

Research Article

Structural Composition of Menispermaceae Family in Central Western Ghats, India

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(Received: January 08, 2024; Revised: April 17, 2025; Accepted: April 18, 2025)

ABSTRACT

This study investigates the diversity, distribution, and conservation status of the Menispermaceae family in the Central Western Ghats of India, emphasizing their ecological roles as climbers and lianas in tropical forest ecosystems. Given their medicinal significance, several Menispermaceae species face conservation threats, with some classified as vulnerable in the Western Ghats. The primary objective was to assess species richness, frequency, density, abundance, and Species Importance Value (SIV) of Menispermaceae, alongside evaluating Alpha and Beta diversity indices to examine spatial variation in species distribution. Stratified random sampling was done by belt transect method for vegetation sampling in twenty selected study sites of Central Western Ghats. As a result of sampling twenty study sites in Central Western Ghats, 9 genera and 10 species with total of 493 individuals of Menispermaceae were found. Among them *Cyclea peltata* exhibited the highest frequency, while *Diploclisia glaucescens* and *Cissampelos pareira* showed the highest density and abundance, respectively. *Coscinium fenestratum* recorded the highest SIV, signifying its ecological prominence. Among the surveyed areas, Uttara Kannada (Karnataka) displayed the highest species diversity, while Kodagu (Karnataka) recorded the highest Climber to Tree Diversity ratio. This study provides crucial insights into the distribution, ecological functions, and conservation needs of Menispermaceae, contributing to a deeper understanding of tropical forest dynamics in the Central Western Ghats.

Keywords: Menispermaceae, Dioecious species, Moonseed, Diversity, Whitfor value, PCA, Climber-Tree ratio.

INTRODUCTION

The Menispermaceae family, commonly known as the 'Moonseed' family, comprises climbing plants that are widely distributed and primarily dioecious. Its name, derived from the Latin words for 'crescent moon' and 'seed', namely 'menis' and 'sperma', carries a mystique (Ortiz *et al.*, 2016). Contemporary evaluations suggest that the taxonomic diversity within the family encompasses roughly 72 genera and 526 species (Ortiz *et al.*, 2007, Ortiz *et al.*, 2016). In India, 14 genera and 22 species were described by Cooke (1901), while in Karnataka, Saldanha (1984) identified 9 species and Bhat (2014) recorded 7 species of Menispermaceae in the South Canara region. Within this botanical family, every single species holds medicinal significance, with one standout being *Coscinium fenestratum*, a Data Deficient species in the Western Ghats of India (IUCN, 2023). Although the Menispermaceae family is broadly distributed, its substantial medicinal value, particularly in the Western Ghats, necessitates focused conservation efforts. The species are extensively utilized by local medicinal practitioners, underscoring the importance of assessing their diversity within natural habitats. Accurate species identification is critical due to the family's polymorphic nature, which poses challenges in taxonomy. Species such as *Coscinium fenestratum*, classified as Data Deficient (IUCN, 2023), further emphasize the need for targeted conservation strategies to preserve these ecologically and pharmaceutically significant plants. The assessment of biodiversity within any region can be quantified through its constituent flora and fauna, which exhibit a heightened presence in the Western Ghats and the northeastern regions of India. The

Western Ghats and the eastern Himalayan region are not merely acknowledged as reservoirs of biological diversity; rather, they represent two critical hotspots of biodiversity. The variation in plant species within the Western Ghats exhibits an increasing trend from east to west and from north to south, which correlates positively with an escalation in precipitation (Karthik & Vishwanath 2012). The Western Ghats host a diverse array of plant species that hold significant economic and medicinal value. The Menispermaceae family represents a crucial source of products that are medicinally beneficial.

In tropical regions, certain areas exhibit higher levels of biodiversity and endemism, necessitating prioritization for conservation efforts. Due to their delicate nature, climber species are susceptible to any alterations in forest environments (Reddy and Parthasarathy, 2006). Recent studies have primarily focused on higher plants and tree species, often overlooking the crucial role of non-arboreal vegetation in contributing to tropical forest biodiversity. Within the realm of tropical forests, climbers represent a plentiful and varied life form, often serving as a distinctive physiognomic characteristic that distinguishes tropical ecosystems from temperate ones (Reddy and Parthasarathy, 2003, Nabe-Nielsen, 2001). The presence of climbers significantly enhances the floristic, structural, and functional diversity of tropical forests, often competing with other types of vegetation. Furthermore, climbers offer various benefits to forests such as providing food sources, habitats, and creating connections between tree canopies that serve as pathways for arboreal animals (Gentry and Emmons, 1987). Additionally, climbers play a crucial role at the ecosystem level by contributing to the carbon balance of

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Tropical forests, accounting for up to 10% of the total fresh aboveground biomass (Putz, 1984).

Our work attempts to address one of the significant climber families Menispermaceae, which includes many medicinal plants, within these parameters. Despite its tiny size, the family includes some plants whose significant pharmacological activity has been acknowledged by science. Promising anti-allergic, immunosuppressive, depressive, anticancer, vasodilatory, and muscle-relaxant properties were demonstrated by alkaloids isolated from *Cissampelos sp.*, such as warifteine, methylwarifteine, berberine, hayatin, and hayatidin (Semwal *et al.*, 2014). In coastal Karnataka, India, the *Coscinium fenestratum* plant is utilized in traditional herpes treatments together with other medicinal herbs (Rai *et al.*, 2013) and also *Coscinium fenestratum* is recognized as significantly affected by considerable exploitation within its natural environment for economic purposes (Karthika, 2019). *Tinospora cordifolia* is an important plant in traditional Ayurvedic medicine. It has long been used to treat a variety of conditions, including fever, jaundice, dysentery, cancer, fever, skin diseases, toxic insects, snake bites, and eye problems (Soham & Shyamashree, 2012).

When it comes to the conservation aspects, limited research has been conducted in India on the diversity and molecular characteristics of the Menispermaceae family. Research has been conducted worldwide on fossils in Eastern Asia. The research also focused on the study of the diversification of tropical rainforests near the Cretaceous–Paleogene boundary (Wang *et al.*, 2012; Wefferling *et al.*, 2013). These studies focused on Menispermaceae fruit characteristics, specifically examining the highly variable endocarps. Endocarps play a crucial role in the identification of extant and fossil specimens, as well as in determining phylogenetic relationships.

Given its considerable pharmacological significance, it is crucial to conserve Menispermaceae species in their native habitat to mitigate the risk of over-exploitation. The Menispermaceae family plays a significant role in forest ecology and possesses notable medicinal properties. Therefore, investigating their diversity and distribution is essential to resolve identification challenges caused by the polymorphic nature of some species (Jain *et al.*, 2025) and to accurately assess their presence in the Central Western Ghats.

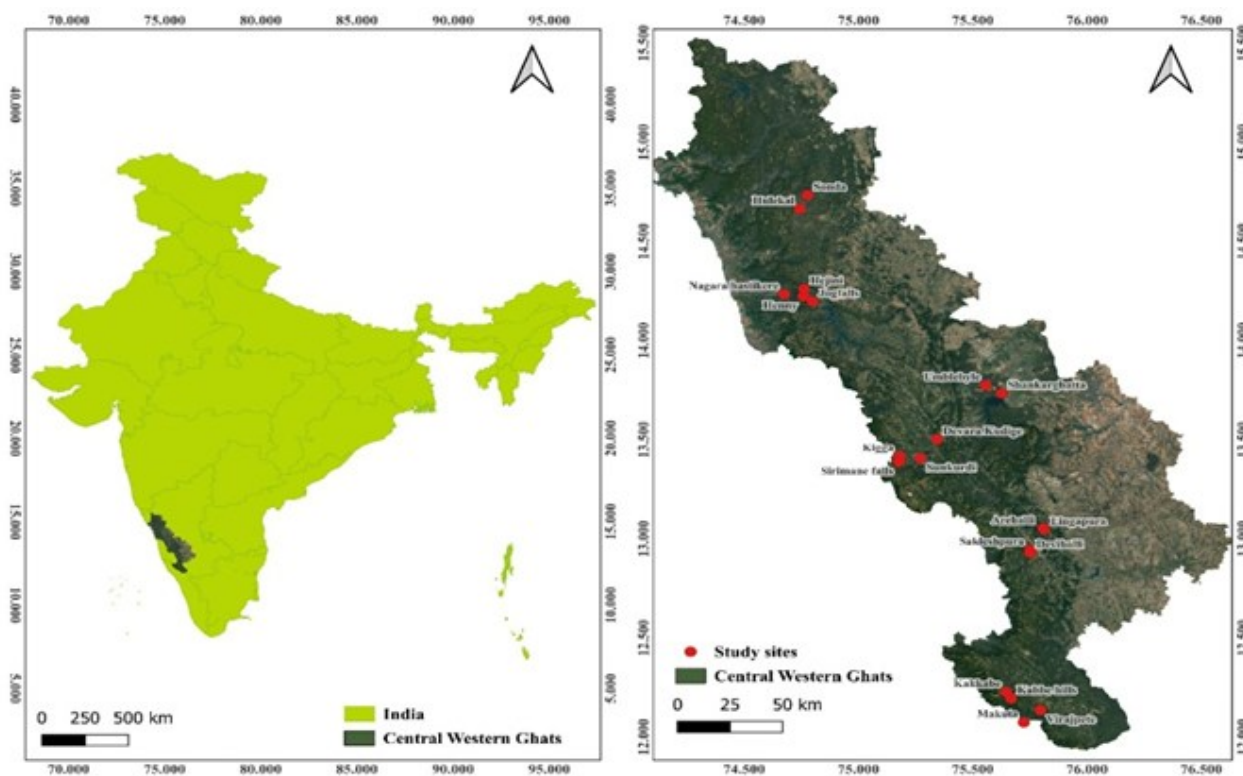


Figure 1. Geographical map of the study site: Central Western Ghats, India

MATERIALS AND METHODS

Study area

The area examined for the research project conducted spanned from the year 2021 to 2023 and included various specific geographical locations located within the Central Western Ghats of Karnataka in India (Fig. 1). It is pertinent to note that the Western Ghats region is renowned for its exceptional richness in terms of both flora and fauna, owed largely to its designation as a prominent biodiversity hotspot on a global scale. Prominent districts such as Uttara Kannada,

Shivamogga, Chikkamagaluru, Hassan, and Kodagu form part of Karnataka's expanse of the Western Ghats, each contributing uniquely to the overall ecological landscape. Within this region, a diverse array of forest ecosystems thrives, ranging from the dry deciduous forests to the lush evergreen forests and the unique Shola vegetation that characterizes the area. Furthermore, the landscape is also adorned with the presence of semi-evergreen forests, moist deciduous forests, and buffer forests, each playing a crucial role in the intricate web of biodiversity within this region.

FIELD METHODS

Table 1. Details of the Distribution sites with forest type, district and geographical location from Central western Ghats, India.

Study site	Location Name	Forest type	District	Latitude in Decimals	Longitude in Decimals
P1	Umblebyle	Dry deciduous	Shivamogga	13.77369	75.55754
P2	Shankarghatta	Moist deciduous	Shivamogga	13.73347	75.62771
P3	Henny	Evergreen	Shivamogga	14.22362	74.76028
P4	Jogfalls	Evergreen	Shivamogga	14.1963	74.79964
P5	Kigga	Evergreen	Chikkamagaluru	13.41648	75.18102
P6	Sirimane falls	Evergreen	Chikkamagaluru	13.38807	75.17775
P7	Sunkurdi	Semi Evergreen	Chikkamagaluru	13.40572	75.27179
P8	Devara Kudige	Semi Evergreen	Chikkamagaluru	13.50089	75.34408
P9	Lingapura	Semi Evergreen	Hassan	13.04594	75.8147
P10	Arehalli	Semi Evergreen	Hassan	13.05198	75.80904
P11	Sakleshpura	Evergreen	Hassan	12.94457	75.75122
P12	Devihalli	Evergreen	Hassan	12.92982	75.75122
P13	Hulekal	Semi Evergreen	Uttara Kannada	14.6637	74.74369
P14	Sondha	Evergreen	Uttara Kannada	14.73305	74.77782
P15	Nagara bastikere	Evergreen	Uttara Kannada	14.23358	74.67545
P16	Hejini	Evergreen	Uttara Kannada	14.25939	74.76279
P17	Makutta	Evergreen	Kodagu	12.07412	75.72405
P18	Virajpete	Evergreen	Kodagu	12.13543	75.79639
P19	Kabbe Hills	Evergreen	Kodagu	12.1941	75.66808
P20	Kakkabe	Evergreen	Kodagu	12.22747	75.64636

Table 2. Checklist of Menispermaceae species

Sl.No	Species	Species code	Collection ID	Herbarium ID
1	<i>Anamirta cocculus</i>	S1	ABMI01	KUAB821
2	<i>Cissampelos pareira</i>	S2	ABMI02	KUAB822
3	<i>Coscinium fenestratum</i>	S3	ABMI03	KUAB823
4	<i>Cocculus hirsutus</i>	S4	ABMI04	KUAB824
5	<i>Cyclea peltata</i>	S5	ABMI05	KUAB825
6	<i>Diploclisia glaucescens</i>	S6	ABMI06	KUAB826
7	<i>Stephania japonica</i>	S7	ABMI07	KUAB827
8	<i>Stephania japonica</i>	S8	ABMI08	KUAB828
9	<i>Tinospora cordifolia</i>	S9	ABMI09	KUAB829
10	<i>Tinospora sinensis</i>	S10	ABMI10	KUAB830

Field surveys were conducted frequently in selected study sites of Central Western Ghats. The determination of the sampling sites was conducted by stratified sampling with a random start method. A standard 4 × 250 m belt transect was laid in each study area covering 2 transects in each study site (Srinivas and Krishnamurthy 2016) (Table.1). Locations of the Menispermaceae species are noted down for mapping. Frequency, density, abundance, Species Importance Value (SIV) and other diversity indices were statistically using the standard formula. Within the transects, Menispermaceae species and allied species were counted. Samples were photographed and collected to prepare the herbarium. Prepared herbariums are deposited in Department of Applied Botany, Kuvempu University (Table.2). Utilizing Floras, Monographs, and literature the identified trees were verified. The currently approved names for the identified tree species were assigned using an online database by means of The World Flora Online (www.worldfloraonline.org). The assignment of a species to the family was done as per Angiosperm Phylogeny Group IV system of classification.

DATA ANALYSIS

Assessment of species composition and structural diversity:

Apparency of a plant was tested by analyzing species availability and availability was tested by applying the phytosociological and diversity indices. Quantitative attributes of the woodland ecosystem including frequency, density, abundance, SIV, relative frequency, relative density, relative and dominance were calculated within a Microsoft Excel document through mathematical formulations (Cottam and Curtis, 1956; Kunwar *et al.*, 2020).

Species Importance Value index was used to characterize the forest locations and verify the patterns of abundance of the species. This was calculated as follows:

Frequency (F) = (Number of transects in which the species occurred) / (Total number of transects studied)

Relative Frequency (RF) = (Frequency of a species) / (Total frequency of all species) × 100

Density (D) = (Number of individuals of the species) / (Total number of transects studied) .

Relative Density (RD) = (Density of a species) / (Total density of all species) × 100

Abundance (A) = (Total number of individuals of a species in all transects) / (Number of transects in which the species occurred) .

Relative Abundance (RA) = (Abundance of a species) / (Total abundance of all species) × 100.

SIV (Species Importance Value) = Relative frequency + Relative density.

Distribution pattern of the Species

(WI) Whitford Value = Abundance/Frequency (Whitford 1949; Srinivas and Krishnamurthy, 2016;

Shashwathi *et al.*, 2024; Magurran and Magurran, 1998; Magurran, 2013).

Analysis of Alpha and Beta diversity:

Alpha diversity was analyzed using Shannon-Wiener and Simpson's diversity indices.

(Magurran 1988). They were calculated with the help of PAST software version-

4.03. and by Microsoft Excel

Shannon – Wiener index: $(H') = -\sum P_i \ln(P_i)$

where, $P_i = n_i / N$

n_i = number of individuals in the species

N = the total number of individuals of all species

Here, quantity P_i is the proportion of individuals found in the species

$$\sum \frac{n_i(n_i-1)}{N(N-1)}$$

Simpson's index (D) =

where n_i = the number of individuals in the i^{th} species

N = the total number of individuals.

A beta diversity study was conducted by comparing 20 different research locations. Using the presence and absence data for Menispermaceae species, Multivariate Cluster analysis was carried out in PAST program version 4.03 to estimate beta diversity (Hammer and Harper *et al.*, 2001). Neighbour Joining and traditional UPGMA algorithms with the Jaccard similarity index were used for cluster analysis.

Variability Test (PCA) for Diversity and distribution pattern of Menispermaceae species

Principal Component Analysis (PCA) is a method that found its application in the realm of PAST4.03. Principal Components (PCs) having eigenvalues greater than 0.05 were singled out, as highlighted by (Jeffers 1967; Török *et al.*, 2021), and standardized values were harnessed for the execution of PCA. The PCA procedures were carried out relying on a variance-covariance matrix (Liu *et al.*, 2020). Assessment of the key influencers on variation was done visually using the Scree plot. Through the PAST4.03 application, a scatter plot was crafted encompassing all diversity and distribution characteristics.

RESULTS

Understanding spatial biodiversity patterns and the mechanisms shaping them is crucial for advancing ecological knowledge (Moakny *et al.*, 2022). Phytosociological parameters, through quantitative data, are key to uncovering community dynamics within forest ecosystems. This study analyzes the diversity and composition fluctuations of arboreal species (Bhat *et al.*, 2020) and highlights the floral diversity of the Central Western Ghats. Each plant species plays a vital role in forest ecosystem balance, with woody climbers contributing significantly to biodiversity and ecosystem functions (Schnitzer & Bongers, 2002; Parthasarathy *et al.*, 2015)

A total of 2160 species were identified across 65 families in twenty study sites located in the Central Western Ghats of India. The Menispermaceae family, known for its climbing characteristics, plays a

Plant species diversity

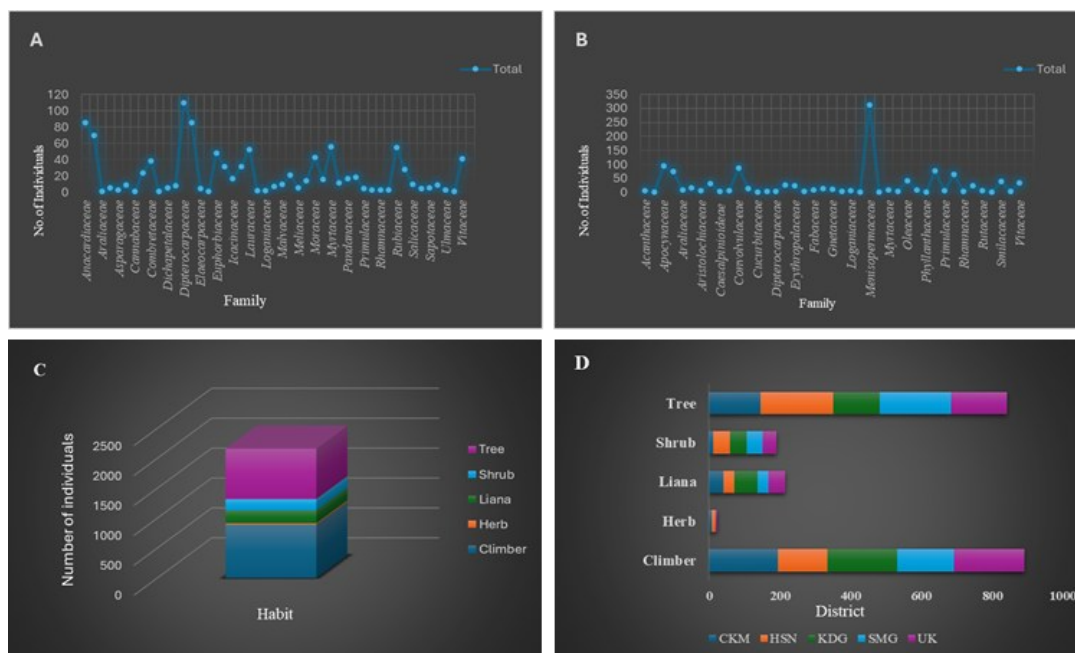


Figure 2. A. Species composition of Tree species in study area B. Species composition of Climber species in study area C. Percentage of Habit diversity in study area D. Percentage of habit occur in each district from study area.

significant role in the ecosystem alongside other climbing species.

Additionally, the presence of trees and understorey vegetation is crucial as climbers rely heavily on them for support. The data on diversity reveals the occurrence of 41 Climber families and 47 tree/Understorey families. Menispermaceae stands out with the highest number of individuals among Climber families, followed by Apocynaceae and Convolvulaceae (Fig. 2.A). In the tree family category, Dipterocarpaceae takes the lead, followed by Anacardiaceae and Ebenaceae (Fig. 2 B). Analysis of habit conditions shows that Climbers (Vines, Woody climbers, creepers) constitute 51.29% of the total, with trees following at 38.93%, and understorey (Herbs and shrubs) lagging behind at 9.76% (Fig. 2 C).

The comparison of all five districts encompassing the twenty study sites reveals that HSN (205) and SMG (202) districts exhibit the highest tree species richness, while UK (200+49) and KDG (197+65) are highlighted as the most diverse sites, particularly in terms of climbers and Liana respectively. HSN (47+10) and KDG (49) the showed the higher diversity in the understorey (Herb+Shrub) category respectively (Fig.2. D). The species composition varies significantly across the five districts and twenty study sites. Overall, in this study UK (448) showed the highest species composition followed by KDG (442) and SMG (438). In contrast, CKM (398) showed lower species composition.

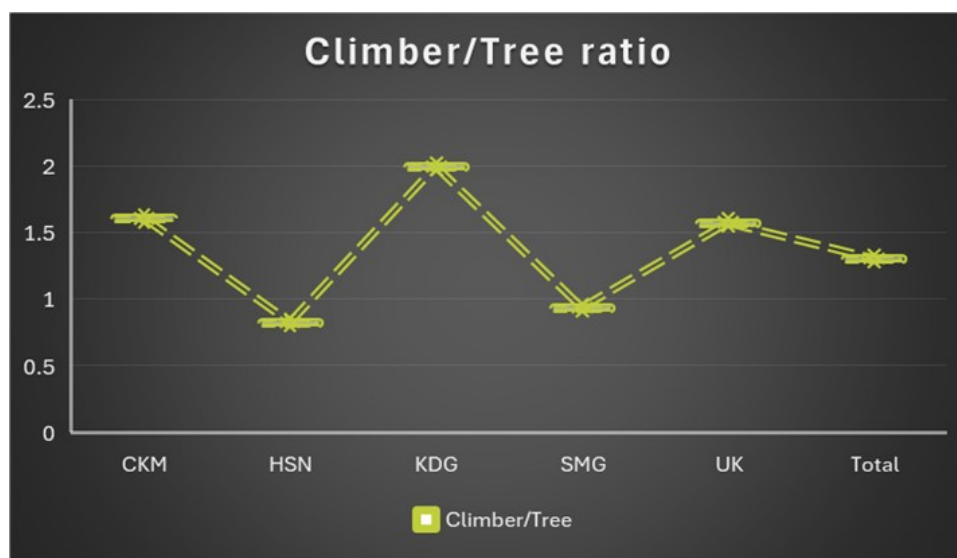


Figure 3. Climber, Tree ratio exhibiting the diversity of Selected study sites.

For the diversity of Climber species, it is very important to know the climber vs tree diversity ratio in that study area. In our study site, KDG district exhibited higher

Climber diversity/ Tree diversity ratio i.e., 2.0 then CKM and UK both exhibited same Climber diversity/ Tree diversity ratio value of 1.6 (Fig. 3).



Figure 4. Menispermaceae Species present in Central Western Ghats, India. A. *Anamirta cocculus* B. *Coscinium fenestratum* C. *Diploclisia glaucescens* D. *Cocculus hirsutus* E. *Stephania japonica* F. *Tinospora sinensis* G. *Tinospora cordifolia* H. *Stephania japonica* I. *Cyclea peltata* J. *Cissampelos pareira*.

Climber Diversity VS Tree Diversity ratio

The number of individuals and species composition of Menispermaceae species were used to examine the species richness of selected study areas. Among the Menispermaceae family members, *Cyclea peltata* and *Diploclisia glaucescens* were noted for showing the greatest abundance, totaling 62 individuals, with *Stephania japonica* closely behind with 61 individuals. *Fibrauria darshanii* was not observed within the study sites situated in the Central Western Ghats region. In a particular study site, namely, *Cissampelos pareira*, *Cocculus*

pareira, *Cocculus hirsutus*, and *Tinospora cordifolia* were exclusively observed within the confines of the moist deciduous forest in the Shimoga district, while *Stephania japonica* was restricted to the Semievergreen patches in Hassan district. A detailed examination of the district-wise distribution revealed that Kodagu exhibited the highest count of Menispermaceae species, totaling 85 individuals, closely followed by Shimoga and Uttara Kannada with 85 and 71 species, respectively. Conversely, Hassan displayed a notably lower count of Menispermaceae species, with a mere 36 individuals being recorded (Fig. 5)

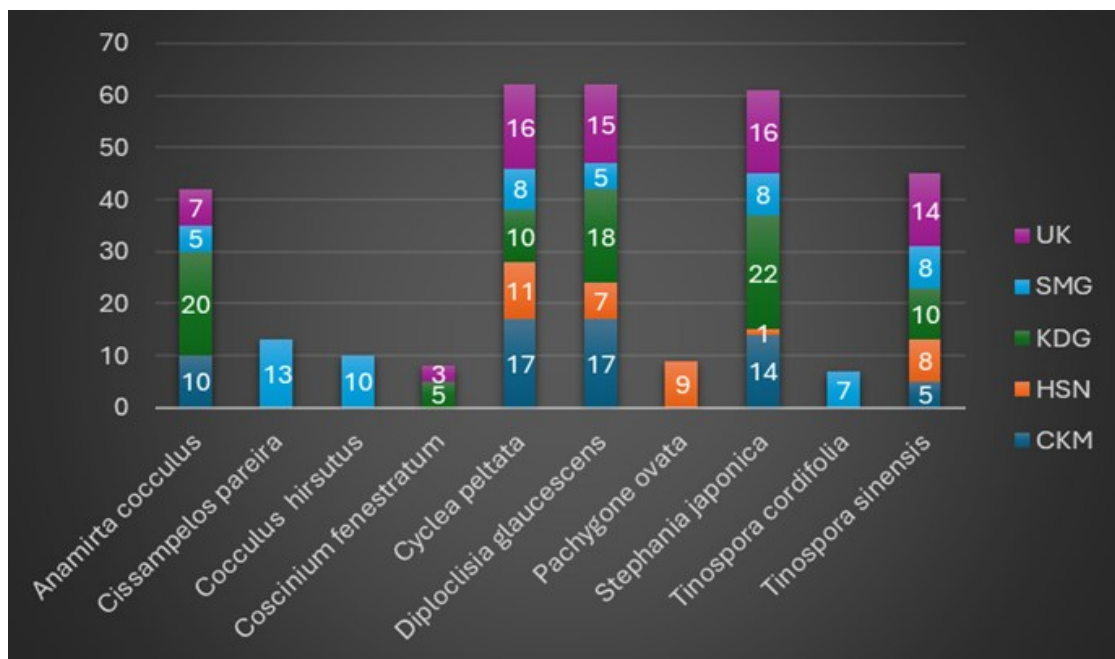


Figure 5. Species composition of Menispermaceae species in different study sites in the Central Western Ghats

As a result of sampling twenty study sites in Central Western Ghats, 9 genera and 10 species with total of 493 individuals of Menispermaceae were found. The species richness of Menispermaceae in the selected study sites was assessed based on species composition and individual counts. Site P16 exhibited the highest richness with six species and 27 individuals, including *Anamirta cocculus* (4), *Coscinium fenestratum* (1), *Cyclea peltata* (2), *Diploclisia glaucescens* (6), *Stephania japonica* (7), and *Tinospora sinensis* (7). P17 followed closely with five species and 23 individuals: *Anamirta cocculus* (5), *Coscinium fenestratum* (3), *Cyclea peltata* (3), *Diploclisia glaucescens* (4), and *Stephania japonica* (8). P18 and P20 each recorded five species and 22 individuals, with similar species distributions. P9-Linapura and P12-Devihalli showed the lowest richness, with three species and nine individuals. A detailed distribution of all 10 species across study sites is shown in Fig. 3.

Among the Menispermaceae, *Cyclea peltata* and *Diploclisia glaucescens* exhibited the highest richness, with 62 individuals each, followed by *Stephania japonica* with 61 individuals. At site P2, *Cissampelos pareira*, *Cocculus hirsutus*, and *Tinospora cordifolia* were exclusively found in the moist deciduous forest. In contrast, *Diploclisia glaucescens*, *Anamirta cocculus*, *Coscinium fenestratum*, *Stephania japonica*, and *Pachygone ovata* were restricted to evergreen and semievergreen sites (P4-P20). *Tinospora sinensis* and *Cyclea peltata* were observed in both evergreen and deciduous forest sites.

Frequency, Density and Abundance of Menispermaceae family in Central Western Ghats of India.

Frequency: *Cyclea peltata* was the most commonly distributed species of the Menispermaceae family, representing a frequency value of 0.9 (21.42%) among 10 species as indicated by a floristic survey conducted in the study area. Conversely, *Diploclisia glaucescens* displayed a notable frequency value of 0.75 (17.85%) and notably avoided dry deciduous forests, being instead documented in 15 distinct locations within evergreen forests. *Cissampelos pareira*, *Cocculus hirsutus*, *Stephania japonica*, and *Tinospora cordifolia*, on the other hand, each presented a minimal frequency value of 0.1 (2.38%) and were restricted to a singular study site

apiece (Table.3).

Density: *Cyclea peltata* and *Diploclisia glaucescens* were the most densely observed species, each with a value of 3.1 (19.07%) recorded. *Stephania japonica* exhibited a similarly high density, with a value of 3.05 (18.76%), in close proximity to *Cyclea peltata* and *Diploclisia glaucescens*. Specifically, *Cyclea peltata* was present in 18 sites, while *Diploclisia glaucescens* was found in 15 out of the 20 study sites. In contrast, *Tinospora cordifolia* displayed the lowest density, with a value of 0.035 (2.15%) (Table.3).

Abundance: *Cissampelos pareira* is most abundant among the Menispermaceae species with a value of 6.5 (15.89%) followed by *Cocculus hirsutus* 5.0 (12.22%) and *Stephania japonica* 4.5 (11.004%). In the study sites the species mentioned above, flourish exclusively in secluded regions of just 3 distinct plant sites evading presence elsewhere (Table.3).

Relative frequency, density, dominance, and SIV of Menispermaceae species.

Based on the overall computation in (Fig.4 B), on the basis of Relative frequency and Relative Density, the species with the highest SIV in Menispermaceae within part of Central Western Ghats of India is *Coscinium fenestratum* (Fig 4 B) with a value of 1.93 (18.7%). Including *Coscinium fenestratum* (Fig.4 B), the following species comprise the top 4 species with the highest SIVs in the Central Western Ghats of India: *Cyclea peltata* 1.12 (10.90%) (Fig.4 I), *Tinospora sinensis* 1.11 (10.85%) (Fig.4 F) and *Tinospora cordifolia* 1.10 (10.73%) (Fig.4 G). Furthermore, species with the highest Relative density vary per sampling site (Table.3).

Spatial Distribution pattern of the Species:

Whitford (1949)'s formula, $WI = \text{abundance/frequency}$ (A/F Ratio), was used to calculate spatial distribution. According to Nda et al., (2013), a probability distribution is implied by a value < 0.025 , a contagious distribution is implied by a value > 0.05 , and a random distribution is implied by a value between 0.025 and 0.05 (Whitford, 1949). In our investigation, each species in the Menispermaceae family displayed greater than 0.05, indicating that the distribution pattern is contagious (Table.3).

Table 3. Ecological parameters of Menispermaceae species in the Central Western Ghats, India

Sl.No	Name of the species	F	D	A	RF	RD	SIV	A/F
1	<i>Anamirta cocculus</i>	0.6	2.4	4.000	14.286	14.769	0.967	6.7
2	<i>Cissampelos pareira</i>	0.1	0.65	6.500	2.381	4.000	0.595	65.0
3	<i>Cocculus hirsutus</i>	0.1	0.5	5.000	2.381	3.077	0.774	50.0
4	<i>Coscinium fenestratum</i>	0.2	0.4	2.000	4.762	2.462	1.935	10.0
5	<i>Cyclea peltata</i>	0.9	3.1	3.444	21.429	19.077	1.123	3.8
6	<i>Diploclisia glaucescens</i>	0.75	3.1	4.133	17.857	19.077	0.936	5.5
7	<i>Pachygone ovata</i>	0.1	0.45	4.500	2.381	2.769	0.860	45.0
8	<i>Stephania japonica</i>	0.7	3.05	4.357	16.667	18.769	0.888	6.2
9	<i>Tinospora cordifolia</i>	0.1	0.35	3.500	2.381	2.154	1.105	35.0
10	<i>Tinospora sinensis</i>	0.65	2.25	3.462	15.476	13.846	1.118	5.3

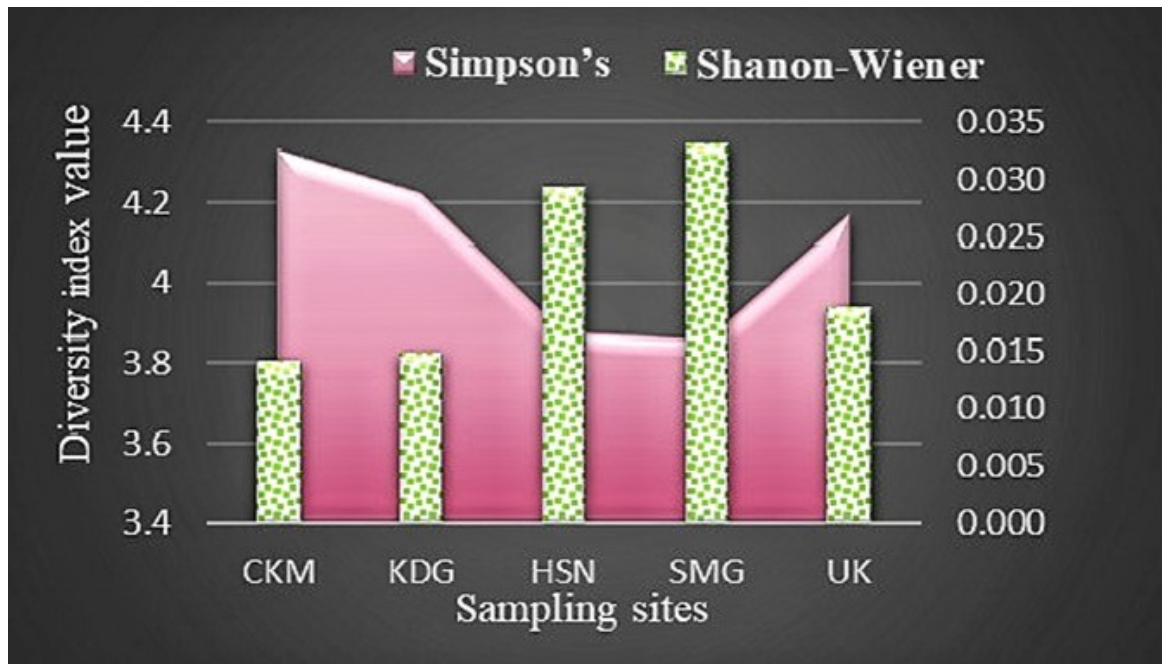
Diversity indices: Overall diversity of study sites

Figure 6. Shanon and Simpson diversity index in sampling sites in Central Western Ghats India.

The Shannon-wiener index (H) and Simpson's index (D), two significant non-parametric diversity indices, were used to quantify the alpha diversity of 5 districts with 20 distinct study sites. Using both the Shannon-Wiener and Simpson's indices helps capture different aspects of diversity. The Shannon index shows how evenly species are distributed, while the Simpson index focuses on species dominance. Together, they provide a fuller picture of both species richness and evenness, reducing bias that could arise if only one index is used. For example, a community with many rare species might have a high Shannon index but a low Simpson index if one species dominates (Magurran, 2013). The Shannon index is a diversity metric that considers both the total number of individuals and taxa. As per the Shannon-Wiener index, the region of SMG (Shivamogga) exhibited the highest value of 4.34 in index value of 0.33 among the five districts, implying relatively reduced diversity levels in this region when

compared with the others (Fig. 6). comparison to other regions, indicating a notable diversity. Conversely, the lowest Shannon value recorded is 3.805, observed in CKM (Chikkamagaluru) (Fig. 6).

According to Simpson's index, a value close to 1 indicates low diversity, while a value approaching 0 signifies high diversity. The current investigation reveals that the Simpson index for the study site SMG (Shivamogga) is recorded at the lowest value of 0.016. This observation implies that the region of Shivamogga demonstrates a diverse range, a pattern that is also reflected in HSN (Hassan) with a corresponding value of 0.017, indicating a noteworthy level of diversity. In contrast, the region of CKM (Chikkamagaluru) presents the highest Simpson index value of 0.33 among the five districts, implying relatively reduced diversity levels in this region when compared with the others (Fig. 6).

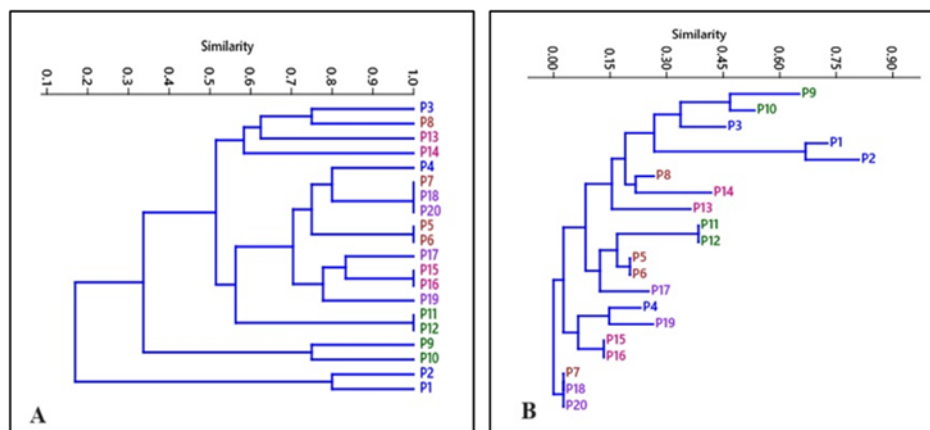
Beta diversity

Figure 7. Dendrogram representing beta diversity A. UPGMA B. Neighbor-joining

Beta diversity

Beta diversity serves as a metric for assessing the fluctuations in species diversity across different transects or environmental gradients, in conjunction with variations in species composition. Ecological communities can vary in species composition, especially in complex environments. Using both UPGMA and Neighbor-Joining methods helps account for different patterns of species turnover, whether constant or variable (Legendre & Legendre, 2012). The assessment of beta diversity encompassed the calculation of Jaccard similarity index across 20 distinct study sites from 5 districts, aiming to elucidate the disparities in Menispermaceae species composition. Subsequently, cluster analysis was carried out utilizing the classical Neighbor Joining and UPGMA algorithms, yielding dendrograms as the output. Remarkably, the clustering patterns of the study sites demonstrated a high degree of similarity in both dendrograms. The beta diversity study focused on Menispermaceae species present in 20 study sites. A total of 5 districts, encompassing the 20 study sites, were considered, including Evergreen, Semievergreen, Moist Deciduous, and Dry Deciduous Forest types.

Both the UPGMA and Neighbor Joining dendrograms depict the similarities among the 20 study sites, as outlined in (Fig.7A) and (Fig.7B), respectively, with distinct branches. Four groups displayed a Jaccard Similarity value of 1.00. The first group consists of P7, P8, and P20, representing Sunkurdi, Vaikuntapura, and Cheluvra, while the other groups, namely P5 and P6 (Kigga and Sirimane Falls), P15 and P16 (Nagara Bastikere and Mahime), and P11 and P12 (Sakleshpura and Devihalli), were identified as similar study sites.

Variability in Diversity and distribution pattern in Menispermaceae species within study site

Principal Component Analysis emerges as a frequently

employed method in the realm of data analysis, aimed at diminishing the dimensions of complex data sets without compromising valuable information. Its primary goal is to pinpoint the minimal set of factors that can account for the most significant portion of variability within the overall dataset, as proposed by Anderson (1972).

For analyzing the distribution patterns, the scree plot represents the study investigates the variation in five elements across different research locations through the application of PCA (Principal Component Analysis) technique on 10 species belonging to the Menispermaceae family. The analysis revealed an eigenvalue exceeding 0.05. Each of these components (species) is depicted through respective biplots on the axes. Notably, SMG is associated with S2, S3, and S9, KDG is linked to S1, S4, S6, S8, and S10, HSN corresponds to S7, and CKM represents S5. A noteworthy observation is the positive correlation between KDG and CKM highlighted by UK, indicating that UK aligns with both species depicted by KDG and CKM. Conversely, SMG and HSN exhibit a negative correlation as the species within these elements are confined to a limited area (Fig.8 A&B).

To explore the range of diversity within Menispermaceae species in the Central Western Ghats of India, various species diversity indices were analyzed. The study involved assessing seven diversity indices for all 10 species, including Frequency (F), Density (D), Abundance (A), Relative Frequency (RF), Relative Density (RD), SIV (Species Importance Value), and A/F (Whitford ratio for diversity patterns). The results, illustrated through the Scree plot (Fig.8 C) and Scatter plot (Fig. 10 D), indicated that while F, D, and A species exhibited similar diversity values, there was an upward trend from RF to A/F. This variation suggests that RF, RD, SIV, and A/F play significant roles in the study of diversity (Fig.8 C&D).

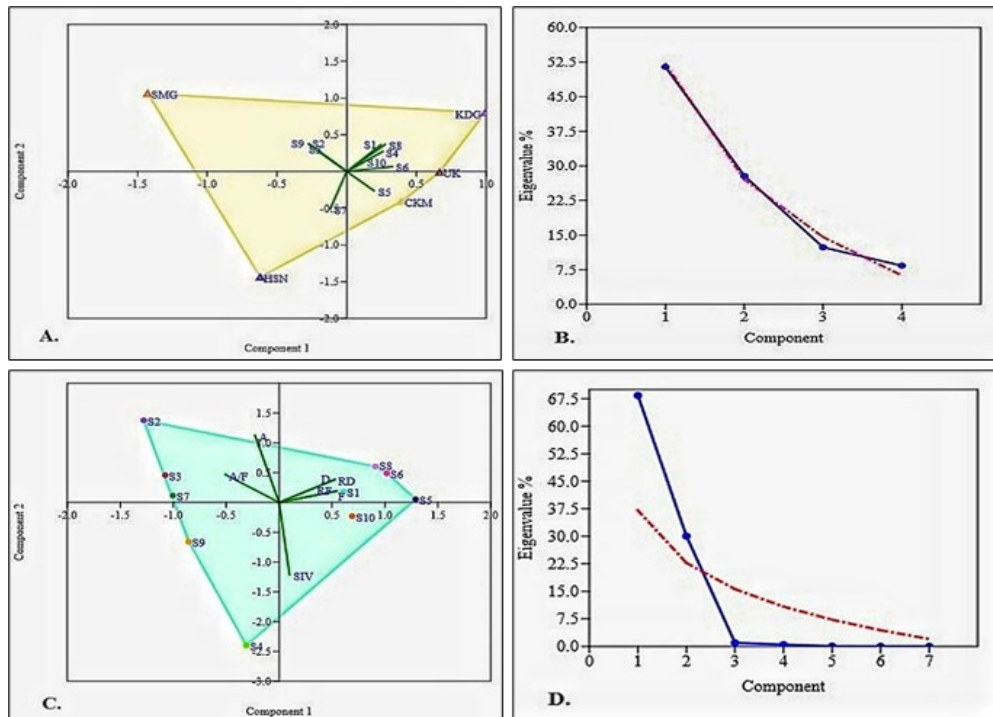


Figure 8. Biplots of the two principal component analyses of Menispermaceae species (A & B) Scatter and scree plot for Variability in Distribution pattern (C & D) Scatter and scree plot for Variability in Diversity concerning species diversity index.

DISCUSSION

Understanding spatial biodiversity patterns and their underlying mechanisms is crucial for ecological studies. Phytosociological analyses provide quantitative insights into forest community structures. A study in the Central Western Ghats assessed the diversity and composition of arboreal species, focusing on Menispermaceae climbers. Seven diversity indices—Frequency (F), Density (D), Abundance (A), Relative Frequency (RF), Relative Density (RD), Species Importance Value (SIV), and the Abundance/Frequency (A/F) ratio were evaluated across 10 species. Findings indicated that while F, D, and A values were similar, RF, RD, SIV, and A/F showed increasing trends, highlighting their significance in diversity assessments.

Comparative analysis across five districts and 20 study sites revealed that HSN and SMG had the highest tree species richness, whereas UK and KDG were more diverse in climbers and lianas. HSN and KDG also exhibited notable understorey diversity. UK demonstrated the highest overall species richness, followed by KDG and SMG, likely due to the presence of undisturbed evergreen forests. This aligns with observations that tropical evergreen forests support greater species richness. Notably, lianas constitute a significant portion of woody plant diversity, with studies reporting 11 to 31 liana species per hectare and up to 1,658 individuals per hectare in certain tropical dry evergreen forests.

Understanding the ratio of climber (including liana) to tree diversity is crucial, as lianas depend on trees for structural support and significantly influence forest dynamics. In the Central Western Ghats, this ratio varied across districts: Kodagu (KDG) exhibited the highest ratio at 2.0, followed by Chikmagalur (CKM) and Uttara Kannada (UK) at 1.6 each. Such variations underscore the interdependence between lianas and their host trees, with disturbances affecting tree populations potentially impacting liana diversity as well. Within the Menispermaceae family, species like *Cyclea peltata* and *Diploclisia glaucescens* were predominant. *Cyclea peltata* thrives in both evergreen and deciduous forests, making it widespread, while *Diploclisia glaucescens* is confined to evergreen and semi-evergreen habitats but shows strong regeneration capabilities. In contrast, species such as *Cissampelos pareira*, *Cocculus hirsutus*, and *Tinospora cordifolia* were less frequent, found in only a few study sites, yet exhibited high abundance where present.

The Species Importance Value (SIV) analysis highlighted *Coscinium fenestratum* as the most ecologically significant species, with an SIV of 1.93. This critically endangered liana is restricted to humid evergreen forests and is renowned for its medicinal properties. Its limited distribution and slow growth rate contribute to its endangered status, emphasizing the need for targeted conservation efforts. These findings illustrate the intricate relationships between lianas and trees in tropical forests, highlighting the importance of preserving both to maintain ecosystem balance and biodiversity. The study of Menispermaceae species in the Central Western Ghats reveals a clustered distribution pattern, as indicated by Abundance to Frequency (A/F) ratios (Whitford values) ranging from 0.06 to 65.00. This suggests that these species tend to aggregate in areas with favorable environmental conditions.

Diversity assessments across 20 research sites show Shannon index values between 3.805 and 4.34,

reflecting high species diversity. Simpson's index values range from 0.016 to 0.33, with lower values indicating greater diversity. Notably, Shivamogga district exhibits the highest Shannon index and the lowest Simpson's index, highlighting its rich biodiversity. Beta diversity analysis, using Jaccard's similarity index and cluster analysis, identifies four clusters with complete similarity (score of 1.00), grouping sites like Sunkurdi, Devara Kudige, and Kakkabe. These clusters are primarily distinguished by forest type, separating evergreen from deciduous species. Principal Component Analysis (PCA) further illustrates the complex interactions between species richness, frequency, and abundance across the study sites. The comprehensive analysis conducted in this study represents the current status of Menispermaceae within the selected study site. The findings of the study indicate that *Cyclea peltata* displayed the highest frequency among the species that were investigated. In addition, *Diploclisia glaucescens* and *Cissampelos pareira* were identified as having the highest density and abundance, respectively. Moreover, it was noted that *Coscinium fenestratum* emerged with the highest index for Species Importance Value. Upon further examination of the various regions that were surveyed, it became evident that Uttara Kannada district in Karnataka, India stood out due to the diverse range of species that were found in the area. Furthermore, when looking at the ratio of Climber Diversity to Tree Diversity, Kodagu district in Karnataka, India was found to have the most elevated value among all the regions that were examined.

CONCLUSION:

The investigation of Menispermaceae species in the Central Western Ghats revealed that *Cyclea peltata* exhibited the highest frequency, *Diploclisia glaucescens* the greatest density, and *Cissampelos pareira* the highest abundance. Additionally, *Coscinium fenestratum* recorded the highest Species Importance Value. Among the surveyed regions, Shivamogga demonstrated exceptional species diversity. This study provides a detailed account of the species distribution, diversity, and ecological roles of Menispermaceae, emphasizing their medicinal value and conservation significance. The findings contribute essential baseline data for targeted conservation strategies, particularly for threatened species within the Western Ghats.

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