Original Research Article

Structure and Species Composition of KpataweeTropical Rainforest in Liberia

ABSTRACT

Tropical rainforests, which are highly valued for their remarkable biodiversity, are under increasing threat from land use practices due to their favorable environmental attributes that make them attractive sites for agricultural growth. The objective of this research was to evaluate the species composition and structure of the tropical rainforest in Kpatawee,Liberia.In order to do this, a transect walk that crossed the forest in both south-north and east-west directions was conducted. Along the transect, six typical sampling plots were created, and tree sampling was done inside of these plots. Using the PlantNet plant species identifier tool, every surviving tree with a diameter of ≥ 5 cm at breast height (DBH) was carefully categorized, along with their scientific names.The results showed that there are 76 different species of trees and shrubs in 42 groups, with *Leguminosae* having the greatest species diversity. *QuararibeaAsterolepis, Hasseltia Floribunda,* and *Castilla Elastica* were among the prominent dominating trees. The presence of stem-stand shrubs, small-sized tree species, and younger individuals of larger trees in the first class were all linked to the inverted J-shaped pattern found in the diameter distribution analysis. The tree layer contributed significantly to the total DBH (65.45%), especially species like *Garcinia Benthamiana, IramyanTherasagotiana*, and*EschweileraDecolarans*. Eight species accounted for 93% of the basal area (BA) of trees with a DBH > 5 cm, which was 16.39 m^2 ha^{-1}.Given these findings, protecting and managing the Kpatawee tropical rainforest sustainably must be given top priority. This study provides important information about the composition and structure of the forest, which will help guide future land use planning and conservation initiatives.

Keywords: Tree species, tropical forest, species composition, forest structure, Kpatawee tropical forest

1. INTRODUCTION

Approximately 70% of all plant and animal species on Earth are found in tropical rainforests, which occupy just 7% of the planet's dry surface area but are incredibly biodiverse (Elisabeth et al., 2015). Numerous essential commodities and services are provided by these ecosystems to local and global societies. Tropical rainforests provide food, building materials, medicinal plants, and other necessities for indigenous populations (Ali et al., 2014). Furthermore, these forests are essential to maintaining the stability of the global environment because they help to regulate temperature, purify the air, and detoxify the soil (Bargali et al., 2015).

Liberia is a perfect example of a nation rich in forest resources, with forests covering over 45% of its land area (FAO, 2014). Deforestation and other environmental issues, however, pose a serious threat to Liberia's forests (FAO, 2015). There are several tangible forest resources with market-determined values, including animals, inland fisheries, fuel wood, timber, and forage. Furthermore, Liberia's forests provide nonmarket-determined benefits like environmental protection, recreational opportunities, and amenities. Regretfully, massive deforestation has resulted in the demise of multiple species and the destruction of Liberia's lush environment.

Within Liberia's forested landscape, the Kpatawee Rainforest is a prominent area that is renowned for its great richness and diversity of plant and animal species. It is home to numerous African vulnerable species that are extremely important for conservation, such as tree species like *Terminalia ivorensis, Pterocarpus soyauxii,* and *Milicia excelsa*(Kindt et al., 2021). But human activity has not spared this rainforest; the main one being the rapacious harvesting of forest resources, both timber and non-timber.

Amidst the challenges presented by deforestation and human disruptions, it is imperative to carry out thorough investigations on biodiversity and ecology. These investigations support conservation efforts by shedding light on the environmental benefits that this rare biodiversity offers. Developing fundamental scientific understanding of the biodiversity and structure of the Kpatawee rainforest is the main goal of this project. It focuses on assessing the species composition and overall structure of the forest. By doing this, it hopes to give stakeholders important information for sustainable forest management and lay the groundwork for tackling the urgent problems of anthropogenic disturbances and deforestation.

2. MATERIAL AND METHODS

2.1 Study site

The study was carried out in the Kpatawe rainforest, Suakoko, Bong County, Liberia. Suakoko District lies at an altitude of 270 m above sea level and is located at 7.0451º latitude and -9.5508º longitude. Climatic variables such as temperature and rainfall pattern are largely tropical, with an annual average temperature of 25 °C and an annual average rainfall of 2013 mm distributed from May to October. The main soil types in the district include *latosols*, *lithosols*, *regosols,* and *alluvial* or swamp soils. The study area is home to many grasses, trees, and shrub species, which are said to be part of the remaining Upper Guinean rainforest. Cassava, rice, and maize farming are the dominant crops grown in the area.

2.2 Vegetation data collection

A transect walk was performed in the forest from east to west and from south to north. A representative sampling plot was installed along the transect walk. Tree sampling was performed on six selected sampling plots. According to Kubota *et al*. (2004), all living trees with a diameter ≥ 5 cm at breast height (DBH) were recorded by species using the latest botanical classification method. All tree species were assigned to their own families. A plant species identifier application was used, and the scientific names of plants were identified.

2.2.1 Tree Basal area calculation

Tree diameter was measured at breast height for species more than 5 cm in diameter and over 3 m in height, according to Zeng *et al*. (2014). The diameter was measured using a diameter tape. Basal area (BA), which is the cross-sectional area of tree stems, was measured through the diameter at breast height, which is 1.3 m above ground level. It helped to measure the relative dominance (the degree of coverage of a species as an expression of the space it occupies) of a species in a forest. It was calculated as:

$$BA = \pi DBH^2/4$$

Where BA = basal area (m^2), DBH = diameter at breast height (cm), π = 3.14

2.2.2 Dominance

Species dominance refers to the degree of coverage of a species as an expression of the space it occupies in a given area. Usually, dominance is expressed in terms of the basal area of the species. In this case, two sets of dominance were calculated: dominance (the sum of basal areas of the individuals in m^2/ha) and relative dominance, which is the percentage of the total basal area of a given species out of the total measured stem basal areas of all species.

$$\text{Dominance} = \text{Total basal area/area sampled}$$

$$\text{Relative dominance} = (\text{Dominance of species A/total dominance of all species}) * 100$$

2.3 Statistical analysis

Descriptive statistics such as DBH, BA, and RD were performed to summarize the structure and species composition of the study forest. JMP 14 Pro was used to perform all the statistical analyses.

3. RESULTS AND DISCUSSION

3.1 Tree Species Composition

The present study investigates the structure and species composition of the Kpatawee rainforest. The total number of tree and shrub species was found to be 76, belonging to 42 families. Regarding species diversity, *Leguminosae* was the most diverse family, followed by*Sapotaceae*, *Chrysobalana, Burseraceae,* and *Myristicaceae.* Based on the stand density, *Dicoryniaguianesis*is the most dominant family, and the 20 individuals recorded in this study are more or less in line with the reports of Goulart et al. (2015).

The most dominant trees under the Kpatawee rainforest are *QuararibeaAsterolepis, Hasseltia Floribunda, Castilla Elastica, HassetiaFloribumda, IryantheraSagotiana, CalophyllumTacanbhaca and Licania Bernoulli*. In contrast, *CoumaGuianensis, Ceiba Pentandra, Pouteria Guianensis, LecythisIdatmon and Dicoryniaguianesis*are rare species. Similarly, Kubota *et al*. (2004) reported *Castilla ElasticaCalophyllumTacanbhaca,* and *HassetiaFloribumda* as dominant species.

3.2 Diameter Class Distribution

A total of 76 individuals of tree species whose DBH was ≥ 5 cm were recorded from the Kpatawee rainforest. DBH was classified into ten classes of 10 cm intervals (Class 1 = 5–15, Class 2 = 16–25, Class 3 = 26–35, Class 4 = 36–45, Class 5 = 46–55, Class 6 = 56–65, Class 7 = 66–75, Class 8 = 76–85, Class 9 = 86–95, and Class 10 = ≥ 96) (Figure 1). The diameter distribution of the Kpatawee rainforest was found to be an inverted J-shaped distribution.

The reason for the J-shaped distribution might be due to a large number of stem-stand shrubs, small-sized tree species, and younger individuals of big-sized tree species, too. Regarding the forest profiles, few tree species in the tree layer have contributed to most of the total DBH of Kpatawee forest. These are *EschweileraDecolarans, Garcinia Benthamiana,* and*IramyanTherasagotiana*(65.45%). Similar results are also reported by Cirimwami*et al*. (2019). According to Mi *et al*. (2012), the normal basal area of virgin tropical forest in Africa is 23–37 m^2 ha^{-1}. The tree height value is also higher in the lower class and decreases in the higher class. This is also true for other forests too (Singh, 2018).

This revealed that the forest is also suffering from selective cutting, which results in smaller to medium-sized individuals attributed to a high rate of regeneration but low recruitment. The DBH distribution of Kpatawee rainforest is in line with some other forests in other countries (Juli & Mike, 2001). The reverse J-shaped population curve of trees suggests an evolving or expanding population, climax, or stable type of population in forest ecosystems, indicating that the forest harbors a growing and healthy population (Zeng *et al*., 2014).

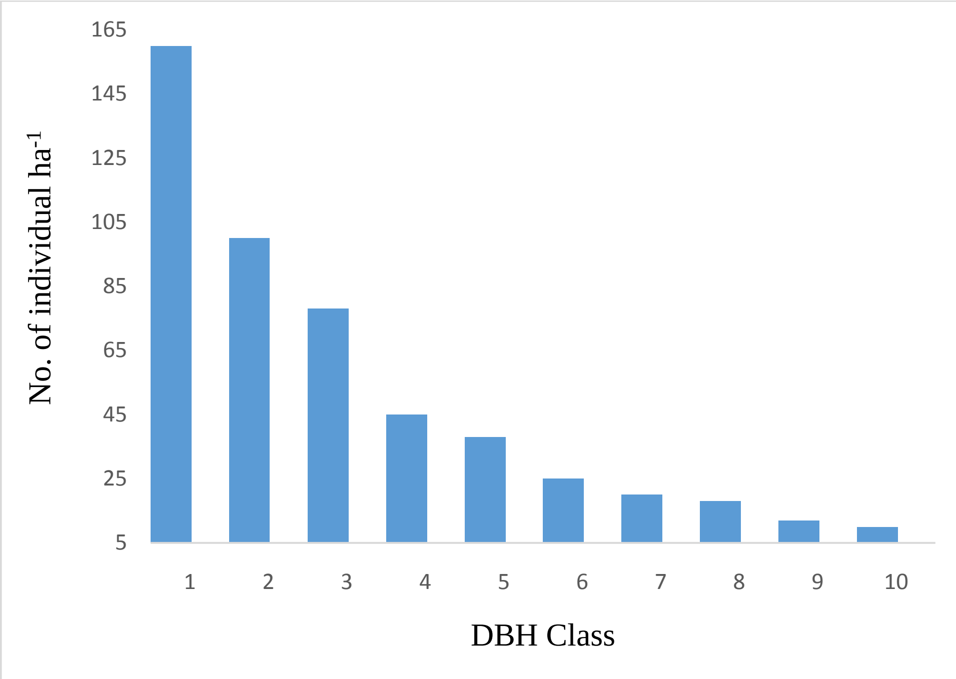

Figure 1. The diameter distribution of Kpatawee rainforest

3.3 Basal Area

Basal area (BA) is an important parameter for measuring the relative importance of tree species in a forest compared to stem counts (Mendez-Toribio *et al*., 2016). Hence, plant species with a larger basal area in a forest are considered to be the most important species in that forest. The sum total BA of tree species with DBH ≥ 5 cm was 16.39 m^2 ha^{-1}. In this particular study, eight species contributed 93% of the BA.

*Dicoryniaguianesis*was the most important tree species in the forest, with a BA of 8.6 m^2 ha^{-1} which is about 44.15%. The second most important tree species was *LecythisIdatmon,* with a BA of 3.4 m^2 ha^{-1} which is 18.46%. Other plant species, such as *Pouteria Guianensis*, *Ceiba Pentandra,CoumaGuianensis,* and *BocoaProuacensis,* had BAs of 0.403, 0.351, 0.294, and 0.204 m^2 ha^{-1}, respectively. This is due to the presence of relatively larger DBH-sized tree species in the study area (Table 1). On the other hand, *Licaniaheteromorpha*contributed the least amount of BA, about 0.001 m^2 ha^{-1} to the Kpatawee rainforest.

3.4 Forest Structure

In this study, tree species structure was determined considering their density at various DBH classes. As a result, species population patterns were determined as an inverted J-shape. This indicated that in the first class, there was a large number of individuals in lower DBH classes, with a gradual decreasing trend toward higher DBH classes. A few species, including *Dicoryniaguianesis,* have shown this pattern, which suggests good recruitment and regeneration. A similar pattern was reported by Hu *et al*. (2018): 17 species at Gara-Ades and 18 species at Menagesha forests. The second pattern shows that individuals are more prevalent in lower DBH classes and less prevalent in intermediate and higher DBH classes (Figure 1).

Some species, such as *QuararibeaAsterolepis,* and *Castilla Elastica,* were in this category. This pattern indicated heavy human pressure on higher DBH classes, leading to a scarcity of mature individuals that can serve as seed sources. The third pattern revealed the presence of a large number of individuals in the lower and higher DBH classes and the absence of individuals at the intermediate DBH classes. Some species, such as *Dicoryniaguianesis* and *LecythisIdatmon,* have shown this pattern. Similar results were reported by Rai *et al*. (2012), in agreement with the second and third population patterns. The fourth pattern depicted the presence of a large number of individuals in the intermediate DBH classes and a small number of individuals in the lower and higher DBH classes. A few species, including *Tabebuia Rosea,* exhibited this pattern. This pattern shows hampered regeneration, which could be attributed to poor recruitment coupled with selective cutting of individuals in the higher DBH classes.

Table 1: Botanical name, diameter at breast height (DBH), basal area (BA) and relative dominance (RD) and their family of the dominant species in the study area

No	Botanical name	Family name	DBH (cm)	BA (m^2)	RD (%)
1	*Abies Alba Mill*	*Pinacea*	35.03	0.096	0.046116
2	*Castanea*	*Fagaceae*	19.11	0.029	0.155001
3	*Ceiba Pentandra*	*Malvaceae*	66.88	0.351	0.012653
4	*Celtis Australis L.*	*Cannabacea*	44.59	0.156	0.028469
5	*CupaniaHirsuta*	*Sapidaceae*	36.62	0.105	0.042193
6	*Dicoryniaguianesis*	*Leguminosae*	332.80	8.694	0.000511
7	*Douglas Fir*	*Pinaceae*	15.92	0.020	0.223201
8	*ElephantopusMadrium*	*Lauracea*	25.48	0.051	0.087188
9	*Fagus Sylvatica L.*	*Fagacene*	15.92	0.020	0.223201
10	*Fraxinus Americena L.*	*Oleacea*	17.52	0.024	0.184463
11	*LecythisIdatmon*	*Lecythidaceae*	208.60	3.416	0.001301
12	*Licaniaheteromorpha*	*Chrysobalanaceae*	49.36	0.191	0.023226
13	*QuararibeaAsterolepis*	*Malvaceae*	1.59	0.000	22.32007
14	*Salix Caprea L.*	*Salicaceae*	14.33	0.016	0.275556
15	*SandwithiaGuyanensis*	*Euphorbiaceae*	19.11	0.029	0.155001
16	*Tabebuia Rosea*	*Bignoniacea*	9.55	0.007	0.620002
17	*Carya Ovata Mill*	*Juglandaceae*	19.11	0.029	0.155001
18	*DiospyrusVestita*	*Ebenaceae*	11.15	0.010	0.455512
19	*GuapiraEggersiana*	*Nyctaginaceae*	25.48	0.051	0.087188
20	*Gustavia Hexapetala*	*Lecythidaceae*	12.74	0.013	0.348751
21	*Hasseltia Floribunda*	*Salicaceae*	3.18	0.001	5.580018
22	*HymenaceaCourbaril L.*	*Leguminosae*	6.37	0.003	1.395005
23	*Pouteria Guianensis*	*Sapotaceae*	71.66	0.403	0.011022
24	*Protium Denerarense*	*Burseraceae*	42.99	0.145	0.030617
25	*Protium Subserratun*	*Burserraceae*	15.92	0.020	0.223201
26	*Quercus Iley*	*Facacea*	7.96	0.005	0.892803
27	*Sandwithia Caprea L.*	*Salicaceae*	19.11	0.029	0.155001
28	*SiparunaDecipiens*	*Siparunaceae*	25.48	0.051	0.087188
29	*BocoaProuacensis*	*Leguminosae*	50.96	0.204	0.021797
30	*Dacryodes Nitens*	*Burseraceae*	36.62	0.105	0.042193
31	*Eperua Falcata*	*Leguminosae*	20.70	0.034	0.132071
32	*HymenacaCourbaril L.*	*Leguminosae*	47.77	0.179	0.0248
33	*HumiriastrunSubcrenatum*	*Humiriaceae*	27.07	0.058	0.077232
34	*IrynatheraSagotiana*	*Myristicaceae*	14.33	0.016	0.275556

35	*Macrolobium Bifolium*	*Leguminosae*	38.22	0.115	0.03875
36	*Picea Abies*	*Pinaceae*	46.18	0.167	0.02654
37	*Platymicium Trinitatis*	*Legumimosae*	7.96	0.005	0.892803
38	*PouroumaVillosa*	*Urticaceae*	9.55	0.007	0.620002
39	*Pradosia Cochlearia*	*Sapotaceae*	44.59	0.156	0.028469
40	*PradosiaPtychandra*	*Sapotaceae*	27.07	0.058	0.077232
41	*Abies Nordmannian*	*Pinaceae*	25.48	0.051	0.087188
42	*Castilla Elastica*	*Moraceae*	1.59	0.029	22.32007
43	*Coffee Arabica L.*	*Rubiaceae*	19.11	0.000	0.155001
44	*CouepiaGuianesis*	*Cyrysobalana*	15.92	0.020	0.223201
45	*CoumaGuianensis*	*Apocynaceae*	61.15	0.294	0.015137
46	*HassetiaFloribumda*	*Nyristicaceae*	2.55	0.001	8.718778
47	*IryantheraSagotiana*	*Myristicaceae*	3.18	0.001	5.580018
48	*Juglan Nigra L.*	*Juglandaceae*	11.15	0.010	0.455512
49	*LicaniaLaxiflora*	*Chrysobalana*	41.40	0.135	0.033018
50	*OrmosiaNelanocarpa*	*Leguminosae*	25.48	0.051	0.087188
51	*Platyniscium Trinitatis*	*Legumisosae*	4.78	0.002	2.480008
52	*Protium Sagotianum*	*Burseraceae*	7.96	0.005	0.892803
53	*Acer Opalus Mill*	*Sapindaceae*	25.48	0.051	0.087188
54	*CalophyllumTacanbhaca*	*Clusiaceae*	3.82	0.001	3.875013
55	*Eperna Falcata*	*Leguminosae*	4.78	0.002	2.480008
56	*HymenaceaeCourbaril*	*Leguminosae*	15.92	0.020	0.223201
57	*Moronobea Coccinea*	*Clusiaceae*	9.55	0.007	0.620002
58	*Octrosia Grandiflora*	*Apocynaceae*	19.11	0.029	0.155001
59	*OxandraAsbecki*	*Annonaceae*	6.37	0.003	1.395005
60	*PourounaVillosa*	*Urticaceae*	15.92	0.020	0.223201
61	*Simarouba Amara*	*Simaroubaceae*	25.48	0.051	0.087188
62	*Terminalia Catappa L.*	*Conbretaceae*	19.11	0.029	0.155001
63	*AcioaGuianensis*	*Chrysobalana*	9.55	0.007	0.620002
64	*AnibaTerminails Ducke*	*Lanraceae*	27.07	0.058	0.077232
65	*CouepiaBracteosa*	*Chrysobalana*	27.07	0.058	0.077232
66	*Canarium Album*	*Burseraceae*	12.74	0.013	0.348751
67	*EcclinusaGuianensis*	*Sapotaceae*	7.96	0.005	0.892803
68	*EschweileraDecolarans*	*Lecythidaceae*	23.89	0.045	0.0992
69	*Garcinia Benthamiana*	*Clusiaceae*	4.78	0.002	2.480008
70	*IramyanTherasagotiana*	*Myristicaceae*	9.55	0.007	0.620002
71	*LicaniaNicranthia*	*Chrysobalana*	35.03	0.096	0.046116
72	*Licania Bernoulli*	*Chrysobalana*	3.18	0.001	5.580018
73	*MaquiraGuianensis*	*Moraceae*	4.78	0.002	2.480008
74	*Morella Cerifera*	*Myricaceae*	19.11	0.029	0.155001
75	*Pouteria Brachyandra*	*Sapotaceae*	36.62	0.105	0.042193
76	*ThyrsodiumGuianensis*	*Anacardiaceae*	31.85	0.080	0.0558

4. CONCLUSION

In this particular study, we explored the structure and species composition of the Kpatawee rainforest, in order to see its ecological dynamics.Our research provides important new information about the biodiversity and overall health of this special ecosystem. A total of 76 species of trees and shrubs were identified, categorized into 42 groups, the most diverse of which is *Leguminosae*. It was discovered that the prominent tree species in the forest were *QuararibeaAsterolepis, Hasseltia Floribunda, Castilla Elastica, HassetiaFloribumda, IryantheraSagotiana, CalophyllumTacanbhaca,* and*Licania Bernoulli*. This finding highlights the significance of these tree species in the structure of the forest.

An inverted J-shaped pattern was found in the diameter class distribution study, which was explained by a mix of stem-stand shrubs, small-sized tree species, and juvenile individuals of large-sized trees. This distribution pattern, which implies a high rate of regeneration but limited recruitment, possibly as a result of selective cutting, highlights the necessity for cautious management.The importance of specific tree species was reaffirmed by basal area analysis, with *Dicoryniaguianesis* and *LecythisIdatmon* emerging as major contributors. Determining the relative importance of various species within the forest ecosystem requires an understanding of their basal areas.

Overall, our research provides important insight into the composition and structure of the Kpatawee rainforest. Subsequent investigations ought to concentrate on deepening the comprehension of the ecological consequences of these trends and approaches for the sustainable administration and preservation of this crucial ecosystem. The long-term health and biodiversity of the Kpatawee rainforest depend on taking extra care to mitigate the effects of selective cutting on the forest's recruitment and regeneration processes.

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