R12

Tropical Agricultural Research Vol. 8 1996, 412-418

Influence of Temperature on Development and Oviposition of *Delphastus pusillus*, A Coccinellid Predator of *Trialeurodes vaporariorum*

K.S. Hemachandra and M.J.W. Copland[1]

Department of Agricultural Biology
Faculty of Agriculture
University of Peradeniya
Peradeniya

ABSTRACT. *Influence of temperature on incubation period, duration of larval and pupal period, pre-oviposition period and the rate of oviposition of Delphastus pusillus, a coccinellid predator, were determined when they were fed on excess eggs of Trialeurodes vaporariorum. The temperature range used was 17-26°C. Significantly higher rates of development of immatures of D. pusillus and a higher rate of oviposition were observed at 26°C. Significantly shorter incubation and pre-oviposition periods were also recorded at 26°C. The consumption of glasshouse whitefly eggs by predatory larvae was higher at 17 and 20°C. Theoretical threshold temperatures for development of egg, L_2, L_3, L_4, pre-pupa and pupa were 6, 12, 11, 7, 13 and 10°C respectively and the thermal constants of those were 100, 23, 26, 58, 23 and 83 degree days respectively.*

INTRODUCTION

Glasshouse whitefly, *T. vaporariorum* is one of the key insect pests on vegetables and ornamental plants in tropical environments (Fransen and Van Lenteren, 1993). Management of this pest has become difficult because of the development of resistance to insecticides (Van Lenteren and Woets, 1988) and the inadequate parasitization of glasshouse whiteflies nymphs by *Encarsia formosa* Gahan (Hymenoptera; Aphelinidae) at high population densities and low temperatures (Albert, 1990). Potential of *D. pusillus*, a coccinellid predator, has been comprehended as a biocontrol agent of many whitefly species. *e.g. Bemisia tabaci, Aleurocanthus woglumi, Aleurotracheius socialis* and *Trialeurodes vaporariorum* (Hoelmer *et al.*, 1993) which requires mass

1 Wye College, University of London, Wye, Ashford, Kent TN25 5AH, United Kingdom.

rearing of predatory beetles for commercial use. Durations of post-embryonic development and rate of oviposition, which depend on temperature influence mass rearing (Alikhan and Yousuf, 1986). This study was carried out to determine the influence of temperature on incubation period, larval and pupal periods, consumption of whitefly egg by larvae and the oviposition rate of *D. pusillus*.

MATERIALS AND METHODS

A culture of *D. pusillus* was established with a sample received from Applied Bionomics, Canada and the coccinellids were maintained on the glasshouse whitefly on tobacco (*Nicotiana tobacum* cv White Burley) at 26°C in Wye College, University of London. The experiments were conducted at 50% RH and 18L:6D.

Duration of incubation period of eggs of *D. pusillus* was first determined at different temperatures (17, 20, 23 and 26°C). The eggs of *D. pusillus* were obtained by caging females in petri dishes (9 cm diameter) on tobacco leaf discs with excess eggs of glasshouse whitefly over 10 hours. Subsequently, leaf discs with the eggs of *D. pusillus* were transferred to agar plates (1% agar, 20 ml/plate) to avoid desiccation. Each leaf disc contained 10-15 eggs and 50 eggs were kept at each temperature. The eggs were examined daily for hatch and the incubation period of each egg at each temperature was recorded.

Duration of larval development and consumption of glasshouse whitefly eggs by the larvae at four temperatures were next examined. A set of first instar larvae of *D. pusillus* were obtained from previously collected eggs and caged individually in small perspex cages, which comprised of 8 mm thick perspex sheet (75 × 38 mm) with a 23 mm diameter hole, sandwiched between a glass slide (75 × 38 mm) and a 3 mm thick perspex sheet (75 × 38 mm) with a 10 mm diameter hole covered with a muslin cloth, held in place by rubber bands. Excess eggs of glasshouse whitefly on tobacco leaf were provided as food. Fifteen individually caged first instar larvae were kept at each of temperature 17, 20, 23 and 26°C. The larvae were examined daily for the moulting and the number of whitefly eggs eaten by the larvae. The tobacco leaf with the glasshouse whitefly eggs beneath the cage was replaced with a fresh tobacco leaf with excess eggs of glasshouse whitefly daily. Thermal constants and threshold temperatures for development were calculated as described by Obrycki and Tauber (1982).

Effect of temperature on oviposition rate of *D. pusillus* was studied using newly emerged mated females, obtained from the laboratory culture. Four sets of ovipositing females each comprising of 12 beetles were caged individually in an arena of 4.2 cm^2 (cage described in previous experiment) on a tobacco leaf with excess eggs of glasshouse whitefly. Each set of beetles were exposed to one constant temperature (17, 20, 23 and 26°C) for a period of 18 days. Each cage was examined daily for *D. pusillus* eggs and the tobacco leaf with whitefly eggs was renewed.

Pre-oviposition period of *D. pusillus* at different temperatures was determined by leaving 40 newly emerged females with males at 17, 20, 23 and 26°C in the cages described above. One female and one male were kept in each cage and the tobacco leaf with glasshouse whitefly eggs were replaced daily. The cages were examined daily for *D. pusillus* eggs and the minimum time taken by females to lay eggs was recorded.

The results of this study was analysed using Mann-Whitney test and '*t*' test in Minitab.

RESULTS AND DISCUSSION

Duration of each instar of *D. pusillus* (egg to adult) increased significantly with decreasing temperature showing a negative correlation (Table 1). The calculated thermal constants for egg, L_2, L_3, L_4, pre-pupa and pupa were 100, 23, 26, 58, 23 and 83 degree days respectively. The calculated threshold temperatures for development of those were 6, 12, 11, 7, 13 and 10°C respectively. Significant linear relationship between development rate and temperatures was observed for all instars except for first instar larvae. Similar relationship has been shown by many predatory coccinellids such as *Adalia bipunctata, Coccinella transversoguttata, Coccinella septempunctata* (Obrycki and Tauber, 1981), *Chilomenes sexmaculata* (Alikhan and Yousuf, 1986), *Hipodamia convergens* (Obrycki and Tauber, 1982), *Coccinella septempunctata* (Butler, 1982) and *Scymnus frontalis* (Naranjo *et al.*, 1990). However, first instar of *D. pusillus* showed no significant linear relationship between development rate and temperature and similar observation has been made with other predatory coccinellids. *e.g.* first and third instar larva of *Adalia bipunctata* and first instar larva of *Coccinella septempunctata* (Obrycki and Tauber, 1981). The larval mortality observed in this experiment was negligible indicating the suitability of temperature range used for larval development.

Table 1. Mean duration (days) of developmental stages of *D. pusillus* feeding on eggs of glasshouse whitefly at different temperatures.

Instar	Duration (days) Mean ± SE			
	26°C	23°C	20°C	17°C
Egg	4.7 ± 0.2^{a}	5.7 ± 0.1^{b}	7.3 ± 0.1^{c}	8.5 ± 0.2^{d}
L_1	2.3 ± 0.1^{a}	3.3 ± 0.4^{b}	2.4 ± 0.3^{a}	5.4 ± 0.5^{c}
L_2	1.6 ± 0.1^{a}	2.5 ± 0.2^{b}	3.2 ± 0.1^{c}	4.2 ± 0.3^{d}
L_3	1.7 ± 0.1^{a}	2.4 ± 0.2^{b}	3.2 ± 0.1^{c}	4.0 ± 0.3^{d}
L_4	3.3 ± 0.2^{a}	3.5 ± 0.2^{a}	4.6 ± 0.2^{b}	6.4 ± 0.3^{c}
Prepupa	1.7 ± 0.1^{a}	2.7 ± 0.2^{b}	3.4 ± 0.2^{c}	5.5 ± 0.3^{d}
Pupa	5.3 ± 0.1^{a}	7.2 ± 0.2^{b}	7.8 ± 0.1^{c}	13.4 ± 0.5^{d}
Total	20.6 ± 0.2^{a}	27.3 ± 0.4^{b}	31.9 ± 0.4^{c}	47.4 ± 0.7^{d}

Values within a row followed by the same letter did not differ significantly at 5% level.

SE = Standard error.

Total consumption of glasshouse whitefly eggs by *D. pusillus* larvae was significantly higher at lower temperatures (17 and 20°C) than at 23 and 26°C (Table 2) which agrees with studies done by Gurney and Hussey (1970) in which *Coleomegilla maculata* consumed 22, 25 and 48 of *Myzus persicae* during the larval development at 24, 21 and 16°C respectively and *Adalia bipunctata* consumed 16, 21 and 24 *M. Persicae* at 24, 21 and 16°C respectively during the larval development. Slow growth of larvae together with high consumption is an advantage in retaining predatory larvae over a long period in the field (Gurney and Hussey, 1970).

The mean oviposition rates of *D. pusillus* together with respective standard errors at 17, 20, 23 and 26°C were 4.3±0.2, 5.7±0.4, 7.7±0.4 and 8.7±0.5 respectively which are significantly different to each other. According

Table 2. **Mean consumption of glasshouse whitefly eggs by each instar of *D. pusillus* at different temperatures.**

Temp. (C^0)	Consumption during development, Mean ± SE (no. of eggs/instar)				
	L_1	L_2	L_3	L_4	Total
26	53.0 ± 4.4^{a}	86.7 ± 11.3^{ac}	162.0 ± 19.0^{a}	413.0 ± 25.7^{a}	714.8 ± 23.5^{a}
23	40.3 ± 8.5^{abc}	109.1 ± 12.4^{a}	107.3 ± 6.1^{b}	421.5 ± 81.6^{a}	625.3 ± 70.3^{a}
20	28.8 ± 3.6^{b}	141.5 ± 8.2^{b}	226.8 ± 21.8^{c}	619.7 ± 20.4^{b}	1016.8 ± 29.2^{b}
17	36.2 ± 3.6^{c}	83.2 ± 9.6^{c}	151.0 ± 7.4^{a}	755.2 ± 43.5^{b}	1003.6 ± 47.4^{b}

Values within a column followed by the same letter did not differ significantly at 5% level.

SE= Standard error.

to Messenger (1959) the relationship between the oviposition rate and the temperature is likely to be a sigmoid curve, and the middle part of the curve could be reasonably presented by a straight line. Linear regression of the data of present study yields the equation; Oviposition rate (eggs/female/day)=0.5 (temperature°C)-4.1 (r^2=98.4). Gawande (1966) reported that *Chilomenes sexmaculata* showed a positive correlation between oviposition and temperature within a certain limit which agrees with the present study. Naranjo *et al.* (1990) reported the same relationship for *Scymnus frontalis* in the range of 15-26°C. Alikhan and Yousuf (1986) have further confirmed above positive relationship of *Chilomenes sexmaculata* feeding on *Brevicoryne brassicae* within 26-32°C. The threshold temperature for oviposition of *D. pusillus* was calculated as 8.2°C which is important for efficient biocontrol agent to have more generations than prey (Hagen *et al.,* 1976). One of the reasons for poor performance of *Encarsia formosa* in controlling *T. vaporariorum* is that the intrinsic rate of increase for *E. formosa* is lower than that of *T. vaporariorum* at or below 20°C (Van Lenteren and Jordaan, 1987).

Mean pre-oviposition period of *D. pusillus* together with respective standard errors at 17, 20, 23 and 26°C were 10.0±0.8, 9.4±0.6, 7.2±0.3 and 5.6±0.5 days which clearly show a negative relationship with the temperature. Similar negative relationship has been observed in *Scymnus frontalis* by Naranjo *et al.* (1990) while feeding on *Diuraphis noxia.*

CONCLUSION

Temperature greatly influences the development rate and food consumption of immature instars, oviposition rate and pre-oviposition period of *D. pusillus*, a predator which has proved its potential as a biocontrol agent of glasshouse whitefly. Maximum rate of production of the beetle in mass rearing can be obtained at 26°C within the tested temperature range (17-26°C) because the shortest duration of immatures (egg to adult), shortest pre-oviposition period of mated females and the highest rate of oviposition were recorded at 26°C. The cost of energy required to maintain this temperature has to be considered in mass rearing, and also the efficiency of the beetles produced at 26°C in controlling *T. vaporariorum* has to be tested.

ACKNOWLEDGEMENT

We thank Mahapola Higher Education Trust fund and President's fund for the financial assistance given.

REFERENCES

Albert, R. (1990). Experience with biological control measures in glasshouses in Southwest Germany. IOBC/WPRC Bull. 13(5): 1-5.

Alikhan, M.A. and Yousuf, M. (1986). Temperature and food requirement of *Chilomenes sexmaculata* (Coleoptera: Coccinellidae). Environ. Entomol. 15(4): 800-802.

Butler, G.D. (1982). Developmental time of *Coccinella septempunctata* in relation to constant temperatures (Col.: Coccinellidae) Entomophaga. 27(3): 349-352.

Fransen, J.J. and Van Lenteren, J.C. (1993). Host selection and survival of the parasitoid *Encarsia formosa* on glasshouse whitefly *Trialeurodes vaporariorum* in the presence of hosts infected with the fungus Aschersonia aleyrodis. Entomol. Exp. Appl. 69(3): 239-249.

Gawande, R.B. (1966). Effect of constant and alternating temperatures on feeding and development of *Chilomenes sexmaculata* FB. pp. 63-67. *In:* Hodek, I. (Ed). Ecology of Aphidophagous Insects. Proceedings of a symposium. Dr. W. Junk publishers, Hague, Prague.

Gurney, B. and Hussey, N.W. (1970). Evaluation of some coccinellid species for the biological control of aphids in protected cropping. Ann. Appl. Biol. 65: 451-458.

Hagen, K.S., Bombosch, S. and Mc. Murtry, J.A. (1976). The biology and impact of predators. pp. 93-142. *In*: Huffaker, C.B. and Messenger, P.S. (Eds). Theory and practice of biological control, Academic Press, New York.

Hoelmer, K.A., Osborne, L.S. and Yokmoi, R.K. (1993). Reproduction and feeding behaviour of *Delphastus pusillus* (Coleoptera: Coccinellidae), a predator of *Bemisia tabaci* (Homoptera: Aleyrodidae). J. Econ. Entomol. 86(2): 322-329.

Messenger, P.S. (1959). Bioclimatic studies with insects. Ann. Rev. Entomol. 4: 183-206.

Naranjo, S.E., Gibson, R.L. and Walgenbach, D.D. (1990). Development, survival, and reproduction of *Scymnus frontalis* (Coleoptera: Coccinellidae), an imported predator of Russian wheat aphid, at four fluctuating temperatures. Ann. Entomol. Soc. Am. 83(3): 527-531.

Obrycki, J.J. and Tauber, M.J. (1981). Phenology of three coccinellid species: Thermal requirements for development. Ann. Entomol. Soc. Am. 74(1): 31-36.

Obrycki, J.J. and Tauber, M.J. (1982). Thermal requirements for developmental of *Hippodamia convergens* (Coleoptera: Coccinellidae). Ann. Entomol. Soc. Am. 75(6): 678-683.

Van Lenteren, J.C. and Jordaan, P.M.H. (1987). *Encarsia formosa* can control glasshouse whitefly at low temperature regimes. IOBC/WPRS. Bull. 1987/X/2: 87-91.

Van Lenteren, J.C. and Woets, J. (1988). Biological and integrated pest control in glasshouses. Ann. Rev. Entomol. 33: 239-269.