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Diversity and variability of paddy pests in Rajnadgaon district of Chhattisgarh: A threat to agricultural sustainability

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Abstract
Chhattisgarh, a central Indian state renowned for its agricultural prowess, is a significant rice-producing region. Rice, being a staple crop, is susceptible to a myriad of insect pests that can significantly impact yield and quality. The diversity and distribution of these pests are influenced by various factors, including climatic conditions, crop management practices, and the presence of natural enemies. This paper delves into the heterogeneity of paddy insect pests in Chhattisgarh, exploring their diversity, distribution, and the factors that contribute to their variability. Paddy cultivation is a critical agricultural activity in Chhattisgarh, a state located in Central India. Known for its rich soil and favourable climate, Chhattisgarh supports extensive rice farming, which is vital for local food security and the economy. However, the success of paddy cultivation is increasingly threatened by a diverse array of insect pests. These pests not only affect the yield but also compromise the quality of the paddy, posing significant challenges to farmers. Chhattisgarh's diverse ecological landscape, including its varied climate, topography, and soil types, contribute to a complex agricultural environment. We identified the 09 order, 20 Family, 74 species and 74 genera entire study area, this heterogeneity creates a mosaic of microhabitats that can harbour a wide range of insect pests, each adapted to specific conditions. Understanding the heterogeneity of these pest populations i.e., the differences in species composition, distribution, and behaviour is essential for developing effective pest management strategies.

Keywords: Distribution, heterogeneity, hemiptera, orthoptera, populations, rice, topography

Introduction
Paddy cultivation is a cornerstone of agriculture in Chhattisgarh, a state in Central India known for its diverse agro-ecological zones [2]. This Rajnadgaon region, characterized by its varied climatic conditions and topographical features, supports a wide array of insect species that interact with paddy crops in complex ways [3]. The heterogeneity of paddy insect populations in Rajnadgaon District reflects a rich tapestry of ecological interactions and evolutionary adaptations, influenced by factors such as soil type, water availability, and local climate variations [4]. Understanding the diversity and distribution of insect species associated with paddy fields is crucial for effective pest management and sustainable agricultural practices [5]. Insect communities in these fields can vary significantly from one area to another, influenced by micro-environmental factors and agricultural practices [6]. This variability poses challenges and opportunities for integrated pest management (IPM) strategies, which must be tailored to local conditions to be effective [7]. The heterogeneity of paddy insects in Rajnadgaon encompasses a range of species, from beneficial predators and pollinators to harmful pests [8]. Each species plays a unique role in the ecosystem, contributing to the overall dynamics of pest populations and crop health [9]. By examining the distribution, abundance, and ecological roles of these insects, researchers can gain insights into the ecological balance within paddy fields and develop more targeted approaches to managing pest populations [10]. In the heart of Central India, the state of Chhattisgarh District Rajnadgaon stands out as a pivotal region for paddy cultivation, a staple crop that supports both local livelihoods and regional economies [11]. The agricultural landscape of Rajnadgaon district is marked by its diverse climatic and environmental conditions, ranging from lush river valleys to drier plateaus [12]. This environmental variability creates a complex and dynamic ecosystem for paddy fields, which in turn fosters a heterogeneous community of insects [13]. Insects play a crucial role in paddy agriculture, influencing crop health and productivity in multifaceted ways [14]. From beneficial predators and pollinators to detrimental pests, the insect fauna associated with paddy fields can vary significantly across different areas [16]. Understanding this heterogeneity is vital for developing effective pest management strategies and promoting sustainable agricultural practices [17]. The diversity of paddy insects in Chhattisgarh reflects the region's ecological complexity, factors such as soil composition, water management practices, and local climate conditions contribute to the varied insect populations found in paddy fields [20]. This variability not only affects the interactions between insects and crops but also impacts the effectiveness of pest control measures [21]. By examining the distribution, abundance, and ecological roles of these insects, researchers can gain valuable insights into the dynamics of pest populations and their influence on paddy cultivation [22]. This understanding is essential for formulating region-specific pest management strategies that balance productivity with environmental sustainability, this essay will explore the heterogeneity of paddy insects in Rajnandgaon, delving into the factors contributing to their diversity, their impact on crop health, and the implications for agricultural practices [23]. Through a detailed analysis, the essay aims to provide a comprehensive overview of how insect diversity shapes paddy cultivation in this unique and diverse region [25]. Paddy fields in Rajnandgaon (C.G.), a state in Central India, are characterized by their ecological

richness and agricultural significance. The heterogeneity of paddy insects in this region is a key aspect of its agricultural landscape, reflecting a complex interplay of environmental factors and biological diversity [26]. This essay examines the variation and diversity of insect populations in Rajnadgaon paddy fields, exploring how different insect species interact with the crop and each other in this unique setting [28]. The term "heterogeneity" in this context refers to the variety and distribution of insect species found in paddy fields across Rajnadgaon District 04 Blocks, this diversity is influenced by a range of factors, including soil types, water management practices, climatic conditions, and agricultural techniques [29]. As a result, the insect populations in these fields are not uniform but exhibit considerable variation from one location to another, understanding this heterogeneity is crucial for effective pest management and sustainable agriculture [30]. Insects in paddy fields can be classified into beneficial species, such as predators and pollinators and harmful pests that threaten crop health, the varying presence and abundance of these species across different areas of District can significantly impact crop yields and the overall health of paddy ecosystems [31]. This essay will define and analyse the concept of insect heterogeneity in Rajnadgaon District paddy fields, discussing the factors that contribute to this diversity and its implications for agriculture [32]. By examining the distribution patterns and ecological roles of various insect species, the essay aims to provide insights into the complex interactions within paddy ecosystems and to suggest strategies for managing insect populations in a way that supports both crop productivity and environmental health [33].

Study Area: The present research work was carried during two cropping seasons of rice i.e. *Kharif* of 2021 to 2023 in Rajnandgaon district, Chhattisgarh [34]. The climatic conditions prevalent in Rajnandgaon are essentially semi-arid and sub-tropical. The district is situated between 21.1346° N latitude and80.8987° E longitude, at an altitude of 307 meters (1010 feet) [From, Figure 01] above the mean sea level [35]. The annual rainfall varied from 1000 to 1200 mm with an average of 1200 mm. In the Chhattisgarh there, climate is tropical. On the map of Chhattisgarh tropic of cancer is centre of the map cross the study area. Humidity is 65 % and wind 13kph (Kilometre Per Hour) entire area of study area many types of soil characteristics like Black Soil, Laterite Soil, Red Soil, Loamy Soil, Black Soil [From, Figure 01] [36].

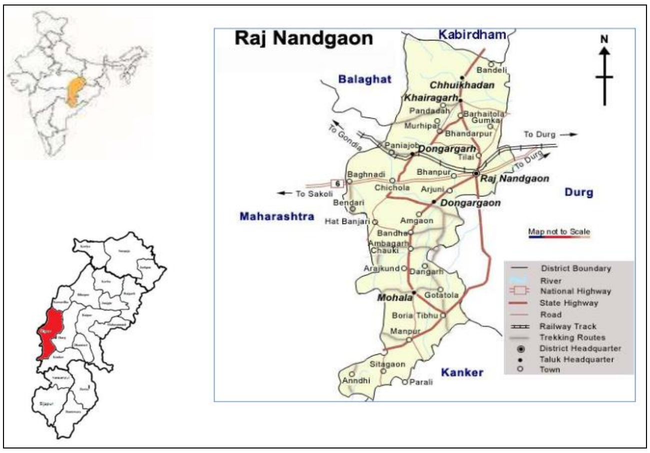


Fig 1: Study area in entire Chhattisgarh [43]

Table 1: Distribution of insect in paddy fields

Order	Family	Common Name	Scientific Name
Hemiptera	Pentatomidae	Southern green stink bug	*Nezara viridula (Linneaus, 1758)* [1]
1. Hemiptera	Delphacidae	*Brown planthopper*	*Nilaparvata lugens (Stål, 1854)* [1]
		White-backed planthopper	*Sogatella furcifera (Horváth, 1899)* [1]
	Cicadellidae	Zigzag leafhoppe	*Recilia dorsalis (*Edwards, 1922) [1]
		Green leafhoppers	*Nephotettix virescens* (Distant, 1908) [1]
		Rice green leafhopper	*Nephotettix nigropictus (Stål, 1870)* [1]
		White leafhopper	*Cofana spectra (Melichar, 1926)* [15]
	Coreidae	Paddy earhead bug	*Leptocorisa acuta* (Thunberg, 1783) [15]
		Slender rice bug	*Leptocorisa oratorius*
	Lophopidae	Sugarcane planthopper	*Pyrillaperpusilla (Walker, 1851)* [27]
2. Orthoptera	Acrididae	Rice grasshopper	*Oxya hyla hyla (Serville, 1831)* [15]
		Rice grasshopper	*Oxya fuscovittata (Serville, 183)* [15]
		Grasshopper	*Heteropternis banian (Stal, 1873)* [15]
		Short- horned- grasshopper	*Heteropternis respondens (Stal, 1873)* [15]
		Grasshopper	*Acrida exaltata* (Walker, 1859) [15]
		Slantface grasshopper	*Acrida gigantea (Linneaus, 1758)* [15]
		Burrowing grasshopper	*Acrotylus humbertianus (*Fieber, 1853) [18]
		Digging grasshopper	*Acrotylus insubricus (*Scopoli, 1786) [18]
		Rice grasshopper	*Oxya velox (Serville, 1831)* [18]
		Rice grasshopper	*Hieroglyphus banian (*Krauss, 1877) [18]
		Rice grasshopper	*Hieroglyphus nigroleptius (*Bolívar, 1912) [18]
		Short-horned- grasshopper	*Acorypha glaucopsis* (Walker, 1870) [18]
			*Tristia pulvinate (*Stål, 1873) [18]
		Long-horned cylindric grasshopper	*Tropidopola longicornis (*Stål, 1873) [18]
		Carinate locust	*Trilophidia annulata* (Thunberg, 1815) [18]
		Band-winged grasshopper	*Oedaleus abruptus* (Thunberg, 1815) [18]
		Band-winged grasshopper	*Oedaleus senegalensis (Krauss, 1877)* [18]
		Sudan plague locust	*Aiolopus simulatrix (*F. Walker, 1870) [18]
		Slender green-winged grasshopper	*Aiolopus thalassanisus thalassanisus (Fabricius, 1781)* [18]

		Short horned grasshopper	*Phaloeba infumata (Brunner von Wattenwyl, 1893)* [18]
		African grasshopper	*Truxalis viridifasciata (Fabricius, 1775)* [18]
		Red-winged grasshopper	*Oedipoda miniata (Pallas, 1771)* [19]
		Migratory locust	*Locusta migratoria (Meyen, 1835)* [19]
		European locust	*Stenohippus mundus (Walker, 1871)* [19]
		Grasshopper	*Dociostaurus apicalis (Fieber, 1853)* [19]
		Grasshopper	*Aulacobothrus luteipes (Walker, 1871)* [19]
		Japanese grasshopper	*Oxya japonica japonica (Thunberg, 1815)* [19]
		Short-horned- grasshopper	*Spathosternum prasiniferum (Walker, 1871)* [19]
		Carinate locust	*Trilophidia annulate (Thunberg, 1815)* [19]
		Band-winged grasshopper	*Oedaleus abruptus (Thunberg, 1815)* [19]
		Senegalese grasshopper	*Oedaleus senegalensis (Krauss,1877)* [19]
		Sudan plague locust	*Aiolopus simulatrix (F. Walker, 1870)* [19]
		Grasshopper	*Aiolopus thalassanisus thalassanisus (Fabricus,1781)* [19]
	Pyrgomorphidae	*Grasshopper*	*Atractomorpha burri (Saussure, 1862)* [19]
3. Coleoptera	Chrysomelidae	*Rice hispa*	*Dicladispa armigera (Olivier, 1808)* [19]
4. Diptera	Chironomidae	*Asian rice gall midge*	*Orseolia oryzae (Wood-Mason, 1889)* [19]
	Ephydridae	*Rice leaf miner*	*Hydrelliaphilippina (Ferino, 1968)* [27]
5. Thysanoptera	Thripidae	*Rice thrips*	*Stenchaetothrip biformis* (Bagnall, 1913) [24]
		Rice thrips	*Haplothripstenuipennis (*Amyot& Serville, 1843) [24]
		Rice thrips	*Bolacothrips indicus* (Bagnall, 1913) [24]
		Rice thrips	*Haplothrips ceylonicus (*Amyot & Serville, 1843) [24]
		Wheat ear thrips	*Anaphothrips sudanensis (Uzel, 1895)* [24]
6. Lepidoptera	Noctuidae	▪ Pink stem borer	*Sesamia inferens (Walker, 1856)* [24]
		Tobacco cutworm	*Spodoptera litura (Fabricius, 1775)* [24]
		Lawn armyworm	*Spodoptera Mauritia (Boisduval, 1833)* [24]
		Paddy armyworm	*Mythimna separate (Walker, 1865)* [24]
	Pyralidae	*Rice caseworm*	*Nymphula depunctalis (Schrank, 1802)* [24]
		Yellow stem borer	*Scirpophaga incertulas (Walker, 1863)* [24]
		Rice white stemborer	*Scirpophaga innotata (Walker, 1863)* [27]
		Dark-headed striped borer	*Chilo polychrysus (Meyrick, 1932)* [27]
		Asiatic rice borer	*Chilo suppressalis (Walker, 1863)* [27]
		Rice leaf roller	*Cnaphalocrocis medinalis (Guenée, 1854)* [27]
		Rice leaf roller	*Marasmia exigua (Lederer, 1863)* [27]
		Rice leaf roller	*Marasmia patnalis* (Bradley, 1981) [27]
7. Coleoptera	Hispidae	*Rice hispa*	*Dicladispa armigera* (Olivier, 1808) [27]
	Curculionidae	Rice plant weevil	*Echinocnemus oryzae (Schoenherr, 1838)* [27]
		Rice Water Weevil	*Lissorhoptrus oryzophilus (Kuschel, 1951)* [27]
	Gryllotalpidae	Oriental mole cricket	*Gryllotalpa orientalis (Burmeister, 1838)* [27]
	Aphididae	Rusty plum aphid	*Hysteroneura setariae (Thomas 1878)* [27]
8. Blattodea	Termitidae	*Wheat termite*	*Microtermes obesi (Holmgren, 1912)* [27]
		Termite	*Odontotermes obesus (*Rambur 1842) [27]
		Termite	*Odontotermes brunneus (Holmgren, 1912)*
9. Lepidoptera	Pyraustidae	Yellow stem borer	*Scirpophaga incertulas (Walker, 1863)* [27]
	Crambidae	Rice leaf roller	*Cnaphalocrocis medinalis (Guene΄e,1854)* [27]

Methodology: To achieve the study's objectives, a combination of field surveys, laboratory analyses, and data modelling will be employed. Field surveys will involve systematic sampling of paddy fields across Rajnadgaon District of Chhattisgarh to collect data on pest species and their abundance. Laboratory analyses will focus on identifying and characterizing the insect species collected. Data modelling will help in understanding the relationships between environmental factors and pest populations.

Heterogeneity analysis

Biodiversity heterogeneity index was calculated using the Shannon – Wiener diversity index (H) (1949).

$H = - \Sigma pi \ Inpi$

Where,

pi = S / N, S is the total number of individuals of one species, N is the total number of all individuals in the sample and in = logarithm to base e

Species richness of insect was calculated using the Margalef index (D) where S is the total number of species, N is the total number of individuals in the sample and ln is the logarithm to base e.

$$D = \frac{(S - 1)}{\ln N}$$

Evenness was calculated by using the Pielou’s evenness index (E) by the formula

Where H is the Shannon-Wiener diversity index and S is the total number of species in the sample.

$$E = \frac{H}{\ln S}$$

Simpson index (D) was used to determine rarity (diversity) information of species present on the sites by the formula.

$$D = \frac{\sum ni\,(ni-1)}{N\,(N-1)}$$

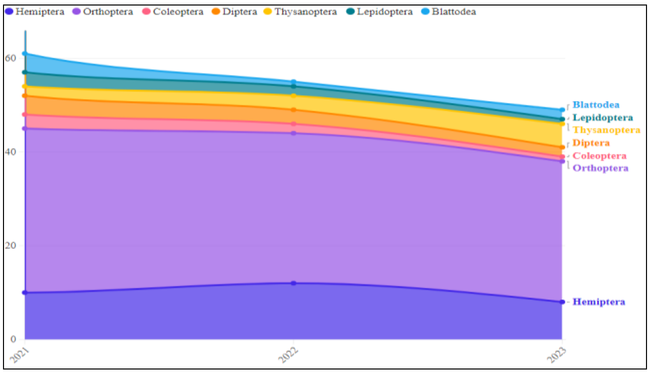
Where ni is the total number of organisms of each individual's species and N is the total number of organisms of all species.

Sorensen similarity index was used to measures similarity in species composition for two sites, FF and RF by the equation.

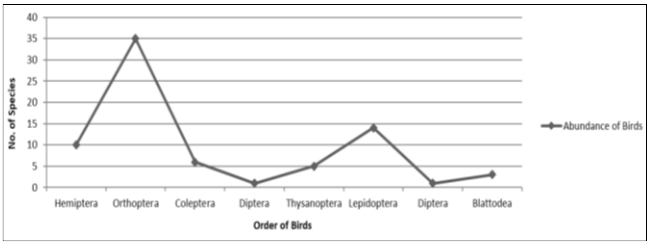
$$C_s = \frac{2ab}{a+b}$$

Where, Cs is *the coefficient of similarity*, a is the number of species found in site A, b is the number of species present in site B and ab is the number of species shared by two sites. Comparison between FF and RF communities based on the mean number of insect species was done using independent sample *t* -test. Significance was assessed at 0.05.

Result and discussion: Our study identified a total of 74 insect species across the paddy fields of Chhattisgarh [37]. Among these, 10 order were found to be predominant, including major pests such as the Southern green stink bug [*Nezara viridula (*Linneaus,1758)] [From, Table 01] and the Brown plant hopper [*Nilaparvata lugens* (Stål, 1854)]. The diversity index, calculated using the Shannon-Wiener index, revealed a moderately high level of species diversity with a score of 3.12, indicating a diverse insect community. The distribution of insect species varied significantly across different regions of Chhattisgarh. The eastern regions, characterized by higher rainfall and dense vegetation, exhibited a greater variety of insect species compared to the drier western regions. For instance, the eastern districts had a higher prevalence of the Short-horned- grasshopper [*Spathosternum prasiniferum* (Walker, 1871)] compared to the western districts. Insect populations showed notable seasonal fluctuations. For example, the abundance of the Japanese grasshopper [*Oxya japonica japonica* (Thunberg, 1815)] peaked during the monsoon season, while the population of the Grasshopper [*Aulacobothrus luteipes (*Walker, 1871)] was highest during the post-monsoon period. This temporal variation suggests that insect life cycles and population dynamics are closely tied to the seasonal changes in paddy cultivation [38]. Analysis of environmental variables revealed that temperature, humidity, and soil type significantly influenced insect distribution. Higher humidity levels correlated with increased populations of certain insect pests like the Band-winged grasshopper [*Oedaleus senegalensis (Krauss, 1877)*] [From, Table 01], while higher temperatures were associated with increased activity of the Green Leafhopper. Soil type also played a role, with clayey soils supporting a higher diversity of insect species compared to sandy soils. The observed diversity of insect species in Chhattisgarh aligns with findings from other paddy-growing regions in Asia, such as the Mekong Delta in Vietnam, which also shows high insect diversity [39]. The presence of key pests like the Rice hispa [*Dicladispa armigera (Olivier, 1808)*][From, Graph 01] underscores the need for targeted pest management strategies. Integrated pest management (IPM) approaches, including biological control and resistant crop varieties, are crucial in mitigating the impact of these pests. The variation in insect species across different regions can be attributed to differences in environmental conditions such as rainfall, temperature, and vegetation density [From, Graph 01]. The eastern regions' higher biodiversity may be due to the more favourable conditions for both paddy growth and insect survival. This spatial heterogeneity highlights the importance of region-specific pest management practices. For example, in the eastern districts, greater emphasis should be placed on monitoring and controlling pests like the Rice Stem Borer. The seasonal variation in insect populations suggests that different pests become more or less problematic depending on the time of year. This temporal heterogeneity necessitates seasonal pest management strategies. For instance, during the monsoon season, control measures for the Rice leaf miner [*Hydrellia philippina (Ferino, 1968)*] should be intensified, whereas post-monsoon strategies should focus on managing the Termite [*Odontotermes brunneus (Holmgren, 1912)*]. The significant impact of environmental factors on insect populations indicates that changes in climate could have profound effects on pest dynamics [From, Graph 01]. As climate change progresses, shifts in temperature and humidity could alter insect behaviour and distribution patterns [40]. Future research should focus on predicting these changes and developing adaptive pest management strategies [From, Graph 02]. Additionally, the interaction between soil types and insect diversity suggests that soil management practices could also influence pest populations [From, Figure 02].



Graph 1: Distribution of species in study area



Graph 2: Distribution of species in study area

Conclusion

The heterogeneity of paddy insects in Chhattisgarh reflects the complexity of managing pest populations in a diverse and variable environment. By understanding the species diversity, spatial and temporal patterns, and environmental influences, we can develop more effective and targeted pest management strategies. This study not only contributes to the scientific understanding of paddy insect dynamics but also provides practical insights for improving pest management practices in Chhattisgarh. As we move forward, integrating these findings into agricultural practices and continuing to investigate the evolving impacts of climate change will be crucial for sustaining productive and resilient paddy cultivation in the region. These findings underscore the importance of adaptive and region-specific pest management strategies. Future research should continue to explore the impacts of climate change on insect populations and develop innovative solutions for sustainable pest control in paddy cultivation.

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