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Developmental Duration and Predatory Efficiency of *Episyrphus balteatus* on Four Aphid Species in Pakistan

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Abstract

Present study examined the predatory preference and its impact on developmental period of *Episyrphus balteatus* on four aphid species i.e., *Brevicoryne brassicae*, *Schizaphis graminum*, *Myzus persicae* and *Rhopalosiphum padi* which were abundantly present in the croplands of Faisalabad, Pakistan. Prey consumption by all larval instars was evaluated under laboratory conditions at an average temperature of 20±5˚C, 60±5% RH and photoperiod of 16:8 h D: L. Predator-prey interaction between two antagonistic groups of insects (Syrphids: *E. balteatus* and four aphid species) was determined. The selection of prey species was carried out on the basis of relative abundance of species in cropland data of whole year and predator-prey interaction by applying regression. Results revealed that the developmental duration was recorded significantly longer by consuming *B. brassicae* and *S. graminum* while larval growth was significantly greater in the presence of *S. graminum* (11.5 days) and *R. padi* (11.4 days) by consuming (410.3) and (397.3) specimens of later two aphid species, respectively. Predatory impact on aphids was more effective on *B. brassicae*, due to its relatively less consumption and increased growth. Highest number of aphid predation was observed during 3rd instar. These studies are important for effective management and control of these aphid species.

Keywords: *Episyrphus balteatus*; Development; Predation; Aphids; Cropland

Introduction

An insect is categorized as pest, if the insect damage causes sufficient reduction in quality as well as yield of crops (Dent, 2000). Aphids (Hemiptera: Aphididae) are soft bodied insects, small in size and herbivore in nature. The aphid populations' increase parthenogenetically, primarily they are found on host plants, especially on growing parts including tips, flowers and developing pods with high density (Blackman and Eastop, 2000; Mushtaq *et al.*, 2013). Aphids are major cause of annual reduction in valuable cereal crops, one of them is wheat, and some species of aphids are the regular insect pests of Brassica crops in Southern Punjab, Pakistan (Razaq *et al.*, 2011). Insecticides have proved to be the solution to tackle the insect pest problems irrespective of the disadvantages associated with use of these chemicals (Priya and Misra, 2007). The economic aspects and side effects of insecticides on environment are not neglect able (Thanavendan and Jeyarani, 2010). The environment friendly solution of such type of problems is the use of natural enemies. Natural enemies attack on various pests of agro-ecosystems; these interact in complex ways (Sutherland and Parrella, 2009; Rana *et al.*, 2010; Inayat *et al.*, 2012). These biological control agents may be predators or parasitoids (Hajek, 2004). Interactions of Predator and prey species are one of the best-suited processes in ecology (Inayat *et al.*, 2011).

An ideal natural enemy is one that consumes sufficient number of the preys at the right time to maintain a pest population below the economic injury threshold for the crop considered (Michaud and Belliure, 2000). The family Syrphidae comprising 6,000 described species represents one of the largest dipteran families (Thompson, 2006). Adult syrphids have strong abilities to forage for aphid colonies. *Episyrphus balteatus* belongs to subfamily Syrphinae, with dorsal side of abdomen is patterned with orange and black bands. *E. balteatus* is among those few species of flies capable of crushing pollen grains for feed (Veen, 2004). Due to aphidophagous nature, its larvae are important predators for controlling aphids (Hong and Hung, 2010) as they voraciously attack and consume a wide range of aphid species (Leroy *et al.*, 2010). The developmental duration and predatory performance vary with change in environmental conditions.

The present study was carried out first time in Pakistan to determine the developmental duration and predatory performance of *E. balteatus* on four aphid species during March-April 2011. The generated information will provide a preliminary step for biological control of these aphid species by conserving *E. balteatus.*

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Materials and Methods

Experimental Material and Rate of Development

Fertilized eggs of predator species were kept in the separate plastic petri dishes (1.5 cm in height and 5.5 cm in diameter). Petri dishes were labeled properly and transferred in the rearing cages of (32×30×30 cm) dimensions, the crop plants or branches infested by individual aphid species were kept in cages to ensure the presence of prey species. Syrphid larvae were provided aphids in sufficient number to satisfy the predator species. Single syrphid species with each aphid species were kept in a separate cage. Each trial was repeated three times. Experiment was conducted in Pest Control Lab at Department of Zoology and Fisheries, University of Agriculture Faisalabad. Continuous observations were made to record the time duration of egg hatching as well as conversion of 1st larval stage to second and 3rd instars, followed by pre-puparium and pupae formation, till the emergence of adults. Experiment was conducted in the months of March and April, 2011, at average temperature of 20±05˚C, 60±5% RH and of 16:8 h D: L photoperiod. Data were taken at an interval of 12 hours to monitor the conversion of each life stage into next one. Rearing cages were cleaned and new aphids were provided on daily basis.

Rate of Predation

In the same experiment extent of predation by larvae of *E. balteatus* was determined by offering them four aphid species *B. brassicae*, *S. graminum*, *M. persicae* and *R. padi*. Predatory efficiency was determined from right after emergence of larvae from egg till pre-pupation stage. All aphids of four species that were used during experiment were of same instars. After 24 h, aphid numbers consumed were recorded, petri dishes were cleaned and predator was provided with fresh preys. As a control, Aphids in petri dishes were used to check the correct non-predation aphid mortality. For 1st instar predator, young aphids were selected so the predator was not reluctant to prey on them. Number of aphids offered to predator increased with increasing age of predator (instars of Syrphids). The number of prey consumed in 24 h by the predator was estimated by subtracting the number of alive from total number of prey that were offered. The remaining live preys were removed and fresh ones were offered to predator at respective densities. Prey consumption at the end of each day or (per-day consumption) and predation rate at the end of each instar was also recorded.

Statistical Analysis

Consumption rate or predatory efficiency of *E. balteatus*, larvae was compared at each larval instar as well as the average per day consumption by using One-way ANOVA at 0.05 probability level. Minitab software version-v11 was used for statistical analysis. Growth rate (length and duration) of *E. balteatus* was also compared by One-way ANOVA (Hothorn *et al.*, 2008).

E. balteatus and selected species of aphids were chosen on the basis of their abundance in sampled data. Correlation among syrphids and aphids species was confirmed by linear regression by using Microsoft excel 2010 (Inayat *et al.*, 2011).

Results

Development

E. balteatus was recorded as one of the aphidophagous syrphids species and was found dominant in aphid colonies in the crops habitat. Table 2 shows developmental duration of each life stage and complete juvenile development period was recorded in the presence of four aphid species, along with body lengths of *E. balteatus*.

Incubation Period

Eggs of syrphids were of sub- spherical or slightly oval in shape, with its length of 3.5 mm. Time duration of egg hatching showed slight variation in the presence of four aphid species. Time duration ranged from 2.3 to 2.9 days for hatching in the presence of *S. graminum*, *M. persicae* and *R. padi* (aphid); maximum prolonged duration was recorded in case of *B. brassicae*.

Larval Duration

Total larval duration prolonged for 9.6 to 11 days when predator fed on *S. graminum*, *R. padi* and *B. brassicae* and least duration was recorded in case, while fed on *M. persicae*. Body length of 3rd instar larvae were measured as (5.9, 8.2 and 10.2 mm), respectively. At 3rd instars level, larvae were green in color. Results revealed that members of subfamily Syrphinae were specialized predator at this stage and found to be voracious feeder on aphids.

Pupal Duration

Larvae first reduced in size and finally stopped predation for conversion into pupae. Pupae were brown in color, anterior rounded portion for adult emergence and posterior tip normally found in attached form. It was relatively smaller in size than larvae. Pupal duration was recorded as maximum of 9.7 days, when its larvae fed on *S. graminum* followed by 9.5 for *B. brassicae* and least 8.1 days in case of *M. persicae*.

Adult Longevity

E. balteatus adults emerged were bright colored, normally orange-yellow abdomen with black strips on body and with average body length of 15.2 mm. These specific banding patterns of abdomen were one of their identification marks also. The survival of this species in rearing cages was from 7.33 to maximum 9 days.

Table 1: Association of *E. balteatus* to its prey (aphid) species through regression

Predator	Prey/Pest	R^2=Values
Episyrphus balteatus	*Schaizaphis graminum*	0.878*
	Myzus persicae	0.8317*
	Brevicoryne brassicae	0.805*
	Rhopalosiphum padi	0.798

Table 2: Time duration in days of different life stages of *E. balteatus* in the presence of four aphid species and its body lengths

Aphid species	Egg Incubation	1st Instar	2nd instar	3rd Instar	Total larval duration	pre-puparium	Pupae	Total pupal duration	Adult	Total duration	Percent Survival
	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	Mean± S.D	
B. brassicae	2.9± 0.20	2.3± 0.20a	3.2± 0.24a	4.5± 0.41b	10± 0.85a	1.5± 0.41b	8± 0.82b	9.5± 1.23b	7.67± 1.2a	30.07± 3.3b	80%
M. persicae	2.8± 0.24	2.2± 0.24a	3.2± 0.24a	4.2± 0.24a	9.6± 0.72a	1.3± 0.24a	6.8± 0.24a	8.1± 0.48a	7.33± 0.5a	26.5± 1.64a	86%
S. graminum	2.3± 0.24	3.1± 0.11b	3.3± 0.47a	4.5± 0.41b	10.9± 0.9b	1.7± 0.24b	8± 0.82b	9.7± 1.06b	9± 1.41b	30.6± 3.5b	76%
R. padi	2.4± 0.31	2.9± 0.12b	3.5± 0.41b	4.6± 0.31b	11± 0.84b	1± 0.41a	8± 0.81b	9± 1.22b	8.67± 0.47b	28.8± 2.5b	78%
Body lengths(mm)	3.5± 0.41	5.9± 0.42	8.2± 0.77	10.2± 0.62	10.2± 0.62	9.8± 0.24	10.9± 0.24	10.9± 0.24	15.16± 0.62		

Same alphabets in columns showing non-significance and different alphabets indicate significance in column

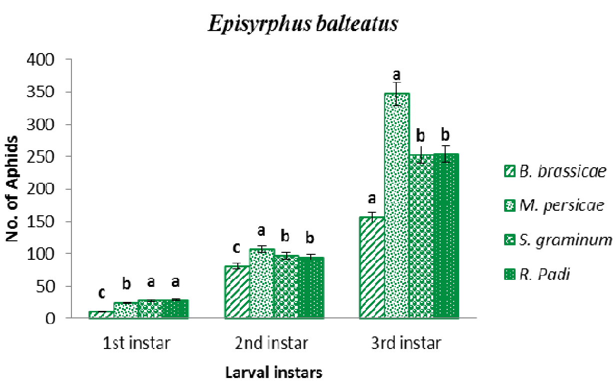

Fig. 1: Predatory efficiency of different larval instars of *E. balteatus* on four aphid species

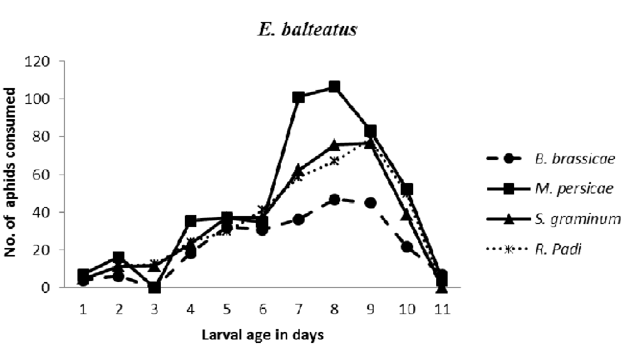

Fig. 2: Difference in mean Per-day consumption of aphids by *E. balteatus* larvae

Predation

E. balteatus is an important aphid consuming agent. Present study revealed that aphid consumption has direct relationship with the age of *E. balteatus* larvae for all aphid species.

Total Consumption

E. balteatus larvae consumed highest mean number of (477.3±43.7) *M. persicae* followed by 410.3 specimens of *S. graminium*, 397.3 specimens of *R. padi* and 244.7 of *B. brassicae* till pupal stage. The above findings showed that there was significant difference (ANOVA: F= 7.89, df=3, p<0.005) in predatory efficiency of *E. balteatus* larvae when fed on four different aphid species.

Consumption at Different Larval Instars

Fig. 1 presents that 3^{rd} instasr larvae of *E. balteatus* consumed highest number of aphids of each species. On the whole, *M. persicae* was highly consumed aphid species especially by the 3^{rd} instar larvae, which differ significantly (ANOVA: F= 2775.43, df=3, p<0.001) on four aphid species. The highest rate of consumption was observed during first and second day of 3^{rd} instar, while it decreased at third day and reduced to negligible on 5^{th} day just before pupation.

Average Per-day Consumption

Average per-day consumption of *E. balteatus* was greater on *M. persicae* as 47.7 specimens and relatively less number of *B. brassicae* as 24.4 specimens were consumed. Average per-day consumption of four aphid species was significantly different (Fig. 2). Difference in per day consumption of *E. balteatus* larvae on four aphid species was calculated by ANOVA: F=63.56, df= 3, 8, p<0.001.

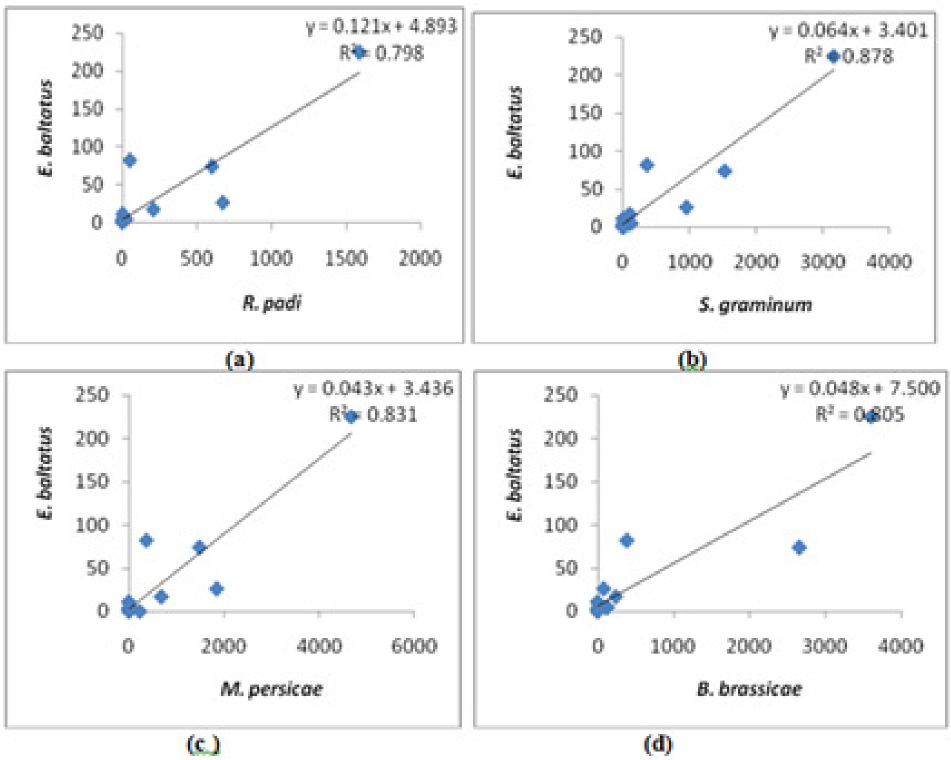

Fig. 3a-d: Linear regression lines showing association of *E. balteatus* to its prey (aphid) species

Survival

Survival of *E. balteatus* larvae was recorded maximum (87%) when fed on *M. persicae* followed by 82% on *B. brassicae*, 80% on *R. padi* and 76% on *S. graminum*.

When correlation was made between *E. balteatus* larvae and aphid species, it revealed their relationship as shown by (Fig. 3a-d). Linear regression analysis depicted that *E. balteatus* showed strong relationships when correlated with *S. graminium* (R^2=0.878) also interacted strongly with *M. persicae*, *B. brassicae* and relatively less with *R. padi* (Table 1).

Discussion

Predatory hoverflies especially subfamily Syrphinae are good models to investigate the relationship between prey specialization and strategies of life history (Branquart, 2000; Sadeghi and Gilbert, 2000). Dual importance of Syrphidae as pollinators and bio-control agents against pests especially the aphids provides a strong reason to protect these natural enemies and their augmentative use in the agro-ecosystems (Sommaggio, 1999).

It was also revealed from results that the developmental period of *E. balteatus* varied significantly with respect to aphid species. These variations may attribute due to preference and difference in consumption of aphid species (Bhadauria *et al.*, 2001).

Results demonstrated that the body size of syrphid larvae increased gradually at different instar levels with the increase in the predation rate on aphids, till the 3rd instar larvae got the size two-three times greater than the 1st instar. The predation at 3rd instar stage of development also increased to the maximum but slowed down just before pupation. It was also observed that there was no considerable variation in larval size of the same instars during predation on different aphid species but little variation in size of emerging adults among the syrphids was evidenced. Dixon (2000) suggested that nutritional quality, quantity and availability of food at larval development effect the body size of adults emerged as a result of that food. More or less similar statement was given by Scholz and Poehling (2000) and Belliure and Michaud (2001). Accordingly, body size of syrphids differed by the variation in the size of their prey (Aphid) species. Maximum larval duration of *E. balteatus* was recorded from 10-12 days.

These results were in coordination to the statement of Tinkeu and Hance (1998) that duration of feeding period was linked to the age of the predator, the youngest predator requiring more time to overcome the resistance of the prey, which decreased gradually as the predator grew. They related the later age with the changes in the morphology of the mouth parts of the predator larvae.

Predation of *E. balteatus* was found generally greater in our results on all selected aphid species. The maximum consumption number of *M. persicae* by *E. balteatus* was confirmed by Hong and Hung (2010). Gagne *et al.* (2002) and Pervez and Omkar (2005) were also of the view that nutritional suitability of prey species and difference in handling especially in laboratory might also affect the consumption rate. Larsson (2005) revealed that predation of aphids by syrphid larvae found to be regular in case of different aphid species. Acting as candidate of biological control agent its larvae consume a wide range of aphid species sometimes exceeding more than hundred species of aphids (Sadeghi and Gilbert, 2000; Leroy *et al.,* 2010). (Rojo *et al.*, 2001; Speight, 2003) also reported the *E. balteatus* as effective predator species of aphids.

Predation by *E. balteatus* during its development is great contribution in the significant suppression of aphids. Analysis of species interaction of *E. balteatus* with aphid species rather than simple description and abundance, provides not only the information but also the understanding of actual work of communities. Understanding about these functionally important species which are pollinators and able to move in various environments, as habitat restoration is an essential component for conservation of ecology.

It was concluded that the prevailing ecological principles and natural selection is responsible to make a species flourishing or failing. These differences were depicted as by feeding preferences of prey species, also variation in developmental period along with differences in morphology for their distribution in different habitats among specific prey species. These studies can be useful for IPM programs for effective management of aphids.

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