

Seasonal diversity of insect flower visitors on *Celosia argentea* in an agroecosystem of Jawhar, Palghar District, Maharashtra, India

Vinod Borse^{1*}, Dr. Sanjay Nikam²

¹ BAIF Development Research Foundation, Pune, Maharashtra, India, KTHM College, Nashik, Maharashtra, India

² N.V.P. Mandal's Arts, Commerce and Science College, Lasalgaon, KTHM College, Nashik, Maharashtra, India

Abstract

Seasonal variation in insect pollinator communities plays a crucial role in sustaining agro-ecosystem functions. The present study investigated the diversity and temporal dynamics of insect flower visitors associated with *Celosia argentea* in agricultural fields of Jawhar, Palghar District of Maharashtra, during 2022-2023. Surveys were conducted twice a month from August to December using a presence-absence approach. A total of 38 taxa belonging to four orders were recorded. Lepidoptera and Hymenoptera were dominant groups, indicating strong pollination activity. Diversity indices showed peak diversity during September (Shannon index $H' = 3.08$), followed by October ($H' = 2.94$), while the lowest diversity was observed in December ($H' = 2.12$). Simpson's Index ranged from 0.85 to 0.95, suggesting moderate to high diversity with low dominance. Seasonal trends revealed that insect activity was closely linked with the flowering intensity of *C. argentea*. The study highlights the ecological significance of wild edible plants in maintaining pollinators' diversity in the agroecosystem.

Keywords: Pollinators, agroecosystem, seasonal diversity, insect visitors, wild edible, natural control

Introduction

Insect pollinators play an essential role in maintaining both natural ecosystems and agricultural productivity by facilitating plant reproduction and influencing crop yield and quality. However, there has been a global decline of pollinator populations, which has been attributed to multiple interacting factors, including habitat degradation, agricultural intensification, pesticide exposure, and climate change (Potts *et al.*, 2010; IPBES, 2016) [8, 17]. These declines have raised serious concerns regarding food security and ecosystem stability, particularly in biodiversity-rich tropical regions. Within agroecosystems, the presence of non-crop vegetation is increasingly recognized as a critical component for sustaining pollinator communities. Field margins, bunds, fallow lands, and uncultivated patches often harbour diverse wild flowering plants that provide a continuous source of nectar and pollen. These floral resources become especially important during periods when cultivated crops are not in bloom, thereby ensuring the persistence of pollinator populations across seasons (Kremen *et al.*, 2007; Garibaldi *et al.*, 2013) [4, 10]. In addition to pollinators, such habitats also support beneficial arthropods, including predators and parasitoids, contributing to natural pest regulation and overall ecosystem resilience (Landis *et al.*, 2000; Gurr *et al.*, 2017) [7, 12]. *Celosia argentea* L. is a widely distributed herbaceous species commonly occurring in tropical agroecosystems. It thrives in rain-fed agricultural landscapes and is frequently found along field edges and in disturbed habitats. The species is notable for its prolonged flowering period, particularly during the monsoon and post-monsoon seasons, making it a reliable and consistent source of floral rewards for a wide array of insect taxa. Beyond its ecological importance, *C. argentea* is also valued as a leafy vegetable and possesses medicinal properties, thereby contributing to rural livelihoods (Grubben & Denton, 2004) [5]. Seasonal fluctuations in climatic factors such as rainfall, temperature, and humidity strongly influence insect abundance and

diversity. Among these, floral availability is considered one of the most significant drivers of insect visitation patterns. In many agroecosystems, insect diversity tends to peak during periods of maximum flowering and declines as floral resources diminish (Potts *et al.*, 2003; Winfree *et al.*, 2011) [16, 22]. Understanding these temporal dynamics is therefore essential for designing agroecological interventions that enhance biodiversity and sustain ecosystem services. Despite growing recognition of the ecological importance of wild flowering plants, field-based studies documenting their role in supporting insect diversity in Indian agroecosystems remain limited. The present study aims to address this gap by examining the seasonal diversity and composition of insect flower visitors associated with *C. argentea* in the rain-fed agricultural landscape of Jawhar, Maharashtra. The study provides insight into plant-insect interactions and highlights the ecological significance of wild flora in sustaining biodiversity within managed ecosystems. This study represents one of the few field-based assessments of insect visitation patterns on *C. argentea*. In Indian agroecosystems, highlighting its ecological role as a seasonal floral resource.

Material Method

Study area

The study was conducted in Kaulale village, situated in Jawhar block of Palghar District, Maharashtra, India. The Region is characterized by undulating terrain and predominantly rainfed agriculture practices. The climate is tropical with a distinct monsoon season (June-September) followed by a post-monsoon period. Agriculture fields are interspersed with semi-natural vegetation, including wild flowering plants such as *Celosia argentea*, which grows abundantly along field margins, bunds, and uncultivated patches. Such heterogeneous landscapes are known to support higher biodiversity by providing diverse ecological niches (Tscharrntke *et al.*, 2005) [21]. The study relied on visual observations and photographic identification, which

may limit species-level resolution, particularly in morphologically complex groups such as Diptera and Hymenoptera. Additionally, the absence of quantitative data may influence the precision of diversity estimates.

Sampling Design and Field Observations

Field surveys were carried out over two consecutive years (2022-2023), covering the flowering period of *C. argentea* from August to December. Observations were conducted twice per month to capture temporal variations in insect visitation patterns. Sampling was conducted during the peak activity of the insect, morning 08:00-11:00 hrs. Evening 16:00-18:00hrs. Multiple sampling patches were selected to ensure spatial representation across the study landscape. Each patch was observed for 10-15 minutes, during which all insect visitors making direct contact with floral structures were recorded. Sampling followed a standardized pollinator observation protocol, ensuring consistency across temporal replicates (Dafni *et al.*, 2005) [3]. Environmental parameters such as temperature, sunlight intensity, and wind conditions were noted in each sampling session. Surveys were avoided during adverse weather conditions, including Rainfall and strong winds, to minimize observational bias.

Documentation and Taxonomic Identification

Insect visitors were documented using digital photography. Multiple images were captured for each individual to record diagnostic morphological features, including wing venation, body coloration, antennal structure, and feeding behaviour. Taxonomic identification was carried out using standard keys and reference literature, including General insect identification (Borror *et al.*, 2005; Gullan & Cranston, 2005, Lepidoptera (Kunte, 2000) [11], Hymenoptera (Michener, 2007) [14], Diptera (Mc Alpine *et al.*, 1981), Odonata (Fraser, 1933-1936; Subramanian, 2005) [6]. Where species-level identification has limitations of photographic evidence, taxa were assigned to the genus level. This conservative approach minimizes misidentification and is widely recommended in biodiversity surveys (Triplehorn & Johnson, 2005) [20]. The study relied on visual observations and photographic identification, which may limit species-level resolution, particularly in morphologically complex groups such as Diptera and Hymenoptera. Additionally, the absence of quantitative data may influence the precision of diversity estimates.

Data analysis

Species diversity was assessed using standard ecological indices like the Shannon Diversity Index (H'), which accounts for both species richness and evenness, and

Simpson's Diversity Index (D), which measures dominance within the community. Monthly variation in diversity indices was calculated to evaluate seasonal trends. Species richness was also analysed to understand temporal changes in the number of taxa. These Indices are widely used in ecological studies to quantify biodiversity patterns and assess ecosystem stability (Magurran, 2004) [13].

Results

Species composition

A total of 38 insect taxa representing four major orders were recorded. Lepidoptera were the most abundant and frequently observed groups, followed by Hymenoptera and Diptera. In contrast, Odonata was represented by relatively few individuals, indicating a limited association with perching on floral resources.

Table 1: Order-wise composition of insect flower visitors recorded on *Celosia argentea*

SRN.	Order	Number of taxa	Relative dominance
1	Lepidoptera	15	High
2	Hymenoptera	12	High
3	Diptera	8	Moderate
4	Odonata	3	Low
	Total	38	

Seasonal Diversity Patterns

Monthly variation in diversity revealed clear seasonal patterns. The highest Shannon diversity value was observed in September ($H'=3.08$), followed by October ($H'=2.94$) and November ($H'=2.71$). August recorded moderate diversity ($H'=2.63$). While the lowest value was noted in December ($H'=2.12$). A similar trend was evident in Simpson's index, with the highest suggest with the highest value recorded in September (0.95) and the lowest in December that insect diversity peaked during the period of maximum flowering and gradually declined as floral resource availability decreased.

Table 2: Monthly diversity indices

SRN	Month	Shannon Index (H')	Simpson's Index
1	August	2.63	0.88
2	September	3.08	0.95
3	October	2.94	0.92
4	November	2.71	0.89
5	December	2.12	0.85

Representative insect flower visitors of *Celosia argentea* and their functional role in the agroecosystem

SRN	Order	Family	Representative species	Functional role
1	Lepidoptera	Nymphalidae	<i>Danaus chrysippus</i>	Pollinator
2	Lepidoptera	Pieridae	<i>Catopsilia pomona</i>	Pollinator
3	Lepidoptera	Lycaenidae	<i>Zizina otis</i>	Pollinator
4	Hymenoptera	Apidae	<i>Apis dorsata</i>	Pollinator
5	Hymenoptera	Apidae	<i>Apis cerana indica</i>	Managed Pollinator
6	Hymenoptera	Apidae	<i>Tetragonula spp.</i>	Stingless pollinator
7	Hymenoptera	Vespidae	<i>Ropalidia marginata</i>	Predator; nectar feeder
8	Diptera	Syrphidae	<i>Episyrphus balteatus</i>	Pollinator; larval biological control
9	Diptera	Muscidae	<i>Musca domestica</i>	Incidental pollinator; decomposer
10	Diptera	Calliphoridae	<i>Chrysomya megacephala</i>	Decomposer, Incidental Pollinator
11	Odonata	Libellulidae	<i>Orthetrum sabina</i>	Predator
12	Odonata	Coenagrionidae	<i>Ischnura spp.</i>	Predator

The insect assemblage included functionally diverse groups comprising pollinators, predators, and decomposers, indicating that *Celosia argentea* supports multiple ecosystem services within the agroecosystem. Elevated diversity recorded in September can be attributed to peak flowering of *Celosia argentea*, which likely provided abundant nectar and pollen resources, attracting a wide range of insect visitors. The relatively stable yet declining diversity observed during October and November indicates a transitional phase, where resource availability begins to decrease. By December, reduced floral abundance appears to have limited insect activity, resulting in lower diversity values.

The consistently high Simpson's Index values across months indicate low dominance and a relatively even distribution of species within the community. This suggests a balanced assemblage of insect visitors, where no single taxon overwhelmingly dominates, patterns often associated with a stable and resource-rich agroecosystem (Magurran, 2004) [13].

A species accumulation curve would further demonstrate the progressive recording of taxa over time, reflecting sampling efficiency.

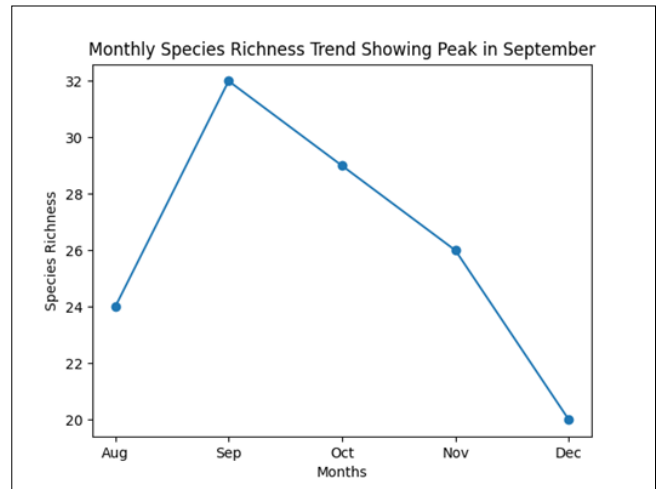


Fig 3: Monthly Species richness trend

Discussion

The results of the present study reveal a pronounced seasonal pattern in the diversity of insect flower visitors associated with *Celosia argentea*. The peak diversity observed during September corresponds with the period of maximum flowering, indicating a strong dependence of insect communities on floral resource availability. Such synchrony between plant phenology and insect activity is a fundamental ecological interaction that supports pollination processes and biodiversity maintenance (Potts *et al.*, 2003) [16].

The dominance of Lepidoptera and Hymenoptera suggests that *C. argentea* serves as an important nectar resource for pollinators. Bees, particularly *Apis* species and stingless bees (*Tetragonula spp.*), are highly efficient pollinators and play a crucial role in sustaining agricultural productivity (Klein *et al.*, 2007) [9]. Lepidopterans, including butterflies and moths, contribute to pollination and serve as indicators of environmental quality due to their sensitivity to habitat changes (Bonebrake *et al.*, 2010) [2]. Dipteran visitors, especially hoverflies (family Syrphidae), were also observed frequently. These insects provide multiple ecosystem services, acting as pollinators in their adult stage and contributing to nutrient cycling, pest control during their larval stage (Rader *et al.*, 2016) [18].

The presence of such diverse functional groups indicates well-structured and ecologically balanced insect communities. The relatively high Simpson's index values recorded throughout the study suggest low dominance and high evenness within the insect community. Such patterns are characteristic of a stable ecosystem where resources are evenly distributed, and multiple species coexist without competitive exclusion (Magurran, 2004) [13].

The gradual decline in diversity from October to December can be attributed to a reduction in floral resources as the flowering period progresses. Seasonal changes in climatic conditions, including decreasing humidity and temperature fluctuations, may also influence insect activity and survival rate (Wolda, 1988) [23]. This trend highlights the importance of maintaining continuous floral resources in the agroecosystem to support insect populations throughout the year.

Overall, the findings emphasize the ecological significance of wild flowering plants such as *C. argentea* in sustaining insect biodiversity. These plants not only support pollinators but also enhance ecosystem services, including biological control and nutrient cycling. Integrating such species into

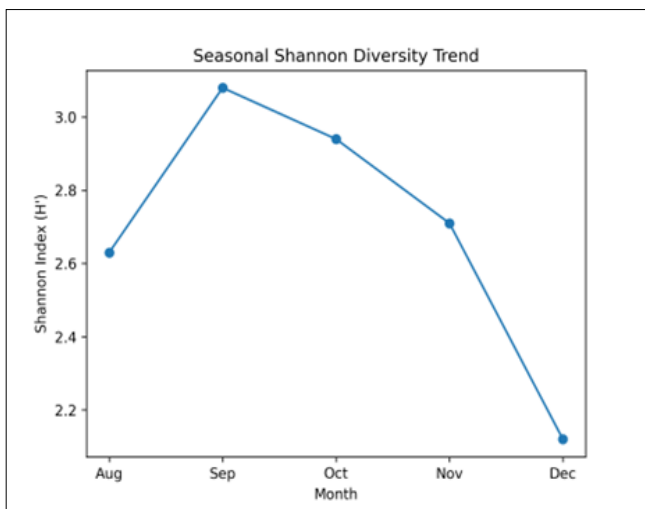


Fig 1: Seasonal variation in Shannon diversity index (H')

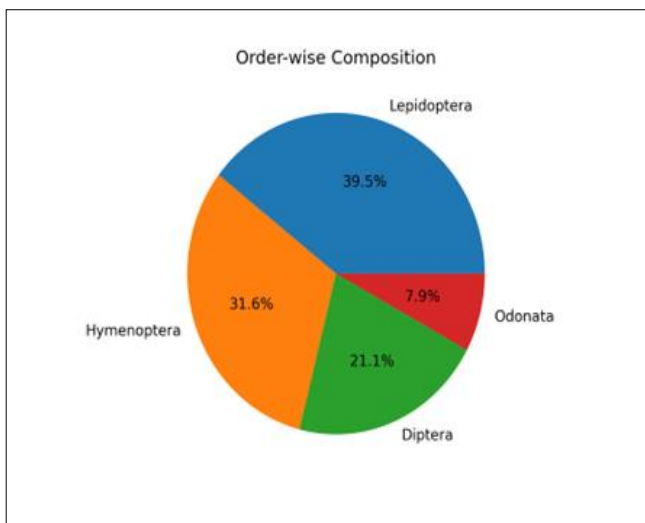


Fig 2: Order-wise composition

agricultural landscapes can contribute to sustainable farming practices and improved ecosystem resilience (Nicholls & Altieri, 2013) [15]. The observed pattern suggests that *C. argentea* acts as a keystone seasonal floral resource within rain-fed agroecosystems.

Conclusion

The study demonstrates that *Celosia argentea* supports a diverse insect community and plays a vital role in maintaining pollinator populations in an agroecosystem. Seasonal variation significantly influences insect diversity, with peak activity during September. Conservation of wild plants in agricultural landscapes is essential for sustaining biodiversity and ecosystem services. Such Species can be strategically integrated into agroecological landscape design to enhance pollination services.

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