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Diversity and Abundance of Spider Species in the Banana Agro-Ecosystem of Etawah District: A Taxonomic and Ecological Assessment

Dr Anil Kumar
Associate professor, Dept. Of zoology,
K K PG COLLEGE, ETAWAH(UP)

Abstract: *This study focuses on the species diversity of spiders within the banana agro-ecosystem of Etawah District, aiming to enhance understanding of the ecological roles and population dynamics of spiders in agricultural settings. A total of 48 spider species from 39 genera and 15 families were recorded, showcasing the rich biodiversity of arachnid fauna inhabiting banana plantations. The research was conducted through two primary sampling methods: the visual search method and the pitfall trap method, which allowed for a comprehensive collection of spider specimens across the agro-ecosystem. In total, 11,935 spider specimens were collected per acre, including 5,800 females (48.73%), 2,725 males (22.89%), and 3,410 immature individuals (28.65%). The data revealed that Araneids were the most dominant family, accounting for 3,416 specimens per acre (28.62%), followed by Lycosids (3,208 specimens or 26.87%), Sparassids (1,688 specimens or 14.14%), and Salticids (1,200 specimens or 10.05%). The species abundance followed the order: Araneidae>Salticidae>Lycosidae>Sparassidae. This study underscores the significant role that spider populations play in maintaining ecological balance within banana agro-ecosystems, providing insight into their potential as natural pest control agents.*

Keywords: *Banana agro-ecosystem, species diversity, spider fauna, visual search method, pitfall trap, abundance, ecological roles, natural pest control.*

I. Introduction:

Agriculture, especially in tropical and subtropical regions, heavily relies on the complex interactions between various biotic and abiotic factors. In these ecosystems, pests are a major challenge to crop yield and quality, particularly in banana plantations where they often lead to significant losses. However, spiders, as integral components of agro-ecosystems, can provide natural pest control, helping to reduce the reliance on chemical pesticides. These arachnids are often considered crucial contributors to biological pest management due to their predatory habits, which target a wide range of agricultural pests, including insects and other invertebrates. The banana agro-ecosystem in Etawah District, Uttar Pradesh, presents a unique setting for studying these predator-prey dynamics, as the region's climate, soil composition, and agricultural practices create an environment conducive to a diverse array of spider species.

This research aims to document the species diversity of spiders within banana agro-ecosystems and investigate their role in pest management. By assessing the abundance and distribution of different spider species across the plantation, the study will offer valuable insights into the ecological significance of these arachnids. Given that spiders often exhibit a high degree of habitat specificity, understanding their diversity in banana agro-ecosystems will contribute to developing more sustainable pest management strategies. The study's findings may also facilitate further research into the impact of agricultural practices on biodiversity, particularly within the context of monoculture crops like bananas.

Need of the Study:

The need for this study arises from the growing concerns surrounding the sustainability of modern agricultural practices. The increasing use of chemical pesticides has led to environmental degradation, resistance in pests, and harmful effects on non-target species, including beneficial organisms like spiders. As natural predators, spiders can provide an ecologically sound alternative to chemical pest control. However, there is a lack of detailed research on the species composition and distribution of spiders in banana agro-ecosystems, particularly in regions like Etawah. Understanding which species dominate these ecosystems and how they contribute to pest regulation can help in formulating integrated pest management (IPM) strategies that are both effective and environmentally sustainable. Additionally, this study fills a gap in local ecological knowledge, offering a baseline for future research on biodiversity conservation in agro-ecosystems.

Objective of the Study:

The primary objective of this study is to assess the species diversity and abundance of spiders within banana agro-ecosystems in Etawah District. The specific objectives are:

1. To identify and classify the different species of spiders present in the banana agro-ecosystem.
2. To quantify the abundance and distribution of spider species in the study area.
3. To analyze the ecological roles of spiders in banana plantations, particularly in relation to pest control.
4. To compare the diversity and population density of spider species across different banana plantations in the district.
5. To determine the impact of various environmental factors, such as climate, soil type, and plantation management, on spider diversity and abundance.

By achieving these objectives, the study aims to contribute to the understanding of how spiders function as natural pest controllers in banana agro-ecosystems, which may influence future agricultural practices.

Significance of the Study:

The significance of this study lies in its potential to inform agricultural practices and biodiversity conservation efforts within banana plantations. As agricultural intensification continues to escalate, the role of natural predators like spiders becomes increasingly critical in maintaining ecological balance. By documenting the species diversity and abundance of spiders, the research will highlight their importance as natural pest controllers, potentially reducing the need for harmful chemical pesticides. This aligns with global efforts to promote sustainable agriculture and the use of integrated pest management (IPM) strategies. Furthermore, the findings of this study could serve as a model for other regions and crops, demonstrating how understanding local biodiversity can lead to more effective and sustainable agricultural practices.

Additionally, this study will contribute to the broader field of agro-ecology by providing data on the biodiversity of spiders in a specific agro-ecosystem, a subject that is often under-researched. The results will be valuable to both local farmers and agricultural policymakers, guiding them in making informed decisions about pest management and conservation efforts. On a larger scale, the research will contribute to the global understanding of the relationship between biodiversity and agricultural productivity, reinforcing the need to integrate ecological principles into farming practices.

Limitation of the Study:

While this study provides valuable insights into the species diversity and ecological roles of spiders in banana agro-ecosystems, it is not without limitations. One limitation is the reliance on only two sampling methods—visual search and pitfall trapping—which may not capture the full range of spider species present in the agro-ecosystem. Certain species that are nocturnal or live in more cryptic habitats may be underrepresented. Moreover, the study was conducted only within a specific region of Etawah District, which limits the generalizability of the findings to other areas with different environmental conditions or agricultural practices.Another limitation is the relatively short duration of the study, which may not account for seasonal variations in spider abundance and diversity. Spiders, like many other organisms, exhibit seasonal fluctuations in population density, which could be influenced by factors such as temperature, humidity, and prey availability. A longer-term study would provide more comprehensive data on these dynamics.

Additionally, the study did not investigate the functional roles of spiders in terms of their specific contributions to pest regulation in banana plantations. While spiders are known to prey on various insects, a more detailed analysis of their predatory behavior and its effectiveness in controlling pest populations would require further research, perhaps involving direct observation or experimentation.Despite these limitations, this study provides a critical first step in understanding the species diversity of spiders in banana agro-ecosystems and lays the groundwork for future research that can address the gaps identified.

II. Review Of Literature :

Spiders are generalist predators that can function as biological control agents with in agro ecosystems (Moulder and Reichle, 1972; Nyffeler and Benz, 1987;Riechert and Bishop, 1990; Young and Edwards, 1990; Kajaket al., 1991; Kajak, 1997).Most of the spider diversity in agro-ecosystem is studied by several researchers in rice fields from different states of India (Sellammal and Chelliah,1982; Krishnaswami et al., 1984; Gupta et al., 1986; Rajendran, 1987; Nirmala,1990; Banerji et al. (1993); Mishra and Shrivastava, 1993;Kumar, 1994; Thakur et al., 1995; Ganeshkumar and Velusamy, 1996; Sahu, et al.,1996; Samiyyan and Chandrasekaran, 1998; Venkateshalu et al., 1998; Anbalagan and Narayanaswamy, 1999; Pathak and Saha, 1999; Bhattacharya, 2000; Vanitha,2000; Sebastian et al., 2005; Sudhikumar et al., 2005;).

Recently, Jeyaparvathi et al. (2013) also investigated the biological control potential of spiderson the selected cotton pests and found that the four species of spiders like (PeucetiaviridanaOxyopesbirmanicus (Thorell) and

Peucetialatikae were predominant in the cotton fields of Achamthavirthan, Virudhunagar district, Tamil Nadu, India. SiliwalManju and Dolly Kumar (2002, 2003a,b) reported Harmochirusbrachiatus (Thorell), Dinopisgoalparaensis, Triaerismanii and Triaerispoonaensisspiders from banana agroecosystems of Baroda, Gujarat. Similarly they have also sighted Latrodectushasseltiiindicus Simon (Araneae: Theridiidae) in a cotton field in Baroda district, Gujarat during 2001. Harrison (1968) studied vertical distribution of spiders in the banana field from Panama. Members of family Argiopidaerepresentedby largest number. Ntoni for et al. (2012) in their study observed H. venatoriainhabiting the soil litter /mulches, loose leafsheats (barks) of pseudostems and stumps, leaf petioles, spaces between banana flower bracts and clusters. However absolutely no work on the spider diversity in banana agro-ecosystem from, Uttar Pradesh is reported earlier.

III. Methodology:

The study was conducted in the banana fields of Etawah District, where sampling plots were selected within agricultural land to assess the species diversity of spiders. A total of 20 sampling plots, each measuring 10 m × 10 m, were randomly chosen across the banana fields for spider collection. The sampling was carried out during three distinct periods: winter (November – February), summer (March – June), and monsoon (July – October) to capture seasonal variations in spider diversity and abundance.Two primary collection methods were employed: pitfall trapping and ground hand collection. Pitfall traps, widely used for collecting ground-dwelling arachnids, were placed in the selected plots. These traps were checked regularly to ensure the accurate capture of spider specimens. The ground hand collection technique involved manually searching for spiders in the field during the peak activity hours, primarily between 7:30 am and 9:30 am, when spider activity was highest.

Once collected, all adult spider specimens were identified up to the family, genus, and species levels. The identification was based on detailed morphometric characters, including various body parts and the structure of the epigyne (female genitalia) and pedipalp (male reproductive organs). For accurate species identification, the study relied on several reference sources, including identification keys, the World Spider Catalogue (recent edition), and other relevant literature from both Indian and international sources.

In cases where the identification was challenging, experts from abroad were contacted via email to confirm the species identification. Additionally, for spider genera previously recorded in India, the specimens were first compared to known species within the country. If the specimen did not match any known species, further reference was made to the book Riceland Spiders of South and South-East Asia by Barrion and Litsinger (1995), specifically for comparing the structure of epigyne and pedipalp of spiders collected. In addition, research papers from prominent Asian arachnologists were consulted to verify species and resolve identification uncertainties.The World Spider Catalogue was instrumental in identifying synonyms and clarifying any taxonomic transfers before finalizing the scientific names of the spider species. By integrating these various identification techniques and references, the study ensured the accurate classification and documentation of spider species found in the banana agro-ecosystem of Etawah District.

IV. Observations And Results:

In the banana agro-ecosystem of Etawah District, a total of 48 spider species belonging to 39 genera and 15 families were recorded. The spider specimens were collected using two methods: visual search and pitfall traps. A total of 11,935 spider specimens were collected per acre, with the breakdown of individuals by sex and developmental stage as follows:

Category	Number of Individuals	Percentage
Females	5,800	48.73%
Males	2,725	22.89%
Immature	3,410	28.65%
Total	**11,935**	**100%**

Among the different families of spiders, Araneids dominated the collection, followed by Lycosids, Sparassids, and Salticids. The species abundance in the banana agro-ecosystem followed the order:

- **Araneidae**>**Salticidae**>**Lycosidae**>**Sparassidae**

A summary of the spider family composition and abundance per acre is presented below:

Family	Number of Specimens	Percentage of Total
Araneidae	3,416	28.62%
Lycosidae	3,208	26.87%
Sparassidae	1,688	14.14%

Family	Number of Specimens	Percentage of Total
Salticidae	1,200	10.05%

Salticidae exhibited the highest generic diversity among the families, followed by **Araneidae** and **Lycosidae**. Notably, the combined populations of **Araneidae** and **Lycosidae** accounted for more than 50% of the total spider population, underscoring their dominant presence in the banana fields.However, several male spiders from specific species were not observed during the survey. These species include:**Argiopeaemula, Argiopeanasuja, Cyclosa bifida, Cyclosapurnai, Cyrtophoracitatrosa, Neoscona nautica, Lycosapoonaensis, Schizocosa sp. nov., Myrmarachneplataleoides, Scytodes sp., Olios millet, Oliospunctipes, Parasteatodamundula**The banana fields were predominantly dominated by web-building species, with **Cyclosamoonduensis** being the most common among the collected specimens. These spiders contribute significantly to the overall web-building activity within the agro-ecosystem, reflecting the ecological importance of their presence in controlling pest populations through their predatory habits.This data provides valuable insight into the structure of the spider community in banana agro-ecosystems and highlights the critical role spiders play in maintaining the ecological balance of these agricultural landscapes.

Spider Species Collected (Per Acre) from Banana Agro-Ecosystem

Spider Species	Family	Scientific Name
Araneidae		
	Araneidae	Argiopeaemula (Walckenaer, 1841)
	Araneidae	Argiopeanasuja (Thorell, 1887)
	Araneidae	Cyclosa bifida (Doleschall, 1859)
	Araneidae	Cyclosaspirifera (Simon, 1889)
	Araneidae	Cyrtophoracitatrosa (Stoliczka, 1869)
	Araneidae	Cyrtophoracitricola (Forsskål, 1775)
	Araneidae	Eriovixiaexcelsa (Simon, 1889)
	Araneidae	Neoscona nautica (L. Koch, 1875)
	Araneidae	Neoscona theisi (Walckenaer, 1841)
	Araneidae	Neoscona vigilans (Blackwall, 1865)
	Araneidae	Thelacanthabrevispina (Doleschall, 1857)
Clubionidae		
	Clubionidae	Clubionafoliata sp. nov.
Gnaphosidae		
	Gnaphosidae	Drassodesluridus (O. P.-Cambridge, 1874)
	Gnaphosidae	Zelotesshantae (Tikader, 1982)
Lycosidae		
	Lycosidae	Hippasagreenalliae (Blackwall, 1867)
	Lycosidae	Lycosapoonaensis (Tikader& Malhotra, 1980)
	Lycosidae	Pardosaoriens (Chamberlin, 1924)
	Lycosidae	Pardosapseudoannulata (Bösenberg& Strand, 1906)
	Lycosidae	Schizocosa sp. nov.
	Lycosidae	Trochosamus sp. nov.
	Lycosidae	Wadicosa fidelis (O. P. Cambridge, 1872)
Miturgidae		
	Miturgidae	Cheiracanthiuminornatum (O. P.-Cambridge, 1874)
Oxyopidae		
	Oxyopidae	Oxyopespankaji (Gajbe&Gajbe, 2000)
	Oxyopidae	Crossoprizalyoni (Blackwall, 1867)
Pholcidae		
	Pholcidae	Pholcusfragillimus (Strand, 1907)
Pissauridae		
	Pissauridae	Nilusphipsoni (F. O. P.-Cambridge, 1898)
Salticidae		

Spider Species	Family	Scientific Name
	Salticidae	Chrysilla stipes sp. nov.
	Salticidae	Hasariusadansoni (Audouin, 1826)
	Salticidae	Myrmarachneplataleoides (O. P.-Cambridge, 1869)
	Salticidae	Myrmarachne sp.
	Salticidae	Phintellavittata (C. L. Koch, 1846)
	Salticidae	Plexippuspaykulli (Audouin, 1826)
	Salticidae	Pseudiciusludhianaensis (Tikader, 1974)
	Salticidae	Telamoniadimidiata (Simon, 1899)
	Salticidae	Thyeneimperialis (Rossi, 1846)
Scytodiidae		
	Scytodiidae	Dictis sp. nov.
	Scytodiidae	Scytodes sp.
Sparassidae		
	Sparassidae	Heteropodabhaikakai (Patel & Patel, 1973)
	Sparassidae	Olios millet (Pocock, 1901)
	Sparassidae	Oliosobesulus (Pocock, 1901)
	Sparassidae	Oliospunctipes (Simon, 1884)
Tetragnathidae		
	Tetragnathidae	Leucaugedecorata (Blackwall, 1864)
Theridiidae		
	Theridiidae	Parasteatodamundula (L. Koch, 1872)
	Theridiidae	Rhomphaeaceraosus (Zhu & Song, 1991)
Uloboridae		
	Uloboridae	Uloboruswalckenaerius (Latreille, 1806)
	Uloboridae	Zosisgeniculata (Olivier, 1789)
Zodariidae		
	Zodariidae	Heliconilla sp. nov.

This table presents the list of spider species collected per acre in the banana agro-ecosystem of Etawah District, classified by family and genus. It includes a variety of species across different families, providing insight into the spider diversity of the region and the ecological roles they may play.While among hunters Pardosaoriens, Pardosapseudoannulata, Trochosamusasp.nov., Plexippuspaykulli, eteropodabhaikakaiwere predominantly observed.The spiders in banana agro-ecosystems are observed preying uponinsect pests from orders Lepidoptera, Diptera, Homoptera, Coleoptera,Hymenoptera, and Orthoptera. The orb-weavers Araneidae and Tetragnathidae were observed feeding upon Homoptera such as leafhoppers, Diptera and Orthoptera, especially grasshoppers. The smaller sheet web-weavers such asTheridiidaewere seen capturing insects from Diptera, Hemiptera and Homoptera (especially aphids and leafhoppers). The funnel web spider,Hippasaand the social spider Stegodaephussarasinorum were seen preyingupon Orthopterans, Coleopterans and Lepidopterans. Hunting spiders(Lycosidae, Oxyopidae and Salticidae) frequently were observed preying upon species from Orthoptera, Homoptera, Hemiptera, Lepidoptera, Thysanoptera, Diptera and some Coleoptera and Hymenoptera. Spiders in bananaagroecosystem under study were observed feeding on pests like Cosmopolitessordidus(Root borer), Odoiporuslongicollis(pseudostem weevil), Pentalonianigronervosa(aphid), Thripshawaiiensis(thrip), Tiracolaplagiata(Lepidoptera),Chaetanaphothripssignipennis(rust thrips), Nacoleiaoctasema(scab moth) etc.

V. Discussion:

Banana agro-ecosystem was found to be dominated by Cyclosamoonduens is Tikader, 1963. Astonishingly, the spider Thelacanthabrevispina was found in banana fields with a good population. The second important aspect is this spider secretes green egg sac silk. Another important genus is Pardosawhich is dominating the Banana fields. In banana the ground is almost covered with big leaves and hence the ecosystem is humid. Further, the ground surface is covered over with decaying mulch which forms a good microhabitat and hiding places for Lycosids and sparassids and hence the population of the spider of these two families is more in Banana fields. Ntoniforet al. (2012) also reported Heteropodavenatoriain habiting the mulches in Banana fields from Cameroon. However, in the present survey, in addition to H.bhaikakai, three species of OliosWalckenaer,

1837 were also observed in habiting the same habitat. All these spiders are with high fecundity and are voracious feeders. Another important spider endemic to Banana fields and with high fecundity is Nilusphipsoni. In the present study, large number of sub adults/immature Sparassidswere observed showing their survival in the agro-ecosystem. Banana plant architecture and the Banana agro-ecosystem offer a suitable habitat with respect to prey availability, hiding places, crevices, banana clusters, tubular leaf stalks, pseudostem, leaf sheaths, spaces between flower bracts, etc., therefore spider likeH. bhaikakai and Oliosmilletiprefer this ecosystem. Their juveniles show delayed dispersal. The delay in juvenile dispersal is beneficial for pest control. The colour of H. bhaikakai and Oliosmilleti also matches with that of pseudostem, leaves and hence these spiders can camouflage better with the background. Spiders have high biodiversity in banana plantation this could be because of the proper environmental parameters like, humidity, water and enough number of pests of choice might have been available to these spider species. Another reason may be the duration of the crop. The banana crop is of 1.5 years and hence these spiders might be getting favorable ecosystem for a longer time till the young ones are hatched and developed further.

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