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AN INVESTIGATION OF DIVERSITY AND BIOECOLOGY OF ARANEOFAUNA OF PATHIRAMANAL ISLAND IN VEMBANAD LAKE, A RAMSAR SITE, KERALA, INDIA

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Abstract. A preliminary checklist of araneofauna of Pathiramanal Island is provided. A total of 147 species belonging to 26 families under 92 genera are documented. *Tylorida ventralis* (Thorell 1877) is considered to be the dominant species, and orb weavers are seen as the dominant guild. Araneidae, Salticidae, Theridiidae, Tetragnathidae and Thomisidae are five dominant families. The Shannon diversity, Simpson's (1-D) diversity, evenness and Chao1 indices have been calculated. Seven species new to science such as *Indopadilla insularis*, *Epeus triangulopalpis*, *Marengo sachintendulkar*, *Indomarengo chavarapater*, *Icius vikrambatrai*, *Piranthus planolancis* (Salticidae) and *Wolongia papafrancisi* (Tetragnathidae) are documented as well as three genera and four species are added to the Indian spider taxonomy. The males of *Meotipa picturara*, *Curubis tetrica* and *Pscellonus planus* are described for the first time. Eight species are synonymized and redescribed. Mating plug formation in *Argyrodes flavescens* is reported for the first time. It is noted that spider species from Pathiramanl Island bear affinities with Oriental and Palearctic regions.

INTRODUCTION

A healthy ecosystem and its smooth functioning is an indicator of the potentiality of the biodiversity of that particular ecosystem (Pettersson 1996). Pathiramanal Island seems to be a healthy ecosystem with a tower of biodiversity of both plants and animals. As far as a local legend goes, Pathiramanal Island originated as a result of divine intervention. A young Brahmin (a person belonging to the Hindu higher caste worthy of priesthood) dived into Vembanad Lake to perform his evening prayers, and the water made way for land to rise from below, thus forming the enchanting Island of Pathiramanal which means 'sands of midnight'. A great charming look, wide waterfront, flourishing coconut palms, floating weeds and hyacinths, tiny birds building nests on weeds, and varieties of rare fauna and flora among the dense foliage of this tiny Island make it really a biodiversity hotspot. But, regrettably, no previous biodiversity studies have been done in Pathiramanal Island. An informal report indicates that the Island possesses some sort of fauna like odonates, birds, mammals, reptiles and arthropods (not a precise data). Arthropod diversity in this area remains undocumented, and a pilot study disclosed that it is a refuge for a rich volume of arachnids, to which spiders make a great contribution. But no organized work has been carried out to date on the taxonomy and diversity of spiders of this biologically unique ecosystem. 23 species of spiders have been named unofficially from this ecological zone. However, it is sure that a number of spiders have yet to be explored in this ecosystem, which prompts the need for an inventory of the spider fauna of this unique environmental sector. As spiders free us from most of insect pests like a key component to balancing the ecosystem both as prey and predator, they are very important animal taxa for humans (Benítez and Méndez 2011). In order to understand the potentiality of the Island and to conserve the spider species there, it is essential to explore the Island comprehensively. Therefore, this study is an attempt to throw light on the diversity, richness, abundance and dominance of spiders in Pathiramanal Island.

MATERIALS AND METHODS

Study Area

Pathiramanal Island (hereinafter, Island) is a small tropical island with an area of approximately 1 km^2. It lies between the latitudes 9°37'07.11" N and longitudes 76°23'04.95" E (Figure 1). Though small in size, Pathiramanal Island is blessed with rich flora and fauna owing to the presence of a wide forest cover and thick vegetation (Figure 2). With respect to its geographical, climatic and ecological features, the Island harbours a rich amount of arachnids, of which spiders have a huge share. The temperature ranges from 28.6° C to 33.5° C, with an annual mean of 31.0° C and plentiful rainfall in June–July (annual rainfall > 250 mm). The dense vegeta-

tion in the Island paves the way for strong winds which allows the circulation of good air thereby reducing the accumulation of pollutants. Till the late seventies of the 20th century, 14 worker families resided in the Island, who were later shifted to the mainland, and now the Island is non-inhabited. Recognizing the potential of the Island, Kerala Government took over the property in 1979 and later transferred it to the governance of the Tourism Department.

The diversity, richness and spatial distribution of spider species were investigated from October 2014 to September 2016. In the present study, four hours of sampling involved active searching for spiders, employing a combination of five collection methods such as aerial hand collection, ground hand collection, litter sampling, sweep netting and vegetation beating. All the specimens collected during the survey were transferred to a fixative (70% alcohol) for preservation. The sex and developmental stage of all trapped individuals were determined in the laboratory. Species-level identification was mainly made by looking at the genital features of the spiders. The palp and epigyne were dissected, and the epigyne was cleared in 10% KOH for identifying the species. A detailed taxonomic study was carried out using the data provided by the World Spider Catalog (2020).

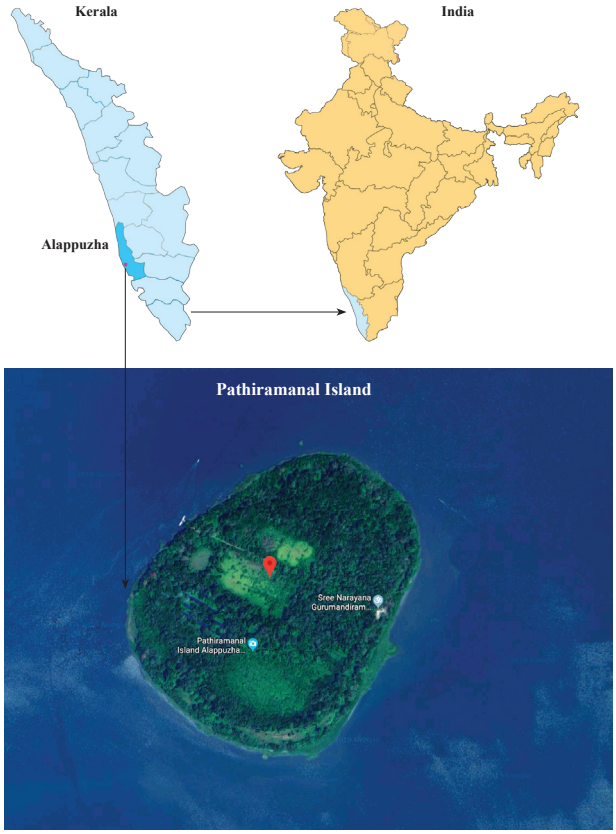

Figure 1. Map of the study area.

Data analysis

Statistical relevance of collected data was supported by calculating the following diversity indices:

Shannon-Weiner diversity index (H') was calculated using the formula:

$$H' = -\sum[(p_i) \times \ln(p_i)],$$

where – $\sum$ = summation, p_i = proportion of total sample represented by species i.

Simpson's diversity index ($D' = 1 - D$) was calculated using the formula:

$$D = 1 - \sum n(n - 1)/N(N - 1)$$

$$D' = 1 - D = 1 - \frac{\sum n\,(n - 1)}{N\,(N - 1)},$$

where – D = Simpson's index, n = total number of organisms of a particular species, N = total number of organisms of all species.

Evenness in species distribution was calculated using Simpson's formula:

$$E = D/D_{max},$$

where

$$D = 1/\sum P_i\ 2.$$

Chao1, an estimate of total species richness, was calculated using the formula:

$$\text{Chao1} = S + F1\ (F1 - 1) / (2\ (F2 + 1)),$$

where – $F1$ = the number of singleton species, $F2$ = the number of doubleton species.

RESULTS

A total of 147 species of spiders belonging to 92 genera and 26 families were collected during the entire sampling period (Table 1). The Shannon diversity, Simpson's (1–D) diversity, evenness, and Chao1 indices were calculated to be 4.05, 0.970, 0.394, and 149.3, respectively. The most dominant five families reported were Araneidae (22%, 33 species), followed by Salticidae (21.5%, 32 species), Theridiidae (11%, 16 species), Tetragnathidae (9.5%, 14 species) and Thomisidae (5.5%, 8 species), while families such as Cheiracanthiidae, Gnaphosidae, Hersiliidae, Linyphiidae, Oonopidae, Philodromidae, Pholcidae, Pisauridae, Psechridae, Scytodidae, Sicariidae and Zodariidae were represented by only one species each. *Tylorida ventralis* was an abundant species throughout the study period. Out of 26 families, 23 are classified as entelegyne spiders and three (Oonopidae, Scytodidae, Sicariidae) are haplogyne spiders. Some families were more widely

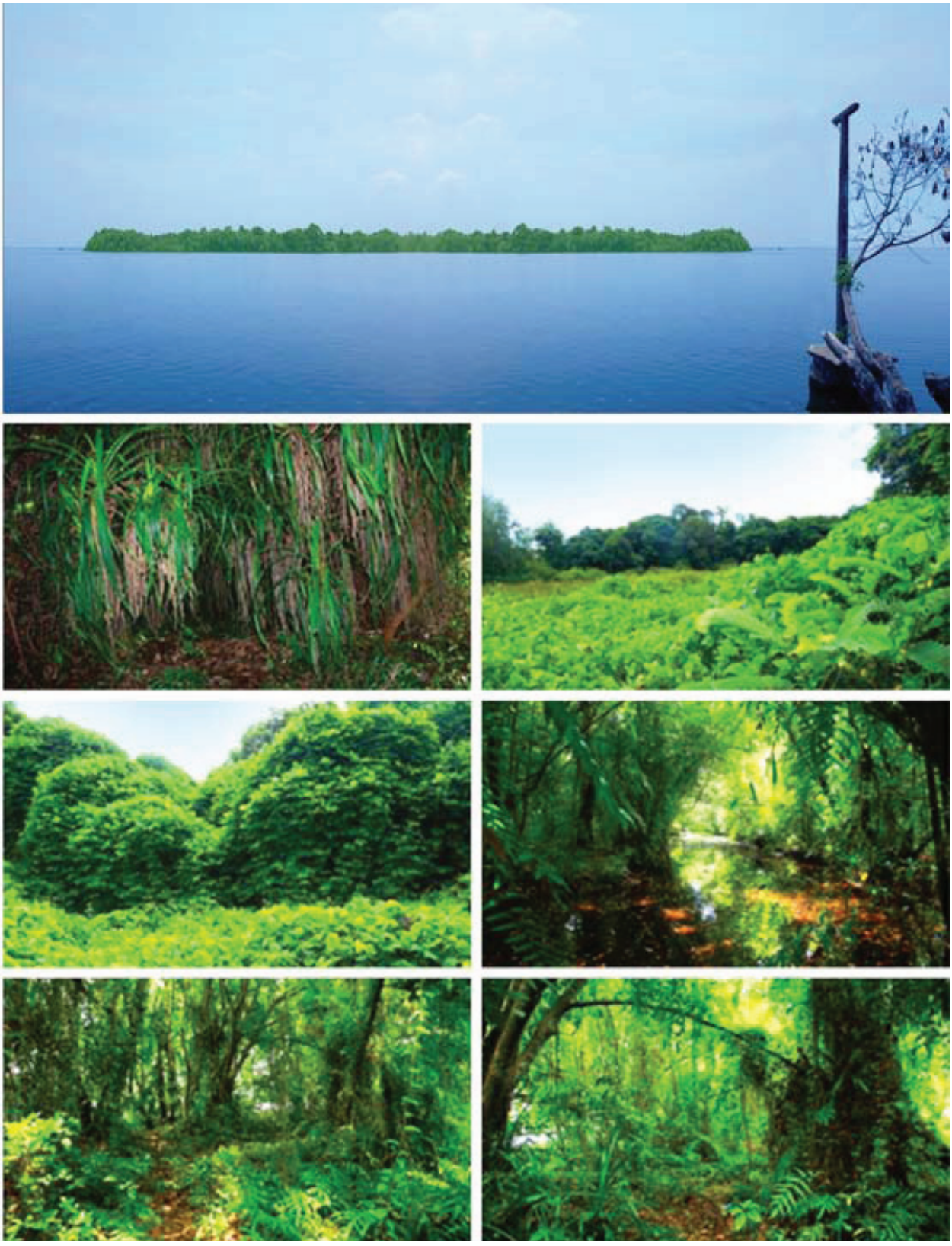

Figure 2. Pathiramanal Island and collection localities of the study area.

distributed throughout Pathiramanal Island, while others were restricted to one or a few habitat types. Two families were found in almost all sites: jumping spiders (Salticidae) and orb-web spiders (Araneidae). Two families were found in 75% of the sites: comb-footed spiders (Theridiidae) and long-jawed spiders (Tetragnathidae). Some other families found in more than 30% of all sites included wolf spiders (Lycosidae), crab spiders

Table 1. Checklist of spiders of Pathiramanal island.

Sl. No.	Family/Species	Remarks
	I. FAMILY ARANEIDAE Menge, 1890	
1	*Anepsion maritatum* (O. Pickard-Cambridge, 1877)	New synonymy
2	*Araneus diadematus* Clerck, 1757	
3	*Araneus ellipticus* (Tikader & Bal, 1981)	
4	*Araneus* sp.3	
5	*Araneus* sp.4	
6	*Argiope aemula* (Walckenaer, 1841)	
7	*Argiope anasuja* Thorell, 1887	
8	*Argiope pulchella* Thorell, 1881	
9	*Chorizopes anjanes* Tikader, 1965	
10	*Chorizopes* sp.2	
11	*Cyclosa bifida* (Doleschall, 1859)	
12	*Cyclosa confraga* (Thorell, 1892)	
13	*Cyclosa mulmeinensis* (Thorell, 1887)	
14	*Cyclosa* sp.4	
15	*Cyrtophora cicatrosa* (Stoliczka, 1869)	
16	*Cyrtophora citricola* (Forsskal, 1775)	
17	*Cyrtophora moluccensis* (Doleschall, 1857)	
18	*Cytrophora unicolor* (Doleschall, 1857)	
19	*Eriovixia excelsa* (Simon, 1889)	
20	*Eriovixia laglazei (*Simon, 1877)	
21	*Eriovixia* sp.3	
22	*Gasteracantha geminata* (Fabricius, 1798)	Redescription
23	*Guizygiella nadleri* (Heimer, 1984)	
24	*Herennia multipuncta* (Doleschall, 1859)	
25	*Neoscona bengalensis* (Tikader & Bal, 1981)	
26	*Neoscona molemensis* Tikader & Bal, 1981	
27	*Neoscona mukerjei* Tikader, 1980	
28	*Neoscona nautica* (Koch, 1875)	
29	*Neoscona theisi* (Walckenaer, 1841)	
30	*Neoscona vigilans* (Blackwall, 1865)	
31	*Neoscona* sp.7	
32	*Parawixia dehaani* (Doleschall, 1859)	First record
33	*Porcataraneus bengalensis* (Tikader, 1975)	
	II. FAMILY CLUBIONIDAE Wagner, 1887	
34	*Clubiona drassodes* O. Pickard-Cambridge, 1874	
35	*Clubiona* sp.2	
	III. FAMILY CORINNIDAE Karsch, 1880	
36	*Castianeira zetes* Simon, 1897	
37	*Corinnoma severum* (Thorell, 1877)	
	IV. FAMILY DICTYNIDAE Karsch, 1880	
38	*Dictyna* sp.	
39	*Nigma* sp.	
	V. FAMILY CHEIRACANTHIIDAE Lehtinen, 1967	
40	*Cheiracanthium danieli* Tikader, 1975	
41	*Cheiracanthium melanostomum* (Thorell, 1895)	
42	*Cheiracanthium* sp.3	
	VI. FAMILY GNAPHOSIDAE Thorell, 1870	
43	*Urozelotus* sp.	
	VII. FAMILY HERSILIIDAE Thorell, 1870	
44	*Hersilia savignyi* Lucas, 1836	
	VIII. FAMILY LINYPHIIDAE Blackwall, 1859	
45	*Nasoona crucifera* (Thorell, 1895)	First record
	IX. FAMILY LIOCRANIDAE Simon, 1897	
46	*Oedignatha binoyii* Reddy & Patel, 1993	
47	*Oedignatha scrobiculata* Thorell, 1881	
	X. FAMILY LYCOSIDAE Sundevall, 1833	

Sl. No.	Family/Species	Remarks
48	*Hippasa greenalliae* (Blackwall, 1867)	
49	*Lycosa* sp.	
50	*Pardosa pseudoannulata* (Bösenberg & Strand, 1906)	
51	*Pardosa sumatrana* (Thorell, 1890)	
52	*Pardosa* sp.3	
53	*Zoica puellula* (Simon, 1898)	
	XI. FAMILY OONOPIDAE Simon, 1890	
54	*Orchestina* sp.	
	XII. FAMILY OXYOPIDAE Thorell, 1870	
55	*Hamataliwa* sp. 1	
56	*Hamataliwa* sp. 2	
57	*Oxyopes birmanicus* Thorell, 1887	
58	*Oxyopes javanus* Thorell, 1887	
59	*Oxyopes shweta* Tikader, 1970	
60	*Oxyopes sunandae* Tikader, 1970	
61	*Oxyopes* sp.5	
	XIII. FAMILY PHILODROMIDAE Thorell, 1870	
62	*Psellonus planus* Simon, 1897	Redescription
	XIV. FAMILY PHOLCIDAE C. L. Koch, 1850	
63	*Crossopriza lyoni* (Blackwall, 1867)	
64	*Pholcus* sp.	
	XV. FAMILY PISAURIDAE, Simon, 1890	
65	*Dendrolycosa gitae* Tikader, 1970	
	XVI. FAMILY PSECHRIDAE, Simon, 1890	
66	*Fecenia protensa* Thorell, 1891	New Synonymy
	XVII. FAMILY SALTICIDAE, Blackwall, 1841	
67	*Brettus cingulatus* Thorell, 1895	
68	*Carrhotus sannio* (Thorell, 1877)	
69	*Carrhotus viduus* (C. L. Koch, 1846)	
70	*Chalcotropis pennata* Simon, 1902	
71	*Cosmophasis* sp.	
72	*Curubis tetrica* Simon, 1902	Redescription
73	*Epeus tener* (Simon, 1877)	
74	*Epeus triangulopalpis* Malamel et al. .2018	New species
75	*Epeus* sp.3	
76	*Epocilla aurantiaca* (Simon, 1885)	
77	*Evarcha pococki* Zabka, 1985	First record
78	*Hyllus semicupreus* (Simon, 1885)	
79	*Icius vikrambatrai* Malamel et al. 2018	New species
80	*Indomarengo chavarapater* Malamel et al. 2018	New species
81	*Indopadilla insularis* Malamel et al. 2015	New species
82	*Marengo sachintendulkar* Malamel et al. 2018	New species
83	*Myrmaplata plataleoides* (O. Pickard-Cambridge, 1869)	
84	*Myrmarachne melanocephala* MacLeay, 1839	
85	*Myrmarachne robusta* (Peckham & Peckham, 1892)	
86	*Myrmarachne prava* Tikader,1973	
87	*Phaeacius lancearius* (Thorell, 1895)	
88	*Phintella vittata* (C. L. Koch, 1846)	
89	*Piranthus planolancis* Malamel et al. 2018	New species
90	*Plexippus paykulli* (Audouin, 1826)	
91	*Portia fimbriata* (Doleschall, 1859)	
92	*Rhene danieli* Tikader, 1973	
93	*Rhene flavicomans* Simon, 1902	
94	*Rhene flavigera* (Koch, 1846)	
95	*Siler semiglaucus* Simon, 1961	
96	*Telamonia dimidiata* (Simon, 1899)	
97	*Thiania bhamoensis* Thorell, 1887	
98	*Uroballus* sp.	

Sl. No.	Family/Species	Remarks
	XVIII. FAMILY SCYTODIDAE, Blackwall, 1864	
99	*Scytodes thoracica* (Latreille, 1802)	
	XIX. FAMILY SICARIIDAE Keyserling, 1880	
100	*Loxosceles rufescens* (Dufour, 1820)	
	XX. FAMILY SPARASSIDAE Berkatu, 1891	
101	*Heteropoda venatoria* (Linnaeus, 1767)	
102	*Olios* sp.1	
103	*Olios* sp.2	
104	*Thelcticopis virescens* Pocock, 1901	
	XXI. FAMILY TETRAGNATHIDAE Menge, 1866	
105	*Dolichognatha* sp.	
106	*Leucauge decorata* (Blackwall, 1864)	
107	*Leucauge granulata* (Walckenaer, 1841)	New synonymy
108	*Tetragnatha cochinensis* Gravely, 1921	
109	*Tetragnatha javana* (Thorell, 1890)	
110	*Tetragnatha mandibulata* Walckenaer, 1841	
111	*Tetragnatha versicolor* Walckenaer, 1841	
112	*Tetragnatha viridorufa* Gravely, 1921	
113	*Tetragnatha* sp.6	
114	*Tetragnatha* sp.7	
115	*Tetragnatha* sp.8	
116	*Tylorida striata (*Thorell, 1877)	
117	*Tylorida ventralis* (Thorell, 1877)	
118	*Wolongia papafrancisi* Malamel et al. 2018	New species
	XXII. FAMILY THERIDIIDAE Sundevall, 1833	
119	*Achaearanea* sp.	
120	*Argyrodes argentatus* O. Pickard-Cambridge, 1880	
121	*Argyrodes bonadea* (Karsch, 1881)	
122	*Argyrodes flavescens* O. Pickard-Cambridge, 1880	
123	*Argyrodes gazedes* Tikader, 1970	
124	*Ariamnes flagellum* (Doleschall, 1857)	
125	*Chrysso* sp.	
126	*Coleosoma blandum* O. Pickard-Cambridge, 1882	
127	*Euryopis* sp.	
128	*Meotipa picturata* Simon, 1895	Redescription
129	*Nihonhimea mundula* (L. Koch, 1872)	
130	*Parasteatoda tepidariorum* (C.L Koch, 1872)	
131	*Parasteatoda* sp.2	
132	*Steatoda* sp.	
133	*Rhomphaea* sp.	
134	*Theridion manjithar* Tikader, 1970	
	XXIII. FAMILY THOMISIDAE Sundevall, 1833	
135	*Amyciaea forticeps* (Cambridgae, 1873)	
136	*Epidius parvati* Benjamin, 2000	First record
137	*Epidius* sp.2	
138	*Indoxysticus minutus* (Tikader, 1960)	
139	*Misumenops* sp.	
140	*Thomisus lobosus* Tikader, 1965	
141	*Thomisus projectus* Tikader, 1960	
142	*Thomisus* sp.3	
	XXIV. FAMILY TRACHELIDAE Simon, 1897	
143	*Trachelas* sp.	
144	*Utivarachna* sp.	
	XXV. FAMILY ULOBORIDAE, Thorell, 1869	
145	*Uloborus krishnae* Tikader, 1970	
146	*Zosis geniculata* (Olivier, 1789)	
	XXVI. FAMILY ZODARIIDAE Thorell, 1881	
147	*Tropizodium virudorbium* Prajapati et al. 2016	

(Thomisidae), huntsman spiders (Sparassidae), and families that were only found in a single site included flat-bellied ground spiders (Gnaphosidae), running crab spiders (Philodromidae), violin spiders (Sicariidae) and mesh-web spiders (Dictynidae).

The spiders of Pathiramanal Island can be divided into seven feeding guilds based on the foraging behaviour. They are ambushers, foliage runners, ground runners, orb weavers, sheet web builders, space web builders and stalkers. The dominant guild was of orb weavers (33%), followed by stalkers (27%), space web builders (13%), ambushers (11%), ground runners (9%), foliage runners (6%) and sheet web builders (1%) (Table 2, Figure 3).

One of the most notable achievements of the study is the discovery and documentation of seven species new to science, such as *Indopadilla insularis, Epeus triangulopalpis, Marengo sachintendulkar, Indomarengo chavarapater, Icius vikrambatrai, Piranthus planolancis* (Salticidae) and *Wolongia papafrancisi* (Tetragnathidae) (Figure 4, Table 3). Three genera and four species are documented as new records from Indian region (Figure 5) and 124 species are newly recorded from Pathiramanal Island. It was surprising to note the presence of the poisonous spider *Loxosceles rufescens* coming under the family Sicariidae.

Mating plug formation is often common in the genus *Argyrodes* since these spiders are found both sexes together and live as kleptoparasites in the webs of large orb-weaving spiders (Koh and Li 2002). Although a number of reports on mating plug formation in this genus had been done before, mating plug formation in the sixth species of *Argyrodes* (*A. flavescens)* was observed for the first time during this study based on the specimens collected from Pathiramanal Island (Figure 6).

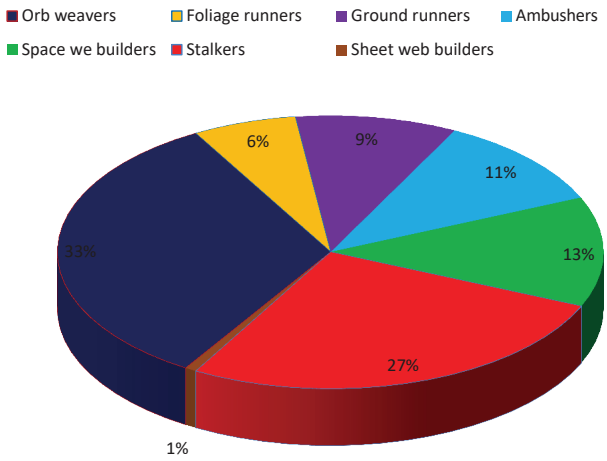

Figure 3. Guild structure of spiders.

Table 2. Total number of families, genera, species and functional guilds of spiders in Pathirmanal island.

Sl. No.	Family	No. of genera	No. of species	Guild
Suborder Araneomorphae				
1	FAMILY ARANEIDAE Menge, 1890	13	33	Orb weavers
2	FAMILY CLUBIONIDAE Wagner, 1887	1	2	Foliage runners
3	FAMILY CORINNIDAE Karsch, 1880	2	2	Ground runners
4	FAMILY DICTYNIDAE Karsch, 1880	2	2	Foliage runners
5	FAMILY CHEIRACANTHIIDAE Wagner, 1887	1	3	Foliage runners
6	FAMILY GNAPHOSIDAE Thorell, 1870	1	1	Ground runners
7	FAMILY HERSILIIDAE Thorell, 1870	1	1	Ambushers
8	FAMILY LINYPHIIDAE Blackwall, 1859	1	1	Space web builders
9	FAMILY LIOCRANIDAE Simon, 1897	1	2	Ground runners
10	FAMILY LYCOSIDAE Sundevall, 1833	4	6	Ground runners
11	FAMILY OONOPIDAE Simon, 1890	1	1	Ground runners
12	FAMILY OXYOPIDAE Thorell, 1870	2	7	Stalkers
13	FAMILY PHILODROMIDAE Thorell, 1870	1	1	Ambushers
14	FAMILY PHOLCIDAEC. L. Koch, 1850	2	2	Space web builders
15	FAMILY PISAURIDAE, Simon, 1890	1	1	Ambushers
16	FAMILY PSECHRIDAE, Simon, 1890	1	1	Sheet web builders
17	FAMILY SALTICIDAE, Blackwall, 1841	25	32	Stalkers
18	FAMILY SCYTODIDAE, Blackwall, 1864	1	1	Ground runners
19	FAMILY SICARIIDAE Keyserling, 1880	1	1	Ambushers
20	FAMILY SPARASSIDAE Berkatu, 1891	3	4	Ambushers
21	FAMILY TETRAGNATHIDAE Menge, 1866	5	14	Orb weavers
22	FAMILY THERIDIIDAE Sundevall, 1833	12	16	Space web builders
23	FAMILY THOMISIDAE Sundevall, 1833	5	8	Ambushers
24	FAMILY TRACHELIDAE Simon, 1897	2	2	Foliage runners
25	FAMILY ULOBORIDAE, Thorell, 1869	2	2	Orb weavers
26	FAMILY ZODARIIDAE Thorell, 1881	1	1	Ground runners
Total		92	147	

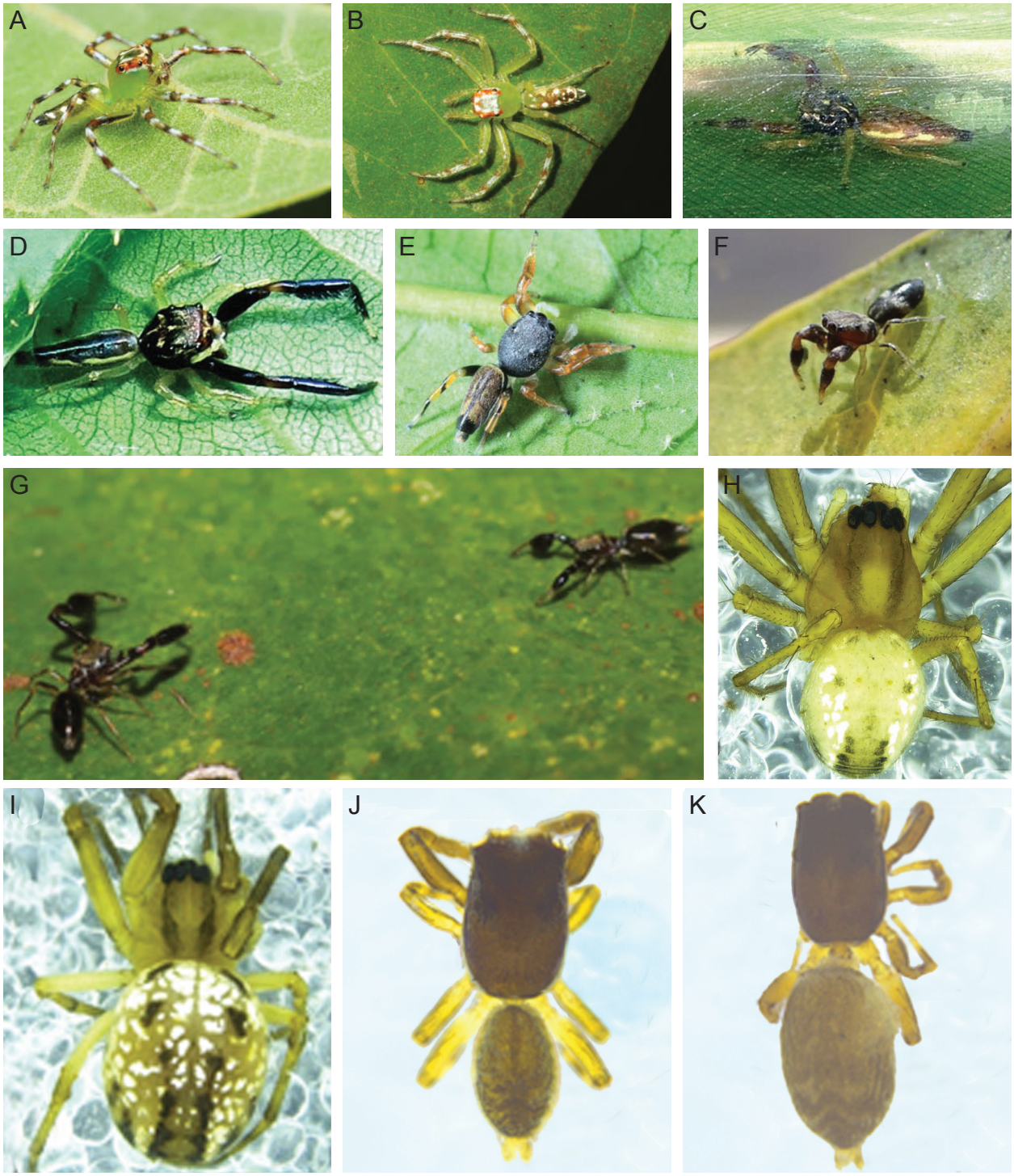

Figure 4. New species described (field photos): A, B, male and female of *Epeus triangulopalpis*; C, D, male and female of *Indopadilla insularis*; E, female of *Piranthus planolancis*; F, female of *Marengo sachintendulkar*; G, male and female of *Indomarengo chavarapater*, H, I, male and female of *Wolongia papafrancisi*; J, K, male and female of *Icius vikrambatrai*.

DISCUSSION

The present study is the first comprehensive documentation of the spider fauna in Pathiramanal Island. The present study revealed that the total spider diversity of Pathiramanal Island represents 10% of total species, 22% of total genus and 43% of total family diversity reported from India (Sebastian and Peter 2009) and accounts for 35% of total species, 40% of total genus and 60.5% of total family diversity from Kerala (Jobi and Sebastian, in preparation). However, it seems that a good number of species remains that probably are new species but cannot be described due to lack of proper literature on these taxa. A high number of species recorded indicates a rich spider diversity of this region which was also indicated by Shannon diversity

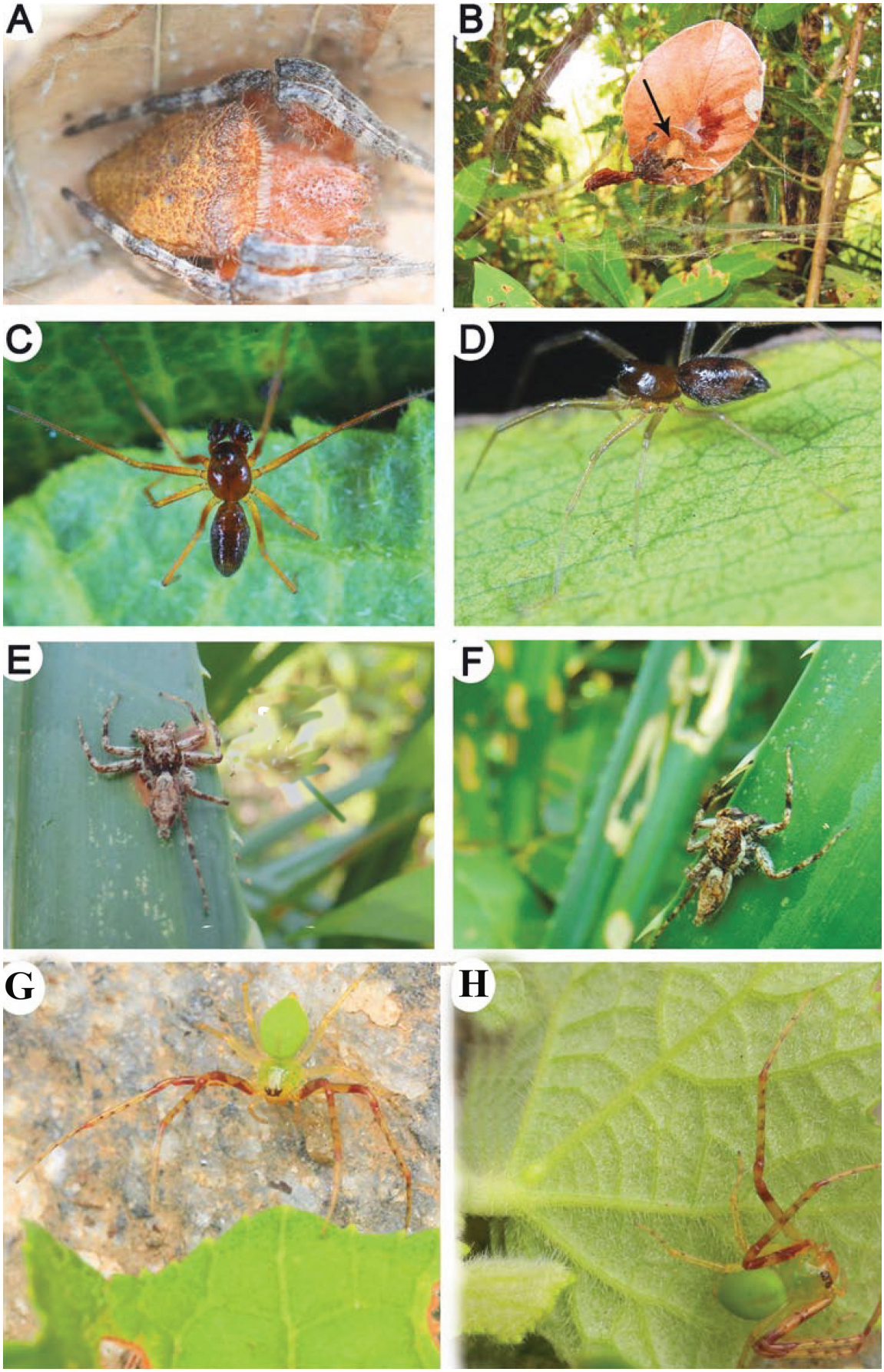

Figure 5. New records from India: A, B, female of *Cytrophora unicolor*; C, D, male and female of *Nasoona crucifera*; E, F, male of *Phaeacius lancearius*; G, H, female of *Epidius parvati*.

Table 3. New species described.

No.	Family	Genus	Species	Status
1	Salticidae	*Epeus*	*triangulopalpis*	New species
2	,,	*Icius*	*vikrambatrai*	,,
3	,,	*Indomarengo*	*chavarapater*	,,
4	,,	*Indopadilla*	*insularis*	,,
5	,,	*Marengo*	*sachintendulkar*	,,
6	,,	*Piranthus*	*planolancis*	,,
7	Tetragnathidae	*Wolongia*	*papafrancisi*	,,

index (H = 4.05) and Simpson's diversity index (1-D = 0.970). Even though the observed species richness was 147, the estimated species richness (Chao1) was found to be 149.3, which designates that a number of species could be collected from a thorough sampling of a long period. The existence of spiders is mainly dependent on the habitat they live in and select based on the physiological factors of the habitat, availability of prey and the apt site for web building.

The guild study was done to form the basis of community organization of spiders in Pathiramanal Island, and the study yielded seven ecological guilds based

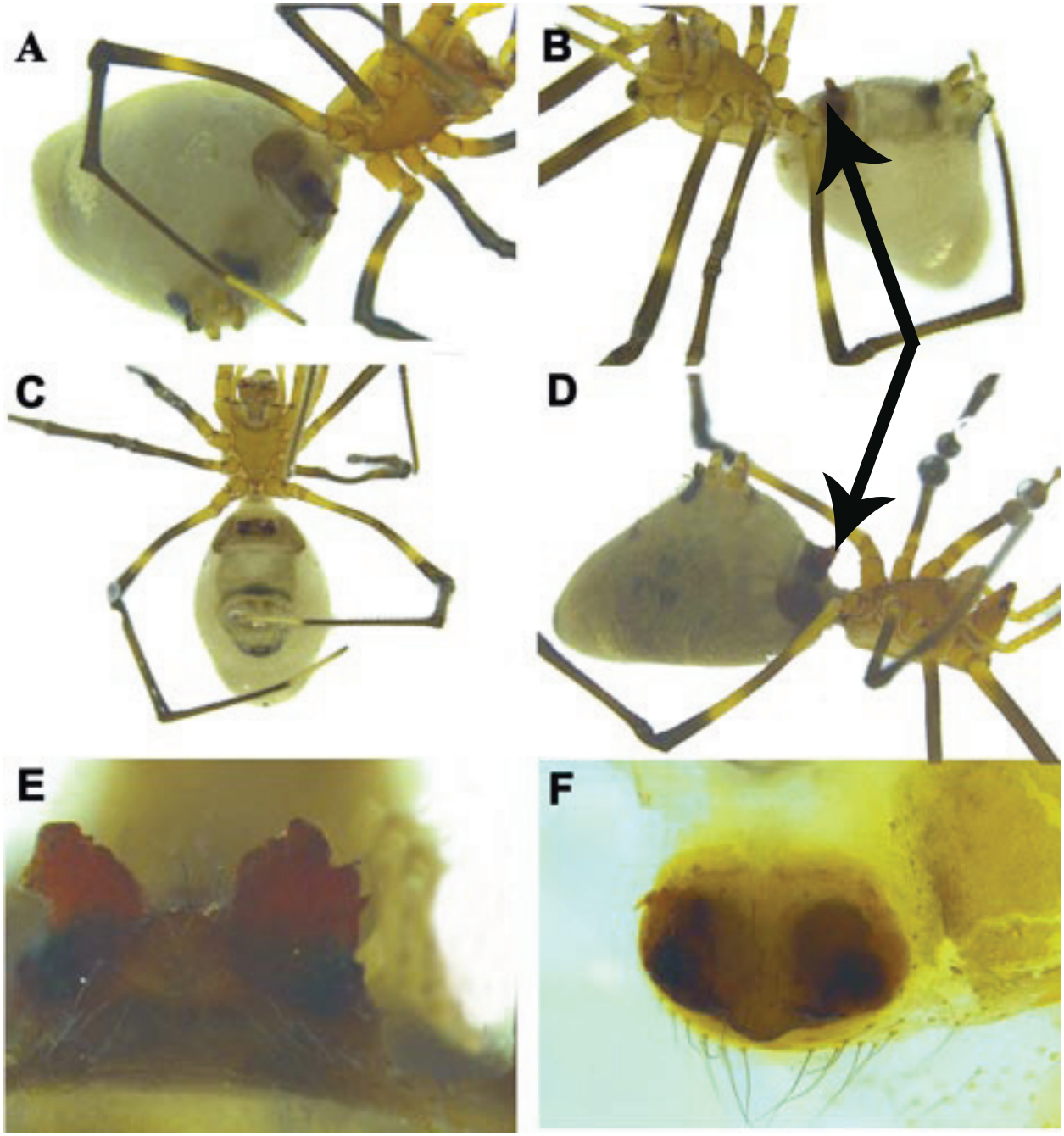

Figure 6. A–D, mating plug formation in *Argyrodes flavescens*; E, epigyne with mating plug (dorsal view); F, epigyne without mating plug.

on their foraging mode (Figure 3). Orb weavers were the dominant guild (33%) including the families such as Araneidae, Tetragnathidae and Uloboridae, and this might be due to the collecting localities of Pathiramanal Island that take care of shelter, reproductive behaviour and foraging of these orb webs. The sheet web builders were the lowest guild type (1%) with the family Psechridae. The presence of the poisonous spider *Loxosceles rufescens* in the Island reminds that tourists should be aware of these spiders because of their ability to cause skin necrosis or loxoscelism with their necrotizing venom.

As *Argyrodes flavescens* is a social spider and often seen with both sexes together, it is easier for male spiders to make plugs in female openings. This observation suggests that their nature of living is critical in plug formation. The reason behind mating plug formation being common in this species could be its kleptoparasitic nature in the webs of host species and the usual presence of males.

According to Holloway (1974), Indian fauna formed as a result of displacement by invaders from other regions of the Oriental region after its separation from Gondwanaland and merger with Asia. So spider species from Pahiramanal Island also bear affinities with Oriental and Palearctic regions since it is a part of Vembanad Lake, a Ramsar site in India. Some species of the genera *Argiope, Cyclosa, Eriovixia, Gasteracantha* (family Araneidae); *Tylorida, Tetragnatha* (family Tetragnathidae) exhibit Sri Lankan affinities. Some species of genera *Argiope*, *Cyclosa*, *Eriovixia*, *Gasteracantha*, *Neoscona* (family Araneidae); *Leucauge*, *Tetragnatha* (family Tetragnathidae) bear Oriental affinities. An araneid species *Eriovixia laglaizei* shows Palearctic affinities.

Spiders can easily colonize any habitat, especially the isolated lands like Pathiramanal Island, as they are able to disperse over long distances using wind currents ('ballooning') in general. The difficulty in spider biodiversity assessment in Pathiramanal Island seems to be related to the lack of historical expeditions focusing on this group of arthropods. High richness and variability as well as the rate of new species records and new species descriptions indicate a satisfactory picture of spider diversity in Pathiramanal Island.

Pathiramanal Island is a land of a dense forest cover and thick vegetation. This investigation showed that an important determinant of spider species richness and diversity in the Island is habitat diversity. The data revealed that structurally vegetation which is more diverse supports a higher number of spider species, which could be explained by a greater variety of available niches within more complex vegetation. Overall, the results showed that vegetation differed from one Island spot to another, and spider composition was also highly dissimilar in different plots of the Island. This study report emphasizes the importance of maintaining a mosaic-like pattern in the habitat, because different vegetation patches (e.g. thick/thin vegetation, tall/short vegetation) can provide habitats for very different spider assemblages and thus enhance the overall spider diversity.

Faunal affinities of spiders collected from Pathiramanal Island

The araneofauna of Pathiramanal Island bears affinities with Oriental and Palearctic regions and with the fauna of Sri Lanka. It is hypothesized that Indian biota is the result of displacement by invaders from other regions of the Oriental region after its separation from Gondwanaland and merger with Asia (Holloway 1974). Species such as *Araneus ellipticus*, *Argiope aemula*, *A. anasuja*, *A. pulchella*, *Cyclosa bifida*, *C. confraga*, *Cyrtophora cicatrosa*, *C. moluccensis, Eriovixia laglaizei*, *Gasteracantha geminata*, *Herennia multipuncta*, *Neoscona molemensis*, *N. vigilans*, *N. nautica*, *Parawixia dehanii* (family Araneidae); *Clubiona drassodes* (family Clubionidae); *Castianeira zetes* (family Corinnidae); *Stegodyphus sarasinorum* (family Eresidae); *Hippasa greenalliae, Pardosa pseudoannulata, P. sumatrana* (family Lycosidae); *Cheiracanthium melanostomum* (family Cheiracanthiidae); *Oxyopes birmanicus, O. javanus* (family Oxyopidae); *Fecenia protensa* (family Psechridae); *Carrhotus viduus, Menemerus bivittatus, Myrmarachne melanocephala, Phintella vittata, Plexippus paykulli, Portia fimbriata, Rhene flavigera, Siler semiglaucus, Telamonia dimdiata, Thiania bhamoensis* (family Salticidae); *Heteropoda venatoria* (family Sparassidae); *Argyrodes flavescens, Ariamnes flagellum, Nihonhimea mundula* (family Theridiidae) and *Zosis geniculata* (family Uloboridae) bear Oriental affinities.

Palearctic affinities are shown by species like *Eriovixia laglaizei, Porcataraneus bengalensis* (family Araneidae); *Clubiona drassodes* (family Clubionidae); *Hippasa greenalliae* (family Lycosidae); *Oxyopes birmanicus*, *O. Shweta* (family Oxyopidae); *Myrmaplata plataleoides* (family Salticidae); *Leucauge decorata, Tetragnatha javana* (family Tetragnathidae) and *Argyrodes flavescens* (family Theridiidae).

It was studied by Bossuyt et al. (2004) analyzing the links between the Western Ghats (southern India) and Sri Lanka, using multiple vertebrate and invertebrate groups, that Sri Lankan fauna derived from mainland India. The current study partially approves this hypothesis from the remarkable similarities exhibited between the spider fauna of Pathiramanal and Sri Lanka. Species such as *Argiope aemula*, *A. anasuja*, *A. pulchella, Cyclosa confraga*, *Cyrtophora cicatrosa*, *C. moluccensis*, *Eriovixia laglaizei*, *Gasteracantha geminata*, *Herennia multipuncta*, *Parawixia dehanii* (family Araneidae);

Stegodyphus sarasinorum (family Eresidae); *Hersilia savigyni* (family Hersiliidae); *Hippasa greenalliae* (family Lycosidae); *Hylus semicupreus, Myrmaplata plataleoides* (family Salticidae); *Heteropoda venatoria* (family Sparassidae); *Argyrodes flavescens, Ariamnes flagellum, Nihonhimea mundula* (family Theridiidae) bear affinities to the Island fauna of Sri Lanka.

CONCLUSION

Until now, Pathiramanal Island was considered to be home to only 23 spider species due to the lack of studies in this region. However, the current survey of the araneofauna in this remote Island has challenged this view. A high species diversity of spiders in Pathiramanal Island can be attributed to a high floral diversity of the Island, which sustains high faunal diversity by providing diverse microhabitat, especially for invertebrates. Contrasting to other ecologically important zones, there is no previous work to compare the spider diversity. This indicates the need for a further systematic sampling in this area. The presence of diverse habitats like big trees, bushes and grasslands in this ecosystem is a revelation to show Pathiramanal Island harbours many smaller but diverse environmental niches, which makes the Island an important centre of speciation in the Vembanad, a Ramsar site. Since Pathiramanal Island shows a surprisingly diverse spider community, further research should be encouraged in this biome to maintain and manage this high diversity, and the factors other than habitat type, which are important in influencing diversity, need to be investigated.

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