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Diversity and Predatory Potential of Coleopteran Species on *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) of Rice

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Abstract

The brown plant hopper, *Nilaparvata lugens* (Stål) is a major insect pest of rice that causes significant losses in yield and grain quality. Coleopteran predators play an important role as biological control agents against rice insect pests. The present study was conducted to investigate the diversity and predatory efficiency of coleopteran species associated with *N. lugens*. Species composition was evaluated using diversity indices such as Shannon-Wiener diversity index (H'), Simpson diversity index (D), Species richness (S) and Species evenness (E). A total of seven predatory coleopteran species were recorded. Among these collected species, *Micraspis discolor* exhibited the highest predatory potential against *N. lugens.* The predatory efficiency of coleopteran species followed the order: *Micraspis discolor* > *Paederus fuscipes* > *Coccinella transversalis* > *Ophionea nigrofasciata* > *Menochilus sexmaculatus* > *Coccinella septempunctata* > *Brumoides suturalis.* Significant H' and D values indicated that the population of coleopteran predators increased with the advancement of crop growth stage. These findings suggest that these natural enemies, particularly coleopteran predators, play a crucial role in suppressing *N. lugens* populations and can contribute to reducing reliance on chemical pesticides in rice ecosystems.

Keywords: Coleoptera, predator, diversity index, species richness, species evenness, pesticides

Introduction

Rice (*Oryza sativa* L.) is one of the most important and oldest cultivated crops in the world that serves as staple food for more than half of the global population. The major rice producing countries are China, India, Pakistan, Southeast Asia, Korea, Japan and other adjacent areas which together contribute about 90 per cent of the global rice production (Kumar, 2022). However, rice cultivation faces several constraints, amongst which insect pests and diseases are responsible for significant annual yield losses (Karthikeyan *et al.,* 2024). The brown plant hopper (BPH), *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae), is one of the most destructive insect pests of rice in Asia. It is a sap-sucking insect that feeds on phloem tissues, causing severe damage through plant desiccation and ovipositional injury, ultimately leading to a condition known as "hopper burn." In addition, it acts as a vector of viral diseases such as grassy stunt and ragged stunt (Zulyusri and Anugrah, 2023). *N. lugens* is widely distributed in different parts of the world such as Asia, Australia and Pacific regions including Bangladesh, Burma, Cambodia, China, Hong Kong, Japan, Korea, India, Pakistan, Sri Lanka, Indonesia, Malaysia, Nepal, Philippines, Singapore, Taiwan, Thailand, Vietnam, Caroline Islands, New Guinea and Solomon Islands in Australia and Pacific Islands. The pest is commonly found in irrigated and rainfed rice ecosystems, whereas its occurrence in upland rice is relatively rare (Kingwell-Banham, 2019).

The excessive use of pesticides for pest control in rice has led to the development of pesticide resistance, resurgence of insect pests, and increased cost of production, making such practices unsustainable and economically unviable (Katti, 2013). These challenges have promoted the widespread adoption of Integrated Pest Management (IPM), an ecologically based approach that is compatible with sustainable agricultural systems (Pedigo, 1996). The use of natural enemies, including parasitoids, predators, and pathogens, constitutes a key component of IPM strategies for regulating pest populations in rice ecosystems (Chandra *et al.*, 2017). The rice ecosystem is unique as it comprises both terrestrial and aquatic components, resulting in high ecological complexity and biodiversity (Premila, 2003). Predatory coleopterans are among the most important natural enemies in rice ecosystems and play a crucial role in regulating populations of major insect pests (Tudi *et al.*, 2021). Members of families such as Coccinellidae and Carabidae are effective predators of key rice pests, including plant hoppers, leafhoppers, and other soft-bodied insects, thereby contributing significantly to natural pest suppression (Heong and Hardy, 2009; Horgan *et al.*, 2021). Coleopteran predators are generally polyphagous, highly adaptable, and capable of surviving under diverse environmental conditions, which enhances their effectiveness across different crop growth stages (Symondson *et al.*, 2002). Their high predation rates and active foraging behaviour enable them to efficiently suppress pest populations and maintain ecological stability in rice agroecosystems (Horgan, 2018). In the context of IPM, predatory coleopterans form an essential component of sustainable pest control strategies.

Effective sampling and estimation techniques must be incorporated into biodiversity inventories, especially for hyper-diverse groups of terrestrial creatures like arthropods (Colwell and Coddington, 1994). Accurate identification and enumeration of individuals to the species level are fundamental for ecological community studies (Gotelli, 2004). A diversity index is a numerical indicator of the number of various types (like species) present in a dataset (a community), and it can also take into account the evolutionary relationships (such as richness, divergence or evenness) among the individuals distributed across those types. In studies involving coleopteran predators, diversity indices serve as important tools for quantifying species composition and ecological relationships within the community. Therefore, the present study was undertaken to investigate the diversity of coleopteran species with the objective of evaluating their predatory potential against *N. lugens* in rice ecosystems. The study aims to generate ecological insights for the effective implementation of IPM strategies.

Materials and Methods

Raising of *N. lugens* population

The present investigation was conducted at the Rice Research Area, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana (30°54’N latitude; 75°48’E longitude and altitude of 247 m above mean sea level) during the *kharif* (wet) crop seasons of 2020, 2021 and 2022. The *N. lugens* population used in the experiment was reared on TN1 plants. Rearing cages were placed in water filled concrete troughs to prevent the entry of natural enemies such as spiders, ants, lizards etc. Thirty days old TN1 plants were used for maintaining the insect culture. The upper ends of the cages were securely tied to prevent the escape of insects. Plants were replaced with fresh ones after complete wilting due to insect feeding. The insect culture was maintained throughout the experimental period to ensure an adequate supply of *N. lugens*. To obtain newly emerged nymphs for experiments, oviposition cages were used, wherein one day old male and female *N. lugens* adults were released for oviposition.

Sampling and collection of coleopteran species

Coleopteran predator species were collected from the paddy crop raised following all recommended agronomic practices of Punjab Agricultural University except for the application of insecticides (Anonymous, 2020). Sampling was carried out from a field of 1500 m^2 area divided into 60 blocks each measuring 5×5 m from 30 days after transplanting (DAT) until the crop maturity. Collection of predatory beetles was performed using multiple methods. Small beetles were collected by aspirator, whereas large species were collected by sweep net or by manual picking. The collected specimens were handled carefully to avoid injury or mortality and were transferred into small plastic vials for further observations under laboratory conditions.

Functional response to test the effect of prey density on predation

The predatory potential of the collected specimens was evaluated individually in plastic containers (50 cm in diameter and 20 cm in height). In each container, 5, 7 and 10 individuals of 4^{th}-5^{th} instar laboratory reared *N. lugens* nymphs were introduced separately. Small pieces of TN1 paddy plants were placed in each container as food for the nymphs. After 24 hours of starvation, a single beetle was introduced into each container containing a known number of BPH nymphs. A control was maintained at each prey density without beetles. The number of nymphs consumed or killed by each coleopteran species was recorded after 24 hours. The experiment was replicated ten times for each species throughout the cropping season.

Identification of coleopteran specimens

For species identification, the collected beetle specimens were killed and preserved in 90 per cent ethanol. The preserved specimens were critically examined under a stereomicroscope (50× magnification) for identification. Specimens that could not be identified were preserved separately in 2 mL Eppendorf tubes. Each tube containing a single specimen was properly labelled in duplicate and sent to the National Bureau of Agricultural Insect Resources (Bengaluru) for further identification.

Diversity indices

To estimate the biodiversity of coleopteran species, various diversity indices including Shannon-Wiener diversity index (H’), Simpson diversity index (D), Species richness (S) and Species evenness index (E) were calculated.

The Shannon-Wiener diversity index measures species diversity in a community and is calculated by formula:

$$H' = -\sum pi \ln (pi)$$

where, H’ is the index of diversity, pi is the proportion of individuals found in the i^{th} species and ln is the natural logarithm.

Simpson’s Diversity Index takes into account the number of species present, as well as the relative abundance of each species and it is calculated by the formula:

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

where, n is the total number of organisms of a particular species and N is the total number of organisms of all species.

Species evenness index (E) is a measure of the relative abundances of species within a community and is calculated by formula:

$$E = H'/\text{Ln } S$$

where, H’ = Shannon -Wiener diversity index, Ln = Natural logarithm

Species richness (S) represents total number of species in a community. It is calculated by formula:

$$D = n - 1/\ln N$$

where, n= number of species recorded, N= the total number of individuals in the sample.

Statistical analysis

One-way Analysis of variance (ANOVA) following post-hoc comparison with Tukey's honestly significant difference (HSD) was used to test the significance of treatments. Statistical analysis was performed using v. 13.0 statistical program (SPSS, 2004).

Results and Discussion

Species recorded

During the three experimental years, seven species belonging to three different families were recorded, all of which showed significant predation against *N. lugens*. Among these, five species belonged to the family Coccinellidae, namely *Micraspis discolor*, *Coccinella transversalis*, *Menochilus sexmaculatus*, *Coccinella septempunctata* and *Brumoides suturalis*. One species each belonged to the families Staphylinidae (*Paederus fuscipes*) and Carabidae (*Ophionea nigrofasciata*). The predominance of coccinellid beetles in the present study highlights their crucial role as natural enemies in rice ecosystems. Coccinellids are widely recognized as efficient generalist predators of soft bodied insect pests, including plant hoppers, thereby contributing significantly to biological control (Hodek *et al.,* 2012; Pervez, 2016). Furthermore, the presence of predator species from different families suggests a complementary and synergistic role in pest suppression. Diverse predator assemblages are known to enhance biological control efficiency by increasing prey capture rates and reducing pest outbreaks (Snyder, 2019).

Predatory potential

The predatory potential of coleopteran species against *N. lugens* varied considerably among species at all prey densities **(Table 1, 2 and 3)**. The overall order of predatory efficiency was recorded as *M. discolor* > *P. fuscipes* > *C. transversalis* > *O. nigrofasciata* > *M. sexmaculatus* > *C. septempunctata* > *B. suturalis*. The higher predatory performance of *M. discolor* indicates its strong feeding ability and adaptability under rice ecosystem conditions, making it a key natural enemy of *N. lugens*. The relatively higher efficiency of *P. fuscipes* and *C. transversalis* further highlights the important role of both staphylinid and coccinellid beetles in regulating pest populations. The observed variation in predation among species may be attributed to differences in feeding behaviour, searching efficiency, and prey handling capacity. The presence of multiple predator species with varying predatory potential suggests a complementary role in pest suppression, thereby enhancing the stability of biological control in agroecosystems (Landis *et al.,* 2000; Snyder, 2019). However, the comparatively lower predatory potential of *C. septempunctata* and *B. suturalis* may be due to species-specific feeding preferences or lower adaptability to the given conditions. Overall, the findings emphasize the importance of conserving diverse coleopteran predators for sustainable management of *N. lugens* in rice ecosystems (Heong *et al.,* 2015).

Table 1: Prey consumption rates of rice field coleopteran predators of *N. lugens* in the laboratory at 5 prey density (Handling time 24 hours)

Species	Mean number of nymphs consumed per day ± S.E	Percentage predation (%)
Micraspis discolor	4.1±0.53[a]	82
Paederus fuscipes	3.9±0.53[ab]	78
Coccinella transversalis	3.4±0.66[bc]	72
Ophionea nigrofasciata	3.2±0.74[d]	64
Menochilus sexmaculatus	2.4±0.48[d]	48
Coccinella septempunctata	1.9±0.7[de]	38
Brumoides suturalis	1.5±0.92[e]	30

$F_{11,119}$ 19.89, P<0.001

Table 2: Prey consumption rates of rice field coleopteran predators of *N. lugens* in the laboratory at 7 prey density (Handling time 24 hours)

Species	Mean number of nymphs consumed per day ± S.E	Percentage predation (%)
Micraspis discolor	6.2±0.97[a]	88.57
Paederus fuscipes	5.8±0.74[ab]	82.85
Coccinella transversalis	5.1±0.94[bc]	72.85
Ophionea nigrofasciata	4.7±1.1[cd]	67.14
Menochilus sexmaculatus	4±1.61[de]	57.14
Coccinella septempunctata	3.3±0.9[ef]	47.14
Brumoides suturalis	2.7±0.92[f]	38.57

$F_{11,119}$ 13.25, P<0.001

Table 3: Prey consumption rates of rice field coleopteran predators of *N. lugens* in the laboratory at 10 prey density (Handling time 48 hours)

Species	Mean number of nymphs consumed per day ± S.E	Percentage predation (%)
Micraspis discolor	8.00±0.89[ab]	80
Paederus fuscipes	7.60±1.28[ab]	76
Coccinella transversalis	6.90±1.22[bc]	69
Ophionea nigrofasciata	6.30±1.61[bc]	63
Menochilus sexmaculatus	5.30±2.45[cd]	52
Coccinella septempunctata	4.60±1.42[de]	46
Brumoides suturalis	3.70±1.41[e]	37

$F_{11,119}$ 9.60, P<0.001

Diversity indices

The biodiversity of coleopteran species varied across different prey densities **(Table 4)**. The Shannon–Wiener diversity index ranged from 1.89 to 3.83, with the highest value recorded at a prey density of 10 (3.83), indicating greater species diversity at higher prey availability. At lower prey densities of 5 and 7, the diversity index values were comparatively lower (1.89 and 1.91, respectively). Simpson's diversity index showed only slight variation across prey densities, ranging from 0.151 to 0.157, indicating relatively stable dominance patterns among species. The highest value (0.157) was observed at a prey density of 5, while the lowest (0.151) was recorded at a prey density of 10. Species evenness index values were relatively similar across treatments, ranging from 1.03 to 1.07, suggesting a uniform distribution of individuals among species irrespective of prey density. The highest evenness (1.07) was observed at prey density 5. Species richness showed variation across prey densities, with the highest value recorded at prey density 7(1.01), followed by prey density 5(0.97), while the lowest richness (0.5) was observed at prey density 10. The higher Shannon-Wiener index at increased prey density suggests that greater prey availability supports a more diverse predator community, likely due to reduced competition and enhanced resource utilization. Similar observations have been reported by Heong *et al.,* 2015 and Snyder, 2019, who emphasized that increased prey abundance promotes predator diversity in agroecosystems. The predator community remained relatively stable across different prey densities, suggesting balanced species distribution and efficient resource utilization (Landis *et al.,* 2000).

Table 4: Diversity indices of spiders at rice phenological stages

Sl No.	Prey density	Shannon-Wiener diversity index (H')	Simpson's Diversity Index (D)	Species evenness index (E)	Species richness (S)
1	5	1.89	0.157	1.07	0.97
2	7	1.91	0.152	1.03	1.01
3	10	3.83	0.151	1.06	0.5

Conclusion

The present study demonstrated that diverse coleopteran predators play a significant role in the biological control of *N. lugens* in rice ecosystems. Among the species evaluated, *M. discolor* exhibited the highest predatory potential, followed by *P. fuscipes* and *C. transversalis*, indicating their effectiveness as key natural enemies. The variation in predatory efficiency among species highlights the importance of predator diversity in ensuring stable and efficient pest suppression. Overall, the findings emphasizes that conservation and promotion of native predator fauna can enhance sustainable pest management and reduce reliance on chemical insecticides in rice cultivation.

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References

Anonymous. 2020. Package of practices for the crops of Punjab (*Kharif* 2020). Directorate of Extension Education, Punjab Agricultural University, Ludhiana. 3 pp.

Colwell RK. and Coddington JA. 1994. Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions of the Royal Society of London Series B Biological Sciences*, 345(1311): 101–118.

Gotelli NJ. 2004. A primer of ecology (3rd ed.), 2001. *Sinauer Associates Incorporated- Nature*, Sunderland, Massachusetts. United Sates, pp. 225.

Heong KL, Cheng JA. and Escalada MM. 2015. Rice Plant hoppers: Ecology, Management, Socioeconomics and Policy. Springer, Dordrecht, The Netherlands.

Heong KL. and Hardy B. 2009. Plant hoppers: New threats to the sustainability of intensive rice production systems in Asia. International Rice Research Institute, Los Baños, Philippines.

Hodek I, van Emden HF. and Honěk A. 2012. Ecology and behaviour of the ladybird beetles (Coccinellidae). Wiley-Blackwell, Chichester.

Horgan FG, Peñalver-Cruz A. and Ramal AF. 2021. Effects of insect herbivores and natural enemies on rice production systems. *Insects*, 12(5): 1-21.

Horgan FG. 2018. Integrated pest management for rice. In: Rice production worldwide. Springer, pp. 315-336.

Karthikeyan K, Faseela KV, Biji KR. and Padmavathi C. (2024). Screening of rice genotypes for resistance against leaffolder. *Journal of Rice Research*, 17(1): 80-86.

Katti G. 2013. Biopesticides for insect pest management in rice – present status and future Scope *Journal of Rice Research,* 6(1): 1-14.

Kumar S. 2022. Impact of insect pests on rice production and management strategies. *Journal of Entomological Research*, 46(2): 123-130.

Landis DA, Wratten SD. and Gurr GM. 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annual Review of Entomology*, 45: 175-201.

Pedigo LP. 1996. Entomology and Pest Management (2nd ed.). Prentice Hall, New Jersey.

Pervez A. 2016. Ladybird beetles (Coccinellidae). Springer International Publishing, Switzerland.

Premila K. 2003. Biodiversity in rice ecosystems. *Indian Journal of Ecology*, 30(2): 123-128.

Snyder WE. 2019. Give predators a complement: Conserving natural enemy biodiversity to improve biocontrol. *Biological Control*, 135: 73-82. https://doi.org/10.1016/j.biocontrol.2019.04.017.

SPSS. 2004. SPSS for Windows, Version 13.0. SPSS Inc., Chicago, USA.

Symondson WOC, Sunderland KD. and Greenstone MH. 2002. Can generalist predators be effective biocontrol agents? *Annual Review of Entomology*, 47: 561-594.

Tudi M, Ruan HD, Wang L, Lyu J, Sadler R, Connell D, Chu C. and Phung DT. 2021. Agriculture development, pesticide application and its impact on the environment. *International Journal of Environmental Research and Public Health*, 18(3): 1112.

Zulyusri Z. and Anugrah C. 2023. Brown plant insect (*Nilaparvata lugens*) pathogen on rice (*Oryza sativa*). *Enrichment: Journal of Multidisciplinary Research and Development*, 1(3): 82-90.