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Ant and spider diversity of Karuvatta, a coastal island in Vembanad, Kerala, India

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ABSTRACT: Ants and spiders are good indicators of ecosystem health; therefore, the present work aims to understand the ant and spider diversity of region Karuvatta, a coastal island in Vembanad wetland ecosystem of Kerala. For the purpose of this study, the island was divided into Karamuttu and Naluchira regions. The study conducted by different collection methods like litter sifting, umbrella method, and handpicking, revealed, 72 species of spiders and 36 species of ants. Diversity indices, species accumulation curves, functional group analyses, and PCA of soil factors were worked out. The results showed that Naluchira had better diversity than Karamuttu. © 2024 Association for Advancement of Entomology

KEY WORDS: Biodiversity, wetland ecosystem, diversity indices, species accumulation curves, functional group analyses, PCA of soil factors

INTRODUCTION

The presence of ants (Hymenoptera, Formicidae) and spiders (Arachnida, Araneae) in a natural environment indicates a healthy ecosystem. Their action towards the environment is essential to the well-being of the habitats in which they live. They are recurrently described as "ecosystem engineers" because they perform many vital ecological services. According to Gadagkar *et al*. (1993), ants are one of the most significant ecological invertebrates in the terrestrial ecosystem because of their enormous biomass, species composition, trophic interactions, mutualistic relationships, and symbiotic relationships that influence the biotic and abiotic community interaction matrix (Dash, 2004). Since changes in ant assemblages are usually associated with changes in other invertebrate assemblages, they have been used in evaluating management conservation practices (Folgarait, 1998) and as a focal group in insect biodiversity studies (Dobson *et al*., 2006).

In the animal kingdom, spiders are among the most prevalent kinds of predatory organisms (Riechert and Lockley, 1984). Also, they are great candidates for land conservation research because they typically have strict humidity and temperature preferences that confine them to locations within the ranges of their physiological tolerances (Riechert and Lockley, 1974). In addition to this, spiders are valuable indicators of the overall species richness and health

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of the ecosystem (Noss, 1990). Despite their ecological roles as important biocontrol agents, (Riechert and Lockley, 1984), regulating decomposer population (Clarke and Grant, 1968) and influencing ecosystem functioning (Lawrence and Wise, 2000), they have received high threats and little attention from conservation communities (Skerl, 1999). The present study of ant and spider diversity is conducted in Karuvatta Island of Vembanad wetland ecosystem in Alappuzha district of Kerala. The evergreen island, home to diverse flora and fauna, predominantly forms habitats for a variety of ants and spiders. Due to their abundance, which allowed for a high sample size and relative ease of sampling compared to large creatures, the two invertebrates, ants and spiders, have been the subject of the current study. This study will shed some light into the abundance of spider and ant diversity in this island ecosystem, and its outcome will also throw light to make a benchmark of Vembanad island in terms of effective conservation and habitat management.

MATERIALS AND METHODS

The study was carried out in Karuvatta village in Alappuzha District of Kerala, India. It is an island surrounded by backwaters and lies in between Haripad and Thottappally in Alappuzha (Fig. 1). The total geographical area of the village is 1440ha ha and the elevation of the study area is 4m above sea level. Sampling was done using the standard transect method. Two sites were selected as the representative of the area and were named as site 1 and 2. Site 1 is Naluchira, a village in Purakkadu panchayath and Site 2 is Karamuttu, a village in Karuvatta panchayath.

Site 1 (Naluchira): Naluchira (Situated at 9.32289°E; 76.40091°N) is a human inhabitant area comprising houses, roads, and canals. The site possesses wide variety of habitats, which include paddy fields, grasslands, and marshy lands. For the study purposes the site 1 is again divided in to 3 sub sites, 1a – cashew plantation site, 1b - grass lands and 1c - marshy land.

Site 2 (Karamuttu): Karamuttu (Situated at 9.3347°E; 76.4095°N) is the eastern part of the Karuvatta island. It is a human inhabitant area comprising houses, roads and canals. The site possesses wide variety of habitats, with paddy fields, grasslands and marshy lands. It also comprises many flowering plants and trees such as acacia, bamboo trees etc. For the study purposes the site 2 is again divided in to 3 sub sites, 2a - marshy land, 2b - bamboo trees and 2c - acacia trees.

Spiders and ants were sampled from May to July 2022 (for a period of three months) between 6am to 11am. Sampling methods included bait traps (used to attract foragers), beating low vegetation, litter sifting, handpicking, sweep net (for only spiders) and visual search. Ant specimens were also collected using subterranean traps (plastic recipients with 8cm diameter and 12cm height with four radial holes to allow ants to access the interior of the trap). Collected specimens were preserved in 70 per cent alcohol for further analyses.

Detailed examination of each spider and ants were done using the Labomed CZM4 Stereomicroscope. The epigynum of female adult spiders were dissected, cleared in KOH (10%), mounted on a temporary slide and observed under a compound microscope (Leica DM1000 LED) to study the internal structures. Adult male spiders were identified by observing their palp. Measurements of the legs and palps were taken using the Leica S8APO version 4.2. Spiders were identified using literature (Sebastian and Peter 2009; Sudhikumar, 2007) and taxonomic keys of Bingham (1903) and Bolton's (1994) Catalogue of Ants of the World. All identified specimens were deposited in the Zoological Museum of the Department of Zoology, University of Kerala, Kariavattom for reference.

The checklists of the specimens of ants and spiders were prepared. The percentage compositions of the different families at different sites were calculated and graphically plotted. The diversity indices were calculated using R environment. Dominance index was estimated using *Estimate Dominance* package and other indices were analysed using *vegan* package in R Core Team, 2021. Principal Coordinate Analysis of different sites was done using *vegan* package in R (Oksanen,

2022). The PCA between the soil parameters and the sites were done using Base R. Species accumulation curves were plotted using *iNEXT* package (Chao *et al*., 2014; Hsieh *et al*., 2016). Normality of the data was checked with the Shapiro-Wilkins Test. Normalization of data was done where needed. ANOVA of the species diversity, indices, and soil parameters was done using Base R package. The post-hoc analysis was done using Tukey's HSD.

Soil collected from all the subsites were analysed for organic carbon content by Walkley and Black rapid titration method. The pH was measured using a pH meter. Moisture was measured by gravimetric method.

Landscape analysis was done using QGIS Tisler 3.28 version. The images were obtained from USGS Landsat 8 data (USGS, 2023).

RESULTS

A total of 36 species of ants were collected from five subfamilies and 18 genera. Subfamily Formicinae had the highest abundance and the most number of species. A checklist of the ants collected is given (Table 1). Their diversity indices were calculated (Table 2). *Camponotus rufoglaucus, Diacamma rugosum, Odontomachus simmillimus* and *Technomyrmex albipes* were found in all sites. Site 1a showed the highest diversity while Site 2a was with least diverse.

The species accumulation curve was found to have reached an asymptote for the island (Fig. 2).

Functional Group Analysis:

The ants were divided into 9 functional groups Opportunists, Specialist predators, Subordinate camponotinii, Tropical Climate Specialists, Hot Climate Specialists, Cold Climate Specialists, Generalised Myrmicinae, Cryptic species, Small Sized Hypogaeic Generalist Foragers (Fig. 3). Hot Climate Specialists were found only in Site 3 while, Cold Climate specialists, Cryptic species and Small-Sized Hypogaeic Generalist Foragers were found only in Site 2.

Total 72 species of spiders belonging to 15 families were reported from both Karamuttu and Naluchira Islands of Karuvatta village, Alappuzha, during the period of three months (May 2022-Jul 2022) study. A checklist of the spiders collected (Table 3), revealed that, the dominant family was Salticidae (19), followed by Araneidae (17), Tetragnathidae (7), Theridiidae, Lycosidae and Thomisidae (4), Clubionidae (3), Liocranidae (3), Corrinidae (2), Hersiliidae (2) Uloboridae and Oxyopidae (2). The

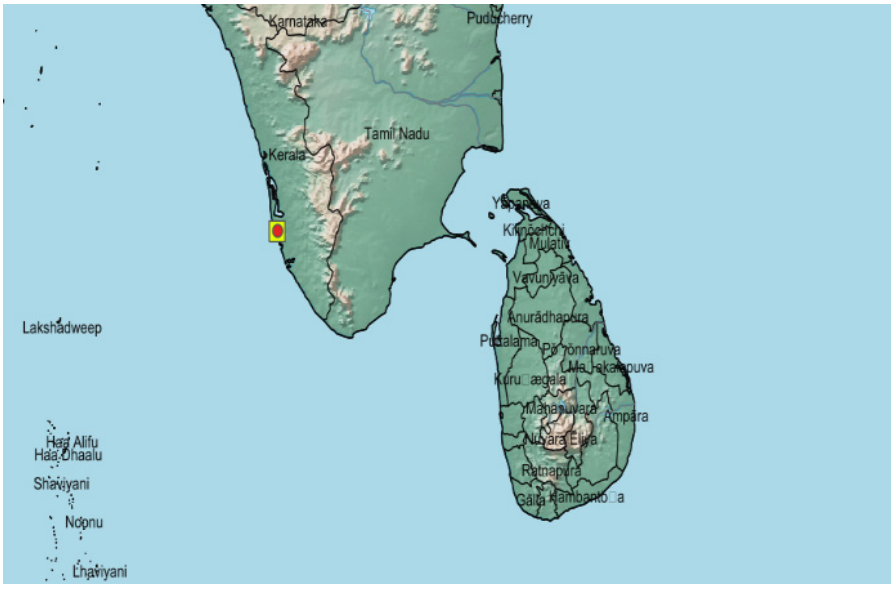

Fig. 1 Collection sites in Karuvatta, Kerala; Red circle- Naluchira and Yellow square- Karamuttu

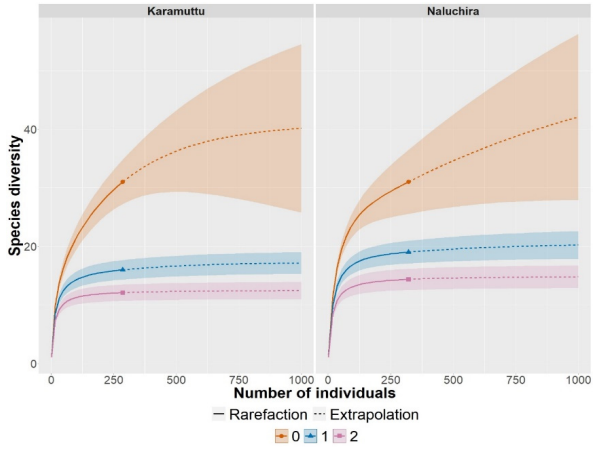

Fig. 2 Species Accumulation Curve of ants

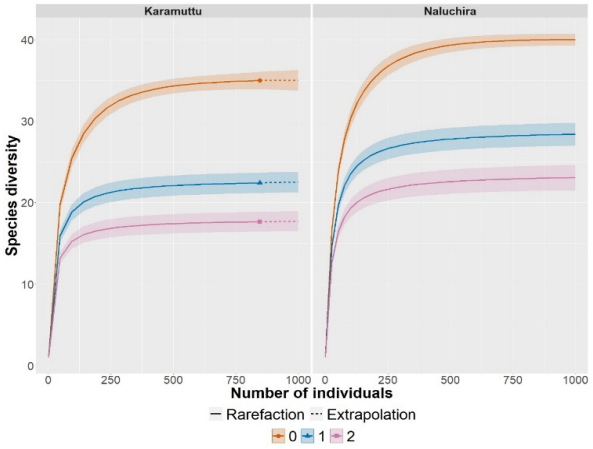

Fig. 4 Species Accumulation Curve of spiders

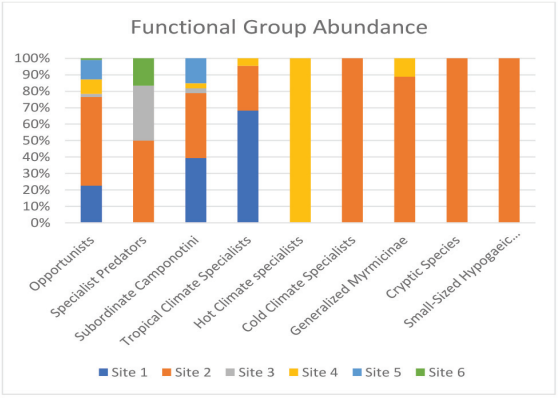

Fig. 3 Functional Group Composition of Ants

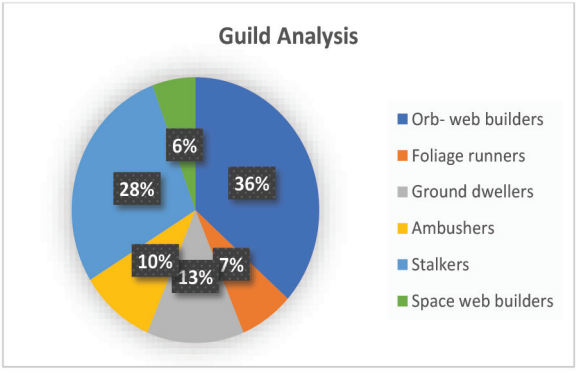

Fig. 5 Guild composition of spiders.

least common families are Cheiracanthidae, Pisauridae and Sparassidae represented with single species.

Diversity indices of total number of spider species from both sites (Table 4), indicated that form subsite of site 1, Cashew Plantation Site (S1a) has the most diversity with Shannon-Weiner Index 3.263. A good diversity in S1a and S1c of S1 Naluchira is due to the presence of vegetation with the abundance of shrubs and bushes in these subsites. The lowest diversity is observed from the Grassland land subsite (S1b) of site 1. Unlike site 1, in site 2 Salticidae is the dominant family with eight species. The family Araneidae ranks second with five species. Considering the diversity of spiders listed under each subsite of site 2, the Marshy land (S2a) has the most diversity with Shannon-Weiner Index and Dominance diversity index as 2.998, 0.06011 respectively. A wide variety of shrubs and small trees in this area provide spiders an ideal habitat for assemblage, mating and capturing small insects as prey. The lowest diversity is observed from Bamboo tree subsite (2b) of site 2. Diversity indices of site 1a was found to be highest, and evenly distributed and least dominant. Site 2b was most dominant. Species accumulation curve has reached an asymptote (Fig. 4).

Guild structure: In the present study six guild structure of the spiders were observed namely stalkers, orb-web weavers, foliage and ground runners, space web builders and ambushers based on foraging behaviour and ecological characteristics (Uetz *et al.,* 1999; Hofer *et al.,* 2001; Young and Edwards, 1990). Among the spider families collected, the spiders belonging to the guild structure orb-web builders were the dominant group

Table 1. Checklist of ants of Karuvatta

No.	Species
	Subfamily: Dolichoderinae
1.	*Dolichoderus* sp.
2.	*Tapinoma indicum* (Forel, 1895)
3.	*Ta. melanocephalum* (Fabricius, 1793)
4.	*Technomyrmex albipes* (Smith, F., 1861)
5.	*Te. vitiensis* (Mann, 1921)
	Subfamily: Formicinae
6.	*Anoplolepis gracilipes* (Smith, F., 1857)
7.	*Camponotus irritans* (Smith, F., 1857)
8.	*Camponotus* sp.
9.	*C. rufoglaucus* (Jerdon, 1851)
10.	*Nylanderia birmana* (Forel, 1902)
11.	*N. bourbonica* (Forel, 1886)
12.	*N. taylori* (Forel, 1894)
13.	*N. yerburi* (Forel, 1894)
14.	*Oecophylla smaragdina* (Fab, 1775)
15.	*Paratrechina longicornis* (Latreille, 1802)
16.	*Polyrhachis tibialis* Smith F., 1858
	Subfamily Myrmicinae
17.	*Carebara* sp.
18.	*Crematogaster dohrni* Mayr, 1879
19.	*C. rothneyi* Mayr, 1879
20.	*Meranoplus bicolor* (Guérin-Méneville, 1844)
21.	*Monomorium indicum* Forel, 1902
22.	*M. orientale* Mayr, 1879
23.	*M. pharaonic* (Linnaeus, 1758)
24.	*Pheidole* sp.
25.	*P. vulcan* Fischer & Fisher, 2013
26.	*Solenopsis geminata* (Fabricius, 1804)
27.	*Tetramorium bicarinatum* (Nylander, 1846)
28.	*T. pacificum* Mayr, 1870
29.	*T. rossi* (Bolton, 1976)
	Subfamily Ponerinae
30.	*Anochetus validus* Bharti & Wachkoo, 2013
31.	*Diaccamma rugosum* (Le Guillou, 1842)
32.	*Odontomachus simmillimus* Smith, F., 1858
33.	*Plathytyrea parallela* (Smith F., 1859)
	Subfamily Pseudomyrmicinae
34.	*Tetraponera nigra* (Jerdon, 1851)
35.	*T. periyarensis* Bharti & Akbar, 2014
36.	*T. pilosa* (Smith F., 1858)

(comprising of 39%) followed by the stalkers (29%) (Table 1, Fig. 5).

The PCA analysis for soil parameters explains 85% of the variation in the values (Fig. 6). The Summary of the soil data is given (Table 6). The subsites 1 and 2 showed positive relation with pH and negative relation to the Organic Carbon. Subsite 4 showed a positive relation to pH. Subsite 3 and 4 showed a positive relation to moisture as they are both marshy lands. Subsite 1, 2, and 5 showed a negative relation to moisture. Subsite 1 and 2 seem to be related.

Table 2. Diversity indices of Ants

Indices	1a	1b	1c	2a	2b	2c	Total
Shannon_H	2.491	2.453	2.353	1.964	2.256	2.156	2.822
Evenness_e^H/S	0.8045	0.6117	0.7516	0.7918	0.6819	0.7196	0.5421
Dominance_D	0.09497	0.1163	0.1182	0.1576	0.1284	0.14	0.07662

Table 3. Checklist of spider fauna collected from Karuvatta island

No.	Species	No.	Species
	Araneidae Clerck, 1757		**Salticidae Blackwall, 1841**
1	*Anepsion maritatum* (O.P Cambridge, 1877)	36	*Asemonea tenuipes* (O.P Cambridge, 1869)
2	*Araneus ellipticus* (Tikader & Bal, 1981)	37	*Bianor angulosus* (Karsch, 1879)
3	*Argiope aemula* (Walckenaer, 1841)	38	*Brettus cingulatus* Thorell, 1895
4	*A. anasuja* Thorell, 1887	39	*Carrhotus viduus* (C.L. Koch, 1846)
5	*A. catenulata* (Doleschall, 1859)	40	*Menemerus bivittatus* (Dufour, 1831)
6	*Chorizopes khanjanes* Tikader, 1965	41	*Myrmaplata plataleoides* (O.P Cambridge,1869)
7	*Cyclosa confraga* (Thorell, 1892)	42	*Phintella vittata* (C. L. Koch, 1846)
8	*Cyrtophora cicatrosa* (Stoliczka, 1869)	43	*Phintelloides undulatus* (Caleb & Karthikeyani, 2015)
9	*C. citricola* (Forsskål, 1775)	44	*Plexippus paykulli* (Audouin, 1826)
10	*Eriovixia laglaizei* (Simon, 1877)	45	*P. petersi* (Karsch, 1878)
11	*Gasteracantha geminata* (Fabricius, 1798)	46	*Rhene flavicomans* Simon, 1902
12	*Guizygiella* sp. Zhu, Kim & Song, 1997	47	*R. flavigera* (C.L. Koch, 1846)
13	*Herennia multipuncta* (Doleschall, 1859)	48	*Telamonia dimidiata* (Simon, 1899)
14	*Neoscona bengalensis* Tikader & Bal, 1981	49	*Myrmarachne spissa*
15	*Neoscona nautica* (L. Koch, 1875)	50	*Marengo sachintendulkar*
16	*N. vigilans* (Blackwall, 1865)	51	*Myrmarachne ramunni*
17	*Neoscona* sp. Simon, 1864	52	*M. melanocephala*
	Cheirancanthiidae Wagner, 1887	53	*M. uniseriata*
18	*Chericanthium melanostomum* Thorell 1895	54	*Myrmarachne* sp.
	Clubionidae Wagner, 1887		**Sparassidae Bertkau, 1872**
19	*Clubiona drassodes* O.P Cambridge, 1874	55	*Olios* sp.
20	*C. filicata* O.P Cambridge, 1874		**Tetragnathidae Menge, 1866**
21	*C. tridentata* Dhali, Roy, Saha & 2016	56	*Leucauge granulata* (Walckenaer, 1841)
	Corinnidae Karsch, 1880	57	*Tetragnatha ceylonica* O. P Cambridge, 1869
22	*Castianeira zetes* Simon, 1897	58	*T. cochinensis* Gravely, 1921
23	*Corinnomma severum* (Thorell, 1877)	59	*T. mandibulata* Walckenaer, 1841
	Hersiliidae Thorell, 1869	60	*Tetragnatha viridorufa* Gravely, 1921
24	*Hersilia savignyi* Lucas, 1836	61	*Tylorida striata* (Thorell, 1877)
25	*H. tibialis*	62	*T. ventralis* (Thorell, 1877)

	Liocranidae Simon, 1897		**Theridiidae Sundevall, 1833**
26	*Oedignatha scrobiculata* Thorell, 1881	63	*Argyrodes argentatus* O.P Cambridge, 1880
27	*Oedignatha* sp.2 Thorell, 1881	64	*Nihonhimea indicum* (Tikader, 1977)
28	*Sphingius barkudensis* Gravely, 1931	65	*Parasteatoda celsabdomina* (Zhu, 1998)
	Lycosidae Sundevall, 1833	66	*Theridion manjithar* Tikader, 1970
29	*Pardosa pseudoannulata* (Bösenberg & Strand, 1906)		**Thomisidae Sundevall, 1833**
30	*P. sumatrana* (Thorell, 1890)	67	*Camaricus formosus* Thorell, 1887
31	*P. parathompsoni* Wang & Zhang, 2014	68	*Thomisus projectus*
32	*P. oriens* (Chamberlin, 1924)	69	*Thomisus* sp.
	Oxyopidae Thorell, 1869	70	*Amyciaea forticeps*
33	*Oxyopes javanus* Thorell, 1887		**Uloboridae Thorell, 1869**
34	*O. birmanicus*	71	*Philoponella feroka* (Bradoo, 1979)
	Pisauridae Simon, 1890	72	*Uloborus krishnae* Tikader, 1970
35	*Dendrolycosa gitae* (Tikader, 1970)		

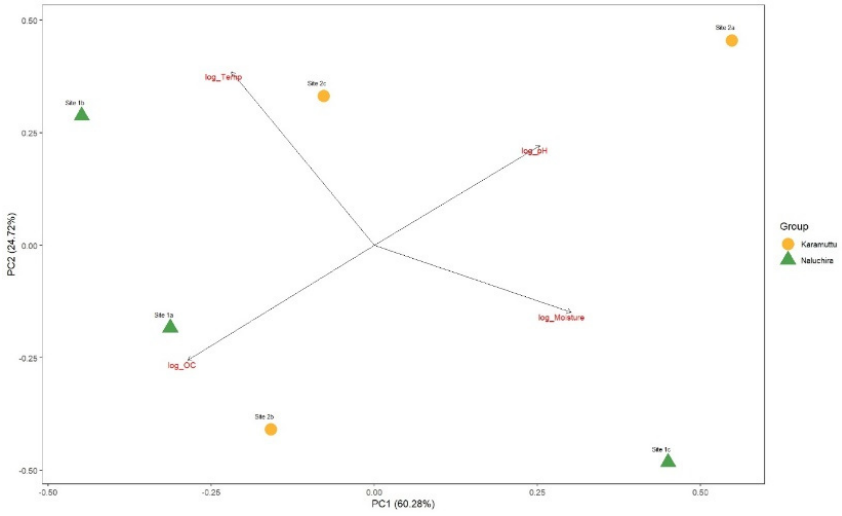

Fig. 6 PCA of soil factors

The satellite image of Karuvatta (Fig. 7) and habitat utilization (Fig. 8) represents a large area of the island covered by paddy field. Also as few habitation areas around the paddy fields.

DISCUSSION

Ants and spiders are very important for ecosystem resilience and maintaining the system in equilibrium regarding edaphic and biological factors. The Karuvatta island in Kuttanad is dominated by paddy fields and both spiders and ants act as biocontrol agents in paddy fields as reported by Way *et al*. (2002) and ants are also known to influence soil properties in paddy fields (Jouquet *et al*., 2008). Hence, it is highly necessary to assess the richness of these two categories of organisms in an ecosystem.

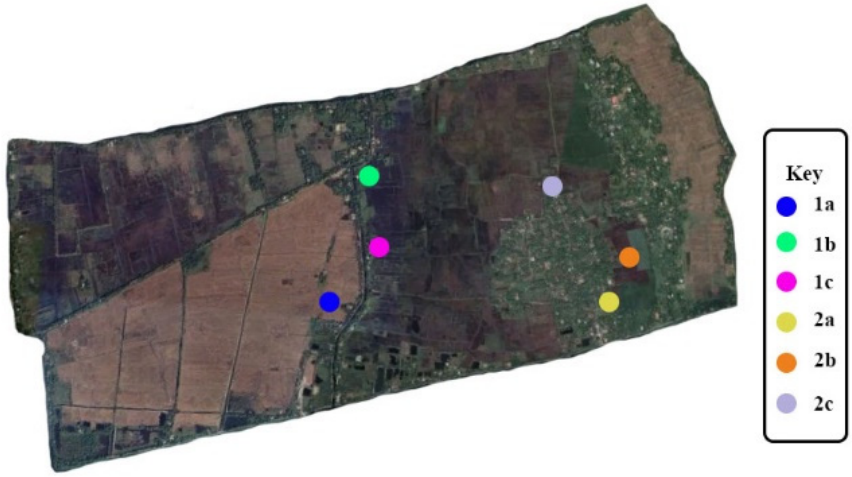

Fig. 7 Satellite Image of Karuvatta Island

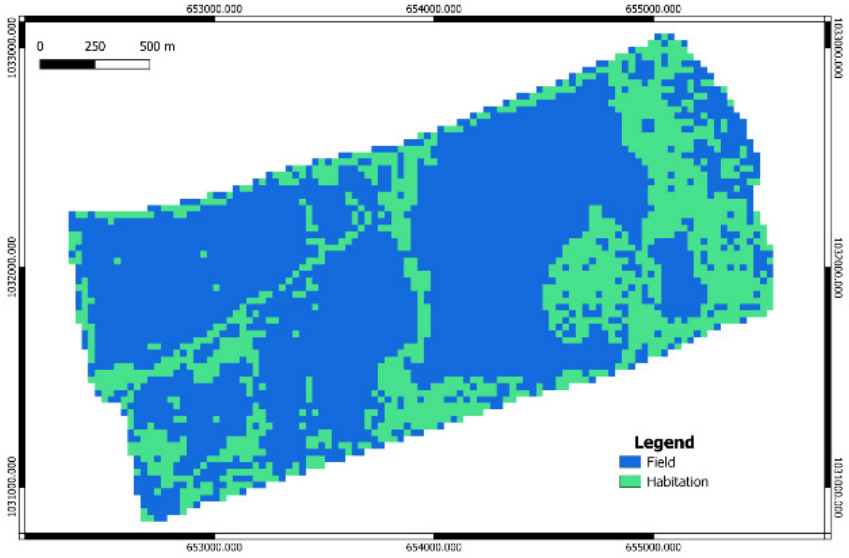

Fig. 8 Habitat Utilization of Karuvatta Island

Table 4. Diversity indices of Spiders

Diversity Indices	1a	1b	1c	2a	2b	2c	Total
Shannon_H	3.263	3.231	3.239	2.998	2.891	2.979	3.67
Evenness_e^H/S	0.7914	0.7444	0.7731	0.7157	0.7202	0.7284	0.6039
Dominance_D	0.04435	0.04736	0.04688	0.06011	0.06592	0.06355	0.03635

Ants are important components of ecosystems because they constitute a great part of the animal biomass and, they act as ecosystem engineers. This study documents the diversity of ants in Karuvatta Island in Vembanad wetland ecosystem, where 36 species of ants belonging to 18 genera and five subfamilies were identified. The subfamily Formicinae accounted for the highest number of species (11 species), followed by subfamily Myrmicinae with 10 species. A similar study was conducted at Kuttanad region of Kerala, India where 25 species of ants belonging to five subfamilies distributed among 17 genera were reported (Rabeesh *et al*., 2017). In a study at Chorao Island, Goa, India a total of 38 ant species belonging to 24 genera and six subfamilies were collected (Pai *et al*., 2009). In another study at Havelock Island in the Andaman Islands, a total of 50 species of ants belonging to 25 genera were identified (Agavekar *et al*., 2019).

Ant diversity studies have also been conducted in various terrestrial ecosystems in India. From Silent Valley National Park, Western Ghats, Kerala, 30 genera representing 40 species and six subfamilies were recorded (Sabitha *et al*., 2018). In a study at selected sites of Aralam Wildlife Sanctuary, Kerala, a total of 19 species of ants were collected and identified by Joseph and Thomas (2021). From Amravati City of Maharashtra, 34 species of ants belonging to five subfamilies were identified (Chavhan and Pawar, 2011). The Udupi District, Karnataka recorded 31 species of ants under 17 genera and five subfamilies (Cunha and Nair, 2013).

Table 5. Guild structure of spiders and number of species

No.	Guild structure	No. of species
1	Orb- web builders	27
2	Foliage runners	5
3	Ground dwellers	9
4	Ambushers	7
5	Stalkers	20
6	Space web builders	4
	Total	72

Table 6. Soil data summary

Naluchira				
	pH	OC	Moisture	Temperature
Mean	3.628	1.977	13.603	24.22
SD	0.115	0.535	11.511	1.92
Minimum	3.52	1.2	5.3	21
Maximum	3.9	2.5	29.1	27
Karamuttu				
Mean	3.614	1.178	16.7	26
SD	0.564	0.555	2.60	1
Minimum	3	0.5	14.2	25
Maximum	4.5	1.95	20.12	27

The Functional group analysis showed that the opportunists and subordinate Camponotini are present in large numbers in all sites. Their general resilience to change and generalist nature has enabled them to conquer most sites. Small-hypogeic generalist foragers should have shown better distribution, but their hypogaeic nature makes them difficult to collect and their representation not accurately possible. More number of species seems to have an association to Naluchira than Karamuttu. Overall, the Naluchira has a better ant diversity and lower dominance and therefore, it is an ecologically balanced habitat.

Spiders are important predatory arthropods that play a crucial role in maintaining the ecological balance. The present observation documents 72 species of spiders belonging to 15 families in Karuvatta village in India. The dominant families were Salticidae and Araneidae, with 19 and 17 species, respectively. A similar study was conducted at Pathiramanal Island in the same wetland ecosystem, where 147 species of spiders belonging to 26 families under 92 genera were documented (Malamel and Sudhikumar, 2020). In Kuruva Island of the Wayanad district in Kerala, 19 spider species belonging to 10 families were identified (Andrews and Jose, 2021). Another study in the St. Estevam Island in Goa documented spiders belonging to eight families, 19 genera, and 29 species (Halarnkar and

Pai, 2018). In the selected islands of the Gulf of Kutch, 123 species of spiders belonging to 81 genera under 25 families were identified (Parmar *et al*., 2015). In the Andaman and Nicobar Islands of the Indian Ocean, 58 species of spiders contained in 41 genera and distributed in 20 families were documented, 26 of which were new to science (Tikader, 1977). In addition, study on diversity of family Tetragnathidae was also conducted in Kuttanad by Babu and Prasad (2022). The dominant family of spiders varies across different studies and locations. In Karuvatta, on of the dominant families was Araneidae similar to that of Pathiramanal Island (Malamel and Sudhikumar, 2020) and Kuruva Island (Andrews and Jose, 2021). The variation in the distribution patterns of spiders may be due to the influence of microhabitat types on species distribution. Many factors determine species composition. This may be related to the changes in the vegetation structure of the habitat. The stalkers (wanderers) and the web-building spiders rely on vegetation for some part of their lives to find food, retreat, or build webs (Sanders and Platner 2007). Therefore, the vegetation structure of different types of plantations in the present study area might influence the diversity of Salticidae and Araneidae compared to other families. Reports are also available on the species diversity and evenness from various localities of the world. In Karuvatta, Naluchira is having a good population of spiders than Karamuttu. The soil analysis of the sub sites in Naluchira and Karamuttu showed different relations to pH, organic carbon, and moisture content. Naluchira had a higher diversity of species and a greater number of associated species compared to Karamuttu. The guilds of the spider families in Karuvatta village were dominated by web spiders, followed by stalkers. Previous studies have shown conflicting results on the prevalence of different types of spiders in different habitats, with some studies finding a higher proportion of jumping spiders and others finding a higher proportion of hunters. These differences may be due to variations in habitat and other factors that affect the distribution and diversity of spiders. Further research is needed to understand the specific factors that influence the distribution and diversity of spider species

Naluchira had better species richness than Karamuttu perhaps because of the larger habitation area in Karamuttu. Naluchira is dominated by paddy fields in terms of area and hence this provides a much lower disturbance than habitation sites.

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