်ရှားရှား လျော့နည်း လေလေဖြစ်သည်။ Shannon-Winer index နှင့် Simpson’s diversity index တွက်ချက် မှုနှစ်မျိုးစလုံးတွင်လည်း အောက်ဆုံးလွှာ၌ ဇီဝမျိုးကွဲ ပါဝင်မှု အများဆုံးတွေ့ရသည်။ ဇီဝဒြပ်ထု ပါဝင်မှုမှာလည်း အောက်ဆုံးလွှာ၌ပင် အများဆုံး တွေ့ရ သည်။

Effect of Altitude on the Species Composition, Diversity and Biomass of Trees in Mann Reserve, Magway Region, Minbu District, Myanmar

1. Introduction

The western mountain ranges of Myanmar is one of the famous forest covered ranges in the world and the timbers are enormously extracted from these ranges since British colonial period. The ranges are characterized by their rich biodiversity and ecological significance and they have long played an important role in the country's natural environment and natural environmental conservation.

Myanmar famous teak, also known as "Kyun" in the world trade is enormously has been produced from these western ranges. The western ranges also provide vital forest products such as Pyinkado, Kanyin, Ingyin and other hardwoods, alongside significant non-wood forest products essential for local livelihoods. Important non-wood forest products include bamboo, rattan, medicinal plants, honey, gums, edible bird nests, edible fruits, food, various kinds of Myanmar orchids; spices including cardamom, black pepper, and long pepper; and other products such as resins, barks for tanning, and natural dyes.

Although Myanmar is highly rich in biodiversity under various anthropogenic threats, botanical exploration in Myanmar still lags, hindering a full understanding of the floristic diversity of the country and leading to a large gap in taxonomic knowledge of its flora (Ye Lwin Aung et al. 2025). Thus, the western mountain ranges of Myanmar need to be explored in aspect of flora and fauna.

Myanmar's forests are important for ecological, social and economic reasons. Forests contribute to the livelihoods of the population, reduce poverty and enhance food security, strengthen resilience and disaster risk reduction, and produce high-value commercial timber, such as teak and rosewood (Kissinger, 2017).

The mountainous regions, including Rakhine Yoma are home to unique flora and fauna, vital water sources, and indigenous communities who depend on the land for their livelihoods. Moreover, over-exploitation of hardwood timbers, illegal and unsustainable loggings, expansion of agriculture and forest fire also lead these ranges to be more deteriorated.

Nowadays, these mountain ranges are facing an alarming rate of degradation, largely due to human activities such as over-exploitation of natural resources and frequent forest fires of which both of accidental and intentional set for land clearance. These activities have led to deforestation, soil erosion, and the depletion of essential ecosystems and cause the environmental decline.

This gradual deterioration threatens not only the biodiversity of Myanmar but also the livelihoods of local communities and the overall environmental health of Myanmar. Environmental conservation and climatic control in these western mountain ranges have become an urgent concern, as the effects of their degradation ripple outwards, impacting water cycles and agriculture. These environmental issues require a balance between development and environmental conservation, as well as a concerted effort to reduce the human-induced pressures on these vital ecosystems.

Mann reserved forest is located in Rakhine Yomain, Minbu District, Magway Region. The biodiversity of this reserved forest is also becoming deteriorated without exception due to over-exploitation of natural resources and frequent forest fires. The ecosystem of Mann reserved forest is unbalanced by its present biodiversity due to human activities.

Corlett (2007) had stated that the forests host high levels of biodiversity and endemism, provide vital ecosystem services, and regulate climate conditions.

Granda et al. (2018) stated that the ability of trees to cope with changing climatic conditions is pivotal for forest ecosystems, especially for tropical or subtropical forests facing warming climatic conditions.

Gaston (2000) and Wang et al. (2021) stated that altitude was a comprehensive indicator reflecting mountainous ecological environments, induced changes in environmental variables, including temperature, humidity, and solar radiation, thereby influencing plant biomass and diversity distribution patterns.

Caietet. et. al. (2023) reported that elevational transects were useful models for studying large-scale patterns of ecosystem processes and the underlying drivers, as they compressed remarkable environmental gradients, especially climate conditions, into relatively short distances.

Mann reserved forest has not been analyzed yet on the present condition of its biodiversity, species richness and composition, and stem biomass above the ground at different level of altitudes according to available literature. The status of the ability of vegetation including trees to maintain changing climatic conditions, the diversity distribution patterns and stem biomass, the diverse forest biomes and species composition along altitudinal gradients are important factors in such kind of reserved forest for conservation.

Alleviation of climate change due to global warming also depends on the health and wealth of forests and considering the emission of carbon dioxide gas from deforestation and deterioration of this reserved forest is also important. Thus this forest has been required to strengthen the conservation efforts and protecting long-term ecological integrity.

Myanmar follows REDD+ program and is practicing on maintenance and protection of forests, thus the ecological data such as biodiversity, species composition and richness are important factors to consider the conservation of Mann Reserve.

Moreover, many gaps of Myanmar floristic study are found and many plant species, especially in remote mountainous areas are likely undocumented due to some limitation such as security matter and botanical explorations have sharply decreased in Myanmar since 1950, leading to a large gap of knowledge on flora of Myanmar (Kress et al, 2003).

In this study, an attempt was made to investigate the patterns of tree species richness and composition, diversity and stem biomass above the ground, along transects of three different elevations (altitudes) on the mountainous region in Mann reserved forest, Minbu District, Central Myanmar.

2. Literature Review

He (2024) described that a comprehensive exploration of the altitudinal patterns of plant species diversity and biomass in mountainous environments is profoundly significant for the conservation of ecosystem and biodiversity, the maintenance of productivity, and ecological restoration. Biodiversity is a key characteristic of a biological community, reflecting its attributes and the relationship between the community and the environment. There are many indicators of community diversity, such as species richness and the relative.

Drivers of ecological change can interact relatively independently with diversity, composition and ecosystem processes and functions such as aboveground biomass due to the individual contributions of species lost, gained or persisting (Ladouceuret et al. 2022).

In ecology, this approach has been used in a diversity of ways to examine the biological relationships that underpin variation among aggregate changes in species richness, composition and additive measures of ecosystem functioning (i.e. biomass, abundance) or traits (Genung et al. 2020, Lefcheck et al. 2021, Ulrich et al. 2021, Winfree et al. 2015).

Therefore, it is critical to examine the current status of species diversity using latest inventory data as such data will provide appropriate guidelines for developing effective system of forest conservation and forest management (Yu Ya Aye, 2014).

Xing & Ree (2017) also reported that spatial climatic heterogeneity supports diverse forest biomes and biodiversity due to temperature changes along altitudinal gradients. Global environmental changes may also substantially impact the growth, phonology, physiology, and other processes of tree species (He et al, 2018).

Stem biomass has been found that it depends on the values of basic specific gravities for their comparison. Stem biomass is related to many important components, such as carbon cycles, soil nutrient allocations, fuel accumulation, and habitat environments in terrestrial ecosystems. However, it is necessary to obtain more accurate and precise biomass estimates for tropical forest tree species in order to improve understanding of the role of tropical forests in the global carbon cycle. (Phyu Phyu Lwin, 2015).

Many biomass equations have been developed, variously including tree diameter, height, wood density, and tree form factor as explanatory variables. The choice in any particular study is important, as different methods can give rise to very different biomass estimates of trees when applied to the same forest inventory data (Phyu Phyu Lwin, 2015).

Equation choice therefore poses a significant problem for regional scale comparisons of biomass estimates, because variation caused by environmental, structural, and compositional gradients, may be confounded with variation resulting from the use of different equations. Ideally, therefore, comparisons of biomass estimate over large spatial scales need to be based on a consistent regression approach (Phyu Phyu Lwin, 2015).

Species diversity is one of the analytical tools applied in determining the degree of variability of tree species within a community or a region. Diversity was the greatest if each species contributed the same proportion to the number of individuals of the forest community. Quantifying tree species distribution and abundance is also an important aspect of forest conservation as they contribute to the structural characteristics of the forest (Yu Ya Aye, 2014). The typical species frequency distribution was that many species with only few individuals were found in combination with a few species, which were represented by high numbers of individuals (Nyi Nyi Kyaw, 2003).

3. Materials and Methods

In this study, 12 plots (100 × 5 m per plot) were investigated along elevation transects on the mountains in Mann Reserve and the elevation patterns of tree species composition, diversity and biomass were explored, as well as the possible drivers. To observe more universal patterns, the three elevation transects were selected, differing in location, range of elevation, and species richness levels.

3.1 Site description and climate

This study was conducted in the lower mixed deciduous forests, upper mixed deciduous forests, and hill and temperate evergreen forests of Mann Reserve, Ngape Township, Minbu District (19.85 °N, 94.48 °E) in northern Myanmar. The altitudes of Mann Reserve range from 150 to 1370 m. This mountain is biogeographically complex and harbors high plant diversity with endemism, as well as endangered plants and animals. Potential tree species such as those from Dipterocarpaceae, Magnoliaceae, Dilleniaceae, Fagaceae, Lamiaceae, Theaceae, and Rubiaceae families, along with other associated species, are widely distributed across all altitudinal bands of the region.

This region is characterized by a typical tropical monsoon climate with distinct dry and wet seasons. Generally, the climate in Myanmar can be divided into two distinct (dry and wet) seasons (Qian and Lee 2000, Aung et al. 2017, Zaw et al. 2021). The climate is subtropical or tropical and it has three seasons: a cool winter from November to February, a hot summer in March and April, and a rainy season from May to October, dominated by the southwest monsoon.

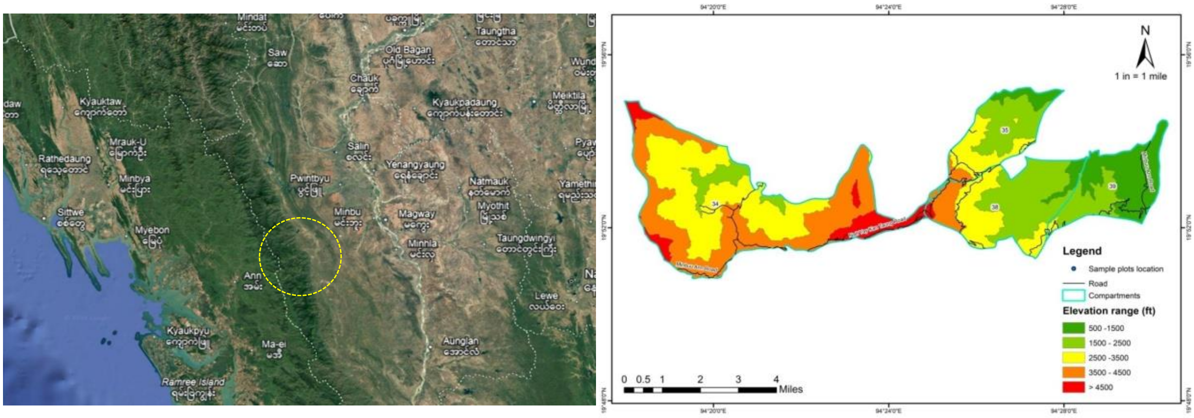
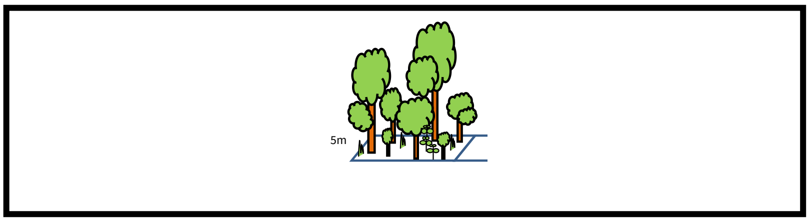


Figure1. Location map of collection site. (Source: Google Earth and SRTM Elevation data)

3.2 Forest inventory survey

Priority is given to the collection work. Mounting the specimens and the identification work were carried out at wood anatomy section, forest research institute. Mounting the specimens and the identification work were later carried out at F.R.I., Yezin Herbarium. Plant species identification was achieved by using "A Checklist of the Trees, Shrubs, Herbs and Climbers of Myanmar" (Kress et al. 2003) and International Plant Name Index (IPNI) at Yezin.This research was assessed the species composition, community structure, and combined encroaching woody species across at three different elevations. A series of forest inventory surveys were conducted within the 12 plots in 2024. During each survey, a standardized line transect method (100×5m) was used in 4 main plots, where all individual trees with a minimum DBH (diameter at breast height at 1.37 m above ground) of at least 5 cm were assessed. In the survey, the species names, tree height, and DBH were recorded. Among them, 30 wood samples were collected for further research.

5 m



100 m

Figure 2. A standardized transect line method of study area

3.3 Data analysis

Plot-level tree species composition, diversity and stem biomass were taken with Microsoft office excel 2007, Shannon-winner's Index and Simpson's Index. Most analyses were processed using RStudio software (R.4.2.1) and some are SPSS software. Correlation of species diversity and biomass with altitude were tested using simple linear regression.

Basal area (BA) = PI( )*(DBH/200)^2

Simpson's index (D)

D = 1 − P^2, where P is the proportion of Basal area

Shannon-Weiner's index (H)

H = −1* P*lnP, where P is the proportional Basal area.

$Volume(v) = \frac{\pi}{4}$ x D2 x H x F (D = radius, H=Height, F = form factor)

Stem Biomass = v * p (v is volume of species, p is density of species)

Tree species diversity indices provide important information about rarity and commonness of species in a community (Suratman 2012). Shannon's diversity index (H') places more weight on the rare species while Simpson's diversity index (1-D) gives more weight to those species which occur more frequently (Magurran 1988). The simple linear regressions were applied to compare the effective size of the different variables on tree species diversity on the standardized coefficients.

The indices were calculated for each of four plots in every level. The indices means the larger the value of H', the greater the species diversity, and vice vasa the greater the species diversity, the larger the value of H' (Magurran 1988).

4.Results

4.1 Species composition

4.1.1 All three levels of elevations

In this research, 71 species of 26 families were observed in all of the three levels of elevations of the study area as shown in Table 1. The total number of individuals of 26 species was found to be 452.

Table 1. Species composition found in all three levels of elevations

No.	Species	Family	Myanmar name	No.of Individuals
1.	*Dipterocarpus alatus* Roxb. ex G.Don	Dipterocarpaceae	Kanyin	2
2.	*Dipterocarpus tuberculatus* Roxb.	Dipterocarpaceae	In	44
3.	*Pentacme siamensis* (Miq.) Kurz	Dipterocarpaceae	Ingyin	68
4.	*Shorea obtusa* Wall. exBlume	Dipterocarpaceae	Thitya	50
5.	*Buchanania latifolia* Roxb.	Anacardiaceae	Lunbo	8
6.	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	Nabe	15
7.	*Melanorrhoea usitata* Wall.	Anacardiaceae	Thitsi	28
8.	*Spondias pinnata* (L.f.) Kurz	Anacardiaceae	Gwe	8
9.	*Terminalia chebula* Retz.	Combretaceae	Panga	11
10.	*Terminalia elliptica* Willd.	Combretaceae	Taukkyan	30
11.	*Terminalia phillyreifolia* (Van Heurck & Mull.Arg.) Gere & Boatwr.	Combretaceae	Yon	5
12.	*Albizia lebbek* (L.) Benth.	Fabaceae	Anyar-kokko	1
13.	*Albizia lebbekoides* (DC.) Benth.	Fabaceae	Bonmeza	5
14.	*Albizia lucida* (Jacques) Benth.	Fabaceae	Thanthat	2
15.	*Albizia odoratissima* (L.f.) Benth.	Fabaceae	Thitmagyi	2
16.	*Cassia fistula* L.	Fabaceae	Ngushwe-wa	1
17.	*Dalbergia cultrata* T.S.Ralph	Fabaceae	Yindaik	12
18.	*Dalbergia fusca* Pierre.	Fabaceae	Yinzat	1
19.	*Erythrina suberosa* Roxb.	Fabaceae	Kathit	2
20.	*Millettia brandisiana* Kurz	Fabaceae	Thitpagan	3
21.	*Xylia xylocarpa* (Roxb.) W. Theob.	Fabaceae	Pyinkado	3
22.	*Bauhinia racemosa* Lam.	Fabaceae	Palan	1
23.	*Phyllanthus emblica* L.	Phyllanthaceae	Zibyu	19

No.	Species	Family	Myanmar name	No.of Individuals
24.	*Strychnos nux-blanda* A. W. Hill	Loganiaceae	Kabaung	18
25.	*Adina cordifolia* (Roxb.) Brandis	Rubiaceae	Hnaw	5
26.	*Ceriscoides turgida (*Roxb.) Tirveng.	Rubiaceae	Yingat -gyi	2
27.	*Mitragyna rotundifolia* (Roxb.) Kuntze	Rubiaceae	Binga	9
28.	*Morinda pubescens* Sm.	Rubiaceae	Nebase	1
29.	*Neonauclea excelsa* (Blume) Merr.	Rubiaceae	Thitpayaung	1
30.	*Berrya cordifolia (*Willd.) Burret	Malvaceae	Pet-wun	2
31.	*Bombax anceps* Pierre	Malvaceae	Kokhe	2
32.	*Bombax insigne* Wall.	Malvaceae	Didu	2
33.	*Grewia tiliifolia* Vahl	Malvaceae	Tayaw	7
34.	*Pterygota alata* (Roxb.) R.Br.	Malvaceae	Letkok	1
35.	*Sterculia versicolor* Wall.	Malvaceae	Shaw	1
36.	*Sterculiarubiginosa* Vent.	Malvaceae	Shawphyu	1
37.	*Ficus spp.*	Moraceae	Thaphan	1
38.	*Dillenia aurea* Sm.	Dilleniaceae	Linyaw	10
39.	*Dillenia pentagyna* Roxb.	Dilleniaceae	Zinbyun	2
40.	*Dillenia indica* L.	Dilleniaceae	Thabyu	1
41.	*Chukrasia tabularis* A.Juss.	Meliaceae	Yinma	4
42.	*Melia dubia*Cav.	Meliaceae	Pantama	4
43.	*Eugenia* sp.	Myrtaceae	Taung-thabye	1
44.	*Syzygium cumini* (L.) Skeels	Myrtaceae	Thabye	6
45.	*Careya arborea* Roxb.	Lecythidaceae	Bambwe	7
46.	*Premna tomentosa* Willd.	Lamiaceae	Kyunbo	1
47.	*Tectona grandis* L.f.	Lamiaceae	Kyun	2
48.	*Vitex limonifolia* Wall. ex C.B. Clarke	Lamiaceae	Kyun-gauk-nwe	1
49.	*Vitex pinnata* L.	Lamiaceae	Kyetyo	3
50.	*Garuga pinnata* Roxb.	Burseraceae	Chinyok	3
51.	*Protium serrata* (Wall. ex Colebr.) Engl.	Burseraceae	Thadi	3
52.	*Croton joufra* Roxb.	Euphobiaceae	Tha yin wa	1
53.	*Croton persimilis* Mull.Arg.	Euphobiaceae	Thetyingyi	1
54.	*Mallotus philippensis*(Lam.) Mull.Arg.	Euphobiaceae	Tawthidin	1
55.	*Bridelia retusa* (L.) Spreng	Euphorbiaceae	Seikchi	3
56.	*Castanopsis armata* (Roxb.) Spach	Fagaceae	Thit-e	2
57.	*Castanopsis hystrix* A.DC.	Fagaceae	Thit-kyain	1
58.	*Sapindus rarak* DC.	Fagaceae	Nyan	2
59.	*Crataeva religiosa* G.Forst.	Capparaceae	Kadet	4
60.	*Heterophragma sulfureum* Kurz	Bignoniaceae	Thitlinda	1
61.	*Markhamia stipulate* (Wall.) Seem. ex K. Schum.	Bignoniaceae	Mahlwa	1
62.	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	Kyaung sha	1

No.	Species	Family	Myanmar name	No.of Individuals
63.	*Diospyros burmanica* Kurz	Ebenaceae	Te	1
64.	*Diospyros Montana* Roxb.	Ebenaceae	Gyok	1
65.	*Schima wallichii* (DC.) Korth.	Theaceae	Laukya	3
66.	*Cratoxylum neriifolium* kurz	Hypericaceae	Bebya	2
67.	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	Pyinma	1
68.	*Lagerstroemia villosa*Wall. ex. Kurz	Lythraceae	Zaungbale	1
69.	*Cordia grandis* Roxb.	Boraginaceae	Hmaike	1
70.	*Magnolia champaca* (L.) Baill.ex Pierre	Magnoliaceae	Sagawa	1
71.	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	Gyo	1
	Total			452

Tabled 2. Species composition of all of three levels of elevation in aspect of the family

No.	Family	Number of species	Number of individuals
1.	Dipterocarpaceae	4	164
2.	Anacardiaceae	4	59
3.	Combretacrae	3	46
4.	Fabaceae	11	33
5.	Phyllanthaceae	1	19
6.	Loganiaceae	1	18
7.	Rubiaceae	5	18
8.	Malvaceae	7	16
9.	Dilleniaceae	3	13
10.	Meliaceae	2	8
11.	Myrtaceae	2	7
12.	Lecythidaceae	1	7
13.	Lamiaceae	4	7
14.	Burseraceae	2	6
15.	Euphobiaceae	4	6
16.	Fagaceae	3	5
17.	Capparaceae	1	4
18.	Bignoniaceae	3	3
19.	Ebenaceae	2	2
20.	Theaceae	1	3
21.	Hypericaceae	1	2
22.	Lythraceae	2	2
23.	Boraginaceae	1	1
24.	Magnoliaceae	1	1
25.	Moraceae	1	1
26.	Sapindaceae	1	1
	Total	71	452

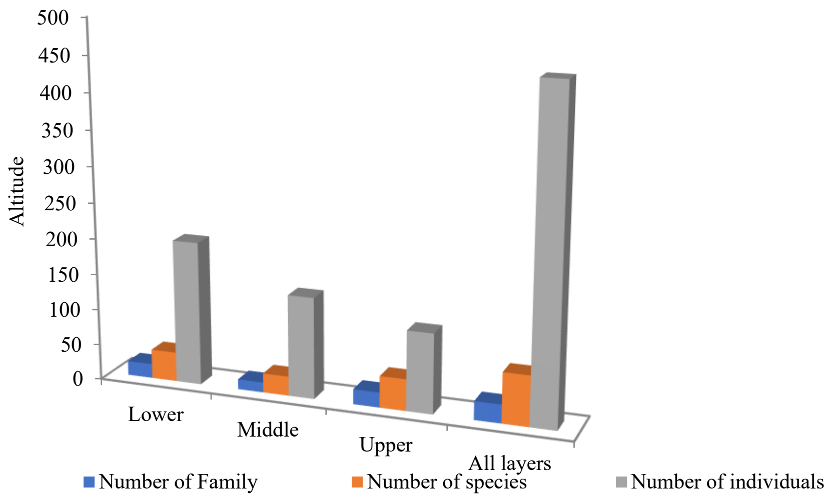


Figure 3. Species composition of all of three levels of elevation

4.1.2 Level I (150 – 450 m high) or Lower layer of elevation

In this lower layer of 150 – 450 m high elevation or level I, a total of 41 species of 20 families were recorded as shown in Table 3 and Figure 4. Total number of individuals of species of 20 families was 200.

Table 3. Species composition found in Level I (150 – 450 m high) or Lower layer of elevation

No.	Species	Family	Myanmar Name	Number of individuals
1.	*Dipterocarpus tuberculatus* Roxb.	Diptarocarpaceae	In	29
2.	*Pentacme siamensis* (Miq.) Kurz	Diptarocarpaceae	Ingyin	17
3.	*Shorea obtusa* Wall. ex Blume	Diptarocarpaceae	Thitya	18
4.	*Buchanania latifolia* Roxb.	Anacardiaceae	Lunbo	5
5.	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	Nabe	11
6.	*Melanorrhoea usitata* Wall.	Anacardiaceae	Thitsi	5
7.	*Spondias pinnata* (L.f.) Kurz	Anacardiaceae	Gwe	2
8.	*Terminalia chebula* Retz.	Combretaceae	Panga	8
9.	*Terminalia elliptica* Willd.	Combretaceae	Taukkyan	24
10.	*Albizia lebbek* (L.) Benth.	Fabaceae	Anyar-kokko	1
11.	*Albizia lebbekoides* (DC.) Benth.	Fabaceae	Bonmeza	1
12.	*Cassia fistula* L.	Fabaceae	Ngushwe-wa	1
13.	*Dalbergia cultrata* T.S.Ralph	Fabaceae	Yindaik	3
14.	*Millettia brandisiana* Kurz	Fabaceae	Thitpagan	1
14.	*Xylia xylocarpa* (Roxb.) W.Theob.	Fabaceae	Pyinkado	1
16.	*Phyllanthus emblica* L.	Phyllanthaceae	Zibyu	14
17.	*Strychnos nux-blanda* A.W.Hill	Loganiaceae	Kabaung	11
18.	*Adina cordifolia* (Roxb.) Brandis	Rubiaceae	Hnaw	3
19.	*Ceriscoides turgida (*Roxb.) Tirveng.	Rubiaceae	Yingat -gyi	1
20.	*Mitragyna rotundifolia* (Roxb.) Kuntze	Rubiaceae	Binga	2

21.	*Morinda pubescens* Sm.	Rubiaceae	Nebase	1
22.	*Berrya cordifolia (*Willd.) Burret	Malvaceae	Pet-wun	1
23.	*Bombax insigne* Wall.	Malvaceae	Didu	2
24.	*Grewia tiliifolia* Vahl	Malvaceae	Tayaw	4
25.	*Pterygota alata* (Roxb.) R.Br.	Malvaceae	Letkok	1
26.	*Dillenia aurea* Sm.	Dilleniaceae	Linyaw	4
27.	*Dillenia pentagyna* Roxb.	Dilleniaceae	Zinbyun	1
28.	*Chukrasia tabularis* A.Juss.	Meliaceae	Yinma	1
29.	*Syzygium cumini* (L.) Skeels	Myrtaceae	Thabye	4
30.	*Careya arborea* Roxb.	Lecythidaceae	Bambwe	7
31.	*Tectona grandis* L.f.	Lamiaceae	Kyun	2
32.	*Vitex limonifolia* Wall. ex C.B.Clarke	Lamiaceae	Kyun-gauk - new	1
33.	*Vitex pinnata* L.	Lamiaceae	Kyetyo	3
34.	*Protium serrata* (Wall. ex Colebr.) Engl.	Burseraceae	Thadi	2
35.	*Croton joufra* Roxb.	Euphobiaceae	Tha yin wa	1
36.	*Heterophragma sulfureum* Kurz	Bignoniaceae	Thitlinda	1
37.	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	Kyaung sha	1
38.	*Diospyros burmanica* Kurz	Ebenaceae	Te	1
39.	*Cratoxylum neriifolium* kurz	Hypericaceae	Bebya	2
40.	*Lagerstroemia villosa* Wall. ex. Kurz	Lythraceae	Zaungbale	1
41.	*Cordia grandis* Roxb.	Boraginaceae	Hmaike	1
			Total	200

Table 4. Species composition of level I (Low level of elevation) in the aspect of the family

No.	Family	Number of Species	Number of individuals
1.	Diptarocarpaceae	3	**64**
2.	Anacardiaceae	4	**23**
3.	Combretaceae	2	**32**
4.	Fabaceae	6	8
5.	Phyllanthaceae	1	14
6.	Loganiaceae	1	11
7.	Rubiaceae	4	7
8.	Malvaceae	4	8
9.	Dilleniaceae	2	5
10.	Meliaceae	1.	1
11.	Myrtaceae	1	4
12.	Lecythidaceae	1.	7
13.	Lamiaceae	3	6
14.	Burseraceae	1	2

15.	Euphobiaceae	1	1
16.	Bignoniaceae	2	2
17.	Ebenaceae	1	1
18.	Hypericaceae	1	2
19.	Lythraceae	1	1
20.	Boraginaceae	1	1
	Total	41	200

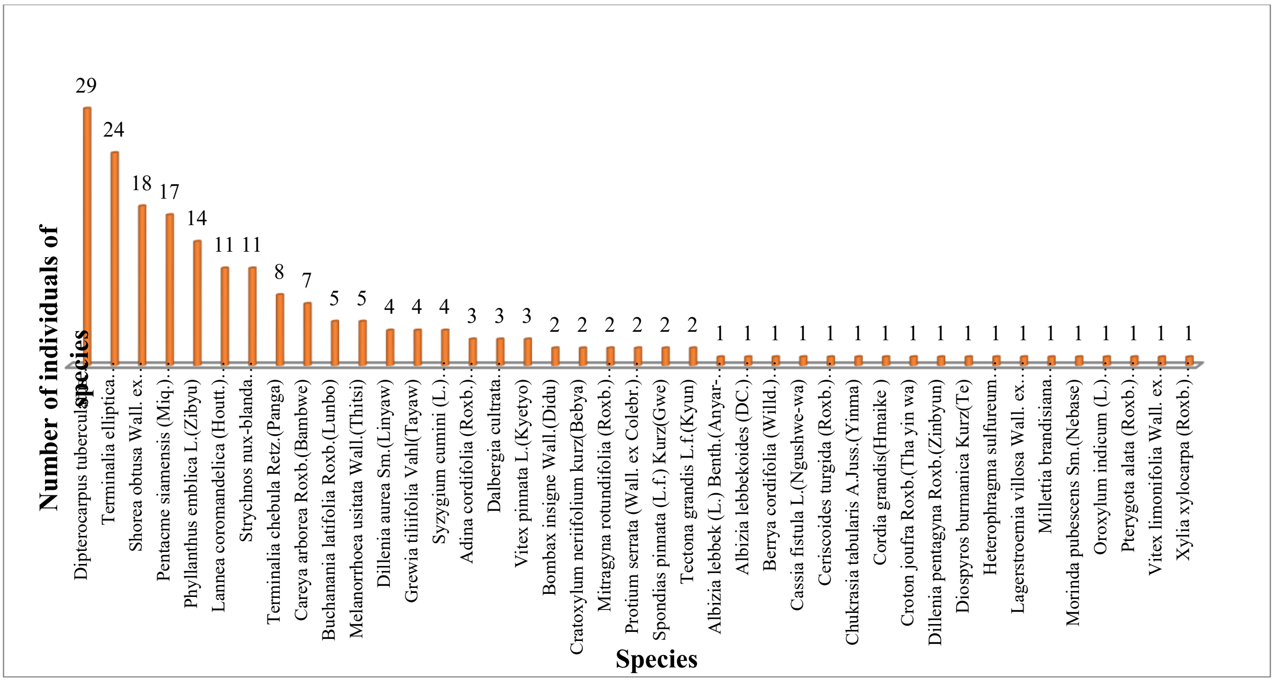


Figure.4 Species composition found in Level I (150 – 450 m high) or Lower layer of elevation

4.1.3 Level II (450 – 750 m high) or Middle layer of elevation

In this lower layer of 450 – 750 m high elevation or level II, a total of 27 species of 14 families was recorded as shown in Table 5 and Figure 5. Total number of individuals of 27 species was 141.

Table 5. Species composition found in Level II (450 – 750 m high) or Middle layer of elevation

No.	Species	Family	Myanmar Name	Number of individuals
1.	*Pentacme siamensis* (Miq.) Kurz	Diptarocarpaceae	Ingyin	33
2.	*Shorea obtusa* Wall. exBlume	Diptarocarpaceae	Thitya	17
3.	*Dipterocarpus tuberculatus* Roxb.	Diptarocarpaceae	In	15
4.	*Melanorrhoea usitata* Wall.	Anacardiaceae	Thitsi	16
5.	*Lannea coromandelica* (Houtt.) Merr.	Anacardiaceae	Nabe	4
6.	*Spondias pinnata* (L.f.) Kurz	Anacardiaceae	Gwe	4
7.	*Terminalia elliptica* Willd.	Combretaceae	Taukkyan	5
8.	*Terminalia phillyreifolia* (Van Heurck & Mull.Arg.) Gere & Boatwr.	Combretaceae	Yon	4
9.	*Terminalia chebula* Retz.	Combretaceae	Panga	3
10.	*Albizia lebbekoides* (DC.) Benth.	Fabaceae	Bonmeza	1

No.	Species	Family	Myanmar Name	Number of individuals
11.	*Dalbergia cultrata* T.S.Ralph	Fabaceae	Yindaik	7
12.	*Millettia brandisiana* Kurz	Fabaceae	Thitpagan	2
13.	*Xylia xylocarpa* (Roxb.) W.Theob.	Fabaceae	Pyinkado	2
14.	*Albizia lucida* (Jacques) Benth.	Fabaceae	Thanthat	1
15.	*Bauhinia racemosa* Lam.	Fabaceae	Palan	1
16.	*Phyllanthus emblica* L.	Phyllanthaceae	Zibyu	2
17.	*Strychnos nux-blanda* A.W.Hill	Loganiaceae	Kabaung	6
18.	*Adina cordifolia* (Roxb.) Brandis	Rubiaceae	Hnaw	1
19.	*Mitragyna rotundifolia* (Roxb.) Kuntze	Rubiaceae	Binga	4
20.	*Ceriscoides turgida (*Roxb.) Tirveng.	Rubiaceae	Yingat - gyi	1
21.	*Grewia tiliifolia* Vahl	Malvaceae	Tayaw	2
22.	*Dillenia aurea* Sm.	Dilleniaceae	Linyaw	3
23.	*Chukrasia tabularis* A.Juss.	Meliaceae	Yinma	3
24.	*Eugenia* sp.	Myrtaceae	Taung-thabye	1
25.	*Crataeva religiosa* G.Forst.	Capparaceae	Kadet	1
26.	*Markhamia stipulate* (Wall.) Seem. ex K. Schum.	Bignoniaceae	Mahlwa	1
27.	*Diospyros montana* Roxb.	Ebenaceae	Gyok	1
			Total	141

Table 6. Species composition found in Level II (450 – 750 m high) or Middle layer of elevation in the aspect of the family.

No.	Family	Species	Number of individuals
1.	Diptarocarpaceae	3	65
2.	Anacardiaceae	3	24
3.	Combretaceae	3	12
4.	Fabaceae	6	14
5.	Phyllanthaceae	1.	2
6.	Loganiaceae	1	6
7.	Rubiaceae	3	6
8.	Malvaceae	1	2
9.	Dilleniaceae	1	3
10.	Meliaceae	1	3
11.	Myrtaceae	1	1
12.	Capparaceae	1	1
13.	Bignoniaceae	1	1
14.	Ebenaceae	1	1
		27	141

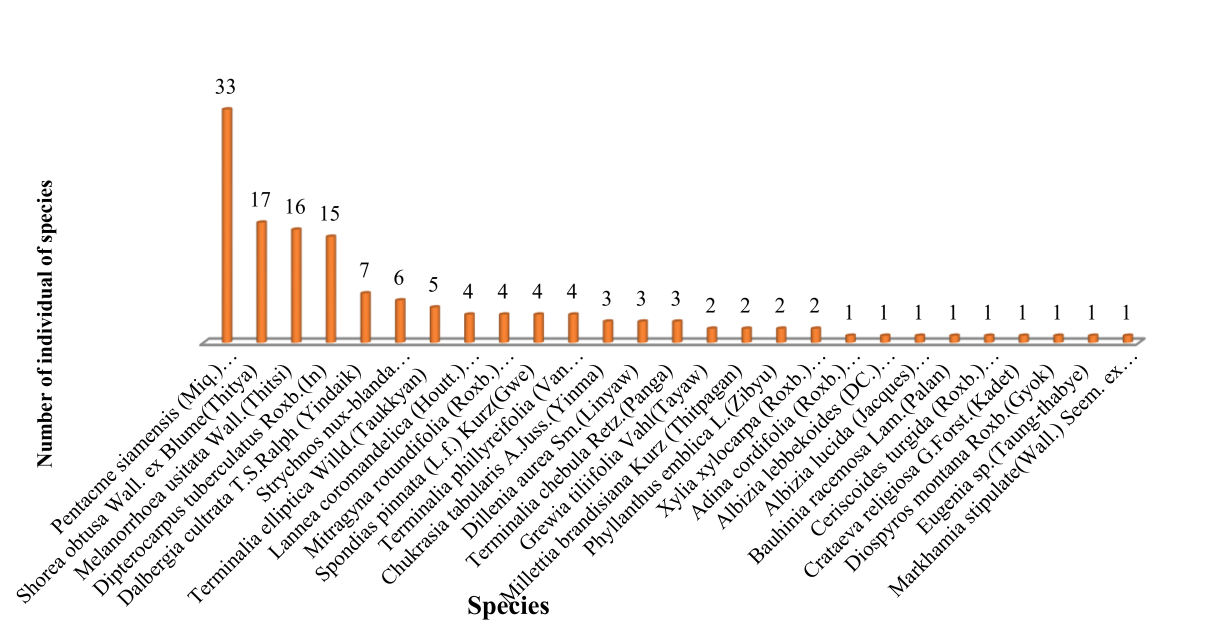


Figure 5. Species composition found in Level II (450 – 750 m high) or Middle layer of elevation

4.1.4 Level III (750 – 1050 m high) or Upper layer of elevation

In this upper layer of 750 – 1050 m high elevation, or level III, a total of 44 species of 21 families was found as shown in Table 7 and Figure 6. Total number of individuals of 44 species was 111.

Table 7. Species composition found in Level III (750 – 1050 m high) or Upper layer of elevation

No.	Species	Family	Myanmar Name	Number of individuals
1.	*Pentacme siamensis* (Miq.) Kurz	Dipterocarpaceae	Ingyin	18
2.	*Shorea obtusa* Wall. exBlume	Dipterocarpaceae	Thitya	15
3.	*Dipterocarpus alatus* Roxb. Ex G.Don	Dipterocarpaceae	Kanyin	2
4.	*Buchanania latifolia* Roxb.	Anacardiaceae	Lunbo	3
5.	*Melanorrhoea usitata* Wall.	Anacardiaceae	Thitsi	7
6.	*Spondias pinnata* (L.f.) Kurz	Anacardiaceae	Gwe	2
7.	*Terminalia elliptica* Willd.	Combretaceae	Taukkyan	1
8.	*Terminalia phillyreifolia* (Van Heurck & Mull.Arg.) Gere & Boatwr.	Combretaceae	Yon	1
9.	*Albizia lebbekoides* (DC.) Benth.	Fabaceae	Bonmeza	3
10.	*Albizia lucida* (Jacques) Benth.	Fabaceae	Thanthat	1
11.	*Albizia odoratissima* (L.f.) Benth.	Fabaceae	Thitmagyi	2
12.	*Dalbergia cultrata* T.S.Ralph	Fabaceae	Yindaik	2
13.	*Dalbergia fusca* Pierre.	Fabaceae	Yinzat	1
14.	*Erythrina suberosa* Roxb.	Fabaceae	Kathit	2
15.	*Phyllanthus emblica* L.	Phyllanthaceae	Zibyu	3
16.	*Strychnos nux-blanda* A.W.Hill	Loganiaceae	Kabaung	1
17.	*Adina cordifolia* (Roxb.) Brandis	Rubiaceae	Hnaw	1

No.	Species	Family	Myanmar Name	Number of individuals
18.	*Mitragyna rotundifolia* (Roxb.) Kuntze	Rubiaceae	Binga	3
19.	*Neonauclea excelsa* (Blume) Merr.	Rubiaceae	Thitpayaung	1
20.	*Berrya cordifolia (*Willd.) Burret	Malvaceae	Pet-wun	1
21.	*Bombax anceps* Pierre	Malvaceae	Kokhe	2
22.	*Grewia tiliifolia* Vahl	Malvaceae	Tayaw	1
23.	*Sterculia versicolor* Wall.	Malvaceae	Shaw	1
24.	*Sterculia rubiginosa* Vent.	Malvaceae	Shaw-Phyu	1
25.	*Dillenia aurea* Sm.	Dilleniaceae	Linyaw	3
26.	*Dillenia indica* L.	Dilleniaceae	Thabyu	1
27.	*Dillenia pentagyna* Roxb.	Dilleniaceae	Zinbyun	1
28.	*Melia dubia* Cav.	Meliaceae	Pantama	4
29.	*Syzygium cumini* (L.) Skeels	Myrtaceae	Thabye	2
30.	*Premna tomentosa* Willd.	Lamiaceae	Kyunbo	1
31.	*Garuga pinnata* Roxb.	Burseraceae	Chinyok	3
32.	*Protium serrata*(Wall. ex Colebr.) Engl.	Burseraceae	Thadi	1
33.	*Croton persimilis* Mull.Arg.	Euphobiaceae	Thetyingyi	1
34.	*Mallotus philippensis* (Lam.) Mull.Arg.	Euphobiaceae	Tawthidin	1
35.	*Bridelia retusa* (L.) Spreng	Euphorbiaceae	Seikchi	3
36.	*Castanopsis armata* (Roxb.) Spach	Fagaceae	Thit-e	2
37.	*Castanopsis hystrix* A.DC.	Fagaceae	Thit-kyain	1
38.	*Sapindus rarak* DC.	Fagaceae	Nyan	2
39.	*Crataeva religiosa* G.Forst.	Capparaceae	Kadet	3
40.	*Schima wallichii* (DC.) Korth.	Theaceae	Laukya	3
41.	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	Pyinma	1
42.	*Magnolia champaca* (L.) Baill.ex Pierre	Magnoniaceae	Sagawa	1
43.	*Ficus spp.*	Moraceae	Thaphan	1
44.	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	Gyo	1
		Total	44	111

Table 8. Species composition found in Level III (750 – 1050 m high) or Upper layer of elevation in the aspect of the family

No.	Family	Species	Number of individuals
1.	Dipterocarpaceae	3	35
2.	Anacardiaceae	3	12
3.	Combretaceae	2	2
4.	Fabaceae	6	11
5.	Phyllanthaceae	1	3
6.	Loganiaceae	1	1
7.	Rubiaceae	3	5
8.	Malvaceae	5	6
9.	Dilleniaceae	3	5

No.	Family	Species	Number of individuals
10.	Meliaceae	1	4
11.	Myrtaceae	1	2
12.	Lamiaceae	1	1
13.	Burseraceae	2	4
14.	Euphobiaceae	3	5
15.	Fagaceae	3	5
16.	Capparaceae	1	3
17.	Theaceae	1	3
18.	Lythraceae	1	1
19.	Magnoniaceae	1	1
20.	Moraceae	1	1
21.	Sapindaceae	1	1
	Total	44	111

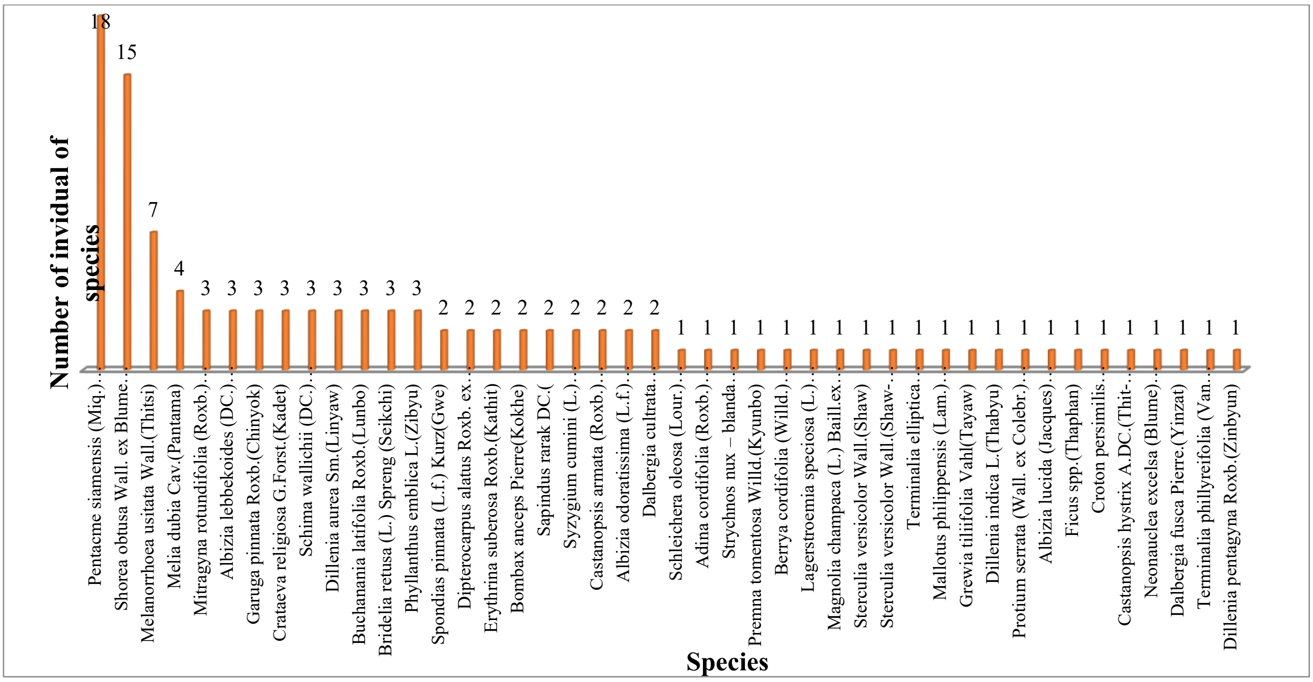


Figure 6. Species composition found in Level III (750 – 1050 m high) or Upper layer of elevation

Table 9. Species composition only found in Level I (150 – 450 m high) or Lower layer of elevation

No.	Species	Family	Myanmar Name
1.	*Albizia lebbek* (L.) Benth.	Fabaceae	Anyaar-kokko
2.	*Bombax insigne* Wall.	Malvaceae	Didu
3.	*Careya arborea* Roxb.	Lecythidaceae	Bambwe
4.	*Cordia grandis* Roxb.	Boraginaceae	Hmaike
5.	*Cratoxylum neriifolium* kurz.	Hypericaceae	Bebya
6.	*Croton joufra* Roxb.	Euphobiaceae	Thayinwa
7.	*Dillenia aurea* Sm.	Dilleniaceae	Linyaw
8.	*Diospyros burmanica* Kurz	Ebenaceae	Te
9.	*Lagerstroemia villosa* Wall. ex. Kurz	Lythraceae	Zaungbala

10.	*Mallotus philippensis*(Lam.) Mull.Arg.	Bignoniaceae	Thitlinda
11.	*Morinda pubescens* Sm.	Rubiaceae	Nebase
12.	*Pterygota alata* (Roxb.) R.Br.	Malvaceae	Letkok
13.	*Tectona grandis* L.f.	Lamiaceae	Kyun
14.	*Vitex limonifolia* Wall. ex C.B.Clarke	Lamiaceae	Kyun-gauk-nwe
15.	*Vitex pinnata* L.	Lamiaceae	Kyetyo

Table 10. Species composition only found in Level II (450 – 750 m high) or Middle layer of elevation

No.	Species	Family	Myanmar Name
1.	*Diospyros Montana*Roxb.	Ebenaceae	Gyok
2.	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	Pyinma
3.	*Markhamia stipulate* (Wall.) Seem. Ex K. Schum.	Bignoniaceae	Mahlwa

Table 11. Species composition only found in Level III (750 – 1050 m high) or Upper layer of elevation

No.	Species	Family	Myanmar Name
1.	*Albizia odoratissima*(L.f.) Benth.	Fabaceae	Thitmagyi
2.	*Bombax anceps* Pierre	Malvaceae	Kokhe
3.	*Bridelia retusa* (L.) Spreng	Euphorbiaceae	Seikchi
4.	*Castanopsis hystrix*A.DC.	Fagaceae	Thit-kyain
5.	*Croton persimilis*Mull.Arg.	Euphobiaceae	Thetyingyi
6.	*Dillenia indica* Lian.	Dilleniaceae	Thabyu
7.	*Dipterocarpus alatus* Roxb. ex G.Don	Diptarocarpaceae	Kanyin
8.	*Erythrina suberosa* Roxb.	Fabaceae	Kathit
9.	*Ficus spp.*	Moraceae	Thaphan
10.	*Garuga pinnata* Roxb.	Burseraceae	Chinyok
11.	*Magnolia champaca* (L.) Baill.ex Pierre	Magnoniaceae	Sagawa
12.	*Mallotus philippensis*(Lam.) Mull.Arg.	Euphobiaceae	Tawthidin
13.	*Melia dubia* Cav.	Meliaceae	Pantama
14.	*Neonauclea excelsa* (Blume) Merr.	Rubiaceae	Thitpayaung
15.	*Premna tomentosa* Willd.	Lamiaceae	Kyun-bo
16.	*Sapindus rarak* DC.	Fagaceae	Nyan
17.	*Schima wallichii* (DC.) Korth.	Theaceae	Laukya
18.	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	Gyo
19.	*Shoreaobtusa*Wall. exBlume	Diptarocarpaceae	Thitya
20.	*Sterculia versicolor* Wall.	Malvaceae	Shaw

Table 12. The species composition commonly found in each of the three levels of elevations (Core species)

No.	Species	Family	Myanmar Name
1.	*Adina cordifolia* (Roxb.) Brandis	Rubiaceae	Hnaw
2.	*Albizia lebbekoides* (DC.) Benth.	Fabaceae	Bonmeza
3.	*Dalbergia cultrata* T.S.Ralph	Fabaceae	Yindaik
4.	*Dillenia aurea* Sm.	Dilleniaceae	Linyaw
5.	*Grewia tiliifolia* Vahl	Malvaceae	Tayaw

6.	*Melanorrhoea usitata* Wall.	Anacardiaceae	Thitsi
7.	*Mitragyna rotundifolia* (Roxb.) Kuntze	Rubiaceae	Binga
8.	*Pentacme siamensis* (Miq.) Kurz	Diptarocarpaceae	Ingyin
9.	*Phyllanthus emblica* L.	Phyllanthaceae	Zibyu
10.	*Spondias pinnata* (L.f.) Kurz.	Anacardiaceae	Gwe
11.	*Strychnos nux-blanda* A.W.Hill	Loganiaceae	Kabaung
12.	*Syzygium cumini* (L.) Skeels	Myrtaceae	Thabye
13.	*Terminalia elliptica* Willd.	Combretaceae	Taukkyan

4.1.5. Species diversity in aspect of Shannon-Winner`s Index and Simpson`s Index

In Man Reserve, Shannon-Winner`s Index and Simpson`s Index of the tested plots were calculated as Table 13 & 14.

Table13. Species diversity index in Mann reserve region

Level	Plot no.	Shannon-Winner`s Index	Simpson`s Index
1	1.1	2.758329826	0.90
	1.2	1.881247705	0.80
	1.3	1.723279830	0.75
	1.4	2.104688253	0.81
2	2.1	1.767085260	0.77
	2.2	2.220455316	0.86
	2.3	2.130614576	0.87
	2.4	1.525218847	0.76
3	3.1	1.392958001	0.68
	3.2	1.983363952	0.83
	3.3	2.137804120	0.83
	3.4	1.667734015	0.68

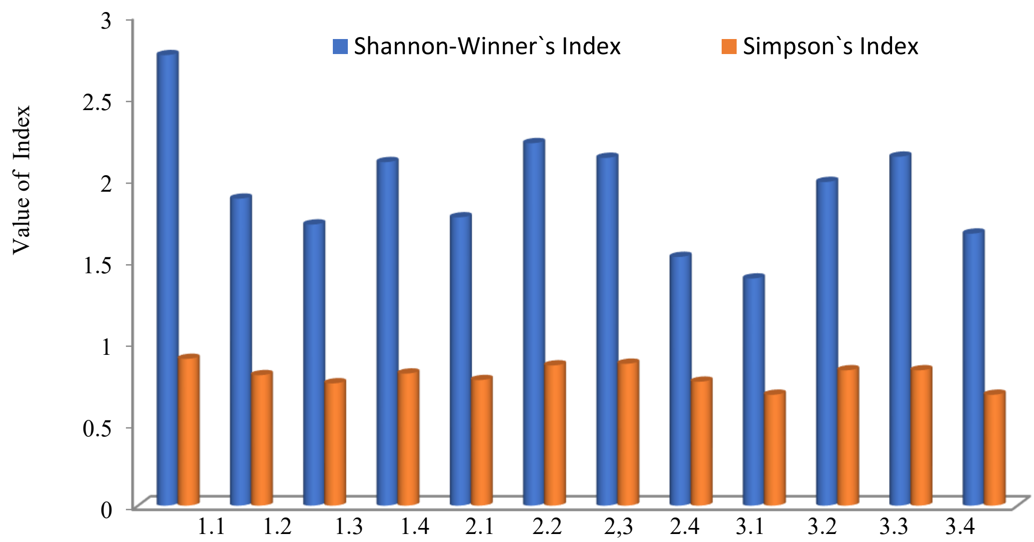


Figure 7. Species diversity of all of the three levels in aspects of Shannon-Winner`s Index and Simpson`s Index

Upper layer = Level III (750 – 1050) m (Plot no. 3.1 – 3.4)
Middle layer = Level_II (450 – 750) m (Plot no. 2.1 – 2.4)
Lower layer = Level_I (150 – 450) m (Plot no. 1.1 – 3.4)

Table14. Species diversity Shannon-Winner`s Indexin Mann reserve region (Highest to lowest value)

Plot No.	Shannon-Winner`s Index
1.1	2.758329826
2.2	2.220455316
3.3	2.137804120
2.3	2.130614576
1.4	2.104688253
3.2	1.983363952
1.2	1.881247705
2.1	1.767085260
1.3	1.723279830
3.4	1.667734015
2.4	1.525218847
3.1	1.392958001

Table 15. Species diversity Simpson`s Indexin Mann reserve region (Highest to lowest value)

Plot no.	Simpson`s Index
1.1	0.9
2.3	0.87
2.2	0.86
3.2	0.83
3.3	0.83
1.4	0.81
1.2	0.8
2.1	0.77
2.4	0.76
1.3	0.75
3.1	0.68
3.4	0.68

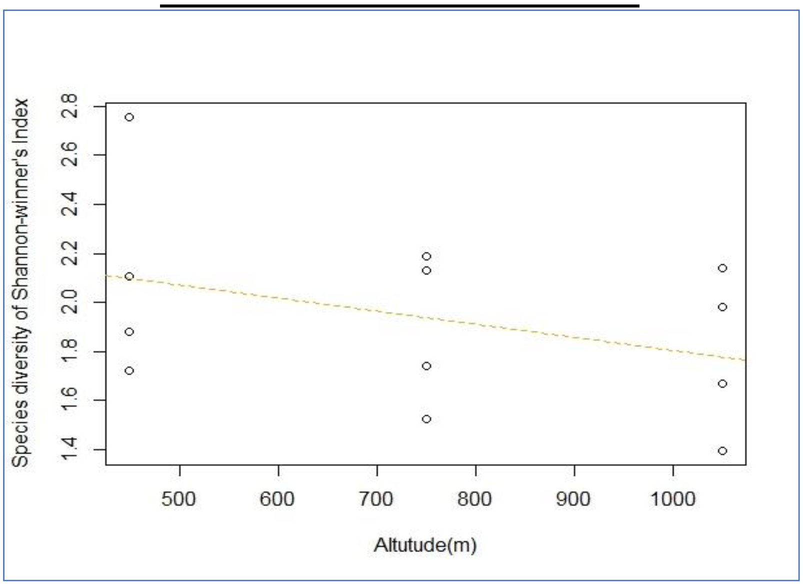


Figure 8. Correlation of Species diversity of Shannon-winner’s Index and Altitude

There was a no significant relationship between Altitude and species diversity of Shannon-winner's Index. $R^2 = 0.144$, P>0.0001

The result model is as follow:

Species diversity of Shannon-winner's Index = 2.337420-0.0005351 Altitude

Species diversity is 2.337420 when Altitude is 0(m) and Altitude increase per unit (m) increases in Species diversity is - 0.0005351.

There was a no significant relationship between Altitude and species diversity of Simpson's Index. $R^2 = 0.144$, P>0.0001)

The result model is as follow:

Species diversity of Simpson's Index = 0.873-0.0001 Altitude

Species diversity is 0.873 when Altitude is 0(m) and Altitude increase per unit(m) increases in Species diversity is -0.0001.

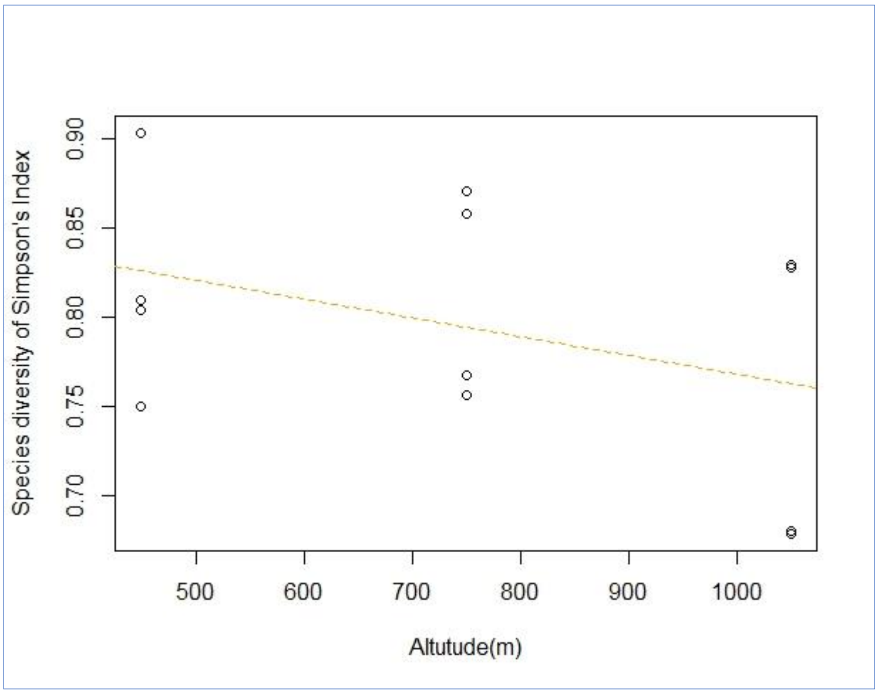


Figure 9. Correlation of Species diversity of Simpson's Index and Altitude

4.1.6. Stem Biomass

There was a no significant relationship between Altitude and Biomass. $R^2 = 0.01242$, P>0.0001

The result model is as follow:

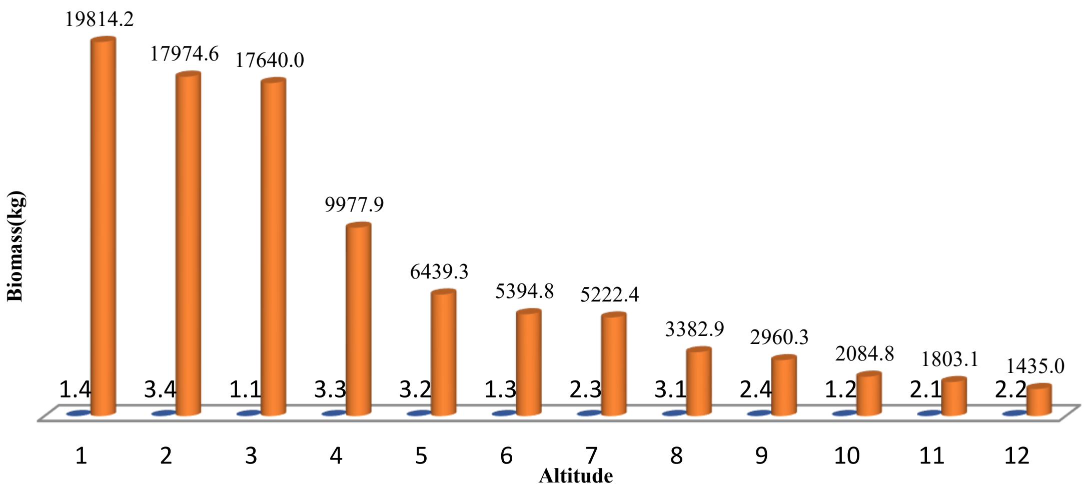
Biomass of species = 10081.312 - 2.983 Altitude

Biomass is 10081.312 when Altitude is 0(m) and Altitude increase per unit(m) increases in biomass is -2.983.

5. Discussion

5.1 Biodiversity and richness found in all of the three elevations (150 – 1050 m) of Mann Reserve

Among 71 species of 26 families observed in all of the three elevations of the study area,the highest number of individuals of species is 68 and found in *Pentacme siamensis* (Miq.) Kurz (Ingyin) of the family Diptarocarpaceae. It is followed by 50 individuals of *Shorea obtusa* Wall. ex Blume (Thitya) and 44 of *Dipterocarpus tuberculatus* Roxb. (In), respectively, of which both are of the family Dipterocarpaceae. It is clear that the Dipterocarp trees are dominant in the study area of transect line. However, the lowest number of individuals of 26 species is found to be only 1 in number in each as shown in Table 1.



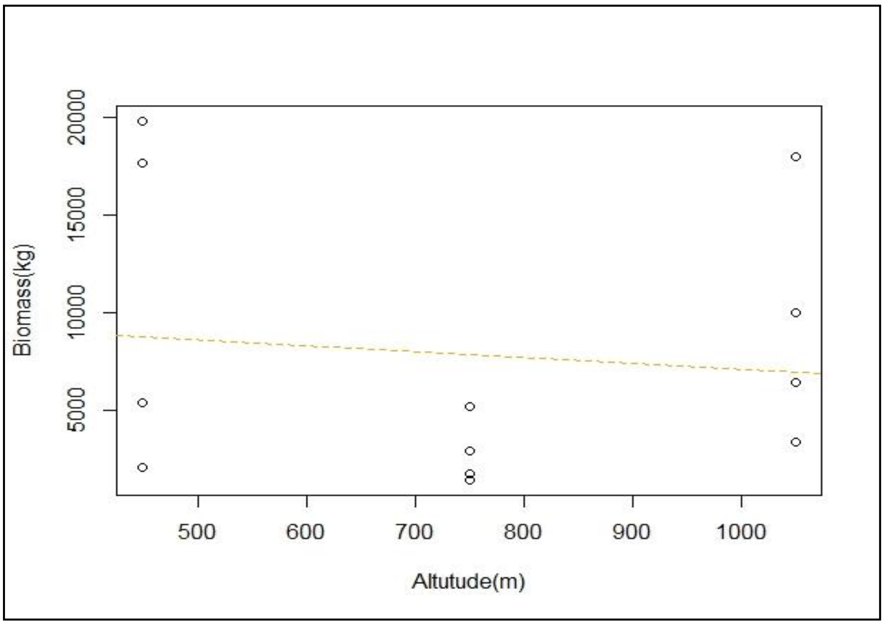


Figure10. Correlation of Stem Biomass and Altitude

In all of the three levels of elevation, 164 individuals of 4 species in Dipterocarpaceae are counted and this number of individuals is the highest in the study area, and it is followed by Anacardiaceae, Combretaceae and Fabaceae (Table 1). The species diversity is found to be the highest in the family Fabaceae i.e., 11 species. However, the lowest diversityis found in the other 10families viz. Phyllanthaceae, Loganiaceae, Lecythidaceae, Capparaceae, Theaceae, Hypericaceae, Boraginaceae, Magnoliaceae, Moraceae and Sapindaceae representing only one species in each family (Table 2).

Only one tree is represented for each of the other 26 species in the transect line of study area (Table 1). The percentage of number of individual of 26 species is very low in the community. However, some members of the family Dipterocarpaceae, Anacardiaceae and Combretaceae, are in high percentage although Phyllanthaceae and Loganiaceae are in moderate percentage.

Among 71 species of 26 families of all the three layers of elevation, the highest diversified species are found in the family Fabaceae, i.e., 11 species as in Table 2. The rest 26 families composed of 1 to 7 species, i.e. low diversified in the study area. In dry zone of Myanmar, the study area has a moderate to high level of species richness for a forest plot. The total of 452individuals counted provides a measure of density. The number of individuals per species is highly skewed or one-sided (i.e., 1 –68) (Table 2), which is typical in natural forests. It is a significant implications for composition. The low tree species richness might be a strong indicator of reduced ecosystem resilience and a high likelihood of environmental degradation.

Among the three different layers of elevation, the highest species richness is observed in the upper layer (Level III) (44 species and 111 individuals) and the lowest in the middle layer (Level II) (27 species, 141 individuals).

The Level I has a similar number of species (41) to Level III (44). However, the total number of individual is 200 so that the density is higher than that of Level III. It shows the highest biodiversity by all measures: 41 species of 20 families.

In abundance of number of individuals, a clear decline is observed from 200 (Level I) to 141 (Level II) to 111 (Level III).

Among them, the dominant family is Dipterocarpaceae across all levels. Its relative dominance increases with elevation.

i.e., Level I: 64/200 = 32%, Level II: 65/141 = 46%, and Level III: 35/111=32%.

All of the four members of the family Dipterocarpaceae is counted as 164 in number out of 452 trees (36.3%) found in all three levels of elevation. This indicates the forest is seemed to be a Dry Dipterocarp Forest type, typical of central dry zone of Myanmar.

In the study area of three levels of elevation, Anacardiaceae (59 individuals of 4 species i.e., 13.0%) and Combretaceae (46 individuals of 3 species, i.e., 10.2%) might be sub-dominant families. These characteristics are of dry zone forests and contribute significantly to the forest structure.

In the study area, Fabaceae shows the highest species richness (i.e., 11 species) but only 34 individuals (7.5%). This is ecologically important; it suggests high niche diversity and a key role in nitrogen fixation, but these species are not dominant in terms of biomass.

5.2 Species composition in each level

5.2.1 Level I (150 – 450 m high) or Lower layer of elevation

In the lower layer of elevation (LevelI), the highest number of individuals of species is 29 and found in *Dipterocarpus tuberculatus* Roxb. (In), and it is followed by 24 individuals of *Terminalia elliptica* Willd. (Taukkyan) of Combretaceae, 18 individuals of *Shorea obtusa* Wall. ex Blume (Thitya) and 17 of *Pentacme siamensis* (Miq.) Kurz (Ingyin) respectively of which both are in the family Diptarocarpaceae (Table 3).

Among 41 species found in level I, the least number is only one for each of the other 18 species. This low percentage of tree species richness also shows the scarcity of many tree species associated in that level.

Species richness of the Level I has a similar number of species (41) to the Level III (44), but the density is found to be highest among the three levels, i.e., 200 individuals.

This lower layer (Level I) shows the highest biodiversity by all measures, 41 species of 20 families.

It is the most floristically complex and diverse. It hosts a wide mix of families typical of lowland tropical deciduous or dry forest. It includes Dipterocarpaceae (64 individuals of 3 species), Anacardiaceae23 individuals of 4 species), Combretaceae (32 of 2 species) and Fabaceae (8 of 6 species). It also includes one species represented family such as Phyllanthaceae and Loganiaceae with a moderate numbers of individuals and the other families with only one species and only one individual of each such as Meliaceae, Euphorbiaceae, Ebenaceae, Lythraceae and Boraginaceae (Table 4).

5.2.2 Level II (450 – 750 m high) or Middle layerof elevation

In this middle layer of 450 – 700 m high, or level II, a total of 27 species of 14 families with 141 individuals were observed as shown in Table 5 and Figure5. Among 141 individuals, the highest number of individuals of the species was 33 and observed in *Pentacme siamensis* (Miq.) Kurz (Ingyin) of the family Diptarocarpaceae and it is followed by 17 individuals of *Shorea obtusa* Wall. ex Blume (Thitya), 16 of *Melanorrhoea usitata* Wall. (Thitsi) of the family Anacardiaceae and 15 of Dipeterocarpus tuberculatus Roxb. (In) of the family Dipterocarpaceae (Table 5).

The lowest number was only 1 – 6 individuals of each of 9 species in level II.Loganiaceae has 6 individuals but only one individual is found in Myrtaceae, Capparaceae, Bignoniaceae and Ebenaceae (Table 5 & 6).

This layer acts as a transitional ecotone. A sharp reduction in total species and families is observed in Level II. The community of this layer becomes noticeably dominated by a few key families (Diptarocarpaceae, Anacardiaceae, Fabaceae and Combretaceae). Many families present in Level I disappear, e.g., Lecythraceae, Burseraceae, Lamiaceae, Hypericaceae, Euphorbiaceae, Lythraceae and Boraginaceae (Table 4, 5 & 6) or the other some families such as Myrtaceae, Bignoniaceae and Ebenaceae are represented by only a single individual.

5.2.3 Level III (750 – 1050 m high) or Upper layer of elevation

In this upper layer of 750 – 1050 m high elevation, or level III, a total of 111 individuals of 44 species in 21 families are found as shown in Table 7, 8 and Figure 6. The highest number of individuals is found to be 18 of *Pentacme siamensis* (Miq.) Kurz (Ingyin) in the family Dipterocarpaceae. It is followed by 15 individuals of *Shorea obtusa* Wall. ex Blume (Thitya) of the same family Dipterocarpaceae and 7 of *Melanorrhoea usitata* Wall. (Thitsi) of Anacardiaceae.

The species composition in this layer is the highest along the transect line, however, the density of individuals is the lowest among the three levels.

This layer shows a shift in forest type. Dipterocarpaceae is being still dominant in this layer, new families characteristics of hill or montane forests appear, such as Fagaceae (*Castanopsis*, Theaceae (*Schimawallichii*), and Magnoliaceae (*Magnolia champaca*). The number of families is increased but the number of individuals is very few in each,and this suggests a more specialized and fragmented habitat, possibly with different soil, moisture, and temperature condition.

In this upper layer, *Dipterocarpus alatus* appears in the place of *D. tuberculatus*. It is a key species turnover indicator.

Among the 21 families in this level, Dipterocarpaceae (3 species), Anacardiaceae (3 species) and Fabaceae (6 species) are the most dominant families with 11 – 35 individuals and they are followed by Malvaceae (5 species with 6 individuals).

Rubiaceae, Dilleniaceae, Euphorbiaceae and Fagaceae are equally distributed with 3 species of each family and in turn with 5 individuals of each species

Combretaceae and Burseraceae with 2 speciesof each are distributed with 2 or 4 individuals. The rest 11families with only 1 species of each are distributed with 1 – 4 individuals (Table 7 & 8).

5.2.4 Core forest community and elevational specialists

The forest in the study area is characterized by strong dominance by a few families and species, a common feature in tropical forests. This character is pronounced in this study area. In each of three layers of elevations, unique species are found such as 15 species of 12 families in Lower layer I (Level I) (Table 9), 3 species of 3 families in Middle Layers (Level II) (Table 10), and 20 species of 14 families in Upper Layers (Level III) (Table 11).

At the same time 13 species of 10 families are recorded in each and every layer of the three levels. These 13 core species are wide-ranging, and highly adaptable forest community of Mann Reserve. These species include particularly *Pentacme siamensis*, *Terminalia elliptica*, *Phyllanthus emblica,* and *Melanorrhoea usitata* across a broad elevational gradient (Table 12).

Among them, elevational specialists are also found in lower layer as well as in upper layer.

Lower layer specialists contain species like *Dipterocarpus tuberculatus,* an abundant species in Layer I and Layer II, but absent in Layer III. *Lannea coromandelica*, *Lagerstromis villosa*, and *Cordia grandis* are confined to the lower warmer slope.

Upper layer specialists include species such as *Dipterocarpus alatus*, members of Fagaceae (*Castanopsid species*), *Schima wallichii* (Theaceae), and *Melia dubia*. Thisindicates the shift to a distinctive upper hill forest community not found below.

5.2.5 Diversity and biomass in all three levels of elevations (150 – 1050 m high) in aspect of Shannon-winner's index and Simpson's index

This research focused on analyzing tree species composition, diversity and stem biomass in Man reserve forest in Myanmar.The study area is noted as a dipterocarp dominant dry forest in Central Dry Zone of Myanmar.

Simpson's index and Shannon-winner's index was used to calculate species diversity. Forest inventory was conducted in three levels which are upper (750 – 1050), middle (450 – 750) and lower (150 – 450). In the study area of Mann Reserve Forest, 70 species were recorded. The indices show that the upper and the lower level were found to be higher in species richness than that of the middle level. The species growing are significantly different in the different layers.

Species diversity is known to facilitate ecosystem biomass (productivity) in natural forests, plantations, and biodiversity experiments. However, discrepancies are commonly observed across different forest types or at different spatial scales, given the complex interactive impacts of numerous biotic and abiotic factors on species diversity and stand biomass. Plant species diversity is greater in the lower level than that of in the upper level. In this area, local people use a lot of Mok-so-ngayok (*Murraya paniculata* (L.) (Jack), Karawe leaves (*Cinnamomum impressinervium* Meissner), and Thit-kya-bo (*Cinnamomum verum*).

In Man Reserve, the value of Shannon-Winer index (H') of Level 1.1 (Plot no. 1.1 of Level I) was found to be the highest, i.e., 2.758329826, and was followed by that of Level 2.2 (2.220455316). The value of Simpson's diversity index of Level 1.1 was also found to be the highest, i.e., 0.90 (Table.13 & 14, Fig. 7 & 8). It is followed by Level 2.3 (i.e., 0.87)

Among the 12 plots tested of all levels, the lowest value of both of Shannon-Winner`s Index and Simpson`s Index was found to be in Level number 3.1.

In terms of species diversity, the larger the value of Shannon-Winer index (H') the greater the species diversity, and vice vasa the greater the species diversity, the larger the value of H' (Magurran, 1988).

Among the 12 sample plots of the three levels, the species diversity was found to be the highest in Plot no. 1.1 of Level I. It is followed by the diversity of Plot no. 2.2 of Level II.

Estimating tree biomass is a useful measure for comparing structural and functional attributes of forest ecosystems across a wide range of environmental conditions (Phyu Phyu Lwin, 2015).

In the study area, each of 4 plots of each level (total 12 plots) was taken to calculate their biomass. Biomass of the plots of the three levels is estimated based on tree diameter, height and wood density of 71 species of 26 families.

Among them, Level 1.4 (Plot no. 4 in Level I) has the highest value of biomass, i.e., 19814.2. It is followed by Level 3.4, i.e., 17974.6 (Fig. 10). The lowest value of biomass is observed in Level 2.2.

6. Conclusion & Recommendation

The forest structure of Mann Reserve is a mature characteristic Dry Dipterocarpus Forest. It has a foundation of high dominance and a matrix of high species richness.

The lower layer is the highest bio-diversified zone and densely populated, representing a rich lowland tropical forest with high species turnover and complexity.

In the Middle Layer, biodiversity is found to be the lowest. It is a simplified, transitional zone dominated by a few hardy, generalist families from the lower layer, with reduced overall diversity.

The upper layer represents a distinct forest community with a few species of hill or montane forest flora such as Fagaceae and Theaceae. But it has a low tree density and a more even spread of species across many families, suggesting it may be more susceptible to disturbances of ecosystem.

It is recommended that conservation is required in the study area. The strategies for these layers must be layer-specific. The lower layers must be protected for its high diversity and valuable timber species. The less dense upper layer is critical for conserving unique hydrological conditions and montane–adapted species.

The core 13 species in all of the three layers are vital for maintaining forest connectivity and resilience across entire reserve.

The status of natural regeneration of these core species should also be considered and checked yearly and one of the strategies should be applied to focus on community-based conservation.

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