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Effects of Canopy Gaps on Shrub Communities within Kakachi Forests of the Kalakkad Mundanthurai Tiger Reserve (KMTR), Tamil Nadu, India

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Abstract

This study examines the impact of light availability on understory shrub composition in the Kakachi range of the Western Ghats' evergreen forests. Through sampling across different locations, measuring light intensity, and analyzing leaf area, it investigates how canopy openings influence shrub species diversity and physical characteristics. The research finds a significant dominance of the Rubiaceae family, suggesting adaptability to various light conditions. Despite methodological challenges, such as measuring light intensity, the study highlights the complex interactions between light availability and understory vegetation dynamics.

1. Introduction

The understory vegetation within an evergreen forest is influenced by various factors encompassing local weather patterns, topography, altitude, competing vegetation communities, soil dynamics, and the availability of light. In areas of evergreen forests where sunlight penetration to the ground is limited, the undergrowth often experiences constraints. For instance, tree fall gaps result in the rapid colonization of the ground by a dense amalgamation of vines, shrubs, and small trees, impeding the penetration of sunlight. While some studies have explored the relationship between light availability and understorey shrub vegetation in different forest types (Jennings, 1999; Canham*et al.*, 1990; Specht & Morgan, 1981), no such investigations have been conducted in the evergreen forests of the Western Ghats. Notably, the understanding of understorey shrub vegetation within the Western Ghats' evergreen forests remains at an early stage. Limited studies have been carried out, including an enumeration of shrubs in Kakachi by Ganesh (1994) and a study focusing on montane sholas in the Nilgiris. Specifically within Kakachi, Krishnan &Davidar (1996) conducted a detailed investigation of the understorey shrubs. This study aims to assess whether variations exist in the composition of understorey shrubs concerning the amount of light received through canopy openings. It seeks to explore whether the leaf area of a species changes with increasing light intensity and whether species thriving across a wide range of light

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gradients significantly contribute to the dominance of the undergrowth.

2. Materials and Methods

2.1 Study area

The Kakachi forest range in the Kalakkad Mundanthurai Tiger Reserve (KMTR), situated within the Western Ghats, experiences an altitude between 1170 and 1306 meters. Receiving an average annual rainfall of 3000 mm and maintaining a mean monthly temperature range of 13 to 23°C (Pascal, 1984; Giriraj*et al.*, 2008), this area represents a mid-elevation wet evergreen tropical forest. Its vegetation exhibits five layers: an upper canopy with trees like *Calophyllum austroindicum*, *Culleniaexarillata*, and others; a subcanopy comprising *Myristica dactyloides* and *Artocarpus heterophyllus*; and understorey shrubs such as *Ardisia pauciflora* and *Diotacanthus grandis*, among others. Limited studies have explored the understorey shrubs in the Western Ghats, including a study by Ganesh et al. (1994) on shrub enumeration in Kakachi and a detailed investigation by Krishnan & Davidar (1996) specific to Kakachi's understorey shrubs.

2.2 Sampling Design

The study involved three sampling areas—Green trail, Wooden Bridge, and Fern house—separated by over 2 kilometers each. Sampling plots measured 5m x 5m, with ten replicates per trail totaling 30 plots across the three areas. Shrubbery over 50 centimeters in height was sampled, excluding smaller shrubs and tree saplings. Each plant species was assigned a code for identification. Species diversity ranged from five to 16 in various plots. Unidentified plants were tagged for expert identification, with sample specimens collected.

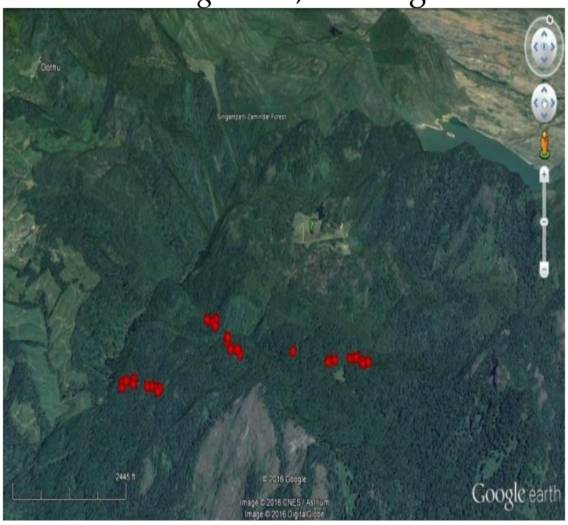


Fig. – 1a. Depicts 30 sample plots in 3 different sites (Green Trail, Wooden Bridge, Fern house) of Kakachi forests mapped on Google Earth.

Fig. – 1b. Tagged Psychotria species in a sampled plot

2.3 Measurement of Light Intensity:

Lux readings were taken at the center of each plot using a light meter (Lutron 101A) to determine average light intensity, with three readings per plot. To minimize spatial and temporal errors, final lux readings from all 30 plots were recorded within a 15-minute span at the end of the day. Canopy Cover Assessment: Photographs of the canopy (Fig 2) were captured at a consistent height (1.5 meters) at the center of each plot using the same camera settings across all 30 plots. Image-J software was utilized to calculate the total canopy cover based on these images

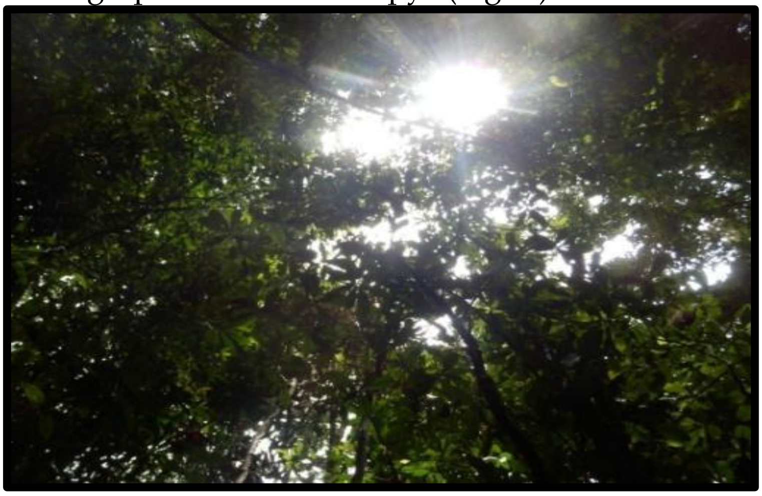


Fig.2. Image of the canopy captured rom the centre of the plot.

2.4 Leaf Area Measurement:

Three leaf samples per species were collected from each plot to represent variations in leaf area across the 30 plots. These leaves were scanned and processed using Image-J software (Fig 3a) to calculate their individual leaf areas. The total area of the three leaves was averaged to obtain a final record. This data was further normalized, and standard deviation was computed for all species across the plots.

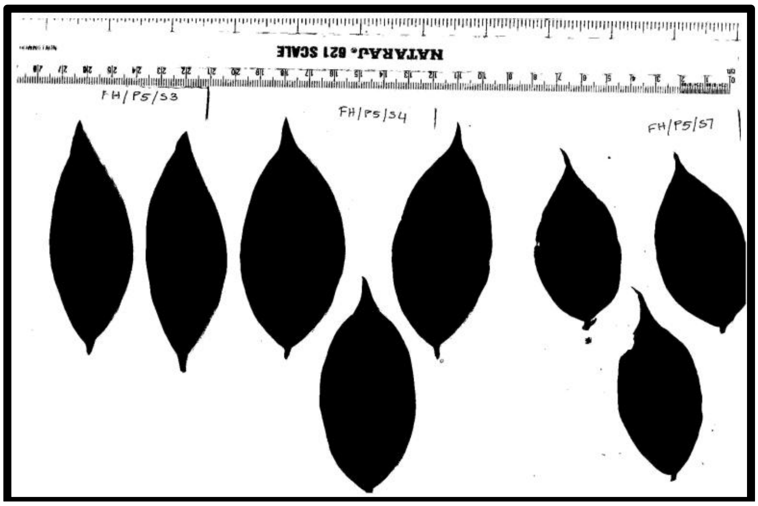
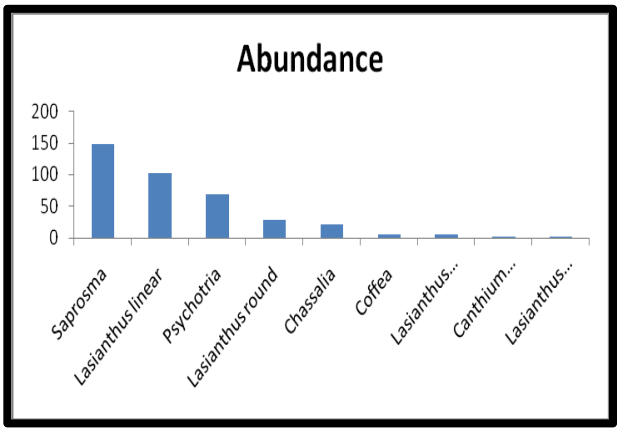


Fig- 3– Leaves scanned from each plot

3. Results and Discussion

3.1. Field observations

Preliminary field observations and available literature highlight dominant families like Rubiaceae, Myrsinaceae, Celastraceae, and Euphorbiaceae in the understorey shrub community of Kakachi. Our initial assessment focused on scrutinizing shrub species abundance. Saprosma species registered the highest count with 149 individuals across 30 plots, followed by Lasianthus species at 103 and Psycotria with 68 individuals. A single collection of *Lasianthus strigillosus* is depicted in Figure 4. Among non-Rubiaceae members, the highest count observed was 59 individuals of *Ardisiasps*., followed by Agristostachys sps. across the 30 plots (see Fig. 5).



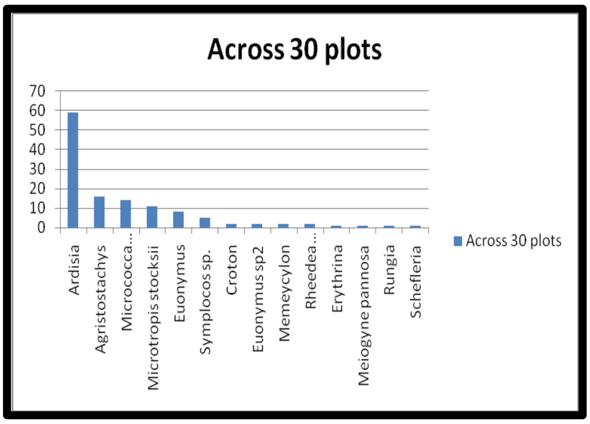


Fig 4 - Species abundance within Rubiaceae. Fig 5 - Species abundance within Non Rubiaceae members.

3.2 Statistical Comparison of Abundance:

A t-test was conducted to compare abundance between Rubiaceae and non-Rubiaceae members. As depicted in Table 1, Rubiaceae members exhibit significantly higher abundance compared to non-Rubiaceae members. Consistent with the findings of Krishanan and Davidar (1996), which highlighted dominant families such as Rubiaceae, Myrsinaceae, Celastraceae, and Euphorbiaceae in Kakachi's understorey shrub community, our results reaffirm the prevalence of Rubiaceae members as the dominant species in the understorey. Among the non-Rubiaceae members, Myrsinaceae (Ardisia sp) emerged as the second most abundant species.

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Sampling sites	df	t value	p value
Green Trail	9	4.9322	0.0008
Wooden bridge	9	4.6553	0.0012
Fern House	9	3.8592	0.0039

3.3 Measurement of Light Intensity and Canopy Opening:

Lux meters were employed to measure light intensity reaching the understorey through canopy openings at various sample plots across three sites. The readings underwent normalization using a reference point for standardization. Table 2 displays the measured light intensities across plots, along with normalized values and their respective standard deviations. Figure 6 visually represents the lux intensity in each plot, revealing the wooden bridge site as having the highest intensity.

Initially, double normalization occurred when standardizing the reference reading to compare light measures across all 30 plots, potentially increasing error. To mitigate this, a correlation between canopy opening and normalized lux intensity was explored using simple linear regression. The analysis revealed a robust correlation (R square value > 70%) between normalized lux intensity and percentage of canopy opening (see figures 7a, 7b, 7c). Consequently, light intensity as a variable was replaced with the percentage of canopy opening for further analysis.

Table – 2 Light intensity measured in GT- Green Trail, WB - Wooden Bridge trail, FH - Fern House trail

Plots	GT(av)	GT(nor)	GT(sd)	WB(av)	WB(nor)	WB(sd)	FH(av)	FH(nor)	FH(sd)
p1	49.333	0.120915	0.0062	96.6667	0.251448	0.0099	341	0.393208	0.011
p2	48.667	0.119281	0.0075	87	0.226303	0.0182	392	0.452016	0.013
p3	38	0.093137	0.0098	116.667	0.303471	0.0117	345.67	0.398589	0.013
p4	28.333	0.069444	0.0028	310	0.806366	0.0239	168	0.193721	0.013
p5	32.667	0.080065	0.0028	153.333	0.398848	0.0169	243.33	0.280588	0.009
p6	99.333	0.243464	0.0163	123.333	0.320812	0.0557	185.33	0.213708	0.012
p7	46.667	0.114379	0.015	207	0.538445	0.0119	204.67	0.236002	0.004
p8	60.333	0.147876	0.0116	301.667	0.78469	0.0261	175.33	0.202177	0.006
p9	46.667	0.114379	0.0111	281	0.730932	0.018	127	0.146444	0.005
p10	68.667	0.168301	0.0086	255.667	0.665036	0.0212	183.67	0.211786	0.012

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reference	408	1	0.0214	888.667	2.311584	0.0197	1112.3	1.282634	0.019
standarise d ref	408	1	0.0214	384.441	1	0.0085	867.23	1	0.015

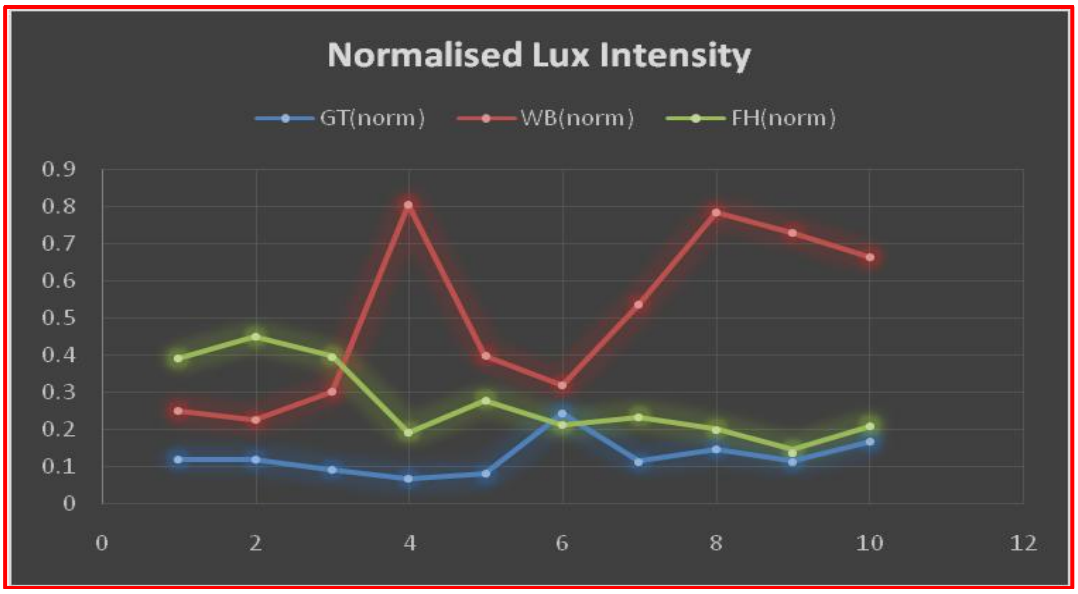

Fig – 6 Lux measurement across the 10 plots across the 3 sites.

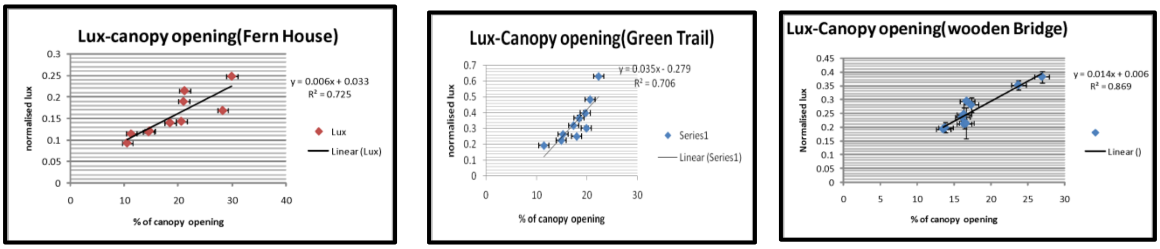

Fig- 7 graphs a, b, and c here indicate a strong correlation between canopy opening and light intensity

3.4 Assessing Composition Variations with Canopy Opening

To address whether understorey shrub composition varies concerning light received through canopy openings, a simple linear regression was conducted. The regression analyzed the frequency of occurrence of Rubiaceae and non-Rubiaceae members against canopy opening. Figure 8 illustrates a positive correlation, indicating an increase in the frequency of Rubiaceae members in tandem with an increase in canopy opening. This trend contrasts with non-Rubiaceae members across all three sites.

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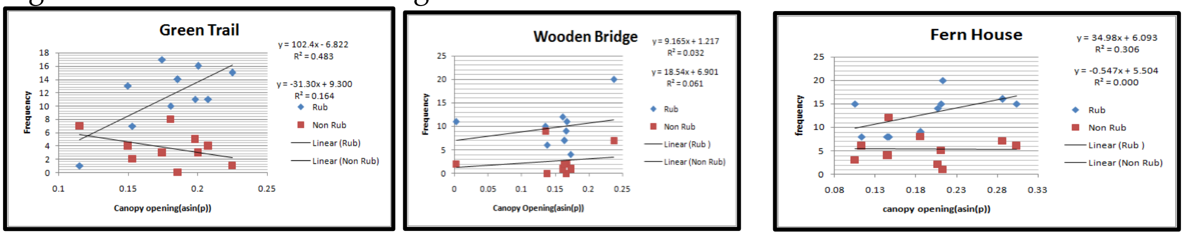
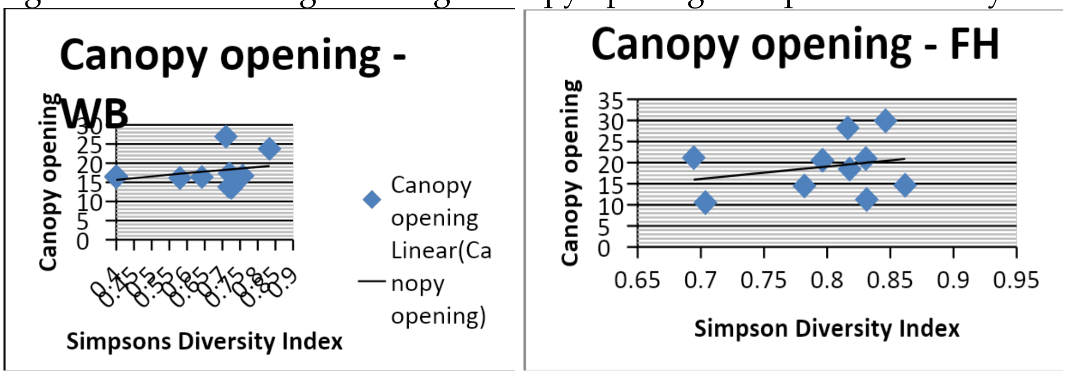
Fig. 8- Influence of light on distribution of Rubiaceae and others



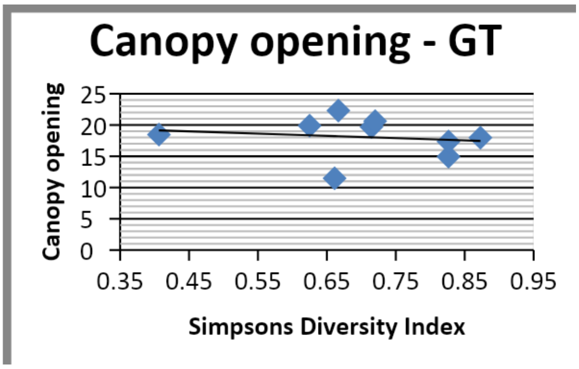
Correlation Analysis between Canopy Opening and Species Diversity

To investigate the relationship between canopy opening and species diversity across the three sites, we utilized PAST software to compute the Simpson Diversity Index. Subsequently, a simple linear regression was conducted using these values to ascertain the correlation between canopy opening and species diversity.

Fig. 9 – influence of light through canopy openings on species diversity



a) b)



c)

Graphs, 9 a, b & c explain the species diversity by calculating the Simpson Diversity Index with light (canopy opening used as a proxy for light).

3.5 Assessing Relationships: Canopy Opening, Species Diversity, and Leaf Area

Analysis of Fig. 9a, b, and c reveals an inconsistent relationship between canopy opening/light and species diversity, given the insignificance of the R values. Thus, we conclude that

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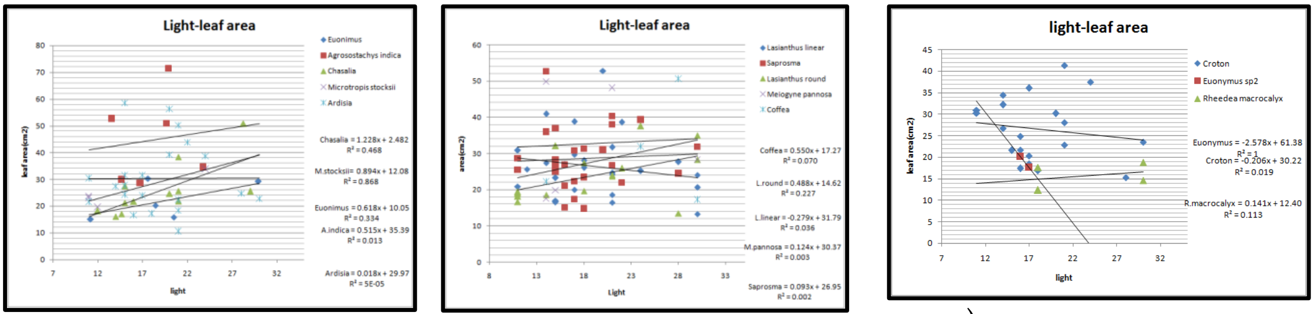
species diversity appears independent of light gradients. However, within the Rubiaceae family, shrub abundance demonstrates an increase with heightened light availability.

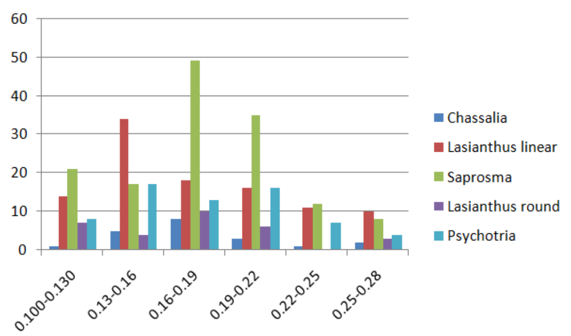
For the investigation on leaf area variation concerning light intensity (as detailed in our methods), simple linear regression was applied to the data. In Fig. 10a, *Chasalia* and *Microtropis stocksii* exhibit increased leaf area with higher light intensity. Conversely, Fig. 10b shows no correlation between leaf area and varying light for *Ardisia* and *Saprosma* species. Notably, one *Lasianthus* species displays a negative correlation with increasing light (Fig. 10c). Moreover, examining the five most abundant species across sites and plotting their occurrence frequency along the light gradient (Fig. 11) suggests that *Saprosma*, *Lasianthus*, and *Psychotria* are notably prevalent across varying light ranges, potentially contributing to the dominance of the undergrowth.

Fig. 10 - Comparison of variation with leaf area and light gradient



b) c) a)

Fig. 11 – Distribution of species across light ranges



To address issues arising from double normalization in light measurements, we replaced light intensity with canopy opening. This step mitigated potential errors due to temporal variations in light levels, although limitations persisted in achieving uniformity within plots. Moreover, our method of measuring light using the photometric method was deemed unsuitable for our ecological analysis, prompting the use of canopy opening as an alternative variable.

Although our analysis solely utilized canopy opening data, Jennings *et al*. (1999) delineated three light measurement methods, highlighting the limitations of our photometric approach. Future studies could explore quantifying light penetration through canopy gaps as detailed by Canham et al. (1990), incorporating photosynthetically active radiation (PAR) values for a more comprehensive analysis.

Our first hypothesis regarding species variation concerning light intensity was refuted. Results indicated no uniform trend in species diversity with increasing canopy opening, negating the hypothesis. Similarly, our third hypothesis of a negative correlation between leaf area and light intensity was unsupported, barring a negative correlation observed in one *Lasianthus* species. Other species like *Chasalia* and *Microtropis stocksii* exhibited increased leaf area with higher light intensity, while *Saprosma* and *Ardisia* showed no correlation with light.

Conversely, the abundance analysis revealed a significant prevalence of Rubiaceae family shrubs over non-Rubiaceae members, suggesting adaptability to varied light conditions. This supports our second hypothesis, indicating certain species' adaptability to a wider light range, contributing to their dominance in the forest understorey. Hence, the predominance of Rubiaceae shrubs in Kakachi's tropical evergreen forests likely results from their adaptability to diverse light intensities, asserting light as a pivotal determinant of shrub abundance. Further studies should delve into other environmental factors' roles in shaping Kakachi forest's understorey shrubs.

4. Conclusion

This investigation into the understory shrub composition of the Western Ghats' evergreen forests, specifically within the Kakachi area, underscores the intricate relationship between light availability and vegetation dynamics. Our findings reveal that variations in light intensity, primarily due to canopy openings, significantly impact the composition and leaf area of understory shrubs, with a marked dominance of the Rubiaceae family. This dominance suggests an adaptability of certain species to a range of light conditions, contributing to their prevalence in the understory vegetation. The study faced challenges in accurately measuring light intensity and ensuring uniform conditions across plots, leading to a reconsideration of light intensity measurement methods for future research. Despite these limitations, the research provides valuable insights into the factors influencing understory vegetation in tropical evergreen forests, highlighting the need for further studies to explore the roles of other environmental factors.

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6. References

Giriraj, A., Murthy, M. S. and Ramesh, B. R. (2008). Vegetation Composition, Structure and Patterns of Diversity: A Case Study from the Tropical Wet Evergreen Forests of the Western Ghats, India. *Edinburgh J. Bot.,* 65(3): 1–22.

Canham, C. D., Denslow, J. S., Platt, W. J., Runkle, J. R., Spies, T. A. and White, P.S. (1990). Light Regimes Beneath Closed Canopies and Tree-Fall Gaps in Temperate and Tropical Forests. Canad. J.Forest Res., 20: 620-631.

Specht, R.L. and Morgan, D.G. (1981). The Balance between the Foliage Projective Covers of Overstorey and Understorey Strata in Australian Vegetation. *Austr. J. Ecol.,12:93-202.

Krishnan, R.M. (1994). Ecology of Understorey Shrubs in a Wet Forest of South India. Thesis submitted for the degree of Doctor of Philosophy. Salim Ali School of Ecology and Environmental Sciences, Pondicherry University, Pondicherry.

Jennings, S. B., Brown, N.D. and Sheil, D. (1999). Assessing Forest Canopies and Understorey Illumination: Canopy Closure, Canopy Cover, and Other Measures. *Forestr.*,72(1),59-73.

Jennings, S. B. (1999). Light Environment, Physiological Tolerance, and the Distribution of Soil- Nutrient- Deficient Trees in a Tropical Moist Forest. Ecol., 80(8):2598-2608.

Krishnan, R. M. and Davidar, P. (1996). Understorey Structure of a Lowland Rain Forest in the Western Ghats, India. *J. Trop. Ecol.*, 12(2): 191-204.

Ganesh, T. (1994). Shrub Enumeration in Kakachi Forest. *J. Ecol.*, 5(2): 103-115.