The Journal of Animal & Plant Sciences, 22(4): 2012, Page: 1019-1023
ISSN: 1018-7081

PREDATOR-PREY ASSOCIATION AMONG SELECTED ARTHROPOD SPECIES IN THE CROPLAND OF MIXED-CROP ZONE (MCZ) AND COTTON-WHEAT ZONE (CWZ)

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ABSTRACT

Wheat, brassica and fodders (maize, sorghum and alfalfa) were sampled for various arthropod taxa in the mixed-crop (MC) and cotton-wheat (CW) zones of Punjab and predator- prey densities were calculated. Line graphs of predator-prey ratio (p/p) in eight monthly samples were plotted for each predator and its prey species. The most linear horizontal pattern thus obtained revealed an association of a predator to its prey(s). Significance of the association was ascertained by simple linear regression on the relative abundances of both the groups. Findings are helpful in applying a species-specific biological control in nature.

Key words: Croplands, Arthropods, Predator-prey relationship.

INTRODUCTION

Study of the predator-prey relationships is one of the fundamental themes in ecology (Barryman, 1992). Trophic structure of many predator and prey species always depicts some mathematical proportionality especially in their abundance ratios. as these ratios indicate population trends of each group in an ecosystem (Hamdan and Awad, 2007; Tommanisini and Maini, 2001). A direct relationship of this proportionality is imperative for the proper functioning of any ecosystem and a vast majority of the naturally maintained ecosystems show- best picture of it. The data obtained from complex food web structure or species association analyses go after this simplification. The incoming pattern of any two species in the crop field is also vital (Dixon, 2000; Dixon and Kindlemann, 1998). Generally it is assumed that predator-prey ratios obtained from abundance data of two species clearly indicates cyclic functioning of complex food web structure. Food chain and food web structures reveal ecological linkages for gratifying their basic life needs (Kindlemann and Dixon, 2001; Kindlemann *et al.,* 2002; Yasuda *et al.,* 2002).

Most of the predator prey studies conducted in Pakistan document vertebrate predators and their prey (Mahmood-ul-Hassan2006; Mahmood-ul-Hassan *et al*., 2007abcde). No study on the mutual interaction of invertebrate predators and their prey is available from Pakistan. The present study focuses on arthropods that are the largest among invertebrates groups, possess extremely diversified niches and act as predators, preys, parasitoids and pests. They determine overall productivity of an ecosystem and control population dynamics of each other (Purves *et al.* 2000). Coccinellids (e.g. *Coccinella septempunctata, C. sexmaculata*; *Hippodemia convergen*; *H. variegata*), lacewings (e.g *Chrysoperla carnea*) and arachnids (e.g *Oxyopes javanus, Neoscona theisi*; *Araneidae nymph*) are the commonest arthropod predators of the agro-ecosystems that have great economic impact in regulating population dynamics of many serious pests of agriculture as their prey(Omkar and Pervez, 2000; Tauber *et al.* 2000; Omkar and Srivastava, 2001; Symondson *et al*. 2002). These polyphagous predators are abundant in the mixed-crop (MC) and cotton-wheat (CW) zones of Pakistan. This paper documents firsthand knowledge on the densities and proportions of some arthropod predator and their prey species in MCZ and CWZ to find out association patterns between them.

MATERIALS AND METHODS

Study area: Agronomically Punjab is subdivided in three distinctive climatic zones on the basis of the average annual rainfall they receive. These arbitrary divisions include rice-wheat (RW), mixed crop (MC) and cotton-wheat (CW) zones. This study was conducted in Faisalabad and Multan districts that lie in mixed crop (MC) and cotton-wheat (CW) zones, respectively. The Faisalabad district lies in the flat plains of Punjab (N 30°31.5′, E 73°74′) at 184 m asl with an average maximum 50 °C (122°F) and minimum −1°C (30.2°F) summer and winter temperatures. The rainfall is highly seasonal (about 400 mm/annum) and most of it is received during monsoon (July and August). Multan district, on the other hand forms the southern part of Punjab (N 30°45′ E 72°4′; 215m asl) with average maximum 54°C (129°F) and minimum 1C (30.2F) summer and winter temperatures. The average annual rainfall is 127 mm and dust storms are the common features of local climate (Akhtar, 2006).

Sampling Strategy: Random Number Table was used to select eight localities each from the map of two zones (i.e. MCZ and CWZ) and each of these localities were sampled once during the study period. Sampling was done for three consecutive days (i.e. 90 minutes before dawn and 90 minutes at dusk) at any particular locality. Of the five acres of fodder, wheat and brassica in both MCZ and CWZ, two acres each were selected for the collection of arthropod fauna. Thus sampling was done for 24 days each (3 days/month/zone) in two zones and a total of 48 days were spent in the field.

Collection, Preservation and Identification: Collection was done by hand picking, sweep netting (38cm dimensions) and automated sifting using electric sifters (Humboldt, USA) were used for collection of foliage arthropods. The collected specimens were preserved in glass vials containing laboratory grade alcohol with few drops of glycerine. Pocock (1985), Rafi *et al.* (2005), Borror and Delong (2005) and Atwal and Dahliwal (1998) were consulted to identify various arthropod groups up to species level.

Calculation of predator to prey (p/p) ratio: The number of arthropod species collected during each month was categorized either as predator(s) or prey(s) on the basis of literature (Inayat *et al.* 2010). Abundance ratio of a predator with its different available preys (p/p ratio)) was then calculated by dividing the density of preys with the density of a predator in a particular month. This ratio (y-axis) was plotted on a graph using Microsoft Excel 2007 against the months (x-axis) and the most horizontal straight line was chosen to represent the best indicator of association between a predator and prey species (Inayat *et al.* 2011). The significance of association was tested using simple linear regression and *R*-values were calculated Microsoft Excel 2007.

RESULTS AND DISCUSSION

The field data showed that *Coccinella septumpuctata* (n = 2247)*, Chrysoperla carnea* (n = 912), *Cheilomenes sexmaculata* (n = 687)*, Oxyopes javanus* (n = 516), *Hippodemia convergens* (n = 513), *Araneidae nymph* (n = 510), *Neoscona theisi* (n = 498) and *Hippodemia variegate* (n = 330) were the numerically most captured predators while *Aphis maidis* (n = 4410), *Empoasca kerri*(n = 3270), *Schizaphis graminum*(n = 2898), *Musca domestica* (n = 2814)*, Lepidopteran larvae* (n = 2130) and *Macrosiphum miscanthi*(n = 1926) were the most captured preys/pests in these croplands.

Predator-prey associations: Numerical abundances of predators and their preys are interdependent upon each other (Gaston, 1996; Shelly *et al.,* 2011). *Coccinella septumpunctata* showed an association with all its preys except *E. kerri* and *Lepidopterous larvae* (Fig 1). Lockwood *et al.* (1990) found that a constant p/p ratio had lower values in more sensitive density ratios. Similar situation was observed in case of *C. septumpuncata* with four prey species as depicted in the form of horizontal linear pattern and significant *R*-values but with lower p/p ratio. Rest of the coccinellids as *C. sexmaculata, H. convergens* and *H. variegata* showed association with *A. maidis* (Fig 2, 3, 4). *Coccinella carnea* (a major neuropteran predator) showed association with *S. graminum* (Fig 5). There are examples that most of the insect predators share same prey but some species are preferred over the other thus coccinellids showed preference for *A. maidis,* whereas *C. carnea* preferred *S. graminum* (Omkar *et al.* 1997). Among arachnids, *O. javanus* showed association with *M. domestica* and *A. maidis* (Fig 6) while *N. theisi* and *Araneidae nymph* showed association with *M. domestica* (Fig 7, 8). Studies conducted under laboratory conditions confirmed that spiders prefer the soft bodied, comparatively bulky and juicy preys when supplied with a variety of food items (Amalin *et al.,* 1999). The *R*-values (Table 3) were observed significant for the above mentioned associations of predator and prey species which further confirms the relationship between two groups.

Prominent fluctuations in a few p/p ratios were also observed during this study which is mainly due to an increased use of chemicals that often alters predator, pest and parasitoid ratios in an agro-ecosystem (Siddiqui, 2005). Environmental perturbation is considered to be an important factor for loss of ecologically important species from the agro-ecosystem. Affinities of coccinellids for single aphid species and spiders for house flies confirms the reduction of other prey species probably due to continuous use of insecticides for controlling aphid attack especially on wheat and brassica crops. Thus increased abundance of *A. maidis* reflects absence of other aphid species in these croplands. There is a maximum likelihood that a single prey species becomes a preferred prey of a generalist predator in a disturbed agro-ecosystem (Brown, 1992). *Aphis maidis* was thus preferred by a majority of coccinellids and a spider species due to its abundance in the crops. *S. graminum* was preferred by lacewing due to its abundance during wheat-brassica crop season while house flies were the preferred food for spiders being present round the year in almost every habitat.

Table 1. Comibined relative abundance (%) of the arthropode taxa sampled from mixed-crop (MCZ) and cotton-wheat zones of Punjab and their numerical ranking (in superscript) during the eight month study.

Arthropod Taxa	MCZ	CWZ	Total
		%RA (n)	
Predators			
Coccinella septumpunctata	44.0 (1547)	26.0 (700)	36.17(2247)[a]
Cheilomenes sexmaculata	11.4 (400)	10.7(287)	11.06(687)[c]
Hippodemia convergens	9.7 (340)	6.4(173)	8.26(513)[e]
Hippodemia variegata	5.1(180)	5.6(150)	5.31(330)[h]
Chrysoperla carnea	9.9(350)	20.9(562)	14.68(912)[b]
Oxyopes javanus	6.1(216)	11.1(300)	8.31(516)[d]
Neoscona theisi	7.6(266)	8.6(232)	8.02(498)[g]
Araneidae nymph	6.3(220)	10.8(290)	8.21(510)[f]
Preys			
Aphis maidis	27.8 (3010)	21.2(1400)	25.3(4410)[a]
Schizaphis graminum	16.6(1800)	16.6(1098)	16.6(2898)[c]
Macrosiphum miscanthi	11.1(1202)	10.9(724)	11.0(1926)[f]
Empoasca kerri	19.4(2100)	17.7(1170)	18.7(3270)[b]
Lepidopteran larvae	9.4(1020)	16.8(1110)	12.2(2130)[e]
Musca domestica	15.7(1700)	16.8(1114)	16.1(2814)[d]

Table 2. Simple linear regression showing the significance of association between selected predator and prey species in the cropland of MCZ and CWZ.

Predator species	Prey species	R^2 values
C. septumpuncata	*A. maidis*	0.923
	S. graminum	0.758
	M. miscanthi	0.708
	M. domestica	0.702
C. sexmaculata	*A. maidis*	0.827
H. convergens	*A. maidis*	0.902
H. variegate	*A. maidis*	0.814
C. carnea	*S. graminum*	0.844
O. javanus	*M domestica*	0.794
	A. maidis	0.728
N. theisi	*M. domestica*	0.842
Araneidae nymph	*M. domestica*	0.792

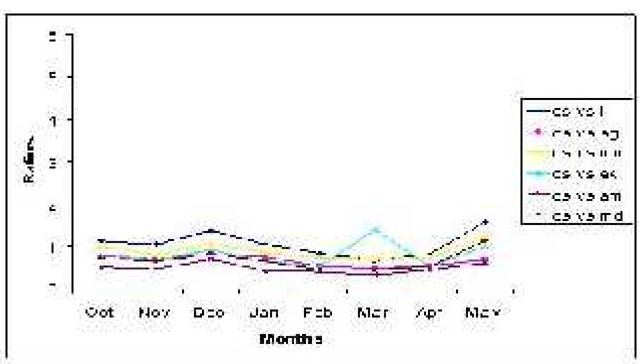

Fig 1: Predator-prey ratio of *C.septumpuctata* with different available preys cs= *C.septumpunctata*, ll= lepidopterous larvae, sg= *S. graminum*, mm= *M. miscanthi*, ek= *E. kerri*, am= *A. maidis*, md= *M. domestica*

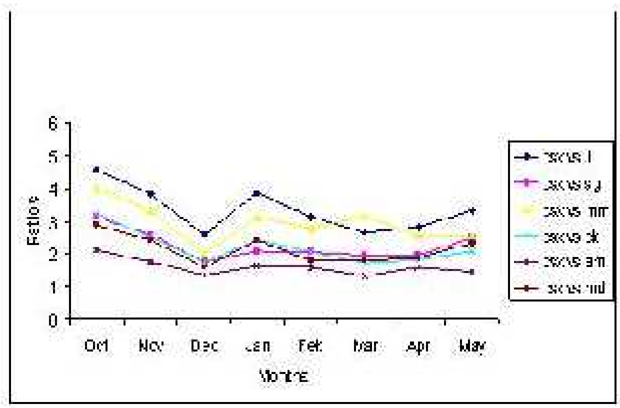

Fig 2: P/p ratio of *C.sexmaculata* with different available preys csx= *C.sexmaculata*

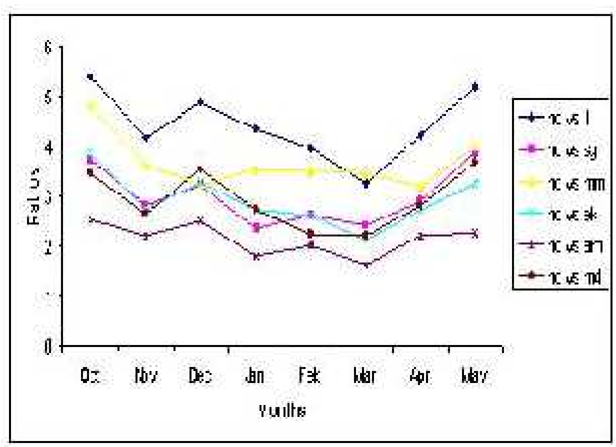

Fig 3: P/p ratio of *H. convergens* with different available preys hc= *H. Convergens*

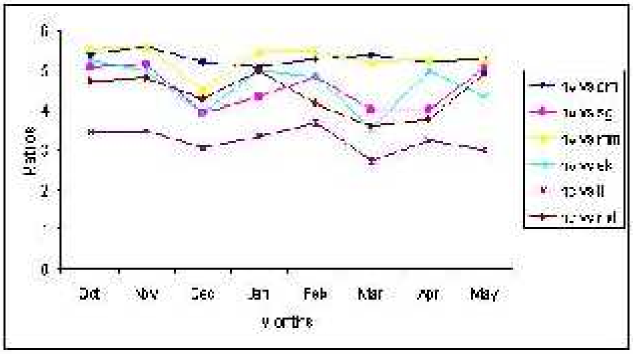

Fig 4: P/p ratio of *H. variegata* with different available preys hv= *H.variegata*

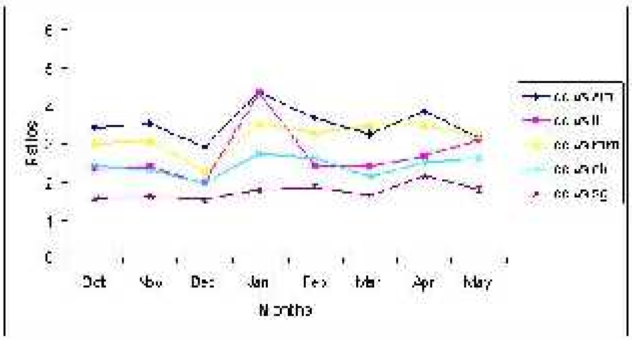

Fig 5: P/p ratio of *C. carnea* with different available preys cc= *C. carnea*

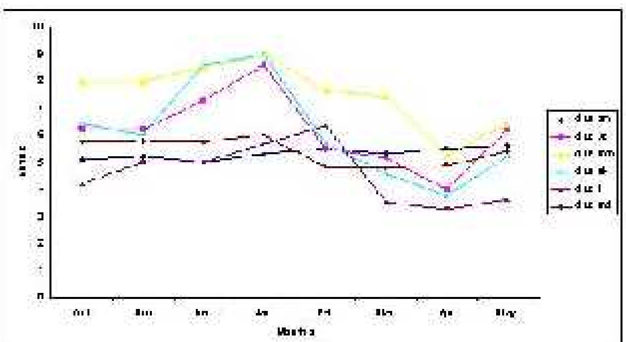

Fig 6: P/p ratio of *O. javanus* with different available preys oj= O. javanus

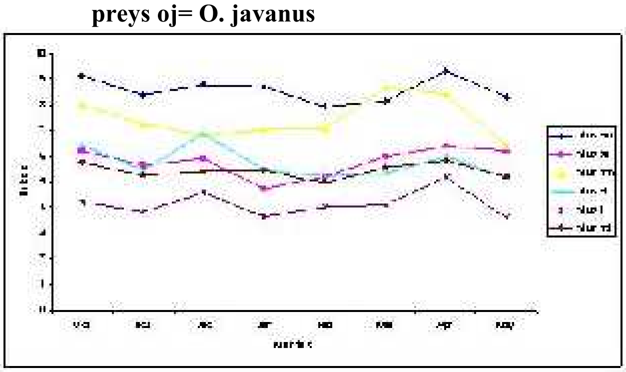

Fig 7: P/p ratio of *N. theisi* with different available preys nt= *N. theisi*

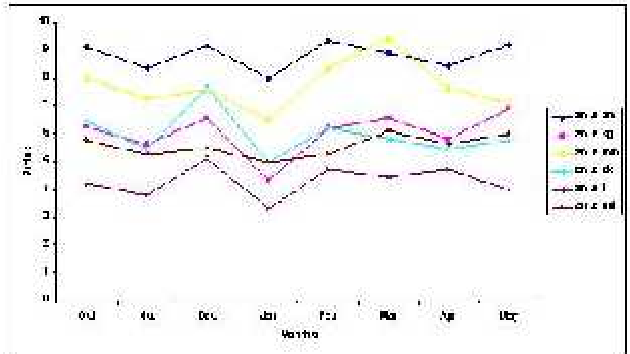

Fig 8: P/p ratio of *Araneidae nymph* with different available preys an= *Araneidae nymph*

Acknowledgement: We gratefully acknowledge the financial support provided by the Higher Education Commission of Pakistan (20-813/R&D/HEC) for providing field and laboratory facilities for this study. by. We are also grateful to the editor JAPS and two anonymous reviewers who have made a lot of effort to refine this manuscript.

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