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Tree Diversity and Abundance of Western Ghats Striped Squirrels, *Funambulus Tristriatus* in Sacred Groves: Evidence from Kannur, Kerala

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Abstract The study was carried out to measure tree species diversity of six spatially heterogeneous Sacred Groves (SGs) to observe the abundance of IUCN Red List (LC) Western Ghats Striped squirrel, *Funambulus tristriatus*, Waterhouse (1837) inside these SGs. Shannon's and Simpson's Indices and IVI were used to examine the tree species diversity. The abundance of squirrels in all six SGs was also recorded through a two-month-long 48-kilometre transect walk survey. The floristic composition exhibited that *Memecylon randerianum* is the dominant species in Neeliyarkottam and Madayi kavu; *Myristica malabarica* is the dominant species in Poongottukavu, and *Carallia brachiata* is the predominant tree species in Iriverikavu. Thazhekavu is home to the mangrove species *Avicennia officinalis*. Chamakavu is a coastal SG with the highest density of *Syzygium caryophyllatum* and the highest IVI of *Gmelina arborea*. The study found that squirrels are significantly encountered in fruit-giving trees with a high canopy. Our descriptive statistical findings reveal that out of the total observed *F. tristriatus* (*n=106),* about 42% of squirrels are encountered in *Memecylon randerianum, followed by Mangifera indica (31%), Artocarpus heterophyllus Lam.* (*4%), Elaeocarpus tuberculatus (3%), etc.* Neeliyar kottam has the most tree species and individual trees with a high diversity of *Memecylon randerianum, Mangifera indica, and* higher squirrel encounters. *F. tristriatus* fed the flowers and berries of *Memecylon randerianum* and flowers and drupes of *Mangifera indica*. In sum, the presence of trees and the diversity of SGs is critical for the survival of *F. tristriatus* in densely populated and rapidly urbanizing districts like Kannur.

Keywords: *Species Diversity, Floristic Diversity, Conservation, Squirrels, Funambulus tristriatus*

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1. Introduction

Global environmental changes, such as land-use change, global warming, and rapid urbanization, have significantly disturbed tropical forests and unique biodiversity [1]. The Western Ghat biodiversity hotspot has also been threatened by habitat fragmentation, loss, and degradation [2]. Rapid urbanization has been affecting almost all lowland areas, except for forests that have been preserved due to Hindu religious and cultural heritage, reverence, and fear{1} [3,4]. Such protected forest regions are called Sacred Groves (SGs). Locals revered and protected them as spiritual and botanical havens [5]. Kirk [6] states that SGs have become remnants of the original forest in some lowland areas. For many years, geo botanists and landscape researchers have been extensively studying phytosociological aspects of SGs in different regions in India [4,7]. The SGs have a complex vegetation structure, closed canopy cover and thick litter bed [8]. In parallel, conservation biologists and biodiversity experts have been exploring the abundance of different species in such SGs and surrounding areas [9,10,11].

SGs in urbanized lowlands have been serving as tropical biodiversity reserves for a long time [3,12]. They serve as the habitat for many native endemic plant species [4]. In a recent review, it was noted that there is a critical knowledge gap on the faunal diversity of SGs, particularly of herbivores [13]. Many studies have contributed to discovering new plant species, gene pools, communities, populations, and microhabitats in various SGs of India [4,14,15]. This research inquiry builds on the different investigations by Rajesh et al. [16], Rajesh et al. [8], and

Rajesh et al. [9] in SG settings of Northern Kerala. Island habitats such as SGs can significantly impact their biodiversity due to the influence of the surrounding landscape [10,17]. The spatial and temporal changes in forest and primaeval forests affect habitat availability for many species [18]. Wild animals, birds, insects, and small mammals seek refuge in SGs; hence they possess a conservation value [14,19]. Animals in SGs are divided into two types: residents and visitors. Snakes of various kinds, frogs, lizards, millipedes, termites, ants, earthworms, and snails, are all found in SGs. Termites, ants, and earthworms contribute to soil composition [8]. They are home to crows, owls, herons, mynas, parrots, hummingbirds, IUNC-listed critically endangered species and other birds (Jyothi and Nameer). All the animals in these SGs help the plants spread their seeds and fruits. However, species of squirrels have no information on distribution, abundance, or ecology with respect to SGs in Kannur.

There are around 140 mammal species in the Western Ghats, of which 38 are endemic Western Ghats ([20], p.855). Squirrels, a mammal species, are locally occurring iconic species in different regions [21]. They provide numerous ecosystem services and are of high economic significance. They are a significant component of the animal biomass of tropical rainforests [22] and significant seed dispersers and pollinators [23]. Besides, some squirrels are often reported to behave invasively against IUCN-listed critically endangered threatened species in bio-hotspots [24]. The Western Ghats striped squirrel, *F. tristriatus*, is one of the seven squirrel species found in Kerala that is endemic to Western Ghats [42]. They are listed as Least Concerned (LC) in the IUCN Red List [26]. Generally, all squirrels exhibit cryptic behaviour that makes field observation challenging [27]. Though they are the least concerned small mammal, some significant research has already been started on *F. tristriatus*. Studies on squirrels cover Cannibalistic behaviour [28]; home range and population [29]; breeding biology [30]; food and nesting habits [30,31]; ecology [32]. Overall, the role of squirrels, although some information on overall distribution, population trends, ecology and behaviour of squirrels is available for peninsular India; however, we still lack the documentation of local distribution patterns and the ecology of several squirrels species, including *F. tristriatus*.

Existing research shows the diversity and abundance of flora and fauna in SGs. It includes Ants in SGs [8,9,16], dung beetles [34]; Spiders [17]; Butterflies [10] birds [35], and human-snake relationship in SGs [36]. From a conservation viewpoint, little empirical literature is available on rodent species like *F. tristriatus*, so they did not attempt to study in a closed ecosystem like SGs. Thus, our primary contribution is to take the floristic inventory of SGs and relate them with the corresponding encounter rate of *F.tristriatus*. This study is the first of its kind to connect the tree diversity of SGs with squirrel abundance/occurrence. The inquiries into the diversity of squirrels sighted in Malabar are not significant in numbers. Only a few authors work extensively on Mammal species found based in the Western Ghats setting [37,38,39]. To our knowledge, no studies have linked the abundance level of *F. tristriatus* in the spatially heterogenous and protected SGs in the North Malabar areas. This research contributes three-fold: First, the study surveys the tree diversity of the six SGs in the district; Second, it observes the abundance/encounter rate of *F. tristriatus* in such a unique ecosystem and finally, it observes the feeding behaviour of *F. tristriatus*. The study also connects the tree diversity of SGs, which leads to the increased sighting of squirrels inside. Our descriptive findings reveal that *F. tristriatus* are in abundance within SGs than in surrounding areas.

The research is organized as follows: Section 2 draws upon the conservation importance of SGs and Squirrels, especially on *F. tristriatus*. Section 3 discusses the research materials and methods, followed by results and discussions of the study. Finally, it concludes by examining the results and implications of the study.

1.1. Sacred Groves

SGs are one of the ideas of traditional biodiversity conservation and management [4,40]. They are traditionally regarded as community-based natural resource management [5]. The SGs have well-developed forest ecosystems and a high level of species richness and biodiversity, depending on the degree to which the SG has been preserved [4]. Chandrashekara and Sankar [7] conducted a comprehensive study about SGs in mid-Kerala, primarily in Trissur and Ernakulam districts. They compared the floristic diversity of three SGs by applying relative frequency, dominance, density, basal area, and IVI. Ramanujam and Cyril [58] studied the woody species diversity of four SGs in the Pondicherry region of south India. They calculated girth at the breast (gbh) and the Important Value Index (IVI) to identify the botanical significance of woody species. Bhagwat et al. [63] examined the critical role of the landscape surrounding the SG in biodiversity conservation in the Kodagu District. They also studied the diversity of trees, birds, and macrofungi at 58 locations in the Kodagu District (ten forest sites, 25 SGs, and 23 coffee plantations).

1.2. Resources in SGs (Flora and Fauna)

SGs are a treasure trove of rare and endemic species [41]. The most prominent family of flowering plants seen in the SGs of Kerala is Rubiaceae. The other abundant and widely distributed families are Fabaceae, Euphorbiaceae, Annonaceae, Apocyanaceae and Poaceae. Besides, the SGs harbour many gymnosperms, pteridophytes, bryophytes, and mushrooms. At least 50 Western Ghats-endemic plants grow in the SGs in northern Kerala. As tree species shrubs, lianas are also present in the SG. The lianas include *Strychnos colubrina, Anamirta cocculus, Tetracera akara* and *Acacia* India. Shrubs are represented by *Ixora nigricans, I. brachiata, Chassalia curviflora*, etc. The seasonal plants include *Geophila reniformis, Borreria sp., Naregamia alata, Centella asiatica, Aerva lanata, Andrographis paniculata* and *Biophytum* sensitive from the ground vegetation. Total parasites like *Cassytha filiformis* and *semiparasites* like *Loranthus spp* are also common. Along with a few angiosperms, ferns, Selaginellas, and many species of macrofungi like Agaricus also occur. Dead trunks of fallen trees harbour a variety of Polyporales, especially species of Fomes and Polyporus, as is expected. These species are known to

produce high-profile humidity in their environment, which promotes luxurious undergrowth growth. Most endangered medicinal plant species can only be seen in the inner groves where human footprints have not yet reached [42]. Around 400 bird species inhabit SGs in Kerala [35]. For example, Jyothi and Nameer [35] reported a white-bellied Sea eagle (*Haliaeetus leucogaster*) in Edayilekkad kavu of Kasargod district and black-headed Ibis (*Threskiornis meanocephalus*) in Thazhe Kavu. It indicates that SGs host critical fauna as well.

1.3. Squirrels

The sciurids or squirrels are mammals under the Rodentia order [33]. The word Sciuridae means "shade-tail" and refers to the bushy appendage possessed by many members [71]. It includes tree squirrels, ground squirrels, chipmunks, marmots (woodchucks), and flying squirrels. Sciurids are found in all continents except Australia and Antarctica. There are 278 squirrel species worldwide, organized into 51 genera [43]. Sixty-two species of squirrels in 28 genera are found in the Indo-Malayan region [37]. Squirrels are classified into three broad categories: giant squirrels, striped squirrels, and flying squirrels [18]. They are primarily arboreal creatures [44]. They spend the majority of their lives atop trees. They have adapted to their arboreal lifestyle by using a long tail, long sharp claws for gripping, a slender body, and a keen sense of smell, sight, and hearing. As with birds, squirrels build their nests high in the canopy. Squirrel nests are referred to as "drey". They are herbivores, feeding on fruits, leaves, bark, and other fibrous plant tissues [45]. Squirrels exhibit nocturnal and diurnal behaviours, which vary by species [46].

In the Indian subcontinent, there are 28 species of squirrels belonging to 12 genera [47]. Seven species of squirrels are found in Kerala, classified into four genera. *Ratufa*, *Funambulus*, *Petaurista*, and *Petinomys* are the species. Only the genera Ratufa and *Funambulus* contain diurnal squirrels. The seven species of squirrels found in Kerala are *Ratufa indica*, *Ratufa macroura*, *F. palmarum*, *F. tristriatus*, and *F. sublineatus* [48], *Petinomys fuscocapillus* and *Petaurista philippensis*, [42]. Most of these species are endemic to the Western Ghats hotspot. The seven species are Three Striped Palm Squirrel, *Funnambulus palmarum* (Linnaeus, 1766), Jungle Palm Striped Squirrel (Western Ghats Striped Squirrel), *Funnambulus tristriatus* (Waterhouse, 1837) and Nilgiri Palm Squirrel, *Funnambulus sublineatus* (Waterhouse, 1838) [27,49]; Travancore Flying Squirrels, *Petinomys fuscocapillus* (Jerdon, 1847), Indian Giant Flying Squirrel (Large Brown Flying Squirrel), *Petaurista philippensis* (Elliot, 1839), Grizzled giant Squirrel (Sri Lankan Giant Squirrel), *Ratufa macroura* (Pennant, 1769), and Malabar Giant Squirrel (Indian Giant Squirrel), *Ratufa indica* (Erxleben, 1777) are found in Kerala [42,50], p. 324). Breeding occurs year-round with an average litter size of 2.6. The main threats to squirrel habitat loss, degradation, and fragmentation are agro-industrial farming, large wood plantations, small-scale logging, human settlement expansion, pesticide use, and poisoning. Molur et al. [39] reported that major damming projects have resulted in a 10% increase in habitat loss over the last two decades

1.4. Distributions and Status of Squirrels

In India, the Malabar giant squirrel, *Ratufa indica*, is found throughout the country [32,45]. 22 (88 per cent) of the 25 fragments surveyed contained giant squirrels. As fragment area decreased and disturbance increased, the density of Malabar giant squirrels increased. This is most likely due to two factors. First, the giant squirrel is a widespread species in various vegetation types, including moist and dry deciduous forests. Second, it has a small home range and feeds on many plant species and parts [29,31]. It is well established that species with such a broad ecological amplitude frequently referred to as 'generalists', increase density in moderately disturbed rain forests [51]. It is found in various wildlife Sanctuaries such as Aralam, Neyyar, Parambikulam, Peppara, Peechi-Vazhani, Srivilliput, and Wayanad and other parks and reserves such as Silent Valley National Park, Periyar Tiger Reserve, Sanjay Gandhi National Park, Parambikulam Tiger Reserve [39,52]. There has been scant investigation on taxonomy, survey, habitat management, and population monitoring of squirrels with respect to Kerala.

Western India is densely forested with large Brown Flying Squirrels (*Petaurista philippensis*) [38]. These animals are naturally nocturnal, sleeping all day curled up in a ball with their heads tucked between their forelegs and their tail coiled around their bodies. They are active at night. They can skim a distance of 50 to 60 yards (Sterndale 1886). Sciurus indicus dealbatus and Sciurus indicus malabaricus are Large Indian Squirrel subspecies. They are found primarily in forest tracts along the western coast, in some parts of Southern India, such as Mysore, and in the vast forested region east of longitude 800E between the Ganges and Godavari rivers (Blanford 1897).

Figure 1. Jungle Palm Striped Squirrel (Western Ghats Striped Squirrel), Funnambulus tristriatus (Waterhouse, 1837)

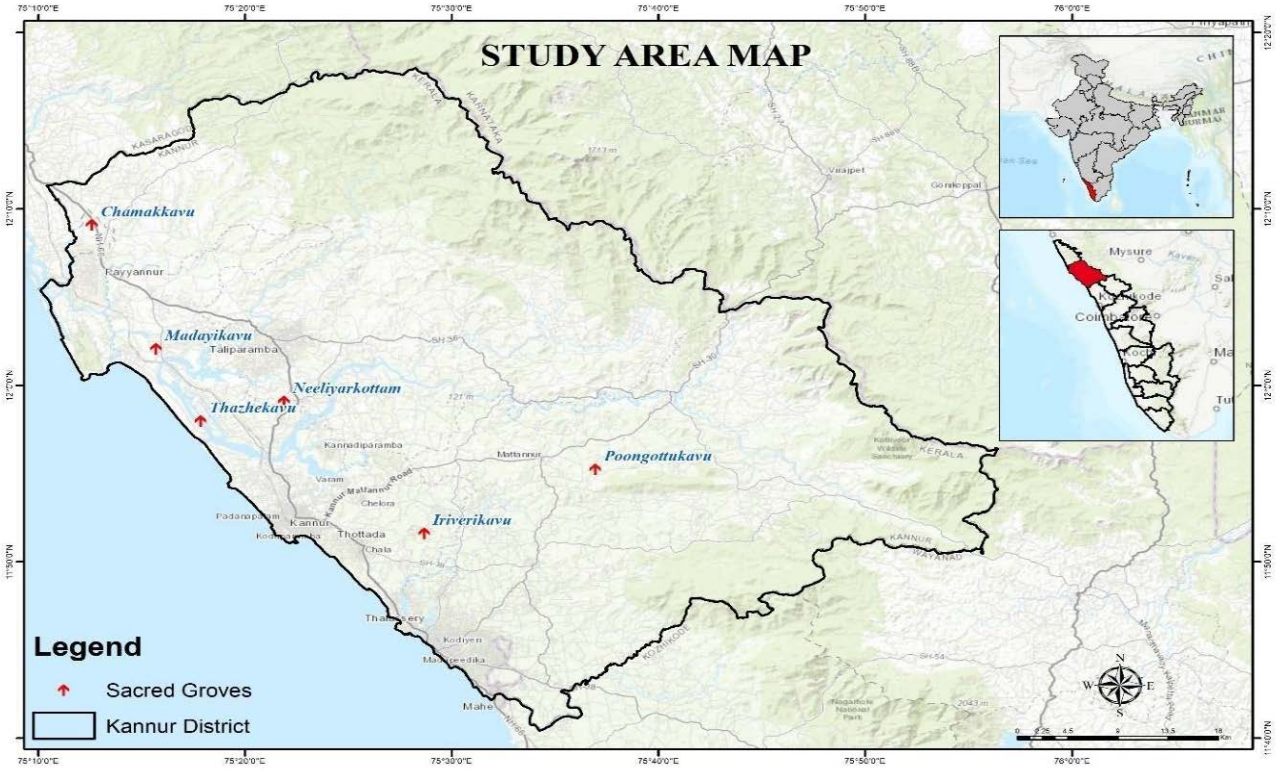

Figure 2. Study Site

1.5. *Funambulus Tristriatus (F. tristriatus)*

F. tristriatus are a reasonably common rodent found along South India's west coast forest and cultivated fields [28,29,30,67]. *F. tristriatus* are indigenous and endemic to southwest Western Ghats [42]. Additionally, they have been noted in Kerala, Maharashtra, Karnataka, and Tamil Nadu [42,53]. They are found at elevations ranging from 700 to 2100 meters in moist deciduous forests, evergreen rainforests, pasturelands, cardamom, tea, and coffee plantations [39,54,55,56]. They are found in dense, higher-elevation canopy regions of moist deciduous forests [25]. It is classified as Least Concern by the IUCN-Red list due to its wide distribution, tolerance of some habitat modification, presumed large population, and lack of rapid decline to qualify for a more threatened category [25].

The study was conducted in select SGs of Kannur {2} District of Kerala in peninsular India (Figure 3). The district experiences a humid climate with an oppressive hot season lasting from March to May. It is followed by the Southwest monsoon, which lasts until September end. October and November are considered to be the post-monsoon or receding monsoon seasons. The mean daily temperature in April and May is around 35° Celsius. December and January have the lowest temperatures-approximately 20° Celsius. Comparatively, the midland has more SGs. The coastal zone is narrow and has fewer SGs.

Table 1 displays the study cite coordinates, altitude, aerial distance from the nearest forest reserve, the area of SGs in hectares, the type of vegetation within SGs, the surrounding vegetation, and the water source for the vegetation within SGs.

Table 1. Study Sites in Kannur, Kerala

Name of SG	Coordinates	Altitude	Aerial Distance from the Reserve Forest	Area of SG (ha)	Vegetation	Neighbouring Vegetation	Water Source
Neeliyarkottam	11°59'05.9 "N 75°21'53.6" E	31(m)	30 k.m.	8.07	Evergreen	Homesteads	Wells
Madayikavu	12°02'05.5 "N 75°15'42.0" E	43(m)	35 k.m.	1.6	moist deciduous	Homesteads and Grasslands.	Well and rain-fed stream
Poongottukavu	11°55'15.0"N 75°36'56.7"E	90(m)	13 k.m.	14.64	Freshwater Myristica swamp	Rubber plantations, paddy fields, and homesteads	perennial Stream
Iriverikavu	11°51'37.2"N 75°28'39.9"E	42(m)	18 k.m.	2.12	Semi-evergreen	Homesteads	Pond
Thazhekavu	11°57'59.3 "N 75°17'51.7" E	3(m)	38 k.m.	7.52	Mangrove	Paddy fields Rubber	Well and pond
Chamakkavu	12°09'06.1"N 75°12'35.8"E	3(m)	60 k.m.	2.5	Evergreen	Homesteads	Well and pond

2. Materials and Methods

2.1. Phytosociological Study

Phytosociology studies plant communities, their composition, evolution, and inter-species relationships [58]. Like Ramanujam and Cyril [59], tree species belonging to different families were recorded, and then the species composition and diversity were studied by random sampling. Field notes were also taken alongside. Local people accompanied on moving into the interior of the grove. Trees were identified with the help of an authentic book like 'Flora of Presidency of Madras' by Gamble (1928) and in consultation with the experts. Random sampling was employed to collect the field data on tree species diversity. Following Murphy and Lugo [60], 4 Square plots of 10m*10m were laid to assess the number of tree species, the number of individuals of each species and girth at breast height (gbh) of trees. The density, frequency and Basal Area were estimated for trees. Girth at the breast (gbh at 1.37 meters above ground) of all trees in each square plot was identified and recorded. The sampling process was carried out from May 2021 through June 2021. According to Magurran [61], there are numerous ways to measure ecological and plant diversity. As calculated in Chandrashekara and Sankar [7], vegetational data were examined with relative frequency, relative dominance, and relative density and the sum of these parameters to fin importance value index (IVI) for various species. To measure the diversity of the tree species, we then calculated Shannon and Wiener's [62] Index and Simpson's (1949) Index.

a) Frequency

It denotes the homogeneity of distribution of various species in the study sites. It indicates reproductive capacity as well as adaptability to the environment.

$$Frequency(F) = \frac{\begin{pmatrix} Number\ of\ Sampling\ Units \\ in\ which\ Species\ Occured \end{pmatrix}}{Total\ Number\ of\ Sampling\ Units}$$

$$Percentage\ Frequency = F \times 100$$

b) Density

The density represents the numerical strength of species in the community—density as the number of individuals per sampling unit. Density was calculated by using the following formulae.

$$Density(D) = \frac{Total\ Number\ of\ Individuals}{Number\ of\ Sampling\ Units\ Studied}$$

c) Importance Value Index (IVI)

It denotes ecological success. The sum of relative frequency, relative dominance and relative density gives Importance Value Index (IVI) for individual species. The three characteristics were computed using frequency, density and basal area for all species falling in all plots using the following formulae:

$$Relative\ Dominance(RDo) = \frac{Total\ Basal\ Area\ of\ the\ Species}{Total\ Basal\ Area\ of\ all\ Species} \times 100$$

$$Relative\ Density(RD) = \frac{Number\ of\ Individuals\ of\ the\ Species}{Number\ of\ Occurenes\ of\ all\ the\ Species} \times 100$$

$$Relative\ Frequency(RF) = \frac{Frequency\ of\ a\ Species}{Frequency\ of\ all\ Species} \times 100$$

$$Important\ Value\ Index(IVI) = RDo + RD + RF$$

d) Shannon's Index

It is a measure of diversity that combines species richness and their relative abundance. Shannon-Wiener Index for diversity is calculated based on the following equation Shannon and Wiener ([62], p. 320):

$$H = -\sum\{(n_i / N)\log_2(n_i / N)\}$$

Where 'H' represents the Shannon index of general diversity, n_i represents the IVI of species' i' and 'N' represents the IVI of the community. Alternatively put,

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

$$p_i = \frac{n_i}{N}$$

H = Shannon's Diversity index, p_i = fraction of entire population made up of species i = 1, 2, …., S. n_i = a number of individuals of the i^{th} species encountered. 'N' = total known individuals for all 'S' species in the population.

e) Simpson's Diversity Index

Simpson's [25] diversity index (D) gives the probability of any two individuals drawn at random from an infinitely large community belonging to different species. It measures the relative abundance of the community. It's calculated as

$$D = \sum_{i=1}^{s} (p)_i^2$$

Where 'D' denotes Simpson's index of diversity with p_i denoting the relative abundance as in the Shannon index of general diversity. As in Shannon's H, $p_i = \frac{n_i}{N}$. 'D' varies from 0-1. Simply stated, if the probability is high that both individuals belong to the species, then the diversity of the community sample is low.

2.2. Western Ghats Striped Squirrel Abundance

2.2.1. Line Transect Survey

Line transects of one kilometre in length were laid randomly at the study sites. Field data was collected by walking along the transects during the morning time between 09:00 a.m and to 11:00 a.m. at weekly intervals. Eight such transects were surveyed for two consecutive months resulting in a total 48 km transect walk. Direct sightings, as well as calls heard, were recorded in the field book.

2.2.2. Species Abundance

The abundance of the species was calculated as the encounter rate of the species along the transects. The

encounter rate of a species is the number of sightings of the individuals of the same species encountered per kilometre transect walk.

$$Abundance\left(No./km\right) = \frac{\left(\begin{matrix}Total\ Number\ of\ Sightings \\ of\ Individuals\ of\ the\ species\end{matrix}\right)}{Total\ Length\ of\ Transect\ Covered\ in\ Kilometres}$$

We used MS Excel and PAST Software for data analysis.

3. Results and Discussions

Part I: Phytosociological Analysis

Site 1: Neeliyarkottam

Neeliyarkottam is a sacred grove in the midlands that is home to a diverse range of plant species, including Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, and Lichens.

A total of 30 species belonging to 29 genera and 20 families have been identified in this grove.

Aporosa lindleyana, *Careya arborea*, *Flacourtia montana*, *Macaranga peltata*, *Vitex altissima* share 100% frequency. *Memecylon randerianum* is the dominant species in this SG, with an IVI value of 58.05, the highest density (8.5), and a total of 2365 basal area. The co-dominant species are *Mangifera indica*, *Carallia brachiata*, with an IVI of 13.34,12.62, respectively. The minimum IVI value (2.299) was reported for the *Acronychian pedunculata*. Shannon-Wiener's diversity index (H) of the study site was 1.257, while the Simpson index (D) was 0.956. It demonstrates the high diversity of the SG. Table 2 exhibits the details of the phytosociological analysis of tree species in the SG.

Site 2: Madayikavu

Madayikavu is a mid-land laterite SG. It is situated as a patch of forest in front of "Madaipaara". But the "Madaipaara" flora outside and this flora inside this Kavu are entirely different. Tree members of the Eriocaulaceae family were dominant in the "Para" region. Drosera sp, Polycarpaea sp, Utricularia sp., etc., were also seen here. This finding is somewhat identical to Pramod and Pradeep (2021), who observed flowering plants in the surroundings of Madayikavu. The flora is composed of different plant groups like trees, climbers, stragglers, woody climbers, and epiphytes. Climbers and stragglers are conspicuous features of this SG. This gives a continuous structure to this grove. This grove contains 21 species belonging to 21 genera and 18 families. No species occurs at a 100% frequency in Madayi kavu. *Adenanthera pavonina*, *Careya arborea*, *Gmelina arborea*, *Mangifera indica*, *Memecylon randerianum*, *Mimusops elengi*, *Olea dioica*, *Strychnos nux-vomica* all cover 50% frequency. The maximum frequency is 50%. *Memecylon randerianum* is the dominant species in this SG, with an IVI value of 41.88 and the highest density (1.5) and a total basal area of 984.74. Melastomaceae is the most dominant family in this grove. *Mangifera indica* and *Mimusops elengi* are the co-dominant species, with IVI values of 24.26 and 19.98, respectively. The minimum IVI value (6.227) was reported for the *Macaranga peltata*. The SG demonstrated the high tree diversity (H = 1.119 and D = 0.935).

Table 2. Phytosociological Analysis in Neeliyarkottam

Sl. No	Name of the Species	Family Name	F	D	BA	RF	RD	RDo	IVI	Pi	Pi log Pi
1	*Acronychian pedunculata L.*	Rutaceae	25	0.25	21.6	1.28	0.77	0.24	2.299	0.007	-0.015
2	*Actinodaphne malabarica Balakr.*	Lauraceae	75	0.75	78.3	3.84	2.32	0.88	7.051	0.023	-0.037
3	*Adenanthera pavonina L.*	Mimosaceae	75	0.75	274.4	3.86	2.32	3.08	9.254	0.023	-0.037
4	*Aglaia elaeagnoidea (A.Juss.)Benth.*	Meliaceae	50	0.5	97.1	2.56	1.55	1.09	5.205	0.015	-0.027
5	*Alseodaphne semicarpifolia Nees.*	Lauraceae	25	0.5	76.3	1.28	1.55	0.85	3.69	0.015	-0.027
6	*Anacardium occidentale L.*	Anacardiaceae	50	0.5	222.9	3.86	1.55	2.50	7.9	0.015	-0.027
7	*Antidesma ascidum Retz.*	Euphorbiaceae	50	0.75	117.3	3.86	2.32	1.31	7.489	0.023	-0.037
8	*Aporosa lindleyana Baill.*	Euphorbiaceae	100	1	236.3	5.12	3.10	2.65	10.88	0.031	-0.046
9	*Artocarpus hirsutus Lam.*	Moraceae	50	0.5	120.8	2.56	1.55	1.35	5.471	0.015	-0.027
10	*Benkara malabarica (Lam.) Tirveng.*	Rubiaceae	50	1	324.6	2.56	3.10	3.64	9.312	0.031	-0.046
11	*Carallia brachiata (Lour.)Merr.*	Rhizophoraceae	75	1.25	436.0	3.86	3.87	4.89	12.62	0.038	-0.053
12	*Careya arborea Roxb.*	Lecythidaceae	100	1	267.8	5.12	3.10	3.00	11.23	0.031	-0.046
13	*Caryota urens L.*	Arecaceae	50	0.75	147.5	2.56	2.32	1.65	6.546	0.023	-0.037
14	*Cinnamomum verum Presl.*	Lauraceae	50	0.5	70.2	2.56	1.55	0.78	4.902	0.015	-0.027
15	*Ficus mysorensis Heyne.*	Moraceae	25	0.25	317.3	1.28	0.77	3.56	5.622	0.007	-0.015
16	*Ficus tsjahela Burm.f.*	Moraceae	25	0.25	278.2	1.28	0.77	3.12	5.183	0.007	-0.015
17	*Flacourtia montana Graham.*	Flacourtiaceae	100	2	390.2	5.12	6.20	4.38	15.71	0.062	-0.074
18	*Gmelina arborea Roxb.*	Verbenaceae	75	1	437.8	3.84	3.10	4.91	11.86	0.031	-0.046
19	*Holoptelea integrifolia (Roxb.) Planch..*	Ulmaceae	75	0.75	133.9	3.84	2.32	1.50	7.675	0.023	-0.037
20	*Hydnocarpus pendandra (B.-H.) Oken.*	Bixaceae	50	0.75	116.7	2.56	2.32	1.31	6.2	0.023	-0.037
21	*Macaranga peltata Muell.Arg.*	Euphorbiaceae	100	1.75	410.1	5.12	5.42	4.60	15.16	0.054	-0.068
22	*Madhuca nerifolia (Moon.) H.J.Lam.*	Sapotaceae	75	1	291.0	3.86	3.10	3.26	10.21	0.031	-0.046
23	*Mangifera indica L.*	Anacardiaceae	25	1.5	316.9	5.12	4.65	3.56	13.34	0.046	-0.061
24	*Melicope lunu-ankenda (Gaertner.)Merr.*	Rutaceae	75	1	267.8	5.12	3.10	3.00	11.23	0.031	-0.046
25	*Memecylon randerianum SM & MR Almeida.*	Melastomaceae	75	8.5	2365	5.12	26.3	26.5	58.05	0.263	-0.152
26	*Mimusops elengi L.*	Sapotaceae	50	1	286.3	3.86	3.10	3.21	10.16	0.031	-0.046
27	*Santalum album L.*	Santalaceae	25	0.25	84.1	1.28	0.77	0.94	3.002	0.007	-0.015
28	*Olea dioica Roxb.*	Oleaceae	50	1	364.3	3.86	3.10	4.09	11.03	0.031	-0.046
29	*Syzygium caryophyllatum (L.) Trimen.*	Myrtaceae	50	0.5	160.1	2.56	1.55	1.79	5.913	0.015	-0.027
30	*Vitex altissima L.*	Lamiaceae	100	0.75	187.9	3.86	2.32	2.11	8.283	0.023	-0.037
D = 0.956 H' = 1.257											

Table 3. Phytosociological Analysis in Madayikavu

Sl No	Name of the species	Family Name	F	D	BA	RF	RD	RDo	IVI	Pi	Pi log Pi
1	*Adenanthera pavonina L.*	Mimosaceae	50	0.5	406.1	6.25	4.76	8.80	19.81	0.04	-0.06
2	*Aglaia elaeagnoidea (A.Juss.)Benth.*	Meliaceae	25	0.25	76.88	3.12	2.38	1.66	7.171	0.02	-0.03
3	*Alstonia scholaris (L.)R.Br.*	Apocynaceae	25	0.25	102.08	3.12	2.38	2.213	7.718	0.02	-0.03
4	*Careya arborea Roxb.*	Lecythidaceae	50	0.5	192.17	6.25	4.76	4.166	15.17	0.04	-0.06
5	*Erythrina stricta Roxb.*	Fabaceae	25	0.25	37.08	3.12	2.38	0.803	6.308	0.02	-0.03
6	*Ficus tsjahela Burm.f.*	Moraceae	25	0.25	469.74	3.12	2.38	10.18	15.69	0.02	-0.03
7	*Gmelina arborea Roxb.*	Verbenaceae	50	0.75	295.41	6.25	7.14	6.405	19.79	0.07	-0.08
8	*Macaranga peltata Muell.Arg.*	Euphorbiaceae	25	0.25	33.33	3.12	2.38	0.722	6.227	0.09	-0.03
9	*Mangifera indica L.*	Anacardiaceae	50	1	391.83	6.25	9.52	8.495	24.26	0.04	-0.06
10	*Memecylon randerianum SMandMR Almeida.*	Melastomaceae	50	1.5	984.74	6.25	14.2	21.35	41.88	0.14	-0.12
11	*Mimusops elengi L*	Sapotaceae	50	0.75	304.08	6.25	7.14	6.593	19.98	0.07	-0.08
12	*Olea dioica Roxb.*	Oleaceae	50	0.5	125.41	6.25	4.76	2.719	13.73	0.04	-0.06
13	*Sterculia guttata Roxb.ex.DC.*	Sterculiaceae	25	0.25	89.08	3.12	2.38	1.931	7.436	0.02	-0.03
14	*Pongamia pinnata (L.) Pierre.*	Fabaceae	25	0.25	86.38	3.12	2.38	1.872	7.377	0.02	-0.03
15	*Strychnos nux-vomica L.*	Loganiaceae	50	0.5	165.41	6.25	4.76	3.586	14.59	0.04	-0.06
16	*Tabernaemontana alternifolia L.*	Apocynaceae	25	0.25	107.81	3.12	2.38	2.337	7.842	0.02	-0.03
17	*Tamarindus indica L.*	Caesalpineaceae	25	0.5	107.34	3.12	4.76	2.327	10.21	0.02	-0.03
18	*Terminalia paniculata Roth.*	Combretaceae	75	1	347.30	9.37	9.52	7.530	26.42	0.09	-0.09
19	*Vateria indica L.*	Dipterocarpaceae	50	0.5	125.41	6.25	4.76	2.719	13.73	0.04	-0.06
20	*Vitex altissima L.*	Verbinaceae	25	0.25	89.66	3.12	2.38	1.944	7.449	0.02	-0.03
21	*Zanthoxylum rhetsa (Roxb.)DC*	Rutaceae	25	0.25	74.75	3.12	2.38	1.620	7.125	0.02	-0.03
	D=0.934 H' =1.119										

Site 3: Poongottukavu

It is considered a Myristica Swamp, associated with the evergreen forest, which is characteristic of this SG. These swamps are characterized by a unique type of root called pnematophores that is negatively geotropic. In this grove, a total of 18 species from 18 genera and 15 families have been identified. No species has a 100 per cent frequency in Poongottukavu. *Elaeocarpus tuberculatus* is the dominant species in this SG, with a frequency of 75% and a total of 323.32 basal area. It also has the highest IVI value of 38.77. The highest density is found in *Myristica malabarica* (2.5). *Myristica malabarica* and *Holigarna arnottiana* are the co-dominant species, with IVI values of 38.20 and 35.07, respectively. *Cinnamomum verum* was found to have the lowest IVI value (8.413). The H is 0.915, while D is 1.004. This exemplifies the diversity of SG.

Table 4. Phytosociological Analysis in Poongottukavu

Sl No	Name of the Species	Family Name	F	D	BA	RF	RD	RDo	IVI	Pi	Pi log Pi
1	*Myristica malabarica Lam.*	Myristicaceae	50	2.5	47.4	8.695	27.77	1.736	38.20	0.27	-0.15
2	*Hopea parviflora Bedd.*	Dipterocarpacea	25	0.5	248.9	4.347	5.555	9.122	19.02	0.05	-0.06
3	*Holigarna arnottiana Hook.*	Anacardiaceae	50	0.75	492.8	8.695	8.333	18.05	35.07	0.08	-0.08
4	*Elaeocarpus tuberculatus Roxb.*	Elaeocarpaceae	75	1.25	323.32	13.043	13.888	11.8	38.77	0.13	-0.11
5	*Lagerstroemia speciosa (L.)Pers.*	Lythraceae	25	0.25	124.72	4.347	2.777	4.569	11.693	0.027	-0.04
6	*Madhuca nerifolia (Moon.) H.J.Lam.*	Sapotaceae	25	0.25	58.89	4.347	2.777	2.15	9.281	0.027	-0.04
7	*Artocarpus integrifolia L.*	Moraceae	25	0.25	98.2	4.347	2.777	3.598	10.722	0.027	-0.04
8	*Cinnamomum verum Presl.*	Lauraceae	25	0.25	35.19	4.347	2.777	1.289	8.413	0.027	-0.04
9	*Carallia brachiata (Lour.)Merr.*	Rhizophoraceae	25	0.25	48.42	4.347	2.777	1.774	8.898	0.027	-0.04
10	*Mangifera indica L.*	Anacardiaceae	25	0.25	154.14	4.347	2.777	5.647	12.861	0.027	-0.04
11	*Memecylon randerianum SMandMR Almeida.*	Melastomaceae	25	0.5	103.18	4.347	5.555	3.780	13.772	0.055	-0.06
12	*Mimusops elengi L.*	Sapotaceae	25	0.25	183.4	4.347	2.777	6.720	13.934	0.027	-0.04
13	*Vateria indica L.*	Dipterocarpacae	25	0.25	102.4	4.347	2.777	3.752	10.966	0.027	-0.04
14	*Sterculia guttata Roxb.ex.DC*	Sterculiaceae	25	0.25	76.51	4.347	2.777	2.803	10.017	0.027	-0.04
15	*Strychnos nux-vomica L.*	Loganiaceae	25	0.25	71.5	4.347	2.777	2.619	9.833	0.027	-0.04
16	*Terminalia paniculata Roth.*	Combretaceae	50	0.5	247.3	8.695	5.555	9.061	23.311	0.055	-0.06
17	*Ficus callosa Willd.*	Moraceae	25	0.25	258.68	4.347	2.777	9.478	16.692	0.027	-0.04
18	*Polyalthia fragrans (Datz.)Bedd.*	Annonaceae	25	0.25	54.14	4.347	2.777	1.983	9.197	0.027	-0.04
D=0.915 H' =1.004											

Site 4: Iriverikavu

It is a midland SG. As shown in Table 5, a total of 12 species belonging to 12 genera and 11 families have been identified in this grove. This SG showed a high tree diversity (H = 0.903 and D = 0.904).In Iriveri kavu no species share 100% frequency. *Carallia brachiate and Terminalia paniculata* both cover maximum (75%) frequency. Terminalia paniculata has a total of 497.6 basal area. *Memecylon randerianum* has the highest density (1). *Terminalia paniculata* is dominating species with the highest IVI value, 45.877. The co-dominant species are *Carallia brachiate and Memecylon randerianum*, with the IVI values 42.665, and 39.064, respectively.

Site 5: Thazhekavu

It is an SG on the coast with mangroves as its main flora. This grove is located in a salt marsh on a small island on the bank of the Valapattanam River. The Rhizophoraceae family of plants dominates the mangrove vegetation found here. A total of 9 species belonging to 7 genera and5 families have been identified in this grove. *Avicennia marina, Avicennia officinalis, Rhizophora mucronata, Rhizophora apiculata* share 100% frequency. Excoecaria agallocha has the highest basal area, and *Avicennia officinalis* has the highest density. Excoecaria agallocha with the highest Ivi value of 79.496, followed by *Avicennia officinalis, Rhizophora apiculata* with the ivi value of 52.956,40.549. As given in Table 6, Shannon Wiener's Index (H) is 1.072, while the Simpson index (D) is 0.904.

Site 6: Chamakavu

This SG is found on the coast**.** A total of 9 species belonging to 8 genera and eight families have been identified in this grove. *Adenanthera pavonina, Carallia brachiate, Gmelina arborea, Syzygium caryophyllatum* and *Ziziphus oenoplia* share a maximum (75%) frequency. Syzygium caryophyllatum has the highest density (1.25), and *Adenanthera pavonina* has the highest total basal area (559.9). *Gmelina arborea* accounts for the highest IVI value, 50.588, followed by *Syzygium caryophyllatum and Hopea parviflora*, with the IVI values 45.013, and 42.769, respectively. *Tabernaemontana alternifolia* has the least IVI value (12.286). Table 7, depicting the phytosociology of tree species, highlight that the Shannon Wiener's diversity (H) index is 0.832, while the Simpson index (D) is 0.852.

Table 5. Phytosociological Analysis in Iriverikavu

Sl. No.	Name of the species	Family Name	F	D	BA	RF	RD	RDo	IVI	Pi	Pi log Pi
1	*Adenanthera pavonina L.*	Mimosaceae	25	0.25	179.	5.55	4.76	5.369	15.68	0.04	-0.06
2	*Anacardium occidentale L.*	Anacardiaceae	25	0.25	109.8	5.555	4.761	3.293	13.609	0.047	-0.062
3	*Artocarpus integrifolia L.*	Moraceae	25	0.25	316.1	5.555	4.761	9.482	19.798	0.047	-0.062
4	*Carallia brachiata (Lour.)*	Rhizophoraceae	75	0.75	390.8	16.66	14.28	11.723	42.665	0.142	-0.120
5	*Cassia siamea Lamk.*	Leguminosae	50	0.5	267.8	11.11	9.523	8.033	28.667	0.095	-0.097
6	*Mangifera indica L.*	Anacardiaceae	25	0.25	368.2	5.555	4.761	11.045	21.361	0.047	-0.062
7	*Caryota urens L.*	Arecaceae	25	0.5	235.3	5.555	4.761	7.058	17.374	0.095	-0.097
8	*Cinnamomum malabatrum (Brum.f.)Blume.*	Lauraceae	25	0.25	175.9	5.555	4.761	5.276	15.592	0.047	-0.062
9	*Memecylon randerianum SMandMR Almeida.*	Melastomaceae	50	1	614.4	11.11	9.523	18.430	39.064	0.190	-0.136
10	*Strychnos nux-vomica L.*	Loganiaceae	25	0.25	92.0	5.555	4.761	2.759	13.075	0.047	-0.062
11	*Terminalia paniculata Roth.*	Combretaceae	75	0.75	497.6	16.66	14.28	14.926	45.877	0.142	-0.120
12	*Zanthoxylum rhetsa (Roxb.)DC*	Rutaceae	25	0.25	86.7	5.555	4.761	2.600	12.916	0.047	-0.062
D = 0.904 H' = 0.903											

Table 6. Phytosociological Analysis in Thazhekavu

Sl. No	Name of the Species	Family Name	F	D	BA	RF	RD	RDo	IVI	Pi	PilogPi
1	*Avicennia marina (Forssk)Vierh.*	Avicenniaceae	100	2	37.8	17.391	16.666	5.057	39.114	0.166	-0.129
2	*Avicennia officinalis L.*	Avicenniaceae	100	3.25	63.4	17.391	27.083	8.482	52.956	0.270	-0.153
3	*Acanthus ilicifolius L.*	Acanthaceae	25	0.25	7.8	4.347	2.083	1.043	7.473	0.020	-0.033
4	*Bruguiera cylindrica (L.)Blume.*	Rhizophoraceae	75	1	16.31	13.043	8.333	2.182	23.558	0.083	-0.089
5	*Excoecaria agallocha L*	Euphorbiaceae	25	1	499.41	4.347	8.333	66.816	79.496	0.083	-0.089
6	*Kandelia candel (L.)Druce.*	Rhizophoraceae	25	0.5	15.83	4.347	4.166	2.117	10.63	0.041	-0.056
7	*Rhizophora mucronata Poir.*	Rhizophoraceae	100	2	31.5	17.391	16.666	4.214	38.271	0.166	-0.129
8	*Rhizophora apiculata Blume.*	Rhizophoraceae	100	1.75	64.1	17.391	14.583	8.575	40.549	0.145	-0.121
9	*Sonneratia alba J.E.Smith.*	Sonneratiaceae	25	0.25	11.3	4.347	2.083	1.511	7.941	0.020	-0.033
D=0.904 H'=1.072											

Table 7. Phytosociological Analysis in Chamakavu

Sl No.	Name of the Species	Family Name	F	D	BA	RF	RD	RDo	IVI	Pi	Pilog Pi
1	*Adenanthera pavonina L.*	Mimosaceae	75	0.75	559.9	14.285	11.111	12.707	38.103	0.111	-0.105
2	*Carallia brachiata (Lour.)Merr.*	Rhizophoraceae	75	0.75	326.1	14.285	11.111	7.401	32.797	0.111	-0.105
3	*Gmelina arborea Roxb.*	Verbenaceae	75	1	946.8	14.285	14.814	21.489	50.588	0.148	-0.122
4	*Hopea parviflora Bedd.*	Dipterocarpaceae	50	1	812.1	9.523	14.814	18.432	42.769	0.148	-0.122
5	*Sterculia guttata Roxb.ex.DC*	Sterculiaceae	25	0.25	484.4	4.761	3.703	10.994	19.458	0.037	-0.052
6	*Syzygium caryophyllatum (L.) Trimen.*	Myrtaceae	75	1.25	538.0	14.285	18.518	12.210	45.013	0.185	-0.135
7	*Tabernaemontana alternifolia L.*	Apocynaceae	25	0.25	168.4	4.761	3.703	3.822	12.286	0.37	-0.052
8	*Vateria indica L.*	Dipterocarpaceae	50	0.75	431.2	9.523	11.111	9.786	30.42	0.111	-0.105
9	*Ziziphus oenoplia Mill.*	Rhamnacee	75	0.75	139.0	14.285	11.111	3.154	28.55	0.111	-0.105
	D=0.852 H'=0.832										

Part II - Western Ghats Striped squirrels in the SGs

Western Ghats Striped squirrels were found in five out of six SGs sites in Kannur. For two months, a weekly line transect observation for one kilometre in 48 kilometres of observation recorded106 individual sightings.

Abundance of *F. Tristriatus* in the SGs

The abundance of the Western Ghats Striped squirrels in the sacred grovesSGs of Kannur was analyzed as encounter rate (number of individuals sighted per kilometres of transect walk). The abundance was found to be (M= 2.208) individuals per km in the SGs of Kannur. The abundance of *F.tristriatus* in various SGs studied is given in Table 8.

Table 8 exhibits that the highest *F. tristriatus* is seen in Site 1: Neeliyar Kottam, with 5.00 (38% of total observation) individuals per kilometre walk. The tree species and the diversity of plants are also more in Site 1. The next squirrel abundant SG is Site 2: Madayi Kavu, with 3.3750 (25% of observations) individual squirrels spotted. However, it is to be noted that the number of fruiting trees here is relatively less than at Site 1, but abundance is relatively high there. This can be attributed to the unique ecological surroundings of Madayi "Para" and the surrounding flowering plant diversity in Madayippara (Pramod and Pradeep, 2021). Likewise, the following two sites, Poongottu Kavu (21%) and Iriverikavu (12%), had an abundance of *F.tristriatus*, respectively. Interestingly, Site 5 did not seem to be a habitat for *F.tristriatus*, Which indicates that squirrels do not prefer to live in mangrove-rich SGs. Additionally, Site 6 contained mangroves partly and had a relatively low encounter rate (4%).

Table 8. Abundance of Western Ghats Striped squirrel in the SGs

Site. No	Study Site (SGs)	Trees Present		Individual sightings during the study period	Abundance No. of (No./km)
		No. of species	No. of Individual Trees		
1	Neeliyar Kottam	30	129	40	5.00
2	Madayi Kavu	21	42	27	3.375
3	Poongottu Kavu	18	36	22	2.75
4	Iriveri Kavu	12	21	13	1.625
5	Tazhe Kavu	9	48	0	0.00
6	Chama Kavu	9	27	4	0.50
	Total (Entire Sacred Groves)			106	M = 2.208

$$Note = abundance\left(No./km\right) = \frac{Total\ No.\ of\ Sightings\ of\ individuals\ of\ the\ species}{Total\ length\ of\ transect\ covered\ in\ Kilometres}$$

Table 9. Feeding Behaviour of *F. tristriatus* in the Sighted Trees and their Number

Sighting Tree	Part Consumed			Fruits Consumed					
	Flower	Leaf	Bark	Multiple Fruits	Drupe	Berry	Pods	Syncope Fleshy	False Fruit
Anacardium occidentale									1
Adenanthera pavonina									
Artocarpus hirsutus								1	
Macaranga peltata									
Memecylon randerianum	8					4			
Syzygium caryophyllatum						2			
Madhuca nerifolia						1			
Alstonia scholaris									
Tamarindus indica							2		
Terminalia paniculata									
Mangifera indica	1				7				
Ficus callosa		1							
Artocarpus integrifolia				1					
Hopea parviflora	2								
Elaeocarpus tuberculatus	1				1				

Table 10. A comparative account of tree diversity attributes and abundance of *Funambulus Tristriatus* in the SGs in Kannur

Sl No.	Study site	Squirrel abundance	No. of Trees species	No. of Individual Trees	Simpson's index	Shannon Wiener index
1	Neeliyar Kottam	5.00	30	129	0.956	1.257
2	Madayi Kavu	3.375	21	42	0.934	1.119
3	Poongottu Kavu	2.75	18	36	0.915	1.004
4	Iriveri Kavu	1.625	12	21	0.904	0.903
5	Thazhe Kavu	0.00	9	48	0.904	1.072
6	Chama Kavu	0.50	9	27	0.852	0.832

F. tristriatus was sighted 106 times during the course of the study. It was a positive identification. They were observed feeding on 33 occasions, and most observations were at the fragmented edge of trees. During the study period, *F. tristriatus* consumed at least three different plant parts of 11 tree species (See Table 9). About 20 out of 33 (61%) consume semi, and completely ripened fruits, 12 out of 33 (36 %) of *F. tristriatus* consume flowers and 1 out of *33 (3%)* consume leaves. Out of fruits *eating F. tristriastus*, 8 of 20 (40 %) are drupe, 7 of 20 (35%) are berry, 2 out of 20 (10%) are pods and 1 of 20 (5 %) share each multiple fruits, falser fruit and syncope fleshy.

According to the results, the SG, Neeliyar Kottam, has the highest abundance with *five* individuals per km, with a Simpson index of *0.956* and a Shannon wiener index of *1.257*. This area contains the most significant number of tree species and individual trees. *Memecylon randerianum* is the highest abundant tree species. Madayi Kavu (*3.375* individuals/km, *SI =0.934, SWI =1.119*) and SG Poongottu Kaavu (*2.75* individuals/km, *SI=0.904, SWI=1.072*) are the next two SGs. These two sites also have a relatively higher distribution of *Memecylon randerianum* and *Mangifera indica* (both are flush fruit-giving trees). The number of tree species is low in Thaye Kavu, but the number of trees is high. Iriverikavu (*1.625*individuals/km, *SI =0.904, SWI =0.903*), Chamakavu (*0.5*individuals/km, *SI =0.852, SWI=0.832*) and Taye kavu (*0* individuals/km, *SI =0.904, SWI =1.072*), no single squirrel found this mangrove-like SG per km.The abundance values at the different study sites show that squirrels are more abundant in areas with more trees. Based on the feeding behaviour of *F. tristriatus* on the sighted trees, they are found to be feeding flowers, fruits and leaves. The presence of fruiting trees plays a major role in the existence of *F. tristriatus.* More importantly, two tree species are highly relevant for the *F. tristriatus.* They are *Memecylon randerianum* and *Mangifera indica*.

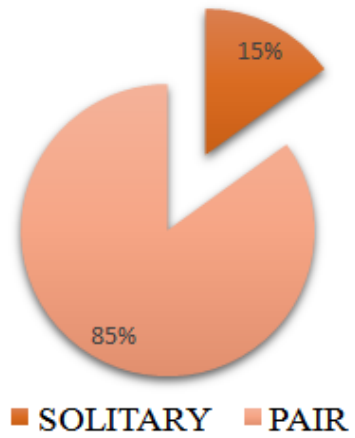

Figure 3. Social Habitat of *F. tristriatus*

Social Habits of *Funambulus Tristriatus* in Kannur SGs

The social habit of wild animals refers to their social behaviour, such as whether they are seen alone, in pairs, or in groups. In the SGs of Kannur, Western Ghats Striped squirrels were seen solitary in nearly *15%* of sightings during the current study. The squirrels were seen in pairs in *85%*.

4. Conclusion

SGs provide a variety of ecosystem benefits. The plants in the SGs increase the amount of oxygen in the atmosphere of the surroundings. Many organisms will benefit from increased humidity in the immediate vicinity as a result of transpiration. As a result, the SGs serve as the lungs of the village. The phytosociological survey revealed that *Memecylon randerianum* is the dominant species in Neeliyarkottam and Madayi kavu. Poongottukavu is rich with Myristica swamp type of SG. *Myristica malabarica* is the dominant plant here. In Iriverikavu, Carallia brachiata is the dominant tree species. Thazhekavu is a sacred mangrove, and *Avicennia officinallis* shows the maximum number. Chamakavu is a coastal SG where *Syzygium caryophyllatum is* recorded in maximum number, and Gmelina Arborea shows maximum IVI. The SGs are still a haven for many animals, particularly squirrels. This study observed the relative abundance of *F. tristriatus* inside six SGs in Kannur, Kerala. In the study area, there were *106* individual sightings of *F. tristriatus* during the sampling period. Western Ghats Striped squirrels were found in five out of the six SGs chosen as study sites.

The presence of fruiting trees plays a major role in the existence of *F. tristriatus*. It thus indicates that *Memecylon randerianum* and Mangifera indica are the two prominent *F.tristriatus* take habitats. Nandini and Parthasarathy (2008) found that Indian Giant Flying Squirrels (Petaurista philippensis) eat *Ficus racemosa* and *Cullenia exarillata*, as well as their bark, mature leaves, and flowers. Our result is somewhat consistent with this finding. The study finds that those two tree species are significant for their dieting and nesting. Therefore, it is imperative to protect such a plant outside the SGs to ensure that this ICUN (LC) red-listed mammal does not get impacted due to anthropogenic activities. We hypothesize that *F.tristriatus* congregating at food trees inflated the encounter rate due to our short sampling period during the flowering and fruiting season of the trees sited. In addition to a phytosociological survey, which helps identify sites with conservation potential, periodic assessments of taxa with high populations and functional roles can aid in the evaluation of habitat quality in such SGs. The inadequacy

of knowledge and information on squirrels in India in general and particularly in Kerala warrants immediate attention to the studies of squirrels in this region, and public awareness is a crucial component of the action that must be taken to implement conservation action plans for squirrels of this region.

The SG of Neeliyar kottam, which has the most tree species and individual trees, has increased the abundance of *F. tristriatus*. This means that the number of squirrels depends on the area's canopy continuity. As a result, the presence of trees and the floral wealth of the SG plays an essential role in the survival of many faunas in these areas and on our planet, especially *F. tristriatus.* Therefore, periodical monitoring of functionally important indicator taxa of Rodents, including *F. tristriatus*, can suggest the quality of SGs for conserving biodiversity.

5. Limitation and Future Directions

All SGs have strict entry restrictions, and thus, studying the inhabitants proved to be a difficult task. Because the SGs are more tightly controlled by religious and customs authorities, our study was given only a period to observe squirrels inside SGs; thus, we couldn't consistently carry out observe longitudinal squirrel occurrence in each study site. We could not observe their behaviour individually. Thus, the tiny sample size and the limited number of study sites have become its major flaw. The findings and conclusions of this study cannot be extended to a broader population of *F. tristriatus* in the region. Thus, more thorough sampling from a wider geographic area is required to capture the tree diversity and *F. tristriatus* abundance in the study area. We could not specifically identify their feeding ecology, plant productivity patterns, and interactions and disturbance levels can also be examined in SGs.

An analysis of Squirrel abundance and tree composition in six SGs in the Kannur district. More research is needed to understand squirrel population status, habitat selection, eating habits, and conservation challenges outside these protected regions. Their behaviour patterns can also be interesting to study. The next steps for research are identified in this article. First, comparing the presence of squirrels in HGs against SGs with a larger dataset. Second, investigate the relationships of squirrels with other species in SGs and their tolerance level against disruptions. A study on human-modified landscapes and *F. tristriatus* abundance is also urgently necessary. A longitudinal investigation of their feeding behaviour, feeding bouts, environment, and nesting is also advised [27]. As shown by Duenas et al. [24], future research can also examine the invasive nature of *F. tristriatus* inside the SGs and their interactions with other IUCN-listed critically endangered species found only in SGs.

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Appendix A

{1}. Historically, SGs in Kerala are part of Hindu Temples located nearby. Therefore, it has a unique link with Hindu religious customs and has limited human interaction. The background information about each SG was gathered from local elders who are part of the administration of temples nearby groves - gathered from Kavu authorities and locals.

{2}. Kannur is one of the most densely populated districts (2,412,365) in Kerala. Geographically, it's located on the northern side of Kerala state. The population density is 852 people per square kilometre. 1090:1000 is the sex ratio. The per capita income ranges between Rs.17 and Rs.260. 92.8 per cent of the population is literate. The district has a total area of 2,971 km^2. The Kannur district is located between latitudes 11°40'00" and 12°48'00" North and longitudes 74°52'00" E and 75°56'00" East. The district is bounded on the east by the Western Ghats (Coorg district of Karnataka State). Kannur is one of India's million-plus urban agglomerations, ranking it sixth in Kerala and twenty-seventh in the country. Read more at: http://www.ecostat.kerala.gov.in/index.php/geo-state-knr.

Photographs of Field Survey

Figure A.1. Data collection

Figure A.2. Line transect at Neeliyarkootam