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Biodiversity of Predaceous Coccinellids and Their Role as Bioindicators in an Agro-ecosystem

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ABTSRACT

The pioneering role in the development of biological pest control has rendered the Coccinellidae of great practical and scientific interest. The species found in the agroecosysytem in terms of biodiversity can be recruited as bioindicators owing to their climatic and trophic characteristics. Two types of habitats were selected for the biodiversity study: crop area and forest area. The data obtained by trapping, hand picking and netting during May-Oct., 2002 showed the diversity, richness and evenness of Coccinellids and their role as bioindicators in this area. A total of 8119 specimens of coleopterous insects were captured out of which 4972 were the coccinellids representing 22 species. In crop area, a total of 2756 specimens were collected, in which 2027 were the coccinellids. Similarly 2945 coccinellid specimens were collected out of a total of 5363 individuals in the forest area. When diversity of both the areas was compared, it was concluded that the coccinellidae was most diverse in the forest area than crop area.

Key Words: Biodiversity; Predaceous; Coccinellids; Bioindicators; Agro-Forest area

INTRODUCTION

The word "*biodiversity*" is a contraction of biological diversity. Diversity is a concept that refers to the range of variation or differences among some set of entities; biological diversity thus refers to variety within the living world. This very broad usage, embracing many different parameters, is essentially a synonym of 'Life on Earth' (Anonymous, 2000).

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 predatory insects include beetles, true bugs, lacewings, flies, midges and wasps. Crop agroecosystems are diversified with these insect predators. Over 600 species of predators in 45 families of insects and 23 families of spiders and mites in cotton and 18 species of predatory insects (not including spiders and mites) have been found in potatoes (Hoffmann & Frodsham, 1993). Ladybugs, ladybirds, or, preferably, lady beetles have been respected through the centuries, as the vernacular indicates, for the term "lady" is in reference to biblical Mother Mary (Roache, 1960). The family to which these insects belong, the Coccinellidae, is extremely diverse in their habits. They live in all terrestrial ecosystems: tundra, forest, grassland agroecosystems and from the plains to mountains (Skaife, 1979). The majority of coccinellid species are beneficial because of their predaceous nature, but some are injurious, being phytophagous on agricultural crops. In spite of their polyphagy, adults tend to prefer certain types of food (or essential prey), which are eaten voraciously. Both the larvae and adults of the coccinellidae feed on scale insects, aphids, or other small soft-bodied creatures or their eggs (Iperti & Paoletti, 1999).

Coccinellids are also regarded as bioindicators (Iperti & Paoletti, 1999) and provide more general information about the ecosystem in which they occur (Andersen, 1999). They play their important role as biocontrol for those crops that are especially susceptible to aphid attack, namely maize, alfalfa, canola, wheat, flax, the forage crop canary seed (or canary grass), peas, apples and potatoes (Coderre, 1988; Wise *et al.,* 1995). Pesticides used in the crop fields where aphids and other preys are likely to be found cause damage to the predatory coccinellids which ultimately results in the reduction of biodiversity.

Agroforests are defined as complex agroforestry systems that look like and function as natural forest ecosystems, but are integrated into agricultural management systems (Ishizuka *et al.,* 1995). Typically, the agro-forest area consists of densely cropped and planted sites with increasing naturalness and surrounded by decreasing intensity of developmental areas. Through consistent monitoring efforts, these areas can be treated as field experiments for addressing basic ecological questions and issues related to the impact of humans on their environment (McDonnell & Pickett, 1990; Niemelä, 1999), and for the assessment of biodiversity.

The objectives of the present study were to explore the predatory ladybeetle fauna of Faisalabad, to estimate the species richness, species evenness and species diversity of coccinellids in forest agro-ecosystem and to know about the role of coccinellids as bioindicators in an agro-forest area.

MATERIALS AND METHODS

Faisalabad lies from 30°-40′ to 31°-47′ north latitudes and 72°-42′ to 73°-40′ east longitudes. The agro-forest area or commonly known "Gutwala", situated in north-east and 24 km away from the main city, was selected for the study of biodiversity. It consists of 120 acres of land under forest ecosystem that is integrated into agricultural management systems. This agro-forest area was classified into two parts i.e., crop area and forest area. In crop area different agricultural crops were marked while forest area was marked with different types of vegetations.

For comprehensive biodiversity study both areas were further divided into three parts each i.e., crop area: sugar-cane, cotton and maize; while forest area: shisham, sufaida, mulberry (phulai, bamboo, grasses of different types were also marked in forest area).

Collection was made randomly by netting, hand picking and light trapping; one light traps per part of both areas. Sampling was done for 2-consecutive days in each week and total population per month was counted. The specimens for each and every collection day were treated separately and were put into vials for biodiversity count. All specimens were manually stored and identified to species level. Mostly the adults of this family were collected in our samples. Some coccinellid larvae also found in the sampled areas. To minimize counting a species twice, all larvae were carefully examined and if they might have been the same species as an adult, we counted them as a single species. The meteorological data were recorded to know environmental impact on the dispersal and diversity of coccinellid beetles. Temperature, humidity and rainfall data were taken for each census day and were averaged for each month.

The data collected was analysed statistically to calculate the diversity, species richness and evenness in both areas separately. The Shannon diversity index was used which is as follows:

$$H = \sum \left(pi - In(pi) \right)$$

or

$$H' = \frac{n \log n - \sum_{i}^{k} fi \log fi}{n} \qquad (Diversity)$$

$$H' \max = \log k \qquad (Max.Diversity)$$

$$J' = \frac{H'}{H' \max} \qquad (Evenness)$$

$$D = 1 - J' \quad \text{(Dominance)}$$

For Diversity Comparison

$$t_{cal} = \frac{H_1' - H_2'}{S^2_{H1'-H2'}}$$

The diversity indices calculated from both of two areas was compared by t-test (Hutcheson, 1970). H_1' is the diversity index from crop area and H_2' is the diversity index from forest area. $S^2_{H1' - H2'}$ is the standard error of the difference between two diversity indices.

Estimation of species. Estimation of coccinellid species in the entire area was made as described by MacArthur and Wilson (1967).

RESULTS AND DISCUSSION

The research study was conducted from May-Oct. in 2002. A total of 8119 specimens of coleopterous insects were captured out of which 4972 were the coccinellids representing 22-species. In crop area, a total of 2756 individuals were collected, in which 2027 belonged to the coccinellidae, similarly 2945 coccinellid specimens were collected in total of 5363 individuals in the forest area. *Coccinella septempunctata* had more population with mean value of 55.41, following *Brumus suturalis* and *Coccinella septempunctata* var *divaricata* with mean values 42.75 and 33.16 respectively in the whole agroforest area.

Diversity, Species richness and evenness (Table I) were calculated by Shannon-Diversity Index (1948). This index considers both the number of species and the distribution of individuals among species. For a given number of species, the largest value H′ results when every individual belongs to different species, and J′ is the relative measure of diversity (Kikkawa, 1996).

In crop area, there were 19-species of coccinellidae with highest population of *Coccinella septempunctata*. The evenness value showed that the whole of the crop area (Table I) was evenly distributed with only the dominance of a few species namely *Coccinella septempunctata, Brumus suturalis,* following the species *Menochilus 6-maculata and Coccinella septempunctata* var *divaricata* with more population as compared to others. The dominance value in crop area (0.09, Table I) indicated that 9 % of the 19-species dominating the crop area.

In forest area, the distribution of 22-species of coccinellidae was heterogeneous. H′ value showed that these coccinellid species were more diverse over forest area. J′ value showed that in forest area relative abundance or evenness within 22-species was more than crop area (0.93) with only the dominance of 7% (0.07) (Table I).

Table I. Result of Shannon-Weiner Diversity Index

Biodiversity components	Crop area	Forest area
Diversity (H')	1.158	1.25
Max. Diversity (H' max)	1.27	1.34
Evenness (J')	0.91	0.93
Dominance (D)	0.09	0.07

H'= Shannon-Weiner Diversity Index, where absolute diversity = 1.00; J'= Evenness or relative Diversity (H'/ H'max), where absolute evenness =1.00; 1-J'= Dominance or heterogeneity (where absolute dominance = 0.00)

Table II. Meteorological data for six months

Months	Temperature (C°) Avg.		Relative Humidity (%)	Rainfall (mm) Total
	Max.	Min.	Avg.	
May	41.5	26.2	28	16.0
June	42.3	29.6	45	5.3
July	37.2	27.9	63	126
August	38.5	27.4	56	64.2
September	36.7	24.9	65	26
October	35.1	21.3	51	1.5

Diversity comparison

$t_{cal} > t_{tab}$

Since t_{cal} lies in the rejection region, therefore, H_o was rejected. It was concluded that the diversity indices are not same for the two areas.

The meteorological data were recorded to know environmental impact on the dispersal and diversity of coccinellid species. Temperature, humidity and rainfall data were taken for each census day and were averaged for each month (Table II). A slight fluctuation in monthly collected population was attributed to the ecological conditions (Fig. 1, 2). The ecological conditions i.e. the monsoon season and the rapid growth of plants (Coley & Aide, 1991), habitat quality (Rice & Riley, 2000) and climatic factors (Didham *et al.,* 1998; Vulinec, 2000) caused the dispersal of insects within this agro-forest area. The random collection methods also considered for this fluctuation (Kikkawa, 1996) but estimation of the coccinellidae over the entire area overcomes this factor (MacArthur & Wilson, 1967).

Table III. Coccinellid species captured across crop and forest area

Name of Species	Crop Area	Forest Area	Means
Balia eucharis Muls.	+	+	17.5
Brumus suturalis F.	+	+	42.75
Coccinella septempuctata L.	+	+	55.41
Coccinella septempuctata var. divaricata L.	+	+	33.16
Menochiolus 6-maculata F.	+	+	28.41
Cryptocephalus triangularis Hope.	+	+	10.0
Henosepilachna dodecastigma Wied.	+	+	24.25
Verania allardi Muls.	+	+	19.08
Adonia variegate Gze.	+	+	32.0
Adonia variegate Gze ssp. Doubleday Muls.	+	+	11.4
Balia dianae Muls.	+	+	16.83
Leis dimidiate F.	+	+	15.5
Balia dianae var. gutavi Muls.	+	+	4.58
Coccinella nomemnotata Hbst.	+	+	33.0
Cycloneda munda Say.	+	+	5.41
Adalia bipunctata Lin.	+	+	17.16
Hippodamia parenthesis Say.	+	+	7.25
Hippodamia tredecimpunctata L.	-	+	1.50
Hippodamia glacialis F.	-	+	3.75
Hippodamia convergens Guer.	-	+	5.75
Megilla fuscilabris Muls.	+	+	20.0
Pullus guimeti Muls.	+	+	5.75
Total number of individuals (Coleoptera)	2756	5363	
Total number of individuals (Coccinellidae)	2027	2945	
Total number of species	19	22	

Estimation of Coccinellid species. The collected species were 22 (Table III) and the estimated number of coccinellid species in the entire area was 73, as described by MacArthur and Wilson (1967).

"The number of species of a particular group of organism increases approximately as the fourth root of the area". In other words, the number of species can be predicted as

$$\textit{Estimated number of species} = \textit{Constant} \times (\textit{Area})^{0.25}$$

Fig. 1. Monthly changes in the population of 19-species of Coccinellidae in Crop Area

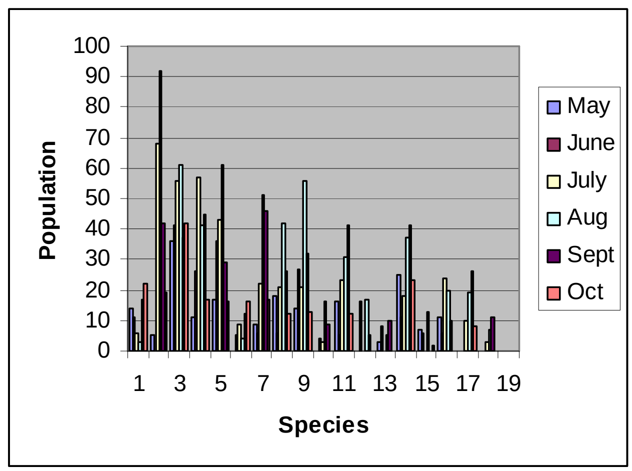
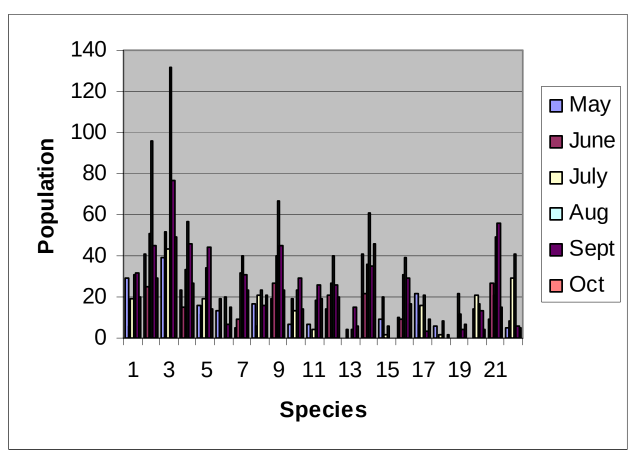


Fig. 2. Monthly changes in the population of 22-species of Coccinellidae in Forest Area



The predaceous and bioindicators role of lady beetles benefit from the maintenance of field diversity, which supports the population of prey such as aphids, thrips and mites (Iperti & Paoletti, 1999). It was also noted that the erosion of predatory potential occurred due to use of pesticides. The ladybird beetles migrated between various crop fields throughout the season depending upon the availability of prey and habitat disturbance (Maredia *et al.,* 1992). Gray's (1989) 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. The actual reason, if not, could be the disturbance in crop area in the form of agricultural practices, and the use of chemicals causes a decrease in the diversity (Perfecto & Snelling, 1995; Favila & Halffter, 1997; Niemelä *et al.,* 2000; Parkash, 2002). Seasonal changes influence the occurrence of aphid outbreaks, the type of plant infested and thus the behaviour of the coccinellids. In the context of biological control, the coccinellids represent an important cause of mortality of coccids, aphids and mites (Iperti & Paoletti, 1999).

CONCLUSIONS

The main objective of this study was the assessment of biodiversity of coccinellidae in this area but their behavior with the change in environment and with the increase in prey population was also studied. From the species richness and diversity comparison through t-test, it was concluded that the forest area was relatively more diverse than crop area. The distribution of 22 species of coccinellidae was heterogeneous in the entire agro forest area (Williamson, 1973; Williams *et al.,* 1996). The females deposited its eggs near prey often in small clusters in protected sites on leaves and stems. The adults live for weeks or months depending on their geographic location and the availability of the prey (Hoffman & Frodsham, 1993). These predatory insects are active searchers for food, and have been known to arrive at heavily aphid-infested fields. These beetles are density dependent predators, their numbers rise as the prey numbers increase (Anonymous, 1999). The prey population, thus thereby determines the ladybird beetle population. The results of present study agreed to the observations of Dufrêne and Legendre (1997), and McGeoch (1998) also indicated that the coccinellids can be considered as useful ecological indicators

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