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Study of Ecological Diversity of Predatory Asopinae Bugs in the Agro-ecosystem of the Mid-Western Plains

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The aim of the present study was to investigate the seasonal abundance of Asopinae predatory stink bugs within an agro-ecosystem. This research was carried out by utilizing sweep nets to collect these insects during the period spanning from May to August in the year 2022. The survey

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yielded two prominent species of predaceous bugs, specifically *Andrallus spinidens* and *Eocanthecona furcellata*. Interestingly, *E. furcellata* emerged as the dominant species within the field conditions. A noteworthy phenomenon occurred in June when a sudden surge in the population of both species was observed. This population increase was attributed to the presence of lepidopteran larvae in the field, which likely served as a rich food source for these predatory stink bugs. The ecological analysis revealed some important findings regarding the diversity and distribution of these insects in the agro-ecosystem. Specifically, the Shannon Diversity Index was notably low, registering at less than 1.99, indicating a limited variety of species within the sampled population. Similarly, the Simpson Index indicated a low degree of diversity or heterogeneity, falling within the range of 0.01 to 0.04, which further supports the notion of a relatively homogeneous population. Additionally, the Margalef Richness Index signalled a level of disturbance, measuring less than 2.05. This disturbance could be linked to various factors affecting the ecosystem, including changes in agricultural practices or environmental conditions. Lastly, the Dominance Index was relatively high, ranging between 0.5 and 1.0, signifying that a few dominant species, particularly *E. furcellata*, exerted a significant influence within the ecosystem. In summary, the ecological indices suggested limited diversity, low heterogeneity, disturbance, and dominance within the stink bug population, shedding light on the dynamics of these beneficial insects in the agro-ecosystem.

Keywords: Andrallus spinidens; Eocanthecona furcellata; asopinae; predatory bugs; mid-western plains.

1. INTRODUCTION

Predatory stink bugs, members of the subfamily Asopinae within the family Pentatomidae in the Order Hemiptera, are commonly referred to as soldier bugs [1]. Their role in natural pest control is of great significance in agro-ecosystems as they contribute to reducing pest populations, thereby decreasing the reliance on chemical pesticides and fostering a more harmonious ecosystem. These remarkable insects are distributed worldwide and are recognized for their potential as biocontrol agents against various insect pests in crop fields [2]. One distinguishing characteristic of Asopinae is their four-segmented rostrum, with the first segment being thickened [3]. Among the prominent representatives of this subfamily in South-East Asia, including India, are the predatory stink bugs *Andrallus spinidens* and *Eocanthecona furcellata*. *A. spinidens*, commonly known as the spined soldier bug, is a brownish insect adorned with distinctive spines on its shoulders. Both nymphs and adults of this species are voracious predators, primarily targeting the larvae of lepidopteran, dipteran, and coleopteran insects. Notably, the nymphal instar does not exhibit predatory behaviour [1]. *E. furcellata*, often referred to as the predatory stink bug, exhibits striking orange and black markings, making it easily recognizable. Similar to *A. spinidens*, both the nymphs and adults of *E. furcellata* play a crucial role in biological pest control, primarily preying on a variety of insect pests, particularly caterpillars and other soft-bodied insects [4]. These predatory stink bugs are gaining increasing attention and recognition in South-East Asia, particularly in India, for their invaluable contributions to sustainable agriculture through pest management [5]. By reducing the populations of harmful insects, they help maintain the ecological balance in agro-ecosystems and promote environmentally friendly farming practices. In India, the mass multiplication of Asopinae predatory stink bugs, such as *A. spinidens* and *E. furcellata*, is an essential component of sustainable pest management strategies in agriculture. In India, where sustainable and eco-friendly agricultural practices are increasingly important, the mass multiplication of Asopinae predatory stink bugs plays a pivotal role in natural pest control, and promoting a balanced ecosystem within agricultural landscapes [6]. The present study was undertaken about seasonal diversity and abundance of stink bugs under field conditions. This study will contribute in enriching the information on the diversity of different predatory bugs and their relevance as biocontrol agents of pests.

2. MATERIALS AND METHODS

For the present study, a specimen of predatory stink bugs belongs to subfamily Asopinae, part of the family Pentatomidae within the Order Hemiptera were collected from May to August, 2022 at an interval of 30 days. The sampling location was Dhan farm, situated in Nagina, District Bijnor, which falls within the mid-western plain zone of India. This region is characterized by the cultivation of major kharif crops, including Sugarcane, Paddy, Maize, Green gram, and Black gram. For the collection of insect, Sweep net (30 cm diameter) and hand picking methods were used in the crop field and nearby fence and marginal path areas. During each visit to the site, we systematically observed and sampled from a total of five different locations. The collected insect populations were then meticulously counted and stored in plastic bags for further studies.The relative abundance predatory stink bugs viz. *E. furcellata* and *A. spinidens* was determined by counting total number of nymph and adults of each species collected each visit during the four months. The population density of each species and its diversity were analyzed. To quantify ecological diversity, we computed various diversity indices commonly utilized by ecologists, including the Shannon Diversity Index, Simpson Index, Dominance Index, Margalef Richness Index, and Equitability Index. The interpretation of these indices, along with their respective rating ranges and values, is presented in Table 1, providing insights into the ecological dynamics of the stink bug populations in this agro-ecosystem. Furthermore, we supplemented our entomological data with weather information collected from the Meteorological station at the Rice Research station in Nagina, Bijnor, Uttar Pradesh. This comprehensive approach enabled us to gain a deeper understanding of the seasonal patterns and ecological interactions of Asopinae predatory stink bugs within this specific agro-environment.

Table 1. Rating ranges, values and interpretation of Ecological Diversity Indices

S. No.	Ecological Diversity Indices	Range	Interpretation	References
1.	Shannon Diversity Index	1.5 to 3.5	<1.99 = Very low 2.00 to 2.49 = low 2.50 to 2.99= Moderate 3.00 to 3.49= High >3.50=Very high	[7]
2.	Simpson Index	0 to 1	0.00= Absence of Diversity (homogeneity) 0.01-0.04= low degree of diversity/ heterogeneity 0.41-0.60= moderate degree of diversity/ heterogeneity 0.61-0.80= moderately high degree of diversity/ heterogeneity 0.81-0.99= high degree of diversity/ heterogeneity 1.00= Absolute (perfect) diversity/ heterogeneity	[8]
3.	Dominance Index	0 to 1	$0 < C < 0.5$ = Low Dominance $0.5 < C \leq 0.75$ = Moderate Dominance $0.75 < C \leq 1.0$ = High Dominance	[9]
4.	Margalef Richness Index	0 to 5	<2.05= Disturbed >2.05 to 5.0= Semi-disturbed >5.00 = Integrated	[7]
5.	Evenness/Equitability Index	0 to 1	<0.5= unbalanced >0.5-0.8= semi-balanced >0.8-0.9= balanced 1= maximum evenness	[7]

3. RESULTS AND DISCUSSION

In our study, we created a checklist (Table 2) of species belonging to the subfamily Asopinae based on existing literature records of these insects previously reported in the Gangetic plains of Uttar Pradesh. The species included in this checklist were *Amyotea malabarica* (Fabricius, 1775), *Andrallus spinidens* (Fabricius, 1787), *Cazira breddini* (Schouteden, 1907), *Cazira insignis* (Schouteden, 1907), *Eocanthecona furcellata* (Wolff, 1801), and *Perillus bioculatus* (Fabricius, 1775), as documented by Pal et al. [10].

During our fieldwork, we encountered only two species of predatory stink bugs from the family Pentatomidae within the order Hemiptera: *E. furcellata* and *A. spinidens*. The identification of the field-collected predatory bugs was performed in accordance with available literature sources. In Table 3, we presented a comprehensive list of the observed predatory stink bug species, along with their respective host ranges and the crops associated with our observations. This compilation serves as a valuable reference for understanding the presence and distribution of these beneficial insects in the studied region. The observations revealed that both of the stink bug species, *E. furcellata* and *A. spinidens*, exhibit polyphagous nature, indicating a wide host range encompassing various crops. In field conditions, we encountered both nymphs and adults of these stink bugs across a diverse range of crops, including Sugarcane, Paddy, Maize, Green gram, and Black gram.Both nymphs and adults were observed actively feeding on numerous insect pests that commonly afflict these crops. The list of targeted pests includes *Amsacta albistriga, Spodoptera litura, Spilosoma obliqua, Helicoverpa armigera, Spodoptera frugiperda, Chilo suppressalis and Mythimna separate.* This predation behaviour of predatory stink bugs in natural pest control was illustratedgraphically based monthly abundance in Fig. 1. This graphical depiction provides insights into the fluctuations in their population density over the four-month observation period.

Population density of Pentatomid predators, *A. spinidens* and *E. furcellata*, along with corresponding weather parameters recorded in the observed location was presented in Table 4. It was observed that the relative abundance of *A. spinidens* was at lowest level in May, 2022 but, sharp increase was observed in next 3 months viz. June, July and August 2022. In May month, maximum and minimum temperature observed 34^{o}C and 24.9^{o}C. The maximum population density recorded was 26.6±0.358 and 30.50±0.164 for *A. spinidens* and *E. furcellata* respectively. As we moved into June, temperature increased and the maximum and minimum temperature observed was 36^{o}C and 24 .5^{o}C and the increase was observed in the population density which was 40.1±0.268 and 52.2±0.307 for *A. spinidens* and *E. furcellata* respectively. During July, maximum and minimum temperatures observed were 33.1°C and 25.6°C, respectively. Maximum rainfall was observed which 127 mm was and with 09 rainy days and sharp increase in population density of *A. spinidens* was recorded (45.90±0.199). This may be attributed due to the favourable environmental conditions.Population density of *E. furcellata* decreased (46.5±0.087), potentially due to competition for food resources between the two species.In the Month of August, only slight increase in the population of *A. spinidens* was recorded (61.6±0.226), while population density of *E. furcellata* increased gradually (73.0±0.138). This may be due to favourable environmental condition for *E. furcellata* and sufficient availability of food or both. The difference in population density of Predatory stink bugs density may be due to alternate host insect availability in crop field. Comparative analysis of various ecological diversity indices was presented in Table 5. The indices examined include the Shannon Diversity Index, Simpson Index, Dominance Index, Margalef Richness Index, and Equitability/Evenness Index.It reveals that the Shannon Diversity Index exhibited a low value, measuring less than 1.99. This suggests a limited variety of species within the sampled population, indicating low species diversity.Similarly, the Simpson Index indicated a low degree of diversity or heterogeneity, falling within the range of 0.01 to 0.04. This shows relatively homogeneous population.The Dominance Index recorded a high value, ranging from 0.5 to 1.0. This suggests that a few dominant species, viz. *E. furcellata* and *A. spinidens*, exerts significant influence within the ecosystem. The Margalef Richness Index indicated disturbance, measuring less than 2.05. This disturbance may be attributed to various factors affecting the ecosystem.Lastly, the Equitability/Evenness Index demonstrated a balanced distribution of species, with values falling within the range of 0.8 to 0.99. This suggests a relatively equitable distribution of resources and ecological niches among the species present.

Table 2. Checklist of insects from subfamily Asopinae found in Gangetic Plains of Uttar Pradesh [10]

S. No.	Taxa	Distribution		
		States	**Biogeographic Zones**	**World wide**
1.	*Amyotea malabarica* (Fabricius, 1775)	Uttar Pradesh, West Bengal, Assam, Maharashtra, Odisha, Tamil Nadu, and Karnataka	Gangetic Plains, North East, Deccan Peninsula	Sri Lanka, Bangladesh, China, Sumatra, Indonesia, Japan, New Guinea, Phillipines, and Taiwan
2.	*Andrallus spinidens* (Fabricius, 1787)	Uttar Pradesh, Uttarakhand, Jharkhand, West Bengal Assam, Delhi, Maharashtra, Meghalaya, Puducherry, Punjab, Sikkim and Tamil Nadu	Gangetic Plains, North East, Deccan and Himalayas.	Australia, China, South Africa, Azerbaijan, Bangladesh, Ethiopia, Indonesia, Iran, North America, Sudan and Taiwan
3.	*Cazira breddini* (Schouteden, 1907)	Uttar Pradesh.	Gangetic Plains	Bhutan and China.
4.	*Cazira insignis* (Schouteden, 1907)	Uttar Pradesh.	Gangetic Plains	Bhutan
5.	*Eocanthecona furcellata* (Wolff, 1801)	Uttar Pradesh, Uttarakhand, Assam, Bihar, Jharkhand, West Bengal, Jammu & Kashmir, Karnataka, Maharashtra, Nagaland, Odisha, Punjab and Tamil Nadu	Gangetic Plains, Himalayas, Deccan peninsula, and North East	Bangladesh, China, Sri Lanka, Japan, Myanmar, Taiwan and Thailand
6.	*Perillus bioculatus* (Fabricius, 1775)	Uttar Pradesh, Bihar, Himachal Pradesh, and Punjab	Gangetic Plains, Himalayas and Semi-Arid.	Bulgaria, Canada, Czechoslovakia, USA France, Germany, Greece, Turkey, Mexico, Moldova, Russia, Serbia and Yugoslavia

Table 3. List of predatory stink bugs species observed, its host range and crop based on our observations

S. No.	Species	Stages observed	Identification features	Host range	Crops in which observed
1.	*A. spinidens*	Eggs, Nymph and Adults	Brownish in colour, Yellow spot at tip of scutellum, Yellowish white streak on each tegmen, dorso-lateral spine on thorax	Polyphagous predatoron lepidopteran larvae viz. *Helicoverpa armigera*, *Spodoptera litura*, *Chilo suppressalis*, *Mythimna separate*, *Melanitis leda*, *Spodoptera frugiperda, Spilosoma obliqua* etc.	Paddy, Maize, Sugarcane, Green gram, Black gram etc
2.	*E. furcellata*	Eggs, Nymph and Adults	Striking coloration which includes bright brownish-black markings	Polyphagous predatoron various lepidopterous larvae of *Amsacta albistriga, Spodoptera litura,Spilosoma obliqua, Helicoverpa armigera Spodoptera frugiperda*etc.	Sugarcane, Paddy, Maize, Green gram, Black gram etc

Table 4. Population density of Pentatomid Predators and Weather Parameters of observed Location

Month	Rainfall (mm)	Rainy Days	Temperature (^{o}C)		Relative Humidity (%)		Population density (Mean±SD)*	
			Maximum	Minimum	Maximum	Minimum	***A. spinidens***	***E. furcellata***
May, 22	55.00	03	34.0	24.9	80	50	26.6 (4.182)** ±0.358	30.5 (6.090) ±0.164
June, 22	116.00	06	36.0	24.5	84	54	40.1 (5.051) ±0.268	52.2 (7.485) ±0.307
July, 22	127.00	09	33.1	25.6	88	73	45.9 (7.060) ±0.199	46.5 (6.616) ±0.087
Aug, 22	79.00	05	32.5	25.6	91	68	61.6 (7.141) ±0.226	73.0 (8.598) ±0.138

** Number of total stink bugs (Nymph +Adults) caught in field sites*
*** Parenthesis values are square root transformed*

Table 5. Ecological Diversity indices for Predatory Stink Bugs (Pentatomidae: Hemiptera)

Month	Ecological Diversity Indices				
	Shannon Diversity Index	Simpson Index	Dominance Index	Margalef Richness Index	Evenness/Equitability Index
May, 22	1.55-1.60	0.214-0.1971	0.786-0.8029	0.9004-0.7695	0.9604-0.9961
June, 22	1.59-1.60	0.2015-0.2019	0.7985-0.7981	0.8298-0.7112	0.9851-0.9914
July, 22	1.60-1.60	0.1985-0.1989	0.8015-0.8011	0.7271-0.3341	0.996-0.995
Aug, 22	1.60-1.61	0.1992-0.1981	0.8008-0.8019	0.7239-0.678	0.9949-0.9987

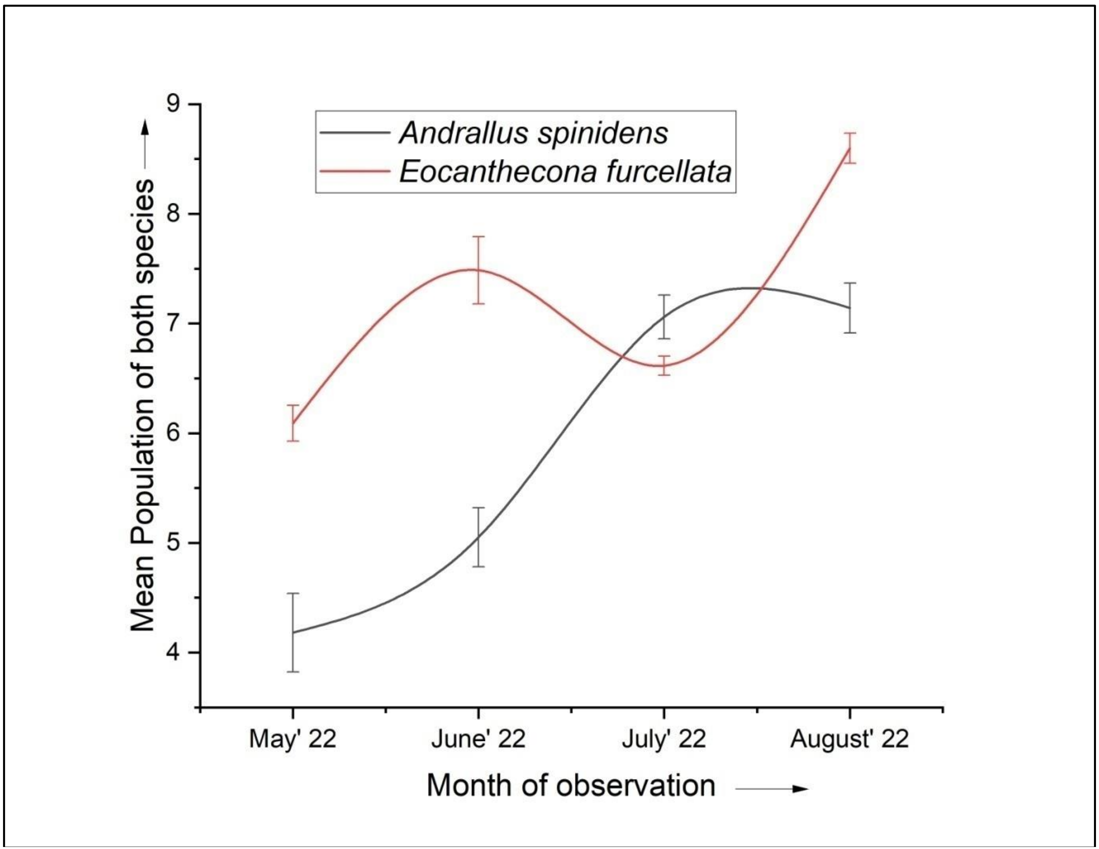

Fig. 1. Graphical representation of mean number of species and month of observation for Predatory stink Bugs viz. *Andrallus spinidens* and *Eocanthecona furcellata* (Pentatomidae: Hemiptera)

The findings from our study align with and complement similar research conducted by Claver and Jaiswal in 2013 [11] in Deoria district of Uttar Pradesh, where they focused on rice fields. In their study, they observed that the population densities of predatory stink bugs associated with Paddy fields indicated a higher prevalence of *A. spinidens* (84.69%) compared to *E. furcellata* (15.03%). This variation in abundance between the two species mirrors, the potential dominance of *A. spinidens* in certain agricultural ecosystem specially paddy field. Additionally, Shephard *et al.* [12] conducted research that that reported *E.furcellata* was not as commonly found as *A.spinidens* in vegetable and soybean fields, which corroborates the prevalence of these species can vary depending on the specific crop and agro-ecosystem. Moreover, Jones and Cherry [13] studies factors influencing the species composition and seasonal abundance of stink bugs. Their research emphasized that host range and the presence of alternate hosts play pivotal roles in shaping ecological diversity within stink bug populations. This insight resonates with our observations and highlights the multifaceted nature of stink bug ecology.Furthermore, Pal et al.[10] compiled a list of five species of predatory stink bugs that serve as potential biocontrol agents for various serious insect pests within agro-ecosystems. This list includes *Amyotea malabarica* (potential predator of rice bug, *Leptocoris acuta*), *A. spinidens, E. furcellata, Perillusbioculatus* (Predator of *Aulacophora indica*, series pest of Bitter gourd), and *Zicrona caerulea*.

4. CONCLUSION

In this study, it can concluded that in mid-western plain of Uttar Pradesh, two prominent predatory stink bugs species co-exist *viz. A. spinidens* and *E. furcellata*. Both these polyphagous predators play a vital role in pest management, primarily targeting lepidopteran larvae. Our seasonal study of their relative abundance in field conditions unveiled a crucial correlation between their density and the availability of insect larvae. Their reproductive rates surged in the presence of ample food resources, with both nymphs and adults actively participating in natural pest control. The findings highlighted the influence of ambient temperature on their population dynamics. These stink bugs exhibited a rapid increase in numbers when favourable temperatures prevailed, with their activity unaffected by photoperiod. During colder periods, adult diapause induced by low temperatures served as a mechanism for overwintering.Interestingly, *E. furcellata* emerged as the dominant species in crop fields, overshadowing *A.spinidens*. However, it became evident that additional research is warranted to comprehensively understand the factors influencing stink bug population dynamics within specific crops such as Paddy, Sugarcane, Maize, Green gram, and Black gram. Although their distribution and relative densities vary across different ecological indices, their potential to contribute to sustainable agriculture remains unwavering. This study contributes to in emphasizing further studies in the complexity of ecological interactions for tailored pest management approaches based on specific crop and pest dynamics.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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