Pak. J. Agri. Sci., Vol. 48(2), 153-157; 2011
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

PREDATOR-PREY RELATIONSHIP AMONG SELECTED SPECIES IN THE CROPLANDS OF CENTRAL PUNJAB, PAKISTAN

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Predator-prey relationship is of great importance in the agro-ecosystems. Insects being the largest group of arthropods have a major role in designing various management strategies against different crop pests. Theoretically, these interactions influence the structure and dynamics of an agro-ecosystem and the present project is a good example of this .A mathematical model was proposed and analyzed to study the dynamics, of autonomous predator- prey model with a logistic abundance ratio. The major coleopteran predators; *Coccinella septempunctata*, *Coccinella undecimpunctata*, *Cheilomenes sexmaculata Hippodamia variegata* and *Calosoma maderae* and important hemipteran prey/pests; *Schizaphis graminum, Aphis maidis, Macrosiphum miscanthi* , *Aphis gossypii* and *Diuraphis noxia* were sampled from mixed crop agro-ecosystems of Central Punjab. The study was conducted to find the monthly abundance ratios of each predator species with all of the prey species in wheat, fodder and brassica crops. A graphed horizontal straight line was taken as constant predator-prey relationship. Chi-square test was applied on the relative abundance of a predator with selected prey species. Accordingly, most of the predators in different crops (wheat fodder and brassica) depicted a straight line showing least changes in nearly all monthly samples with *S. graminum.* By using such results species specific biological control can be implemented against targeted pests of the cropland.
Keywords: Coccinellids, carabid, aphids, predator-prey abundance ratio

INTRODUCTION

No insect population exists as an isolated entity. Rather, at any location many populations of organisms interact to varying degrees in a community. Different species within an ecological community interact in a number of ways. In agro-ecosystems, the study of trophic interactions is important with regard to pest management. Individuals of a population feed on, and in turn are fed upon other species (Tscharntke and Hawkins, 2004).

Many natural enemies of insects are polyphagous and have different relationships with their various prey items i.e., many carabid and coccinellid beetles. A broad diet tends to buffer populations of such generalists from fluctuations in abundance of any prey species. Most insect populations are preyed upon by several natural enemies, thus it is useful to know how each can affect the population dynamics of predator and prey species. It is also useful to understand the combined effect (Hassel, 1986). This is a central issue in the manipulation and use of predators in integrated pest management programmes. A predator's use of these food resources has important implications for the outcome and stability of predator-prey dynamics (Begon *et al.*, 1986).

Coccinellids and carabids are most widespread and abundant predators in many agricultural systems. They are known to have a strong impact on aphid species (Hodek and Honek, 1996). *C. septempunctata, C. undecimpunctata, C. sexmaculata* and *H. variegata* populations comprise major coccinellid componants , while *Calosoma maderae* is the main carabid predator in the croplands .Presence of these predators in the crop fields with abundant aphid populations initiated studies on the their abundance ratio with different aphid species in Central Punjab; these were *Schizaphis graminum, Aphis maidis, Macrosiphum miscanthi, Aphis gossypii* and *Diuraphis noxia*.

Theoretical models take into account the basic parameters governing dynamics of the interactions between generalist predators and their many pest and non-pest prey. In practice, however, inter and intra-specific interactions between generalist predators, and between the predators and their prey, within multi-species systems under the influence of rapidly changing biotic and abiotic variables are difficult to predict. A review of manipulative field studies showed that in approximately 75% of cases, generalist predators, whether single species or species assemblages, significantly reduced pest numbers (Symondson, 2002).

The aim of the present work was to determine the best predator- prey (p/p) relationship, amongst selected insect species in three different crops. A constant p/p ratio in monthly samples will be used as an indicator of the intimate relationship between two interacting taxa.

MATERIALS AND METHODS

Fields of fodder, wheat and Brassica were selected for study of (predator and prey/pests) species. Studies were conducted in selected agriculture fields from January to May, 2008 and 2009. At each locality two blocks (each > 5 acres), of different crops were selected. Within each block, two acres were selected randomly for sample collection.

The collection of insect fauna was conducted fortnightly from, ground surface and foliage. Sweep net were used to sweep insects present above the vegetative canopy. Heavy duty muslin nets (38 cm dimension) were used to sweep through the vegetation in figure eight fashion. Direct hand picking was also employed to collect the foliage fauna. Each collecting period was three hours. The ground fauna was captured by the pitfall trapping method. Twenty-pitfall traps were placed in a field of one acre at regular intervals The pitfall traps used were 15 cm in diameter and 25 cm in depth having about 200 ml of aqueous solution of 10% formalin and were placed in the ground with their openings at the surface level. The traps were kept in the fields for 12 hours. All the captured insect specimens were washed in 70% alcohol (used as antiseptic) and were stored in glass vials with 70% alcohol, and a few drops of glycerin. The identification up to species level was done with the help of related taxonomic information in "Fauna of British India "and available online keys in different websites. The trophic guild of the species identified was confirmed from recent available literature.

The p/p ratio of a predator with an aphid prey species was estimated by simply dividing the density of a predator with density of a prey species within monthly samples. The p/p abundance ratio of selected species was plotted against time scale of monthly samples. A straight line was considered as constant and an indicator of a desirable association (for crop growth) among the predator and prey species in question. Chi-square tests were applied to validate the association.

***Assumptions of predator-prey association*:** The predation efficiency depends on the cost-effective availability of its prey species. It also depends on the adaptive efficiency of the predator in approaching, manipulating and utilizing the prey species. Quantity and quantity of the prey species is also an important factor. An optimality model favors specialist/stenophagous predators and assures the availability of an almost fixed number of preys in the area. Even for generalists there is some hierarchy of preferred food items and so is the adaptability of the individuals within the population of a generalist predator.

RESULTS

Monthly predator-prey abundance ratio of each of the selected predator with all the aphid species was plotted (Fig. 1-8). Constant or nearly constant p/p ratios were depicted as straight line parallel to the time scale, for some of the species in different crop fields. This was considered an indication of close intimate relationship among the mutually antagonist species. Generally predator prey species with minimum ratio showed constant and less fluctuating associations while higher values indicated significant variations and loose relationship between predator and prey species. The ratios of a predator with different prey species showed variable fluctuations through time (monthly samples). The chi-square (x^2) test results also showed synchrony with the graphic results. Significant values were observed for species showing minimum fluctuations in the monthly p/p abundance ratios (Table 1).

***Predator prey associations*:** Amongst all the predators *C. undecimpunctata* showed most consistent association with *S. graminum* in Brassica fields (Fig. 2). It also showed a constant linear monthly relationship with *S. graminum* and *M. miscanthi* in wheat (Fig. 6). It showed fluctuations with

Table 1. Chi-square test showing the significance of association between selected predator and prey species in fodder, brassica and wheat (M.C.Z.)

Crop	Predator	Prey	Chi-square (x^2)	Significance
Brassics	*C. undecimpunctata*	*S. graminum*	33.00	Significant
	C. maderae	*S. graminum*	28.26	Significant
	H. variegata	*S. graminum*	27.00	Significant
	C. sexmaculata	*S. graminum*	25.00	Significant
	C. septempunctata	*S. graminum*	18.10	Significant
Wheat	*C. undecimpunctata*	*S. graminum*	31.28	Significant
	C. undecimpunctata	*M. miscanthi*	27.68	Significant
	H. variegata	*S. graminum*	28.00	Significant
Fodder	*C. maderae*	*S. graminum*	14.63	Significant

rest of the prey species in other crops. Another coccinellid predator *H. variegata* showed a constant association only with *S. graminum* in wheat (Fig. 7) and Brassica fields (Fig. 4). The carabid predator *C. maderae* showed a linear relationship only with *S. graminum* in Brassica (Fig. 5) and fodder fields (Fig. 8).

C. septempunctata showed a constant association with *S. graminum* only in Brassica (Fig. 1). Similarly *C. sexmaculata* showed a constant association with only *S. graminum* in brassica (Fig. 3). The chi-square values (Table 1) were also observed as significant for the above mentioned predator and prey species. In summary aphid *S. graminum* was preferred by all coccinellid predators in wheat and brassica and *C. maderae* in fodder fields, probably due to its abundant availability in all crops.

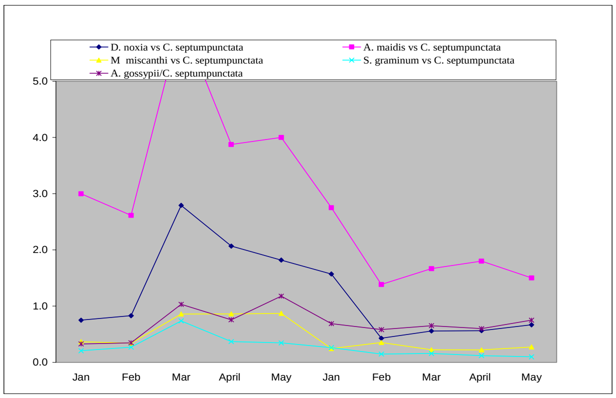

Figure 1. Extent of variation in the abundance ratio of *C. septempunctata* with aphid species in Brassica MCZ

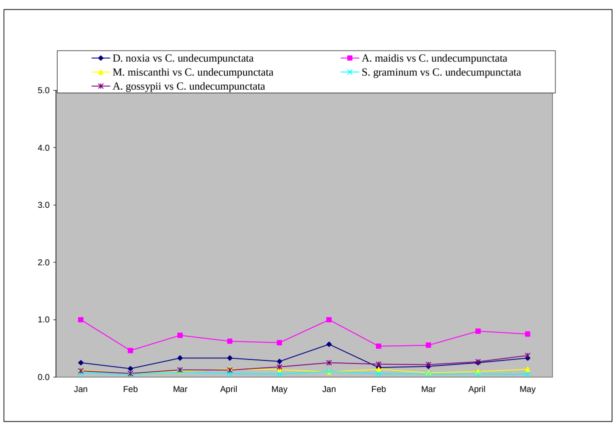

Figure 2. Extent of variation in the abundance ratio of *C. undecimpunctata* with aphid species in Brassica MCZ

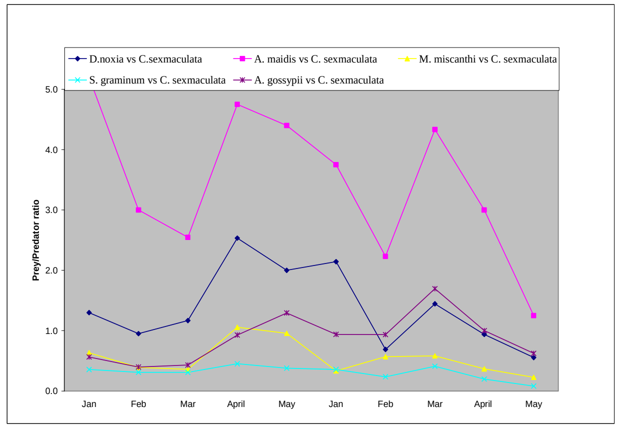

Figure 3. Extent of variation in the abundance ratio of *C. sexmaculata* with aphid species in Brassica MCZ

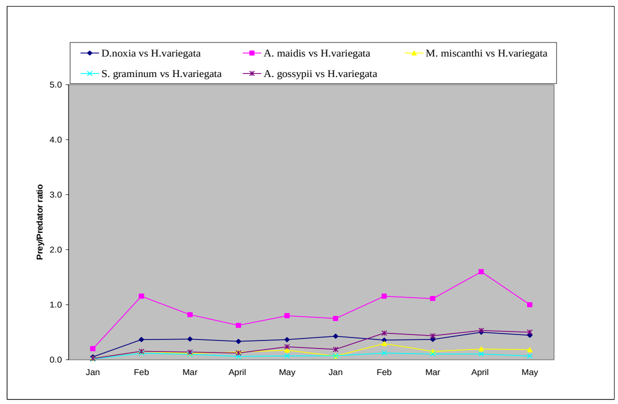

Figure 4. Extent of variation in the abundance ratio of *H. variegata* with aphid species in Brassica MCZ

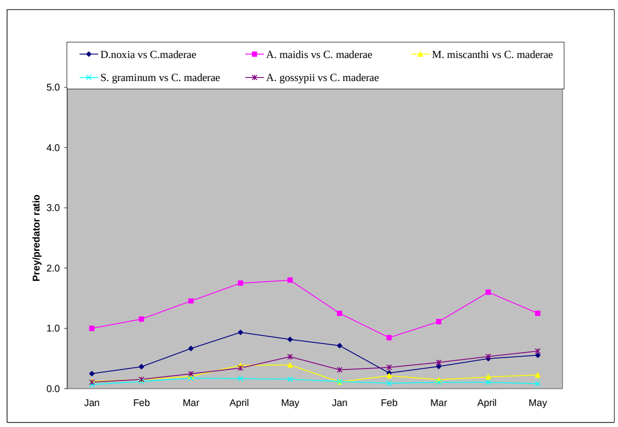

Figure 5. Extent of variation in the abundance ratio of *C. maderae* with aphid species in Brassica MCZ

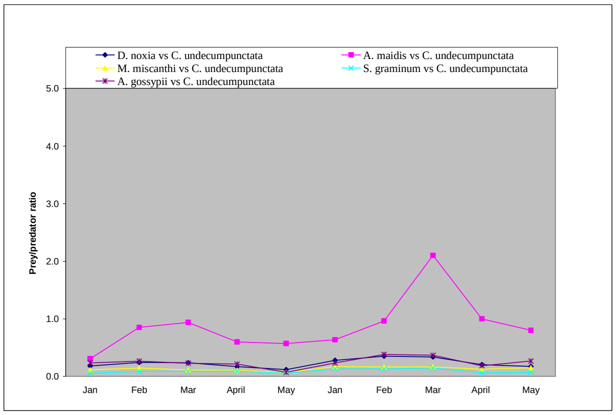

Figure 6. Extent of variation in the abundance ratio of *C. undecimpunctata* with aphid species in Wheat MCZ

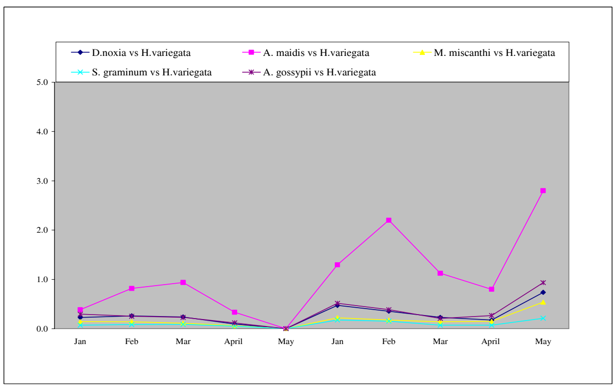

Figure 7. Extent of variation in the abundance ratio of *H. variegata* with aphid species in Wheat MCZ

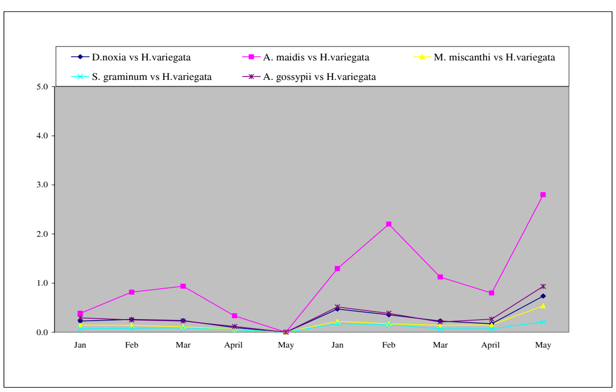

Figure 8. Extent of variation in the abundance ratio of *C. maderae* with aphid species in fodder MCZ

DISCUSSION

Predator-prey models (almost straight line through time scale), interpret the rate of consumption usually as a behavioral phenomenon. The classical assumptions are that predators encounter prey at random and that the trophic function depends on prey abundance only. The trophic function must be considered on the slow time scale of population dynamics at which the models operate. It is reasonable to assume that the trophic function depends on the ratio of prey to predator abundances. Several field and laboratory observations support this hypothesis (Arditi and Ginzburg, 1989). In a laboratory study, the predation rate of adult/larvae of *H. variegata*, *C. undecimpunctata*, and *C. novemnotata* on cerial aphid *S. graminum* showed a constant p/p ratio. At specific prey density, different predators consumed a definite prey number. Also the consumption rate of a predator increased, with the increase in prey number (Doghairi, 2004).

Siddiqi (2005) studied the predator-prey abundance ratios of arthropods in wheat constant in food webs of different habitats within agro-ecosystems The predator prey ratio appears to remain constant in food webs of different habitats of agro- ecosystems. In the present study same trend was observed. *C. undecimpunctata* , *H. variegata*, *C. septempunctata* *C. sexmaculata* and *C. maderae* predators showed constant or nearly constant density ratio with *S. graminum*.

Lockwood (1990) studied predator prey ratios in arthropods, based on species richness and diversity. He reported that predator and prey species which showed constant p/p ratios had lower abundance ratio values than more sensitive density ratios, with higher p/p ratio values. The same trend was observed in the present study. *C.undecimpunctata* , *H. variegate, C. sexmaculata C. septempunctata and C.maderae* showed a constant abundance ratio with S. graminum which was depicted in the form of straight line, with a significant chi-square value (Table 1). While the same predators showed higher, more sensitive ratios depicted as fluctuations with other prey species.

Closs and Shirley (1999) found that predator-prey density ratio changed little when taxa within the Food- web are aggregated to large trophic groups. In our study we also found that predator and prey species which had larger aggregations showed little changes in the p/p abundance ratio. *C. undecimpunctata* and *S. graminum* had largest aggregation in wheat and Brassica crops and horizontal linear, constant association with highly significant chi-square value (31.28 and 33, respectively). Many insect predators share the same prey species, but some prey species are preferred over others (Omkar, 1997). This may be because of difference in handling of the prey species by the predators. Same trend was observed in the present study. In wheat, Brassica and fodder; *S. graminum* was preferred prey species of most of the predators as compared to other prey/pest species present in the field.

The majority of the predators-prey association trend observed in the present study did not show constant, horizontal, linear relationship. Fluctuations were observed in the predator-prey abundance ratio .Chi-square test further confirmed the association to be non- significant (Table 1). One of the probable causes of this trend may be the heavy use of insecticides in the agro-ecosystems .Insecticide use has increased dramatically in the last two decades in Central Punjab (Siddiqi, 2005). In the absence of other effective means the farmers are relying more and more on these insecticides. The pesticide application alters the pest and predator or parasitoid ratios in the agro-ecosystems causing more harm than good (Hussain, 1984). As many as five predator species showed feeding affinities towards single prey species and seemed to confirm the reduction of other prey species as a result of use of pesticides especially in wheat. In addition to the aphid species recorded in the present study *Acyrthosiphon pisum* and *A. gossypii* were also reported in the wheat crops of Faisalabad (Raza, 2009; personal communications). Seemingly abundance of S. graminum might also be the result of occupation of niches vacated by other aphid species present in the cropland under study. Increase of pest resistance to insecticides has been reported by Brown (1992). Furthermore, the species competing for the same food source are also expected to face stress due to scarcity of food.

Ruby (2010; personal communications) also found similar results on the coccinellid predators *C. septumpunctata, C. sexmaculata, H. convergens* and *H. variegata* predating on *A. maidis* in her study in the same area in the year previous to this study. Thus our work will provide essential base line information of the insect fauna to agronomists in the area. They can take steps to sustain croplands in more efficient manner , which not only lead to increases in crop yield but also stabilize the food webs in the agro-ecosystems of Central Punjab.

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