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SPIDER DIVERSITY (ARACHNIDA; ARANEAE) IN DIFFERENT PLANTATIONS OF WESTERN GHATS, WAYANAD REGION, INDIA

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Abstract.

The study was conducted to explore the spider diversity in different plantations of Western Ghats Wayanad, Kerala State, India. The investigation was carried out for a one year period from February 2019 to February 2020. A total of 93 species belonging to 71 genera under 19 families were recorded from the selected habitats. This represents 49% families recorded from the Western Ghats, Kerala. The highest species richness was found in the coffee plantation (site A) with 51 species belonging to 11 families. The tea plantation (site B) recorded 26 species belonging to 11 families. The rubber plantation (site C) showed the lowest species richness with 16 species belonging to ten families. Guild structure analysis of the collected spiders revealed seven functional groups viz.., orb-web builders, stalkers, ambushers, cob-web builders, ground runners, foliage runners and sheet-web builders. It is concluded that the structure of the vegetation is expected to influence the diversity of spiders in different plantations.

Key words: *agro-ecosystem, ecological guilds, ground dweller, orb web weaver, plant dweller, species richness, stalker, web builder*

Introduction

Spiders are diverse and ubiquitous invertebrate predators in terrestrial ecosystems (Wise 1993; Nyffeler 2000; Lone et al. 2015; Radermacher et al. 2020). Spiders are considered the major agent controlling insect communities in agricultural ecosystems because of their high abundance and insectivorous foraging habit (Nyffeler and Benz 1987; Marc et al. 1999; Nyffeler 2000; Ludwig et al. 2018). Studies have shown that the exclusive predatory behaviour of spiders has a notable impact on the agro ecosystems (Samiayyan 2014; Michalko et al. 2019) and influence of spiders on prey populations depend on spider density or biomass (Greenstone 1999; Riechert 1999; Sunderland and Samu 2000; Liu et al. 2015).

Habitat heterogeneity has been suggested to be an important component that affects the density and diversity of spider species in both natural (Greenstone 1984) and agro ecosystems (Rypstra and Carter 1995; Downie et al. 1999). The habitat heterogeneity is represented mainly by vegetational diversity, architectural features, level of vegetational stratification, water availability and topsoil structure. The structural complexity of habitats offers the spatial arrangement for web placement; therefore, web building spiders are particularly more responsive to structural complexity (Colebourne 1974; Riechert and Gillespie 1986; Uetz 1991).

In agro-ecosystems, a diverse group of spiders may inhabit a wide range of biotopes and they are likely to be active throughout the day. Therefore, assemblages of spider species will leave fewer refuges for potential prey in time and space. Spiders usually exert a strong influence on pest numbers in concert with other natural enemies. By reason of variation in spider size and/or prey capture strategies, spiders are able to capture prey that varies in size and/or developmental stages (Sunderland 1999; Henaut et al. 2001). In addition to killing the pests by direct attack, spiders cause pest mortality by dislodging them from plants or trapping them in the webs. On the whole, spiders promote the diversity and stability of the natural enemy community and they act as a robust basis of pest control (Sunderland 1999).

Western Ghats mountain ranges of India, by far the most densely populated global biodiversity hotspot (Cinacotta et al. 2000), has a mosaic of natural, semi-natural and agro-ecosystems in close

proximity to one another. Human-induced changes in land use are globally ubiquitous and specifically of high importance in the Western Ghats (Rahman et al. 2011). With an increase in anthropogenically dominated habitats, previously abundant natural habitats have become smaller and more fragmented (Kumara et al. 2004; Chakraborty et al. 2019). The replacement of native forests by monoculture plantations affects the diversity of biological communities, particularly in montane forest ecosystems of southern Western Ghats (Anand et al. 2010). On the whole, agricultural land-use changes have affected the forest ecosystems of Wayanad in two major ways: first, a conspicuous shrinkage of the forest cover and the second, the loss of structural integrity of the remaining forests (De Fries et al. 2010; Kumar et al. 2010). Due to enculturation, unregulated mass tourism, deforestation and monoculture agricultural practices - the habitats in Wayanad are degraded and biodiversity is vanishing at a faster rate**.** Previous studies in this ecosystem have focused on vertebrates (Ranganathan et al. 2010; Caudill et al. 2014), while only a few studies have been performed on the relationship between spiders and plantations (Kapoor 2008; Sruthi et al. 2019, Prasad et al. 2020). The present study aimed at estimating species richness and composition of spiders in different plantations of the Western Ghats, Wayanad region, Kerala.

Materials and Methods

Study Area

Wayanad district is one of the hill stations of Kerala set high on the Western Ghats with an altitude ranging from 700 to 2100 meters. Wayanad falls under two climatic zones: per humid and moist sub-humid zones (Raju et al. 2013) (Fig. 1). Annual rainfall averages 1635mm with the highest rainfall recorded in the regions of Lakkidi, Vythiri and Meppadi in Wayanad. Forests in the Wayanad District are unique and exclusive in composition and they represent the transition zone of moist laden forests of South-Western Ghats to the Northern drier forests. Total forest area of Wayanad is 2,131 km^2 which represents 83.3% of the total geographical area of the District (Balasubramanian et al. 2019). High altitude agriculture of Wayanad is characterized by the specialized multi-tier cropping system. The gross cropped area of Wayanad covers 97.82% of the geographical area and is dominated by cash crops. The major plantation crops include the perennial crops such as coffee, tea, pepper, rubber and cardamom that together represent

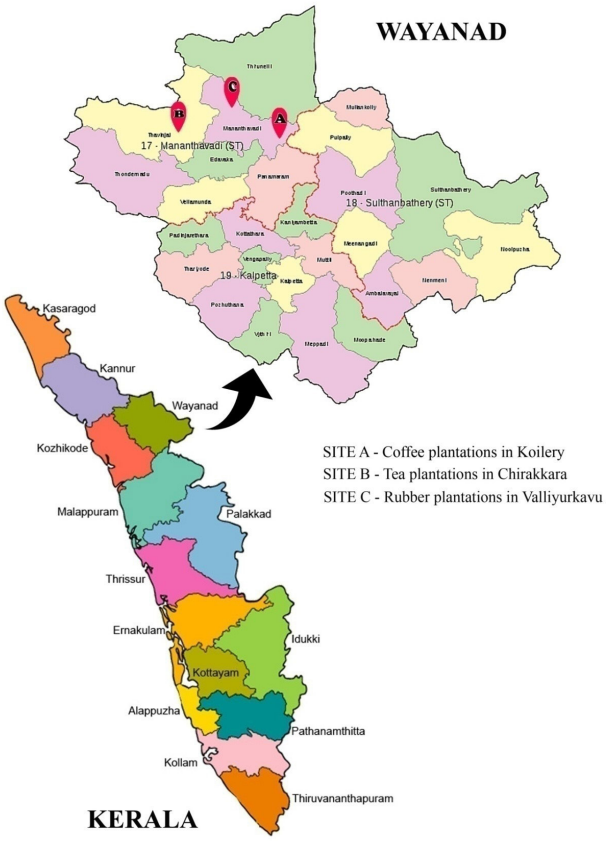

Figure 1: Study location.

38% of the total cropped area (Kumar and Ichikawa 2010).

Three stations were chosen for the present study (Fig. 2).

1. SITE A - Coffee plantations in Koilery
Koilery (11.7867268, 76.0455579) is a small village located about 7.9 km away from Mananthavady, and is rich in agricultural fields and plantations. Robusta is the most popular variety of coffee being cultivated here. The site constitutes wide range of other plants and animals.
2. SITE B – Tea plantations in Chirakkara
Chirakkara (11.8535994, 75.9644254) is a village located 11 km away from Mananthavady. The area is rich with tea plantations. The region encompassed ditches and streams.
3. SITE C – Rubber plantations in Valliyurkavu
Valliyurkavu (11.804787, 76.027880) is a small village located about 3.8 km away from Mananthavady. The area is rich with different plantations.

Methodology

The current investigation was carried out from February 2019 to February 2020. Spiders were col-

STUDY AREA

Coffee plantations in Koilery (SITE A)

Tea plantations in Chirakkara (SITE B)

Rubber plantations in Valliyurkavu (SITE C)

Figure 2: Study sites.

lected by Line transect and Quadrat methods. At each site, two transects were established (transect lines were 500 m wide) in a 0.405 hectare study area. Two 10 mx10 m quadrates were placed at every 200 m interval. All surveys were conducted in the morning hours between 7:00 am to 11:30 am.Visual searching method was followed for sampling. Ground search was made under leaf litter and fallen or dry wood. Sweep netting method was followed to collect the foliage dwelling spiders in the herbs and shrubs. Beating was done with a wooden stick and an inverted umbrella was placed under the trees to catch the spiders. Data on web patterns and microhabitat types were recorded with every encounter. The microhabitats types such as ground, litter, foliage, flower, and tree trunk were recorded visually for the presence of spiders. The collected spiders were placed separately in vials with 70% ethyl alcohol. The collection date, compartment name and nature of habitat were recorded on each vial. Spiders were photographed using Oppo A71 13-mega pixel camera and identified up to the species level following the identification keys (Gravely 1931; Helsdingen 1969; Tikader and Malhotra 1980; Tikader and Biswas 1981; Tikader 1982; Żabka 1985; Barrion and Litsinger 1995; Huber 2000; Caleb 2016; Sankaran and Sebastian 2018). The spider guild classification was composed according to the families of spiders collected (Sebastian et al. 2012).

Results

A total of 93 species belonging to 71 genera under 19 families were recorded from the selected habitats. In the present study, Araneidae was the dominant family constituting 23 species under 13 genera, followed by Salticidae (20 species), Thomisidae (9 species), Theridiidae (8 species), Tetragnathidae (7 species), Lycosidae (5 species), Oxyopidae (3 species), Sparassidae (3 species), Uloboridae (3 species), Pholcidae (2 species), Corinnidae (2 species), Clubionidae (1 species), Cheiracanthiidae (1 species), Hersiliidae (1 species), Linyphiidae (1 species), Liocranidae (1 species), Scytodidae (1 species), Selenopidae (1 species) and Philodromidae (1 species) (Table 1, Fig. 3).

The results reveal that the coffee plantation has the highest diversity of spiders when compared to the other habitats. The highest species richness was recorded in the coffee plantation (site A) with 51 species belonging to 11 families. Of these, 53% were web builders, 37% represented plant dwellers and 10% represented ground dwellers. The tea plantation (site B) exhibited the second highest species richness with 26 species belonging to 11 families. Of these, 46% web builders, 46% represented plant dwellers, and only 8% living in ground. The rubber plantation (site C) showed the lowest species richness with 16 species belonging to ten families. Of these, plant

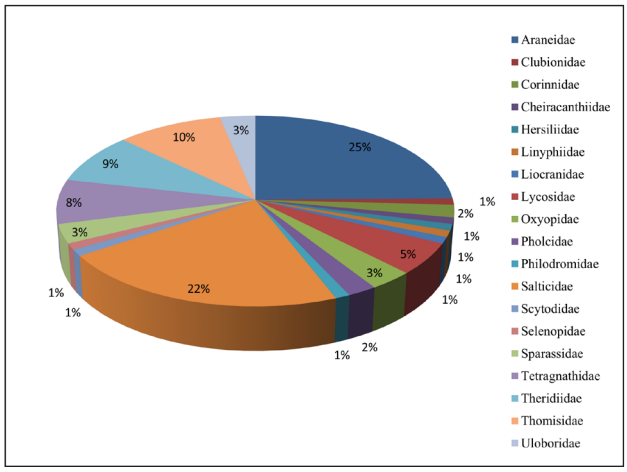

Figure 3: Species distribution in different families found in the study area.

Table 1: Systematic list of spiders recorded from different plantations of Western Ghats, Wayanad

SL NO.	SPECIES
Araneidae (Orb-web builders)	
1	*Acusilas coccineus* Simon, 1895
2	*Arachnura angura* Tikader, 1970
3	*Araneus ellipticus* (Tikader & Bal, 1981)
4	*Araneus mitificus* (Simon, 1886)
5	*Araneus* sp.
6	*Argiope pulchella* Thorell, 1881
7	*Argiope* sp.
8	*Cyclosa hexatuberculata* Tikader, 1982
9	*Cyclosa* sp.
10	*Cyrtarachne* sp.
11	*Cyrtophora cicatrosa* (Stoliczka, 1869)
12	*Cyrtophora citricola* (Forsskal, 1775)
13	*Eriovixia laglaizei* (Simon, 1877)
14	*Eriovixia* sp.
15	*Gasteracantha geminata* (Fabricius, 1798)
16	*Gasteracantha kuhli* C. L. Koch, 1837
17	*Herennia multipuncta* (Doleschall, 1859)
18	*Neoscona bengalensis* Tikader& Bal, 1981
19	*Neoscona mukerjei* Tikader, 1980
20	*Neoscona* sp.
21	*Neoscona theisi* (Walckenaer, 1841)
22	*Nephila pilipes* (Fabricius, 1793)
23	*Paraplectana* sp.
Clubionidae (Foliage runners)	
24	*Clubiona* sp.1
Corinnidae (Ground runners)	
25	*Apochinomma nitidum*(Thorell, 1895)
26	*Castianeira zetes* Simon, 1897
Cheiracanthiidae (Foliage runners)	
27	*Cheiracanthium melanostomum* (Thorell, 1895)
Hersiliidae (Foliage runners)	
28	*Hersilia savignyi* Lucas, 1836
Linyphiidae (Sheet-web builder)	
29	*Neriene sundaica* (Simon, 1905)
Liocranidae (Ground runner)	
30	***Oedignatha* sp.**
Lycosidae (Ground runners)	
31	*Hippasa agelenoides* (Simon, 1884)
32	*Lycosa tista* Tikader, 1970
33	*Pardosa mysorensis* (Tikader & Mukerji, 1971)
34	*Pardosa pseudoannulata* (Bösenberg & Strand, 1906)
35	*Pardosa sumatrana* (Thorell, 1890)
Oxyopidae (Stalkers)	
36	*Hamadruas* sp.
37	*Oxyopes javanus* Thorell, 1887
38	*Oxyopes shweta* Tikader, 1970
Pholcidae (Cob web builder)	
39	*Pholcus* sp.
40	*Smeringopus pallidus* (Blackwall, 1858)
Philodromidae (Ambushers)	
41	*Tibellus elongatus* Tikader, 1960
Salticidae (Stalkers)	
42	*Asemonea tenuipes* (O. Pickard-Cambridge, 1869)
43	*Brettus cingulatus* Thorell, 1895
44	*Burmattus* sp.
45	*Chalcotropis pennata* Simon, 1902
46	*Epeus tener* (Simon, 1877)
47	*Epeus indicus* Prószyński, 1992
48	*Epocilla aurantiaca* (Simon, 1885)
49	*Hasarius adansoni* (Audouin, 1826)
50	*Hyllus semicupreus* (Simon, 1885)
51	*Menemerus bivittatus* (Dufour, 1831)
52	*Myrmaplata plataleoides* (O. Pickard-Cambridge, 1869)
53	*Myrmarachne* sp.
54	*Phintella vittata* (C. L. Koch, 1846)
55	*Plexippus paykulli* (Audouin, 1826)
56	*Plexippus petersi* (Karsch, 1878)
57	*Portia fimbriata* (Doleschall, 1859)
58	*Rhene flavigera* (C. L. Koch, 1846)
61	*Siler semiglaucus* (Simon, 1901)
59	*Telamonia dimidiata* (Simon, 1899)
60	*Thiania bhamoensis* Thorell, 1887
Scytodidae (Ground-runners)	
62	*Scytodes thoracica* (Latreille, 1802)
Selenopidae (Ambushers)	
63	*Selenops* sp.
Sparassidae (Ambushers)	
64	*Heteropoda venatoria* (Linnaeus, 1767)
65	*Martensopoda* sp.
66	*Olios* sp.
Tetragnathidae (Orb-web builder)	
67	*Leucauge decorata* (Blackwall, 1864)
68	*Leucauge tessellata* (Thorell, 1887)
69	*Opadometa fastigata* (Simon, 1877)

Table 1, continued: Systematic list of spiders recorded from different plantations of Western Ghats, Wayanad

SL NO.	SPECIES
70	*Tetragnatha hasselti* Thorell, 1890
71	*Tetragnatha mandibulata* Walckenaer, 1841
72	*Tetragnatha viridorufa* Gravely, 1921
73	*Tylorida ventralis* (Thorell, 1877)
Theridiidae (Cob web builder)	
74	*Achaearanea durgae* Tikader 1970
75	*Argyrodes flavescens* O. Pickard-Cambridge, 1880
76	*Argyrodes* sp.
77	*Chikunia nigra* (O. Pickard-Cambridge,1880)
78	*Chrysso urbasae* (Tikader, 1970)
79	*Episinus* sp.
80	*Meotipa* sp.
81	*Twaitesia margaritifera* O. Pickard-Cambridge, 1881
Thomisidae (Ambushers)	
82	*Amyciaea forticeps* (O. Pickard-Cambridge, 1873)
83	*Boliscus* sp.
84	*Diaea* sp.
85	*Indoxysticus minutus* (Tikader, 1960)
86	*Loxobates* sp.
87	*Phrynarachne* sp.
88	*Strigoplus netravati* Tikader, 1963
89	*Thomisus lobosus* Tikader, 1965
90	*Thomisus shillongensis* Sen, 1963
Uloboridae (Orb-web builders)	
91	*Uloborus khasiensis* Tikader, 1969
92	*Uloborus krishnae* Tikader, 1970
93	*Zosis geniculata* (Olivier, 1789)

dwellers represented 56% while web builders and ground dwellers comprised 31 and 13%, respectively.

The dominant spider family found in the coffee plantation was Araneidae (31%) followed by Salticidae (23%) and Thomisidae (12%). Liocranidae (2%), Oxyopidae (2%) and Linyphiidae (2%) were the least observed families in the coffee plantation. In the tea plantation, Araneidae (23%) was the most abundant family, followed by Salticidae (15%), Thomisidae (11%) and Sparassidae (11%). Scytodidae (4%), Selenopidae (4%), Oxyopidae (4%), and Lycosidae (4%) were the least observed families in the tea plantation. The dominant spider family recorded in the rubber plantation was Salticidae (25%) followed by Lycosidae (13%), Tetragnathidae (13%), Theridiidae (13%). Araneidae (6%), Oxyopidae (6%), Hersiliidae (6%), Cheiracanthiidae (6%), Clubionidae (6%) and Philodromidae (6%) were rarely noted families in the rubber plantation (Figs. 4).

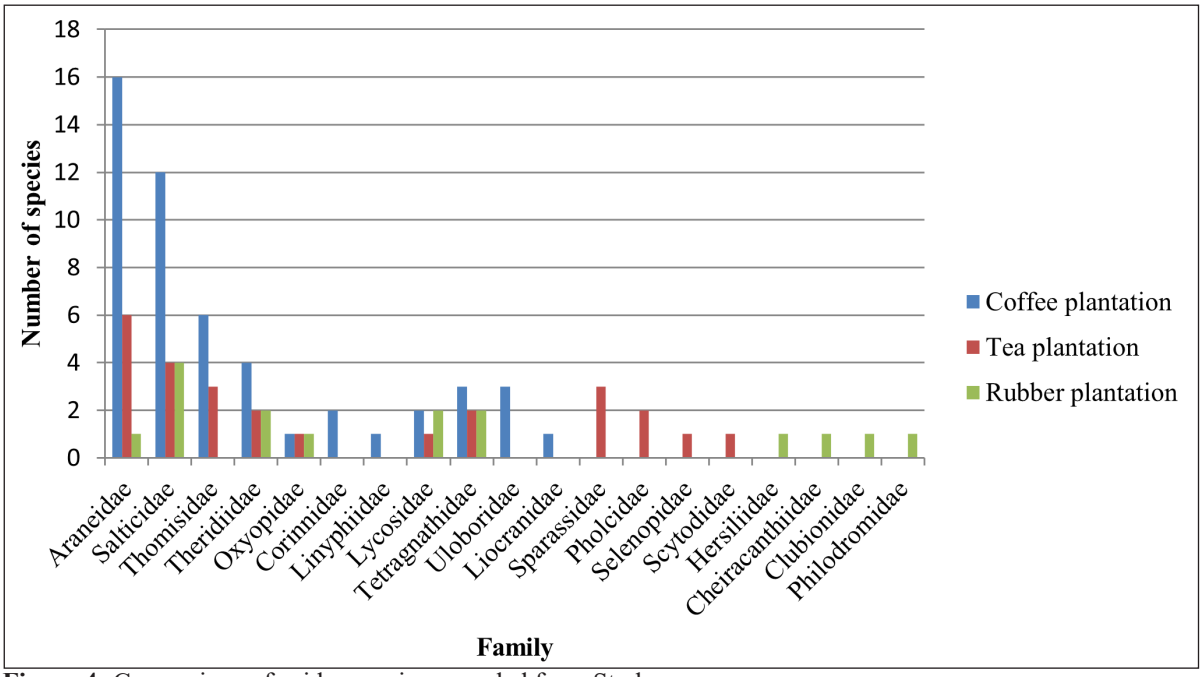

Figure 4: Comparison of spider species recorded from Study areas.

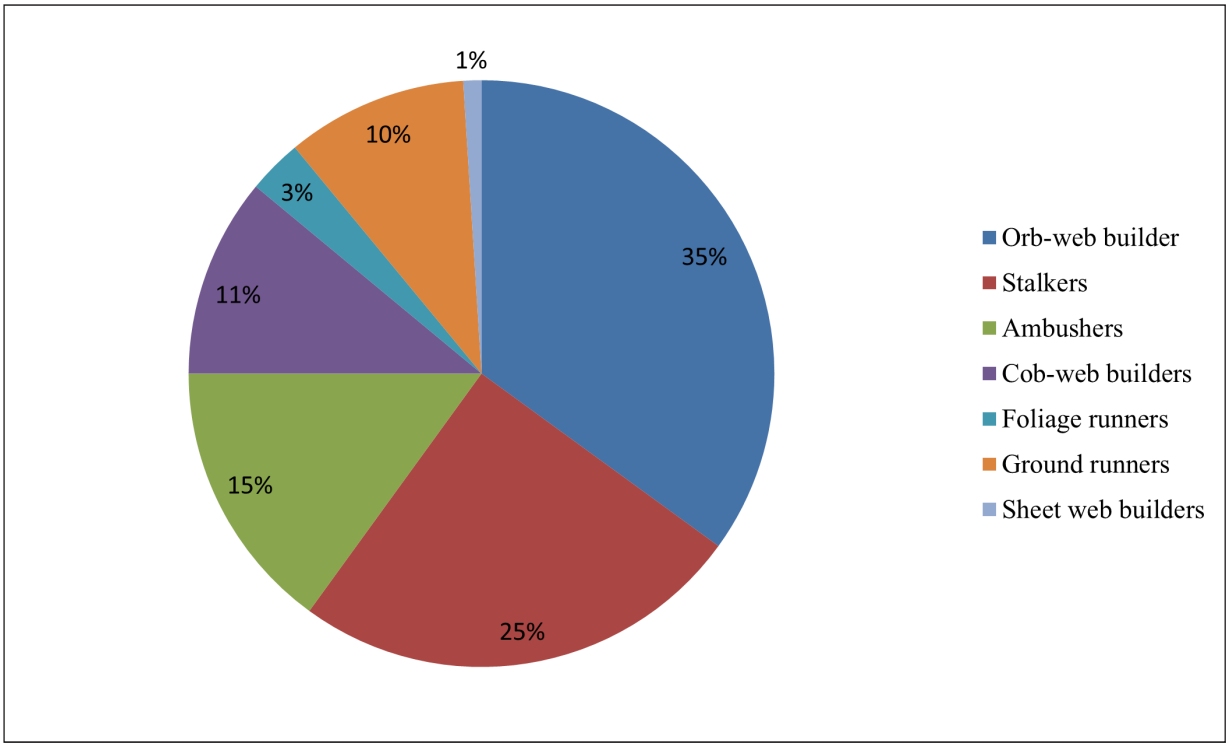

Figure 5: Guild structure analysis of spiders recorded from the study area

The spiders were grouped into seven functional guilds based on their foraging mode. Orb-web builders were the dominant feeding guilds with 35% followed by stalkers 25%, ambushers 15%, cob-web builders 11%, ground runners 10%, foliage runners 3% and sheet-web builders 1%. The dominant orb-web builders constituted 33 species. Stalkers composed of a total of 23 species belonging to the families, Salticidae and Oxyopidae (Figs. 5-6).

Discussion

As generalists, spiders are ingenious predators and an integral part of ecosystem, playing an important role in the structure of food webs and communities (Bucher et al. 2015; Stokmane and Spungis 2016; Ludwig et al. 2018). Spiders have also an important role in the ecosystem maintenance and are considered as the prospective biological control agents (Riechert and Bishop 1990). The status of spider diversity is an important constraint to evaluate the community level of biological organization. Higher species diversity is an indication of a healthier and complex community because a greater variety of species allows more interactions, hence greater system stability which in turn indicates good environmental conditions (Hill 1973).

In the current study, a total of 93 species belonging to 71 genera under 19 families were recorded from the different plantations of the Western Ghats, Wayanad region, Kerala. The 19 families recorded from habitats of Western Ghats represent 49% of all currently recognised families from the Western Ghats, Kerala (Sebastian et al. 2012). Previous study by Sudhikumar et al. (2005) reported 72 species belonging to 57 genera of 20 families from Mannavan Shola forest, Munnar. Dey et al. (2013) recorded 47 spider species belonging to 36 genera of 14 families from the artificial mixed plantation in West Tripura, India. Jose et al. (2018) analysed the diversity of spiders in Kavvayi river basin and recorded 112 species belonging to 81 genera and 21 families. Sruthi et al. (2019) documented 150 species belonging to 73 genera under 20 families from different ecosystems of the Western Ghats, Wayanad. The number of families recorded in the present study is as high or higher than the numbers recorded for other habitats in the Western Ghats (Dey et al. 2013; Jose et al. 2018; Sruthi et al. 2019). The families that were abundant (such as Araneidae, Salticidae and Thomisidae) were also widely distributed in the different plantations of the Western Ghats, Wayanad region (Dharmaraj et al. 2017; Jose et al. 2018). The spiders of the families such as Liocranidae and Philodromidae were not as cosmopolitan in nature (Karthikeyani et al. 2017; Dhali et al. 2017) and they were recorded during the endeavour of the present study.

Figure 6: Spider species diversity in different families reported from different plantations of Western Ghats, Wayanad

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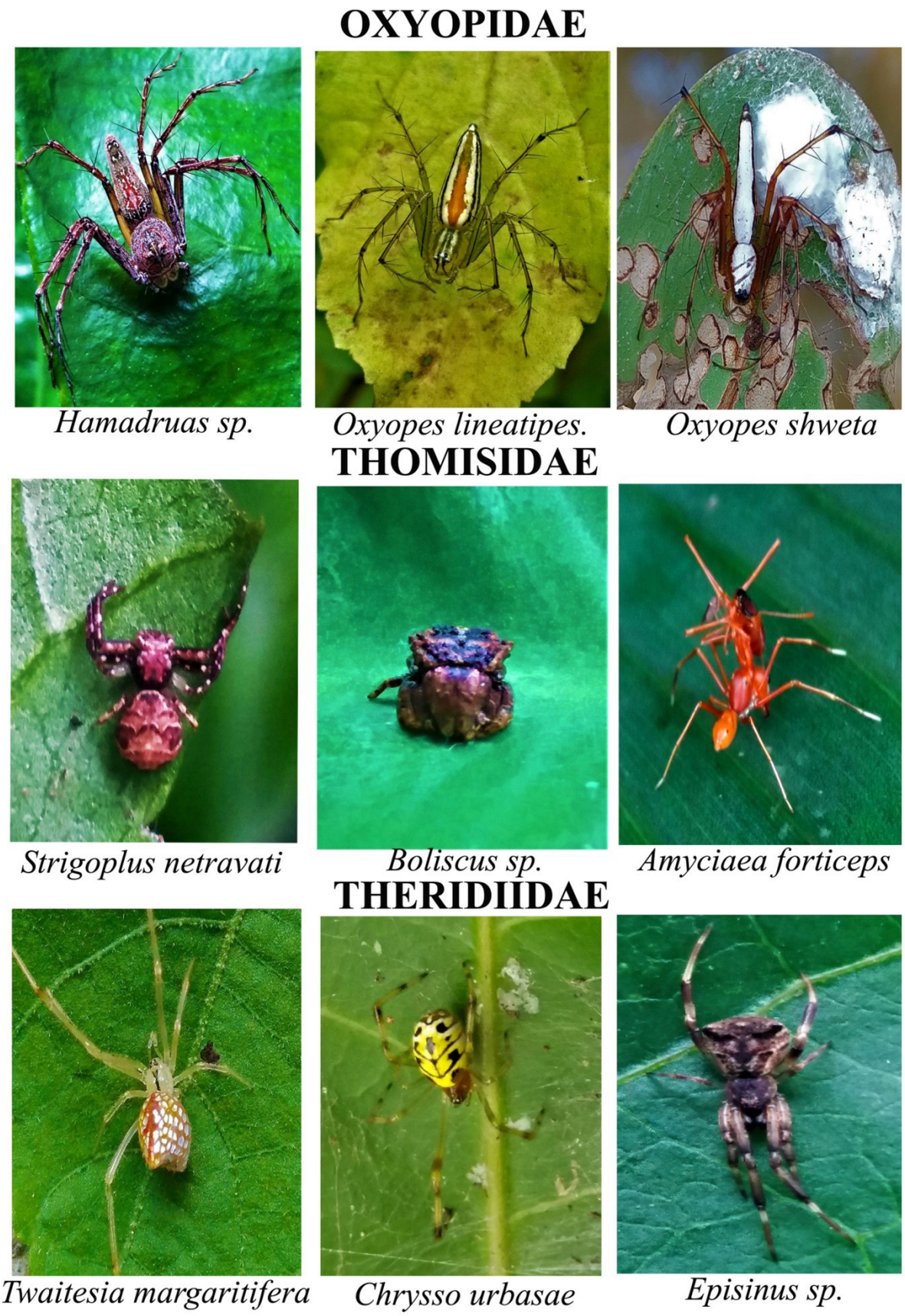

Figure 6: Spider species diversity in different families reported from different plantations of Western Ghats, Wayanad

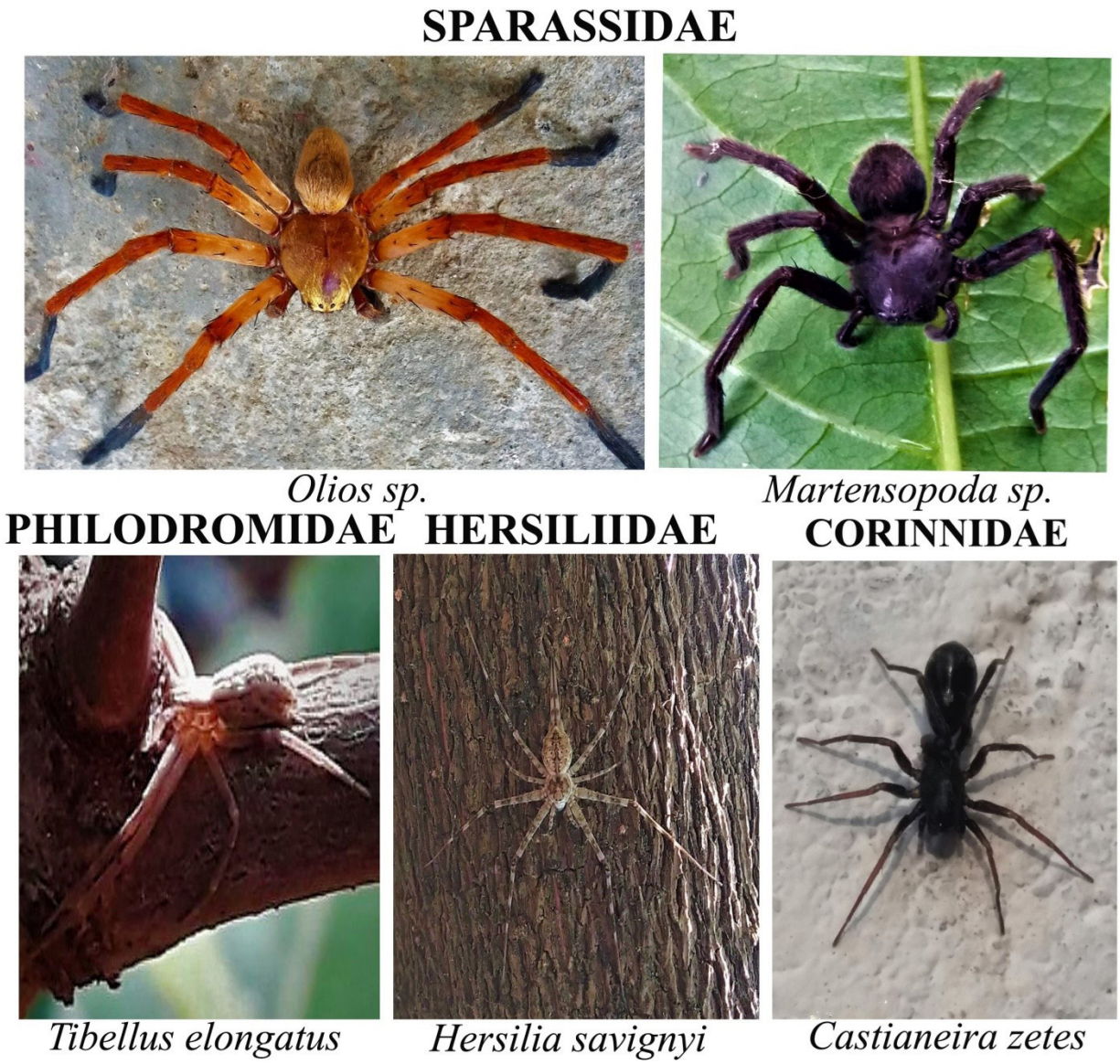

Figure 6: Spider species diversity in different families reported from different plantations of Western Ghats, Wayanad

The results of the present study indicate that the coffee plantations (site A) showed the highest species richness with 51 species belonging to 11 families. The vegetation structure of the habitat supports both the web building and non-web building spiders. Additionally, the exclusive presence of more spider species at one site may be related to the existence of a favourable microclimate and/or an adequate web support for these species. Besides, the site was less exposed to the application of chemical pesticides. When spiders were divided according to their functional group, there was a considerable effect of habitat on the richness of web builders and plant wanderers. The web building and plant wandering spiders depend on vegetation for some part of their lives, either for finding food or for web building (Sanders and Platner 2007). There were many more plant wanderers and web builders sampled than ground-dwellers. Hence, the structure of the vegetation is expected to influence the diversity of spiders found in the coffee plantation. Many other studies have also demonstrated that there exists a definite correlation between structural complexity of habitat and spider species diversity (Uetz 1979; Rosenzweig 1995; Rendon et al. 2006; Rodriguez et al. 2015; Malvido et al. 2020). In the current study, both the tea and rubber plantations exhibited lower species richness. These plantations comprise lower floral and faunal richness when compared to that of coffee plantation. In addition to this, exogenous applications of chemical pesticides

could also influence the spider diversity of these regions. The lower species richness and abundance in the tea and rubber plantation systems could be due to lack of habitat heterogeneity. Land use intensification can reduce the abundance and diversity of spider species through physical removal, destruction of their microhabitats or through changing the microclimatic conditions within the habitat. Previous studies in the Western Ghats have also indicated the effects of land use changes on the diversity of soil biota (Rossi and Blanchart 2005; Rahman et al. 2011; Mandle and Ticktin 2015).

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