



Research Article

Diversity and Distribution of Coccinellid Beetles in Irrigated and Rainfed Fields of Gujrat, Punjab, Pakistan

Mubashar Hussain*, Muhammad Faheem Malik, Sehreen Siddique, Muhammad Umar, Tamkeen Zainab, Fatima Zafar

Department of Zoology, University of Gujrat-50700, Punjab, Pakistan.

Article History

Received: June 24, 2017

Revised: December 09, 2017

Accepted: December 12, 2017

Published: March 26, 2018

Authors' Contributions

MH presented the concept and designed the study, collected the data and wrote the manuscript. MFM interpreted the results. SS reviewed the literature. MU collected the data while TZ analysed it. FZ prepared the final version of the manuscript.

Keywords

Ladybird beetles, Diversity, Crop-lands, Gujrat

Abstract | In order to assess the biodiversity and distribution of coccinellid beetles (Coleoptera: Coccinellidae), samples were collected from rainfed and irrigated fields of Gujrat, Punjab, Pakistan during 2015-2016. Adult specimens were collected fortnightly from crops, weeds and shrubs from randomly selected locations i.e. Dolat Nagar, Lala Musa, Jalalpur Jatan, Guliyana, Fateh Pur and Kunjah. Analysis of specimens indicated a representation of 14 species, 6 genera and 3 sub families across all sites. Maximum abundance was noticed for *Coccinella septempunctata* (19.63 %) followed by *Coccinella undecimpunctata* (14.70 %), *Coccinella transversalis* (11.14 %) and *Coccinella sexmaculata* (10.29 %). Greater diversity (H' : 2.481), dominance (1-D: 0.8964) and evenness (J' : 0.7474) of coccinellid beetles were recorded from under-study sites. However, variations in the abundance of species were observed i.e. *Coccinella* was the most abundant genus with four species (*C. septempunctata*, *C. transversalis*, *C. undecimpunctata* and *C. trifasciata*). The specimens collected from different sites showed variations in the diversity (H') and dominance (D) of species i.e. maximum in Kunjah (H' : 2.535 and D: 0.1016) followed by Lala Musa (H' : 2.511 and D: 0.09681) and Guliyana (H' : 2.463 and D: 0.1048). Taken together, these results depict that coccinellid species showed fair distribution in irrigated and rainfed fields of Gujrat. While these results define the foundation, further studies are warranted to investigate species diversity, abundance and distribution under different agro-climatic conditions particularly with reference to different pests and their host plants.

To cite this article: Hussain, M., Malik, M.F., Siddique, S., Umar, M., Zainab, T. and Zafar, F., 2017. Diversity and distribution of coccinellid beetles in irrigated and rainfed fields of Gujrat, Punjab, Pakistan. *Punjab Univ. J. Zool.*, 33(1): 1-6. <http://dx.doi.org/10.17582/pujz/2018.33.1.1.6>

Introduction

The Coccinellidae family has great economic and ecological importance due to having 4000 predatory species (Fleming, 2000). Coccinellidae, with about 6000 described species, is the most abundant and diverse family with worldwide distribution (Vandenberg, 2002). In Indo-Pak Subcontinent, approximately 300 coccinellid species have been reported (Rahatullah *et al.*, 2010) out of which 91 species are reported in Pakistan (Ashfaq, 2013; Urooj and Ali, 2016).

The success of this family is backed up by variations in habits and habitats making them to invade almost all terrestrial ecosystems with great dominance amongst insect predators (Ashfaq, 2013; Urooj and Ali, 2016; Skaife, 1979). Both larval and adult stages of Ladybird beetles are predators of large number of agricultural pests i.e. jassids, aphids, scale insects, mealy bugs, whiteflies and psyllids (Naz, 2012; Rahatullah *et al.*, 2011; Delfosse, 2005; Khan *et al.*, 2007; Irshad, 2001).

Insecticides have been phenomenal in controlling pests of agricultural crops; however, have affected greatly non-targeted natural enemies of these pests including coccinellid beetles. Intensive agriculture has led to the use of

*Corresponding author: Mubashar Hussain
dr.mubashar@uog.edu.pk

farm inputs such as fertilizers, insecticides, herbicides and fungicides for enhancing crop productivity and resulting in ecological consequences of biodiversity loss and ecosystem instability (Urooj and Ali, 2016). The repeated use of insecticides having variable persistence and residual effect is considered as ecologically hazardous with negative impacts on biodiversity and ecosystem stability (Khan *et al.*, 2007). It is hypothesized that farm inputs, especially pesticides, have deleterious effects on coccinellid species resulting in lowering their diversity and abundance, and ultimately leading towards biodiversity loss.

Keeping in view the significance of these beetles as biological control agents and bio-indicators, the current study was conducted to explore the diversity and distribution of Coccinellids from Gujrat, Punjab, Pakistan. In this study, diversity of ladybird beetles was explored from agro-ecosystem of district Gujrat provided current status of diversity, abundance, distribution of species. The study showed that district Gujrat was rich in species diversity. Therefore, species recorded from the study area highlighted the presence of different species with variations in their abundance. The study suggests more exploratory studies with reference to host plants and their pest population dynamics and predator-prey interrelationship in district Gujrat along with their predatory efficiencies.

Materials and Methods

Coccinellids were collected from agricultural fields of district Gujrat, Punjab, Pakistan located between two famous rivers of Pakistan; Chenab River and Jhelum River with an area of about 1232.4 miles² (3192 km²). It is located between Latitude: 32°34'22" N and Longitude: 74°04'44" E. The sampling was carried out from district Gujrat i.e. Dolat Nagar, Lala Musa, Jalalpur Jatan, Guliyana, Fateh Pur and Kunjah during 2015-16 to explore the diversity and distribution of ladybird beetles in irrigated and rainfed fields.

Sampling method

A preliminary survey was made to locate the required fields randomly. Each selected site was further divided into six sampling locations within sites representing each town. The study sites were well distributed around Gujrat city and were at a fair distance (2-3 km) from residential areas of the selected towns. The farmers were interviewed for seeking preliminary information regarding use of chemicals (pesticides and herbicides) during the season for the pest and weed management. The specimens were collected from the study sites from March 2015 to February 2016. The specimens from crops and weeds were collected randomly by netting, hand picking and light trapping (Biranvand *et al.*, 2014).

Insect preservation and identification

The specimens collected during the sampling were treated and identified using identification key and available literature (Zahoor *et al.*, 2003). The identified specimens were preserved, identified, labeled and deposited in the Laboratory of Systematics and Pest Management, University of Gujrat.

Statistical analysis

The diversity and abundance of recorded species was determined in each site (rainfed and irrigated). The estimated values of species diversity, dominance and richness were determined by applying Shannon-Wiener Index and Simpson Index (Magurran, 2004). ANOVA was also applied and means were compared to work out differences in the species abundance at different sites.

Results And Discussion

A total of 3311 specimens of ladybird beetles constituting 14 species and 6 genera belonging to 3 subfamilies were collected and identified from six different localities (Guliyana, Kunjah, Dolat Nagar, Lala Musa, Jalalpur Jatan and Fateh Pur) of district Gujrat, Pakistan. The results showed significant differences in the abundance of species at various sites ($F_{(13,74)} = 33.67, P < 0.05$) and between them ($F_{(4,74)} = 8.039, P < 0.05$).

Abundance of species

The *C. septempunctata* ($n=650$) appeared to be the most abundant species followed by *C. undecimpunctata* ($n=487$), *C. transversalis* ($n=369$) and *Cheilomenes sexmaculata* ($n=427$). The *C. septempunctata* was found in highest numbers at all sites whereas least abundant species was *Brumus suturalis* ($n=66$). Maximum abundance percentage was shown by *C. septempunctata* followed by *C. undecimpunctata* whereas *Brumus suturalis* was least abundant species (Figure 1). Most abundant genus reported was Coccinella ($n=1775$) which is represented by *C. septempunctata*, *C. transversalis*, *C. undecimpunctata* and *C. trifasciata*. Afterward, the abundance was followed by Epilachna ($n=708$) with five species including *E. borealis*, *E. indica*, *E. tredecimnotata*, *E. varivestis* and *E. vigintioctopunctata* (Table I).

Table I: Overall result of Shannon-Wiener Diversity Index of coccinellid species recorded from Gujrat, Punjab, Pakistan.

Biodiversity Components	Value
Diversity (H')	2.481
Dominance (1-D)	0.8964
Evenness (J')	0.7474

Abundance of species at different sites

Guliyana

Data recorded from Guliyana ($H': 2.463, J': 0.7823$,

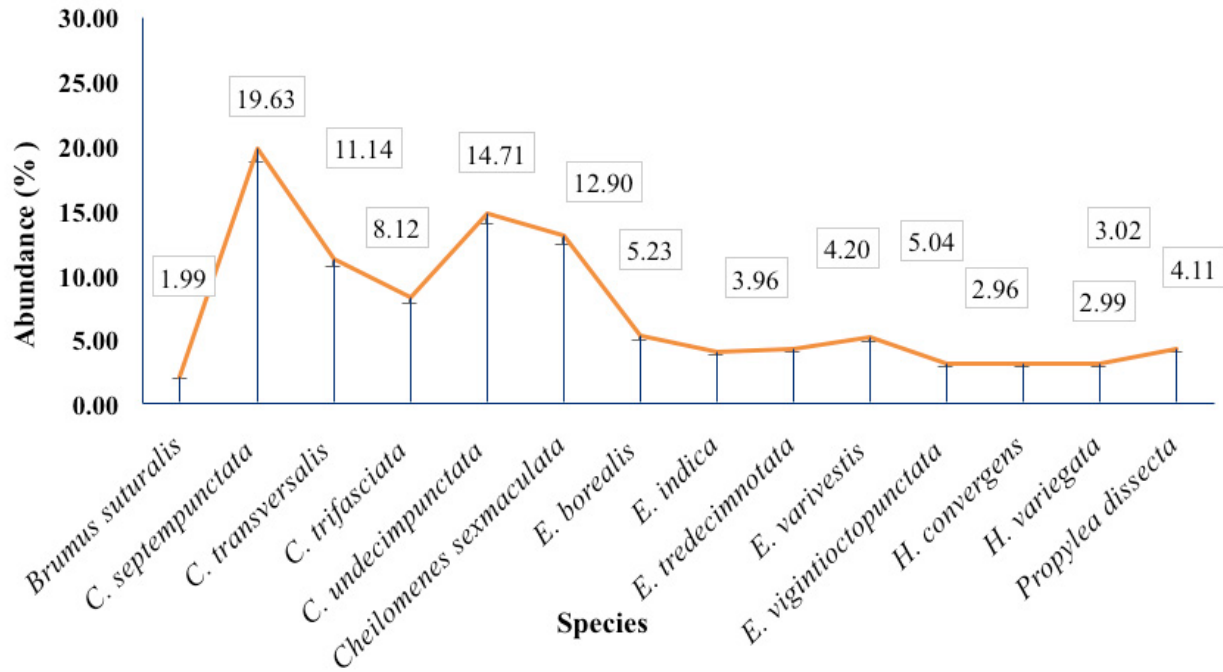


Figure 1: Abundance (%) of Coccinellid Species Recorded From Irrigated and Rainfed Fields of Gujrat, Punjab, Pakistan

1-D: 0.1048) exhibited the presence of 14 different species of ladybird beetles amongst which *C. septempunctata* was found to be the most abundant species whereas *Hippodamia variegata* was absent.

Kunjah

The species diversity at Kunjah include presence of 14 species and abundance recorded showed (H' :2.535, J' : 0.7888, 1-D: 0.101) *C. septempunctata* ($n=81$) was most abundant whereas *B. suturalis* ($n=22$), *E. vigintioctopunctata* ($n=12$) and *E. indica* ($n=12$) was the least abundant species (Table II).

Dolat Nagar

The data recorded from Dolat Nagar (H' :2.472, J' :0.74, 1-D:0.1032) confirmed the presence of 14 different species of ladybird beetles. The *C. septempunctata* ($n=119$) and *C. undecimpunctata* ($n=97$) were two most abundant species whereas *C. sexmaculata* ($n=22$), *E. varivestis* ($n=18$) and *C. trifasciata* ($n=18$) were moderately abundant and *B. suturalis* ($n=08$) was least abundant (Table II).

Lala Musa

Coccinellid diversity recorded at Lala Musa (H' :2.511, J' :0.7702, 1-D: 0.09681) showed the most abundant species were *C. septempunctata* ($n=108$), *C. undecimpunctata* ($n=82$), *C. transversalis* ($n=63$), *C. sexmaculata* ($n=61$) and *C. trifasciata* ($n=55$).

Jalalpur Jattan

H. variegata was not recorded from any site during sampling from Jalalpur Jattan. On the other hand, the data collected from different sites of Jalalpur Jattan (H' :2.454, J' :0.7753, 1-D: 0.1063) depicted that *C. septempunctata* ($n=94$) was the most abundant species among all reported species and least abundant species was *H. variegata* ($n=12$).

Fateh Pur

A total of 14 species of ladybird beetles were recorded from sites located in Fateh Pur (H' :2.374, J' :0.7157, 1-D: 0.1174) which showed *C. septempunctata* ($n=132$), *C. undecimpunctata* ($n=92$), *C. transversalis* ($n=81$) were among the most abundant species whereas *B. suturalis* ($n=07$) was the least abundant species (Table II).

Table II: Shannon-Wiener Diversity Index of coccinellid species recorded from different sites located in district Gujrat, Punjab, Pakistan.

Biodiversity components	Guliyana	Kunjah	Dolat Nagar	Lala Musa	Jalalpur Jattan	Fateh Pur
Diversity (H')	2.4630	2.5350	2.4720	2.51100	2.4540	2.3740
Evenness (J')	0.7823	0.7888	0.7400	0.77020	0.7753	0.7157
Dominance (D)	0.1048	0.1016	0.1032	0.09681	0.1063	0.1174

H' = Shannon-Wiener 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 III: Diversity, abundance, dominance, evenness and richness of species recorded from irrigated and rainfed fields of Gujrat, Punjab, Pakistan

S#	Species	Dominance (D)	Simpson (1-D)	Shannon (H)	Evenness	Menhinick	Margalef	Fisher alpha	Berg-Parker
	<i>Coccinella septempunctata</i>	0.9969	0.003067	0.01149	0.5058	0.07839	0.1544	0.2549	0.9985
	<i>Coccinella transversalis</i>	0.9893	0.010720	0.03353	0.5171	0.10380	0.1690	0.2779	0.9946
	<i>Coccinella undecimpunctata</i>	0.9878	0.012170	0.03730	0.5190	0.09035	0.1614	0.2660	0.9939
	<i>Coccinella trifasciata</i>	0.9711	0.028870	0.07642	0.5397	0.12100	0.1783	0.2924	0.9853
	<i>Cheilomenes sexmaculata</i>	0.9715	0.028480	0.07557	0.5393	0.10750	0.1710	0.2810	0.9855
	<i>Propylea dissecta</i>	0.9191	0.080940	0.17500	0.5956	0.16780	0.2018	0.3296	0.9577
	<i>Epilachna varivestis</i>	0.9228	0.077220	0.16870	0.5919	0.15160	0.1938	0.3170	0.9598
	<i>Epilachna borealis</i>	0.9155	0.084490	0.18110	0.5992	0.14870	0.1924	0.3146	0.9558
	<i>Epilachna indica</i>	0.8797	0.120300	0.23860	0.6347	0.16900	0.2024	0.3305	0.9357
	<i>Epilachna tredecimnotata</i>	0.8748	0.125200	0.24610	0.6395	0.16380	0.1998	0.3265	0.9329
	<i>Epilachna vigintioctopunctata</i>	0.8185	0.181500	0.32710	0.6935	0.19160	0.2132	0.3478	0.8991
	<i>Hippodamia variegata</i>	0.7813	0.218800	0.37680	0.7288	0.20410	0.2191	0.3573	0.8750
	<i>Hippodamia convergens</i>	0.7964	0.203600	0.35690	0.7145	0.18810	0.2115	0.3452	0.8850
	<i>Brumus suturalis</i>	0.7112	0.288800	0.46370	0.7950	0.22360	0.2282	0.3721	0.8250

The study highlights the presence of coccinellid diversity in district Gujrat both in irrigated and rainfed areas of District Gujrat. The presence of 14 species and 6 genera in the study area demarcates richness of diversity in the study area (Table III). Coccinellids have been reported from the Faisalabad, Pakistan by Gilani (1976). The geographical distribution of sixteen species belonging to Coccinellids along with their host plants has been reported from Peshawar Valley (Shah, 1985). The presence of similar species has been reported from Chitral by Din (2002). Khan *et al.* (2007) conducted a similar kind of survey of predatory Coccinellids and reported 12 species in the District Chitral.

Predatory Coccinellids from Bagh, Sudhnuti and Poonch Districts of Azad Jammu Kashmir has been reported (Rafi *et al.*, 2005). Taxonomic notes and distributional list of 75 species of ladybeetles were recorded from Pakistan (Rafi *et al.*, 2005). Abbas *et al.* (2013) endorsed the presence of 91 species in Pakistan. Our study also highlights the diversity of coccinellid species in agricultural ecosystem that hypothesized lesser use of farm inputs increases diversity of non-pest beneficial species. The results earlier presented that the intensified agricultural practices loaded with inputs (fertilizers, herbicides, pesticides, etc.) have impact on non-target species (predators, parasitoids and pollinators) and has hazardous environmental impact are in conformation with our findings that showed variations in diversity and abundance of Coccinellids in different scenarios of microclimate (Abbas *et al.*, 2013).

Irrigated areas offer more cropped area around the year which is devoid of fallow seasons thus more food

available in irrigated areas and consequently more pest species resulting in higher number of coccinellid predators (Hayat *et al.*, 2014). The results showed fluctuating population of Coccinellidae in the study area throughout the year with highest numbers were recorded during March-April during the sampling period. Similar observations were recorded in the earlier studies reporting that the months of March and April were found more favorable for the family Coccinellidae (Abbas *et al.*, 2013). The higher abundance was recorded from wheat fields showing more number of species and greater numbers of each species as compared to collection made from other vegetation.

Similar findings were reported in studies conducted in Faisalabad (Abbas *et al.*, 2013). The results showed most abundant and dominant species was *C. septempunctata* at all the sites. Similar, abundance and dominance of *C. septempunctata* was reported from Pakistan (Akram *et al.*, 1996; Rahatullah *et al.*, 2011). Predatory ladybird beetles from various Districts of Khyber Pakhtunkhwa (Swabi, Mardan and Nowshera) presented their results and their findings also confirm trends showed by species for diversity, dominance and richness found in our study (Urooj and Ali, 2016). The results identifies the variations in the composition of species in different parts of the study area indicating their probable role in the natural control different pest species under field conditions. The study showed that District Gujrat was represented by 14 species which are important predators of many pest species with similar ecological role and potentially different predatory efficiencies. More exploratory studies need to be conducted particularly with reference to host plants and their pest and their impact on the diversity and distribution of these species in

district Gujrat along with their predatory efficiencies.

Conclusion

The diversity and distribution of Coccinellid beetles (Coleoptera; Coccinellidae) was explored in Gujrat, Punjab, Pakistan during 2015-2016 in order to assess biodiversity in rainfed and irrigated fields. The results exhibited higher diversity, dominance and richness of coccinellid beetles' (H' : 2.481, $1-D$: 0.8964 & J' : 0.7474) in the studied areas. This may be attributed to diversified flora and climate of the locations characterized by rainfed as well as irrigated areas surrounded by rivers and sub-mountainous topography. The data also showed greater diversity and abundance values for species collected from sites that are characterized by cultivation practices in irrigated fields as compared to rainfed. The sites, where no pesticides were used except selected herbicides during Rabi and Kharif season for the control of seasonal weeds, showed higher diversity and abundance.

Acknowledgement

We thank post graduate students of Zoology, UOG for providing assistance in collection and handling of specimens and reviewers and editors for comments that greatly improved the manuscript.

Conflict of Interest

Authors claim no conflicts of interest associated with this research work.

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