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Biology and Larval Feeding rate of *Episyrphus balteatus* (Dip.: Syrphidae) on *Aphis pomi* (Hom.:Aphididae) at Laboratory Conditions

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ABSTRACT: Biological characteristics and larval feeding rate of hoverfly *Episyrphus balteatus* De Geer were determined on *Aphis pomi* De Geer at laboratory conditions. The experiments were carried out in growth chamber at 25±2ºC, RH 50-60% and a photoperiodism of 16:8 (L:D) h. The incubation period, larval period, pupal period and developmental time of *E. balteatus* were determined as 4.00, 11.33, 7.20 and 23.50 days, respectively. Adult longevity considerably increased (9.50 days) when fed with honey solution but in non-feeding situation, it lasted for only 3.5 days. There were significant differences (P<0.1) observed in daily and total feeding rate among the first, second and third instar larvae. Each larva of *E. balteatus* fed on 465.60 aphids during larval period and revealed a high potential for feeding on *A. pomi* The third instar larvae played an important role in feeding rate, such that 67.69% of total larval feeding was due to this instar level. Per capita daily feeding rate of first, second and third instar larvae amounted to 8.40, 36.82 and 64.33, respectively. Because of considerable reproduction as well as feeding rate, hoverfly *E. balteatus* can be employed in biological control, and in integrated management programs of different aphid species, specially *A. pomi.*

Keywords: *Episyrphus balteatus*, *Aphis pomi*, Biology, Feeding rate

INTRODUCTION

Aphids cause curls in leaves, reduced growth of plants and deformations in plant organs by feeding on shoots, leaves, stems, fruits and roots of plants (Eastop, 1966; Dixon, 1977). The green apple aphid, *A. pomi* is a holocyclic and monoecious aphid species that is widespread in Palaearctic region. It is one of the most important pests in apple orchards with infestation occurring regularly each year both on globally popular and local apple cultivars. The species is especially harmful in nurseries and young orchards and it characteristically re-infests apple trees over the May-June period (van Emden and Harrington, 2007). 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).

Syrphid flies provide important ecosystem services and are useful ecological indicators, largely due to the diversity of species with different range of behavior and habitat (Burgio and Sommaggio, 2007; Sommaggio and Burgio, 2014). 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 goal of this study was to quantify the growth, development and larval consumption rates of syrphid larvae under laboratory conditions as an important step toward understanding the potential of dominant syrphid species to control populations of *A. pomi* in apple orchards in Kermanshah. The present study was carried out in Iran (Kermanshah) to determine the developmental duration and voracity of *E. balteatus* on *A. pomi* species during March-June 2014. The generated information will provide a preliminary step for biological control of these aphid species by conservation *E. balteatus*.

MATERIALS AND METHODS

A. Experimental Material and Rate of Development

The female flies of *E. balteatus* captured while orienting to attractive plants. Gravid females of *E. balteatus* that had swollen abdomen released to Petri dishes (8 cm diameter and 1 cm height).The leaves or branches of apple tree infested by *A. pomi* aphid were kept in cages to ensure the presence of prey species. Syrphid larvae were provided aphids in sufficient (200) number to satisfy the predator species. Cannibalism occurs in wide variety of predators (Banquart *et.al.*, 1997), to avoid this behavior, an individual larva were reared in a single Petri dish throughout their developmental period. The dishes were held in the growth chamber and eggs were observed for larval eclosion at 24-h intervals. Each trial was repeated 10 times. Experiment was conducted in Pest Control Lab. at the Department of Plant protection, Research center of Agriculture Kermanshah, Iran. 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 to April, 2014, at average temperature of 25±2°C, 605% RH and of 16:8 h D: L photoperiod. Data were taken at an interval of 24 hours to monitor the conversion of each life stage into next one. Rearing cages were cleaned and new aphids were provided on daily basis.

B. Rate of Predation

In the same experiment, extent of predation by larvae of *E. balteatus* was determined by offering them A. pomi. Efficiency was determined from right after emergence of larvae from egg till pre-pupation stage. All aphids that were used during experiment were of same instars (same biomass). After 24 h, consumed aphid numbers 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. 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 subtraction 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.

C. Statistical Analysis

Mean developmental times of immature stages used to analysis of the results. Comparisons were made upon predation rates of 3 larval stages and longevity of adults using two-sample t-test at = 0.05. Proc Univariate in SAS (SAS 9.1, 2003)

RESULTS

A. 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 *A. pomi*, along with body lengths of *E. balteatus*.

B. Incubation Period

Eggs of syrphids were of sub- spherical in shape, with its length of 3.5 mm. Time duration ranged from 4±0.33 days for hatching in the presence of *A. pomi*.

C. Larval Duration

Total larval duration prolonged for 11±0.23 days when predator fed on *A. pomi*, was recorded in case. Body length of 3rd instar larvae were measured as (8±1.35). 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.

D. 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 mean of 7.20±0.20 days.

E. 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 mm. These specific banding patterns of abdomen were one of their identification marks also.

The survival of this species in rearing cages was considerably increased (9.50 days) when fed with honey solution (10%) but in non-feeding situation, it lasted for only 3.5 days. Adult emergence was recorded and gender determination were based on adult possessing holoptic or dicoptic eyes.

F. Total Consumption

E. balteatus larvae consumed highest mean number of 465.60 *A. pomi* till pupal stage.

G. Consumption at Different Larval Instars

Table 2 presents that 3rd instasr larvae of *E. balteatus* consumed highest number of aphids that 67.69% of total larval feeding was due to this instar level. The highest rate of consumption was observed during first and second day of 3rd instar, while it decreased at negligible just before pupation (Fig. 1).

Table 1: Mean duration of biological stages of *E. balteatus* on *A. pomi* at 27 ± 2°C.

Developmental stage	Mean±SE
Egg	4.00 ± 0.33
1st instar larva	3.00 ± 0.21
2nd instar larva	3.40 ± 0.16
3rd instar larva	4.90 ± 0.34
Pre-pupa	1.00 ± 0.00
Pupa	7.20 ± 0.20
Pre-imaginal	23.50 ± 0.58
Longevity of adults with feeding	9.70 ± 0.42
Longevity of adults without feeding	3.50 ± 0.17

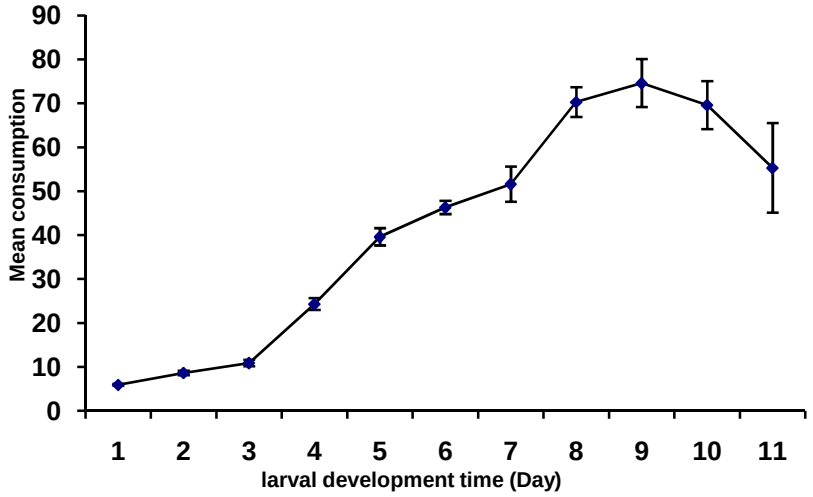

Fig. 1. Daily consumption trend of *E. balteatus on A. pomi.*

H. Average Per-day Consumption

Average per-day consumption of *E. balteatus* was on *A. pomi* as 64.33±2.63 specimens in 3rd instar were consumed. Average per-day consumption of three instars were significant differences (P<0.1) (Table 2).

Table 2: Daily and total feeding rate of larval stages of *E. balteatus on A. pomi* Mean ± SE.

Developmental stage	Mean Daily feeding rate	Mean total rate
1st instar larva	8.40 ± 0.44^{c}	25.20 ± 2.23^{c}
2nd instar larva	36.82 ± 1.67^{b}	125.20 ± 7.03^{b}
3rd instar larva	64.33 ± 2.63^{a}	315.20 ± 16.27^{a}

Values marked with different letters in each column are significantly different (p<0.01)

DISCUSSION

Predatory hoverflies especially subfamily Syrphinae are good models to investigate 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 stages. Results demonstrated that the body size of syrphid larvae increased gradually at different instar levels with the increase in the predation rate on *A. pomi*, till the 3rd instar larvae got the size two or 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. Dixon (2000) suggested that nutritional quality, quantity and availability of food at larval development affect the body size of adults emerged as a result of kind of 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 may be related to with the changes in the morphology of the mouth parts of the predator larvae in the later age. The third instar larvae played an important role in feeding rate, such that 67.69% of total larval feeding was due to this instar level. Each larva of *E. balteatus* fed on 465.60 aphids during larval period and revealed a high potential for feeding on *A. pomi*. Because of considerable reproduction as well as feeding rate, hoverfly *E. balteatus* can be employed in biological control, and in integrated management programs of different aphid species, specially *A. pomi.*

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