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Predation efficacy of ladybird beetle (Coleoptera: Coccinellidae) against wheat aphid under laboratory conditions

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Abstract
To evaluate predatory efficacy of *Coccinella septempunctata* (L) on wheat aphid (*Schizaphis graminum*), research was conducted in a laboratory at 27±2 ^{0}C temperature and 62±5% relative humidity (RH) at Entomological Research department, Ayub Agricultural Research Institute, Faisalabad during research period 2016 to 2017. The predatory efficacy of male and female adults was found to be 806.50 ± 2. 61 and 923.50 ± 1.71 aphids respectively. The results revealed that the 4th instars larvae with the highest predation performance while the 1st larval instars reported the lowest. The female beetles were found to be more cogent in aphid predation as compared with the males. The larval maximum duration was found to be 12.12 and average duration was of 11.61 days. The pupal stage was maximum 4.03 and average duration 3.65 days. The average development period was recorded 18.82 days. The results indicate that the duration of fourth instar was nearly equal to the first instar. While second instar ccupied minimum duration period.

Keywords: Ladybird beetle, Coleoptera: Coccinellidae, wheat aphid, laboratory

Introduction
Wheat consists of 13% water, 71% carbohydrates, 1.5% fat and 13% protein (Shewry P. R, 2002). It is a nutritious, convenient, economical source and a source of the basic dietary product – breads which is consumed by more than 70% of the human population. This cereal is grown on 23% of global cultivated area and is of the great importance in bread, diet, farmaceutic and other industry, but also important product of international trade on worldwide market (Istvan, 2006).

Aphids are very severe pest of agriculture (Minks A.K and harrewijn P, 1987) [12]. In Pakistan four aphid species have been reported damaging the wheat crop (Hashmi *et al*., 1983). In these four aphid species the serious pest in Pakistan is *Schizaphis graminum* (Mohayuddin, 1981) [2]. These species are considered the most important for winter wheat crop (Ghanim, 1984) [10].

Now in Pakistan aphid is known as a regular pest of wheat crop be-cause of drastic increase in its population and is responsible for its low rate as high as 50% reduction in grain weight per ear (Van Emden *et al*., 2007, Capinera, J. L, 2008) [9]. In biological control, lady bird beetles have significant importance. The reason of importance is to control the large number of pests that are soft bodied such as aphids on which both larvae and adult feeds (Frazer, 1988) [19]. The lady bird beetle has long oviposition period and high reproductive potential (Karpacheva, 1991) [20]. Now, as a bio- control agent, the lady bug is sold and commercially repro- duced in particularly for aphids which are responsible for the loss of billions of dollars annually (Oerke, 1994) [21].

Coccinellidae is a family of small beetles (Hawkes wood, 1987) [16]. The size range of lady bird beetle is 7.6-10 mm and have seven spots on their body. Body colour is orange with seven spots on the body. Its body is round shape and thorax is black with pale yellow patches at front corners (Lyneborg, 1976) [13]. Both larvae and adult feed on aphids (Buczacki, 2002) [15] Instead of using of very toxic and hazardous insecticides, biological control of aphid is a better surrogate to protect the plant (Bellows, 2001) [11].

The population of aphids may increases very rapidly but they can be controled by use of coccinellids under the natural condition (Gilkeson and kelin, 2001) [17]. Aphid cause drastic damage to the agricultural crops by injecting saliva to the plant tissues and sucking cell sap.

Aphids eventually reduce the photosynthetic area of the plants because they secrete honey dews which help in sooty mold development (Zia *et al*., 2010) [18]. Our poor farmers are becoming poorer and crops vulnerable due to attack of pest and disease. In this aspect research on predators like *Coccinella septempunctata* Linn. In Pakistan may play an important role as a part of integrated pest management program.

Fortunately, the beneficial aspects of insects outweigh the detrimental effects, thus there is need to take advantage of beneficial species to develop a method of high selectivity in pest control and the full manipulation of the beneficial insects. The significance of predator (lady bird beetle) for a safest control of insect pest (aphid), this study will help to find out the effect of temperature, supply of feed, humidity, seasonal variations and age of the beetle on aphid predation by *Coccinella septempunctata* and use *Coccinella septempunctata* for the biological control of aphids.

Material and method

The experiment was conducted in the toxicology laboratory at the Entomological Research Department, Ayub Agriculture Research Institute Faisalabad, from 2016 to 2017. The experiment was conducted in completely randomized design consisting of 4 treatments and each treatment comprised of 5 replicates. The laboratory conditions were sustained at 27± 2 ^{0}C and 62±5% relative humidity.

Stock Culture of Wheat Aphids

Rearing of wheat aphids (*Schizaphis graminum*) was done on wheat plants in semi-natural conditions. Apterous forms of the aphids collected from field in last week of January, 2017, were released on these plants. The pest took a fortnight to establish enough population which was used to check predatory efficacy of both the adults and larval stages of lady bird beetle *Coccinalla septempunctata* (Linn).

Rearing of *Coccinella septempunctata*

Adults and eggs of the beetle (*Coccinella septempunctata*) were collected from wheat fields (Ayub Agriculture Research Institute Faisalabad) by using sweep net. The adults were kept in plastic jars (15 per jar), each of which was provided with rough filter paper at bottom to avoid possible damage to adults from bottom deposition. Aphids were provided to the adult predators on round

discs of brassica leaf and mouth of each jar was covered with muslin cloth. The leaf discs and muslin cloth were replaced daily.

Eggs were laid by the females of *C. septempunctata* on muslin cloth and leaves. These eggs and field collected eggs were placed in petri dishes. The upper collar portion of these petri dishes were waxed to inhibit the larval escape. These petri dishes were placed in an incubator running 27 ± 2 °C and 62 ± 5% Relative humidity. Super saturated salt of ammonium nitrate was also kept in the incubator (South wood, 1966) in order to maintain the required humidity.

On hatching, these larvae were transferred to clean jars, the nymphs and adults of aphids were provided on brassica leaves. Fresh aphids were added daily in each jar. On pupation, the leaves from the jars were poured out in rearing cage where the adults were allowed to emerge. After three days of the adults' emergence, these were shifted to the jars for egg laying. The rearing process continued till considerable population of different instars of *Coccinella septempunctata* was procured for further experimentation.

Predatory Efficacy Test

Predatory efficacy of *Coccinella septempunctata* Linn relies on the surrounding environment, its size and the searching behavior of the beetle. To investigate the predatory efficacy of larvae of the predator against aphids, newly hatched larvae of the *Coccinella septempunctata* were placed singly in six petri Dishes having what man filter paper. A counted number of aphids were provided on brassica leaf in each petri dish daily. Upper collar portion of the petri dishes was treated with Vaseline and covered with muslin cloth to avoid larval escape. Every day, old leaves were replace with new ones and unconsumed number of aphids were observed. The larvae of the predator were also checked daily for their moulting to calculate the duration of each larval instar. This practice was continued up till pupation.

To check the aphid consumption by adult beetle, the newly emerged adults were transferred in Petri dishes (6.0 ×1.0 cm). Aphids were supplied every day to the adult on brassica leaf. The food was swapped after 24 hours. The number of aphids consumed by an adult beetle was recorded every 24 hours till death. Average consumption rate was calculated by formula

$$\text{Average consumption rate} = \frac{\text{Aphid consumed}}{\text{Aphid offered}} \times 100$$

Statistical analysis

Data were statistically analyzed using ANOVA (Statistic, version 8.1 Tallahassee, USA) and means were separated at significance level 0.05 using DMRT (Duncan Multiple Range Test Method) In figure and graphs, the original data and their standard errors have been presented.

Results and Discussion

Consumption of aphids by different stages of *Coccinella septempunctata* increased from 1st instar larvae to 4th instar larvae. No of aphids consumed by 4th instar larvae was found to be maximum of all the larvae 50.6 ± 4.82. While minimum no of aphids was consumed by 1st instar larvae with the mean of 9.20 ± 0.51. Second instar larvae consumed minimum 11 and maximum 13 aphids with an average of 12.20 ± 0.71. Minimum no of aphids consumed by third instar larvae was found to be 27 and maximum no of 33 with an average of 26.0 ± 1.52. Among adults, female consumed minimum 917 and maximum 930 aphids with an average 923.50 ± 1.71 and male devoured maximum 815 aphids with an average 806.50 ± 2.61. The female beetle showed higher aphid predation than male as shown in Figure 1. Over all female consumed the maximum no of aphids with an average of 923.50 ± 1.71 (Table 1).

On comparison, the predatory efficacy of the entamophagous adults and larvae conducted in the present studies is supported by the results of Saleem (2014), who observed that adult's female and male beetle devoured 916.60 ± 1.69 and 802.40 ± 2.56 aphids on an average per day respectively. While larvae instars average aphid consumption was 57.40 ± 4.67, 28.60 ± 1.50, 13.60 ± 0.81, 8.40 ± 0.50 respectively. The results of present studies also supported by the result of Solangi *et al*., (2007) reported that four larval stages as 21.80 ± 3.29, 41. 90 ± 7.78, 66.25 ±20.13, 122.15 ± 25.20 aphids respectively. On the other hand M. K Behera *et al.*, (1999) reported predatory potential of 1st, 2nd, 3rd and 4th in stars as 9.17+1.0,

Table 1: Predatory efficacy of larvae and adult of *Coccinella septempunctata*

Different stages	Predatory efficacy		Number of aphid consumed
	Minimum	Maximum	
1-larvae			Mean ± SE
1st instar	8	10	9.20 ±0.51
2nd instar	11	13	12.20 ±0.71
3rd instar	27	33	26.0 ±1.52
4th instar	47	72	50.6±4.82
2-Adult			
Male	798	815	806. 50 ± 2. 61
Female	917	930	923.50 ±1.71

Table 2: Numbers of wheat aphid consumed by different instars of *Coccinella septempunctata*

No of observation	Days											Total
	1st instar		2nd instar		3rd instar			4th instar				
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	
Mean ± S.E	2	6	3	7	6	9	10	12	14	15	16	100
	4	7	5	8	3	8	8	14	16	18	17	108
	3	4	6	5	4	9	12	13	18	19	21	114
	4	5	3	8	8	6	14	15	19	20	23	125
	6	5	7	9	7	11	15	18	20	22	25	145
	3.8	5.4	4.8	7.4	5.6	8.6	11.8	14.	17.4	18.8	20.4	592
	+	+	+	+	+	+	+	+	+	+	+	+
	0.52	0.57	0.58	0.48	0.51	0.71	0.94	1.17	1.23	1.00	1.17	11.4
	9.20 ± 0.53 12.20± 0.82 26.0 ± 1.51 71.0 ± 4.67											

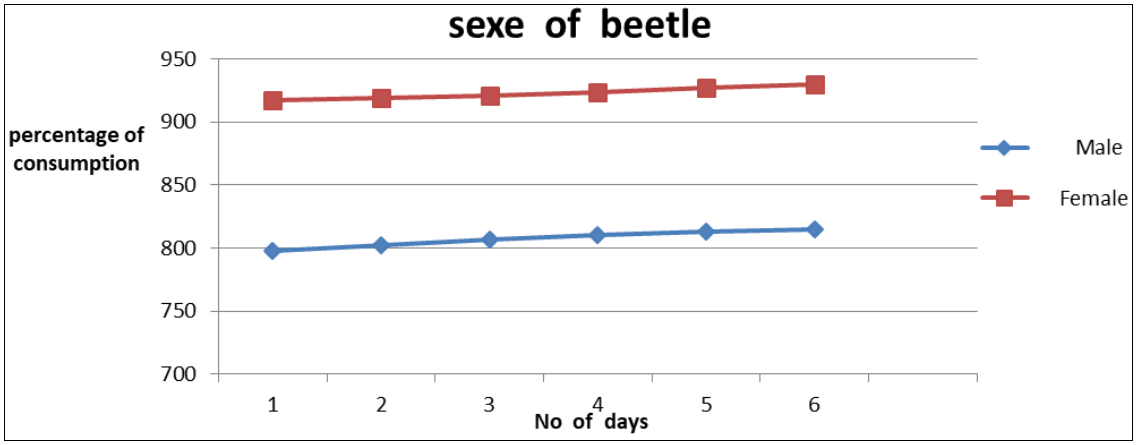

Fig 1: consumption rate of male and female

20.8+3.3, 34.1+3.5 and 37.5+4.7 aphids respectively. Which is in accordance with the findings of present studies.

Five replication were prepared in which the number of *Coccinella septempunctata* was kept constant along with the aphids supplied for consumption. The number of aphids consumed per petri dish by the beetles varied. At first day, 1st instar larvae consumed less aphids with an average of 3.8 ± 0.52 than consumed at second day 5.4 ± 0. 57. Similar pattern of aphid's consumption was found in 2nd, 3rd, 4th instar larvae.

Overall number of wheat aphids (*Schizaphis graminum*) consumed by beetle *Coccinella septempunctata* Linn during its total larval development period varied 100 to 145 with an average of 592 ± 11.4 aphids (Table 2).

It is explanatory from the data (Table 3) that show larval minimum 11.14, maximum 12.12 and average duration was 11.61 days respectively. The pupal stage was minimum 3.32, maximum 4.03 and average duration 3.65 days. The average development period was recorded 18.82 days. The results indicate that the duration of fourth instar was nearly equal to the first instar. While

Second instar occupied minimum duration period.

The present observations are closely related to the results obtained by Anjum Suhail (1999) [5] who reported average duration of 1st, 2nd, 3rd and 4th instar larva, 3.50, 1.54, 2.21, and 4.32 days, respectively. The duration of pupal stage was 3.64 days on an average.

Conclusion

From the present investigation, it can be concluded that aphid Predation depends on temperature, supply of food, humidity, seasonal variation and age of the beetle. The adults of *Coccinella septempunctata* was an efficient bio-control agent and the final instars larvae feed large number of aphid. So larval instars and adults may be used for the biological control of aphid specially on *Schizaphis graminum*. This beetle has great potential for use biological control of aphid species.

Table 3: Duration of various life stages of *Coccinella septempunctata* L.

Sr. No	Larval Instars					Pupal stage	Total develop-mental period
	1st	2nd	3rd	4th	Total		
1	3.50c	1.61d	2.26b	4.31b	11.68	3.49e	18.79
2	3.52c	1.59d	2.03 a	4.00a	11.14	3.32f	18.05
3	3.41b	1.70e	2.31c	4.61d	12.03	4.03a	19.51
4	3.60d	1.38a	2.22b	3.99a	11.19	3.69c	18.37
5	3.71e	1.49b	2.33c	4.59d	12.12	3.86b	19.68
6	3.33a	1.53c	2.19b	4.48c	11.53	3.52d	18.53
Mean	3.51	1.55	2.22	4.33	11.61	3.65	18.82

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