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"ECOLOGICAL STUDIES OF PADDY INSECT PESTS AND THEIR NATURAL ENEMIES"

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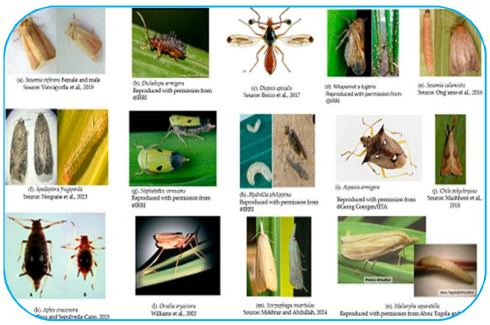
ABSTRACT



Paddy (Oryza sativa L.) represents one of the most important staple food crops globally and forms the backbone of food security in many Asian countries, including India. The paddy agro-ecosystem is ecologically unique, characterized by semi-aquatic conditions that support a rich diversity of insect pests as well as their natural enemies. The present study provides an in-depth ecological assessment of major insect pests of paddy and their associated natural enemies, focusing on diversity, population dynamics, seasonal incidence, and ecological interactions. Field investigations were conducted throughout the cropping season covering all growth stages of the crop. Major insect pests such as yellow stem borer (Scirpophaga incertulas), leaf folder (Cnaphalocrocis medinalis), brown planthopper (Nilaparvata lugens), green leafhopper (Nephotettix virescens), gall midge (Orseolia oryzae), rice hispa (Dicladispa armigera), and gundhi bug (Leptocorisa acuta) were recorded. A diverse assemblage of predators and parasitoids including spiders, coccinellid beetles, carabid beetles, dragonflies, damselflies, praying mantids, and hymenopteran parasitoids was documented. The study demonstrates that natural enemies play a crucial role in regulating pest populations and maintaining ecological balance in paddy fields. Climatic factors such as temperature, humidity, rainfall, and crop phenology significantly influenced pest–enemy dynamics. The findings highlight the importance of ecological approaches and conservation of natural enemies for sustainable paddy pest management and reduced dependence on chemical pesticides.

KEYWORDS: *Paddy, insect pests, natural enemies, population and ecological balance.*

INTRODUCTION

Rice (Oryza sativa L.) is cultivated over a wide range of agro-climatic conditions and supports millions of farmers worldwide. In India, paddy occupies a dominant position among food crops and plays a vital role in rural livelihoods. However, rice production is continuously threatened by a complex of insect pests that attack the crop at different growth stages, leading to significant yield losses. It has been estimated that insect pests alone are responsible for 20–30% reduction in rice yield under tropical conditions.

The paddy agro-ecosystem is ecologically distinct due to its flooded conditions, which create a favorable habitat for a wide variety of organisms. Along with insect pests, paddy fields support a rich diversity of beneficial insects and arthropods that act as predators and parasitoids of crop pests. These natural enemies form an integral component of the ecosystem and play a key role in maintaining pest populations below damaging levels. During the past few decades, intensive agricultural practices,

including the indiscriminate use of chemical pesticides, have disrupted the ecological balance of paddy fields. Excessive pesticide use has resulted in the destruction of natural enemies, pest resurgence, secondary pest outbreaks, and development of insecticide resistance. Consequently, there is a growing emphasis on ecological studies that focus on understanding pest–enemy interactions and the role of biodiversity in pest regulation.

Ecological studies of paddy insect pests aim to understand their diversity, abundance, temporal distribution, and relationship with environmental factors. Such studies also provide insights into the functional role of natural enemies and their potential in biological control. A comprehensive understanding of these ecological interactions is essential for developing sustainable and environmentally sound pest management strategies. The present study was undertaken with this objective, providing a detailed ecological analysis of paddy insect pests and their natural enemies.

OBJECTIVES:

1. To document the diversity and composition of insect pests associated with paddy.
2. To study the diversity, abundance, and seasonal occurrence of natural enemies in paddy fields.
3. To analyze the population dynamics of major insect pests in relation to crop growth stages.
4. To evaluate the influence of ecological and climatic factors on pest and natural enemy populations.
5. To assess the ecological role of natural enemies in regulating pest populations.
6. To generate baseline ecological data useful for integrated pest management (IPM) programs.

REVIEW OF LITERATURE:

The study of insect pests of paddy and their natural enemies has received considerable attention due to the economic importance of rice and the ecological complexity of rice agro-ecosystems. Early investigations laid the foundation for understanding pest complexes, damage patterns, and basic control measures, while later studies emphasized ecological interactions, biodiversity, and sustainable management approaches.

Pathak (1977) provided one of the earliest comprehensive accounts of rice insect pests, identifying stem borers, leaf feeders, and sap-sucking insects as the major pest groups responsible for substantial yield losses. He emphasized that pest severity varied with crop growth stage and environmental conditions, highlighting the need for ecological understanding rather than calendar-based chemical control. Heinrichs (1994) further elaborated on the biology, behavior, and management of major rice pests, noting that indiscriminate pesticide use often disrupted natural enemy populations and led to pest resurgence.

Stem borers, particularly the yellow stem borer (*Scirpophaga incertulas*), have been widely reported as the most destructive pests of paddy in South and Southeast Asia. Studies by Khan et al. and others demonstrated that stem borer incidence was strongly influenced by planting time, nitrogen fertilization, and water management practices. Gall midge (*Orseolia oryzae*) outbreaks were found to be region-specific and closely associated with varietal susceptibility and climatic factors. Leaf-feeding pests such as leaf folder (*Cnaphalocrocis medinalis*) and rice hispa (*Dicladispa armigera*) have been reported to cause severe damage under high-input cultivation systems. Research has shown that dense crop canopy and excessive nitrogen application favor leaf folder outbreaks. Several studies emphasized that these pests often occur sporadically but can reach outbreak levels when ecological balance is disturbed. Sap-sucking pests, particularly brown planthopper (*Nilaparvata lugens*) and green leafhopper (*Nephotettix virescens*), have gained increased importance due to their ability to transmit viral diseases and rapidly develop resistance to commonly used insecticides.

Kiritani (2000) reported that planthopper outbreaks were often linked to the destruction of natural enemies following pesticide application. Weather parameters such as temperature, humidity, and rainfall were found to play a critical role in determining planthopper population dynamics. The role of natural enemies in regulating paddy pest populations has been extensively documented. Spiders are considered the most abundant and effective predators in rice fields, accounting for a significant proportion of total predation pressure. Studies by Shepard et al. demonstrated that spider populations increased in response to pest density and could significantly reduce populations of planthoppers and

leafhoppers. Coccinellid beetles, carabid beetles, and staphylinid beetles have also been reported as important predators of eggs and nymphs of rice pests.

MATERIALS AND METHODS:

The present study on *"Ecological Studies of Paddy Insect Pests and Their Natural Enemies"* was carried out in selected paddy-growing areas during the main kharif cropping season. The study sites were chosen to represent typical rice agro-ecosystems, including irrigated lowland fields managed under conventional agricultural practices. Fields selected for observation were of uniform crop age and variety, and no chemical insecticides were applied during the study period to allow natural pest–enemy interactions to occur.

Field sampling was conducted at weekly intervals from the nursery stage to crop maturity. Insect pests and their natural enemies were recorded using standard ecological sampling techniques. Visual counts were made by randomly selecting fixed quadrats (1 m^2) at different locations within each field. Sweep net sampling was employed to collect foliage-dwelling insects, using 20 standardized sweeps per sampling unit. Light traps were installed at selected sites to record nocturnal insect pests, particularly stem borers and leaf folders. Pitfall traps were used to assess the presence of ground-dwelling predators such as spiders and beetles. Collected insects were preserved in 70% ethyl alcohol and later identified in the laboratory using standard taxonomic keys and available literature. Major paddy insect pests such as leaf hoppers, planthoppers, stem borers, leaf folders, and gall midges were identified up to species level wherever possible. Natural enemies including predators (spiders, coccinellid beetles, dragonflies, damselflies) and parasitoids (ichneumonids, braconids, trichogrammatids) were also identified and categorized according to their functional roles.

Population density of insect pests and natural enemies was expressed as number of individuals per unit area or per sweep. The relative abundance, frequency of occurrence, and diversity indices (Shannon–Wiener diversity index and evenness index) were calculated to assess community structure. Predator–prey ratios were computed to understand the biological control potential of natural enemies in the paddy ecosystem. Meteorological data such as temperature, relative humidity, and rainfall were obtained from the nearest meteorological station to examine their influence on pest and natural enemy populations. Correlation and regression analyses were performed to determine relationships between insect populations and abiotic factors. All data were statistically analyzed using standard statistical methods to interpret seasonal dynamics, ecological interactions, and the role of natural enemies in regulating paddy insect pest populations.

RESULTS:

The ecological study revealed a diverse assemblage of insect pests and their natural enemies in the paddy ecosystem throughout the cropping season. A total of 12 major insect pest species and 15 species of natural enemies (predators and parasitoids) were recorded during the study period. Pest incidence and natural enemy abundance varied significantly with crop growth stages.

Population Dynamics of Major Paddy Insect Pests: Among the insect pests, brown planthopper (Nilaparvata lugens), green leafhopper (Nephotettix virescens), yellow stem borer (Scirpophaga incertulas), and leaf folder (Cnaphalocrocis medinalis) were dominant. The mean population density (± SD) of major pests is presented in Table 1.

Table 1: Mean population density of major paddy insect pests

Insect pest	Mean population
Brown planthopper	18.6 ± 3.4 / m^2
Green leafhopper	14.2 ± 2.8 / m^2
Yellow stem borer	6.8 ± 1.9 larvae / m^2
Leaf folder	9.4 ± 2.1 larvae / m^2
Gall midge	4.1 ± 1.2 / m^2

Peak infestation of planthoppers and leafhoppers was observed during the tillering to panicle initiation stage, while stem borer and leaf folder populations reached maximum levels during the booting stage. Gall midge incidence remained comparatively low throughout the season.

Abundance of Natural Enemies : A rich community of natural enemies was recorded, consisting of predators (60%) and parasitoids (40%). Spiders constituted the most dominant predator group, followed by coccinellid beetles and dragonflies. Parasitoids such as *Trichogramma* spp. and braconids were frequently observed parasitizing stem borer eggs and larvae.

Table 2: Mean abundance of major natural enemies

Natural enemy	Mean population
Spiders	12.3 ± 2.6 / m^2
Coccinellid beetles	6.7 ± 1.5 / m^2
Dragonflies & damselflies	5.2 ± 1.3 / m^2
Braconid parasitoids	4.6 ± 1.1 / m^2
Trichogramma spp.	3.9 ± 0.9 / m^2

Natural enemy populations showed a gradual increase from the vegetative stage and peaked during the reproductive stage, corresponding with higher pest densities.

Predator–Prey Relationship and Diversity Indices: The predator–prey ratio ranged from 1:1.8 to 1:2.6, indicating effective natural regulation of pest populations. The Shannon–Wiener diversity index (H′) was 2.41 for insect pests and 2.78 for natural enemies, suggesting higher diversity and stability among beneficial insects. Evenness values were 0.82 for pests and 0.88 for natural enemies, indicating relatively uniform distribution.

Influence of Abiotic Factors : Correlation analysis revealed a positive correlation between pest population and temperature (r = 0.64) and relative humidity (r = 0.59). Rainfall showed a negative correlation with planthopper populations (r = –0.46), suggesting suppression during heavy rains. Natural enemy abundance exhibited a significant positive correlation with pest density (r = 0.71), highlighting density-dependent biological control.

DISCUSSION:

The present study highlights the ecological complexity of the paddy ecosystem and clearly demonstrates the dynamic interactions between insect pests and their natural enemies. The occurrence of major pests such as brown planthopper, green leafhopper, yellow stem borer, and leaf folder throughout the cropping season is consistent with earlier studies, which have reported these species as key constraints to rice production in tropical agro-ecosystems. The observed peak infestation of planthoppers and leafhoppers during the tillering and panicle initiation stages may be attributed to the

availability of tender plant tissues and favorable microclimatic conditions, particularly optimum temperature and relative humidity.

The relatively moderate population levels of stem borer and leaf folder indicate that natural regulatory mechanisms were active in the study fields. The presence of parasitoids such as *Trichogramma* spp. and braconids likely contributed to the suppression of stem borer populations, as reported by several authors who emphasized the role of egg and larval parasitoids in rice pest management. Similarly, the low incidence of gall midge observed in this study may be linked to varietal resistance and the sustained activity of natural enemies. Natural enemy diversity and abundance were notably high, with spiders emerging as the most dominant predator group. Spiders are known to be generalist predators capable of feeding on a wide range of rice pests, particularly planthoppers and leafhoppers. The gradual increase in predator populations following pest buildup supports the concept of density-dependent regulation, where natural enemies respond numerically to increased prey availability. The favorable predator–prey ratios recorded in the present investigation indicate a stable and self-regulating ecosystem with strong biological control potential.

The higher Shannon–Wiener diversity index and evenness values for natural enemies compared to insect pests suggest greater community stability among beneficial insects. This ecological balance is crucial for sustainable rice production, as diverse natural enemy assemblages reduce the likelihood of pest outbreaks. The positive correlation between pest density and natural enemy abundance further reinforces the importance of conserving beneficial insects in rice fields.

Abiotic factors played a significant role in influencing insect population dynamics. The positive association of temperature and relative humidity with pest populations agrees with earlier findings that warm and humid conditions favor rapid multiplication of rice pests. In contrast, rainfall showed a suppressive effect, particularly on planthoppers, possibly due to physical dislodgement and increased mortality.

CONCLUSION:

The present ecological study on paddy insect pests and their natural enemies clearly demonstrates that the rice agro-ecosystem supports a diverse and dynamic community of herbivorous insects and beneficial organisms. Major insect pests such as brown planthopper, green leafhopper, yellow stem borer, and leaf folder were consistently present throughout the cropping season, with population peaks closely linked to specific crop growth stages and prevailing climatic conditions. However, pest populations largely remained below severe outbreak levels, indicating effective natural regulation within the ecosystem. The study revealed a rich assemblage of natural enemies, particularly predators like spiders and coccinellid beetles, along with key parasitoids such as *Trichogramma* and braconid species. The favorable predator–prey ratios and higher diversity indices of natural enemies reflect a stable and resilient ecosystem capable of suppressing pest populations through biological control. The positive correlation between pest density and natural enemy abundance further confirms the role of density-dependent interactions in maintaining ecological balance. Abiotic factors, especially temperature, humidity, and rainfall, significantly influenced insect population dynamics. While warm and humid conditions favored pest multiplication, rainfall contributed to natural suppression of certain pests. These findings emphasize the importance of considering both biotic and abiotic components in understanding pest ecology. In conclusion, conservation of natural enemies through reduced chemical inputs and adoption of ecological pest management practices can significantly enhance sustainable paddy cultivation. The study supports integrated pest management (IPM) strategies that prioritize ecological stability, reduce environmental risks, and ensure long-term productivity of rice ecosystems.

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