



Research Article

Biodiversity and predatory potential of coccinellids of rice ecosystems

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ABSTRACT: Coccinellid species belonging to fifteen genera, under five tribes of the family Coccinellidae were collected and identified in this study. *Harmonia (Fab.)* was the most predominant in southern regions and *Coccinella septempunctata* L. was more abundant in the northern and hill regions. Margalef richness index ranged from 9.07 to 14.00 while the species richness directly measured by Hills number H0 ranged from 5-10, with highest species richness present at Malan, Himachal Pradesh. The highest predation was observed in female *H. octomaculata* which fed on a maximum of 8.00, 7.42 and 6.59 brown planthopper (BPH), WBPH white backed planthopper (WBPH) and green leafhopper (GLH) respectively per day, while the lowest was observed in *Propylea dissecta* which fed on 3.18 to 4.50 hoppers per day. Coccinellids like *H. octomaculata* can be utilized in biological control programmes as a part of Integrated Pest Management to reduce pest outbreaks.

KEY WORDS: Biodiversity, BPH, coccinellids, predatory potential, rice, WBPH

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INTRODUCTION

Coccinellids are widely prevalent and most abundant species of predators in agricultural ecosystems and are extensively studied (Snyder, 2009), due to the conspicuous colours and also the ecosystem services they provide (Hodek *et al.*, 2012). These predatory beetles are also easy to multiply in the laboratory and have been successfully used in applied biological and conservation biological control of sucking pests. Coccinellid assemblages on crops depend on the prey available and many other factors such as microclimate, surrounding vegetation and management practices. In view of impacts of climate change there is much concern over factors that may threaten the temporal and spatial patterns of coccinellids within ecosystems (Honek *et al.*, 2017). The biodiversity of coccinellids vary from region to region within a crop ecosystem. In India the coccinellid assemblages have been reported in many crops and on rice and as many ten to thirteen species have been reported from a single location (Chowdhury *et al.*, 2015; Vinothkumar, 2013). The present study was undertaken to

document the species spectrum of coccinellids in different rice ecosystems in the country and to assess the predatory potential of some key coccinellids on rice hoppers.

MATERIALS AND METHODS

Biodiversity of coccinellids

The coccinellids and their hopper prey were sampled every week for three years, 2013-2015 on the Rajendranagar experimental farm of the Indian Institute of Rice Research (IIRR), Hyderabad by sweep nets, visual counts in unsprayed plots and 200m of field bunds. Through sweep nets, single samples were also collected in rice fields of the following places representing Malan (Himachal Pradesh) and Almora (Uttarakhand) for hill regions; Pusa (Bihar), Kalimpong (West Bengal), Navsari, Nawagam (Gujarat), Jeypore, Sambalpur (Odisha), Ludhiana (Punjab), Kaul (Haryana) for northern region; Mudigere (Karnataka), Maruteru (Andhra Pradesh), Pattambi (Kerala), Hyderabad and Kampasagar (Telangana) for southern region and the biodiversity and distribution of species were analysed using

BioDiversityPRO (McAleece *et al.*, 1997). The coccinellid diversity during the flowering phase was used to calculate the biodiversity of species at each place. The indices used were selected to represent Species richness, diversity, abundance and evenness in each location.

Biology and predatory potential

The coccinellids namely, *Harmonia octomaculata*, *Cheilomenes sexmaculata*, *Coccinella transversalis*, *Propylea dissecta* and *Micraspis discolor* collected from rice fields, were paired and reared in separate Petri dishes (9 x 2 cm) under controlled laboratory conditions (27±2°C, 65±5% RH) in BODs. They were provided with third instars of *Aphis craccivora ad libitum*. The eggs laid by the respective coccinellids were collected and incubated under controlled conditions and the emerging neonates were used for studies on biology and predatory potential of different species of rice hoppers viz., the brown planthopper, *Nilaparvata lugens* Stal. (BPH), the white backed planthopper, *Sogatella furcifera* Hovarth (WBPH) and the green leafhopper, *Nephotettix* (Distant) (GLH).

Statistical analysis

Simpson’s Diversity, Hill’s Numbers, Margalef richness, Hill’s Numbers, Berger-Parker Dominance were calculated by using Biodiversity Pro.

Simpson’s index (λ and 1/λ)

$$\lambda = \sum_{i=1}^S p_i^2$$

where pi is the proportional abundance of the ith species, given by

$$p_i = \frac{n_i}{N}, I = 1,2,3 \dots S$$

where ni is the number of individuals of the ith species and N is the known total number of individuals for all species in the population. Since the Simpson index value decreases with increasing diversity, we calculated 1/λ for easier interpretation.

The Margalef richness index (d)

$$d = (S - 1) / \ln N$$

Where S is the number of species, and N is the total number of individuals in the sample.

Berger-Parker index (1/d)

The Berger–Parker index equals the maximum pi val-

ue in the data set, *i.e.* the proportional abundance of the most abundant type. This corresponds to the weighted generalized mean of the pi values when q approaches infinity

$$\text{Berger–Parker index} = 1/\infty D$$

The Hill’s diversity numbers

The Hill’s diversity numbers were calculated as per Ludwig and Reynolds, (1988).

$$\text{Hill’s numbers} = \sum_{i=1}^S (p_i)^{1/(1-A)}$$

where pi is the proportion of individuals belonging to the ith species and A = 0,1, 2, 3 etc. The zero, first and second order of this equation is the three most important measures of diversity.

H₀ = S where S is the total number of species, N₁ = e^{H'}

Where H' is the Shannon’s index and

H₂ = 1/λ, Where λ is the Simpson’s index.

H₀ is the number of all species in the sample regardless of their abundances, H₂ is the number of very abundant species and H₁ measures the number of abundant species in the sample.

$$H' = \sum_{i=1}^{S^*} (p_i \ln p_i)$$

where H' is the average uncertainty per species in an infinite community made up of S* species with known proportional abundances p₁, p₂, p₃,....., p_{s*}.

RESULTS AND DISCUSSION

Fifteen species belonging to eleven genera, under five tribes of the family Coccinellidae were collected and identified in this study (Plate 1) viz., *Harmonia octomaculata* (Fabricius), *Cheilomenes sexmaculata* (Fabricius), *Coccinella transversalis* Fabricius, *Coccinella septempunctata* (Linnaeus), *Scymnus nubilus* (Mulsant), *Scymnus latemaculatus* (Motschulsky), *Micraspis discolor* (Fabricius), *Micraspis vincta* (Gorham), *Micraspis* sp., *Brumoides suturalis* (Fabricius), *Hippodamia variegata* (Goeze), *Oenopia sexareata* (Mulsant), *Rodolia* sp., *Stethorus* sp. and *Propylea dissecta* (Mulsant). *Illeis indica* (Timberlake) was also observed on bunds but not included in this list as it is predominantly a mycelial feeder. *Harmonia octomaculata* was the most predominant in southern regions and *C. septumpunctata* was more abundant in the northern and hill regions. Simpson’s diversity index (1/D) is the probability of two individuals being conspecifics if drawn randomly from an infinitely large community. In biodiversity analy-

sis, Simpson's diversity index ranged between 4.04 at Sambalpur, Odisha to 11.25 at Mudigere, Karnataka. Moderate diversity was observed in most locations (Table 1). Berger-Parker Dominance (1/d) expresses proportional importance of most abundant species and higher the value, lesser the dominance of the most abundant species. Berger-Parker Dominance (1/d) showed value between 2.19 and 4.83, indicating no over dominance among the species observed. Hill's abundance index (H1) ranged between 10.30 at Sambalpur and 29.50 at Almora. This indicated moderate abundance of coccinellids in rice ecosystems. Margalef richness index ranged from 9.07 to 14.00 while the species richness directly measured by Hills number H0 ranged from 5-10, with highest species richness present at Malan, Himachal Pradesh. Coccinellid communities usually consist of a few dominant and several less common and even rare species. Some communities, including those in agricultural crops, are species poor, although abundant in terms of the number of individuals (Honek *et al.*, 2016). Changes in coccinellid communities in rice ecosystem are due to agricultural practice, habitat deterioration, invasion of non-native species and climate change (Honek *et al.*, 2017).

The biology and development of five major coccinellid species namely, *H. octomaculata*, *C. sexmaculata*, *C. transversalis*, *P. dissecta* and *M. discolor* on the brown planthopper revealed that all species could complete their lifecycle successfully on this pest (Table 2) indicating that it was a suitable prey for coccinellid species tested. However, only *H. octomaculata* grubs could feed and survive only on

BPH while the first and early second instars of *C. transversalis* and *P. dissecta* required aphids for survival. Assessing the prey and non-prey food spectrum of the Coccinellidae, is essential to the understanding of this group, and for their application as biological control agents (Weber and Lundgren, 2009). Many reports record *C. sexmaculata*, *C. transversalis* and *P. dissecta* as aphidophagous predators and they appear to be opportunistic feeders on rice hoppers, migrating from weeds that host aphids (Lydia *et al.*, 2012). Opportunistic species of lady beetles vary in their preferences (Evans, 2009). However, Parasuraman (1989) reported that eight species of predatory coccinellid was found on BPH and GLH in rice and Vinothkumar (2013) found positive correlations between coccinellid number and rice hopper reduction.

Comparative study on the feeding efficiency of different coccinellids on hopper pests of rice revealed variation in their voracity. Highest predation was observed in female *H. octomaculata* which fed on a maximum of 8.00, 7.42 and 6.59 BPH, WBPH and GLH respectively, while *P. dissecta* fed lowest on 3.18 to 4.50 hoppers per day (Table 3). Among all coccinellids, *H. octomaculata* was the most voracious on hopper pests and amenable for rearing. This species can therefore be utilised for augmentation and applied biological control of hoppers. *C. transversalis* though fed on BPH, WBPH and GLH in the laboratory, required aphids for survival. Coccinellid predation on hoppers has been recorded by many workers (Samal and Misra, 1982; Garg and Sethi, 1983). Some species are of regional importance like

Table 1. Biodiversity of coccinellids of rice ecosystems

Location	State	Simpsons Diversity (1/l)	Margalef M Base 10.	Hill's Number H0	Hill's Number H1	Berger-Parker Dominance (1/d)
Almora-HR	Uttarakhand	10.22	10.14	9.00	29.50	4.80
Hyderabad-SR	Telangana	4.76	9.07	8.00	17.01	2.50
Jeypore-NR	Odisha	9.50	10.95	9.00	26.91	3.80
Kalimpong-NR	West Bengal	8.50	11.15	9.00	24.61	4.50
Kampasagar-SR	Telangana	6.67	11.63	8.00	20.54	2.67
Kaul-NR	Haryana	9.17	13.44	8.00	22.17	2.75
Ludhiana-NR	Punjab	8.11	10.02	8.00	23.94	4.17
Malan-HR	Himachal Pradesh	8.64	9.57	10.00	28.52	4.83
Maruteru-SR	Andhra Pradesh	4.16	9.07	7.00	15.35	2.19
Mudigere-SR	Karnataka	11.25	14.00	6.00	17.97	5.00
Navasari-NR	Gujarat	9.17	13.44	6.00	17.26	3.67
Nawagam-NR	Gujarat	8.25	12.97	7.00	19.13	3.00
Pattambi-SR	Kerala	5.00	10.76	7.00	15.65	2.50
Pusa-NR	Bihar	4.47	10.59	6.00	12.88	2.63
Sambalpur-NR	Odisha	4.04	11.90	5.00	10.30	2.50

HR- Hill region; SR-Southern region; NR-Northern region

Table 2. Developmental period of coccinellids on brown planthopper, *Nilaparvata lugens* Stal

Life stages of coccinellids on BPH	<i>Harmonia octomaculata</i>	<i>Cheilomenes sexmaculata</i>	<i>Coccinella transversalis</i>	<i>Propylea dissecta</i>	<i>Micraspis discolor</i>
Total development duration (days)	32 ± 0.50	31.45 ± 1.96	24.17±1.15	14.68±1.21	23.1 ± 0.33
Egg	07 ± 0.20	04.42 ± 0.50	03.87±0.56	02.10±0.05	4.11 ± 0.52
I instar*	03 ± 0.10	02.11 ± 0.36	01.18±1.08	01.13±0.85	2.78 ± 1.05
II instar	04 ± 0.58	05.58 ± 0.43	03.36±0.83	01.87±0.93	3.43 ± 0.78
III instar	06 ± 0.66	06.88 ± 1.12	05.33±0.75	02.35±1.10	4.57 ± 0.77
IV instar	07 ± 0.85	04.58 ± 0.50	04.21±0.50	01.90±0.76	4.83 ± 0.93
Pupal period	05 ± 0.12	07.00 ± 0.45	06.22±0.43	05.32±1.16	4.20 ± 0.50

*First and early second instars of *C. sexmaculata*, *C. transversalis* and *P. dissecta* required aphids for survival

Table 3. Predatory potential of coccinellids of rice fields on the three hopper species in the laboratory

Coccinellid species	Prey species fed per day		
	BPH	WBPH	GLH
<i>Harmonia octomaculata</i>			
Adult Female ♀	8.00 ± 2.61	7.42 ± 0.78	6.59±1.12
Adult male ♂	6.93 ± 1.49	7.36 ±1.50	5.42±1.36
III instar	3.06 ± 1.03	3.86 ±0.97	2.83±0.97
<i>Cheilomenes sexmaculata</i>			
Adult Female ♀	4.60 ± 0.69	3.87±0.72	4.47 ±0.93
Adult male ♂	2.35 ± 0.45	3.12±0.50	3.14± 0.31
III instar	1.16 ±0.78	2.40±0.43	1.56 ±1.12
<i>Coccinella transversalis</i>			
Adult Female ♀	5.65±2.06	6.15±2.12	4.30±1.07
Adult male ♂	4.50±1.64	5.25±2.10	3.89±1.85
III instar	5.40±2.14	4.78±1.18	3.58±2.11
<i>Micraspis discolor</i>			
Adult Female ♀	5.87±2.27	5.93±1.77	4.74±1.32
Adult male ♂	5.52±2.11	5.15±2.22	4.12±1.07
III instar	4.10±1.67	4.47±1.56	3.77±2.13
<i>Propylea dissecta</i>			
Adult Female ♀	4.50±1.85	4.13±2.17	3.87±1.33
Adult male ♂	3.73±1.25	3.18±1.09	3.33±1.87
III instar	3.92±1.92	3.42±2.56	2.77±1.11

Stethorus sp. which can be multiplied and augmented for management of leaf mite, *Oligonychus oryzae* (Hirst) in locations where the pest occurs frequently. Begum *et al.*, 2002 observed that *M. discolor*, an abundantly present coccinellid of rice fields can be used as a biocontrol agent for BPH, consuming 47.6 third instar nymphs during larval development and 112.6 nymphs during 30 days as adults. The potential uses of *M. discolor*, for control of BPH has also been corroborated by other workers. Smal and Misra, 1985; Islam *et al.*, 2016). Similarly, preference of *Micraspis* for the green leafhopper over *Aphis gossypii* was reported by Rattanapun (2012). On the other hand the opportunistic feeding of this *Micraspis* sp. on hoppers was established by

Shanker *et al.*, 2013. Assessment of field predation through gut analysis revealed a spectrum of prey including pollen, thrips and green leafhopper. Choice tests however showed them to have a greater preference for pollen but also feeding opportunistically on the hopper prey offered.

CONCLUSION

Comprehensive evaluation of predatory potential of coccinellids on hopper pests has been attempted for the first time in this study. The results indicate that as group they have potential for biocontrol of hoppers and need to be conserved or augmented. Many coccinellids have been found to



Plate 1. Coccinellid diversity of rice fields: a - *Brumoides suturalis* (Fabricius), b - *Scymnus nubilus* (Mulsant), c - *Propylea dissecta* (Mulsant) d - *Coccinella transversalis* Fabricius, e - *Hippodamia variegata* (Goeze), f - *Coccinella septempunctata* (Linnaeus), g - *Oenopia sexareata* (Mulsant), h - *Harmonia octomaculata* (Fabricius), i - *Rodolia* sp., j - *Micraspis discolor* (Fabricius), k - *Stethorus* sp. and l - *Cheilomenes sexmaculata* (Fabricius)

colonize weeds at the beginning of the crop season and conservation of floral diversity in fields can help enhance natural biological control by these predators. Due to the ease of mass multiplication, coccinellids like *Harmonia octomaculata* can be utilized in biological control programmes as a part of Integrated Pest Management to manage pest outbreaks.

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