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Research Article

Diversity of coccinellid predators in upland rainfed rice ecosystem

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ABSTRACT: The diversity of coccinellids and impact of pest population on coccinellids density has been studied in the upland rainfed rice agroecosystem in Bharathy variety cultivated in different rice establishment techniques at Hybrid Rice Evaluation Centre, Tamil Nadu Agricultural University, Gudalur. The Nilgiris for three years during Kharif 2010 to Kharif 2012. Three aspects, population of coccinellids and pests in different rice establishment techniques, diversity of coccinellids species in different rice establishment techniques and impact of pest density on the population of coccinellids were studied. A total of 13 species of coccinellids were observed from four different treatments of upland rice crop at different days after transplantation. Among the coccinellids, *Cheilomenas sexmaculatus*, *Coccinella transversalis*, *B rumoides suturalis*, *Harmonia octomaculata* and *Microspia discolour* were predominant during crop season and they have significant positive correlation with the population of brown plant hopper and green leaf hopper. Regression analysis revealed that 71 percent of *C. sexmaculatua*, 89 percent of *C. transversalis*, 62 percent of *B. suturalis*, 79 percent of *H. octomaculata* and 75 percent of *M. discolour* population depends on the incidence of BPH and GLH in the upland rainfed rice ecosystem. Diversity indices revealed that diversity of coccinellids was more in the direct sown without weeding operation method than other methods.

KEY WORDS: Biodiversity, coccinellids, upland rice, rainfed rice**,** diversity indices.

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INTRODUCTION

Biodiversity of insects in forestry parlance can be summarized with two of its components species richness and evenness. The “richness” indicates the number of species present in a designated area whereas “evenness” stands for the relative abundance of each species (Vanclay, 1992). Species richness provides an extremely useful measure of diversity when a complete catalogue of species in the community is obtained (Magurran, 1988).

The coccinellids are predators of a variety of pests *viz*., aphids, leaf-hoppers, scale insects, mealybugs, mites and other softbodied insects (Omkar and Bind, 1996). Some are specific in their food choice, while many are polyphagus. The family Coccinellidae comprises 5,200 described species worldwide (Hawkeswood, 1987). A survey of the available literature revealed only a few studies on the species composition of coccinellid beetles in India with no specific mention about the previous records from, rainfed upland rice agroecosystem. However, Poorani (2002) have listed 400 species of coccinellids from Indian sub region, which includes the erstwhile state of Tamil Nadu. Joshi and Sharma (2008) recently have reported 31 species of coccinellid beetles with 19 new records from district Haridwar, India. Arthropod pest and predator populations in rice fields are intimately associated with each other (Settle *et al*., 1996). A lot of ecological research has been done on this and many scientific publications brought out on the occurrence, abundance, and diversity of arthropods, besides the variations due to topography, geographical conditions, and weather conditions (e.g., Landis *et al.*, 2000; Juen *et al.*, 2003). Yet, there has been few studies demonstrating how the abundance and diversity of arthropod pests and predators on the high altitude rain fed rice ecosystem. The present work on coccinellids was mainly aimed towards determining the number of coccinellids species, their prevalence and relative abundance in different planting methods of high altitude rain fed rice agro ecosystem.

MATERIALS AND METHODS

The present study was carried out in the rice variety Bharathy cultivated at the Hybrid Rice Evaluation Centre, Tamil Nadu Agricultural University, Gudalur an altitude of 1350 m above MSL. Nilgiri District, Tamilnadu during Kharif 2010 to Kharif 2012. It has sub tropical climate having three main seasons *viz.,* Monsoon season

(Kharif), from June till October/ November, the cool dry winter (Rabi) from October/November to January /February and the hot dry season (Summer) from February /March till the onset of rains. Temperature ranges from minimum of 4–18°C to maximum 20–32°C with a relative humidity 35– 65% to 70–100%. Annual precipitation is 2182.5 mm. Ninety percent of the precipitation takes place within four months, i.e., from June to September, July and August being the rainiest month.

The observations were made in the rice fields at four different establishment techniques, namely transplantation with weeding operation, direct seed sowing with weeding operation, transplantation without weeding operation, and direct seed sowing without weeding operation (4 treatments). Crop was established in an area of 50 cent (10 m x 5 m) for each technique. The observations were made once in a week starting from 30 days after transplanting (DAT) up to the harvest of the crop. The number of coccinellids and pests found in the field was sampled through net sweeping and visual observations. The number of sweeps (ten times) was uniformly maintained in all the treatments. Other management practice such as fertilizer application was followed uniformly for all the treatments as per the crop production guide (2005) except plant protection measures. Data on different days after treatments were polled together and the mean was taken for analysis. Pearson's correlation coefficient was used to determine the association between the coccinellids and pests. The SPSS software (Version 16.0) was used for the data analysis. Diversity indices (species richness, evenness and diversity) were calculated by using the formulae given below.

Species richness

Margalef index $R = \frac{S-1}{\ln(n)}$ Margalef, 1958

Diversity index

Simpson index $\lambda = \sum_{i=1}^{s} Pi^2$ Simpson,1949

Hunter-Gaston index $D = \frac{\sum ni(ni-1)}{N(N-1)}$ Simpson, 1949 Hunter-Gaston, 1988

Shannon Diversity index $H' = -\sum_{i=1}^{s} (Pi)(\ln(Pi))$ Shannon, 1948 Shannon and Weaver, 1949

Evenness index

Alatalo Evenness index $E_1 = \frac{(1/\lambda)-1}{e^{H'}-1}$ Alatalo, 1981

Pielou Evenness index $E_2 = \frac{H'}{Log_2(S)}$ Pielou, 1966

Shannon – Weaver index $E_3 = \frac{H'}{\ln(S)}$ Shannon and Weaver, 1949

Where,

S – Total number of species in a community, n – Total number of individuals observed, P_i – Proportion of individuals belonging to the i^{th} species.

RESULTS AND DISCUSSION

A total of 11 species of coccinellids *viz*., *Chilomenes sexmaculat* Fab., *Coccinella transversalis* Fab., *Brumoides suturalis* Fab., *Hormonia octomaculata* Fab., *Chilocorus nigritus* Fab., *Micraspis discolor* Fab., *Micraspis* spp., *Illeis indica* Timberlake, *Scymnus nubilus* Mulsant, *Propylea dissecta* Mulsant, and *Rodolia breviuscula* Weise were observed from four different treatments of upland rice crop during Kharif 2010 at different days after transplantations. During Kharif 2011 and 2012, a total of 13 species of coccinellids *viz*., *C. sexmaculata*, *C. transversalis*, *B. suturalis*, *H. octomaculata*, *C. nigritus*, *M. discolor*, *Micraspis* spp., *I. indica*, *S. nubilus*, *P. dissecta*, *R. breviuscula*, *Rodollia concdor* Lewis and *Scymnus coniferarum* Crotch were observed from four different treatments of upland rice crop at different days after transplantations.

The population of coccinellids in different establishment techniques of rice during different years were given in Table 1. The results indicated that *C. sexmaculata*, *C. transversalis*, *B. suturalis*, *H. octomaculata*, and *M. discolor* were the major coccinellid species observed throughout the study period in all the establishment techniques. During Kharif 2010, coccinellid population was more at direct sown crop than transplanted crop. The population of predominant species of coccinellid *C. sexmaculata* was more in the direct sown crop without weeding (4.00 per ten plants) followed by direct sown crop with weeding (3.43 per ten plants), transplanting without weeding (2.80 per ten plants) and transplanting with weeding (2.20 per ten plants) (Table 1). Whereas during Kharif 2011 the population of *C. sexmaculata* was highest in the direct sown crop with weeding (4.23 per ten plants), but during Kharif 2012 *C. sexmaculata* was more at direct sown crop without weeding (3.71 per ten plants). Same trend was observed in the incidence of other species of coccinellid also. Generally, the incidence of coccinellid was more at direct sown crop than transplanted crop invariable of weeding.

The incidence of pests *viz*. brown plant hopper (BPH), *Nilaparvata lugens* Stal, green leaf hopper (GLH), *Nephotettix virescens* Distant, white backed

Table 1. Coccinellid population in different establishment technique of upland rice ecosystem

Coccinellid Sp	Transplanting with weeding			Direct seed sowing with weeding			Transplanting without weeding			Direct seed sowing without weeding		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Chilomenes sexmaculatus	2.20	2.80	2.40	3.43	4.29	3.57	2.80	3.60	3.00	4.00	4.14	3.71
Coccinella transversalis	1.60	2.40	1.80	1.86	2.57	2.00	1.80	2.40	1.20	2.14	3.47	2.86
Brumoides suturalis	1.80	2.00	1.80	3.29	3.86	3.71	3.00	3.20	2.60	3.43	4.14	3.57
Harmonia octomaculata	0.80	2.00	1.20	2.14	2.86	2.71	1.40	2.40	1.00	2.43	3.14	2.71
Chilocorus nigrita	0.80	0.20	0.60	1.57	1.14	1.29	1.20	0.80	1.00	2.00	1.43	1.71
Micraspis discolor	0.40	0.80	0.40	1.00	1.86	1.57	0.80	1.20	0.40	1.14	2.00	1.86
Micraspis spp.	0.00	0.00	0.20	0.43	0.00	0.29	0.40	0.00	0.40	0.43	0.86	0.00
Illeis indica	0.00	0.20	0.20	0.29	0.43	0.00	0.20	0.20	0.00	0.00	0.43	0.29
Scymnus nubilus	0.20	0.00	0.00	0.57	0.43	0.43	0.20	0.00	0.40	0.43	0.86	0.71
Propylea dissecta	0.00	0.00	0.00	0.43	0.00	0.14	0.00	0.00	0.20	0.14	0.71	0.86
Rodolia breviuscula	0.00	0.00	0.00	0.29	0.14	0.00	0.00	0.00	0.00	0.57	0.86	0.14
Rodollia concolor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.43	0.57
Scymnus coniferarum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.29

plant hopper (WBPH) *Sogatella furcifera* Horvath, rice aphids, *Rhopalosiphum padi* L., and rice thrips, *Haplothrips* sp., in different establishment techniques were recorded and presented in Table 2. The population of coccinellids was correlated with pest population. Correlation matrix showing the relationship between the coccinellids and pest population was furnished in Table 3. The results infer that population of BPH and GLH showed significant positive correlation on *C. sexmaculata* population with a correlation coefficient (r) of 0.707 and 0.634 respectively. The result of multiple regression analysis showed a R^2 value of 0.71 indicating that 71 percent of the variation in *C. sexmaculata* population was influenced by population of BPH and GLH. The multiple regression equation fitted with pest population to predict the *C. sexmaculata* population is $Y = 1.24 + 0.12\ X_1 + 0.06\ X_2$ where, X_1 - population of BPH, X_2 - population of GLH. The impact of pest population on *C. transversalis* was similar as that of *C. sexmaculata*. The results of multiple regression analysis showed a R^2 value of 0.89 indicating that 89 percent of the variation in *C. transversalis* population was influenced by population BPH and GLH. The multiple regression equation fitted with pest population to predict the *C. transversalis* population is $Y = –0.10 + 0.09\ X_1 + 0.13\ X_2$ where, X_1 – population of BPH, X_2 – population of GLH.

The population of *B. suturalis*, *H. octomaculata*, and *M. discolor* exerted a significant positive association

Table 2. Pest population in different establishment techniques of upland rice ecosystem

Pests	Transplanting with weeding			Direct seed sowing with weeding			Transplanting without weeding			Direct seed sowing without weeding		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Nilaparvata lugens Stal	8.92	14.26	9.72	10.92	16.37	11.26	10.27	15.32	11.20	11.37	18.62	12.87
Nephotettix virescens Distant	5.10	8.82	7.28	5.39	9.54	8.24	8.64	10.08	4.92	9.24	12.37	8.27
Sogatella furcifera Horvath	2.17	5.87	3.92	2.84	6.37	4.39	2.57	6.02	4.22	2.62	4.37	4.24
Rhopalosiphum padi L.,	0.00	0.00	0.00	0.00	0.00	0.00	2.87	0.00	1.64	3.27	0.00	2.62
Haplothrips sp.,	3.92	2.12	4.18	4.24	2.37	4.37	4.64	3.64	5.82	5.32	3.81	6.42

Table 3. Correlation matrix between Coccinellids and sucking pests found in the field

Coccinellid species	BPH	GLH	WBPH	Aphids	Thrips
Chilomenes sexmaculatus	0.707*	0.634*	0.386	0.114	0.009
Coccinella transversalis	0.842**	0.847**	0.443	-0.111	-0.233
Brumoides suturalis	0.594*	0.587*	0.209	0.160	0.137
Harmonia octomaculata	0.751**	0.750**	0.470	-0.068	-0.150
Chilocorus nigrita	0.018	0.144	-0.420	0.570	0.607*
Micraspis discolor	0.729**	0.707*	0.411	-0.010	-0.053
Micraspis spp.	0.171	0.252	-0.373	0.153	0.248
Illeis indica	0.705*	0.536	0.439	-0.260	-0.377
*Scymnus nubilus*t	0.350	0.207	-0.161	0.201	0.400
Propylea dissecta	0.324	0.194	-0.097	0.202	0.498
Rodolia breviuscula	0.505	0.539	-0.163	0.122	0.077
Rodollia concolor	0.551	0.508	0.275	0.089	0.278
Scymnus coniferarum	0.609*	0.565	0.060	0.006	0.159

BPH – Brown plant hopper, GLH – Green leaf hopper, WBPH – White backed plant hopper
* – significant at 5% level, ** – significant at 1% level,

with BPH (r = 0.594, 0.751, 0.729, respectively) and GLH (r = 0.587, 0.750, 0.707, respectively). The results of multiple regression analysis showed a R^2 value of 0.62, 0.79, 0.75, respectively for *B. suturalis*, *H. octomaculata*, and *M. discolor* indicating that 62, 79 and 75 percent of the population variation in *B. suturalis*, *H. octomaculata*, and *M. discolor* population was influenced by population BPH and GLH. The multiple regression equation fitted with pest population to predict the *B. suturalis*, *H. octomaculata*, and *M. discolor* population is $Y = 0.91 + 0.09 X_1 + 0.11 X_2$, $Y = –0.54 + 0.11 X_1 + 0.15 X_2$, $Y = –0.78 + 0.09 X_1 + 0.09 X_2$, respectively. where, X_1 - population of BPH, X_2 – population of GLH. Correlation between *I.indica* and *S. coniferarum* population and pest population revealed that the population of BPH had significant positive association with *I. indica* (r = 0.705) and *S. coniferarum* (r = 0.609). However the impact of GLH and other sucking pests was not significant. The results of multiple regression analysis showed a R^2 value of 0.70 and 0.60 indicating that 70 and 60 percent of the variation in *I. indica* and *S. coniferarum* population was influenced by population of BPH. The multiple regression equation fitted with pest population to predict the *I. indica* and *S. coniferarum* population is $Y = –0.29 + 0.04X_1$ and $Y = –0.38 + 0.04 X_1$, respectively, where, X_1 - population of BPH. The population of thrips showed significant positive impact on the population of *C. nigritus* with a correlation coefficient (r) of 0.607. However the impact of BPH, GLH and WBPH was not significant. The result of multiple regression analysis showed a R^2 value of 0.60 indicating that 60 percent of the variation in *C. nigritus* population was influenced by population of rice thrips. The multiple regression equation fitted with pest population to predict the *C. nigritus* population is $Y = 0.11 + 0.24 X_5$ where, X_5 – population of thrips. The impact of pest population on all other coccinellid species was not significant (Table 3).

Results of the diversity index were furnished in the Table 4. The diversity indices revealed that the species richness was more in the direct sown without weeding upland rice agro-ecosystem and also posses more Morgalef index value compared to other methods. Species diversity was more in the direct sowing without weeding crop by registering low Simpson and Hunter-Gaston Index and high Shanon diversity index than other methods. The results of evenness indices revealed that, there is no significant difference in the evenness of the coccinellid species among the different methods of crop establishment techniques (treatments). Hence, it infers that the diversity of coccinellids was more in the direct sown method than transplanting method, weeds will support the growth and abundance of the coccinellids by acting as alternate host.

The study revealed that a total of 13 different species of coccinellid were recorded in the four different crop

Table 4. Coccinellid diversity in different establishment techniques of upland rice ecosystem

Year	S	R	D	ë	H'	E_1	E_2	E_3
Transplanting with weeding								
2010	7	2.92	0.08	0.20	1.73	0.86	0.62	0.89
2011	7	2.56	0.12	0.21	1.68	0.89	0.60	0.86
2012	8	3.25	0.09	0.19	1.79	0.84	0.60	0.86
Direct sowing with weeding								
2010	11	3.67	0.09	0.15	2.08	0.81	0.60	0.87
2011	9	2.79	0.12	0.17	1.89	0.86	0.60	0.86
2012	9	2.90	0.11	0.17	1.89	0.86	0.60	0.86
Transplanting without weeding								
2010	9	3.24	0.10	0.17	1.90	0.83	0.60	0.86
2011	8	2.64	0.12	0.18	1.82	0.86	0.61	0.87
2012	9	3.44	0.10	0.19	1.87	0.78	0.59	0.85
Direct sowing without weeding								
2010	10	3.20	0.10	0.16	1.99	0.84	0.60	0.87
2011	13	3.83	0.08	0.12	2.27	0.81	0.61	0.89
2012	12	3.72	0.09	0.13	2.16	0.84	0.60	0.87

S – Number of species, R – Margalef Species richness index, D – Hunter-Gaston Diversity index,
ë – Simpson Diversity index, H' – Shanon Diversity index, E1 – Alatalo Evenness index,
E2 – Pielou Evenness index, E3 – Shanon – Weaver Evenness index

establishment techniques of rainfed upland rice ecosystem. BPH is the most favourite host for the coccinellids in the rice ecosystem and diversity and species richness was more in the direct sown rice crop without weeding operation. Our results in accordance with Gray's (1989) who postulated that in habitats affected by increased disturbance, diversity should decrease; opportunist species should gain dominance and mean size of the dominant species decrease. Our results corroborate this hypothesis to some extent. Weeding is the major operation where we more disturbances were done to the biodiversity, crop with more weeds naturally harboured more insect species diversity. A total of eight species of coccinellids were recorded in rice ecosystem during Kharif 2000. In partially weeded plot, all the eight species were present, where as in weeded plot, five taxa were recorded. The coccinellids showed more abundance in partially weeded plot than in weeded plot (Kandibane *et al*., 2006).

In this study, overall population of coccinellids in four different techniques were also computed and the results indicated that the direct seed sowing without weeding operation method harbouring more coccinellids. Hence this technique can be adopted as the important technique for upland rice establishment. Further, these techniques provide favourable micro-climate for coccinellid survival by preventing mortality from heavy rainfall. This could be the reason for the more number of coccinellids in the field. Moreover the coccinellids can move around and to capture the prey easily. The nature of feeding habits of any animal depends on the nature of the food availability. The results clearly indicated that the number of coccinellids depends on the availability of the pest. Our findings support the hypothesis that the population of the coccinellids proportionately increased with the population of prey. Parasuraman (1989) reported that eight species of predatory coccinellid was found on BPH and GLH in rice. The ladybird beetles migrated between various crop fields throughout the season depending upon the availability of prey and habitat disturbance (Maredia *et al*., 1992). According to Riechert and Bishop (1990), the increase in predator density could decrease the pest population and pest damage. Thus coccinellids serve as buffer in the upland rice establishment techniques and limit the exponential growth of prey population in all the technique.

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