Understanding Araneae diversity and web patterns in selected habitats of Goa, India

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MISS. VIBHUTI ULHAS GAWAS

Roll Number: 21P044014

Under the Supervision of

DR. NITIN SAWANT

School of Biological Sciences and Biotechnology
Programme Zoology

GOA UNIVERSITY

DATE: APRIL 2023

Examined by: Seal of the School

DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation report entitled, " Understanding Araneae diversity and web patterns in selected habitats of Goa, India" is based on the results of investigations carried out by me in the Programme Zoology at the School of Biological Sciences and Biotechnology, Goa University under the supervision of Dr. Nitin Sawant, and at the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will not be responsible for the correctness of observations or other findings given in the dissertation.

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Date:

Place: Goa University

Miss. Vibhuti Ulhas Gawas
21P044014
Department of Zoology
School of Biological Sciences and Biotechnology

COMPLETION CERTIFICATE

This is to certify that the dissertation report entitled " Understanding Araneae diversity and Web patterns in selected habitats of Goa, India" is a bonafide work carried out by Miss. Vibhuti Ulhas Gawas under my supervision in partial fulfillment of the requirements for the award of the degree of Master of Science in Zoology at School of Biological Sciences and Biotechnology, Goa University.

Date: April, 2023 Dr. Nitin Sawant

Programme Zoology

Dr. Savita Kerkar

School of Biological Sciences and Biotechnology

Date: April, 2023 SchoolStamp

Place: Goa University

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INTRODUCTION

1.1 INTRODUCTION

Invertebrates are the most diverse and abundant animals in most natural ecosystems but their importance in sustaining those systems is commonly not appreciated (New, 1995). The distribution of invertebrates must be known in order to evaluate their conservation status and identify any potential management requirements. Arachnids are a significant but understudied group of arthropods that play an important role in regulating insect and other invertebrate populations in most ecosystems (Russell-Smith, 1999). They use a remarkable variety of predation strategies, occupy a wide range of spatial and temporal niches, exhibit taxon and guild responses to environmental change, and are extremely sensitive to small changes in habitat structure, including vegetation complexity, litter depth. Spiders act as bio indicators, which can reflect the state of environment by monitoring stress levels as they are very sensitive to habitat change and has rapid response to disturbances, which can be used for conservation prioritization

By spinning threads with a sheath, a sheath-core structure varying the proportions of the sheath and core (Kovoor, 1987), combining fibrils with different tensile strengths and extensibilities (Stubbs et al. 1992) and creating composite materials, spiders create silks with mechanical proper. Spiders are capable of spinning a variety of webs with diverse patterns suitable for different ecological functions. Spiders create a variety of webs, such as circular orb webs, flat and funnel-shaped sheet webs, irregular cobwebs, trapdoor burrows, messy tangle webs, tube-shaped funnel webs, and flat platform webs. These webs are influenced by various factors, including the type of prey, size and strength of the spider, environment, and season. Researchers have developed materials inspired by spider silk for their strength, light weight ness, and flexibility, drawing insights from spider web patterns in their studies of these unique creatures.

It is suspected that the diversity, distribution, and insectivorous feeding habits of spiders play a significant role in maintaining the balance of nature (Oyeniyi Abiola Oyewole., 2014). There are over 51,022 known spider species in the world, with new ones discovered and described every year, (World Spider Catalog, 2023). Spider diversity is not evenly distributed around the world, with some areas having higher numbers than others. The Amazon Basin's tropical rainforests have between 5,000 and 7,000 different species compared to 3000 on entire Europe continent (Cardoso et al., 2017), while Madagascar has a high level of endemism with over 90% of its species being unique to island alone(Goodman et al., 2006). Spider species have evolved to coexist with other animals and their distribution is restricted to the presence of these host species and those that live in predator-free environments may have different behavioral patterns or less powerful venom (Cushing et al., 2018). This suggests that spiders have adapted to their environment and developed specialized traits to survive alongside other species. It also highlights the importance of understanding the ecological relationships between different organisms in an ecosystem. Research on spider diversity and distribution can offer significant insights into the mechanisms that support biodiversity and the factors which influence species distributions. (Cardoso et al., 2017)

India has a rich and diverse spider fauna, with over 1940 spider species documented thus far. The country's diverse habitats, which range from tropical rainforests to alpine meadows, contribute significantly to its diversity. Despite their diversity, spiders in India are still poorly studied, with many species remaining unnamed. (Majumder et al., 2020). Further-more Tarantulas of Poecilotheria, which are mostly found in Western Ghats, classified as endangered under IUCN Red List (Smith, 2008), due to habitat loss and degradation making the conservation of India's spider diversity a top priority for researchers and conservationists.

Goa, is situated at the west coast of India, has a wide variety of habitats, including tropical rainforests, coastal areas, and wetlands. This diversity of ecosystems has resulted in a large number of spider species in the state. According to Singh, there are over 350 spider species documented in Goa, belonging to 34 families. More research is needed to better understand the diversity and ecology of Goa's spider species, as well as to develop effective conservation strategies for threatened species. The present study aims to fill the lacuna of knowledge in understanding the spider diversity of different habitats of Goa.
The updated spider fauna, published by Rajendra Singh and B.B. Singh of Goa state, lists 173 species of spiders from 23 families (Singh & Singh, 2022). Long-term and meaningful conservation demands an in-depth understanding of the species found in various ecosystems. In consideration of this, it has become vital to conduct research on Goa's diversity.

Spiders are known to be sensitive to environmental and structural changes, making them ideal for studying organism-habitat relationships (Wise, 1993). Therefore their potential use as indicators of environmental change constitute an important tool for management conservation plans. There has been growing recognition of spiders' importance in conservation, with efforts to document spider diversity and designate some species as conservation flagships as spiders can also be used as bioindicators to monitor the effects of habitat fragmentation and degradation on forest ecosystems (Cardoso et al., 2017). Additionally, spiders are crucial in the food web, providing food for birds, reptiles, and mammals. They help maintain ecological balance by regulating insect populations, which is particularly important in agricultural and forestry systems where the use of chemical pesticides can have negative environmental impacts (Nyffeler et al. 2016). Spider populations in grassland ecosystems are positively correlated with temperature and precipitation, making them useful indicators of environmental changes (Nyffeler et al. 2016). Some spider species also have unique adaptations that enable them to survive in specific habitats, and monitoring spider populations can provide valuable information for assessing ecosystem health and conservation efforts.

The study aims to describe the status of spider species and comparing the species diversity on the different selected habitats of Goa.

1.2 LITERATURE REVIEW

1. Bell (1998) in his study The zonation and ecology of a sand-dune spider community highlights the importance of habitat structure in dune ecosystems, specifically in relation to spider distribution. The study provides evidence of distinct habitat zones with varying vegetation structure and ground cover, and suggests that these factors play a crucial role in shaping spider communities in dune ecosystems. Further research on the interrelationships between vegetation structure, ground cover, microclimatic influences, and spider distribution would enhance our understanding of dune ecosystem dynamics and contribute to conservation and management efforts in these unique habitats.
2. Halarnkar & K (2018), documented the diversity of spiders of two different habitats St.Estevan, an island and Marcela, a plantation area. A total of 1058 and 1339 spiders were observed at site 1 and site 2 respectively. Distribution and occurrence of spiders are influenced by habitat structure and vegetation parameters, alteration by anthropogenic activities can cause degradation of habitat and even cause local extinction of the species.
3. Isaia *et al* (2006) compared spider species diversity in vineyards with other European agroecosystems and found that the number of species collected (96) was relatively high compared to other systems such as apple orchards, maize fields, Leguminosae, and wheat. The two sampling methods used in the study showed marked differences in species composition, with only 13 out of 96 species being shared between them. The study highlighted the importance of landscape heterogeneity, particularly the presence of woods, as a significant environmental factor influencing spider assemblages in vineyards. The presence of refuge areas, such as woods, was found to be fundamental in providing habitats for spider diversity in agroecosystems. The

study also suggested that sheet web and dome web weavers were influenced by landscape structure and management regimens, with their dominance indicating increasing landscape homogeneity. The high number of species found in vineyards indicates that they can be suitable habitats for spiders, and the study suggests that spider diversity could be an important factor to consider for biocontrol purposes in vineyard ecosystems. Further research will include additional environmental variables related to agricultural practices to better understand spider assemblages in vineyards.

4. Pinkus-Rendon *et al* (2006) studied spider diversity in a tropical habitat gradient found that spider diversity and species composition in a complete landscape were influenced by habitat complexity. Habitats with structural complexity, such as deciduous forest, secondary forest, and coffee plantations had greater spider diversity compares to habitats with lower complexity such as crop fields and suburban areas. Some habitats such as Acacia woodlots and hedgerows, had relatively high diversity despite being human managed systems. The results also suggested that habitat heterogeneity and disturbance gradients influenced spider diversity, with stable habitats and habitats with intermediate disturbance level showing higher diversity compare to highly disturbed habitats. The study concluded that habitat complexity and structure played an important role in determining spider diversity and species composition in the landscape.

5. Polchaninova (2023) study conducted in northeastern Ukraine demonstrates that the remnants of natural forest and grassland habitats in the forest-steppe region play a crucial role in supporting rich spider fauna and contribute to local biodiversity. The study emphasizes the importance of maintaining these habitats as refugia for rare and typical dry grassland spider species, and highlights the need for combining

undisturbed areas with traditional pastoralism in the conservation management of fragmented forest-steppe habitats to maintain high biodiversity. The findings also reveal the influence of grazing and abandonment on spider assemblages, with ungrazed areas showing more stable and diverse spider populations compared to grazed and abandoned plots. Overall, the study emphasizes the significance of preserving these habitats to protect spider biodiversity in agricultural landscapes.

6. Rubio *et al* (2008) conducted study in the Eastern Chacoan District of Argentina found that protected habitats in the region have a diverse spider population, representing a significant percentage of spider families recorded in it Argentina and the Corrientes province. The study also revealed that habitat type, land use, and vegetation architecture influences spider communities, with structural diversity of vegetation playing a role in species composition. The study noted differences in spider assemblages between adjacent habitats and the presence of rare species. Overall, the findings highlights the importance of considering habitat type, land use, and vegetation structure in understanding spider diversity in the region.

7. Saini (2012) in his study investigated the ecology and diversity of spider species in the Shekhwati Aravalin region of Rajasthan, India. A total of 328 spiders representing 12 families and 32 distinct species were recorded and identified, with Araneidae, Salticidae and Oxyopidae being the most abundant families in Woodland habitat and Araneidae being the most abundant in marshy and pasture habitats. Spider populations showed two periods of increased abundance in early and late summer corresponding with ambient temperature ranges of 200 C to 250 C. Spider communities were found to fluctuate in repose to different ecological conditions in different habitats. The study also highlighted the role of spiders as expert silent predators, suppressing insect populations and maintaining ecological equilibrium.

Adaptations to various environments has facilitated spider survival in a broad functional group. The findings of this study provide baseline information on spider species distribution, response to environment, disturbance and food availability in the study region and suggest potential for using spiders as biocontrolling agents.

8. Sebastian (2005) conducted study on Spiders in mangrove forest in Mangalavanam, an urban forest in Kochi city, revealed that this mangrove forest, despite being threatened by rapid urbanization and destruction, harbors a diverse spider community in addition to a multitude of migratory birds. The presence of a rich diversity of spiders in Mangalavanam indicates the overall biodiversity of this urban forest, as spiders are considered to be useful indicators of species richness and ecosystem health . This highlights the importance of preserving this forest patch intact from a biodiversity conservation perspective, emphasizing the need for conservation efforts to protect this urban forest and its associated spider community from the ongoing threats of urbanization and habitat destruction.
9. Singh (2022) in his study of Spatial mapping of spiders (Araneae) in the Gomarda Wildlife Sanctuary highlights key findings related to spider communities in different habitats, emphasizing the influence of habitat structure on spider diversity. Natural forests with high vegetation complexity tend to exhibit higher diversity, while secondary forests and croplands have lower diversity. The abundance of dominant spider species is influenced by niche availability and microclimate. Grasslands, exposed to anthropogenic pressure, show lower incidence of web weavers. The review also discusses the correlation between vegetation structure and spider abundance, with higher abundance of dominant species in habitats with medium to higher trees and homogeneous niches for web-dwelling spiders. biodiversity.

1.3 OBJECTIVES

- To document the presence and abundance of spider species in different habitats
- Assess spatial and Temporal patterns of spider diversity in selected habitats
- To understand the web architectural diversity in different spider families

STUDY AREA

2.1 STUDY AREA

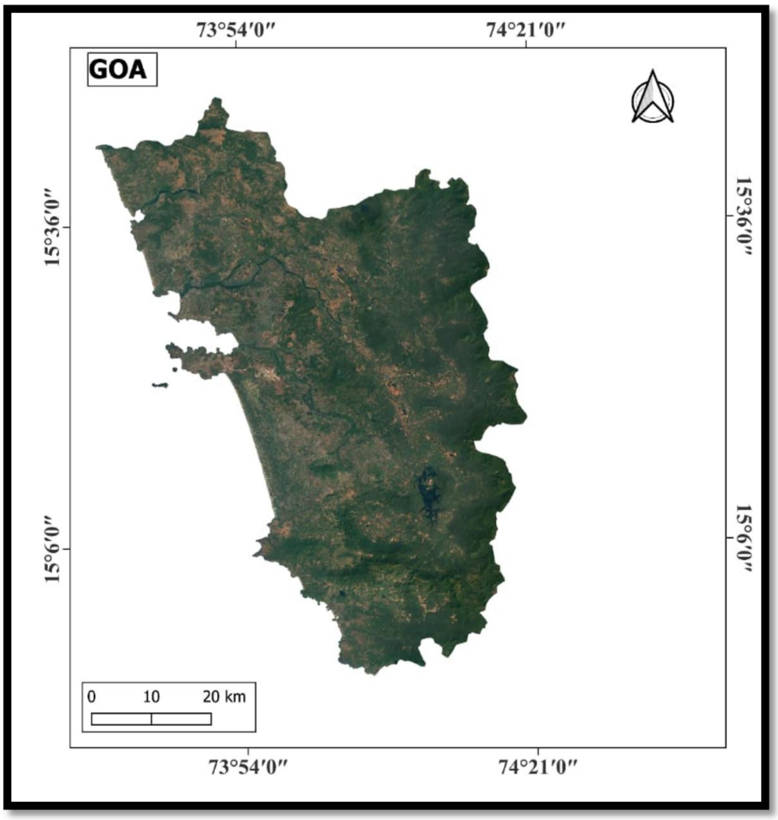

Figure 1 : Map showing the study area

Study Area	Location	
	Latitude	Longitude
Forest	15^0 35'29.24" N	$74^0$11'32.97" E
Mangrove	$15^0$30'45.26" N	$73^0$52'13.10" E
Wetland	$15^0$31'57.88" N	74^0 0'27.75" E
Agriculture	$15^0$31'24.22" N	$73^0$52'27.28" E
Sandunes	$15^0$28'52.37" N	$73^0$48'26.83" E

Table 1: Table showing geographical coordinates of study area

Sanddunes

Miramar Beach, located near the capital city of Goa, Panaji, is a popular tourist destination with clear waters and long stretches of golden sand. The beach is also home to sand dunes, which are an integral part of its ecology. Sand dunes are formed by the wind and are typically found along beaches. The sand dunes in the area are filled with Ipomoea plant species. In addition, many spider species live in these sand dunes and play an important role in maintaining the ecosystem's health by controlling pest populations that can damage plants. Spiders are an essential component of the biodiversity in this area.

Plate 1: Study Area of Sanddune habitat

Agriculture

The study area, located in Chorao village, Tiswadi taluka, was chosen for its diverse agricultural cultivation. The monsoon season witnesses the cultivation of rice, and in post-monsoon, a variety of vegetable crops, including chillies, spinach, red amaranth, and radish, are grown. Spiders are crucial in maintaining the health and productivity of agricultural systems as they inhabit agricultural landscapes and feed on pests that can harm crops. Their presence reduces the need for harmful pesticides, thereby improving the overall health of the ecosystem. Additionally, spiders aid in nutrient cycling, and studying their diversity in agriculture can provide valuable insights into the system's functioning.

Plate 2 : Study Area of Agriculture Habitat

Wetland

The wetland located in Navelim village in Bicholim Taluka is a thriving ecosystem, boasting a diverse range of flora and fauna. This wetland is a habitat for various bird species, both migratory and resident, as well as fish, amphibians, and reptiles. Surrounded by agricultural land, the wetland serves as a crucial source of water for local farmers. In addition, wetlands play an important role in ecosystem services such as water purification and carbon storage. The humid and moist environment of wetlands also supports a wide variety of spider species that play a vital role in controlling pest populations and providing a food source for other organisms. Protecting and conserving wetlands is necessary to maintain biodiversity and ensure public health.

Plate 3 : Study Area of Wetland Habitat

Mangrove

Mangroves are an important component of the coastal ecosystem in the state of Goa, located on the western coast of India.The study site comes under the protection of Dr. Salim Ali Bird Sanctuary in Chorao village in Tiswad taluka. The major mangrove species found in Goa are *Avicennia marina, Rhizophora mucronata*, and *Ceriops tagal*. Mangroves are characterized by the presence of salt-tolerant trees and shrubs. They are typically located in inter tidal zones, where land and sea meet, and play important ecological roles such as protecting coastlines, filter and purify water , making them important for the overall health of coastal ecosystems.

Plate 4: Study Area of Mangroves Habitat

Forest

Madei Wildlife Sanctuary is a protected area in North Goa, India, covering 208.5 square kilometres and named after the Madei River that flows through it. The sanctuary is known for its diverse flora and fauna and includes the study area near Chidambaram waterfall in Maloli village, which is located in a semi-evergreen forest in Sattari taluka These areas are protected from human activities, making them useful for comparison with areas outside this area that may have higher levels of disturbance. These areas also provide a controlled environment for studying the effects of various factors on spider populations, which are highly sensitive to environmental changes. Such studies can provide valuable insights into the health and biodiversity of ecosystems.

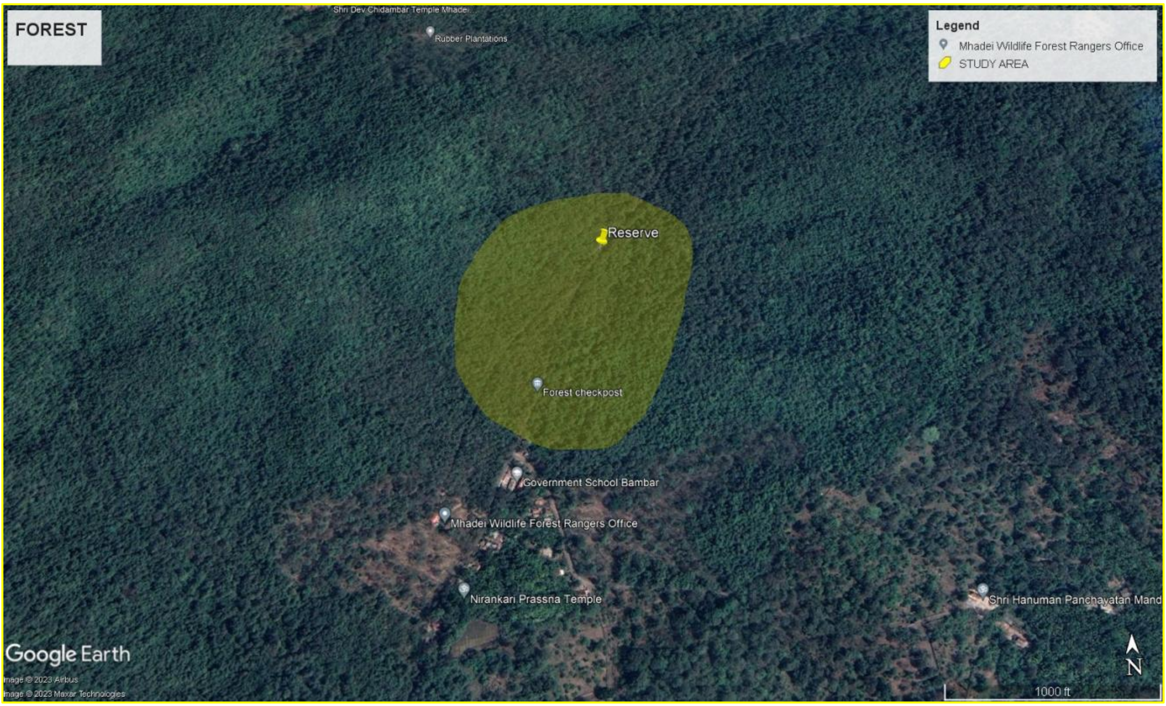

Plate 5: Study Area of Forest Habitat

METHODOLOGY

3.1 METHODOLOGY

Visual Search Method:

The visual search method is one of the most basic and commonly used methods for sampling spiders. As the name suggests, this method involves manually searching for spiders in their natural habitat. This method is particularly useful for sampling ground-dwelling spiders or spiders that are easily visible. The visual search method is a non-destructive sampling technique, which means that the spiders can be captured and released without causing harm to them or their habitat. To conduct a visual search, researchers typically walk through the habitat and visually scan the area for spiders. This method requires a keen eye and patience, as spiders can be difficult to spot due to their small size and often cryptic coloration. Additionally, researchers may need to search during specific times of day when the spiders are most active or visible. The visual search method has several advantages. Firstly, it is a non-invasive method that does not harm the spiders or their habitat. Secondly, it is relatively low cost and does not require specialized equipment.

Beating Method:

The beating method is a sampling technique that involves beating vegetation or other surfaces with a stick or net to dislodge spiders and other arthropods. This method is particularly useful for sampling spiders that live in vegetation. To conduct the beating method, researchers typically hold a beating sheet or tray under a section of vegetation or other surface and then beat the vegetation with a stick or net. The dislodged spiders and arthropods then fall onto the beating sheet or tray, where they can be easily collected. This method can be used to sample a large area in a relatively short amount of time. However, this method may not be effective for sampling spiders that live in burrows or that are highly mobile.

Leaf litter sampling:

Leaf litter sampling is a method of collecting spiders from the forest floor. This method involves collecting leaf litter, which consists of dead leaves, twigs, and other organic matter that has fallen to the ground. This method is particularly useful for collecting ground-dwelling spiders that are difficult to observe visually. Many spider species spend their entire lives on the forest floor and are well camouflaged, making them difficult to spot with the naked eye. By collecting leaf litter, researchers can obtain a more accurate representation of the spider community in a particular habitat.

Leaf litter sampling is typically conducted by collecting several samples of leaf litter from different locations within a study site. The samples are then taken to the laboratory where they are sorted and identification of species is done.

3.2 Preservation:

The specimens were preserved in 70% alcohol and were kept in small vial and were individually labeled.

3.3 Identification

Identification of species were carried out with the help of field guide experts, and field guide books

- A field guide to the Spider Genera of India by Ayan Mondal, Debomay Chanda, Atul Vartak & Siddharth Kulkarni
- The taxonomy and nomenclature is followed as per World Spider Catalogue (2023).

3.4 Data analysis

Simpson Diversity:

Simpson's Diversity Index (D) is a measure of biodiversity that quantifies the probability that two randomly chosen individuals from a community or sample belong to different species. It is calculated by summing the squared proportions of individuals belonging to each species in the community or sample and subtracting the sum from 1. A higher value of Simpson's Diversity Index (D) indicates higher diversity, as it represents a lower probability of two individuals belonging to the same species. The range for Simpson's Diversity Index (D) is between 0 and 1, where 0 indicates no diversity and 1 indicates maximum diversity. Intermediate values between 0 and 1 represent varying levels of diversity, with higher values indicating higher diversity and lower values indicating lower diversity.

Shannon Weiner Index

The Shannon-Weiner Index (H) is a measure of biodiversity that quantifies the information or uncertainty associated with the species diversity in a community or sample. It takes into account both the species richness (number of species) and evenness (relative abundance of each species) in the community or sample and provides a single value that represents the diversity. It measures the probability that two individuals randomly selected from an area will belong to the same species.

Margalaf Index

Margalaf index is a measure of the richness of a community, taking into account the number of species present and the total number of individuals.

Equitability:

Equitability is a measure of the relative abundance of different species in a community or sample. It ranges from 0 to 1, with 0 indicating complete dominance of a single species and 1 indicating perfect evenness or equal abundance of all species. A higher value indicates a more even distribution of individuals among different species, while a lower value indicates a more skewed or unequal distribution. Equitability is commonly used to assess the evenness or balance of species abundance in a community or sample.

The equitability index ranges from 0 to 1, with a value of 1 indicating that all species in the community have an equal proportion of individuals

Species richness:

Species richness refers to the number of different species present in a particular area or ecosystem. It is a measure of biodiversity that quantifies the diversity of life within a given habitat, indicating the variety of species that coexist in a particular location.

OBSERVATION

Table 2: Checklist of spiders identified in five habitats

Serial Number	Species Name	Family	Genus	Guilds
1	Anepsion maritatum	Araneidae	Anepsion	Orb Weavers
2	Araneus sp	Araneidae	Araneus	
3	Argiope viridisomus	Araneidae	Argiope	
4	Argiope anasuja	Araneidae	Argiope	
5	Argiope aemula	Araneidae	Argiope	
6	Argiope sp	Araneidae	Argiope	
7	Argiope pulchella	Araneidae	Argiope	
8	Argiope sp	Araneidae	Argiope	
9	Argiope sp	Araneidae	Argiope	
10	Bijoaraneus mitificus	Araneidae	Bijoaraneus	
11	Cyclosa bifida	Araneidae	Cyclosa	
12	Cyclosa insulana	Araneidae	Cyclosa	
13	Cyclosa sp	Araneidae	Cyclosa	
14	Cyclosa sp	Araneidae	Cyclosa	
15	Cyclosa spirifera	Araneidae	Cyclosa	
16	Cyrtophora sp.	Araneidae	Cyrtophora	
17	Cyrtophora cicatrosa	Araneidae	Cyrtophora	
18	Erovixia sp.	Araneidae	Erovixia	
19	Gasteracantha geminata	Araneidae	Gastercantha	
20	Gasteracantha sp	Araneidae	Gastercantha	
21	Gasteracatha kuhli	Araneidae	Gastercantha	
22	Gea sp	Araneidae	Gea	
23	Gea sp	Araneidae	Gea	
24	Herennia sp	Araneidae	Herennia	
25	Hypsosinga sp.	Araneidae	Hyposinga	
26	Lipocrea sp.	Araneidae	Lipocrea	
27	Neoscona bengalensis	Araneidae	Neoscona	
28	Neoscona mukerjei	Araneidae	Neoscona	
29	Neoscona molemensis	Araneidae	Neoscona	
30	Neoscona sp theisi	Araneidae	Neoscona	
31	Neoscona sp	Araneidae	Neoscona	
32	Neoscona sp	Araneidae	Neoscona	
33	Neoscona sp	Araneidae	Neoscona	
34	Nephila maculata	Araneidae	Nephila	
35	Nephila pilipes	Araneidae	Nephila	
36	Parawixia dehaani	Araneidae	Parawixia	
37	Poltys sp	Araneidae	Poltys	
38	Thelacantha brevispina	Araneidae	Thelecantha	
39	Cheiracanthium sp	Cheiracanthiidae	Cheiracanthium	Sac spider
40	Clubiona drassodes	Clubionidae	Clubiona	Sac spider
41	Clubiona sp	Clubionidae	Clubiona	
42	Clubiona sp	Clubionidae	Clubiona	
43	Ctenus sp	Ctenidae	Ctenus	Wandering spider
44	Ctenus sp	Ctenidae	Ctenus	
45	Hersilia savignyi	Hersiliidae	Hersilla	
46	Hippasa agelenoides	Lycosidae	Hippasa	Fast runners
47	Hippasa sp	Lycosidae	Hippasa	
48	Lycosa sp.	Lycosidae	Lycosa	
49	Lycosa sp.	Lycosidae	Lycosa	

Serial Number	Species Name	Family	Genus	Guilds
50	Pardosa sp	Lycosidae	Pardosa	
51	Pardosa sumatrana	Lycosidae	Pardosa	
52	Hamadruas sp	Oxyopidae	Hamadraus	Diurnal Runner
53	Oxyopes sp	Oxyopidae	Oxyopes	
54	Oxyopes birmanicus	Oxyopidae	Oxyopes	
55	Oxyopes javanus	Oxyopidae	Oxyopes	
56	Oxyopes shweta	Oxyopidae	Oxyopes	
57	Oxyopes sp	Oxyopidae	Oxyopes	
58	Philodromus sp	Philodromidae	Philodromus	Ambush hunter
59	Pholcus phalangioides	Pholcidae	Pholcus	Scattered line weaver
60	Dendrolycosa sp.	Pisauridae	Dendrolycosa	Diunal runners
61	Polyboea sp	Pisauridae	Polyboea	
62	Pisaura sp.	Pisauridae	Pisaura	
63	Aelurillus sp.	Salticidae	Aelurillus	Jumping spiders
64	Afraflacilla sp.	Salticidae	Afraflacilla	
65	Asemonea tenuipes	Salticidae	Asemonea	
66	Bianor sp.	Salticidae	Bianor	
67	Bianor sp.	Salticidae	Bianor	
68	Brettus cingulatus	Salticidae	Brettus	
69	Carrhotus sp	Salticidae	Carrhotus	
70	Carrhotus viduus	Salticidae	Carrhotus	
71	Cyrba sp	Salticidae	Cyrba	
72	Epocilla sp	Salticidae	Epocilla	
73	Evacin sp	Salticidae	Evacin	
74	Hasarius adansoni	Salticidae	Hasarius	
75	Hyllus semicupreus	Salticidae	Hyllus	
76	Icius alboterminus	Salticidae	Icius	
77	Langona sp.	Salticidae	Langona	
78	Marengo sp.	Salticidae	Marengo	
79	Menemerus bivattatus	Salticidae	Menemerus	
80	Menemerus fulvus	Salticidae	Menemerus	
81	Menemerus sp	Salticidae	Menemerus	
82	Menemerus sp	Salticidae	Menemerus	
83	Myrmarachne sp	Salticidae	Myrmarachne	
84	Myrmarachne melanocephala	Salticidae	Myrmarachne	
85	Myrmarachne plataleoides	Salticidae	Myrmarachne	
86	Phlegra sp.	Salticidae	Phelgra	
87	Phidippus	Salticidae	Phidippus	
88	Phintella sp	Salticidae	Phintella	
89	Phintella vittata	Salticidae	Phintella	
90	Plexippus paykulli	Salticidae	Plexippus	
91	Plexippus petersi	Salticidae	Plexippus	
92	Rhene flavigera	Salticidae	Rhene	
93	Rhene sp.	Salticidae	Rhene	
94	Stenaelurillus albus	Salticidae	Stanaelirillus	
95	Stenaelurillus sp	Salticidae	Stanaelirillus	
96	Stenaelurillus sp	Salticidae	Stanaelirillus	
97	Stenaelurillus sp	Salticidae	Stanaelirillus	
98	Stenaelurillus digitus	Salticidae	Stanaelirillus	
99	Telamonia dimidiata	Salticidae	Telamonia	

Serial Number	Species Name	Family	Genus	Guilds
100	Gnathopalystes sp.	Sparassidae	Gnathopalystes	Huntsman spider
101	Heteropoda sp	Sparassidae	Heteropoda	
102	Heteropoda sp	Sparassidae	Heteropoda	
103	Olios sp	Sparassidae	Olios	
104	Guizygiella sp.	Tetragnathidae	Guizygiella	Orb weavers
105	Opadometa sp.	Tetragnathidae	Opadometa	
106	Tetragnatha mandibulata	Tetragnathidae	Tetragnatha	
107	Tetragnatha sp	Tetragnathidae	Tetragnatha	
108	Tetragnatha viridorufa	Tetragnathidae	Tetragnatha	
109	Tetragnatha sp	Tetragnathidae	Tetragnatha	
110	Tylorida sp.	Tetragnathidae	Tylorida	
111	Ariamnes sp	Theridiidae	Ariamnes	Cob web spider
112	Meotipa sp.	Theridiidae	Meotipa	
113	Phycosoma sp.	Theridiidae	Phycosoma	
114	Steatoda sp.	Theridiidae	Steatoda	
115	Theridion sp.	Theridiidae	Theridion	
116	Amyciaea forticeps	Thomisidae	Amyciaea	Crab spider
117	Camaricus formosus	Thomisidae	Camaricus	
118	Camaricus sp.	Thomisidae	Camaricus	
119	Monaeses sp	Thomisidae	Monaeses	
120	Oxytate sp	Thomisidae	Oxytate	
121	Oxytate sp.	Thomisidae	Oxytate	
122	Thomisus sp	Thomisidae	Thomisus	
123	Thomisus sp	Thomisidae	Thomisus	
124	Thomisus sp	Thomisidae	Thomisus	
125	Thomisus sp	Thomisidae	Thomisus	
126	Uloborus sp.	Uloboridae	Uloborus	Orb weaver

Serial number	Species name	Reserve area	Wetland	Mangroves	Agriculture	Sandunes
1	Aelurillus sp.			+		
2	Afraflacilla sp.			+		
3	Amyciaea forticeps		+			
4	Anepsion maritatum	+				
5	Araneus sp.	+				
6	Argiope aemula				+	
7	Argiope anasuja				+	
8	Argiope sp	+				
9	Argiope viridisoma				+	
10	Argiope pulchella				+	
11	Argiope sp	+				
12	Argiope sp			+		
13	Ariamnes sp			+		
14	Asemonea tenuipes		+	+		
15	Bianor sp.					
16	Bianor sp.	+			+	
17	Bijoaraneus mitificus	+				
18	Brettus cingulatus		+	+		
19	Camaricus formosus	+				
20	Camaricus sp.		+			
21	Carrhotus sp	+				
22	Carrhotus viduus	+	+	+	+	
23	Cheiracanthium sp		+			
24	Clubiona drassodes					+
25	Clubiona sp					+
26	Cluniona sp					+
27	Ctenus sp	+				
28	Ctenus sp.		+			
29	Cyclosa bifida					+
30	Cyclosa insulana					+
31	Cyclosa sp	+		+		+
32	Cyclosa sp		+			
33	Cyclosa spirifera					+
34	Cyrba sp		+			

35	Cyrtophora cicatrosa			+		+
36	Dendrolycosa sp.		+			+
37	Epocilla sp	+	+			
38	Erovixia sp.	+	+			+
39	Evacin sp.				+	
40	Gastercantha germinata			+		+
41	Gastercantha sp			+		
42	Gastercatha kuhli					+
43	Gnathopalystes sp		+	+		
44	Guizygiella sp.		+			
45	Hamadraus sp			+		
46	Oxyopes sp		+			
47	Hasarius adansoni		+		+	
48	Herennia sp.	+				
49	Hersilla savignyi		+	+	+	
50	Heteropoda sp		+			
51	Heteropoda sp		+			
52	Hippasa agelenoides	+				+
53	Hippasa sp			+		
54	Hyllus semicupreus	+	+	+	+	
55	Hyposinga sp.	+				
56	Icius alboterminus				+	
57	Langona sp.	+		+		
58	Lipocrea sp.		+			
59	Lycosa sp.				+	
60	Lycosa sp.	+				
61	Lysiteles sp.	+				
62	Marengo sp		+			
63	Menemerus bivattus	+			+	
64	Menemerus fulvus	+	+		+	
65	Menemerus sp					+
66	Myrmarachne sp	+				
67	Menemerus sp			+		
68	Menemerus sp					+
69	Menemerus sp		+			
70	Meotipa sp		+			

71	Misumessus sp			+	+	
72	Myrmarachne melanocephala		+	+		
73	Myrmarachne plataloides		+		+	
74	Neoscona bengalensis				+	
75	Neoscona mukerjei				+	
76	Neoscona molemensis		+			
77	Neoscona theisi	+				
78	Gea sp		+			
79	Neoscona sp			+		
80	Neoscona sp	+				
81	Neoscona sp		+			
82	Nephila maculata			+		
83	Nephila pilipes	+	+		+	+
84	Olios sp					+
85	Opadometa sp	+				
86	oxyopes biramanicus	+		+	+	
87	Oxyopes javanus	+	+		+	
88	Oxyopes shweta		+			
89	oxyopes sp			+		
90	Oxytate sp.	+	+			
91	Parawixia dehaani				+	
92	Poltys sp		+			
93	Pardosa sp				+	+
94	Pardosa sumatrana				+	
95	Phelgra sp.			+		
96	Phidippus sp	+				
97	Phintella sp.	+				
98	Philodamia sp.	+				
99	Philodromus sp.		+			
100	Phintella vittata	+	+	+		
101	Pholcus phalangioides		+			+
102	Phycosoma sp.	+				
103	Polyboea sp				+	
104	Pisaura sp.					+

105	Plexippus paykulli	+	+			
106	Plexippus petersi				+	
107	Stanaelirillus sp	+				
108	Rhene flavigera					+
109	Rhene sp.	+		+		
110	Stanaelirillus albus	+			+	
111	Stanaelirillus sp			+	+	
112	Stanaelurillus digitus				+	
113	Steatoda sp.	+				
114	Telamonia dimidiata	+	+	+		
115	Tetragnatha mandibulata			+		
116	Tetragnatha sp			+		
117	Tetragnatha viridorufa					+
118	Tetragnaths sp			+		
119	Thelecantha brevispina	+				
120	Gea sp		+			
121	Theridion sp.	+				
122	Thomisus sp 2			+	+	
123	Thomisus sp 2					+
124	Thomisus sp	+				
125	Tylorida sp			+		
126	Uloborus sp					+

Table 3: Table showing absence and presence of species in five habitats

4.1 SPATIAL DISTRIBUTIONS OF SPECIES

Abundance of Spider species in five Habitats

Total of 1521 individuals were observed during the entire period of one year from all the five habitats.

	Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	
Reserve	33	34	34	33	31	28	42	29	30	27	32	28	
Wetland	29	33	24	29	34	24	29	25	35	33	44	38	
Mangrove	22	25	34	30	32	32	24	33	39	24	20	47	
Agriculture	23	21	21	19	18	14	19	16	31	18	17	16	
Sandunes	14	17	13	11	12	13	15	17	15	13	15	13	
Total	**121**	**130**	**126**	**122**	**127**	**111**	**129**	**120**	**150**	**115**	**128**	**142**	**1521**

Table 4: Table showing Abundance of spiders in five habitats

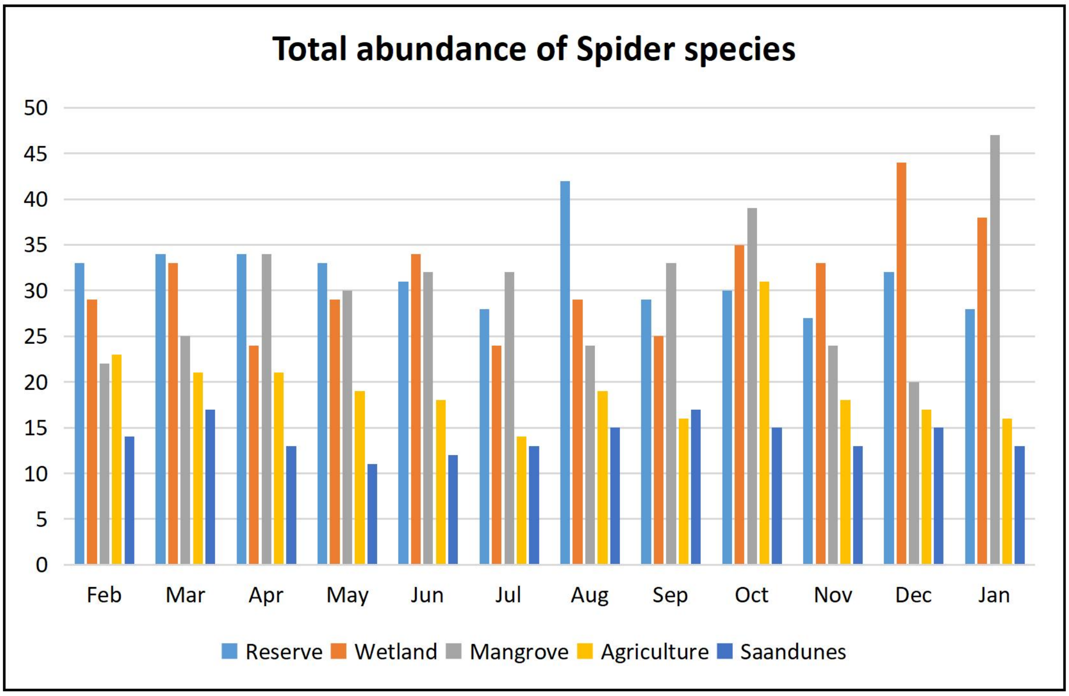

Figure 2: Graph showing total abundance of spider species

Abundance of Different Families in five habitats

Family	Species
Araneidae	38
Cheiracanthiidae	1
Clubionidae	3
Ctenidae	2
Hersiliidae	1
Lycosidae	6
Oxyopidae	6
Philodromidae	1
Pholcidae	1
Theridiidae	5
Salticidae	37
Sparassidae	4
Tetragnathidae	7
Thomisidae	10
Pisauridae	3
Uloboridae	1
Total	**126**

Table 5: Table showing Abundance of families in different habitats

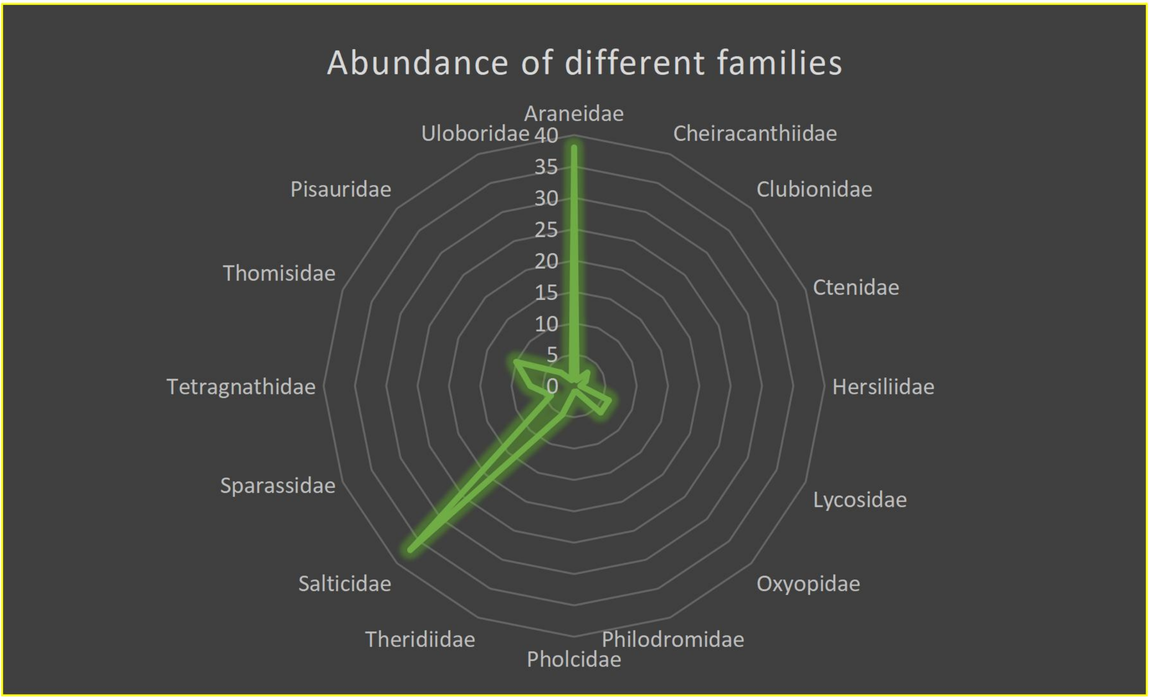

Figure 3 : Graph showing abundance of different families in five habitats

4.2 ALPHA DIVERSITY INDICES

	Total species	Total individuals	Shannon	Equitability	Simpson	Margalef
Wetland	36	377	2.773	1.018	0.936	4.172
Mangroves	36	362	2.896	1.047	0.952	4.419
Reserve	50	381	3.298	1.065	0.971	6.071
Agriculture	31	233	2.666	1.072	0.943	3.793
Sandunes	23	168	2.495	1.099	0.942	3.344
Total	**176**	**1521**				

Table 6 : Alpha Diversity Indices

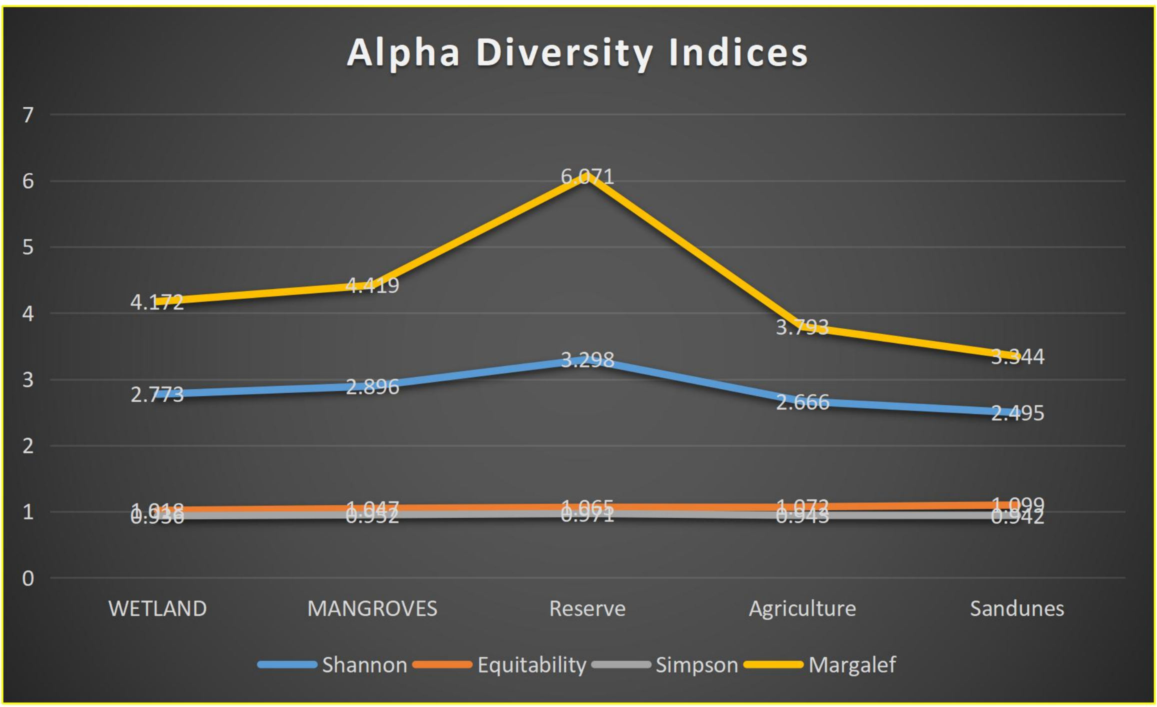

Figure 4 : Alpha Diversity Indices

ONE WAY ANNOVA TEST

The repeated measures ANOVA showed that there was a statistically significant differences between the means of groups (F=54.71, p<0.05). The P-value summary indicates that the significance level is less than 0.01.

Repeated measures ANOVA summary	
Assume sphericity?	No
F	54.71
P value	0.0017
P value summary	**
Statistically significant (P < 0.05)?	Yes
Geisser-Greenhouse's epsilon	0.3348
R squared	0.9319

Table 7: ANNOVA Test

4.3 TEMPORAL DISTRIBUTIONS OF SPECIES

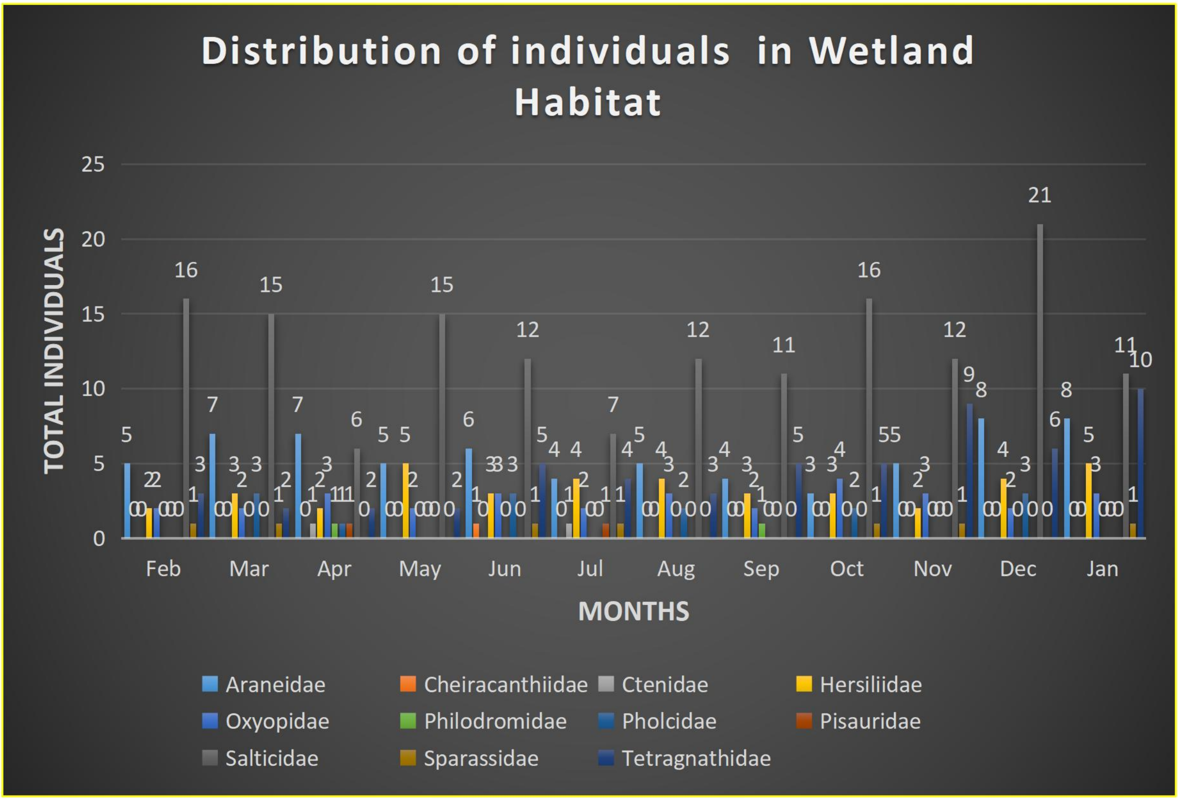

Figure 5: Distribution of Individuals in Wetland Habitat

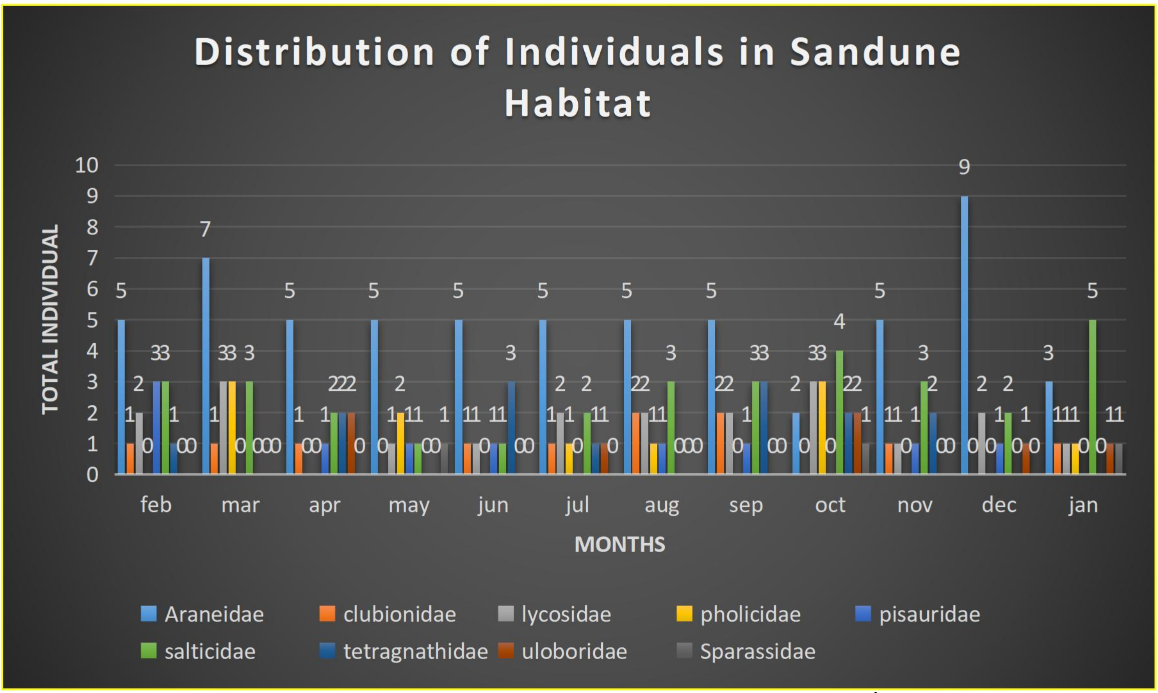

Figure 6: Distribution of Individuals in Sanddune Habitat

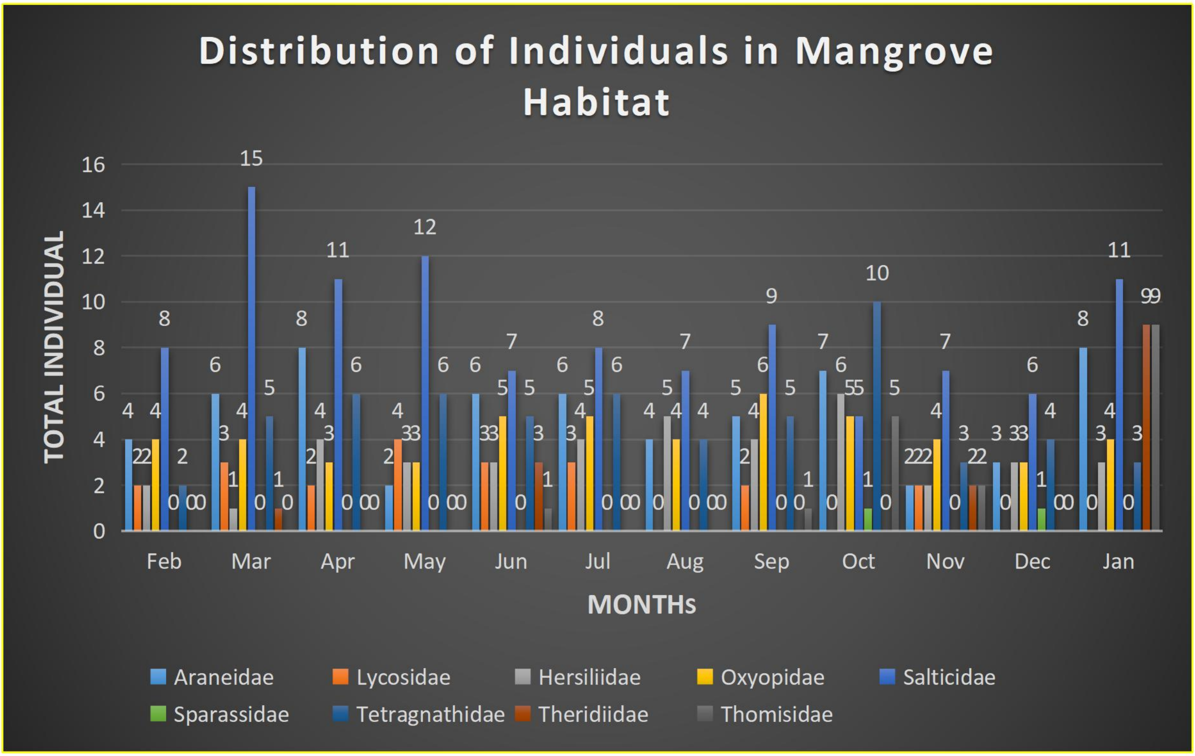

Figure 7: Distribution of Individuals in Mangrove Habitat

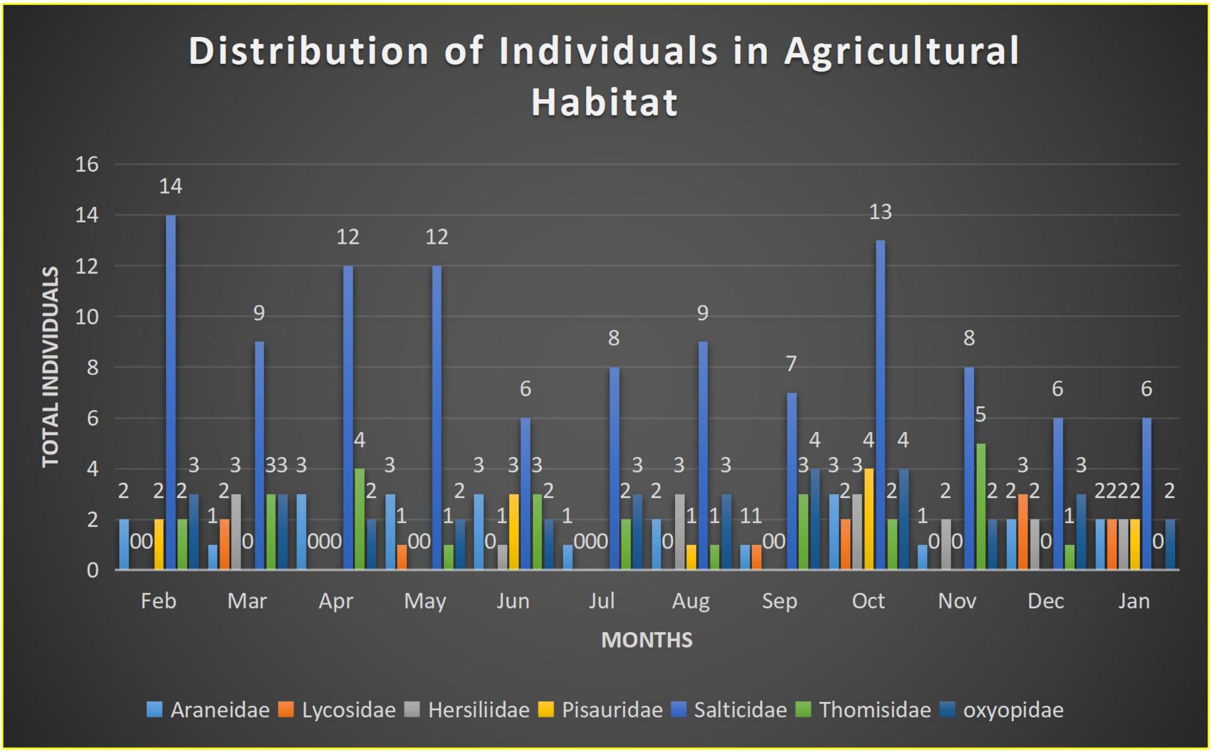

Figure 8: Distribution of Individuals in Agriculture Habitat

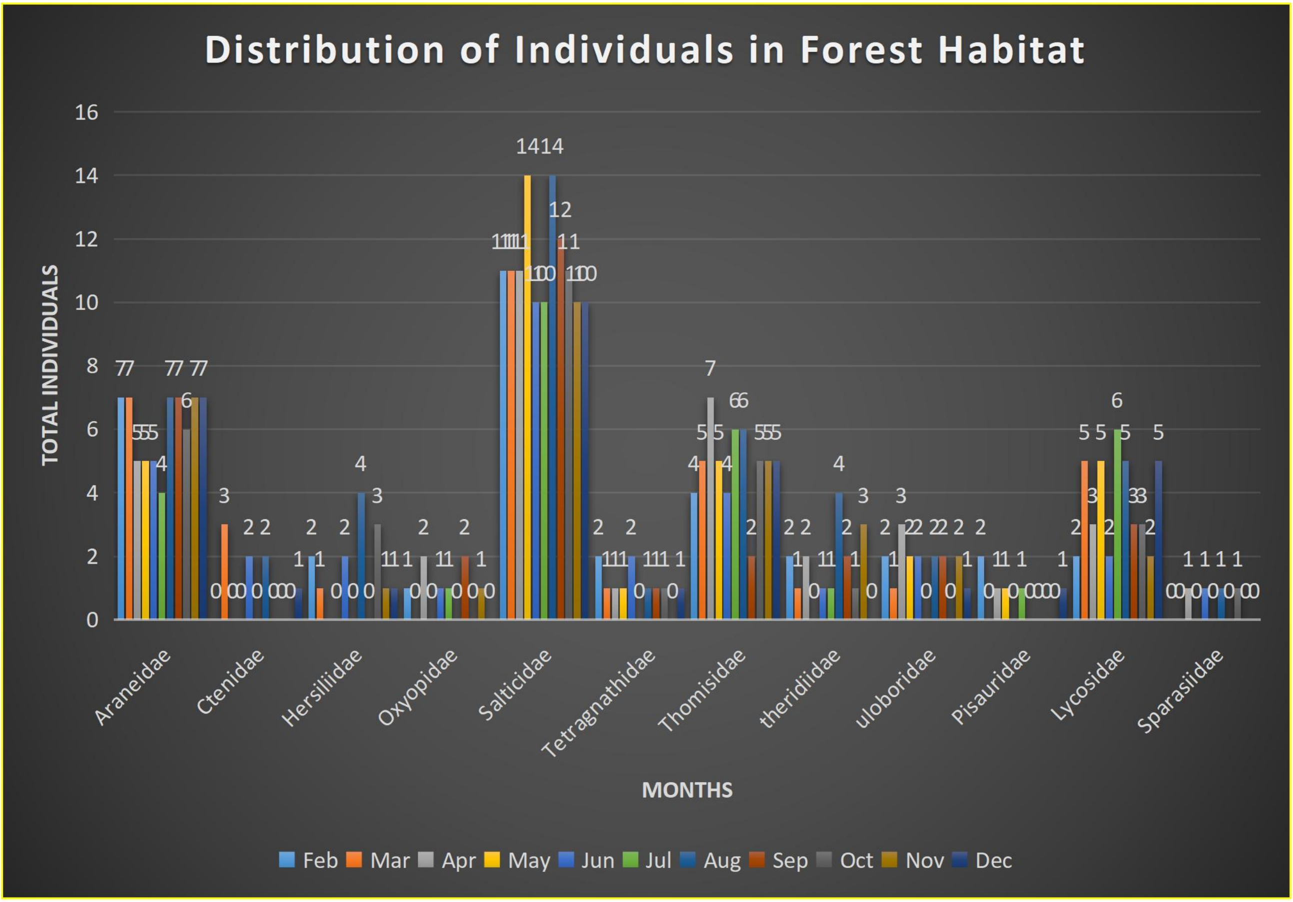

Figure 9: Distribution of Individuals in Forest Habitat

Average Temperature of five habitats over a period of one year

The average temperature among all five habitats over a period of one year.

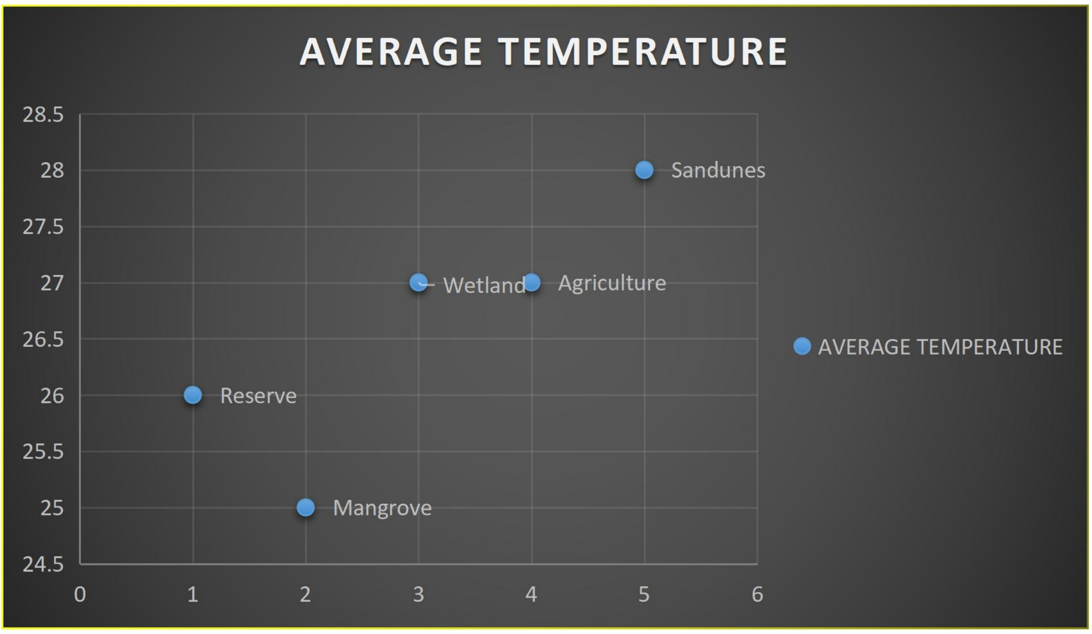

Figure 10: Distribution of Individuals in Wetland Habitat

4.4 WEB PATTERNS

Funnel web

The funnel shaped web is a type of spider web that is built by spiders in the family Lycosidae, commonly known as funnel weavers. The structure of a funnel-shaped spider web consist of two main components: the funnel and and the horizontal sheet.The funnel is a vertical tube like structure, with narrow entrance at the top and wider opening at the bottom. The flat sheet of the web is usually constructed horizontally on the ground or at a slight angle against a vertical surface such as rocks. The silk threads used to build the web are typically arranged in a radial pattern, with spokes radiating out from the entrance of the funnel.The structure of the funnel shaped web is designed to efficiently capture prey. The funnel allows the spider to quickly detect and capture prey that enters the web, while the horizontal sheet provides a larger surface area for trapping insects.The spider typically sits at the narrow end of the funnel, waiting for prey to stumble into the web. The narrow entrance of the funnel web allows the spider to quickly detect and capture prey that enters the web.

Plate 6: Funnel Web

Circular Orb weaver

Orb webs are type of spider web that are built by orb- weaver spiders, which belong to family Araineidae. Orb webs are circular or rslightly oval in shape, with a spiral of sticky silk that radiates out from the center of the web. The structure of an orb web is highly organised and consist of several distinct components. The main components of an orb web are the radial threads, frame threads and siral threads. The radial threads extend from the center of the web outwars towards the periphery, and are used as support for the web. The frame threads are thicker and stronger than the radial threads, and run around the outer edge of the web to reinforce the structure. The spiral threads form a spiral pattern that winds around the radial thread, and are sticky to capture prey. These webs have additional structure that enhance the effectiveness at capturing prey, which includes hub, which is thicker section found at centre of web where spider waits for prey and stabilimenta, zigzag lines often found in center of web,

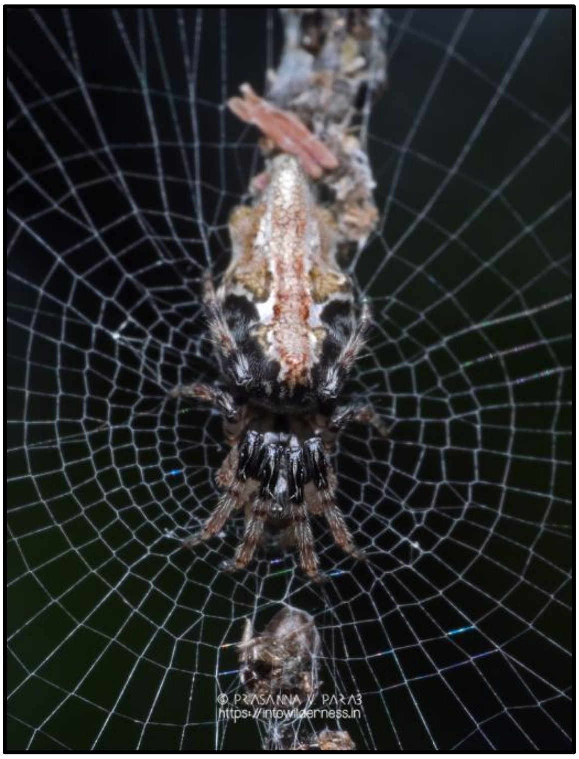

Plate 7: Circular web

Signature webs

The X-shaped web is a tyoe of orb web. It is created by some species of orb weaving spiders, particularly those in the genus Argiope. The stabilimentum is a distinctive patterns made of silk that is woven into the central part of the spiders web. The function is not properly understood, but it is thought to make the web more visible to birds and other animals, reducing the likelihood of accidental destruction of the web.

The web typically consist of radial threads that are stretched between anchor points such as branches or vegetation. The spider then constructs spiral threads that are woven in a specific pattern around the radial threads, with a gap in the centre of the web. This gap often takes the shape of an ‘x’ with the arms of the ‘x’ forming a zigzag pattern.

Plate 8: Signature Webs

Leaf mines

Spiders do not create leaf mines themselves but these are created by a variety of insect species. The larvae of these insects feed on the tissue inside the leaves, creating characteristic patterns of tunnels or blotches. The exact shape and size of leaf mines can vary depending on the species of insect and the tyoe of plant being consumed. Some spider species like spin their webs around or near these leaf mines to take advantage of the presence of insects for prey capture. The presence of spider weebs in leaf mines can be used as an indicator of the diversity and abundance of insects in an ecosystem. In general, ecosystems with high levels of insect diversity and abundance are likely to have more leaf mines present.

Plate 9 : Leaf Mine web

Cob web

Cob webs are irregular and messy webs spun by many different species of spiders. They are characterized by their tangle of threads that crisscross in many directions, creating a three- dimensional web. The threads of cobwebs are usually made of irregular, sticky silk that are typicall used to trap insects and other small prey. Cob webs are created when spiders lay down sticky silk in random patterns, often in corners or other sheltered areas. These webs are particularly built to serve as a retreat for the spider. These webs also provide shelter for other small insects and spiders.

Plate 10: Cob Web

Sheet web

Sheet webs are constructed by variety of spider species and are named for their flat, sheet like appearance. The structure of a sheet web usually consists of a horizontal sheet of silk supported by a series of threads that attach to nearby objects, such as plants or rocks. The sheet itself is composed of a densely woven mesh of silk fibers, which are usually more tightly woven towards the center of the sheet web and more loosely woven towards the edges. Many species of spiders use sheet webs for hunting, as they allow the spider to remain hidden while waiting for prey to become trapped in the web. Some spiders, such as Linyphiidae family, also use sheet webs as a form of shelter and protection.

Plate 11: Sheet Web

Ladder web

The ladder like web spun by Hersiliidae spiders on trees is a distinctive and complex structure. The web consists of a series of horizontal threads with regularly-spaced vertical threads connecting them, creating a ladder like appearance. The vertical threads are usually thicker than horizontal threads. These webs are often found on tree trunks and branches in in wooded areas. Hersiliidae spiders are known for being agile and fast moving, and they use their ladder like webs to hunt prey. They position themselves at the centre of a web called as hub and use their long legs to feel for vibrations caused by insects or other potential prey. When they sense a suitable prey item, they quickly move to capture it.The ladder like web structure is believed to have evolved as a way for Hersiliidae spiders to more effectively capture prey in the complex and cluttered environment of tree trunks and branches.

Plate 12 : Ladder Web

DISCUSSION

Role of Habitat

The study's primary objective was to document the presence and abundance of spider species in selected habitats in Goa. Over the course of one year, 1521 individuals representing 126 species, 72 genera, and 16 families were recorded at five sites comprising forest, mangrove, wetland, agricultural, and sand dune habitats. The presence and abundance of individuals belonging to specific families will also be determined by the physical properties of the vegetation (Halankar *et al*., 2018), as demonstrated by the members of the Salticidae of forest habitat in the current study.

The findings revealed that spider abundance varied significantly over time and across habitats. In terms of habitat difference, it was observed that forest and wetland habitats had the highest spider abundance, while agriculture and sand dunes had the lowest, as similar observations were made (Polchaninova *et al*., 2023), where diversity was lowest in grazing areas due to intensive grazing pressure and pasture abandonment, which resulted in vegetation suppression. Spider abundance was intermediate in the mangrove habitat. A variety of factors, such as differences in vegetation cover, prey availability, or micro climate, could explain this pattern. Climate factors such as temperature , humidity, and precipitation select the species that can live in each locality (Rodriguez-Artigas. *et al.,* 2016). Spiders tend to be more abundant and diverse in forest areas than in other habitat types, and their composition varies greatly throughout habitats (Singh &Kaur, 2020). According to the current findings, forests and wetlands have a higher density of trees and shrubs, making them more favourable habitats for spiders. The family Salticidae had the largest abundance in forest , wetland, mangrove, and agricultural habitats, followed by the family Araneidae, and Araneidae being the dominant family in sand dunes. Similar observations were made by Ried and Miller (1989), where agroecosystems with more structural complexity can support a more diverse spider community, particularly in the Araneidae and Salticidae families.

Araenidae was the most commonly observed family, with 38 species, followed by Salticidae with 37 species and Thomisidae with 10 species observed. Tetragnathidae (7), Lcosidae (6), Oxyopidae (6), Theridiidae (5), Sparassidae (4), Clubionidae (3), Ctenidae (2), Cheiracanthiidae (1), Hersililiidae (1), Pholicidae (1), Philodromidae (1), and Uloboridae (1) families were observed in smaller numbers. It has been demonstrated that habitat type and land use have a significant impact on spider communities (Weeks & Holtzer, 2000). This remark can be applicable to this study because all habitat types feature unique families and species, demonstrating that all habitats are vital for the conservation of the spiders' biodiversity.

Role of climate

The average temperature of five habitats ranged from 20°C to 30°C. In the forest habitat, the family Araneidae was found to be the most abundant, with the highest number of individuals recorded in the month of August and the lowest number of individuals, recorded in the month of November. The variation in diversity of spider species among each month is expected to be due to the differences in temperature, humidity, and other physical factors of the environment. The seasonal abundance is also influenced by the different activity patterns of spider species and the morphology of the spider community (Halarnkar & Pai, 2018). The abundance may be due to changes in temperature and humidity levels that occur as the monsoon season transitions into the drier winter season, which may trigger changes in spider behaviour and activity levels.

Behavioral patterns

Menemerus male species were observed moving their pedipals quickly when females were present; this could be breeding behaviour. *Amyciaea forticeps, an* ant like crab spider, was noticed feeding on a red weaver ant. Similarly, *Myrmarachne plataleoides*, which resembles the weaver ant, and *Myrmarachne melanocephala*, which resembles the arboreal bi-coloured ant, were observed present in ant colonies and feeding on them. Plexippus species exhibit a variety of morphological forms, which can be attributed to various stages of moulting. *Hersilia savignyi* was perfectly camouflaged with the bark on which it was residing, as well as the ladder type web and resting hub was observed. Tetragnatha species, which are mostly found on sticks, organise themselves as sticks when disturbed. Crab spiders were mostly seen at night on flowers, preying on moths and small insects. Heteropoda species were seen carrying their egg sacs, demonstrating parental care. Also, when threatened or disturbed, spiderlings were released from the egg sac, indicating a reflex response to safeguard the spiderlings. The structure of spider guilds is influenced by the host plant, micro environment, and level of disturbance (Uetz *et al*., 1999). Based on their foraging mode, 10 functional groups were identified in this study. A similar study was done by Pandit and Pai (2017), which documented nine foraging guilds on the Taleigao plateau, Goa.

Alpha Diversity Indices

To evaluate the value of alpha diversity for each habitat, diversity indices such as Shannon Index, Simpson Index, Equitability, and Margalef species richness were calculated through PAST (Paleontological Statistics Software Package for Education and Data Analysis) software. This study aimed to document spider diversity in five different habitats in Goa, and it was determined using several metrics to access the alpha diversity of each habitat. This rich diversity of spiders is also indicative of the overall biodiversity of this urban forest, since spiders are considered useful indicators of species richness and health of terrestrial ecosystems (Noss 1990). It was seen that the forest habitat had the highest number of species (50), while the sand dunes had the lowest (23). The Shannon Index is a measure of species diversity, taking into account both species richness and evenness. High biodiversity gives ecosystems the flexibility to adapt and survive in a continually changing world. Therefore, addressing decreased biodiversity is crucial to ensure the continued existence of these ecosystems (Htun,2020). Study results showed that the Forest habitat had the highest Shannon Index value (3.298), indicating a high level of diversity and evenness among the species present. The Sand dunes habitat had the lowest Shannon Index value (2.495), indicating a lower level of diversity and evenness. forest habitat might have a greater variety of resources and micro habitats that support a wide range of species and it is less disturbed by human activities, while the Sanddunes habitat might be a more extreme environment with fewer resources and harsher conditions that could support fewer species or might be more heavily impacted by human activities such as development or recreation. Higher species diversity, according to Hill (1973), is an indicator of a healthier and more complex community because a larger range of species allows for more interactions, which leads to greater system stability, which indicates good environmental conditions.

Equitability measures the evenness of species abundance, with a value closer to 1 indicating more evenness. Results showed that the sand dune habitat had the highest equitability value (1.099), indicating that the species present were relatively evenly distributed in terms of abundance. This could be due to several factors, such as low competition among species for resources or similar ecological niches that allow for an even distribution of individuals among different species. The wetland habitat had the lowest equitability value (1.018), indicating that species abundance was less even, which could be due to high competition among species for resources or may be due to habitat fragmentation that restricts the movement of species and leads to uneven distribution. The Simpson Index is a measure of dominance, with higher values indicating lower dominance. Results showed that all habitats had relatively low Simpson values, indicating no single species dominated the community. The wetland habitat had the lowest Simpson value (0.936), indicating a lower level of dominance and high evenness. The Margalef Index is a measure of species richness, taking into account the number of species present and the total number of individuals observed. The results showed that Forest had the highest Margalef Index value (6.071), indicating a high level of species richness relative to the number of individuals observed, which indicates a healthy ecosystem, as the presence of many different species suggests a well-functioning food web.

The output of the repeated measures ANOVA indicates that there is a statistically significant difference in spider diversity across the five habitats studied. This means that the types and numbers of spiders found in each habitat are not the same, and this difference is highly unlikely to have occurred by random chance alone. The p-value of 0.0017 suggests that the probability of observing such a large difference in spider diversity between the five habitats by random chance alone is less than 0.05, which is a commonly accepted threshold for statistical significance. Therefore, conclude that the difference in spider diversity between the five habitats is statistically significant.

Overall, the results provide important insights into spider diversity in Goa and suggest that each habitat has its own unique spider community with variations in species composition and abundance. This study highlights the importance of assessing biodiversity using multiple metrics to gain a more comprehensive understanding of the ecological communities present in a given area. To conclude, data on the distribution and diversity of spiders in Goa’s various habitats serves as a database on arachnid diversity and inspires further studies because they are crucial indicators of change in vegetation parameters, quality, and habitat disturbances in addition to pest management (Halarnkar & Pai, 2018).

CONCLUSION

The study analyzed the presence and abundance of spider species across five different habitats in Goa over the course of one year. The results showed that spider abundance varied significantly across habitats, with forest and wetlands having the highest abundance and sand dune habitats having the lowest. The family Salticidae was the most abundant family in all habitats except sand dunes, where Araneidae was the most dominant family. The study also noted the impact of physical properties of the vegetation on spider abundance, with forests and wetlands having a higher density of trees and shrubs, making them more favorable habitats for spiders.

The study noted that the average temperature of the five habitats ranged from 20°C to 30°C, and the variation in spider diversity among each month was likely due to differences in temperature, and other physical factors of the environment. Seasonal abundance was also found to be influenced by changes in temperature levels that occurred during the transition from monsoon to the drier winter season.

To evaluate the value of alpha diversity for each habitat, diversity indices such as Shannon Index, Simpson Index, Equitability, and Margalef Index were calculated. The study aims to establish the importance of different habitats for spider conservation, demonstrating the vital role of all habitats in conserving spider biodiversity

Overall, the study provides valuable insights into the impact of habitat and climate factors on spider abundance and diversity in different habitats in Goa. The findings can be useful in understanding the ecology of spider communities and can aid in the conservation of spider biodiversity in different habitats.

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