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# Predator Prey Interaction between Lepidopteran Pests and Coccinellids Insects of Cotton in Southern Punjab Pakistan

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**ABSTRACT**

In biological control program Predators are exploited to manage pest population. The objective of present study was to find relationships between predator's *Coccinellid septempunctata*, Lynx spider and preys *Helicoverpa armigera*, *Pectinophora gossypiella*, *Earias vitella* populations found on cultivated cotton crops (government approved varieties) in Southern Punjab, Pakistan. Data was collected after ten days of interval during crop season from 2014 to 2016 randomly. Significant Correlations coefficients were observed which can be used for effective pest control program to predict predator prey ratio.

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**Authors' Contribution**
**MNA conducted the study and compiled and interpreted the results. AF provided technical support, critically reviewed the manuscript and helped in data analysis.**

**Key words**
**Lady bird beetle, Lynx Spider, Chewing insect pests, Correlation, Cotton crop.**

## INTRODUCTION

Genetically modified cotton produced special type of protein called as Cry1Ac from *Bacillus thuringensis* (Bt) to control the bollworms and planted in wide area of different countries (Chen *et al*., 2017; James, 2002). Large number of insect pests attacked cotton but most dangerous to the crop is bollworms, like as *Helicoverpa armigera* (Hübner) (Olsen and Daly, 2000), *Helicoverpa zea* (Boddies), *Heliothes virescens* (fabricius), *Helicoverpa punctigera* (wallengren), and *Pectinophora gossypiella* (Saunders) (Patin *et al*., 1999). The protein produced by the Bt cotton was targeted to lepidopterans but number of other cotton insect's species like as *Amrasca devastans* (Jassid), *Bemisia tabaci* (White fly) are unharmed by Cry1Ac protein (Naranjo *et al*., 2008). In the beginning, transgenic cotton variety produced only a single Cry protein, but later on it was replaced by varieties that produced two types of protein, named as Bollgard-II (BG-II) formerly it is Bollgard-I (Naranjo *et al*., 2008). Transgenic cotton produced Cry protein throughout the farming season and so non-target and target pests have adequate opportunity for exposure to these proteins. Among these insects, parasitoid and predators are included that feed on arthropod, which used to eat plant tissue having Bt proteins (Harwood *et al*., 2005; Obrist *et al*., 2005, 2006; Torres *et al*., 2006; Torres and Ruberson, 2008; Meissle and Romeis, 2009). Among all bollworms pink bollworm (*Pectinophora gossypiella*) is a major pest and reduced the cotton production in many countries of the world. Use of highly toxic chemicals to control this pest not only hazardous to health but also the cause of economic losses (Henneberry *et al*., 1996). Biological control is a reliable and long-lasting solution to check the harmful insect of cotton and technique which is mature and nature friendly (Bale *et al*., 2008; Badshah *et al*., 2018). Predator control the prey population by eating and parasitizing them (Sathe and Bhosle, 2001; Sattar *et al*., 2011). Predators like as *Coccinella septempunctata, Chrysoperla carnea* (Shahid *et al*., 2013), *Menochilus sexmaculatus, Geocoris* spp., and parasitoid *Apanteles* spp., *Trichogramma* spp., minimize the number of various cotton insect pests like as *S. exigua, H. armigera, Bemisia tabaci* and *Aphis* spp. (Ahmad *et al*., 2011; Mohamed *et al*., 2016; Sivasubarmanian *et al*., 2009; Wells *et al*., 2001). Predator population usually depends upon the number of preys available. Certain predators prefer some prey while others can feed on any available prey. Among different kinds of predators, some common ones are lady beetles and spider who usually feed on different prey including bollworms which are chewing pests like as american, pink and spotted bollworms of cotton (Cassida and Quistad, 1998). Adults and larvae of seven spotted lady beetle primarily feed on *Aphis* spp but also predate on various eggs and caterpillars of moths' pest, like as American, pink and spotted bollworm (Knutson and Ruberson, 2005). Spiders not only a good predator of sucking pests but they also feed on maggots of *H. armigera, Spodoptera litura*, and *H.*

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*armigera* were mostly preferred (Sivasubarmanian *et al*., 2009). Predators are those insects that feed on other insects in different phases of life. Predators feed on eggs, larvae, pupae or even adults making food chains. Hence these predator's populations depend upon the availability of prey masses (Head *et al*., 2005). One predator can consume several types of prey. Sometimes predators are specific for prey. But commonly this specificity is rare as certain type of prey never appear in abundance. Predators can be called as biological hunters and usually bigger in size than their prey (Vennila, 2008). The correlations between the predator and prey populations are important in depicting population of predators. Pests are insects causing huge economic losses to cotton crops in Pakistan amounting 20-30% every year (Sattar *et al*., 2011). This amount of loss due to insects not only discourages farming community but also hinders export of cotton and cotton products along with affecting the quality of cotton. Relationships among pest prey and predator populations are determined by statistical means using correlation and regression techniques. Correlations depict strength of relationship while regression gives dependence of one population over the other (Rutledge *et al*., 2003). Population of prey can be used as independent variable and predator's population as dependent one to estimate prediction equations. The linear relationship between predator and prey population is used to predict population of any one of them as prey population can be used to predict predator's population at a certain time. Similarly correlations between the two populations can be used to estimate mutual increase or decrease in populations. Relationship between predator and prey is basic concept of ecology (Barryman, 1992). This relationship is intricate but based on some mathematical phenomenon and can be mentioned in numbers like ratios. These ratios show how population changes occur with respect to change in predator and prey populations in the ecosystem (Hamdan and Awad, 2007; Tommasini and Maini, 2001). This balance in ecosystem is based and maintained directly by the proportionate changes in predator prey and all universal ecosystems follow this patterns and it is imperative for their proper functioning and subsistence/survival otherwise they would collapse. The linkage in food chain and food webs are so strong that they provide necessities of life to each partner for its survival (Kindlemann and Dixon, 2001; Kindlemann *et al*., 2002; Yasuda *et al*., 2002). Currently such studies provide relationships between predators and their prey found in cotton field using correlations are lacking in Pakistan especially in southern part of Punjab province. In Pakistan the studies on predator prey relationship as documented in literature showed that predators were vertebrates (Mahmood-ul-Hassan, 2006; Mahmood-ul-Hassan *et al*., 2007a, b, c, d, e). Insect predator studies are scarce. Some other studies relating pests and their predators that had greater economic impact are also available (Omkar and Pervez, 2000; Omkar and Srivastava, 2003; Symondson *et al*., 2002). As Pakistan has different belts specified for cash crops like wheat belt, cotton belt etc. The specific predators and prey are common. But in mixed cropping zone multiphagous predators can be found. Such predators are more useful than monophagous depending upon single type of prey. Therefor, it is need of the hour to underline such relationships in each belt to economic biological control and minimize economic losses to farmers. Hence an effort was made to estimate correlations between predator and prey populations particularly chewing pests (bollworms as prey) and their predators (seven spotted lady beetle and spiders) in Pakistan.

## MATERIALS AND METHODS

Field study was carried out from 2014-2016 to investigate the predator prey relationship between chewing insect pests of cotton like as American bollworm (ABW), pink bollworm (PBW), spotted bollworm (SBW) and their predators including seven spotted lady beetle and spiders. Pearson coefficient of correlation between prey and predator population were determined in southern part of Punjab province. These correlations are helpful in making predictions of fluctuations in populations of both prey and their predators. The study was limited to few insects present in abundance after a thorough preliminary survey of the crop sowing areas prior to start of research project.

*Study area*

The study area located near river Chenab with 30°11′52″N 71°28′11″E co-ordinate and 129m altitude. Four Bt and one non Bt varieties were selected to investigate the population dynamics of chewing worms in relation with the predators. Bt cotton varieties include (MNH-988, Lalazar, Sitara-009, IUB-33) and one non Bt *i.e.* NIAB non-Bt. The seeds of these varieties were obtained from the local seed suppliers, before sowing these were treated with 95% concentrated sulfuric acid to remove the fuzz on cotton seed. The variables of interest were kinds of predators, their population counts, different types of prey and their population. Adult counts of American, pink, spotted bollworms and adult population counts of lady beetles feed on larvae and spiders mainly predate on adult that comprised the variables of interest.

*Sampling*

For planting of seed, cotton raised beds were prepared, distance between two seeds were managed in between 20cm. Number of predators (lady beetles and spiders) and their prey (american, pink, and spotted bollworms) in ten

randomly selected cotton fields of study area were counted from April to October by ten days interval during three years of study from 2014 to 2016. For this purpose there was collection of bolls from the cotton field, 10 green bolls of a given age from each cotton line were harvested and transported to the laboratory. Over the course of the study, bolls ranging from 12 to 30 days, were harvested on different dates. Bolls were left undisturbed for 24 h. After 24 h, entrance holes of pink bollworms were counted and then 10 bolls from each cotton line were placed in a separate plastic box and incubated for 7 d at 27 ± 2°C. After incubation, bolls were cracked open and the number of live and dead larvae were counted. PBW mines that occurred in the internal carpel wall were counted and measured.

**Table I.- Pearson correlation coefficients between predator and prey populations during 2014, 2015 and 2016.**

| Variable | Adult ABW | Lady beetle | Adult PBW | Adult SBW |
|---|---|---|---|---|
| **2014** | | | | |
| Lady beetle | 0.1165 | | | |
| P-Value | 0.2366 | | | |
| Adult PBW | 0.6943 | 0.2821 | | |
| P-Value | 0.0000 | 0.0036 | | |
| Adult SBW | 0.7378 | -0.0387 | 0.8583 | |
| P-Value | 0.0000 | 0.6952 | 0.0000 | |
| Spider | 0.1291 | 0.7166 | 0.2957 | 0.0764 |
| P-Value | 0.1894 | 0.0000 | 0.0022 | 0.4386 |
| **2015** | | | | |
| Lady beetle | 0.0207 | | | |
| P-Value | 0.8341 | | | |
| Adult PBW | 0.8934 | 0.2672 | | |
| P-Value | 0.0000 | 0.0059 | | |
| Adult SBW | 0.7329 | -0.1562 | 0.6795 | |
| P-Value | 0.0000 | 0.1115 | 0.0000 | |
| Spider | 0.0743 | 0.7441 | 0.2507 | -0.0230 |
| P-Value | 0.4510 | 0.0000 | 0.0099 | 0.8155 |
| **2016** | | | | |
| Lady beetle | 0.3862 | | | |
| P-Value | 0.0000 | | | |
| Adult PBW | 0.7732 | 0.3198 | | |
| P-Value | 0.0000 | 0.0009 | | |
| Adult SBW | 0.8396 | 0.3121 | 0.9180 | |
| P-Value | 0.0000 | 0.0012 | 0.0000 | |
| Spider | 0.5217 | 0.7722 | 0.3649 | 0.4058 |
| P-Value | 0.0000 | 0.0000 | 0.0001 | 0.0000 |

Correlations with P-Value > 0.05 are significant.

*Data analysis*

Person correlations between average populations of predators (lady beetles and spiders) and prey (American, pink and spotted bollworm) population were found to understand predator and prey relationships. After collection of data, the data were edited and checked for inconsistencies. Pearsonian correlations were computed by Statistix version 8.1 software using following formula:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

## RESULTS

Bollworms predated and parasitize by different natural enemies. Among these, seven spotted lady beetle and spiders are most important insect for biological control. Relationships between predator and prey populations can be presented in the form of correlations and prediction equations (regression). Pearsonian coefficients of correlations were calculated among predators (lady beetle, spider) and prey American bollworm (ABW), spotted bollworm (SBW), pink bollworm (PBW) populations (Table I).

*Predator prey relationships*

Correlation coefficients between populations of lady beetle (predator) and ABW, PBW, SBW were low and non-significant during the year 2014. The correlations between spider (predator) and ABW, SBW populations were low and non-significant but low and significant for PBW population in this year. The correlation between both predator's populations were high and significant ($P<0.01$) during 2014 (Table I). In 2015, correlation between lady beetle population and ABW, SBW were low non-significant and negative low non-significant, respectively. PBW had lower but significant ($P<0.05$) correlations with lady beetle population. Spider population bore very low non-significant correlation with ABW, negative very low non-significant correlation with SBW and low but significant ($P<0.05$) correlation with PBW population. Mutual correlation between predator's populations were very low and significant (Table I). In 2016, correlation analysis showed that population of lady beetles moderate and significant ($P<0.001$) with populations of ABW, PBW and SBW. Spider populations also showed intermediate to high and significant ($P<0.001$) correlations with ABW, PBW and SBW populations along with lady beetle population (Table I) during this year. Population dynamics of bollworms] eggs and adults with the predators is shown in Figure 1. In 2014, as the time proceed during the cropping season the bollworm eggs and adults population increases, at the

same time predators are also enhanced that continue till harvesting (Fig. 1A). However, in 2015, increased number of bollworm eggs and adults were observed till the mid of the season but their number changed to maximum near the harvesting as shown in Figure 1B. An abrupt increase of bollworm eggs was observed during the year 2106 that were gradually decreased with the time. In addition, adult population was found to be increased gradually and reach to maximum at the end of the season, respectively (Fig. 1C).

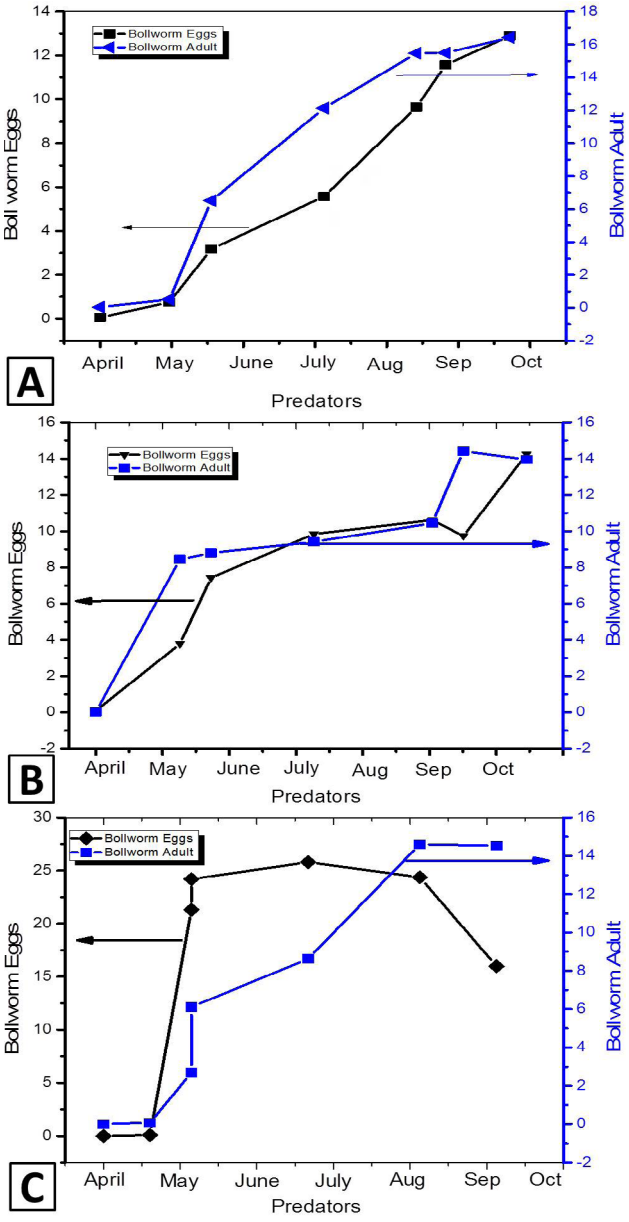


Fig. 1. Population dynamic of predator and prey of cotton crop during the year 2014 (A), 2015 (B) and 2016 (C).

## DISCUSSIONS

Relationships among predators, and preys are key indicators of their populations and can become a tool for effective insect management programs. These relationships might be in the form of correlations or dependencies (regression) that can be calculated by using some suitable software and helpful in understanding population dynamics and changes. Correlations are strength of relationship between two variables. Lady beetle showed more attraction for pink bollworms than ABW and SBW during 2014 as shown by the coefficient of correlation between their populations. Spiders also showed similar amount of attraction for PBW as depicted by higher correlations. Both lady beetle and spider had least correlations with SBW. The same pattern of correlations was observed in next year where beetle and spiders showed higher correlations with PBW populations and least correlations with SBW populations. In 2016, the correlation coefficients were quite higher than previous years. Lady beetles had highest correlations with ABW, followed by PBW and SBW population. The pattern was quietly changed during this year. Spider had similar change in correlations in order of ABW>SBW>PBW. This change in correlation pattern made it clear that predator populations were not choosy and they depended only on the quantity or population size prey. Any type of chewing worm could be used as prey without any specificity or choice. Higher correlations were obtained where population of both predator and prey were higher in numbers. This showed that during early two years of study, PBW population was higher as compared to other two pests while in third year of study the size of pest populations. The correlations between predator and prey population had been used for prediction and can efficiently be used for setting of biological control/ insect pest management programs. Similarly, regression tools can be used for obtaining prediction equation where we can easily use prey population to predict predator's populations (Omkar and Srivastava, 2003). Relationship between predator and prey provided clue to control their population size to minimize losses to crops (Ashfaq *et al*., 2011; Dhaka and Pareek, 2007). Such efforts had been done to establish biological control (Torres and Ruberson, 2006; Reddy *et al*., 2015). Predator consumes prey to lower their populations, would ultimate provide competition among them for feed. This phenomenon would ultimate reduce predators population by itself (Hagler and Naranjo, 1994; Sigsgaard *et al*., 2002).

## CONCLUSIONS

Relationship between predator prey populations is a

good source of estimating their populations and predicting them. They are helpful in making strategies to set up effective biological control program and help in efficient insect control management program. The change in pattern of correlation defines the effect of certain factors like biotic and abiotic ones. The correlations among chewing pests remained nearly similar in each year of study at each location. It showed certain pests can live together without harming others. It meant that control program for one type of pest could prove effective for the other living together. Similarly some predators can live together like spider and lady beetle as depicted by the high correlations in their populations. This suggested that these predators preyed on similar type of insect pests. High correlations depicted that if certain predator or prey had high population, its counterpart would also be present in higher numbers.

*Statement of conflict of interest*

The authors declare no conflict of interest.

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