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COMPARATIVE DIVERSINESS OF SPIDERS (Araneae) IN DIFFERENT LOCALITIES OF COIMBATORE, TAMILNADU, INDIA AND THEIR WEB TYPES

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ABSTRACT

Having inhabited the planet for approximately 400 million years ago, spiders are a large and diverse class of predatory arthropods that hold a unique position as the largest class of arthropods in nature. Because of their resistance to starvation and desiccation as well as their capacity to catch prey with their web architecture, spiders have the potential to be used as biocontrol agents in a range of environmental settings. Coimbatore, which is close to the Western Ghats range, is a better location for studying biodiversity. In order to observe the morphology of spiders belonging to various families and patterns of web construction, the current investigation seeks to provide a baseline comparative study of spider diversity, types of webs and prey capturing in two localities, Site A - Semmedu and Site B - Alandurai in Coimbatore, Tamilnadu, India. Every chosen location was sampled using a visual search technique and all species along with the web type was captured on camera using a DSLR. According to this study, 103 individuals were found in Sites A and B. Of these, 48 species were identified, representing 28 genera across 9 families: Araneidae (32%), Salticidae (30%), Lycosidae (17%), Oxyopidae (13%), Hersiliidae (3%), Pisauridae (2%), Sparassidae (1%), Tetragnathaidae (1%) and Thomisidae (1%). The Simpson's, Shannon-Weiner, Margalef, and Menhinick indices were used to calculate the Diversity index and conclude that Site A – Semmedu is highly diversed with 1.643 for Shannon-Weiner, 0.7665 for Simpson Index,1.703 in Margalef and 1.024 for Menhinick index.

Keywords

Alandurai, Biodiversity, Diversity Index, Semmedu, Spiders.

INTRODUCTION

Biodiversity is often used as a measure of health in biological systems and Spiders play a crucial role in biodiversity globally. Tamil Nadu is the thirteenth largest state in India in terms of total forest area, covering an area of 130,058 km. It boasts fourteen wildlife and bird sanctuaries, five national parks, four tiger and elephant reserves, and three biosphere reserves. The area is known for its rich diversity of flora and fauna. (Mittermeier *et al*., 1999). The Western Ghats, observed as hotspot of India, crosses Tamil Nadu and cover a region of around 27,069 km2. (Karthikeyani *et al*., 2017). Coimbatore with 11.0168° N latitude, 76.9558° E longitude located near the range of Western Ghats, and is impacted by climate change, serves as a better place to investigate spider diversity.

Arthropods comprise more than 900,000 described insect species and about 43,678 spiders, the members of the class Arachnida and order Araneae. (Platnick, 2013).The only significant class of arthropods that is exclusively predatory in nature is the spider family. (Jose *et al*., 2020). Among invertebrates, spiders belonging to Arthropoda – Arachnida - Araneae are the largely diverse and are common natural predators, ranking 7th in the world's biodiversity. (Penney *et al*., 2003). Spiders are obligatory carnivores and their diet consists mainly of ants, mosquitoes, flies, moths, and sometimes even other spiders, they consume many preys and they do not damage plants (Rajeswaran *et al*., 2005). Spiders use two methods to immobilize the prey: biting and injecting venom that causes paralysis or wrapping and swathing in silk. However, because they don't have teeth, spiders only consume liquids. Their chelicerae appendages are found at the forepart of the cephalothorax and are used in grabbing the prey and injecting venom. Digestion fluids then break down the food into liquid. (Oyewole *et al.*, 2014).

About 400 million years ago, spider web organization and silks started to co-evolve. Some spiders weave real orb webs, spiders weave irregular webs, spiders sometimes create umbrella-shaped, intricately inverted webs, and spiders create sheet webs that stretch out over the ground with a funnel shape. Spiders are often classified as weavers or non-weavers based on their capacity to weave webs. Spiders have modified and adapted their web construction to provide protection, guards, and an effective means of capturing prey to survive in a variety of environments (Regassa *et al*., 2021). Space, sheet, funnel, orb web, single-line snare web, and horizontal dome-shaped web are the six types of webs, of all of them, orb webs are the most common and the most predominant. (Krishna Kant and Priyanka, 2015). The predatory action of spiders is accomplished by the presence of webs.

Control of populations of insect in agricultural settings by Spiders can replace the use of chemicals (Umarani and Umamaheshwari, 2013). Because they manage various pests on cultivated crops, spiders are considered friendly to farmers (Veeramani *et al*., 2023). Any scientific study with Spiders acting as a pest controlling agents by capturing various insects in a variety of microhabitats, and various ecosystems with their web pattern has not yet been conducted. This diversity has been attempted to photograph the web types of various families and to understand the preying habits of the identified spiders.

MATERIALS AND METHODS

Study area

The examination of spider diversity was conducted in Coimbatore district, Tamil Nadu which has an area of 4723 km^2 located between 10.9675° N and 76.9182° E with an elevation of 420 m. It is surrounded by the Western Ghats range on the west and, Nilgiri Biosphere Reserve on the North. A diversity study was carried during the period from June 2023 – September 2023 in two villages Semmedu and Alandurai of Coimbatore district.

A visual search method was used to spot the spiders in each sampling site and each spider was photographed without disturbing it. Field Survey was carried out on alternate days a week and at two different times in a day 6.30 to 10.30 am and 3 to 5 pm. Photographed specimens were identified using taxonomic keys Tikader B. K. (1980), Tikader B. K. (1982), B. K. Tikader (1987), World Spider Catalog, and Indian Biodiversity Portal. The Shannon–Wiener, Simson's index, Evenness, Margalef, and other indices was used to calculate the Diversity index (Sebastain *et al*., 2005).

SHANNON-WEINER INDEX

$$\text{Diversity index} = -\sum((pi) * \ln(pi))$$

$\sum$ - Summation

Pi – Species Proportion

ln – Natural log

SIMPSON DIVERSITY INDEX

Simpson Diversity index = N (N-1)/ ni (ni-1)

ni – No. of individuals in a particular species

N – No. of individuals (all species)

EVEN NESS

Evenness = H/S

H – Shannon-Weiner index

S – Total count of species

MARGALEF

Diversity index = (S-1)/ ln N (2)

S – No. of species

N – total no. of individual

MENHINICK

Diversity index = S/ ffi N p

(N) - The No. species / square root of the total No. of individuals

RESULTS AND DISCUSSION

Spider Diversity was carried out in two sites A – Semmedu and B – Alandurai (Figure 49). The investigation reports 103 individuals in which 61 individuals were identified in Site A and 42 individuals from Site B (Table 1. & Figure 1 – 48) and overall, of 48 species of 27 genera with 9 families were identified during the duration of the diversity survey. The most predominant families were Araneidae and Salticidae, Argiope genera were found abundant in the Araneidae family. Araneidae (15), Salticidae (15), Hersiliidae (1), Pisauridae (2), Oxyopidae (6), Thomisidae (1), Tetragnathaidae (1), Lycosidae (6) and Sparassidae (1) in numbers (Table 2).

S.NO	FAMILY	SPIDER SPECIES	COMMON NAME	HABIT	WEB TYPE
1	Araneidae	*Argiope catenulate* [1859, Doleschall]	Grass Cross spider	Orb-web weavers	ORB Web
2		*Argiope pulchella*[1881, Thorell]	Garden Cross spider	Orb-web weavers	ORB Web
3		*Argiope keyserlingi*[1878, Karsch]	St. Andrew's Cross spider	Orb-web weavers	ORB Web
4		*Argiope aethereal* [1841, Walckenaer]	Northern Saint Andrew's cross spider	Orb-web weavers	ORB Web
5		*Argiope argentata*[1775, Fabricius]	Silver Garden spider	Orb-web weavers	ORB Web
6		*Araneusdiadematus*[1757, Clerck]	European Garden spider	Orb-web weavers	ORB Web
7		*Araneussturmi*[1831, Hahn,]	Evergreen Orb-weaver	Orb-web weavers	ORB Web
8		*Cyclosaconica*[1772, Pallas]	Trashline Spider	Orb-web weavers	ORB Web
9		*Cyclosa bifida* [1859, Doleschall]	'Long-bellied cyclosa'	Orb-web weavers	ORB Web
10		*Cyrtophoracicatrosa*[1869, Stoliczka]	Dome Spider	Orb-web weavers	ORB Web
11		*Cyrtophoracitricola* [1775, Forsskal]	Tropical Tent Web Spider	Orb-web weavers	ORB Web
12		*Cyrtophoraexanthematica*[1859, Doleschall]	Double-tailed Tent Spiders	Orb-web weavers	ORB Web
13		*Gasteracantha geminate* [1798, Fabricius]	Oriental Spiny Orb-weaver	Orb-web weavers	ORB Web
14		*Gasteracanthamammosa*[1758, Linnaeus]	Spiny Backed Orb-weaver	Orb-web weavers	ORB Web
15		*Thelacanthabrevispina*[1857, Doleschall]	Asian Spiny-Backed orb -weaver	Orb-web weavers	ORB Web
16		*Anasaitiscanosa*[1837,	Twin-Flagged jumping	Stalkers	No Web

		Walckenaer]	Spider		
17		*Colonus sylvanus*[1846, Hentz]	Sylvana Jumping Spider	Stalkers	No Web
18		*Carrhotusviduus*[1846, C. L. Koch]	Jumping Spider	Stalkers	No Web
19	Salticidae	*Hyllus semicupreus*[1885, Simon]	Heavy-Bodied jumper	Stalkers	No Web
20		*Marpissamuscosa*[1757, Clerck]	Fencepost Jumping Spider	Stalkers	No Web
21		*Menemerusfulvus*[1829, Hahn]	Grey House Jumper	Stalkers	No Web
22		*Menemerusbivittatus*[1831, Dufour]	Grey Wall Jumper	Stalkers	No Web
23		*Phidippusclarus*[1884, Keyserling]	Brilliant Jumping Spider	Stalkers	No Web
24		*Phidippusregius*[1846, C.L.Koch]	Regal Jumper	Stalkers	No Web
25		*Plexippuspaykulli*[1826, Audouin]	Pantropical Jumping spider.	Stalkers	No Web
26		*Plexippuspetersi*[1878, Karsch]	Tropical Flycatcher or small zebra jumper	Stalkers	No Web
27		*Portia labiate* [1887, Thorell]	White-Mustached Jumping Spider	Stalkers	No Web
28		*Portia fimbriata* [1859, Doleschall]	Fringed Jumping spider	Stalkers	No Web
29		*Telamonia dimidiate* [1899, Simon]	Two-Striped jumper	Stalkers	No Web
30		*Trite planiceps*[1899, Simon]	Black-Headed Jumping spider	Stalkers	No Web
31		*Arctosastigmosa*[1875, Thorell]	Wolf Spider	Burrowers	No Web
32		*Hippasaagelenoides*[1884, Simon]	Grass Funnel-web Spider	Burrowers	Sheet Web

33	Lycosidae	*Hippasagreenalliae*[1867, Blackwall]	Wolf Spider	Burrowers	Sheet Web
34		*Hippasaholmerae*[1895, Thorell]	Lawn Wolf spider	Burrowers	Sheet Web
35		*Hippasamadraspatana*[1924, Gravely]	Wolf Spiders	Burrowers	Sheet Web
36		*Hippasapisaurina*[1900, Pocock]	Wolf Spider	Burrowers	Sheet Web
37	Oxyopidae	*Oxyopesbirmanicus*[1887, Thorell]	Burmese Lynx Spider	Hunters	No Web
38		*Oxyopesjavanus*[1887, Thorell]	Striped Lynx spider	Hunters	No Web
39		*Oxyopessalticus*[1846, Hentz]	Striped Lynx spider	Hunters	No Web
40		*Oxyopesshweta*[1970, Tikader]	White Lynx spider	Hunters	No Web
41		*Oxyopessunandae*[1970, Tikader]	Striped Lynx spider	Hunters	No Web
42		*Peucetiaviridans*[1832, Hentz]	Green Lynx spider	Hunters	No Web
43	Pisauridae	*Dolomedesscriptus*[1845, Hentz]	Striped Fishing spider	Hunters	Funnel Web
44		*Pisaurinamira*[1837, Walckenaer]	Nursery Web spider	Hunters	Funnel Web
45	Hersiliidae	*Hersiliasavignyi*[1836, Lucas]	Two-Tailed spider	Camouflage-hunters	No Web
46	Sparassidae	*Heteropodavenatoria*[1767, Linnaeus]	Giant Crab spider	Hunters	No Web
47	Tetragnathidae	*Leucaugefastigata*[1877, Simon]	Pear-Shaped leucauge	Orb-web weavers	ORB Web
48	Thomisidae	*Thomisuslobosus*[1965, Tikader]	Flower-Crab spider	Ambusher	No Web

Table 1. List of Spider species in the study area


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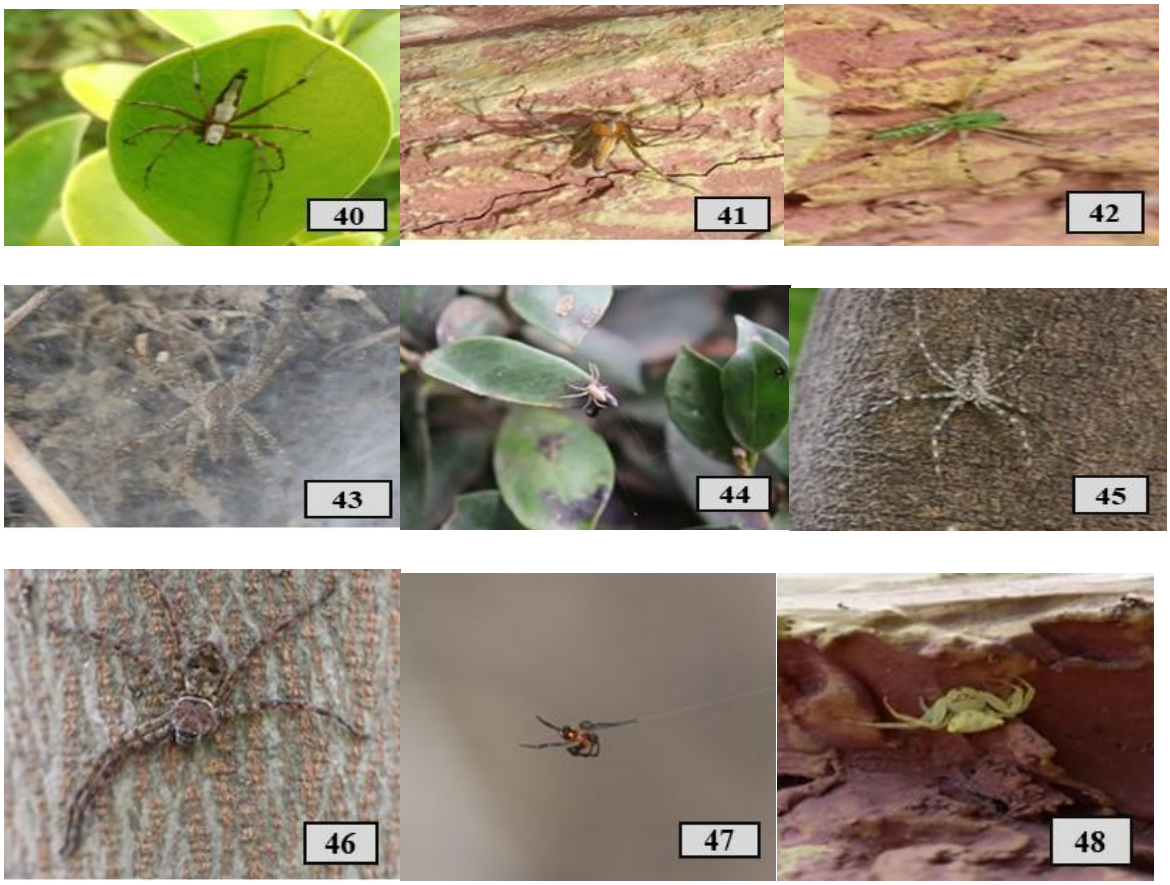

Figure 1 – 48. 1. *Argiope catenulate* 2. *A. pulchella*3. *A. keysingerli* 4. *A. aetherea* 5. *A. argentata* 6. *Araneus diadematus* 7. *Araneus sturmi* 8. *Cyclosa conica* 9. *C. bifida* 10. *Cytrophora cicatrosa* 11. *Cytrophora citricola* 12. *Cytrophora exanthematica* 13. *Gasteracantha germinata* 14. *Gasteracantha mammosa* 15. *Thelacantha* 16. *Anasaitis canosa* 17. *Colonus sylvanus* 18. *Carrhotus viduus* 19. *Hyllus semicupreus* 20. *Marpisaa muscosa* 21. *Menemerus fulvus* 22. *Menemerus bivattatus*23. *Phidippus clarus* 24. *Phidippus regius* 25. *Plexippus paykulli* 26. *Plexippus petersi* 27. *Portia labiata* 28. *Portia fimbriata* 29. *Telamonia dimidiata* 30. *Trite planiceps* 31. *Arctosa stigmosa* 32. *Hippasa agelenoides* 33. *Hippasa greenalliae* 34. *Hippasa holmerae*35. *Hippasa madraspatana* 36. *Hippasa pisaurina* 37. *Oxyopes birmanicus* 38. *Oxyopes javanus* 39.*Oxyopes salticus* 40. *Oxyopes shweta 41. Oxyopes sunandae* 42. *Peucetia viridans* 43. *Dolomedes scriptus* 44. *Pisaurina mira* 45. *Hersilia savignyi* 46. *Heteropoda venatoria* 47. *Leucauge fastigata* 48. *Thomisus lobosus*

Figure 49. Study area of Coimbatore – Site A Semmedu and Site B Alandurai

SL.NO	FAMILY	GENERA	NUMBER OF SPECIES	TOTAL NUMBER OF INDIVIDUALS
1.	Araneidae	6	15	34
2.	Salticidae	11	15	30
3.	Lycosidae	2	6	17
4.	Pisauridae	2	2	2
5.	Hersiliidae	1	1	3
6.	Sparassidae	1	1	1
7.	Tetragnathidae	1	1	1
8.	Thomisidae	1	1	1
9.	Oxyopidae	2	6	14
	TOTAL	27	48	103

Table 2. Number of individuals

DIVERSITY INDICES	SITE A (SEMMEDU)	SITE B (ALANDURAI)
Individuals	61	42
(D) Dominance	0.2335	0.2744
(SID) Simpson	0.7665	0.7256
(H”) Shannon	1.643	1.391
(e^H/S) Evenness	0.6466	0.8038

Brillouin	1.471	1.238
Menhinick	1.024	0.7715
Margalef	1.703	1.07
Fisher alpha	2.462	1.479
Berger-Parker	0.3115	0.381

Table 3. Diversity Indices of Site A and Site B

The diversity indices are tabulated in (Table 3). The diversity index of Site A was 1.643 and 1.391 in Site B according to Shannon-Weiner Index. As stated by Simpson (SID) the indices of Site A 0.7665 and 0.7256 for Site B. Margalef index predict 1.703 for Site A followed by 1.07 for Site B. The Evenness index was found to be 0.6466 and 0.8038 in Site A and Site B respectively. In accordance with the compared diversity indices (Figure 50) in Site A (Semmedu) has more richness of spider species in comparison with Site B (Alandurai). The phylogenetic tree of the identified families was constructed (Figure 52).

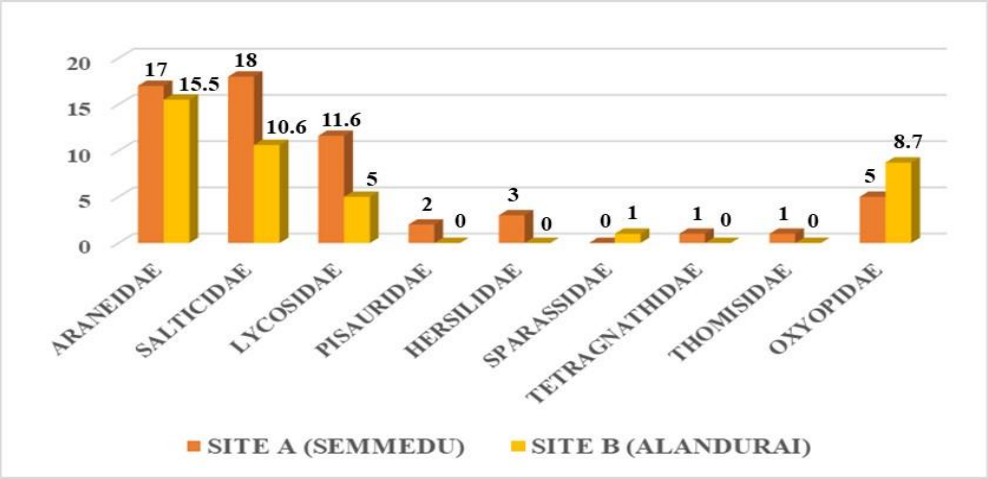

Figure 50. Comparative diversity of spider families in Site A and Site B

SPIDER WEB TYPES AND PREYING HABITS

The Araneidae and Salticidae family was described to be the predominant family mentioned. The study found that the Araneidae family ranked highest in number of individuals. Orb-weaver spiders are the members of the family Araneidae. Web construction and silk spinning are two of araneology's most amazing features. It is said that there are two groups of spiders that spin orb webs namely cribellate orb weavers which belong to the family Uloboridae - weavers of calamistered sticky silk and ecribellate orb weavers that

belong to the family Araneidae - weavers of true viscid silk (Coddington. J. A, 1986). Although the structure of webs and silks varies greatly between species, individual variations exist in web and silk dynamics. (Boutry. C *et al*., 2013). The spiders belonging to the genera *Araneus, Argiope, Leucauge,* and *Gasteracantha* weave their webs in the crevices between rocks, within the branches of tiny trees, and within low shrubs. They usually spin new webs every night or fix broken ones. Based on preying behaviour and the ultra-structure of silk threads, web architecture shows high diversity and also cause variation in the silk gland spigot complements (Ramirez. M. J *et al*., 2013). The orb web's structure and shape are extremely adaptive since it may be adjusted daily to the local conditions based on factors including wind, temperature, humidity, and silk supply. (Vollrath. F *et al*., 1997).

Spiders in rice fields act as predators and help in reducing planthoppers, and leafhoppers. Eight spider species from seven different families have been found in rice crops in Gudalur, Nilgiri district, Tamil Nadu. The spider species include *Oxyopesjavanus*, *Oxyopesrufisternum*, *Thomisus*sp, *Clubiona*sp, *Argiope*sp, and *Plexippus*sp, (Vinothkumar, 2012). An updated list of the variety of spiders found in the Tamil Nadu State is provided in the study by Rajendra singh 2023, it is reported that there are 547 species of spiders altogether that have been found under 257 genera, of 46 families, found from 33 districts of Tamil Nadu. In relation with Mahalakshmi and Jeyaparvathi S., 2014, conducted a study on cotton land area of Thailakulam, Virudhunagar, Tamil Nadu and identified 19 species belonging to 18 genera, among those Salticidae (31.57) had the highest population, Oxyopidae (15.78) had the lowest population, this study also shows that Salticidae was the dominant family found. The study was carried out in Emerald Valley, Parsons Valley, and Avalanche of Nilgiris by Dharmaraja, *et al*., 2018 in which 59 species of 25 genera and 11 families was gathered, with the majority of the species being found in the Salticidae, Oxyopidae, Araneidae, and Lycosidae families.

The wolf-spiders, or *Lycosidae* family of spiders, are special in that they are both predators and weavers. The only spiders in the genus *Hippasa* create large, sheet-like webs on the ground that conceal them with funnel retreats. When any prey gets entangled in the webs, the spider emerges from its funnel-like refuge to suck, kill, and bite it. It waits for the prey to fall onto the extended sheet.*Hippasaholmerae* function as a biological pesticide in agricultural areas. It typically preys on insects by directly leaping on them, including homopterans, orthopterans, lepidopterans, dipterans, and, least preferred, coleopterans (Aravind Y et al., 2012). According to research on the significance of wolf spiders' leg attributes for catching food, chelicerae are sufficient for retaining prey; fangs or legs are not

required for cheliceralgrabbing (Rovner. J. S., 1980). This family of spiders engages in cannibalism predation while coexisting (Rypstra. A. L & Samu F., 2005).

The term "hunting" or "running" spider refers to the group of spiders that do not construct webs or snares in order to capture their insect prey for meals. This group includes the spiders from the families Gnaphosidae, Clubionidae, Heteropodidae, Salticidae, Oxyopidae, and Thomisidae. These spiders may wait and stalk their prey, or they race after them and catch them by running them down.The Oxyopidae family of lynx spiders are polyphagous insectivores that mostly feed on Heteroptera, Hymenoptera, and Dipteran insects. Different spider species differ in the extent to which they are specialised in eating (Nyffeler. M., *et al.,* 1992). For research looking at how prey selection and early experience impact later spiderlings of this species, Oxyopessalticus was captured (Punzo F., 2002). In general, all species are powerful, huge spiders that take their food by mouth parts directly; they do not employ silk in any kind of predation scenario (Williams. D. S., 1979). The genus Dolomedes, which includes fishing spiders, is part of this family. The Dolomedes species of spider is nearly entirely aquatic, and it exploits waves on the water's surface to find food. Hydrodynamic flow fields infrequently cause prey detection to occur (Bleckmann H & Lotz T, 1987).

Hersiliidae spiders are known to prey on tiny insects like ants. The swiftly moving Hersiliidae encircle their victim with silk bands as they sprint around it in circles and confront it with their elongated PLS (Peters, 1967; Kreuz. J. *et al.,* 2024). Omnivores are spiders in the family Sparassidae (Deo. R. & George. S. E., 2022). Rather than creating their web, these spiders attack other people's web sites to hunt and gather food (Jackson. R. R., 1987). According to Lesar and Unzicker (1978), members of this family of spiders weave webs fashioned like wheels to capture prey like tiny flying insects and other arthropods. As a predatory tactic, they employ the "seize-pull out" technique (Yashida. M., 1987). The Thomisidae family of crab spiders hunts flowers (Morse. D. H., 1984). Ants and flower-dependent insects are the prey of the spiders (Oliveira. P. S & Sazima. I., 1985). Each spider family had a unique pattern of web construction following the preying behaviour and mating behaviour.

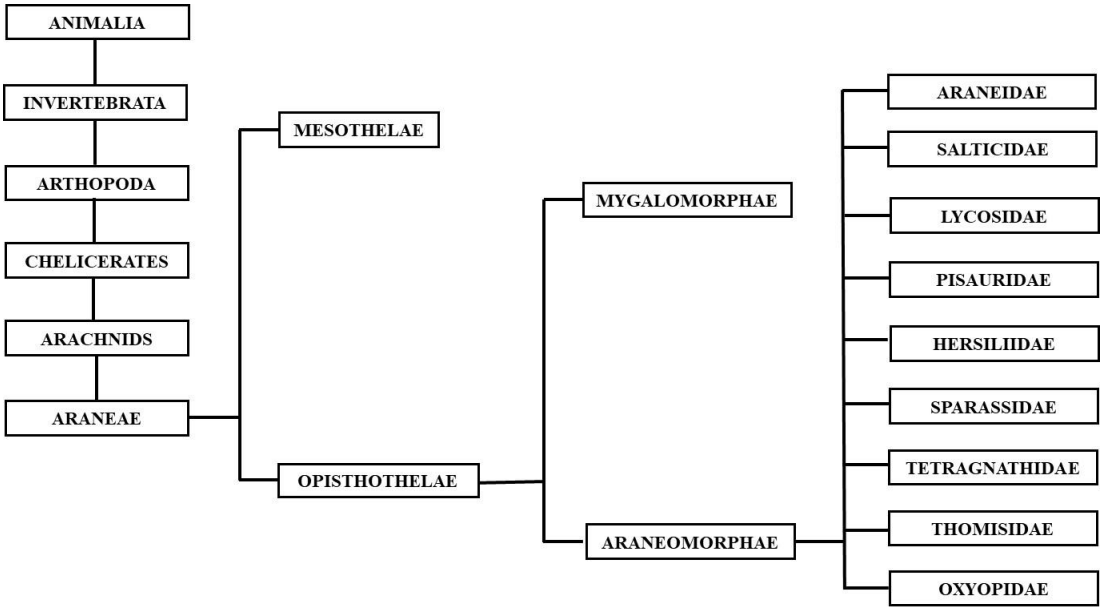

Figure 51. Phylogenetic Tree of Identified Family

CONCLUSION

A whole of 48 species corresponding to 9 families was identified. Araneidae and Salticidae were the dominating ones among the identified families. Hersiliidae, Sparassidae, Tetragnathaidae, and Thomisidae were identified to be the least number in diversification. Each geographical location possesses unique species diversity, richness, and evenness due to various geographical reasons like temperature, climate, and humidity. Abundance of spiders were comparatively higher in Semmedu due to the ambient temperature, moisture with low counts in Alandurai due to Higher temperature and humidity. Hence this diversity study was a baseline work and web types were captured, to understand the preying and predatory actions, further study must be carried out to understand various perspectives of spider diversity such as habitats, pest-controlling agents, and the medicinal applications of spider webs.

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CONFLICT OF INTEREST

The authors hereby declare no competing interest.

AUTHOR CONTRIBUTION

Sri Raagavee Sivakumar drafted the manuscript and did a field study. Rajashree Ganeshan, Monika Madhanraj, Sowmitha Thangaraj have done the field study and analyzed the data. Sornapriya J. edited the manuscript. Susheela P has designed the study, co-wrote, supervised, and approved for the final submission

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