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RESEARCH ARTICLE

Diversity and Distribution of Ladybird beetles (Coccinellidae) in the Cropland of Faisalabad District

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Abstract

The present study was conducted in the Faisalabad district (30° 31.5 N and 73° 74 E), Pakistan to assess diversity and distribution of ladybird beetles (Coleoptera: Coccinellidae) on five economically important crops (wheat, sugarcane, fodder, maize and vegetables) and their associated weeds. A total of 2204 specimens of coccinellids were collected belonging to four sub-families viz., Coccinellinae (n = 2076), Chilocorinae (n = 122), Epilachninae (n = 03) and Scymninae (n = 03) as well as twelve species. Fodder 57.19% (n = 1129) and wheat 37.34% (n = 737) were comprised more abundant coccinellids while sugarcane 3.04% (n = 60), vegetable 1.38% (n = 27) and maize 1.06% (n = n = 21) contribution was negligible. Fodder was also recorded more diverse (H´ = 1.541) and significantly different from all crops (p = 0.000). *C. septempunctata* 60.33% (n = 1191) and *C. sexmaculata* 19.50% (n = 385) were recorded more abundant species as well as widely distributed on all the crops. Among weeds *C. dactylon* 19.13% (n = 44) *and F. indica* 21.30% (n = 49) constituted more abundant and more diverse (H´ = 1.343, H´ = 1.115) coccinellids. It is concluded that agricultural crops and their associated weeds comprising of a variety coccinellids species, which are better control agents of insect pests.

Introduction

The ladybird beetles (Coleoptera; Coccinellidae) are enormously diverse in their habits (Moreton, 1969; Anonymous, 2000). They constitute of 5,200 described species occurring all over the world (Hawkeswood, 1987). They occupy various niches in an ecosystem most of them are predaceous in nature and some are phytophagous and they severely damage agricultural crops. Whereas larvae and adults of predatory species feed almost 39 species such as scale insects, aphids, thrips, leafhoppers, whiteflies, mealybugs, mites as well as other small soft-bodied species and their eggs (Moreton, 1969; Gautam, 1989; Iperti and Paoletti, 1999). Fleming (2000) and Rahatullah et al. (2010) documented 4,000 predatory species of this family, of which more than 300 species from Indo-Pak subcontinent. While 71 species are found only in Pakistan (Irshad, 2001; Khan et al., 2006).

The modern agriculture receives heavy inputs such as fertilizers, chemicals for better yield. Hence in Pakistan, insects pests are controlled by Insecticides, which is not only expensive but also its residues left over the sprayed surface of the crops or in the soil and have turn out to be a subject of concern of environmental pollution. The haphazard use of pesticides causes phytotoxicity and damage of favourable organisms such as predators, parasitoids, microorganisms and pollinators (Luckman and Metcalf 1978). Global warming has cautioned us and the unpleasant consequences of insecticide use are always alarming and also increasing pest out break because of pest resistance. These entomological backlashes have forced the scientists to think about entomologically friendly pest management programs (Hodek, 1970). Therefore, utilization of natural enemies in biological control is an excellent pest management tactic to reduce the population level of invasive pests (Delfoss, 2005). Exploration into the potential employment of predatory insects or mites to control aphid pests received more attention or decline

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of chemical damages to the environment (Jafari, 2011). The coccinellid beetles are considered economically very important in agro-ecosystem as they have been successfully employed in the biological control of many injurious insects (Agarwala and Dixon, 1992).

Keeping in view the importance of these useful predators, the present study was conducted to evaluate diversity and distribution of coccinellids on five crops viz., wheat, fooder, sugarcane, maize and vegetables as well as their associated weeds in Faisalabad district.

Material and Methods

Faisalabad is located between longitude 73°74 East, latitude 30°31.5 North, with an elevation of 184 meters (600 ft) asl, in the rolling flat plains of northeast Punjab. The city covers an area of almost 830 square kilometers (320 sq mi) and the district covers 1,280 square kilometers (490 sq mi). The city shows the extreme climate, with the maximum temperature in summer reaching 50 °C (122 °F) and a winter temperature of −1 °C (30.2 °F), while the average rainfall is about 2,000 mm (79 in), that is sufficient to keep the soil very fertile. The study was conducted in the months of October 2010 through April 2011(Mahmood-ul-Hassan et al., 2010).

A preliminary survey was made to locate the required fields cultivated with conventional tillage randomly. Crop fields spreading over an area of 2 ha on each site were selected for sampling. At least 20 sites were randomly selected throughout the sampling period in the cultivations around Faisalabad city almost 20 to 30 km distant from main city.

Sampling was initiated in October 2010 and all the available cultivations were selected for the sampling and it continued for the total duration of 6 months. For the collection of coccinellids (Coleoptera) from the cropland, at least 10 acre area was selected on each locality. Samples were collected weekly, the coccinellids include immature insects and their adults either present temporarily or inhabiting permanently on the crops and weeds were collected by Hand Picking, Sweep Hand Net. The specimens were preserved in the glass vials containing 70% ethanol, and brought to lab. Department of Zoology and Fisheries, University of Agriculture, Faisalabad.

The specimens were identified with the help of available literature as well as already identified specimens which are preserved in the insect Museum, Department of Entomology, University of Agriculture, Faisalabad.

Statistical analysis was conducted to determine diversity, richness, evenness and abundance in different crops, by applying Shannon-Weiner diversity index given by Shannon (1948) to determine:

Result and Discussion

A total of 2204 specimens belonging to four different sub-families, nine genera and 12 species were captured throughout the sampling period. The sub-family Coccinellinae (n = 2076) was the most abundant comprised of 9 species belonging to 6 genera. *Coccinella*, *Cheilomenes* and *Hippodamia* were most abundant genera. *C. septempunctata* (n = 1339), *C. transversalis* (n = 14) and *C. novemnotata* (n = 9) were the most abundant species among the *Coccinella*. Genus *Cheilomenes* represented by single species, *Cheilomenes sexmaculata* (n = 438), whereas *Hippodamia* represented by two species *Hippodamia convergens* (n = 88) and *Hippodamia variegata* (n = 68). *Harmonia axyridis* (n = 60), *Micraspis allardi* (n = 46) and *Propylea dissecta* (n =14) were also most recorded species of sub-family Coccinellinae. The sub-families viz., Chilocorinae, Epilachninae and Scymninae were each represented by single species (Table 1). Previously Similar survey of predatory and mycophagous coccinellid beetles (Coleoptera: Coccinellidae) was conducted by Joshi and Sharma (2008) at four sites, representing four different ecosystems in district Haridwar, India. Selyemova et al. (2007) recorded a total of 3,636 individuals, which belonging to 17 species of adult lady beetles (Coleoptera, Coccinellidae) in the spruce forests of Pol' ana Mts (the West Carpathians). Second sub family Chilocorinae was representing 1 species with 122 specimens was the third most abundant species in the study area. Sub families Epilachninae and Scymninae represented with single species *Epilachna indica* and *Scymnus spp.* respectively (Table 1). In Pakistan, Khan et al. (2007) surveyed the Chitral District and documented a total of 2600 specimens of Coccinellids, Twelve different species belonging to 9 genera of 3 tribes and 2 sub-families.

The family coccinellidae was found to be fluctuating throughout the sampling period. March and April were found more favorable for the family coccinellidae with 1295 (58.76%) and 635 (28.81%) specimens respectively of the total data. Three sub-families coccinellidae were recorded during the month of March while four during the month of April. The sub-family Coccinellinae was found abundant during these months while the species *Coccinella septempunctata* with 802 (61.93 %) specimens, *Cheilomenes sexmaculata* with 269 (20.77%) were not only abundant during the month of April but also during March, following the *Hippodamia variegate* and *Hippodamia convergens* had same abundance viz 12 (1.89%) during March and 56 (4.32%), 76 (5.87%) respectively during April. The species *Epilachna indica* and *Scymnus*

spp. were found least abundant during these months (Table 2). The datewise flactuation of recorded species is represented in Fig. 1.

Table 1. Ladybird beetles (Coleoptera: Coccinellidae) found in the cropland of Faisalabad throughout sampling period.

Family	Sub family	Species	Total
Coccinellidae	**Coccinellinae**		**2076**
		Coccinella septempunctata	1339
		Cheilomenes sexmaculata	438
		Micraspis allardi	46
		Coccinella transversalis	14
		Harmonia axyridis	60
		Coccinella novemnotata	9
		Propylea dissecta	14
		Hippodamia variegata	68
		Hippodamia convergens	88
	Chilocorinae	*Brumoides suturalis*	122
	Epilachninae	*Epilachna indica*	3
	Scymninae	*Scymnus spp.*	3
	4	**12**	**2204**

Table 2. Monthly variation in relative abundance (%) of ladybird beetles (Coleoptera: Coccinellidae) collected from November 2010 to April 2011.

Months	November	December	January	February	March	April	
Species	**% Relative abundance (n)**						**Total**
Coccinellinae	**76.63(82)**	**56.76(63)**	**68.57(24)**	**80.95(17)**	**99.53(632)**	**97.14(1258)**	**94.19(2076)**
Coccinella septempunctata	26.17(28)	31.53(35)	42.86(15)	19.05(4)	71.65(455)	61.93(802)	60.75(1339)
Cheilomenes sexmaculata	8.41(9)	5.41(6)	5.71(2)	57.14(12)	22.05(140)	20.77(269)	19.87(438)
Micraspis allardi	15.89(17)	1.80(2)	20.00(7)	4.76(1)	1.10(7)	0.93(12)	2.09(46)
Coccinella transversalis	-	-	-	-	0.47(3)	0.85(11)	0.64(14)
Coccinella novemnotata	-	1.80(2)	-	-	-	0.54(7)	0.41(9)
Harmonia axyridis	25.23(27)	16.22(18)	-	-	0.47(3)	0.93(12)	2.72(60)
Propylea dissecta	0.93(1)	-	-	-	-	1.00(13)	0.64(14)
Hippodamia variegata	-	-	-	-	1.89(12)	4.32(56)	3.09(68)
Hippodamia convergens	-	-	-	-	1.89(12)	5.87(76)	3.99(88)
Chilocorinae	**21.50(23)**	**43.24(48)**	**31.43(11)**	**19.05(4)**	**0.31(2)**	**2.63(34)**	**5.54(122)**
Brumoides suturalis	21.50(23)	43.24(48)	31.43(11)	19.05(4)	0.31(2)	2.63(34)	5.54(122)
Epilachninae	**1.87(2)**	**-**	**-**	**-**	**-**	**0.08(1)**	**0.136(3)**
Epilachna indica	1.87(2)	-	-	-	-	0.08(1)	0.14(3)
Scymninae	-	-	-	-	**0.16(1)**	**0.15(2)**	**0.136(3)**
Scymnus spp.	-	-	-	-	0.16(1)	0.15(2)	0.14(3)
Total	4.85(107)	5.04(111)	1.59(35)	0.95(21)	28.81(635)	58.76(1295)	2204

n= Number of coccinellids

Table 3. Relative abundance (%) of ladybird beetles (Coleoptera: Coccinellidae) fauna collected from wheat, sugarcane and fodder throughout the sampling period.

Species	Crops					Total
	Wheat	Fodder	Sugarcane	Maize	Vegetables	
	% Relative abundance (n)					
Coccinellinae	**99.05(730)**	**90.17(1018)**	**100(60)**	**100(21)**	**85.19(23)**	**93.82(1852)**
Coccinella septempunctata	74.22(547)	50.93(575)	80(48)	4.76(1)	74.07(20)	60.33(1191)
Cheilomenes sexmaculata	16.42(121)	20.73(234)	20(12)	80.95(17)	3.70(1)	19.50(385)
Micraspis allardi	1.63(12)	2.48(28)	-	14.29(3)	-	2.18(43)
Coccinella transversalis	1.22(9)	0.44(5)	-	-	-	0.71(14)
Coccinella novemnotata	-	0.80(9)	-	-	-	0.46(9)
Harmonia axyridis	0.54(4)	4.96(56)	-	-	-	3.04(60)
Propylea dissecta	0.54(4)	0.71(8)	-	-	-	0.61(12)
Hippodamia variegata	2.04(15)	3.90(44)	-	-	-	2.99(59)
Hippodamia convergens	2.44(18)	5.23(59)	-	-	7.41(2)	4.00(79)
Chilocorinae	-	-	-	-	**14.81(4)**	**5.88(116)**
Brumoides suturalis	0.95(7)	9.30(105)	-	-	14.81(4)	5.88(116)
Epilachninae	-	**0.27(3)**	-	-	-	**0.15(3)**
Epilachna indica	-	0.27(3)	-	-	-	0.15(3)
Scymninae	-	**0.27(3)**	-	-	-	**0.15(3)**
Scymnus spp.	-	0.27(3)	-	-	-	0.15(3)
Total	37.34(737)	57.19(1129)	3.04(60)	1.06(21)	1.38(27)	1974

Table 4. Shannon diversity indices of coccinellids on wheat, sugarcane and fodder crops. (ns: p>0.05, *: p<0.05, **: p<0.01, ***: p<0.001).

Crops	N_0	H´	Eveness	Mean	Stdev	N_0	H´	Eveness	Mean	Stdev	t- test	*df*	*p*- value
Fodder vs Wheat	12	1.541	0.620	94.08	±0.032	9	0.910	0.414	81.89	±0.044	11.482	>120	0.000***
Fodder vs Sugarcane	12	1.541	0.620	94.08	±0.032	2	0.500	0.721	30	±0.071	13.285	88	0.000***
Fodder vs Maize	12	1.541	0.620	94.08	±0.032	3	0.594	0.540	7	±0.174	5.324	23	0.000***
Fodder vs Vegetables	12	1.541	0.620	94.08	±0.032	4	0.820	0.591	6.75	±0.173	4.088	29	0.000***
Wheat vs Sugarcane	9	0.910	0.414	81.89	±0.044	2	0.500	0.721	30	±0.071	4.900	113	0.000***
Wheat vs Maize	9	0.910	0.414	81.89	±0.044	3	0.594	0.540	7	±0.174	1.753	24	0.092ns
Wheat vs Vegetables	9	0.910	0.414	81.89	±0.044	4	0.820	0.591	6.75	±0.173	0.503	31	0.618ns
Sugarcane vs Maize	2	0.500	0.721	30	±0.071	3	0.594	0.540	7	±0.174	0.498	28	0.622na
Sugarcane vs Vegetables	2	0.500	0.721	30	±0.071	4	0.820	0.591	6.75	±0.173	1.708	36	0.096ns
Maize vs Vegetables	3	0.594	0.540	7	±0.174	4	0.820	0.591	6.75	±0.173	0.918	47	0.363ns

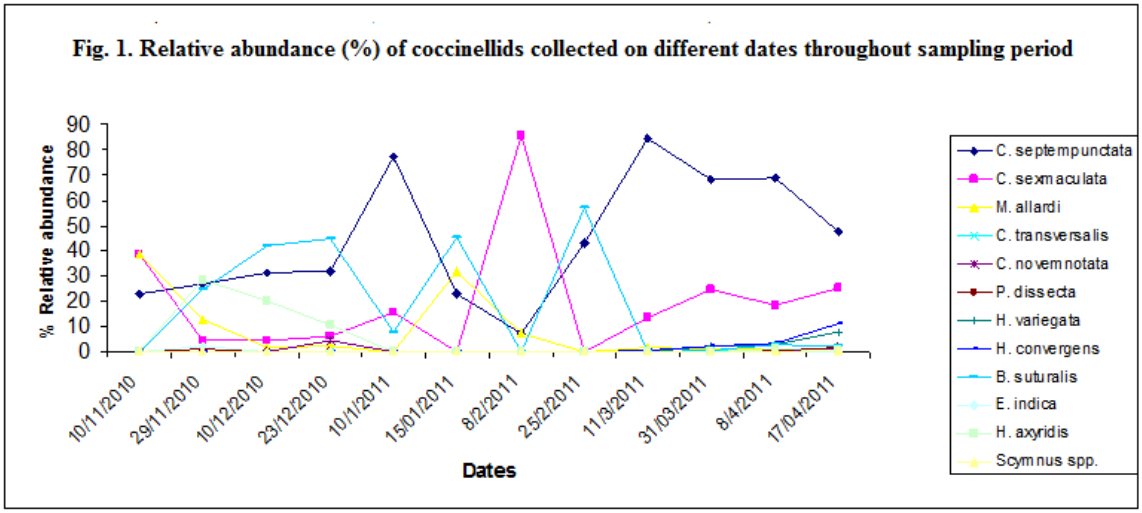

Table 5. Relative abundance (%) of ladybird beetles (Coleoptera: Coccinellidae) fauna collected from weeds of wheat, sugarcane and fodder throughout the sampling period.

	Wheat			Sugarcane			Fodder			Total
	Cynodon dactylon	*Phalaris minor*	*Euphorbia hirta*	*Poa annua*	*Conyza ambigua*	*Euphorbia hirta*	*Amaranthus indica*	*Funaria indica*	*Convolvulus arvensis*	
Species	% Relative abundance (n)									
Coccinellinae	**93.18(41)**	**100(27)**	**100(30)**	**100(8)**	**100(7)**	**100(8)**	**100(26)**	**97.96(48)**	**93.55(29)**	**97.39(224)**
Coccinella septempunctata	50.00(22)	59.26(16)	83.33(25)	62.50(5)	100(7)	100(8)	53.85(14)	57.14(28)	74.19(23)	64.35(148)
Cheilomenes sexmaculata	29.55(13)	33.33(9)	13.33(4)	25.00(2)	-	-	34.62(9)	26.53(13)	9.683(3)	23.04(53)
Micraspis allardi	4.55(2)	-	-	-	-	-	3.85(1)	-	-	1.30(3)
Coccinella transversalis	-	-	-	-	-	-	-	-	-	-
Coccinella novemnotata	-	-	-	-	-	-	-	-	-	-
Harmonia axyridis	-	-	-	-	-	-	-	-	-	-
Propylea dissecta	2.27(1)	-	-	-	-	-	3.85(1)	-	-	0.87(2)
Hippodamia variegate	2.27(1)	7.41(2)	3.33(1)	12.50(1)	-	-	3.85(1)	4.08(2)	3.23(1)	3.91(9)
Hippodamia convergens	4.55(2)	-	-	-	-	-	-	10.20(5)	6.45(2)	3.91(9)
Chilocorinae	**6.82(3)**	-	-	-	-	-	-	**2.04(1)**	**6.45(2)**	**2.61(6)**
Brumoides suturalis	6.82(3)	-	-	-	-	-	-	2.04(1)	6.45(2)	2.61(6)
Total	19.13(44)	11.74(27)	13.04(30)	3.48(8)	3.04(7)	3.48(8)	11.30(26)	21.30(49)	13.48(31)	230

Table 6. Relative abundance (%) of ladybird beetles (Coleoptera: Coccinellidae) fauna collected from weeds of wheat, sugarcane and fodder throughout the sampling period

N_0	H´	E	Mean	Stdev	N_0	H´	E	Mean	Stdev	t- test	d*f*	*p*- value
Wheat weeds												
Cynodon dactylon					***Phalaris minor***							
44	1.343	0.690	6.286	±0.139	27	0.869	0.791	9	±0.104	2.727	71	0.008 * *
Cynodon dactylon					***Euphorbia hirta***							
44	1.343	0.690	6.286	±0.139	30	0.534	0.486	10	±0.147	3.988	70	0.000* * *
Phalaris minor					***Euphorbia hirta***							
27	0.869	0.7910	9.00	±0.104	30	0.534	0.486	10	±0.147	1.856	53	0.069ns
Sugarcane weeds												
Poa annua					***Conyza ambigua***							
8	0.900	0.819	2.67	±0.189	7	0.000	0.000	7	0.00	4.759	8	0.001* * *
Poa annua					*Euphorbia hrita*							
8	0.900	0.819	2.67	±0.189	8	0.000		8	0.00	4.759	8	0.001* * *
Conyza ambigua					***Euphorbia hrita***							
7	0.000	0.000	7	0.00	8	0.000	0.000	8	0.00	0.00	0.00	-
Fodder weeds												
Amaranthus indica					***Funaria indica***							
26	1.076	0.668	5.2	±0.424	49	1.115	0.692	9.8	±0.313	0.074	54	0.941ns
Amaranthus indica					***Convolvulus arvensis***							
26	1.076	0.6686	5.2	±0.424	31	0.912	0.566	7.75	±0.427	0.272	57	0.786ns
Funaria indica					***Convolvulus arvensis***							
49	1.115	0.692	9.8	±0.313	31	0.912	0.566	7.75	±0.427	0.383	62	0.703ns
Wheat weeds					Sugarcane weeds							
101	1.077	0.553	14.43	±0.230	23	0.470	0.427	7.67	±0.594	0.952	30	0.349ns
Wheat weeds					**Fodder weeds**							
101	1.077	0.553	14.43	±0.230	106	1.133	0.582	15.14	±0.226	0.088	>120	0.930ns
Sugarcane weeds					**Fodder weeds**							
23	0.470	0.427	7.67	±0.594	106	1.133	0.582	15.14	±0.226	1.043	30	0.305ns

Wheat 37.34% (n = 737) and fodder 57.19% (n = 1129) were comprised more coccinellids fauna, while other crops contribution was recorded negligible as well as both of these crops represented highest number of species as well. Fodder was comprised maximum richness (12 species) and wheat was recorded second more rich (9 species). Sugarcane, maize and vegetable were recorded least number of species (Table 3). Very interestingly both the species *Coccinella septempunctata* and *Cheilomenes sexmaculata* were found abundant on all the crops showed that both of these species had broad range of habitat as well as both contributing 79.83%. *Coccinella septempunctata* was previously reported from Faisalabad (Laylpur) by a number of authors (Rehman 1940; Khan and Sultan 1949). Shah (1983) recorded *Coccinella septempunctata* from Peshawar on a variety of plants including *Hibiscus esculantus*, *Solanum melongena*, *Lactuca sativa* and *Glycine max*. Evans (2000) reported that old world ladybird *Coccinella septempunctata* had rapidly established itself throughout North America due to successful feeding. *Coccinella septempunctata* was not only abundant but also the most dominant species of Pakistan (Akram *et al*., 1996). *Epilachna indica* and *Scymnus spp.* showed narrow range of habitat and was capture only on wheat, not found on any other crops.

Diversity of Coccinellidae was evaluated on the major crops and compared with each other, fodder was recorded significantly different from all other crops (p = 0.000). Wheat was found significantly different from sugarcane (p = 0.000) while non-significant was recorded for maize and vegetable as well as sugarcane non-significantly different from maize and vegetable, maize and vegetable (Table 4).

A total of 230 specimens were recorded from wheat, sugarcane and fodder associated weeds. *F. indica* (21.30%) and *C. dactylon* (19.13) were comprised more coccinellids, whereas *C. ambigua* (3.04%) was recorded with least coccinellids. *C. septempunctata* (64.35%) was recorded with broad distribution and found on all weeds, while *Micraspis allardi* (1.30%) and *Propylea dissecta* (0.87%) had narrow distribution and was recorded only on *C. dactylon* and *A. indica* as well as *C. dactylon* (H´ = 1.343) *and F. indica* (H´ = 1.115) were the most diverse and significantly different from other weeds(Table 5, 6).

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