SERKET سركت

The Arachnological Bulletin of the Middle East and North Africa

Volume 17 **Part 4**

May, 2021 **Cairo, Egypt**

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ISSN: 1110-502X

Serket (2021) vol. 17(4): 429-437.

Regional diversity of spiders in the selected sacred groves of northern Kerala, India

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Abstract

Sacred groves of Northern Kerala operate as an ideal centre for biodiversity conservation. Several threatened animals and plants are still well conserved in the sacred groves. Present study intends to discover the regional diversity of spiders from the selected sacred groves of Kasargod and Kannur districts. Fifteen sacred groves from Kasargod and Kannur districts were selected for this study. Spider sampling was carried out from February 2016 till January 2018. The sampling methods such as line transect method, handpicking in ground and strata, and beating were used to catch specimens. The caught specimens were preserved and identified to species and genus level using available literature. This study found 11308 individuals of 257 species come under 136 genera. Abundance of spiders in the sacred groves of Kasargod district was 2904 individuals with 109 species and 8404 individuals with 220 species collected from Kannur district. The study revealed that regional wide diversity of spiders was greater in the sacred groves of Kasargod and Kannur.

Keywords: Araneae, Abundance, Diversity, Kerala, Sacred sites, India.

Introduction

The correct estimation of local and regional species richness has been considered critical for determining the shape of the relationship between these two factors (Srivastava, 1999). The ecological interpretation of diversity is not straight forward. It might be expected that diversity should increase with habitat heterogeneity. In fact, more structurally complex habitat harbour more spider species per plot, probably due to more

niches being available. The probability of species interactions is higher and the interpretation of patterns more easily related to processes operating at the local scale, such as vegetation heterogeneity and diversity (Collins *et al.*, 2002). Previous studies suggesting that species assemblages are random samples drawn from a pool of potential colonists, and also that spider communities may be largely structured by interspecific competition or local features of the habitat (Wise, 1993). Spider assemblages, in a particular small patch, probably correspond to a collection of individuals of the species present, under the constraints of habitat structure and limited niche space. Habitat management may also have intense effects on local spider assemblages, since local spider richness seems to be related to well-developed and complex vegetation. It is also important to consider the potential utility of measures of species richness in habitat management and conservation-management of sacred groves. If saturation occurs at the local scale, then diversity could be of limited value in identifying levels of mean species richness at the local scale. An investment in standardized sampling within regions, to obtain measures of diversity, would greatly enhance the understanding of processes operating at local and regional scales (Borges & Brown, 2004).

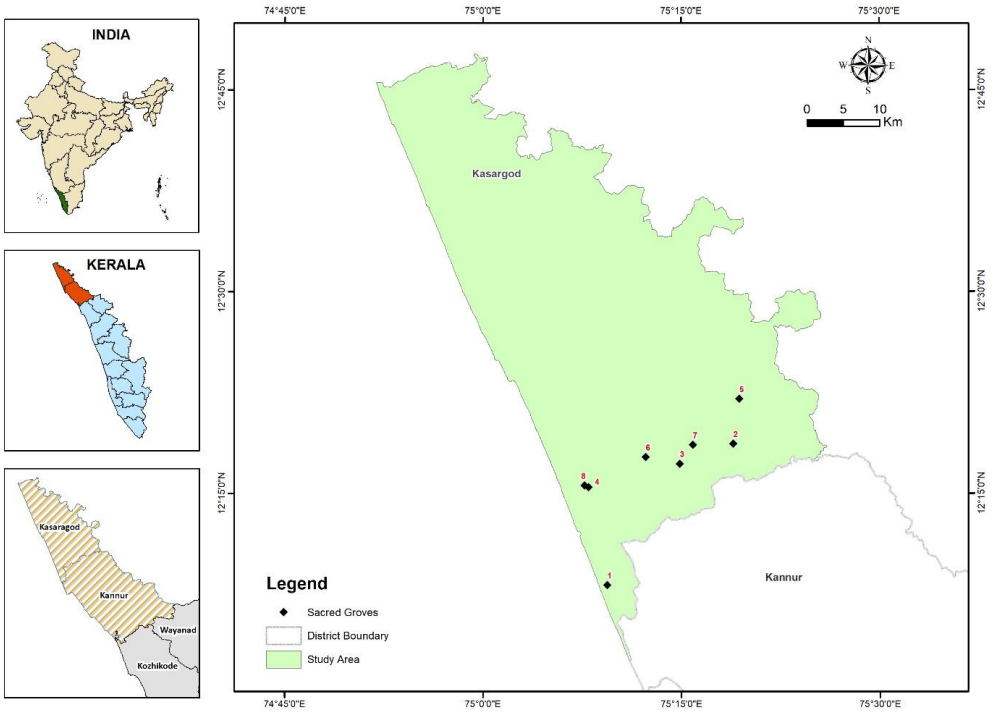

Fig. 1. Map showing the study area of Kasargod district. (1) Edayilekadu Kavu, (2) Kammadom Kavu, (3) Koyithatta Sree Dharmasastha Kavu, (4) Mannam Purathu Kavu, (5) Sree Malliyodan Kavu, (6) Payyamkulam Kavu, (7) Periyanganam Sree Dharmasastha Kavu, and (8) Puthiya Parambathu Kavu.

India is exceptionally rich in sacred groves with around 13,720 sacred groves spread across 19 states (Kapoor, 2006). The state of Kerala harbours 1500 to 2000 sacred groves, the extent of which varies from 0.004 ha to >20 ha. Sacred groves are supposed to be relics of ancient vegetation and remnants of larger forest tracts. Documenting and understanding spider assemblages in tropical ecosystems like sacred groves in the present context of rapid loss is an important task (Chandran *et al.*, 1998). Sacred groves play an important role in ensuring smooth ecosystem services such as clean environment that is, air, soil, and water conservation, flora and fauna conservation, temperature control and

conservation of traditional knowledge. Microclimatic features, soil cover, litter cover, water resources, highly diverse flora of these areas support varied array of fauna. So that they are of central importance as far as ecological conservation and policy regarding conservation and management of forest at state and national levels are concerned (Kapoor, 2006). The aim of the present study is to provide data on the regional diversity of spiders in sacred groves of Kasargod and Kannur districts of Kerala, India.

Table 1. Details of sites covered for regional diversity in sacred groves of Kasargod district.

Sl. No	Name of sacred groves	Location	Co-ordinates	Area of sacred grove (ha)
1	EDAYILEKADU KAVU	Thrikkarippoor	12º08'10.72"N 75º09'23.88"E	6.40
2	KAMMADOM KAVU	West elery	12º18'41.0"N 75º18'55.8"E	24.00
3	KOYITHATTA SREE DHARMA SASTHA KAVU	Koyithatta	12º17'11.4"N 75º14'53.88"E	3.00
4	MANNAM PURATHU KAVU	Neeleswaram	12º15'27.6"N 75º07'59.4"E	2.83
5	SREE MALLIYODAN KAVU	Konnakkad	12º22'1.24"N 75º19'22.8"E	3.00
6	PAYYAMKULAM KAVU	Kinaur, Karinthalam	12º17'41.7"N 75º12'18.96"E	5.00
7	PERIYANGANAM SREE DHARMA SASTHA KAVU	Periyanganm	12º18'36.0"N 75º15'52.56"E	2.00
8	PUTHIYA PARAMBATHU KAVU	Puthukky, Neeleswaram	12º15'34.56"N 75º07'41.16"E	3.00

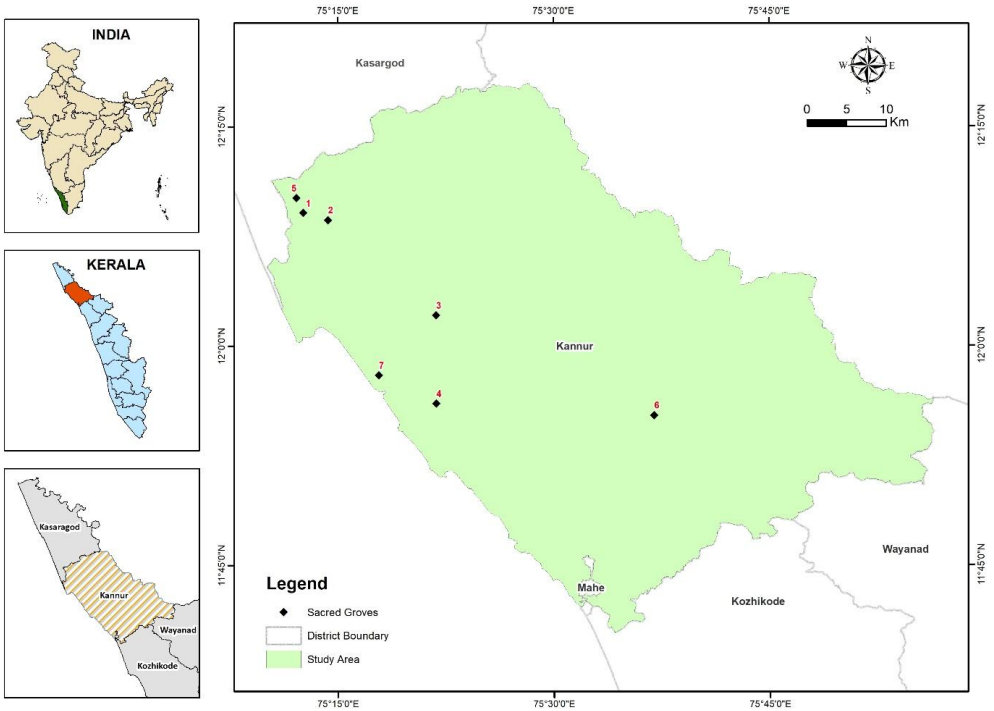

Fig. 2. Map showing the study area of Kannur district. (1) Chama Kavu, (2) Konganichal Kavu, (3) Madayi Kavu, (4) Neeliaar Kottam, (5) Palathara Kunji Kavu, (6) Poongottu Kavu, and (7) Thazhe Kavu.

Table 2. Details of sites covered for regional diversity in sacred groves of Kannur district.

Sl. No	Name of sacred groves	Location	Co-ordinates	Area of sacred grove (ha)
1	CHAMA KAVU	Vellur, Payyannur	12º09'07.03"N 75º12'35.5"E	3.640
2	KONGANICHAL KAVU	Thulluvadakkam, Alappadambu	12º08'36.41"N 75º14'18.76"E	3.320
3	MADAYI KAVU	Eripuram, madayi	12º02'05.5"N 75º21'50.0"E	6.06
4	NEELIAAR KOTTAM	Morazha, Anthoor	11º56'03.8"N 75º21'50.0"E	8.7
5	PALATHARA KUNJI KAVU	Karivellur	12º10'07.0"N 75º12'07.9"E	1.00
6	POONGOTTU KAVU	Mattannur, Poongottu	11º55'14.7"N 75º36'58.9"E	14.60
7	THAZHE KAVU	Thekkumbadam, Mattul	11º57'59.3"N 75º17'50.9"E	7.52

Material and Methods

The study areas were located in Kasargod and Kannur districts of northern Kerala. Kasargod district is one of the 14 districts in the southern Indian state of Kerala; it is located in 12°30'0"N, 075°0'0"E with an area of 1,992 km^2. The following 15 sacred groves were selected for the study according to the area and habitat type: (1) Edayilekadu Kavu, (2) Kammadom Kavu, (3) Koyithatta Sree Dharmasastha Kavu, (4) Mannam Purathu Kavu, (5) Sree Malliyodan Kavu, (6) Payyamkulam Kavu, (7) Periyanganam Sree Dharmasastha Kavu, and (8) Puthiya Parambathu Kavu are the sacred groves coming under Kasargod district (Fig. 1 & Table 1).

Kannur is one of the 14 districts along the west coast in the state of Kerala; it is located in 11°52'8.04"N, 075°21'19.66"E with an area of 2,966 km^2. The sacred groves coming under Kannur district are: (1) Chama Kavu, (2) Konganichal Kavu, (3) Madayi Kavu, (4) Neeliaar Kottam, (5) Palathara Kunji Kavu, (6) Poongottu Kavu, and (7) Thazhe Kavu (Fig. 2 & Table 2).

The general floristic composition and physiognomy of vegetation of the sacred grove are typically like the low-level evergreen forest. Floristic variations have occurred in many sacred groves exposed to human and animal interferences and climatic and edaphic changes. Generally, vegetation of the study area is divided into evergreen, semi-evergreen, freshwater Myristica swamp, moist deciduous, and mangroves (Sumesh & Sudhikumar, 2020).

The meteorological data of the study area during the study period were as follows: average annual rainfall was 779.94 mm in 2016-2017 and 970.51 in 2017-2018. May and October were the wet months while November to April is relatively dry. Relative humidity was always greater than 75%. Range of the temperature was between 18.43°C and 32.99°C. Different parameters like rainfall data, temperature, relative humidity and location details were recorded using various methods. Sampling area sites were recorded by using global positioning system (GPSmap76CSx). Temperature and relative humidity were recorded by using hygrometer (MextechM288CTHW digital thermo hygrometer with indoor/outdoor temperature). Rainfall data sets for the representative area over the study region was derived from the high-resolution gridded rainfall data sets of India Meteorological Department (IMD- Pai *et al.*, 2014).

Spider sampling was carried out from February 2016 till January 2018. The study period was divided into pre-monsoon, monsoon, and post-monsoon seasons and samples were collected from each season. A total of 90 samples were collected during the study from 15 sacred groves. Spiders were collected in the morning from 7.00 am to 10.00 am and evening from 4.00 pm to 7.00 pm. Line transect method (Lubin, 1978) were adopted in this study. A total of 30 fixed transects (100 m in length) were established across the 15 sacred groves. Spiders were collected along 100 m transect length of two transects per habitat. Each transect was sampled 1 hour, thus adding up to 1-2 hours for a study area. Standard sampling techniques such vegetation beating, litter sampling, ground hand collection, aerial hand collection, and sweep netting were employed to collect the spiders from their own habitats. To avoid the edge effect, transects were fixed 25 m inside from the boundary.

All collected specimens were kept in separate vials with proper labelling and other notes of taxonomic importance. They were sorted and an effort was made to identify live specimen using reference books like Sebastian & Peter (2009) up to at least family or genus level and recorded from the field itself. They were preserved in 70% ethyl alcohol. Some adults of each species or morpho-species were preserved as voucher specimen with proper cataloguing. Comparatively large specimens were photographed with the help of special digital camera and lens (Canon EOS 5D digital SLR and Canon 180 mm macro lens). Preserved specimens were examined under a stereo zoom microscope (Leica-M205C) in the laboratory for taxonomic identification. They were subjected to detailed taxonomic examination. Adult specimens were identified by the detailed examination of genital structures like epigyne and palp. Juveniles also identified by morphological examination by using standard literature (Sebastian & Peter, 2009; Tikader, 1987; Barrion & Litsinger, 1995; Jocqué & Dippenaar-Schoeman, 2006).

The abundance-based data were analysed with SpadeR package version 0.1.1 (Species Prediction and Diversity Estimation, Chao & Chiu, 2016) and iNEXT package 2.0.9 (Hsieh *et al.*, 2016; Chao *et al.*, 2014) also give the 95% confidence intervals to define the sampling variation, constructed using 200 bootstrap replications (Chao, 1987; Chao & Chiu, 2016). The relative abundance based Morisita-Horn dissimilarity index (q=1) was used to find the overall and the pairwise dissimilarities of the five habitats, using the SpadeR package (Chao & Chiu, 2016). Regional diversity analysis was done by using a non-parametrical test called Wilcoxon rank sum test.

Table 3. Diversity parameters of the two regions.

VARIABLES	KASARGOD	KANNUR
Total individuals	2904.00	8404.00
Species richness	109.00	220.00
Estimated richness ± se	122.60±8.17	227.38±4.36
Mean richness ± sd	15.44±6.02	39.64±9.04
Mean abundance ± sd	60.50±41.34	200.10±67.89
Average observed Shannon ± sd	10.31±3.60	24.05±8.01
Average Simpson Diversity	7.85	16.64
Observed Simpson sd	2.77	6.54
Singleton	17.00	19.00
Doubleton	13.00	23.00

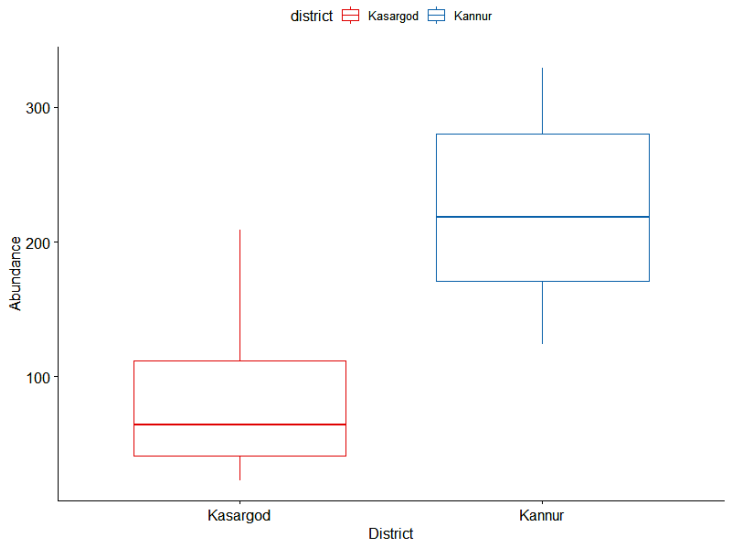

Fig. 3. Box plots showing the abundance of spider assemblages in Kasargod and Kannur districts.

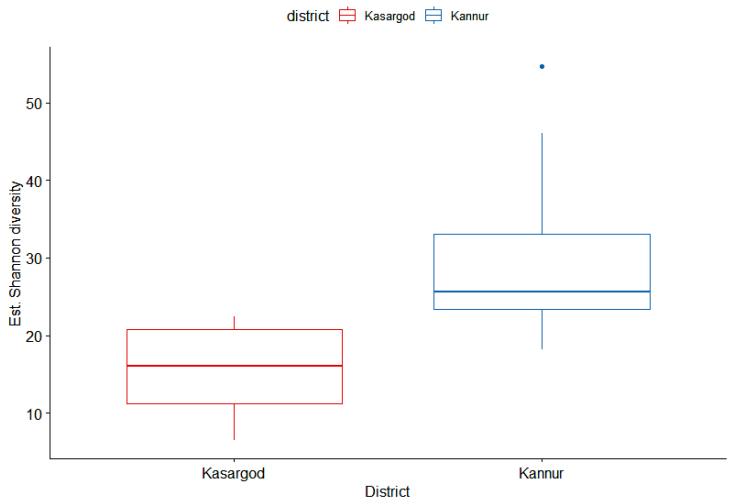

Fig. 4. Box plots showing the estimated Shannon diversity of spider assemblages in Kasargod and Kannur districts.

Results

This study assesses diversity in the study areas located in two districts (Kasargod and Kannur) of northern Kerala. Analyzing different facets of local diversity (abundance and diversity) and the contribution of species differentiation (beta diversity) among localities and habitat types to the composition of regional diversity. This study found 11308 individuals of 257 spider species/ morpho-species. Local diversity differs among two sampled localities. At the habitat level, the different facets of biodiversity followed a clear pattern, where sacred grove spiders of Kannur have higher abundance and diversity than Kasargod.

Abundance and Diversity

Abundance and variation of species diversity (Shannon index) follow the same trend. A total of 2904 individuals with 109 species were collected from Kasargod district

and 8404 individuals with 220 species were collected from Kannur district. Singletons and doubletons were higher in Kannur district (19 and 23) and other variables are represented in Table (3). For testing hypothesis, we took 4 evergreen habitats from both districts to compare diversity, whether there is any significant difference in the abundance and estimated Shannon diversity among samples from two districts. Wilcoxon rank sum test was used to test the hypothesis. Sacred groves of Kannur district have significantly higher values of abundance (Fig. 3) and diversity (Fig. 4). Result of the test was $p < 0.001$, for abundance ($w=13.5$, $p=1.594e-08$) and diversity ($w=25$, $p=6.21e-08$), so these regions show a significant variation (Figs. 3 & 4).

Beta diversity

The overall similarity in Kannur district was 80.01%, with a 95% confidence interval of 79.25% and 80.77%. Overall similarity of Kasargod district was 79.12%, with a 95% confidence interval of 77.80% and 80.44% (Tables 4 & 5). The similarity between the two districts were 68.58% with a 95% confidence interval of 66.65% and 70.50%.

Table 4. Overall similarity within group.

Regions	Estimate	se	95%LCL	95%UCL
Horn size weighted (q=1) Kasargod	0.7912702	0.006722607	0.7780938	0.8044465
Horn size weighted (q=1) Kannur	0.8001879	0.003874392	0.7925941	0.8077817

Table 5. Similarity between groups.

	Estimate	se	95%LCL	95%UCL
Horn size weighted (q=1)	0.6858151	0.009833422	0.6665416	0.7050886

Discussion

The geographical and climatic patterns have a crucial role in spider assemblages. Analysis of different facets of regional diversity in sacred groves of Kannur and Kasargod districts shows significant difference. A clear difference present in between climatic, geographical features and elevation pattern in both districts. Kannur experiences a rare humid tropical monsoon climate and has an elevation of 1.02 metres (2.98 ft). Kasargod has a tropical climate and has an average elevation of 19 metres (62 ft). Analyzing different facets of local diversity (abundance and diversity), and the contribution of species differentiation (β diversity) among localities and habitat types is very important to determine the composition of regional diversity. At the habitat level, the different facets of biodiversity followed a clear pattern, where sacred grove spiders of Kannur than Kasargod. Land management strategy design incorporating patterns of spider diversity at an appropriate regional scale is essential for the spider biodiversity conservation (New, 1999). It is feasible starting from the local knowledge of the diversity considering that this has a high correlation with the vegetation complexity that appears as a powerful predictor of the local spider species richness on a regional scale (Jiménez-Valverde & Lobo, 2007).

In sacred groves, the presence of contrasting habitats and the variation between localities have a great influence in orb-weaving spider communities, leading to an important contribution of beta diversity to the regional spider species richness. Management for conservation in the sacred groves should be directed towards promoting natural spatial heterogeneity, giving special emphasis to habitat mosaics in different

localities (Rubio & Moreno, 2010). However, to provide a better framework for conservation management, other biological groups should be studied. Moreover, microhabitat variables and disturbance effects should also be investigated because they may stand for important factors influencing diversity, especially in order to assess the potential anthropogenic activities in this type of protected areas.

Many more habitats have to be studied until the relationship between local and regional species pool of spiders can be understood. This study has considered diversity in spider assemblages with respect to sample size and habitat heterogeneity. However, other factors such as productivity, latitudinal gradient and size of the regional species pool have been suggested to influence species richness (Huston & Huston, 1994; Koleff & Gaston, 2002). It was not possible to assess the impact of these factors quantitatively because only limited sites per habitat type were sampled. But with its emphasis on the diversity patterns at small scale the present study may help to outline ideas for design of monitoring programmes and future inventories.

This study revealed that the value of different habitats will depend on their size and location. The amount of under story vegetation has a strong influence on spider abundance and diversity, thus affecting the amount of habitat available to spider occurrence. Therefore, diversity can be maintained as far as suitable habitat structure is provided. So that spiders can perceive the connectivity of different habitats. Studies revealed that optimum species richness influence habitat heterogeneity (Uniyal & Hore, 2008). This allows a narrow niche separation (Bonn & Kleinwächter, 1999), hence benefiting the persistence of species with divergent habitat preferences and interrelated sets of species traits. This study recommends that the spider fauna of sacred groves is rich and useful for monitoring work, and that support for the conservation of this area should be continued. More individual spider species need to be studied in order to evaluate their indicator values that would help in establishment of a longer list of indicator species for sacred grove management. Thus, it might be wise to extend this survey to other parts of Kerala, since it might increase the number of known species in this ecosystem.

Acknowledgments

The authors are thankful to Fr. Dr. Jolly Andrews, Principal, Christ College, Irinjalakuda, Kerala, India, for providing necessary facilities for this research. We are deeply acknowledging the authorities of different sacred groves of Kannur and Kasargod districts for providing the permission for sample collection and this study was funded by e-grantz: SC-ST Development Department, Government of Kerala, India.

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