Int J Adv Life Sci Res. Volume 7(3) 152-165
https://doi.org/10.31632/ijalsr.2024.v07i03.014

International Journal of Advancement in Life Sciences Research

Online ISSN: 2581-4877

Journal homepage http://ijalsr.org

Original Article

Web Spinning and Non-Spinning Spiders of Semi-Arid Agro Ecological Habitat of Agra region and their Role in Pest Control

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Abstract

The spider fauna has a significant role in the agro-ecological system in the cultivable lands across the Agra region. The survey covered an area of 28.5 sq km, and the spider webs were collected by various sampling methods during the nocturnal and diurnal periods. A total of twenty-nine spider species belonging to nine families were collected for web spinning as well as non-web spinning spiders. During the period of nine months, which include the late summer, monsoon, and pre-winter seasons, Abundant web spinning spiders, predominantly from the family Araneidae, were widely spread, while the least number of spiders were found in the family Thomisidae. Individual web-spinning spider species of the Araneidae were predominantly represented by the genus *Argiope sp,* with a small representation by *Miseumenavatia*. The largest and strongest web is spun by the genus *Neoscona sp* and a fragile web by *Uloborus*. The largest web is spun individually by *Neoscona* and a group/community based on *Cytrophora*. The reduction in the number of ground-dwelling spiders is mainly due to the impact of the use of pesticides by farmers. The agro ecosystem of Agra is impacted by the large use of pesticides by the farmers. The cultivation of potato, wheat, and mustard in Agra. Produces 40% quantity of potato, wheat, and mustard in India and their cultivation seems to give better natural niche for spider than other field crops.

Keywords: *Agro ecology, Ground dweller, Non-web-spinning, Semi-arid habitat, Web-spinning*.

Introduction

Spiders are ubiquitous in nature with the fossils dating back to the Devonian age. Currently 52,116 species of spiders worldwide comprising of 4,428 genera and 135 families (World Spider Catalog 2024 Version 25.0) with 1686 species of spiders belonging to 61 families and 438 genera being updated taxonomically from the Indian region of which only 65 species of spiders belonging to 11 families have been recorded in the semi-arid habitat of central India (Anjali & Prakash, 2019; Raghu & Kumar, 2022, Yadav & Prakash, 2021).

Agra, located in the northern state of Uttar Pradesh, India, features a diverse agriculture and ecosystem influenced by its geography, climate, and human activity. A variety of crops are cultivated in Agra including wheat, rice, sugarcane, mustard, and potatoes. Mostly potatoes are cultivated and then wheat and mustard. The climate of Agra is also conducive for horticulture and floriculture. In horticulture fruits are cultivated like mangoes, guavas, and papayas whereas in floriculture flowers like marigold, rose, and jasmine are grown in the region. River Yamuna provides the river ecosystem for agriculture and serving as a habitat for aquatic life. Terrestrial ecosystems around Agra include agricultural lands,

Received on :10th May 2024; Revised version received on :1st June 2024; Accepted: 3rd July 2024

forests, and urban areas. The agricultural landscape consists of fields growing crops like wheat, rice, sugarcane, and vegetables. Water pollution, air pollution, Urbanization and habitat destruction have led to the loss of natural habitats and biodiversity in and around Agra. Deforestation, conversion of agricultural land to urban use, and encroachment on green spaces have all contributed to habitat fragmentation and loss of species diversity. Agra being in the Indo-Gangetic plain has the predominant alluvial type of soil which is formed by the deposition of silt, clay, and sand carried by rivers.

Agra is characterized as semi-arid due to its climatic conditions, which exhibit characteristics of both arid and humid climates but tend to lean towards aridity. Semi-arid regions typically receive lower amounts of rainfall with an average annual precipitation is relatively low, often below 700 millimeters (27.6 inches) per year. Semi-arid regions often experience high rates of evaporation due to warm temperatures and dry air and it exhibits temperature extremes, with hot summers and cool to mild winters. Agra experiences hot summers with temperatures frequently exceeding 40°C and relatively cooler winters with temperatures dropping to around 5°C-10°C.

Spiders use silk, a protein-based natural fiber, to weave their webs of high tensile strength and extensibility. The seven types of silk glands on the posterior side produce silk with unique properties and applications (Foelix, 1996). The idea of spinning webs of various shapes and sizes are to create a trap for the prey, for the insects some webs are sticky, while others simply allow the prey to walk across the web and detect their presence via their vibration. The architecture of the web is also crafted specifically for trapping required prey by which an effective broad identification of the spiders also can be done (Anjali & Prakash, 2019).

The Agro-ecology seeks to develop environmentally and socially sustainable food system and spiders as pest controllers, have demonstrated their potential to be used as biological control agents (Benamu 2020). The Agra region is part of a semi-arid ecosystem (26°44'N and 27°55'S and 77°26W and 78°32 E). In the extreme weather of Agra, enormous number of pests have impacted the agricultural system even though the agro-ecological semi-arid habitat of this region promotes spider growth and development of spiderlings (Anjali & Prakash 2012). Despite the diversity of fauna in this region, the spider taxonomy is understudied; therefore, the present study focuses on the importance of the diversity of spider in arid/semi-arid environment through taxonomic identification, their role in ecological assessments in the agro-ecosystem and their prey based evaluation.

Material and Methods

Sampling was done from three wide sites depending on the agro system practiced in these locations. The area of the Sampling sites is depicted in Fig. 1. Site 1 Pilipokhar (Khandohli); Site 2 Dayalbagh and Site 3 Keetham. Six different collection methods such as Hand collection, Visual searching, Beating limb, Pit fall, Sweeping net, and Transect method were used to collect spiders (Anjali & Prakash,2012; Anjali & Prakash 2015) but Visual Searching and hand collection methods were most frequently used. The keys and Catalogues of Pocock (1941), Tikader (1987), Sebastian & Peter (2009), and World Spider Catalog (2024) were also referred for identification. Spiders were photographed in their habitat before bringing them live to the lab for documentation.

Figure 1. Semi-arid Sampling sites

Results

A total of 1550 adult spiders belonging to 29 species and 9 families of both web and Non-web building Spiders are scored in the Agra agroecosystem (Table. 1).

Table 1. Checklist of spiders found during survey

Family	Species Name	No. of Spiders
Araneidae	*Araneus diadimatus*	78
	Neoscona thesi	104
	Neoscona nautica	68
	Neoscona crucifera	17
	Cytrophora cicarosa	23
	Cytrophora citricola	146
	Cyclosatribolata	50
	Argiope pulchella	172
	Argiope aurantia	68
	Argiope anasuja	112
	Zygiella indica	82
	Zygiella x-notata	41
Salticidae	*Hasarius adansoni*	7
	Maevia poultani	5
	PLexipuss paykulli	56
	Menemerus bivittatus	26
	Menemerus semilimbatus	21
	Myrmarachne	5
Hersiliidae	*Hersiliasavigyni*	10
Pholsidae	*Artema Atlanta*	51
	Crossopriza lyoni	23
	Pholcus phalangiodes	36
Thomisidae	*Misumena vatia*	3
Lycosidae	*Pardosa milvina*	55
	Lycosa	48
Oxyopidae	*Oxyopes*	37
Tetragnathidae	*Leucauge argyra*	81
	Leucauge decorata	116
Uloboridae	*Uloborus sp*	9
Total 9	*29*	1550

The web-building spiders recorded are – *Crossopriza lyoni*, *Artema atlanta* are house spiders and *Neoscona theisi*, *N.crucifera, Cytrophora citricola, Cyclosa trilobata, Zygiella x-notata, Argiope anasuja, A.pulchella,Uloborus,Lecuage decorate and L.argyra.* These areorb spiders and can vary in sizes and colour. House spiders (*Crossopriza lyoni* and *Artema atlanta*) spin dense webs around windows, doors and leaves (Fig 2 – 15).

The non-web-building spiders are predominantly running or hunting ground spiders do not use a web to catch their prey as it actively pursue their prey, either by running after them or ambushing them. Four common non web spinning groups were found at the selected sites: Jumping spiders (Salticidae), Wolf spiders (Lycosidae), Crab spider (Thomisidae) and Oxyopes (oxyopidae) (Fig 16-27).

Figure 2. *Argiope anasuja*

Figure 3. *Argiope pulchella*

Figure 4. *Argiope sps*

Figure 5. *Artema atlanta*

Figure 6. *Citrophora citricola*

Figure 7. *Crossopriza Lyoni*

Figure 8. *Leucauge argyra*

Figure 9. *Leucauge decorata*

Figure 10. *Neoscona theisi*

Figure 11. *Neoscona crucifera*

Figure 12. *Cyclosa trilobata*

Figure 13. *Zygiella x-notata*

Figure 14. *Uloborus sps*

Figure 15. *Neoscona sps*

Figure 16. *Maevia poultoni*

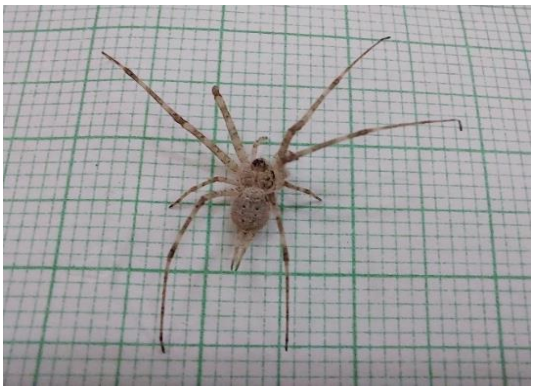

Figure 17. *Hersilia savignyi*

Figure 18. *Plexippus paykulli*

Figure 19. *Hasarius adansoni*

Figure 20. *Menemerus bivittatus*

Figure 21. *Menemerus semilimbatus*

Figure 22. *Myrmarachne*

Figure 23. *Oxyopes sps*

Figure 24. *Lycosa*

Figure 25. *Pardosa milvina*

Figure 26. *Misumena vatia*

Figure 27. *Pardosa sps*

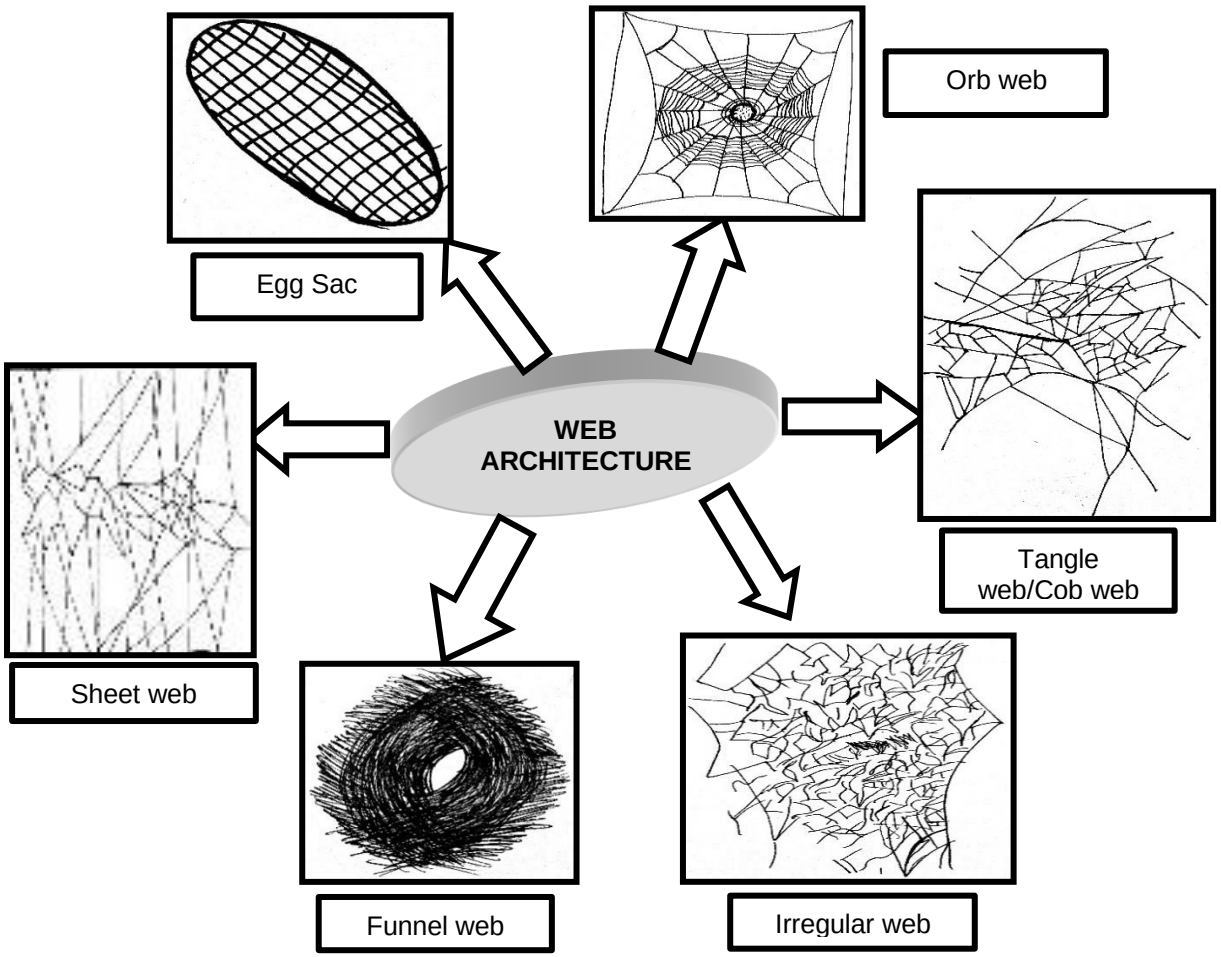

Figure 28. Types of Spider webs in Semi-arid habitat

Orb Web - The orb web is the most common types of spider web and is made up of spokes that are connected in the middle by a strong external frame (Fig 29 A & 29 B). These spokes are then connected with a spiraling elastic thread to form a large surface area for catching prey.

Figure 29 A. Orb web of *Neoscona* sps.

Figure 29 B. Orb web

Tangle Web/Cobweb – Mostly **i**ndoors, cobwebs are common in low-traffic areas, particularly in corners. They're designed to appear cluttered and disorganized. They're frequently anchored to the top of a structure, with multiple threads dangling from it (Fig 30).

Figure 30. Tangle web/ Cobweb

Funnel Web - The funnel web, as the name suggest is shaped like a funnel. Thread expanses span a variety of distances before coming together in the middle to form a cyclindrical holes. The funnel weaver spider hides in this hole and reaps some of the benefits of this web design (Fig 31A & 31 B).

Figure 31 A. Funnel Web

Figure 31 B. Funnel Web

Sheet web - In the Sheet Web the classic web design is turned horizontally in these intriguing webs. These hammock-like webs can be found drapes over grass, bushes or other structures. Some of these webs are flat and lay flat on the grass, while others are dome-shaped and lay flat on the ground (Fig 32 A and 32 B).

Figure 32 A. Sheet web of *Citrophora sps*.

Figure 32 B. Sheet web of *Citrophora sps*.

Irregular Web - The Irregular Web (Fig 33 A and 33 B) are similar to cobwebs, yet they're outside. They're technically cobwebs, but for the sake of clarity they are commonly seen under leaves and rocks, as well as in grassy areas.

Figure 33 A. Irregular web

Figure 33 B. Irregular web

Egg sac - When spiders lay eggs, they do so in large numbers. The number of eggs varies between 2 to 1000. Female spiders develop an egg sac to store all of these eggs. Egg sacs are available in a variety of shapes, from discs to flawless spheres. They also come in a variety of colours, ranging from white to dark brown to black. Females make them by laying eggs on a silk mat, covering them with another silk mat, and then winding everything up in a ball (Fig 34 A, B and C).

Figure 34 A. Egg sac

Figure 34 B. Egg sac with Nymph

Figure 34 C. Silk fibre of Egg sac with Nymph

In the semi-arid agro-ecological habitat, the highest number of spiders found in the family Araneidae (961) which is followed by the Tetraganathiidae (197), Salticidae (120), Pholsidae (110), Lycosidae (103), Oxyopidae(37), Hersilidae (10), Uloboridae (9), Thomisidae (3) [Fig.36]. The highest number of species of spiders belong to family Araneidae (n=12, 41%) which is followed by Salticidae (n=6, 21%), Pholsidae (n=3, 10%), Tetraganathidae (n=2, 7%), Lycosidae (n=2, 7%), Oxyopidae (n=1, 4%), Hersilidae (n=1, 4%), Uloboridae (n=1, 3%), Thomisidae (n=1, 3%) [Fig.35].The highest number of spiders collected were *Argiope pulchella* (172, Aranidae) and lowest number of spiders were *Misumena vatia* (3, Thomisidaae) shown in [Fig.37].

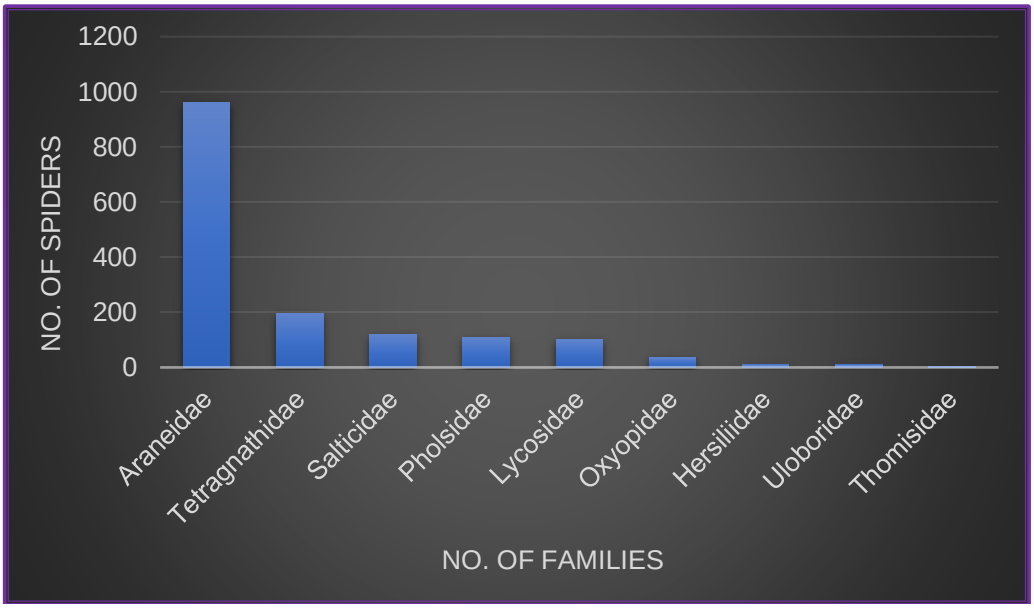

Figure 36. **Number of Families recorded**

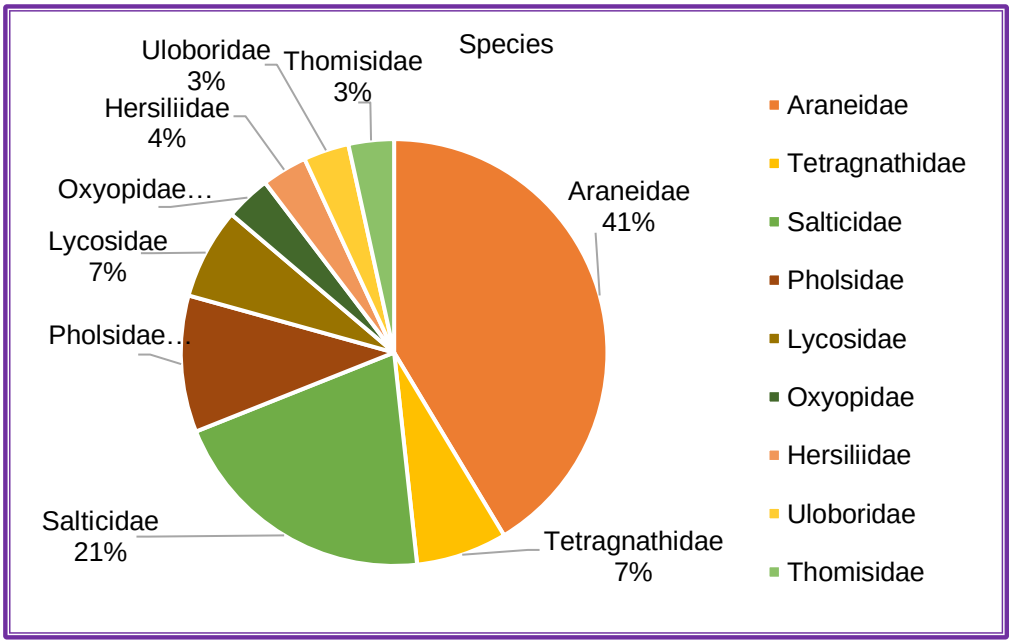

Figure 35. Percent distribution of families found during survey

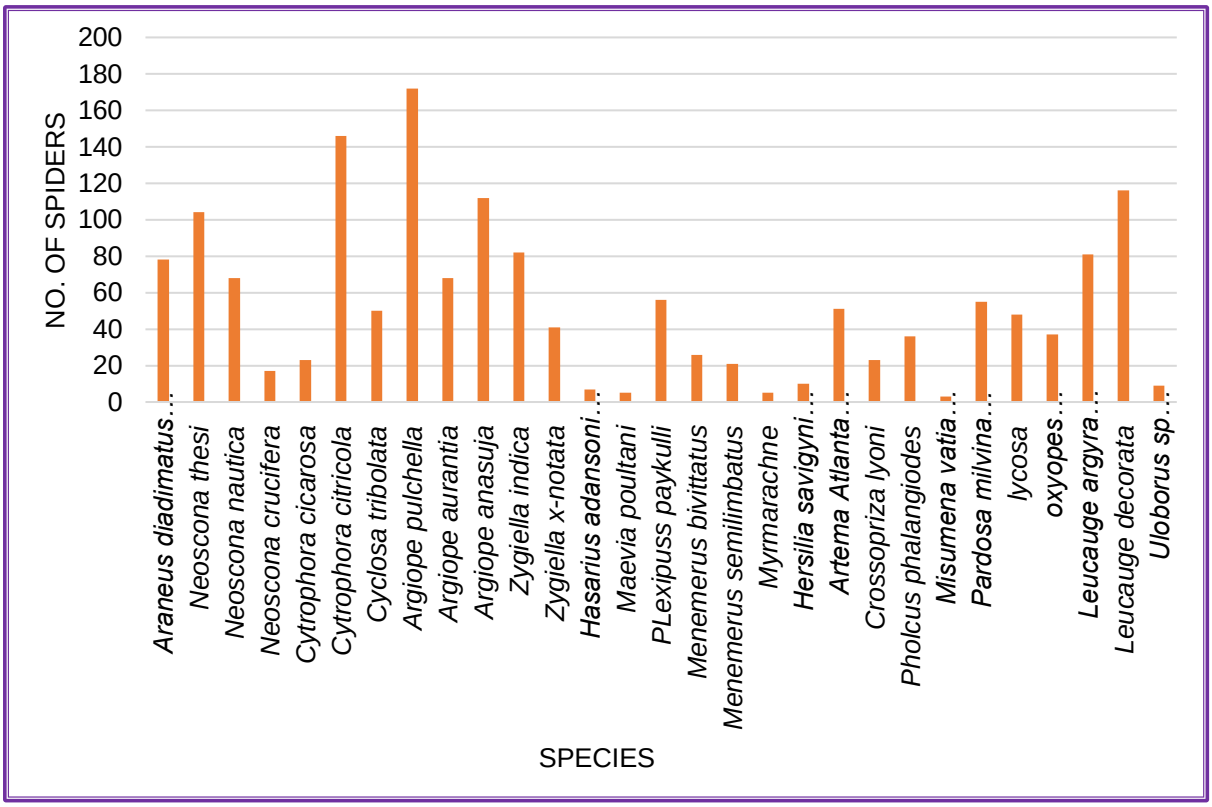

Figure 37. Number of spider species were recorded in the agro ecosystem

Discussion

Agro-ecology of Agra district is rain deprived agro-ecological system where intensive pesticides, fertilizers, organic manures are used widespread largely for paddy and potato farming. The occupants of the rural areas in this region are small non-organized farmers. The annual yield therefore fluctuates from high to low yield depending upon the traditional practices and mechanized farming depending upon the economic condition of the farmers. The yield of products is low because of ineffective natural, biological components and inadequate knowledge. Arachnids provide natural shield by spinning their specific web which attracts various insects and serves as biological control agent (Fig 38). It has been observed that spiders have the highest biomass of predatory arthropods which along with their behavior serve as primary consumers (Pearce *et al,* 2004).

Figure 38. Insects captured in the Web

Because of their propensity to colonies in many agro-ecosystem they can operate as efficient natural enemies of phytophagous insects due to their consistent and plentiful presence during all stages of crop growth (Riechert & Lockley, 1984). Spiders are the generalist predators, which include not only adult insects but also eggs and larvae of Lepidoteran and Colepteran in addition to being indicators of the quality of the environment in agricultural areas (Clausen, 1986). The potential number of studies on spiders as pest controllers in agro ecosystem is growing and the uses of pesticide decreasing (Benamu 2020). Spiders also prey on other arachnids and spiders, including those of their own species, to keep their own populations under check. They also enforce the food web of the agro ecosystem by providing assortment of food for birds, reptiles, wasps, and mammals. Use of indiscriminate synthetic pesticides is currently affecting the population and diversity of spiders. Conservation is a challenge and a necessity to maintain robust agro-ecological system of this region. Spiders can survive in harsh conditions like high temperature and less rainfall. Thirty four species of spiders belonging to twelve families were recorded in semi-arid habitat of Agra region by Anjali & Prakash in 2012 and the last report on diversity of spiders in the flood plains of the TTZ of Agra region there are about 44 species which belongs to 29 genera of 11 families of spiders were recorded (Yadav & Prakash 2021). In the present study1550 adult spiders were recorded which belong to 29 species and 9 families in the selected sites of Agra agro-ecosystem (Table 1).

The webs of spiders are natural protein fibers, commonly called silk fibers, possess tensile strength and flexibility. Spider silk is also a promising bio-engineeringand biotechnology prospects: in medical (Altman *et al*, 2003), bulletproof jackets, parachutes, and fishing nets as they are not tearable (Singh, *et al,* 2012).

Table 2- Frequency of insects/pests in selected sites with the web type.

INSECTS/PEST	WEB TYPE	FREQUENCY			TOTAL
		SITE 1 (Pilipokhar)	SITE 2 (Dayalbagh)	SITE 3 (Keetham)	
Houseflies	OW/CW	20	58	4	82
Fruit flies	OW/CW	49	37	12	98
Moths	OW	-	12	17	29
Beetles	IW	47	29	43	119
Wasps	SW	65	43	18	126
Bees	SW	58	52	49	159
Mosquitoes	OW	56	78	82	216
Ants	IW	69	62	54	185
Aphids	SW/IW	54	44	63	161
Thrips	SW/IW	26	16	11	53
Butterflies	OW/IW	-	2	4	6
TOTAL		**444**	**433**	**357**	**1234**

*OW- Orb web, CW- Cob web, SW- Sheet web, IW- Irregular web

The total 1234 insects/pests are found in webs which are trapped from which in site 1 (Pilipokhar) have highest number of insects/pests (n=444) are trapped in webs which is followed by site 2 (Dayalbagh) n=433 and site 3 (Keetham) n=357. Mosquitoes n=216 are abundantly trapped in the webs whereas butterflies n=6 least trapped in the webs. Mostly mosquitoes are trapped in the Orb web (Table 2). In Keetham and Dayalbagh maximum numbers of mosquitoes are trapped in webs whereas in Pilipkhor maximum number of Ants istrapped. Butterflies are least trapped in Dayalbagh and Keetham whereas in Pilipokhar moths and butterflies are not found in webs. In Pilipokhar pests like Thrips and Aphids are mostly found on the webs. (Fig.39).The size of the web is determined by the spider's size, larger the spider wider the web and *vice versa*. While web-building spiders utilize their distinctive web to haunt insects the ground-dwelling or running spiders instead engage in active haunting.

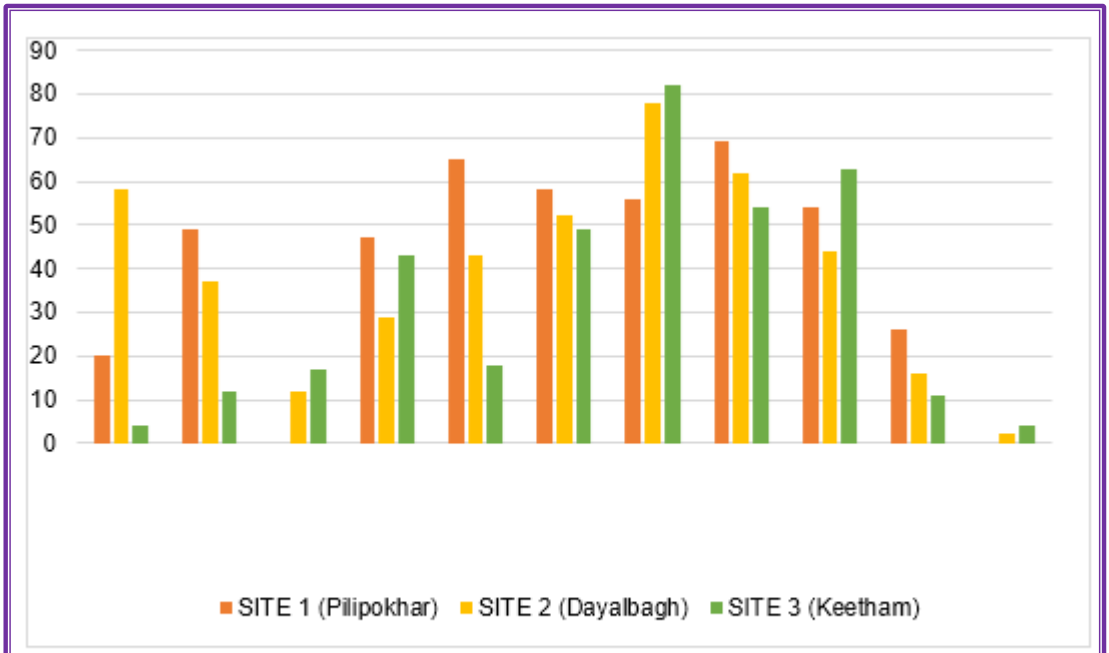

FIGURE 39. Graph shows the frequency of the insects/pests

Conclusion

Spiders serve as excellent pest control agents because they have the ability to survive in rain deprived habitat, tolerate starvation and desiccation in the semi- arid ecosystem. Moreover, spiders become active as soon as conditions improve and are among the first predators capable of controlling pests. The risks of using spiders to control pests are minimal as they don't harm plants and are predaceous at all stages of development of the pest. They occupy a wide range of niches, attacking multiple pest species at once. Saving these species, means saving biodiversity, the ecosystem, and our gene pool. Widespread applications of pesticides by farmers also kills spider population. Some pesticides are also retained in spider webs, which can be harmful to spiders that ingest them on a daily basis. Since, spiders also feed on both adult and larval mosquitoes, they control malaria and dengue. The most important reason for spider conservation is their role in providing free ecosystem services such as controlling insect pest populations, feeding birds and bees, and producing spider silk and venom. Awareness and educational research activities would not only raise knowledge of identifiable animal species and its ecological importance in securing our food security as expected in the United Nations SDG goals.

Acknowledgement

The author acknowledges the Department of Zoology, Dayalbagh Educational Institute, Agra, India for research support and Departmental Research Committee for encouraging the work

Conflict of Interest

There is no conflict of interest amongst the authors.

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