The Ecoscan 8(1&2): 53-57, 2014
AN INTERNATIONAL BIANNUAL JOURNAL OF ENVIRONMENTAL SCIENCES

BIODIVERSITY AND SEASONALITY OF PREDACEOUS COCCINELLIDS (COLEOPTERA: COCCINELLIDAE) IN MANGO AGRO-ECOSYSTEM OF JHARKHAND

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ABSTRACT

Coccinellids are the major natural enemies of many sucking pest in agro-ecosystems. A total of 2301 specimens of predaceous coccinellids were collected and identified to 16 species, of which 7 were recorded for the first time from Jharkhand, belonging to two sub families of family coccinllidae. *Anegleis cardoni, Cheilomenes sexmaculata* and *Illeis indica* were found most frequent and abundant. When species diversity was compared among different locations and it was found that Shannon-Wiener diversity index varied from 2.126 to 1.376 indicated that species were less diverse but were frequently present. Peak population of coccinellids in mango orchards of region was recorded in the month of February and March. Thus, these results are discussed with current thinking of coccinellids as an important part of integrated pest management in mango orchards of region.

KEY WORDS
Biodiversity
Coccinellids
Mango
Predaceous

Received : 03.02.2014
Revised : 28.04.2014
Accepted : 26.05.2014

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INTRODUCTION

The coccinellids are commonly referred to as ladybirds (Britain, Australia, South Africa), ladybugs (North America) or ladybeetles (various countries). Coccinellids have received considerable attention by the insect pest management specialists because of their role as predator of agriculturally important insect pest. Numerous species of coccinellids are predators of hemipteran pests such as aphids, mealybugs and scale insects, as well as thrips (Thysonoptera) and mites (Acarina) in different parts of the world (Hawkeswood, 1987; Majerus, 1994). Poorani (2004) has listed 400 species of Coccinellids from Indian region, which includes the 9 species of coccinellids from erstwhile state of Bihar including Jharkhand. The coccinellid fauna of the Indian subcontinent is rich and diverse, but remains very poorly studied as compared to those from other zoogeographical regions of the world. The prey consumption capacity of coccinellids is directly dependent upon their density in the natural habitat (Ramanand and Roy, 2008). The consumption rates by predators are a function of the quantitative and qualitative state of the prey in their ambient habitat. As the density of prey increases, the predation increases accordingly. The rate of predation and species diversity of coccinellid community is also influenced by plant community structure and microclimate (Tooker and Hanks, 2000). This is because of different species of ladybird exhibit a preference for specific vegetation types coupled with suitable food in sufficient abundance. Habitat preference by coccinellids varies seasonally as the changes in microclimatic characteristics influence the distribution of prey populations (Hawkeswood, 1987). The presence of predatory coccinellids and their diversity in ecosystems also depends on the associated prey insect and more particularly to the locality (Rekha *et al.,* 2007). Mango, like most fruit crops, is usually attacked by two or three major pests, several secondary pests, and a large number of occasional pests in localized areas where it is grown. Of approximately 260 species of insects and mites that have been recorded as minor and major pests of mango, 87 are fruit feeders, 127 are foliage feeders, 36 feed on the inflorescence, 33 inhabit buds and 25 feed on branches and trunk (Pena, 1997). Out of these few sucking pests are major problem in the Jharkhand, a part of Chotanagpur plateau.

At present, no information is available on the presence of the coccinellids in mango orchards and their role as bio-control agent of mango pests in eastern plateau and hill region is available. The diverse prey capture strategies and microhabitat exploitation of different species would exert predation pressure on variety of mango pests. Therefore study was undertaken with objectives to investigate the species diversity of coccinellids in mango ecosystem and to know the seasonal population dynamics of coccinellids in relation to weather fluctuation in the Jharkhand.

Table 1: Study locations of biodiversity and seasonality of coccinellids

S. No.	Study site	Location (s)	Latitude DM	Longitude DM	Elevation m (asml)	Number of mango plants	Age of mango orchards
1.	Ranchi	Churu	23° 452 N	85° 302 E	620	1250	15-20
		Plandu	23° 172 N	85° 242 E	649	857	15-25
		Ramakrishna mission ashram	23° 26′N	85° 32′E	590	100	10
2.	Lohardaga	Birendra Prasad mango orchard	23° 25′N	84° 40′E	542	125	25
3.	Gumla	Mr. Kerketta mango farm	22° 52′N	84° 51′E	560	500	5-8
		Farmers mango orchard, Marda	22° 48′N	84° 21′E	571	700	7-9
4.	Khunti	Farmers mango orchard, Giarappa	23° 09′N	85° 16′E	631	100	10-12

Table 2: Coccinellid species captured across the region

Name of Species	Total number of individual captured				Mean no. of individual/ month/quadrat
	Ranchi	Lohardaga	Gumla	Khunti	
Anegleis cardoni (Weise)	616	58	68	56	39.9
Cheilomenes sexmaculata (Fabricius)	468	20	30	25	27.15
Illeis indica Timberlake	224	10	12	10	12.8
Megalocaria dilatata (Fabricius)	82	0	6	8	4.8
Phrynocaria unicolor (Fabricius)	82	6	0	8	4.7
Cryptogonus orbiculus (Gyllenhal)	76	7	6	7	4.5
Chilocorus melas Weise	56	2	3	3	3.2
Coccinella septempunctata Linnaeus	57	0	4	3	3.0
Psyllobora bisoctonotata (Mulsant)	58	0	3	3	1.6
Brumoides suturalis (Fabricius)	32	0	0	0	1.9
Pharoscymnus horni (Weise)	31	0	0	1	2.0
Chilocorus nigrita (Fabricius)	32	0	0	0	2.1
Micraspis discolor (Fabricius)	30	1	0	1	1.7
Ortalia quadripunctata Gorham	30	0	1	1	1.4
Ortalia dohrni Gorham	30	1	1	0	1.2
Rodolia breviuscula Weise	31	0	0	1	1.6
Total number of species	16	10	8	13	
Total number of individuals	1935	105	134	127	2301

MATERIALS AND METHODS

Study Area

The present study was carried out in the mango orchards at Ranchi Gumla, Khunti and Lohardagha of Jharkhand state of India (Table 1). The random collection of adult coccinellids was carried out from each mango orchard as a quadrant.

Methodology

Adults of coccinellids beetles were collected randomly by "Sweep Sampling Method" as per Gadakar *et al*. (1990), aspirator and hand picking depending upon height of mango trees during February, 2011 to June, 2012. One hundred randomly selected plants from each orchard were sampled once a week and total population per month was counted. Adult beetles belonging to Coccinellidae (Insect family) were collected in our samples. All specimens were preserved and identified to species level using taxonomic keys (Omkar and Bind, 1996; Omkar and Pervez, 2000; Poorani, 2004). The population of coccinellids were counted by using the method described in Manual for Mango Pest Surveillance (NICRA team of Mango Pest Surveillance, 2012).

Statistical analysis

The data were analysed statistically to calculate the quantitative characters *viz*. Relative Frequency (RF) and Relative Density (RD) of the coccenllids community using the formula given by Cottom and Curtis (1956).

Diversity indices

Various diversity indices were studied to understand the diversity of community in space and time.

Species richness (S)

Number of species in a quadrat or habitat.

Species diversity index

The simplest species richness index is based on the total number of species (S) and the total number of individuals of all species (N) in a quadrat or habitat. Margalef's richness index: It was calculated by given formula of Margalef (1968)

$Da = (S-1)/\log_e N$

Da = Margalef's richness index

Shannon-Wiener diversity index (H^1): This index (Shannon and Weiner, 1963) was used to determine the species diversity.

Table 3: Quantitative characteristics of coccinellid species in mango agro-ecosystem of the Jharkhand region

Coccinellid species	Ranchi		Lohardaga		Gumla		Khunti	
	RF	RA	RF	RA	RF	RA	RF	RA
Anegleis cardoni	31.835	22.851	50.746	2.523	55.238	2.152	44.094	2.077
Cheilomenes sexmaculata	24.186	17.361	22.388	1.113	19.048	0.742	19.685	0.927
Illeis indica	11.576	8.310	8.955	0.445	9.524	0.371	7.874	0.371
Megalocaria dilatata	4.238	4.056	4.478	0.297	0.000	0.000	6.299	0.396
Phrynocaria unicolor	4.238	4.056	0.000	0.000	5.714	0.297	6.299	0.396
Cryptogonus orbiculus	3.928	2.819	4.478	0.223	6.667	0.260	5.512	0.260
Chilocorus melas	2.894	2.077	2.239	0.111	1.905	0.074	2.362	0.111
Coccinella septempumctata	2.946	2.819	2.985	0.198	0.000	0.000	2.362	0.148
Psyllobora bisoctonotata	2.997	2.869	2.239	0.148	0.000	0.000	2.362	0.148
Brumoides suturalis	1.654	4.748	0.000	0.000	0.000	0.000	0.000	0.000
Pharoscymnus horni	1.602	2.300	0.000	0.000	0.000	0.000	0.787	0.074
Chilocorus nigrita	1.654	4.748	0.000	0.000	0.000	0.000	0.000	0.000
Micraspis discolor	1.550	1.484	0.000	0.000	0.952	0.049	0.787	0.049
Ortalia quardipunctata	1.550	1.484	0.746	0.049	0.000	0.000	0.787	0.049
Ortalia dohrni	1.550	1.484	0.746	0.049	0.952	0.049	0.000	0.000
Rodolia breviuscula	1.602	2.300	0.000	0.000	0.000	0.000	0.787	0.074

Table 4: Parameters of abundance of coccinellids in mango agro-ecosystem of the Jharkhand region during 2011-2012.

Regions	Diversity indices					
	N	S	H′	Da	E	D
Ranchi	1935	16	2.126	1.982	0.766	0.635
Lohardaga	134	10	1.522	1.838	0.661	0.366
Gumla	105	8	1.376	1.504	0.663	0.294
Khunti	127	13	1.807	2.477	0.704	0.507

N = Total number of individuals, S = Numbers of species, H′ = Shannon-Wiener diversity index, Da = Margalef's richness index, D = Dominance index, E = Evenness index

$H^1 = \text{“}n_i/N \ln n_i/N$

Species evenness index (E): This was calculated as per Pielou (1975)

$EI = H^1/\ln N$

Species dominance index (D)

This was calculated as per Simpson (1949).

RESULTS AND DISCUSSION

All the coccinellids collected from four locations are listed in Table 2. A total of 2301 specimens representing 16 different species of coccinellid beetles were collected from different locations of the Jharkhand. The identified species belong to three tribes from two sub families of family Coccinellidae. The dominating tribe was Coccinellini with seven species of sub family of Coccinellinae. Similarly, the tribe Chilocorini (sub family- Chilocorinae) had three species followed by tribe Psylloborini (sub family- Coccinellinae) with only one species. Of these 16 species; seven new coccinellids species (*Illeis indica, Megalocaria dilatata, Phrynocaria unicolor, Cryptogonus orbiculus, Psyllobora bisoctonotata, Brumoides suturalis* and *Chilocorus nigrita*) have been reported first time from the Jharkhand region (Poorani, 2004). *Anegleis cardoni* (Weise) was most predominate lady beetle (39. 90 individual/ month/ quadrant) followed by *Cheilomenes sexmaculata* (Fabricius) and *Illeis indica* Timberlake with 27.15 and 12.8 individual/ month/ quadrant, respectively in the mango orchards of the region (Table 2). The occurrence of species and the richness of coccinellid communities varied from year to year and from locality to locality (Table 5). Seasonal variation in coccinellid can be attributed to availability of sufficient food resources, climatic conditions and plant density (Rekha *et al*., 2007).

The parameters for coccinellids communities' analysis *i.e.* relative frequency and relative density are presented in Table 3. Relative frequency of the coccinellids communities ranged from 1.550 to 31.835 i.e. of all the species, chance of occurrence of *O. quadripunctata* & *M. discolor* was least and *A. cardoni* occurred most in the mango orchard of Ranchi. Similar pattern of relative frequency of species observed from other location also. Species abundance did not give a total picture of the numerical strength of a species because it considers only the quadrats of species occurrence. Therefore relative values to total abundance for all the species in all sampled quadrats are indicative of actual numerical strength of a species. In the present study, *B. suturalis*, *P. horni, M. discolor* and *C. nigrita* recorded negligible to lowest while *A. cardoni* and *C. sexmaculata* had highest relative abundance among species from different locations (Table 3). The perusal of data presented in Table 3 indicated that *A. cardoni, C. sexmaculata* and *I. indica* were found most frequent and abundant. The difference could be attributed to the agro-ecological and biological factors of locations on species (Kedar *et al.,* 2011). The relative abundance of coccinellids species may also be influenced by inter-specific competition (Charanasri and Nishida, 1975).

Out of numerous indices formulated by different workers for diversity study, the commonly used diversity indices were adopted and data pertaining to species abundance of the coccinellids in mango orchards of Jharkhand is presented in Table 4. Total number of species recorded from orchards varied

Table 5: Seasonal population dynamics (Mean coccinellids/m² area) of coccinellids in different region of Jharkhand

Observation period	Ranchi		Lohardaga		Gumla		Khunti	
	2011	2012	2011	2012	2011	2012	2011	2012
1st fortnight of January	DN	1.33±0.02	-	0.87±0.05	-	0.95±0.03	-	1.20±0.09
2nd fortnight of January	DN	3.11±0.04	-	1.24±0.02	-	1.97±0.05	-	2.65±0.13
1st fortnight of February	2.52±0.02	4.33±0.09	0.80±0.04	2.97±0.08	1.54±0.04	3.69±0.06	1.98±0.02	4.05±0.43
2nd fortnight of February	4.02±0.05	3.86±0.24	1.05±0.06	2.65±0.10	2.14±0.04	3.97±0.08	3.65±0.25	4.01±0.38
1st Fortnight of March	1.98±0.03	3.66±0.60	1.68±0.05	2.64±0.40	1.65±0.02	3.95±0.04	3.24±0.30	2.38±0.45
2nd Fortnight of March	1.26±0.09	2.33±0.05	1.50±0.04	1.27±0.09	1.20±0.03	2.64±0.03	1.32±0.09	2.15±0.087
1st Fortnight of April	0.3±0.01	0.54±0.02	0.98±0.02	0.37±0.008	0.40±0.008	0.34±0.009	0.4±0.008	1.67±0.13
2nd Fortnight of April	0.27±0.009	0.42±0.01	0.24±0.01	0.3±0.004	0.30±0.009	0.25±0.009	0	1.24±0.95
1st Fortnight of May	0	0.42±0.01	0	0.24±0.01	0.10±0.002	0	0	0.65±0.05
2nd Fortnight of May	0	0.21±0.009	0	0	0	0	0	0.25±0.007
1st Fortnight of June	0	0	0	0	0	0	0	0
2nd Fortnight of June	0	0	0	0	0	0	0	0

DN = Data not recorded

Table 6: Correlation between weather parameters and coccinellid population in different region of Jharkhand

Weather parameters	Temperature				Humidity		Rainfall	
	2011		2012		2011	2012	2011	2012
	Min.	Max.	Min.	Max.				
Ranchi	-0.51*	-0.21	-0.53*	-0.32	0.38	0.26	-0.18	-0.01
Lohardaga	-0.62*	-0.39	-0.74**	-0.33	0.15	-0.05	-0.20	-0.21
Gumla	-0.41	-0.48*	-0.49*	-0.50*	-0.54*	-0.38	-0.12	-0.02
Khunti	-0.48*	-0.35	-0.31	-0.16	0.30	0.16	-0.03	-0.13

*significant at $p < 0.05$, ** significant at $p < 0.001$

from 8 to 16 from different mango orchards. Shannon-Wiener diversity index (H') was found to be significant different for Ranchi orchards (2.126) to other three orchards, while no appreciable difference was noted in case of Lohardaga, Gumla and Khunti mango orchards coccinellids. This index is also an expression of community structure and complexity of a habitat.

A high index value suggests more diverse and stable community (Didham *et al.,* 1998). Margalef's richness index (Da) from all locations values were recorded from 1.504-2.477 and were found at par and it can be stated that though the species found in these mango orchards were less diverse but were frequently present. The evenness value showed that the whole of the region was evenly distributed with the dominance of a few species namely *A. cardoni* followed by *C. sexmaculata* and *I. indica*. The dominance index indicated that in Ranchi and Khunti some of the species are dominating to others but in case of Lohardaga and Gumla dominanacy is less among species (Table 4). So that species richness in a community and their evenness in abundance or equitability *i.e.* species evenness are the two parameters that define species diversity. As species are lost, diversity decreases and as species become less evenly distributed in abundance, diversity also decreases. In a diverse situations, species cannot be very dominant and in a low diversity community one or two species will be much more abundant than others (Pielou, 1975; Zahoor *et al.*, 2003; Hemchandra *et al.,* 2010).

The occurrence of species and the richness of coccinellid communities varied with time and locality. Seasonal variation was also observed in the lady beetles population (Table 5), plant density and the availability of sufficient food resources (Thalji, 2005). The peak period of lady beetles activity (second fortnight of February and first fortnight of March) generally coincided with the peak abundance of their prey (scale insect, mealy bugs, mango hoppers and thrips) in mango plant. This provides the relationship between the temporal abundance of coccinellid species and the different phenological stages of pest insects found in the ecosystem (Santos *et al.,* 2010). The maximum incidence of soft bodied insect pests i.e. scale, *Rastrococcus iceryoides* (Green); hoppers, *Amritodus atkinsoni* (Lethierry) and *Idioscopus clypealis* (Lethierry); *I. nagpurensis,* mealy bug, *Drosicha mangiferae* Green and Thrips, *Thrips hawaiiensis* (Morgan) reported between month of December to June on mango crops (Suresh and Kavitha, 2007; Kaushik *et al.,* 2012). A slight fluctuation in fortnightly collected population of coccinellid over the year was attributed to the ecological conditions i.e. climatic factors (Table 6) (Didham *et al.,* 1998; Vulinec, 2000) and type of vegetation grown (Rice and Riley, 2000) which caused the dispersal of insects within this region. A model study on coccinellids done by Skirvin *et al.* (1997) showed that pest-prey association to be most successful in moderately warm summers. The predicted maximum number of coccinellids was slightly affected by temperature, but their total number was in complex way. The greatest effect of coccinellids to reduce both maximum and total pest number was predicted to occur during relatively hot summers.

The predaceous role of lady beetles is maintained by pest population and field diversity (Iperti and Paoletti, 1999). It was also noted that the attrition of lady beetles and their predatory potential occurred may be due to indiscriminate use of pesticides. The coccinellids migrated between various ecosystems throughout the season depending upon the availability of prey and habitat disturbances (Maredia *et al.,* 1992). In the context of biological control, our results substantiate that seasonal synchrony of coccinellids with

mango sucking pests may represent an important cause of mortality of coccids, hoppers, mealy bugs and thrips (Iperti and Paoletti, 1999; Prabhakar and Roy, 2010). These beetles are density dependent predators, their numbers rise as the prey numbers increase. Thus, these results are discussed in light of current thinking with most abundant and diverse coccinellids as an important part of integrated pest management in mango orchards of region.

ACKNOWLEDGMENT

We are grateful to the Indian Council of Agricultural Research (ICAR), New Delhi, for providing financial assistance for this study under the National Initiative on Climate Resilient Agriculture on "Understanding the Changes in Host Pest Interactions and Dynamics in Mango under Climate Change Scenarios".

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