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Ecological Attributes of Sacred Groves in West Khasi Hills, Meghalaya, India

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Abstract

Sacred groves, imbued with cultural significance through associations with deities, rituals, taboos, and ethnic heritage, establish an inseparable connection between contemporary society and historical roots. Across our country, diverse traditional communities engage in nature worship, each expressing their unique ethnic practices. The fundamental belief underlying these practices is the imperative to safeguard all natural creations, characterized by their immense richness in diversity and endemism. Conducted in 2020-21, this research focused on three sacred forests—Law Lyngdoh Mawnai, Law Lyngdoh Nonglait, and Law Lyngdoh Mawlong—in Meghalaya, India. Sampling involved 20 quadrats randomly placed within the study area 10 x 10 m^2 (trees) and 5 x 5 m^2 (shrubs), with an experienced guide aiding species identification. Findings revealed Law Lyngdoh Mawnai's have 23 tree species and 15 shrub species, Law Lyngdoh Nonglait's-17 tree species and 17 shrub species, and Law Lyngdoh Mawlong's- 22 tree species and 19 shrub species. The Ecological attributes for all sites ranged as follows: species richness (2.80-3.79), species diversity (2.10-2.71), evenness index (0.74-0.87), dominance index (0.09-0.21), and similarity index (21.21-34.48).

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Introduction

Sacred groves, remnants of ancient, untouched forests, hold immense ecological and cultural significance, particularly within indigenous societies. Meghalaya, nestled in the northeastern corner of India, is a bio-geographical crossroads where the paleo-arctic, Indo-Malayan, and Indo-Chinese realms converge. The state's diverse topography, characterized by significant variations in rainfall, temperature, altitude, and soil types, creates a mosaic of ecological niches that support a rich tapestry of tropical and subtropical vegetation. The remote and inaccessible humid areas of Meghalaya, in particular, serve as refugia for a diverse flora, providing a glimpse into the region's ancient botanical heritage. These sacred spaces, known locally as

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"*Law Kyntang*," "*Law Lyngdoh*," or "*Law Niam*," stand as testament to the harmonious coexistence between humans and nature. Preserved by local communities under the guidance of traditional beliefs and practices, these groves serve as sanctuaries for deities and ancestral spirits. This reverence has ensured their protection for generations, making them invaluable repositories of biodiversity and ecological knowledge.

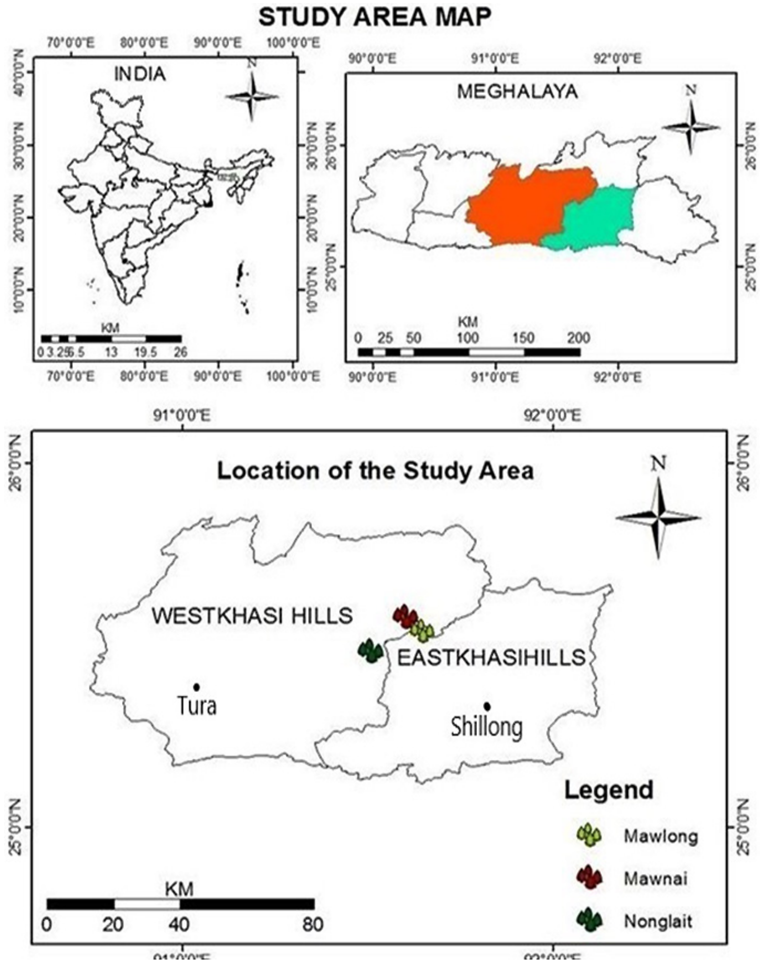

Fig. 1: Map illustrating study site

Sacred groves, physically forested areas, are culturally linked to rituals, taboos, and hold significance in biodiversity, culture, and ethnic heritage. Nature worship, practiced by various traditional communities, emphasizes the protection of natural creations. These groves, found in Asia and Africa, have historical roots dating back thousands of years, often associated with pre-agricultural societies.[1] Traditional approaches to nature conservation involve beliefs that include prescriptions and proscriptions, such as forbidding the removal of even small twigs from sacred groves. These groves benefit society, serving as indicators of potential natural vegetation.[2] Despite going by different names, such as *Law shnong* or *Law Adong,* in the Khasi Hills district, these groves share the same status and are used for various rituals and religious events.[3] Sacred groves are vital for conservation, housing indigenous and vulnerable flora, maintaining local micro-environmental conditions, controlling soil erosion, and contributing to biogeochemical cycles.[4] However, human activities pose a threat to these groves, with degradation caused by the erosion of traditional beliefs and practices. The shift from traditional worship to Christianity has led to the loss of faith in sacred groves, contributing to their disappearance.[5] The degradation of primary forests due to various human activities further exacerbates the threat to these sacred areas.

In response to these challenges, an extensive survey was conducted to study the phytosociology of three Sacred Groves in the West Khasi Hills District, aiming to understand their ecological importance and address conservation concerns.

Materials and Methods

The study, conducted during 2020-21 in selected sacred groves in the state of Meghalaya, focused on exploring the ecological attributes of three sacred groves in the West Khasi Hills region. Various diversity indices, including Important Value Index (IVI), Species diversity, Dominance, and Evenness, were analysed for both trees and shrubs.

Study Site

The research was conducted within three sacred groves located in the West Khasi Hills district of Meghalaya: Law Lyngdoh Mawnai (Site 1), Law Lyngdoh Nonglait (Site 2), and Law Lyngdoh Mawlong (Site 3). The geographical locations of these three sites in the heart of Meghalaya's West Khasi Hills are shown in Fig 1.

Law Lyngdoh Mawnai, located in Mawnai village within Hima Nongkhlaw's Syiemship, spans 23.7 hectares and is positioned at 25° 34' 48" N latitude and 91° 35' 44" E longitude (Fig. 2). Law Lyngdoh Nonglait, located in Nonglait village within Hima Mawiang Syiemship, spans approximately 50 hectares and is located at Latitude 25° 29' 12" N and Longitude 91° 30' 23" E. (Fig.3). Law Lyngdoh Mawlong, located in Mawlong village within Hima Nongkhlaw's Syiemship, covers around 200 hectares and is located at Latitude 25° 32' 29" N and Longitude 91° 38' 40" E. (Fig. 4)

Fig. 2: Law Lyngdoh Mawnai sacred groves source: Google

Fig. 3: Law Lyngdoh Nonglait sacred groves source: Google

Fig. 4: Aerial view of Law Lyngdoh Mawlong sacred groves

Climate and Soil

The district experiences a varied climate, ranging from mildly tropical to temperate and sub-tropical in different areas. Influenced by the southwest monsoon, it guarantees summer rainfall, averaging 1200mm to 3000mm annually. The district's diverse topography results in various soil types, with red gravelly and red loamy soils being common. These soils are acidic, with high organic matter and nitrogen but low phosphorus levels. Areas with recurrent fires show minimal soil development, often leaving bare rock surfaces. Poor soil overlays the rocks, serving as the rooting medium for pine vegetation.

Sampling Method

A botanical survey was conducted to record and categorize plant species at the study site based on their habits, identifying each species of trees and shrubs. The survey employed a total of 120 quadrats, divided equally among the three sites. For each site, 40 quadrats were sampled: 20 quadrats measuring 10 meters by 10 meters and another 20 quadrats measuring 5 meters by 5 meters. Within each site, 20 quadrats were specifically designated for studying trees, while the remaining 20 were used for examining shrubs. The quadrats were placed at intervals of 200 meters from one another. The local names of the species were determined using various sources, including forest staff, experience guide and villagers from the local area. A file of specimens was prepared for identification, referring to the Herbarium, and the species were identified by using pictures and local name and cross reference it with research paper, journals and books.

Data Analysis

The following equations were used in the assessment process

Frequency= (Number of quadrates in which the species occurred)/(Total number of quadrates)×100

Density= (Total no.of individuals of a species in all quadrats)/(Total number of quadrat)

Abundance= (Total no.of individuals of a species in all quadrats)/(Number of quadrates in which the species occurred)

Basal Area= $[(\pi \times Gbh)/2]^2$

Relative Frequency = (No.of quadrats in which a species occurs)/(Total No.of quadrats in which all the species occurred)×100

Relative Density= (Total No.of individual of a particular spcies in all quadrat)/(Total No.of individuals of all species in all quadrats)×100

Relative dominance= (Total basal area of a particular species)/(Total basal area of all species)×100

Important Value Index (IVI)= Relative Frequency + Relative Density + Relative Dominance

Species Richness (Margalef's index of richness)[6] (DMg)= S-1/Log (N)

Where,
S=Total no. of species
N=Total no. of individual

Species Diversity[6]
$H' = -\Sigma (Pi) [\ln (Pi)]$

Where,
Pi= n/N (proportion of each species in the sample)
n= Number of individual species
N= Total number of individuals

Evenness Index[6]
$E = H'/\ln S$

Where,
H'= Shannon's index value,
S = Total no. of species.
Log = Bits per individual

Index of dominance[6]
$D = \Sigma(n/N)^2$

Where,
D=Simpson index of dominance
n= Number of individual species
N= Total number of individuals

Similarity index[7]
$S = (a \times 100)/(a+b=c)$

Where,
a= represent the total number of species present in both first and second sample
b= represent the total number of species present in first sample only
c= represent the total number of species present in second sample only

Results

Distinct trends in composition, distribution, and species richness are shown by comparing the diversity of tree species in the three sacred groves as shown in Table 1. Between the three sites, 42 different tree species belonging to 25 different groups were found. Site 1 home 331 individuals representing 23 species from 18 families. Site 2 had 305 individuals spanning 17 species from 13 families. Site 3 included 287 individuals across 22 species from 13 families. Common species across all sites include C*astanopsis tribuloides, Ilex venulosa, Magnolia oblonga, Magnolia champaca, Myrica esculenta, Prunus nepalensis and Schima wallichii.*

Table 1: Composition and distribution of Trees in Law Lyngdoh Mawnai (Site1), Law Lyngdoh Nonglait (Site2) and Law Lyngdoh Mawlong (Site3)

Botanical name	Family Name	Local Name	Site 1	site 2	site 3
Aralia armata (Wall.) Seem.	Araliaceae	Diengtympu	-	2	3
Beilschmiedia brandisii (Meisn.) Kosterm.	Lauraceae	Sohkhyllam	-	-	1
Betula alnoides Buch.Ham. ex D.Don (Wikipedia).					
Betulaceae	Dienglieng	1	-	-	
Cascaria glomerata Roxb	Flacourtia	Diengshiahd	15	-	-
Castanopsis tribuloides (Sm.) A.DC.	-ceae	-ohkha			
Fagaceae	Sohot	34	126	85	
Celtis tetrandra Roxb.					
Ulmaceae	Diengshini	12	-	-	
Chukrasia velutina M.Roem.	Meliaceae	Diengpoma	-	5	-
Cinnamomum bijolghota (Buch.-Ham.) Sweet.	Lauraceae	Diengtyrdop	1	-	-
Cinnamomum cecicodaphne Meisn.	Lauraceae	Diengpingwait	-	14	8
Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	Lauraceae	Dienglatyrpad	-	5	-
Cinnamomum verum J.Presl.	Lauraceae	Diengseisia	-	-	2
Citrus latipes (Swingle) Tanaka.	Rutaceae	Sohkynphor	64	-	6
Derris elliptica (Wall.) Benth.	Fabaceae	Sohphyllad	1	-	-
Docynia indica (Wall.) Decne.	Rosaceae	Sohphoh	7	-	-
Engelhardia spicata Lesch. ex Blume	Juglandaceae	Dienglyba	3	-	-
Eurya acuminata DC.	Theaceae	Dieng shit	-	-	4
Exbucklandia populnea (R.Br. ex Griff.) R. W. Br.	Hamamelidaceae	Diengdoh	-	6	-
Ficus elastica Roxb. ex Hornem.	Moraceae	Diengjri	3	-	-
Ficus sp.	Moraceae	Dieng dud	-	-	2
Fraxinus ornus L.	Oleaceae	-	18	-	-
Glochidion sphaerogynum Kurz.	Euphorbiaceae	Diengthiang um	-	9	-
Ilex venulosa Hance.	Aquifoliaceae	Diengshyieng	21	34	42
Lithocarpus dealbatus (Hook.f. & Thomson ex Miq.) Rehder.	Fagaceae	Diengsai	-	-	7

Magnolia oblonga (Wall. ex Hook.f. & Thomson) Figlar	Magnoliaceae	Diengniar	12	22	13
Magnolia champaca (L) Baill. Ex Pierre	Magnoliaceae	Diengrai	24	36	10
Murraya koenigii (L.) Spreng.	Rutaceae	Diengpnor	-	-	8
Myrica esculenta Buch.-Ham. ex D.Don	Myricaceae	Diengsohphie	18	3	58
Myrica nagi	Myricaceae	Sohphielurdi	12	-	-
Pinus kesiya Royle ex Gordon.	Pinaceae	Diengkseh	31	-	-
Pourthiaea arbutifolia (Lindl.) Decne.	Rosaceae	Sohryngkham	-	-	2
Prunus nepalensis (Ser.) Steud.	Rosaceae	Sohiong	7	4	1
Pterocarya stenoptera C.DC.	Juglandaceae	Diengkynjri	2	-	1
Pyrus pashia Buch. Ham. ex D.Don.	Rosaceae	Diengsohjhur	-	-	2
Quercus glauca Thunb.	Fagaceae	Chanamdngiem	-	13	15
Quercus serrata Murray.	Fagaceae	Diengrtiang	-	10	-
Rhododendron arboreum Sm..	Ericaceae	Tiewsaw	6	-	-
Rhus succedanea L.	Anacardiaceae	Diengkain	-	4	-
Schefflera digitata J.R.Forst. & G.Forst.	Araliaceae	Diengsansla	26	-	-
Schima wallichii (DC.) Korth.	Theaceae	Diengngan	8	8	14
Symplocos chinensis (Lour.) Druce.	Symplocaceae	Diengiong	-	-	2
Symplocos khasiana C.B.Clarke.	Symplocaceae	Diengpei	-	4	-
Syzygium jambos (L.) Alston.	Myrtaceae	Diengjam	5	-	1
Total			331	305	287

The most important tree species in Site 1, as measured by the Importance Value Index (IVI), is revealed in Table 2 with *Ficus elastica* (41.1), *Citrus latipes* (30.9), and *Castanopsis tribuloides* (26.1) having the highest IVI. In site 2 *Castanopsis tribuloides* (64.4) represent the highest IVI, followed by *Magnolia champaca* (43.3), and *Ilex venulosa* (28.4) while In site 3 *Castanopsis tribuloides* (50.6) showed the highest IVI followed by *Myrica esculenta* (40.4), and *Ilex venulosa* (30.3). In site 1 the most abundant families is Fagaceae followed by Juglandaceae, Magnoliaceae, and Myricaceae, in site 2 it is dominated by Fagaceae, followed by Lauraceae, Magnoliaceae, Anacardiaceae, Aquifoliaceae, and Araliaceae while in site 3 features Fagaceae, Rosaceae, Lauraceae, and Rutaceae as prominent families. From IVI values, the most dominant tree species site 1 are *Ficu elastica Citrus latipes* and *Castanopsis tribuloides*. In Law Lyngdoh Nonglait *Castanopsis tribuloides* dominated, followed by *Magnolia champaca* and *Ilex venulosa* and in site 3 showcases *Myrica esculenta* as the most dominant, followed by *Castanopsis tribuloides* and *Ilex venulosa.*

The composition and distribution of shrub species diversity across the three sacred groves provides a comprehensive overview of their composition and distribution shown in Table 3. A total of 21 shrub species were found across three sites, belonging to 14 different families. Site 3 exhibited the most diverse shrub community with 19 species, while Site 2 had 17 species and Site 1 had 15 species. Site 1 had 725 shrub individuals across 13 families, Site 2 had 1307 individuals from 14 families, and Site 3 had 1039 individuals also from 13 families. Common species found across all sites include *Ardisia crispa, Boehmeria nivea, Sarcandra glabra, Inula cappa, Lindera agregata, Melastoma malabathricum, Polygonum molle, Smilax ovalifolia, Solanum xanthocarpum, Urena lobata, Viburnum corylifolium and Viburnum foetidum,* indicating a consistent presence of these species across diverse ecological niches. Dominant families across these sites include Rosaceae, Ericaceae, and Adoxaceae, highlighting the rich biodiversity within each grove and underscoring the importance of tailored conservation strategies to preserve these unique ecosystems.

Table 2: Quantitative analysis of tree in Law Lyngdoh Mawnai, Law Lyngdoh Nonglait and Law Lyngdoh Mawlong

Species	Law Lyngdoh Mawnai			Law Lyngdoh Nonglait			Law Lyngdoh Mawlong		
	Density (Trees ha^{-1})	Total Basal Area (m^2 ha^{-1})	IVI	Density (Trees ha^{-1})	Total Basal Area (m^2 ha^{-1})	IVI	Density (Trees ha^{-1})	Total Basal Area (m^2 ha^{-1})	IVI
Aralia armata	-	-	-	0.1	0.24	3.7	0.2	0.1	4
Beilschmiedia brandisii	-	-	-	-	-	-	0.1	1.2	7.8
Betula alnoides	0.1	2.01	5.3	-	-	-	-	-	-
Casearia glomerata	0.8	0.68	8.4	-	-	-	-	-	-
Castanopsis tribuloides	1.7	1.79	26.1	6.3	1.06	64	4.3	1.2	50.6
Celtis tetrandra Roxb.	0.6	4.42	14.5	-	-	-	-	-	-
Chukrasia velutina	-	-	-	0.25	0.4	6.4	-	-	-
Cinnamomum bejolghota	0.1	2.54	6.4	-	-	-	-	-	-
Cinnamomum glanduliferum	-	-	-	0.7	2.24	23	0.4	1.6	17.5
Cinnamomum tamala	-	-	-	0.25	0.59	7.6	-	-	-
Cinnamomum verum	-	-	-	-	-	-	0.1	0.1	2.1
Citrus latipes	3.2	0.52	30.9	-	-	-	0.3	0.4	7.5
Derris elliptica	0.1	0.52	2.2	-	-	-	-	-	-
Docynia indica	0.4	0.97	5.8	-	-	-	-	-	-
Engelhardtia spicata	0.2	1.23	5.9	-	-	-	-	-	-
Eurya acuminata	-	-	-	-	-	-	0.2	0.4	6.3
Exbucklandia populnea	-	-	-	0.3	1.17	10	-	-	-
Ficus elastic	0.2	18.46	41.1	-	-	-	-	-	-
Ficus sp.	-	-	-	-	-	-	0.1	0.9	7.5
Fraxinus ornus	0.9	0.18	11.5	-	-	-	-	-	-
Glochidion sphaerogynum	-	-	-	0.45	0.8	11	-	-	-
Ilex venulosa	1.1	1.01	14.1	1.7	0.63	28	2.1	0.4	30.3
Lithocarpus dealbatus	-	-	-	-	-	-	0.4	0.9	11.9
Magnolia champaca	1.2	3.13	25.1	1.8	3.16	43	0.5	1.1	16.9
Magnolia oblonga	0.6	1.03	10.6	1.1	1.44	28	0.7	0.4	13.1
Murraya koenigii	-	-	-	-	-	-	0.4	0.3	7.1
Myrica esculenta	0.9	0.84	12.8	0.15	1.51	11	2.9	0.8	40.4
Myrica nagi	0.6	0.63	10.6	-	-	-	-	--	-
Pinus kesiya	1.6	0.62	14.7	-	-	-	-	-	-
Pourthiaea arquta	-	-	-	-	-	-	0.1	0.1	2.8
Prunus nepalensis	0.4	0.86	8.7	0.2	0.71	7.9	0.1	0.5	4
Pterocarya stenoptera	0.1	1.47	5.3	-	-	-	0.1	2.8	17.2
Pyrus pashia	-	-	-	-	-	-	0.1	0.3	4.2
Quercus kamroopii	-	-	-	0.65	0.5	12	0.8	0.5	13.8
Quercus serrata	-	-	-	0.5	0.27	9.9	-	-	-
Rhododendron arboretum	0.3	0.28	4.8	-	-	-	-	-	-
Rhus succedanea	-	-	-	0.2	0.41	6.2	-	-	-
Schefflera elata	1.3	0.99	17.2	-	-	-	-	-	
Schima wallichii	0.4	1.09	9.5	0.4	2.21	20	0.7	2.1	22.7
Symplocos chinensis	-	--	-	-	-		0.1	1.1	8.6
Symplocos khasiana	-	-	-	0.2	0.4	6.1	-	-	-
Syzygium jambos	0.3	2.63	8.6	-	-	-	0.1	0.4	3.7

Table 3: Composition and distribution of shrubs in Law Lyngdoh Mawnai, Law Lyngdoh Nonglait and Law Lyngdoh Mawlong

Botanical name	Family Name	Local Name	Site 1	site 2	site 3
Agapetes variegata (Roxb.) D.Don ex G.Don	Ericacea	Sohlamut	37	-	-
Ageratina adenophora (Spreng.) R.M.King & H.Rob.	Ericacea	Bat iong/Bat Garmany	-	44	114
Ardisia crispa (Thunb.) A.DC.	Primulaceae	Sohnewyear	18	53	7
Boehmeria nivea (L.) Gaudich.	Urticaceae	Slanai	41	81	103
Chloranthus brachystachys *Blume*	Chloranthaceae	Sohkrismas	22	107	8
Inula cappa (Buch.-Ham. ex D.Don) DC.	Asteraceae	Jalangngap	103	151	172
Lantana camara L.	Verbenas	Sohpangkhlieh	-	59	60
Lindera aggregata (Sims) Kosterm.	Lauraceae	sohmritthok	85	91	63
Melastoma malabathricum L.	Melastome	Jakhra	96	132	49
Neillia thyrsiflora D.Don	Rosaceae	Syntiewlieh	20	-	-
Polygonum orientale L.	Polygonaceae	Jalangnoh	66	65	29
Rhododendron fortunei Lindl.	Ericacea	Tiewlieh	-	-	28
Rubus ellipticus Sm.	Rosaceae	sohjemryngdang	-	87	36
Rubus indicus Thunb.	Rosaceae	Sohshiah	-	79	38
Rubus moluccanus L.	Rosaceae	slanepbah	11	-	26
Rubus niveus Thunb.	Rosaceae	Diengsohkh -awiong	-	37	8
Smilax glyciphylla Sm.	Smilacaceae	Sohkrot	79	120	69
Solanum xanthocarpum Schrad. & H.Wendl.	Solanaceae	Sohpdok	20	27	34
Urena lobata L.	Malvaceae	Sohbyrthit	74	108	94
Viburnum carlesii Hemsl.	Adoxaceae	Sohlangksew	15	25	48
Viburnum foetidum Wall.	Adoxaceae	Sohlang	38	41	53
Total			725	1307	1039

The Importance Value Index (IVI) for each shrub species in the three sacred groves is detailed in Table 4. In Site 1, *Viburnum foetidum* (7.6), *Viburnum corylifolium* (7.5), and *Inula cappa* (7.3) were the most dominant shrubs, while *Sarcandra glabra* (2.4), *Ardisia crispa* (2.5), and *Rubus moluccanus* (3.6) were the least abundant. In Site 2, *Smilax ovalifolia* (26.3), *Inula cappa* (26.1), and *Sarcandra glabra* (23.3) exhibited the highest IVI, while *Rubus niveus* (9.3) and *Solanum xanthocarpum* (10.4) had the lowest IVI. In Site 3, *Inula cappa* (36.1) was the most dominant shrub, followed by Ageratina adenophora (24.5), and *Urena lobata* (21.8). *Rubus niveus* (6.8) and *Rubus moluccanus* (6.9) were the least abundant shrubs in this site. The dominant shrub families in Site 1 were *Adoxaceae* and *Rosaceae,* while Rosaceae was the most prominent family in Site 2 and Site 3. In conclusion, *Boehmeria nivea*, *Inula cappa, Viburnum foetidum*, and *Smilax ovalifolia* were the most dominant shrub species across the three sacred groves, with varying degrees of dominance in each site.

Table 4: Quantitative analysis of shrubs in Law Lyngdoh Mawnai, Law Lyngdoh Nonglait and Law Lyngdoh Mawlong

Species	Law Lyngdoh Mawnai			Law Lyngdoh Nonglait			Law Lyngdoh Mawlong		
	Density (Trees ha^{-1})	Total Basal Area (m^2 ha^{-1})	IVI	Density (Trees ha^{-1})	Total Basal Area (m^2 ha^{-1})	IVI	Density (Trees ha^{-1})	Total Basal Area (m^2 ha^{-1})	IVI
Agapetes variegata	1.85	0.000343	18.28	-	-	-	-	-	-
Ageratina adenophora	-	-	-	2.2	0.000459	15.82	0.35	0.000638	9.64
Ardisia crispa	0.9	0.000363	13.61	2.65	0.000192	13.53	5.15	0.000331	21.16
Boehmeria nivea	2.05	0.001066	26.86	4.05	0.000235	16.41	0.4	0.000485	7.94
Chloranthum brachystachys	-	-	-	-	-	-	8.6	0.000529	36.02
Inula cappa	5.15	0.000598	34.48	7.55	0.000352	26.07	3	0.000562	16.79
Lantana camara	-	-	-	2.95	0.000349	14.33	3.15	0.000427	18.45
Lindera aggregata	4.25	0.000178	25.5	4.55	0.000241	18.03	2.45	0.000511	16.62
Melastoma malabathricum	4.8	0.000406	29.75	6.6	0.00032	23.31	1.45	0.000118	7.12
Neilia thyrsiflora	1	0.000328	10.99	-	-	-	-	-	-
Polygonum molle	3.3	0.000398	22.34	3.25	0.000333	15.3	1.65	0.000691	16.47
Rhododendron fortunei	-	-	-	-	-	-	1.8	0.0006	13.46
Rubus ellipticus	-	-	-	4.35	0.000341	17.88	1.9	0.000409	12.89
Rubus indicus	-	-	-	3.95	0.000279	18.55	1.3	0.000126	6.94
Rubus moluccanus	0.55	0.00021	7.12	-	-	-	0.4	0.00022	6.79
Rubus niveus				1.85	0.000241	9.27	3.45	0.000544	18.92
Sarcandra glabra	1.1	0.00043	16.76	5.35	0.00039	23.34			
Smilax ovalifolia	3.95	0.000352	28.94	6	0.000323	26.3	1.7	0.000507	12.91
Solanum xanthocarpum	1	0.000201	9.02	1.35	0.000306	10.38	4.7	0.000458	21.79
Urena lobata	3.7	0.000334	24.04	5.4	0.000224	18.27	2.4	0.000237	11.09
Viburnum carlilifolium	0.75	0.000573	12.5	1.25	0.000446	11.83	2.65	0.000811	20.52
Viburnum foetidum	1.9	0.000688	19.82	2.05	0.000845	21.39	2.65	0.000811	20.52

Table 5 : Phyto-sociological attributes and diversity indices for trees species in the three Sites

Diversity Attributes	Site-1	Site-2	Site-3
The sum of plant species (S)	23	17	22
Total number of individuals (N)	331	305	287
Species richness (Margalefs index, 1988) Dmg=(S-1)/Ln N	3.79	2.80	3.71
Species diversity (Shannon & weiner, 1963 (H')=-Σ(pi)[ln(pi)]	2.71	2.10	2.3
Eveness index (Pielou, 1975) E=H'/ln S	0.87	0.74	0.73
Dominance index (Simpson (1949) $D=\Sigma(n/N)^2$	0.09	0.21	0.16
Similarity index (Sorensen, 1948)	**Site 1-2**	**Site 1-3**	**Site 2-3**
	21.21	28.57	34.48

Table 6 : Phytosociological attributes and diversity indices for shrubs species in all site.

Diversity Attributes	Site-1	Site-2	Site-3
The sum of plant species (S)	15	17	19
Total number of individuals (N)	725	1307	1044
Species richness (Margalefs index, 1988) Dmg=(S-1)/Ln N	2.12	2.22	2.58
Species diversity (Shannon & weiner, 1963) (H')=-Σ(pi)[ln(pi)]	2.50	2.72	2.69
Eveness index (Pielou, 1975) E=H'/ln S	0.92	0.96	0.91
Dominance index (Simpson (1949) $D=\Sigma(n/N)^2$	0.09	0.07	0.081
Similarity index (Sorensen, 1948) S	**Site 1-2**	**Site 1-3**	**Site 2-3**
	60	61.9	89.5

Discussion

The study conducted in the sacred groves of Law Lyngdoh Mawnai, Law Lyngdoh Nonglait, and Law Lyngdoh Mawlong in the West Khasi Hills District reveals substantial biodiversity, indicative of their ecological significance. The pattern of species richness observed, with site 3 exhibiting the highest richness, followed by site 2 and site 1, may be influenced by mild disturbances such as the selective felling of mature trees. These disturbances can enhance habitat heterogeneity and promote higher biodiversity.The distribution and dominance of tree species varied across the sites, with *Ficus elastic Roxb*, *Citrus latipes*, and *Castanopsis tribuloides* being most dominant in site 1, *Castanopsis tribuloides, Magnolia champaca*, and *Ilex venulosa* in site 2; and *Myrica esculenta*, *Castanopsis tribuloides*, and *Ilex venulosa* in site 3. The presence of dominant families such as Fagaceae, Lauraceae, and Rosaceae further highlights the ecological uniqueness of each site.In the pristine landscapes of Law Lyngdoh Mawlong, the rare and exquisite orchid commonly called as Creeping Lady's-tresses or Dwarf Rattlesnake (*Goodyera* sp.), has been documented. This discovery highlights the region's rich botanical diversity and the ecological significance of preserving such habitats.

Comparative analysis with other studies on sacred groves in Meghalaya underscores both similarities and distinctions. For example, the sacred groves in the Jaintia Hills have similar levels of species richness and diversity compared to those in the West Khasi Hills,[8] emphasizing their ecological importance and conservation value. Additionally, the Diversity index (H’) values for the studied groves, which ranged from 2.10 to 2.71 for trees and 2.5 to 2.72 for shrubs, are consistent with those found in tropical forests.[9] Moreover, these values surpass those reported for Namdapha National Park.[10]

The evenness indices (0.87, 0.74, and 0.73 for trees, and 0.92, 0.96, 0.91 for shrubs across the three sites) indicate a relatively balanced distribution of species.[11] The similarity indices suggest distinctive floristic compositions among the tree species (below 50%), while shrub species compositions were more similar across the sites (above 50%). Our findings support the existing literature on Meghalayan sacred groves, demonstrating comparable trends in species distribution and diversity.[5]

The findings of this study are in line with those of other Himalayan regions, where comparable Shannon Wiener diversity values have been recorded and found comparable diversity values in the sacred groves of the Indian Himalayas, indicating that the protected status of these areas plays a crucial role in maintaining their biodiversity.[12] The higher diversity values in our study is similar when compared to those in the Garhwal Himalaya and this may be due to the long-term protection and the diverse geographical features of the sacred groves, which include variations in altitude, aspect, and fertile soils.[13] This study found that the majority of species in this study exhibited a clumped or contagious distribution pattern. It was found that approximately 85% of the total plant species were clumped, while 10% were randomly distributed and only 5% exhibited a regular distribution pattern. This observation aligns with the finding which noted that most plant species in natural forests display a clumped distribution pattern.[14] Clumped distribution is commonly observed in natural forests, whereas random distribution is typically found in uniform environments where individuals are scattered without a discernible pattern. In contrast, regular distribution suggests high competition among species.[15]

Overall the sacred groves in the West Khasi Hills District are characterized by a high level of biodiversity and ecological importance, providing habitat for numerous endemic and rare plant species.These findings underscore the importance of preserving these groves, not only for their cultural and spiritual significance but also for their role in maintaining ecological balance and diversity.

Conclusion

The observed variations in diversity indices among the sites underscore the distinct ecological conditions maintained by each grove. Particularly noteworthy is the role of sacred groves as sanctuaries for endemic and rare plant species, emphasizing the imperative for their conservation. The highest Shannon's diversity index in site 3, alongside fluctuations in species richness, evenness, dominance, and similarity indices, elucidates the nuanced ecological dynamics within each grove, accentuating the need for tailored conservation strategies that account for their unique attributes.The presence of Lantana *camara L.* poses a significant ecological threat due to its invasive nature. To mitigate its impact and restore ecological balance, a multifaceted approach combining prevention, control, and eradication strategies is imperative.

In a broader context, this research significantly contributes to the understanding of sacred groves as pivotal repositories of biodiversity. The findings underscore the urgency for sustained efforts in their preservation and sustainable management. The ecological insights derived from this study are poised to inform future conservation initiatives, providing a roadmap for ensuring the enduring vitality of these sacred ecosystems and the myriad life forms they nurture. This research thus serves as a valuable foundation for advancing our comprehension of sacred groves and advocating for their continued protection in the face of environmental challenges.

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Ethic Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

- **Kerry Willson Marbaniang:** Field Survey and collection of data, Collection of plants Specimens for herbarium preparation, Identification, data analysis, preparation of research paper.
- **Dippu Narzary:** Data analysis, preparation of research paper, contributed to data interpretation, reviewed and revised the manuscript.
- **Hemant Kumar:** Supervised the study, contributed to data interpretation, reviewed and revised the manuscript, provided guidance.

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