EFFECT OF TEMPERATURE AND DIET ON THE LIFE CYCLE AND PREDATORY CAPACITY OF *EPISYRPHUS BALTEATUS* (DE GEER) (SYRPHIDAE: DIPTERA) CULTURED ON *APHIS GOSSYPII* (GLOVER)

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ABSTRACT

The larvae of hoverfly *Episyrphus balteatus* (De geer) are important predators for controlling the aphids in cruciferous vegetable fields in Hanoi. The effects of temperature on the development and the predatory capacity of *E. balteatus* larvae were studied in laboratory. The life span of *E. balteatus* is 21.2 days at 26.6^{o}C and 19.6 days at 29.9^{0}C. The predatory capacity of third instar *E. balteatus* larvae is an average of 32.2 prey per day at 27.5 ^{0}C and 30.6 prey per day at 30.6^{0}C. Honey and pollen increased the longevity of the adults. This paper also shows the effect of different prey species on the feeding capacity of ***E.** balteatus* larvae which was significantly greater on *Aphis gossypii* and *Myzus persicae* than on *A. craccivora*. *E. balteatus* has a high predatory capacity on aphids and therefore can be used as a bio-control agent against aphids of crucifers.

Key words: predatory fly, biological control, cruciferous vegetables.

INTRODUCTION

The hoverfly *Episyrphus balteatus* (De Geer) belongs to the subfamily *Syrphinae* (Stubbs and Falk, 1996; Kaczorowska, 2006; John et al., 2006). The larvae of this species are predators of more than 100 aphid species worldwide (Sadeghi and Gilbert, 2000). This insect is the most common in central Europe (Tenhumberg and Poehling, 1991), in the UK (Stubbs and Falk, 1996; Gilbert, 1993) and in the South Asia. Experiments performed in Indonesia, in which *E. balteatus* were collected from broad beans (*Vicia faba* L.), demonstrated that this species has a potential and important role in the biological control of aphids in the natural agro-ecosystem (Kalshoven, 1981). In Vietnam, the cotton aphid (*Aphis gossypii*) is one of the important insect pests of many crops, particularly cruciferous vegetables. The major method used by farmers to control this aphid species is to use insecticides that have, in many cases, adverse impacts on environment and food safety (Nguyen Thi Kim Oanh 1996, Quach Thi Ngo 2000).

It is necessary to find natural enemies that can control effectively the aphids in such situations. The major objectives of this study were to determine the effect of temperature on the life cycle and predatory capacity of *E .balteatus* larvae on *A. gossypii.* It also sought to assess the feeding capacity of *E. balteatus* larvae on different prey species.

MATERIALS AND METHODS

All experiments were done in the Department of Entomology, Hanoi Agricultural University, Vietnam. *E. balteatus* were collected from various cruciferous vegetables such as *Brassica oleracea var. capitata, Brassica chinensis*, *Brassica oleracea* var. *botrytis, and Brassica oleracea var. gongylodes* in Hanoi.

Life cycle

The flies were reared following the protocol of Bargen (1998). Adult flies were fed with bee pollen and crystalline sugar. Females readily laid their eggs on cruciferous plants (*B. chinensis*) with cotton aphid colonies attacking these plants. Immediately after hatching, larvae were transferred to the rearing cages (18 x 13.5 x 6.5 cm) and the second instar aphids were provided as food on leaf cuttings. Aphids were collected from cruciferous plants in the fields and reared on cruciferous plants placed in rearing sheft boxes until the second instars emerged. The number of aphids was counted everyday in order to provide additional food for larvae of *E. balteatus* until pupation. Temperatures for rearing were measured in the morning, afternoon and evening, with 80% relative humidity, 16 hours of daylight and artificial lighting of 5000 lux (cd/m^2).

Eggs were observed daily and larvae were observed in Petri dishes. The feeding process of 30 larvae and fresh cruciferous leaver provided daily until pupation. Pupae were observed daily for adult emergence and sex was determined. Eggs, larvae, pupae were also collected daily and preserved in 70 % ethanol.

Effects of various food on the longevity of *E.balteatus* adults

Adult flies were transferred to the rearing cages (18 x 13.5 x 6.5 cm). Three experiments of foods, water (control), pollen and honey + pollen 10% (honey mixed with pollen follow the ratio 1:1), were performed with three replicates. In each experiment, 30 adult flies were provided with food daily until natural death and the life span recorded.

Feeding capacity of *E.balteatus* larvae on *A. gossypii and* different prey species

Immediately after hatching, the larvae of *E. balteatus* were taken and reared individually in Petri dishes. Three aphid species, *A. gossypii, Myzus persicae* and *A. craccivora,* used for this experiment were collected from cruciferous fields. Aphids were reared on cruciferous plants placed in sheft boxes. Aphids at second instar were transferred into each Petri dish as food for larvae of *E. balteatus*. The larval stages of *E. balteatus* (first instar, second instar, third instar) were tracked using 30 individuals for each stage. Each individual of *E. balteatus* was provided with 50 second instar larvae of prey every day. The number of prey eaten daily and the development time of the *E. balteatus* larvae were recorded. The experiments were performed with 3 independent replicates.

RESULTS AND DISCUSSION

Effect of temperature on development of *E. balteatus*

The life cycle of *E. balteatus* was significantly influenced by the rearing temperature. Two temperature modes, 26.6^{o}C and 29.9^{o}C on average, were used to assess the life cycle and developmental stages of the fly. The life cycle was 21.2 days at 26.6^{o}C and reduced to 19.6 days at 29.9^{o}C (Table 1). The egg period was 3.1 and 2.8 days, respectively. The fly has three instars, in which the first instar period was 2.1 and 1.7 days, the second instar period was 2.2 and 2.2 days, and the third instar period was 3.3 and 3.2 days, respectively. The pupal development took 7.9 and 7.7 days, respectively. As with most insects, duration for each development stage decreases with increasing temperature. The effect of temperature on development of *E. balteatus* was similar with that described by Bargen (1998).

Table 1. Effect of temperature on the developmental stages of *E. balteatus* on *A. gossypii*

	Duration (days) at respective temperature (^{o}C)	
Developmental stage	**29.9**	**26.6**
Egg	2.8 ± 0.13^{b}	3.1 ± 0.10^{a}
First instar	1.7 ± 0.16^{b}	2.1 ± 0.10^{a}
Second instar	2.2 ± 0.13^{b}	2.2 ± 0.14^{a}
Third instar	3.2 ± 0.14^{b}	3.3 ± 0.16^{a}
Pupa	7.6 ± 0.17^{b}	7.9 ± 0.09^{a}
Pre – Oviposition	3.2 ± 0.14^{b}	3.2 ± 0.16^{a}
Total life cycle	$\mathbf{19.6 \pm 0.18^{b}}$	$\mathbf{21.2 \pm 0.14^{a}}$

Note: Means followed by different letter in the same column are significantly different ($p< 0.05$).

Effect of food on the longevity of adult *E. balteatus*

The longevity of the adult fly at the two temperature modes is presented in Table 2. The longevity of the adult fly depended on both the rearing temperature and food type. The longevity of adult was slightly prolonged when they were reared at 25.5^{0}C compared with that when they were reared at 28.1^{0}C.

Table 2. Effects of pollen and honey on the longevity of *E. balteatus* adults.

Average Temperature (^{0}C)	**Food type**	**Adult longevity (days)**
28.1	Water	3.1 ± 0.2^{a}
	Pollen	6.8 ± 0.3^{b}
	Honey + pollen 10%	7.3 ± 0.3^{c}
25.5	Water	3.6 ± 0.4^{a}
	Pollen	7.2 ± 0.3^{b}
	Honey + pollen 10%	7.8 ± 0.3^{c}

Note: Means followed by different letter in the same column are significantly different ($p < 0.05$).

With food type was water (used as control), the average life span of the adult was lowest, with 3.1 and 3.6 days at the two temperature modes, 25.5 and 28.1 ^{0}C, respectively. When the adults were fed pollen or a mixture of honey + pollen 10%, the average life span of the adult was prolonged. For instance, the life span of the adults reared on honey + pollen 10% was highest, with 7.3 and 7.8 days at the two temperature modes. These observations are similar with those observed by Iwai and Hideki (2007), Tenhumberg and co-workers (1991) and Bargen **(**1998).

It is known that the rearing temperature and food type may affect directly some biological characteristics of insects such as longevity and egg-laying rate. As reported by Bargen (1998), some foods are much more suitable for *E. balteatus* adult; for instance, the honey and crystalline sugar can promote egg production of *E. balteatus*

Feeding capacity of *E. balteatus* larvae on cotton aphid (*A. gossypii)*

The predatory capacity of *E. balteatus* larvae of each stage on cotton aphid was assessed at two rearing temperatures (Table 3). The predatory capacity of first instar larvae was lowest, eating an average 6.5 prey per day at 27.5^0C and 6.0 prey per day at 30.6^0C. The capacity of the second instar larvae was slightly higher, eating an average 7.23 prey per day at 27.5^0C and 7.07 prey per day at 30.6^0C. At the third instar stage, the larvae had the highest predatory capacity, eating an average of 17.9 prey per day at 27.5^0C and 17.2 prey per day at 30.6^0C. In total, each larva can eat an average 32.1 prey per day at 27.5^0C and 30.5 prey per day at 30.6^0C.

These results demonstrate that *E. balteatus* larvae can be an important predator of cotton aphid.

Table 3. Feeding capacity of *E. balteatus* larvae on *A. gossypii*

Developmental stage	Average temperature (^{0}C)	Predatory capacity of different instars of *E. balteatus* (prey/day)
First instar	30.6	6.0 ± 0.23^b
Second instar		7.1 ± 0.26^b
Third instar		17.2 ± 0.54^b
Total prey eaten		$\mathbf{30.6 \pm 1.04^b}$
First instar	27.5	6.5 ± 0.19^a
Second instar		7.2 ± 0.26^a
Third instar		17.9 ± 0.28^b
Total prey eaten		$\mathbf{32.2 \pm 0.62^b}$

Note: Means followed by different letter in the same column are significantly different ($p< 0.05$)
Thirty insects were used in this experiment.

Feeding capacity of *E. balteatus* larvae on different prey species

The results presented in Table 4 show the feeding capacity of *E. balteatus* larvae on diffrent aphid species. The feeding capacity of the *E. balteatus* larvae on *A. gossypii* was similar with that on *M. persicae* (31.2 and 31.4 prey per day, respectively) and significantly greater than that on *A. craccivora* (28.2 prey per day).

Table 4. Feeding capacity of *E. balteatus* larvae on different prey species.

Prey	Average temperature (^{0}C)	Predatory capacity of *E. balteatus* larvae (prey/day)
A. gossypii	29.5	31.2 ± 1.03^b
A. craccivora		28.2 ± 0.55^a
M. persicae		31.4 ± 1.88^b

Note: Means followed by different letter in the same column are significantly different ($p< 0.05$)

Hindayana and co-workers (2001) showed that the predatory capacity of *E. balteatus* larvae was highest on *A. gossypii.* It was significantly higher than that on 3 other aphid species, *A. fabae, Aulacorthum solani* and *Acyrthosiphon pisum,* with 246.5, 147.5, 83.1 and 61.5 total prey eaten per fly larvae, respectively. Our results further demonstrated that the average number of aphids consumed *by E. balteatus* during larval development depended on the body size of the different prey species. Of the 3 aphid species used in this study, the body size of *A. gossypii* and *M. persicae* is almost the same but larger than that of *A. craccivora*.

CONCLUSIONS

Rearing temperature affected both growth and development of *E. balteatus.* The cycle of this species was prolonged at low temperature. Honey and pollen increased the longevity of the adults. The feeding capacity of *E. balteatus* larvae was significantly greater on *A. gossypii* and *M. persicae* than on *A. craccivora*. The data from this work also provided further evidence that *E. balteatus* has high predatory capacity on aphids, and therefore can be used as a bio-control agent against aphids of crucifers.

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