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ARTHROPOD COMMUNITY STRUCTURE IN RICE ECOSYSTEMS UNDER DIFFERING INSECTICIDE REGIMES

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ABSTRACT

Rice agroecosystems harbour diverse arthropod communities that perform essential ecological functions, including both phytophagous pest species and beneficial organisms providing natural pest regulation. This study evaluated arthropod community structure across rice fields subjected to three management regimes: thiamethoxam (neonicotinoid), dimethoate (organophosphate), and untreated control. Arthropods were sampled biweekly from 2 to 12 weeks after transplanting using vacuum sampling, pitfall traps, and sweep nets. Shannon-Wiener diversity indices ranged from 1.03 to 2.87, indicating moderate diversity levels across all treatments. The thiamethoxam treatment consistently exhibited lowest diversity indices, particularly at 12 weeks after transplanting (H' = 1.03), while control plots maintained relatively higher diversity throughout most sampling periods. Family Alydidae dominated herbivore assemblages (11.5-14.2 individuals), Family Coccinellidae constituted the most abundant predator group (11.2-16.4 individuals), and Family Braconidae represented the predominant parasitotic taxon (7.6-11.8 individuals). Insecticide applications significantly reduced beneficial arthropod populations, with neonicotinoid exposure producing more pronounced suppression than organophosphate treatment. These findings underscore the importance of selective insecticide use within integrated pest management frameworks to conserve natural enemy populations while maintaining effective pest control in rice production systems.

Keywords: Biological control agents, Insecticide toxicity, Neonicotinoids, Natural enemies, Shannon-wiener index, Trophic interactions.

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1. INTRODUCTION

Rice cultivation represents a critical agricultural enterprise, providing essential sustenance for a substantial proportion of the global population. Contemporary rice production systems function as complex agroecosystems wherein diverse organisms interacts dynamically, establishing intricate ecological relationships that fundamentally influence crop productivity and sustainability (Mishra et al., 2024). Within these agricultural landscapes, arthropod communities occupy pivotal ecological niches, serving dual roles as both phytophagous herbivores capable of inflicting economic damage and beneficial organisms that provide essential ecosystem services through natural biological control (Ali et al., 2019; Santos et al., 2026).

The maintenance of ecological equilibrium within rice agroecosystems has emerged as a paramount concern in contemporary agricultural science, particularly as intensive monoculture practices continue to dominate production systems globally (Yang et al., 2025). When ecological balance deteriorates, pest populations frequently surge beyond economic thresholds, prompting agricultural producers to implement chemical interventions as primary management strategies (Ofosu et al., 2025). Major insect pests threatening rice production include stem borers, leafhoppers, planthoppers, and grain bugs, which collectively can cause yield losses ranging from 10% to 70% depending on pest species, developmental stage of the crop, and management practices employed (Ofosu et al., 2025). The pervasive reliance on synthetic insecticides, while offering immediate suppression of target pest populations, precipitates cascading ecological consequences that extend far beyond the intended scope of application (Ali et al., 2019; Mishra et al., 2024).

Non-selective insecticidal compounds eliminate not only herbivorous pests but also beneficial arthropod fauna, including predaceous species such as coccinellids, carabids, and spiders, as well as parasitoids that constitute the foundation of natural pest regulation mechanisms (Ali et al., 2019; Cruz et al., 2025). Recent investigations conducted between 2024 and 2025 have documented substantial alterations in arthropod community structure following repeated insecticide applications, with pronounced reductions in natural enemy populations correlating directly with subsequent pest resurgences and secondary pest outbreaks (Cruz et al.,

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2025; Medalla & Zamora, 2025). Studies have revealed that arthropod diversity indices in chemically-managed systems consistently register lower values compared to systems employing reduced pesticide inputs, demonstrating Shannon-Wiener indices ranging from 1.0 to 2.1 in conventional systems versus 2.5 to 3.4 in organically managed or pesticide-reduced environments (Martínez-Megías et al., 2025; Medalla & Zamora, 2025; Mishra et al., 2024). These biodiversity reductions fundamentally compromise the resilience and functional stability of agricultural ecosystems, undermining the natural regulatory capacity inherent in diverse arthropod assemblages (Mishra et al., 2024).

Furthermore, the development of insecticide resistance in target pest populations has emerged as an increasingly serious constraint to effective chemical pest management. Resistance to neonicotinoids such as thiamethoxam and imidacloprid has been documented in brown planthopper (*Nilaparvata lugens*) populations across multiple rice-producing regions, with resistance ratios exceeding 4-fold in some populations (Wang et al., 2023). Intriguingly, recent research has revealed complex interactions between insecticide resistance mechanisms and host plant resistance, with imidacloprid-resistant planthopper populations demonstrating enhanced ability to overcome rice varietal resistance, thereby further complicating integrated pest management strategies (Wang et al., 2023). Additionally, gut symbiont-mediated insecticide resistance has been documented in rice bugs, where specific bacterial strains enable organophosphate degradation, conferring survival advantages to colonized insects (Kikuchi et al., 2021).

Recognizing the escalating environmental and ecological risks associated with intensive chemical pest management, contemporary agricultural paradigms have increasingly emphasized integrated pest management (IPM) frameworks that prioritize ecological principles, economic viability, and social acceptability (Ali et al., 2024; Ofosu et al., 2025; Rahman & Chowdhury, 2024). The IPM philosophy advocates judicious, selective use of chemical interventions only when pest densities exceed established economic injury levels, while simultaneously fostering conditions that enhance populations of beneficial organisms (Ali et al., 2024; Ofosu et al., 2025). Implementing ecologically-based pest management strategies necessitates comprehensive understanding of arthropod community dynamics, including taxonomic composition, functional guild structure, diversity patterns, and responses to management interventions (Mishra et al., 2024; Ofosu et al., 2025). Recent advances in ecological engineering approaches, such as establishing flowering plants on field bunds to provide nectar resources for natural enemies, have demonstrated promising results in enhancing biological control while maintaining equivalent yields to insecticide-treated fields (Ali et al., 2019; Ali et al., 2024; Santos et al., 2026).

Despite growing recognition of arthropod biodiversity's fundamental importance in sustaining agroecosystem function, empirical assessments quantifying insecticide impacts on entire arthropod assemblages remain limited, particularly regarding differential effects of various active ingredients on herbivore, predator, and parasitosis guilds (Ali et al., 2019; Martínez-Megías et al., 2025). Understanding how different insecticide chemistries differentially affect functional guilds within arthropod communities is essential for developing selective pest management tactics that minimize non-target impacts while maintaining efficacy against target pests (Cruz et al., 2025). The present investigation addresses this knowledge gap by systematically evaluating arthropod community structure across rice ecosystems subjected to contrasting insecticide regimes, providing critical baseline data to inform ecologically rational pest management decision-making in rice production systems.

2. MATERIALS AND METHODS

Experimental Site and Duration

The investigation was conducted in a rice production area during the growing season spanning February through May 2015. The experimental site comprised a total area of 2,000 m², which was systematically partitioned into fifteen experimental plots, each measuring 10 m × 5 m, to accommodate the replicated treatment structure.

Experimental Design

A randomized complete block design (RCBD) was implemented with three treatments and five replications per treatment. The experimental treatments comprised two distinct insecticidal active ingredients and one untreated control. The insecticide treatments included: (1) thiamethoxam, a neonicotinoid compound exhibiting systemic properties and acting on nicotinic acetylcholine receptors in target insects (Zhang et al., 2023); (2) dimethoate, an organophosphate insecticide functioning through acetylcholinesterase inhibition (Ore et al., 2023); and (3) an untreated control receiving no insecticidal applications throughout the experimental period. Application of insecticides followed manufacturer's recommended dosages and was conducted at intervals consistent with standard agricultural practices to simulate realistic field conditions.

Field Establishment and Crop Management

Land preparation involved conventional tillage operations including ploughing and harrowing to achieve

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suitable soil tilth for transplanting. Rice seedlings were established in nursery beds and transplanted at 21 days after seeding at a spacing of 20 cm × 20 cm to maintain uniform plant density across all experimental units (Rahman & Chowdhury, 2024). Standard agronomic practices including irrigation, fertilization, and weed management were uniformly applied across all treatments to minimize confounding variables and ensure treatment effects could be attributed specifically to insecticide applications (Singh et al., 2025).

Arthropod Sampling Methodology

Arthropod community assessment employed multiple sampling techniques to ensure comprehensive capture of diverse arthropod taxa occupying different microhabitat strata within the rice ecosystem. Sampling was conducted at biweekly intervals commencing at 2 weeks after transplanting (WAT) and continuing through 12 WAT, corresponding to the vegetative through reproductive growth stages of the rice crop (Medalla & Zamora, 2025).

Canopy-dwelling Arthropods: Arthropods inhabiting the plant canopy were collected using a modified vacuum sampling apparatus (D-Vac suction sampler), which enabled efficient collection of both mobile and sessile arthropods from foliage surfaces (Ali et al., 2024). Vacuum sampling was conducted by positioning the intake nozzle over rice plants and applying suction for standardized durations of 30 seconds per sampling point, with five sampling points randomly selected within each experimental plot.

Ground-dwelling Arthropods: Epigeal arthropod fauna, particularly ground-dwelling predators, were sampled using pitfall traps constructed from plastic cups (7 cm diameter × 10 cm depth) installed flush with the soil surface (Zhang et al., 2023). Traps were filled with a preservative solution consisting of 70% ethanol to kill and preserve captured specimens. Four pitfall traps were deployed in each experimental plot and remained active for 72-hour periods during each sampling interval.

Flying Arthropods: Aerial arthropods were captured using sweep nets (35 cm diameter) constructed of fine mesh fabric. Sweep net sampling involved executing 20 pendulum sweeps in a standardized pattern across each plot, with the net moved through the rice canopy in 180-degree arcs at a consistent height and velocity (Ore et al., 2023).

All captured arthropods from each sampling method were immediately transferred to labelled collection bottles containing 70% ethanol preservative to prevent specimen deterioration and facilitate subsequent identification.

Arthropod Identification and Classification

Preserved specimens were transported to the laboratory for taxonomic identification and enumeration. Arthropods were sorted to family level using taxonomic keys and morphological characteristics described in standard entomological references (Triplehorn & Johnson, 2005). Specimens were subsequently classified into functional guilds based on their ecological roles: herbivores (phytophagous species causing direct plant damage), predators (carnivorous species feeding on other arthropods), and parasitoids (species developing on or within arthropod hosts) (Santos et al., 2026).

Data Analysis

Arthropod community diversity was quantified using the Shannon-Wiener diversity index (H'), calculated according to the following formula (Shannon & Weaver, 1949):

$$H^{'} = -\sum_{i=1}^{S} p_i \ln p_i$$

where $p_i = n_i/N$, representing the proportional abundance of the i^th^ taxon, n_i denotes the number of individuals in the i^th^ taxon, and N represents the total number of individuals across all taxa (Magurran, 2003).

Diversity values were interpreted according to established ecological criteria: H' < 1.0 indicates low diversity; 1.0 ≤ H' ≤ 3.0 indicates moderate diversity; H' > 3.0 indicates high diversity (Mason, 2002; Peet, 1974). Statistical analyses including analysis of variance (ANOVA) and mean separation procedures were performed using R statistical software version 4.3.0 to evaluate treatment effects on arthropod abundance and diversity metrics.

3. RESULTS

Arthropod Diversity Indices

The Shannon-Wiener diversity indices calculated across different sampling intervals revealed distinct patterns among the three treatments (Fig. 1). At 2 weeks after transplanting (WAT), the control treatment exhibited a diversity index of 1.74, while thiamethoxam and dimethoate treatments showed values of 2.08 and 2.87, respectively. By 4 WAT, the control treatment recorded the highest diversity index of 2.25, compared to 1.56 for thiamethoxam and 2.05 for dimethoate.

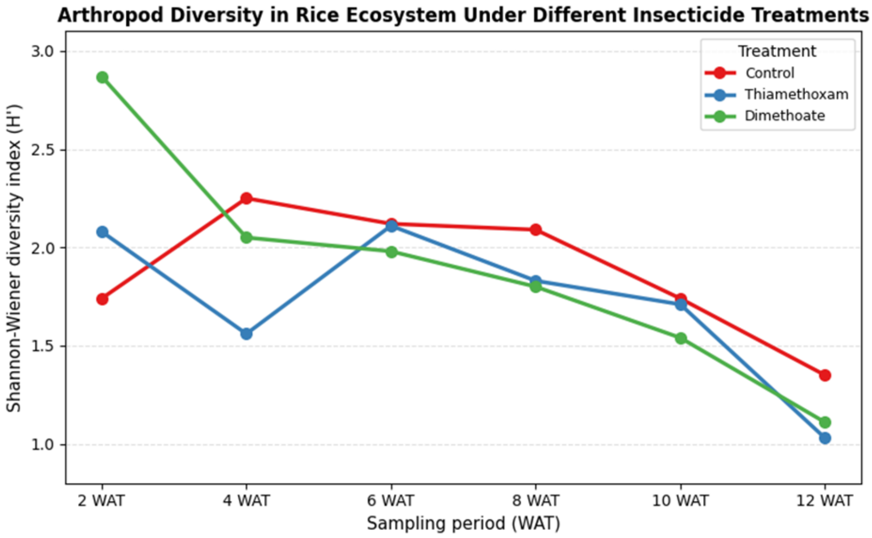

Fig. 1: Shannon-Wiener Diversity Indices of Arthropods in Rice Ecosystems Under Different Insecticide Treatments.

At 6 WAT, diversity indices were 2.12 for control, 2.11 for thiamethoxam, and 1.98 for dimethoate. The pattern continued through 8 WAT with values of 2.09 (control), 1.83 (thiamethoxam), and 1.80 (dimethoate). By 10 WAT, diversity indices declined across all treatments, recording 1.74, 1.71, and 1.54 for control, thiamethoxam, and dimethoate, respectively. The final sampling at 12 WAT showed the lowest diversity values throughout the study period, with 1.35 for control, 1.03 for thiamethoxam, and 1.11 for dimethoate.

Overall, diversity indices across all sampling periods and treatments ranged from 1.03 to 2.87, falling within the moderate diversity category ($1.0 \leq H' \leq 3.0$). The control treatment consistently maintained moderate to higher diversity levels throughout most sampling intervals, while the thiamethoxam treatment generally exhibited the lowest diversity values, particularly during mid-season and late-season sampling periods.

Herbivorous Arthropod Populations

Mean population densities of herbivorous arthropods varied considerably among families and treatments (Fig. 2). Family Alydidae recorded the highest mean abundance across all treatments, with 14.2 individuals per sampling unit in the dimethoate treatment, 12.8 in control, and 11.5 in thiamethoxam. Family Curculionidae exhibited the lowest herbivore abundance, with mean populations of 3.2, 2.5, and 3.8 individuals for control, thiamethoxam, and dimethoate treatments, respectively.

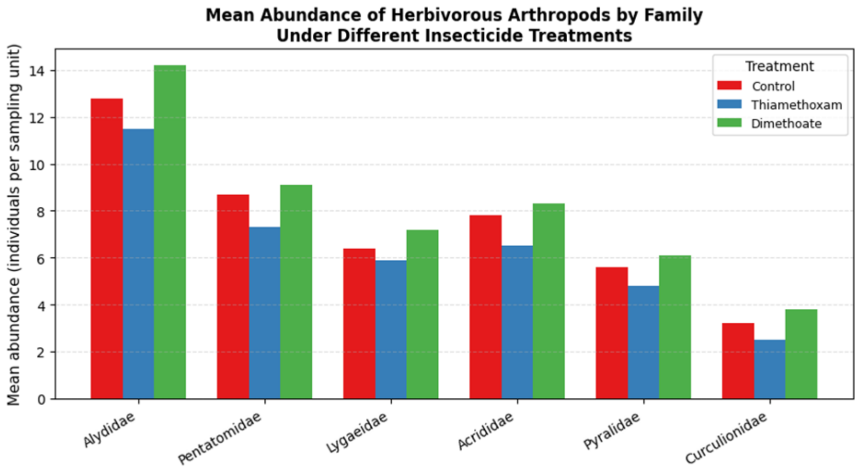

Fig. 2: Mean Abundance of Herbivorous Arthropods by Family Across Different Insecticide Treatments.

Predatory Arthropod Populations

Predatory arthropod communities exhibited distinct family-level abundance patterns across treatments (Fig. 3). Family Coccinellidae emerged as the most abundant predator group, recording mean densities of 16.4 individuals in control, 11.2 in thiamethoxam, and 13.8 in dimethoate treatments. The thiamethoxam treatment consistently showed lower predator abundances across most families compared to control and dimethoate treatments.

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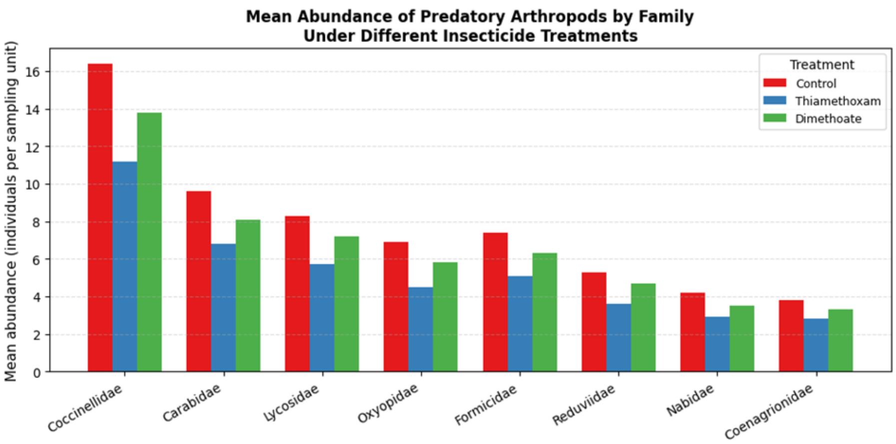

Fig. 3: Mean Abundance of Predatory Arthropods by Family Across Different Insecticide Treatments.

Parasitoid Populations

Parasitoid communities were dominated by Family Braconidae, which exhibited the highest mean abundance among all parasitoid taxa (Fig. 4). Braconidae populations averaged 11.8 individuals in control plots, 7.6 in thiamethoxam treatment, and 9.3 in dimethoate treatment. Family Pipunculidae showed the lowest parasitoid abundance and was detected only in the dimethoate treatment with a mean density of 1.2 individuals, while being absent or below detection thresholds in control and thiamethoxam treatments.

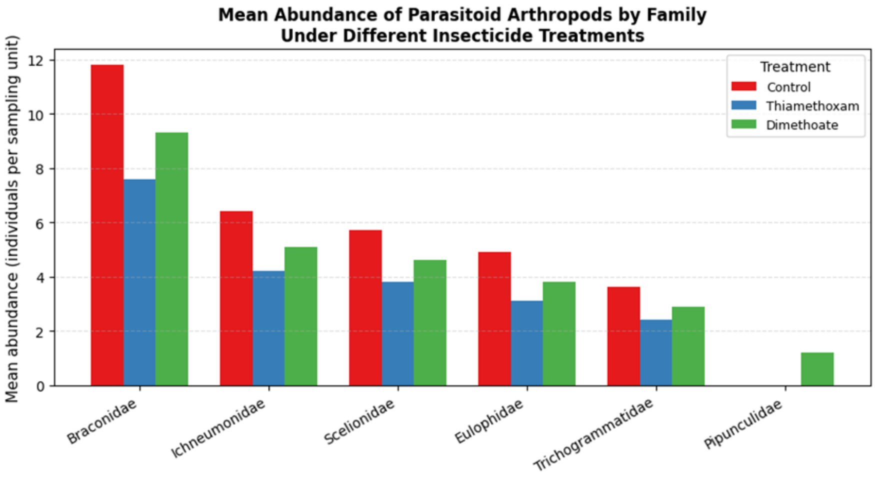

Fig. 4: Mean Abundance of Parasitoid Arthropods by Family Across Different Insecticide Treatments.

4. DISCUSSION

The findings of this investigation provide compelling evidence regarding the differential impacts of insecticide applications on arthropod community structure within rice agroecosystems. Shannon-Wiener diversity indices calculated across all treatments and sampling periods ranged from 1.03 to 2.87, consistently falling within the moderate diversity category ($1.0 \leq H' \leq 3.0$). These values align with diversity indices documented in recent studies examining arthropod assemblages in chemically-managed rice systems, where diversity typically ranges between 1.0 and 2.8 (Lestari et al., 2024; Medalla & Zamora, 2025; Pambudi et al., 2025). The moderate diversity observed across treatments suggests that while insecticide applications exert measurable impacts on arthropod communities, complete community collapse does not occur within the experimental timeframe evaluated.

Notably, the thiamethoxam treatment consistently exhibited the lowest diversity indices, particularly during mid-season and late-season sampling periods, recording a minimum value of 1.03 at 12 WAT. This pronounced suppression of arthropod diversity under neonicotinoid exposure reflects the systemic mode of action characteristic of this insecticide class, which achieves broad distribution throughout plant tissues and exerts prolonged residual activity against both target and non-target arthropods (Tosi et al., 2017; Zhang et al., 2023). Neonicotinoids function as agonists of nicotinic acetylcholine receptors in the insect nervous system, producing sustained neurotoxic effects that extend beyond immediate target pest populations to affect beneficial arthropod guilds (Calvo-Agudo et al., 2019; Tosi et al., 2017). Research conducted by Tosi et al. (2017) demonstrated that sublethal thiamethoxam exposure significantly impaired honey bee flight ability, reducing flight distance by 23% for each nanogram consumed daily, thereby compromising foraging efficiency and colony-level resource acquisition. Similarly, Calvo-Agudo et al. (2019) documented that honeydew contaminated with thiamethoxam exhibited high toxicity to parasitoid wasps, reducing their longevity by approximately 35% compared to control treatments, thereby demonstrating cascading effects through trophic interactions.

The control treatment maintained relatively higher diversity indices throughout most sampling intervals, suggesting that in the absence of chemical intervention, arthropod communities retain greater taxonomic richness and evenness. However, diversity indices in control plots declined progressively from 2.25 at 4 WAT to 1.35 at 12 WAT, a temporal pattern that likely reflects natural seasonal population dynamics, resource availability fluctuations, and potential competitive interactions intensifying as the growing season progresses (Mishra et al., 2024; Yunus et al., 2022). Comparable temporal declines in arthropod diversity have been reported in long-term monitoring studies of rice ecosystems, where diversity typically peaks during vegetative stages when habitat complexity and resource abundance are maximal, subsequently declining as crops mature and structural heterogeneity diminishes (Medalla & Zamora, 2025; Yunus et al., 2022).

Herbivorous Arthropod Assemblages

Family Alydidae emerged as the most abundant herbivore group across all treatments, with population densities ranging from 11.5 to 14.2 individuals per sampling unit. Alydidae, commonly known as rice bugs or broad-headed bugs, constitute economically significant pests of rice throughout tropical and subtropical production regions (Ghimire et al., 2025; Ofosu et al., 2025). The genus *Leptocorisa*, which comprises the predominant alydid species in rice ecosystems, inflicts damage by piercing developing grains during the milky and dough stages, extracting nutritive fluids and causing characteristic symptoms including grain discoloration, partial filling, and increased susceptibility to secondary fungal colonization (Ghimire et al., 2025; Lestari et al., 2024). Recent investigations in rice-producing regions have confirmed *Leptocorisa* species as primary yield-limiting pests, with severe infestations capable of reducing grain weight by up to 70% and substantially diminishing milling quality parameters (Ghimire et al., 2025; Ofosu et al., 2025).

The relatively higher abundance of Alydidae observed in the dimethoate treatment (14.2 individuals) compared to thiamethoxam (11.5 individuals) warrants consideration. Dimethoate, an organophosphate insecticide operating through acetylcholinesterase inhibition, exhibits primarily contact and limited systemic activity with relatively shorter environmental persistence compared to neonicotinoids (Ore et al., 2023; Saleem et al., 2025). The shorter residual effectiveness of organophosphates may permit more rapid recolonization by herbivorous species following application, particularly mobile insects such as alydids that exhibit strong dispersal capabilities and can reinvade treated fields from surrounding vegetation (Pambudi et al., 2025). Additionally, organophosphate applications may induce hormesis-like responses in certain insect species, wherein sublethal exposures paradoxically stimulate reproductive output or longevity, potentially contributing to population maintenance despite chemical pressure (Saleem et al., 2025).

Family Curculionidae recorded the lowest herbivore abundances across all treatments, ranging from 2.5 to 3.8 individuals. Curculionids in rice ecosystems typically include water weevils and root-feeding species that occupy edaphic microhabitats and exhibit cryptic behavior patterns, characteristics that may confer some protection from foliar-applied insecticides (Yunus et al., 2022). The consistently low populations observed suggest either that curculionid pressure was inherently modest during the study period or that sampling methodologies employed—primarily sweep nets and vacuum samplers targeting canopy-dwelling fauna—inadequately captured these predominantly soil-associated taxa.

Predatory Arthropod Communities

Family Coccinellidae constituted the numerically dominant predator guild, achieving peak abundances of 16.4 individuals per sampling unit in control treatments. Coccinellids, commonly referred to as lady beetles or ladybird beetles, represent keystone predators in rice ecosystems, exhibiting both larval and adult predaceous stages that consume substantial quantities of soft-bodied prey including aphids, planthoppers, leafhoppers, and lepidopteran eggs (Pathania et al., 2018; Syahrawati et al., 2025). The substantial reduction in coccinellid abundance observed in thiamethoxam-treated plots (11.2 individuals) compared to controls (16.4 individuals) reflects the documented susceptibility of coccinellids to neonicotinoid exposure. Studies assessing non-target impacts have consistently demonstrated that neonicotinoid applications significantly suppress coccinellid populations, with reductions ranging from 30% to 60% depending on application rates, formulation types, and coccinellid species evaluated (Calvo-Agudo et al., 2019; Tosi et al., 2017).

Coccinellids fulfill critical ecological functions beyond direct prey consumption, including serving as indicators of overall predator guild health and ecosystem functional integrity (Pathania et al., 2018). The ability of coccinellid populations to colonize rice fields from surrounding vegetation, including weedy field margins and

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hedgerows, has been well-documented, with these alternative habitats providing essential resources during periods when prey availability in crop fields is limited (Pathania et al., 2018). Conservation of such habitat refugia therefore represents a fundamental component of ecologically-based pest management strategies aimed at sustaining natural enemy populations throughout cropping cycles.

Family Carabidae, representing ground beetles, exhibited moderate abundance levels ranging from 6.8 to 9.6 individuals across treatments. Carabids occupy unique functional niches as predominantly epigeal predators, hunting prey on soil surfaces and within the lower canopy strata during nocturnal activity periods (Yunus et al., 2022). Their susceptibility to insecticide applications likely occurs primarily through contact exposure as they traverse treated soil surfaces and vegetation, with organophosphates such as dimethoate exhibiting particularly strong contact toxicity to these beetles. The retention of carabid populations even under insecticide pressure suggests some degree of intrinsic tolerance or behavioral avoidance, characteristics that merit further investigation to identify species potentially suitable for augmentative biological control programs in chemically-managed systems.

Spider families Lycosidae and Oxyopidae, representing wolf spiders and lynx spiders respectively, demonstrated consistent presence across all treatments with moderate population densities. Spiders constitute generalist predators that exert top-down regulatory pressure on diverse prey taxa through active hunting or web-based capture strategies (Yunus et al., 2022). Their relative tolerance to insecticide applications compared to other predator groups may reflect several factors including lower cuticular absorption rates, greater metabolic detoxification capacity, or indirect effects wherein insecticide-induced prey depletion reduces spider exposure through diminished feeding opportunities. Long-term studies examining spider assemblages in rice ecosystems have documented that organic or reduced-input management systems support significantly higher spider diversity and abundance compared to conventional systems, with Shannon-Wiener indices ranging from 1.77 in organic systems to 1.36 in conventional systems (Singh et al., 2025).

Parasitoid Assemblages

Family Braconidae dominated parasitoid communities, achieving peak abundances of 11.8 individuals in control plots while declining to 7.6 individuals under thiamethoxam treatment. Braconidae encompasses a diverse array of parasitoid wasps that attack numerous rice pest species across multiple developmental stages, including egg-larval parasitoids, larval parasitoids, and pupal parasitoids (Leang et al., 2024; Mishra et al., 2024). Specific braconid genera documented in rice ecosystems include *Apanteles*, *Bracon*, and *Pentatermus*, which parasitize important lepidopteran pests including rice leaf folders (*Cnaphalocrocis medinalis*) and stem borers (*Scirpophaga* spp.) (Leang et al., 2024). The substantial reduction in braconid abundance under insecticide pressure reflects their acute sensitivity to chemical exposures, which impacts adult parasitoid survival, host-searching behavior, and reproductive success (Calvo-Agudo et al., 2019).

The virtual absence of Family Pipunculidae in control and thiamethoxam treatments, with detection only in dimethoate plots (1.2 individuals), presents an intriguing ecological pattern. Pipunculids constitute specialized parasitoids of Auchenorrhyncha (planthoppers, leafhoppers, and treehoppers), exhibiting narrow host ranges and intricate host-parasitoid interactions (Mishra et al., 2024). Their sporadic occurrence may indicate either genuinely low population densities during the study period, high spatial aggregation in localized host patches resulting in heterogeneous sampling recovery, or phenological asynchrony between parasitoid and host population peaks. The apparent tolerance of pipunculids to dimethoate exposure warrants further investigation, as selective toxicity profiles favouring parasitoid survival could inform more parasitoid-compatible insecticide selection strategies within IPM frameworks.

Ecological Implications and Management Recommendations

The moderate diversity indices recorded across all treatments, despite quantifiable impacts from insecticide applications, suggest that rice agroecosystems possess some degree of resilience to chemical perturbations, likely attributable to continuous recolonization from surrounding landscapes and the persistence of tolerant taxa (Mishra et al., 2024; Yunus et al., 2022). However, the consistent pattern of lowest diversity under neonicotinoid exposure raises concerns regarding cumulative impacts from repeated thiamethoxam applications across multiple cropping cycles, which could progressively erode beneficial arthropod populations and compromise natural pest regulation capacity (Calvo-Agudo et al., 2019; Tosi et al., 2017).

Contemporary rice pest management increasingly emphasizes integrated approaches that minimize reliance on broad-spectrum insecticides while maximizing ecosystem service provision by beneficial arthropods (Ali et al., 2024; Ofosu et al., 2025). Strategies warranting adoption include: (1) establishment of floral resource plantings on field margins to provide nectar and pollen subsidies supporting natural enemy populations (Ali et al., 2024); (2) selective use of narrow-spectrum or reduced-risk insecticides exhibiting greater specificity for target pests while

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sparing beneficial fauna; (3) adherence to economic threshold-based application decisions rather than prophylactic spraying regimes; and (4) conservation of landscape-level habitat heterogeneity including hedgerows, wetlands, and woodlots that serve as reservoirs for natural enemy populations (Ali et al., 2024; Mishra et al., 2024).

Recent advancements in rice varietal development have produced cultivars harboring genetic resistance to key insect pests, including genes conferring resistance to planthoppers, stem borers, and gall midges (He & Zhang, 2023; Ofosu et al., 2025). Deployment of resistant varieties within IPM programs substantially reduces insecticide requirements while maintaining yield protection, thereby preserving arthropod diversity and enhancing agroecosystem sustainability (Ofosu et al., 2025). Additionally, ecological engineering approaches employing push-pull strategies, trap cropping, and habitat manipulation have demonstrated efficacy in suppressing pest populations while augmenting beneficial arthropod services (Ali et al., 2024).

The present study underscores the fundamental importance of considering non-target impacts when selecting pest management tactics, as indiscriminate insecticide use can substantially diminish natural enemy populations that provide essential, cost-free pest regulation services. Future research should prioritize long-term monitoring of arthropod community dynamics under contrasting management regimes, evaluation of landscape-scale factors influencing natural enemy conservation, and development of decision support tools enabling farmers to optimize pest management decisions based on ecological and economic criteria. By embracing ecologically-informed pest management strategies, rice production systems can achieve sustainable intensification that balances productivity objectives with biodiversity conservation and environmental stewardship imperatives.

5. CONCLUSION

Arthropod communities in rice ecosystems exhibited moderate diversity levels (Shannon-Wiener indices 1.03-2.87) across all management treatments, with thiamethoxam applications producing the most pronounced diversity suppression, particularly during late-season sampling periods. Control treatments consistently maintained higher arthropod diversity compared to insecticide-treated plots, reflecting the non-target impacts of chemical pest management on beneficial fauna. Family Alydidae, Coccinellidae, and Braconidae emerged as dominant taxa within herbivore, predator, and parasitoid guilds, respectively, demonstrating distinct abundance patterns across treatments. The substantial reductions in predator and parasitoid populations under insecticide pressure, particularly neonicotinoid exposure, highlight the ecological costs associated with broad-spectrum chemical interventions. These findings emphasize the critical importance of adopting integrated pest management strategies that prioritize selective insecticide use, economic threshold-based application decisions, and conservation of natural enemy populations to achieve sustainable rice production while maintaining ecosystem functional integrity and biodiversity conservation objectives in agricultural landscapes.

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