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Population dynamics of natural enemies Ladybird beetle *Coccinella septumpunctata* L. (Coccinellidae: Coleoptera) and syrphid fly *Episyrphus balteatus* Degeer (Syrphidae: Diptera) on six okra cultivars in Peshawar

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Abstract
Whitefly *Bemisia tabaci* (Genn.) (Hemiptera; Aleyrodidae), aphid *Aphis gossypii* (Glov.), (Hemiptera: Aphididae) and jassid *Amrasca biguttula biguttula* Ishida pose heavy threat to okra in Peshawar each year. For efficient control of insect pests of okra, study of population dynamics of pests and its natural enemies is very important. In the present research work population densities of natural enemies Ladybird beetle *Coccinella septumpunctata* L. (Coccinellidae: Coleoptera) and syrphid fly *Episyrphus balteatus* DeGeer (Syrphidae: Diptera) were determined on six okra cultivars in Peshawar in 2014. The experiment was conducted in Randomized Complete Block Design with three replications. The results revealed that overall mean density of the *C. septumpunctata* was significantly higher on Malay (1.60 individual's leaf^{-1}) and lower on Local Peshawri (1.03 individual's leaf^{-1}). Overall mean density of *E. balteatus* was significantly higher on F1 Syngenta (1.60 individual's leaf^{-1}) and lower on Neelum Green (0.70 individual's leaf^{-1}). Cultivar Bharati Kaveri yielded significantly higher (9027.778 kg ha^{-1}) while Malay lower (6712.963 kg ha^{-1}). The findings of the present research will lay down a base for developing efficient control strategies, mainly using natural enemies, against the insect pests of okra in Peshawar.

Keywords: C. septumpunctata, E. balteatus, okra cultivars, population dynamics.

1. Introduction
Okra (*Abelmoschus esculentus* L.) belongs to family Malvaceae or Mallow. It is known Bhendi locally and Lady's finger internationally. It is very popular summer vegetable for home gardening while it is also grown commercially throughout the world especially in Indo-Pak sub-continent. It is probably originated in Ethiopian region of Africa [1].

Okra is a widely cultivated vegetable crop within tropical and subtropical regions, for its immature pods which are consumed either fresh or after processing [2]. The immature pods are consumed as boiled vegetables. It is also dried and used as soup thickeners or in stews [3]. The green fruits are rich sources of vitamins, calcium, potassium and other minerals. Despite the nutritional value of this important vegetable crop, its optimum yields (2-3 ton ha-1) and quality have not been attained in the tropical countries partly because of a continued water shortage and other climatic limitations. Okra plant require relatively average temperatures and unable to tolerate low and high temperature for long time. Okra requires high amount of irrigation water for its production, despite having notable drought tolerance [4].

In 2009 the total production of okra in Pakistan was 114.657 thousand tones cultivated on an area of 15.081 thousand hectares, while in Khyber Pakhtunkhwa the total production was 18.156 thousand tones cultivated on an area of 2.126 thousand hectares [5].

Okra attracts a large number of insect pests including jassids, *Amrasca devastans* Dist and *Amrasca biguttula* (Shirr); aphids, *Aphis gossypii* (Glov.) cutworm, *Agrotis spp*. and mites *Tetranychus spp*. Among insect pests, aphid's especially *A. gossyii* is considered one of the most important pest of okra [6]. The aphids are soft bodied insects which suck the cell sap from the leaves, secrete lots of honey dew on the leaves, weakening the plants and reducing both quantity and quality of the fruits. In addition to okra the aphids also feed on a variety of plants including the cucurbits, cotton, citrus and fruits. They also attack strawberry, beans, sugarbeet, spinach, eggplant, asparagus, a number of ornamental plants and many weeds [7].

Fourteen predatory species, in seven families, including members of coccinellids, chrysopids, syrphid, mantids and spider at variable levels, were found attacking mainly *Bemisia tabaci* and

Aphis gossypii besides other soft insects. Chrysopids and spiders were the dominant predators in autumn and summer seasons, whereas syrphids, chrysopids and coccinellids were the abundant groups during winter. However, *Chrysoperla carnea* was the most prevalent species in okra fields all the year round [8]. Host plant resistance is an important component of integrated pest management [9]. Highly resistant varieties will pressurize the pest population to select for resistance breaking strains. On the other hands, partial plant resistance will exert a lesser selection pressure on the pest population [10]. Moderate levels of resistance have many advantages in relation to IPM. Among the most desirable features of plant resistance from an ecological point of view are its specificity to a pest or complex of pest organisms, cumulative effect, persistence, harmony with the environment, ease of adoption and compatibility with other components in pest management. A partially resistant variety could provide the foundation open which other management measures could be built [11]. This can be used as an adjunct to other control measures and interact well with other components of IPM, i.e. chemical and biological control measures [12].

Information was lacking on the population dynamics of natural enemies *C. septumpunctata* and *E. balteatus* on the available okra cultivars in Peshawar. Therefore, the present work was initiated to study thoroughly all these aspects for achieving the objectives.

2. Materials and Methods

2.1. Experimental layout

The experiment was conducted at the New Developmental Farm (NDF) of The University of Agriculture, Peshawar (UAP) during 2014. The experiment was laid out in Randomized Complete Block Design (RCBD). There were six treatments viz. Local Peshawari, Arizona, Malave, F1 Syngenta, Neelum Green and Baharati Kevri. Each treatment was replicated three times. Each treatment measured 4 x 3.6 m^2. There were seven rows in each treatment and each row had 15 plants. Plant to plant and row to row distance was kept 12 cm and 60 cm, respectively. A buffer zone of 60 cm wide was kept between adjacent treatments to isolate them from one another. Uniform cultural practices including ploughing, irrigation, fertilizer and weeding were followed in each treatment throughout the cropping season.

2.2 Population dynamics of natural enemies

Data of *C. septumpunctata* and *E. balteatus* was recorded on three randomly selected leaves, one each from top, middle and bottom portion of the ten randomly selected plants, avoiding the two boarder rows, in each treatment. Data was collected at weekly intervals. The collected individuals were transferred to glass bottles with the help of camel hair brush and transported to the Insect Diagnostic Laboratory of the Insect Museum at the Department of Entomology. The collected individuals were labeled and permanently deposited in the Insect Museum.

2.3 Statistical analysis

The data recorded for each parameter was analyzed statistically by using Statistix 8.1 Software and means were separated by using Fisher Protected Least Significance Difference Test at 5% level of significance [13].

3. Results and Discussion

3.1 Population density of C. septumpunctata

C. septumpunctata appeared on the okra cultivars from June 10 and was continuously prevalent till August 12, where its maximum mean density of 3.00 individual's $leaf^{-1}$was recorded on July 15 on Arizona and Malay (Table 1). Overall mean density of the beetle was significantly higher (1.60 individual's $leaf^{-1}$) on Malay and lower (1.03 individuals $leaf^{-1}$) on Local Peshawari. The beetle density was significantly affected by disappearance of pests with rainfall and crop maturity.

Our results are comparable to those of some earlier researchers. Lower Ladybird beetle population was observed initially, but it subsequently increased in the coming weeks and peaked during 4th week after which it declined [14]. Ladybird beetle is one of the most important factors that decline the aphid's population [15]. Ladybird beetle was recorded as a major predator of sucking insect pest [16].

Table 1: Mean Density of C. Septumpunctata $Leaf^{-1}$ on Six Okra Cultivars in Peshawar in 2014.

Cultivar	Mean Density Of C. Septumpunctata $Leaf^{-1}$										Over All Mean
	Mean 10/6/14	Mean 17/6/14	Mean 24/6/14	Mean 1/7/14	Mean 8/7/14	Mean 15/7/14	Mean 22/7/14	Mean 29/7/14	Mean 5/8/14	Mean 12/8/14	
Local Peshawar	0.00 g	0.33 fg	1.00 d-g	1.33 c-f	1.00 d-g	2.00 a-d	2.00 a-d	1.00 d-g	1.00 d-g	0.67 efg	1.03b
Arizona	0.00 g	0.00 g	0.67 efg	2.00 a-d	1.67 b-e	3.00 a	1.67 b-e	0.67 efg	1.33 c-f	0.33 fg	1.13b
Malay	1.33 c-f	0.00 g	1.33 c-f	2.00 a-d	2.67 ab	3.00 a	2.33 abc	1.33 c-f	1.33 c-f	0.67 efg	1.60a
F1-Syngenta	0.00 g	0.67 efg	0.67 efg	1.67 b-e	1.67 b-e	1.67 b-e	2.67 ab	1.33 c-f	1.67 b-e	0.67 efg	1.27ab
Neelum Green	0.00 g	0.33 fg	0.33 fg	1.67 b-e	2.00 a-d	1.67 b-e	2.33 abc	1.33 c-f	0.67 efg	0.67 efg	1.10b
Bharati Kaveri	1.00 d-g	0.00 g	0.67 efg	1.67 b-e	2.33 abc	2.00 a-d	2.00 a-d	2.00 a-d	0.67 efg	0.33 fg	1.27ab
Lsd	0.39	0.22	0.78	1.72	1.89	2.22	2.17	1.28	1.11	0.56	

Means in columns followed by different letters are significantly different at 5% level of significance (LSD test).

3.2 Population density of E. balteatus

E. balteatus appeared on okra on June 16 and continued its prevalence till August 5, where its density peaked with 2.67 individual's $leaf^{-1}$ on Neelum Green on July 15. Overall mean density of the fly was significantly higher (1.10 individual's $leaf^{-1}$) on F1-Syngenta and lower (0.70 individuals $leaf^{-1}$) on Neelum Green. Its density was affected by decline in pest's density due to rainfall and crop maturity.

The present results are comparable to those of some earlier researchers. Density of syrphid fly initially increases in the season and then gradually decreases [14]. Syrphid fly larvae attack aphids [17]. Plant characters like leaf areas, plant senescence, and biological control agents are the major factors that reduce aphid's populations [15].

Table 2: Mean Density of E. Balteatus Leaf^{-1} on Six Okra Cultivars in Peshawar in 2014.

Cultivar	Mean Density Of And *E. Balteatus* Leaf^{-1}										Over All Mean
	Mean 10/6/14	Mean 17/6/14	Mean 24/6/14	Mean 1/7/14	Mean 8/7/14	Mean 15/7/14	Mean 22/7/14	Mean 29/7/14	Mean 5/8/14	Mean 12/8/14	
Local Pesh.	0.00 h	0.67 fgh	0.33 gh	0.67 fgh	1.67 cde	2.00 abc	1.33 def	0.33 gh	0.67 fgh	0.00 h	0.77 b
Arizona	0.00 h	0.00 h	0.67 fgh	0.67 fgh	2.33 ab	2.00 abc	1.33 def	1.00 efg	0.33 gh	0.00 h	0.83 ab
Malay	0.00 h	0.00 h	0.67 fgh	1.00 efg	1.00 efg	2.00 abc	1.33 def	0.67 fgh	0.67 fgh	0.00 h	0.73 b
F1 Syngenta	0.00 h	0.67 fgh	0.67 fgh	1.33 def	2.00 abc	3.00 a	1.67 cde	1.00 efg	0.67 fgh	0.00 h	1.10 a
Neelum Green	0.00 h	0.00 h	0.33 gh	0.33 gh	1.33 def	2.67 ab	1.33 def	0.67 fgh	0.33 gh	0.00 h	0.70 b
Bharati Kaveri	0.00 h	0.33 gh	0.67 fgh	0.67 fgh	1.00 efg	2.33 ab	1.33 def	0.67 fgh	1.00 efg	0.00 h	0.80 b
Lsd	0.00	0.28	0.56	0.78	1.56	2.33	1.39	0.72	0.61	0.00	

Means in columns followed by different letters are significantly different at 5% level of significance (LSD test).

3.3 Yield of okra

Yield of okra, collected weekly for 14 weeks, was significantly higher (9490.74 kg ha^{-1}) for Arizona and lower (6712.96 kg ha^{-1}) for Malay [18]. Our results are comparable to those of some earlier researchers. Okra verities give low yield with high aphid's infestation [19]. Hybrid Nirali give high yield because it is more resistant against aphids [14].

3.4 Conclusion

C. septumpunctata and *E. balteatus* prevailed on the six okra cultivars from mid-June to Mid-August, 2014. Mean density of the beetle (Arizona and Malay) and fly (Neelum Green) peaked in mid-July. *C. septumpunctata* overall mean density was significantly higher on Malay and lower on Local Peshawari. *E. balteatus* overall mean density was significantly higher on F1-Syngenta and lower on Neelum Green. Population densities of the two natural enemies were significantly affected by disappearance of pests with rainfall and crop maturity. Mean okra yield was significantly higher for Arizona and lower for Malay.

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