Temperature and Food Requirements of *Chilomenes sexmaculata* (Coleoptera: Coccinellidae)

M. A. ALIKHAN AND M. YOUSUF[1]

Department of Biology, Laurentian University,
Sudbury, Ontario P3E 2C6, Canada

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ABSTRACT Adult longevity, duration of development from hatching to adult emergence from the pupae, numbers of eggs laid, and prey consumed by *Chilomenes sexmaculata* F. were evaluated at constant temperatures ranging from 26 to 34°C. Adult survival varied from 6.1% at 34°C to 65.7% at 30°C. Maximum oviposition rate was attained at 32°C, but fecundity was highest at 30°C. Low oviposition rate and fecundity at 26 and 34°C indicated that these temperatures were near the threshold of activity for the adult.

KEY WORDS *Chilomenes sexmaculata*, longevity, food consumption, fecundity, development period, temperature

Chilomenes sexmaculata F. is an important predator of aphids, coccids, psyllids, aleurodids, and mites in northern Pakistan (Sharga 1948). Consequently, in developing a reasonable management system for these pests, attention must be paid to the factors responsible for the seasonal variations of *C. sexmaculata* populations. Of the many exogenous factors affecting the predator, abiotic factors are probably the most important influences (Ferran & Larroque 1980). Earlier studies by Modawal (1941), and Bagal & Trehan (1945) indicated that populations of *C. sexmaculata* respond favorably to temperatures between 19.8 and 29°C in the field. However, precise laboratory data on temperature and food requirements of this species are lacking.

The objective of the research reported here was to examine the effects of selected constant temperatures on the growth, oviposition, and feeding of *C. sexmaculata*. Additionally, the study may provide some basis for predicting coccinellid populations during the alfalfa growth season in northern Pakistan.

Materials and Methods

Colony Maintenance. A colony of *C. sexmaculata* was established in the greenhouse from adults collected from around the Agricultural University Faisalabad (Pakistan) campus in February 1980 from *Trifolium alexandrinum* L. and *Medicago sativa* L. fields. Regular introduction to the colony of field-captured adults helped to reduce inbreeding effects. The insects were fed on *Brevicoryne brassicae* (L.) on *M. sativa* rooted in pots (12.5 cm) in a standard nursery soil mix (Matkin & Chandler 1957). The photoperiod was maintained at 10:14 (L:D) (approximating the length of early spring days in northern Pakistan) with supplementary fluorescent lighting of 3.2 klx. Plants were fertilized weekly with a modified Hoagland's solution (Matkin & Chandler 1957). All plants, when used, were 1 month old and supported a minimum number of 25 aphids per leaf. The mean daily temperature inside the greenhouse varied from 19.2 to 22.5°C (±2.5°C) at 55–60% RH.

Experimental Procedures. Coccinellid pupae from the greenhouse colony were transferred into glass vials to isolate newly emerging adults. On the day of emergence, a single female, along with two males, was caged on an *M. sativa* plant, under a plastic container (2 liter, 11.5 cm diam by 15.5 cm high). The plants were removed to an environmental chamber (with built-in humidity control, Model E15, Controlled Environments, London, U.K.) where light intensity was adjusted to 1.7 klx. There were 10 containers per treatment, and they were replicated five times for each of the five experimental temperatures (26, 28, 30, 32, and 34°C [±0.5°C] at 55–60% RH).

The containers, with their plants, were acclimated for 24 h to the test temperature before the introduction of aphids and coccinellids. Data on the coccinellids dying before oviposition were not included in the analysis. Adults were transferred to new plants every day at 1200 hours until the female died. Groups of 450 larvae per treatment were also transferred daily until they pupated. All observations were recorded daily at 1200 hours.

The feeding rate of coccinellid larvae and adults was calculated by introducing 250 apterous viviparae *B. brassicae* adults (of approximately the same total weight, ascertained by weighing three samples each of 20 adult aphids) per coccinellid per day into each cage. Aphids not consumed by the coccinellid at the end of each experimental day were discarded. Daily net change (natality minus

[1] Current address: Dep. of Entomology, Univ. of Agriculture, Faisalabad, Pakistan.

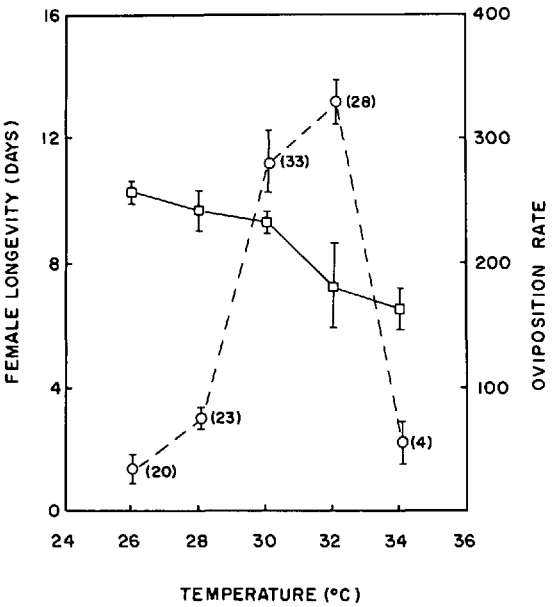

Fig. 1. Female longevity (-□-) and oviposition rate (-○-) in *C. sexmaculata* at five constant temperatures. Vertical bars represent the SE of the mean. Actual number of females forming the sample is given in parentheses at each point.

mortality) per 100 aphids, measured in the absence of coccinellids, was used to adjust the daily feeding rates. Separate feeding rates for male and female coccinellids were not calculated. Data for viable eggs (based on the number of newly hatched larvae) and feeding rate were averaged for every 2 days of female life; this provided a clear picture of feeding and ovipositional trends. Records in each treatment were also kept on the overall survival (newly hatched larvae to adult emergence), the length of the developmental period from larval eclosion to adult emergence, female longevity, and the number of malformed adults with crinkled and reduced elytra. The data were analyzed by an analysis of variance, with Duncan's multiple range test, using a DEC2020 computer, with SPSS (Anonymous 1985a) and BMD (Anonymous 1985b) software. Data were checked for normality before analysis.

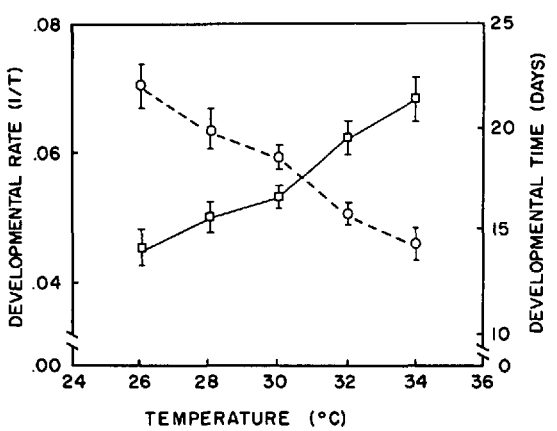

Fig. 2. Developmental time (-□-) and developmental rate (-○-) (from egg eclosion to adult emergence in both cases) of *C. sexmaculata* at five constant temperatures. Vertical bars represent the SE of the mean. Average of 450 larvae at each temperature.

Table 1. Percentage survival to adult stage, and malformed adults in *C. sexmaculata* at five constant temperatures

Temp (°C)	Survival[a] (% ± SE)	Malformed adults[b] (% ± SE)	No. of adults ♂	No. of adults ♀
26	41.7 ± 3.16a	5.3 ± 0.71e	383	555
28	46.8 ± 2.42a	4.5 ± 0.51e	577	476
30	65.7 ± 3.09b	2.4 ± 0.11f	341	1,137
32	56.4 ± 2.31c	22.7 ± 4.58g	432	837
34	6.1 ± 1.42d	44.7 ± 8.58h	74	63

RH, 55–60%. Means followed by the same letter are not significantly different ($\alpha = 0.05$). Average of 25 samples at each temperature.

[a] Overall survival (newly hatched larvae to adult emergence).

[b] Percentage of total number of emerging adults.

Results

There were inverse linear relationships between temperature and adult female longevity (Fig. 1), and temperature and mean developmental time from eclosion to adult emergence (Fig. 2). Adult longevity ranged from 6.5 days at 34°C to 10.3 days at 26°C. Average developmental time from egg eclosion to adult emergence varied from 21.9 days at 26°C to 14.5 days at 34°C.

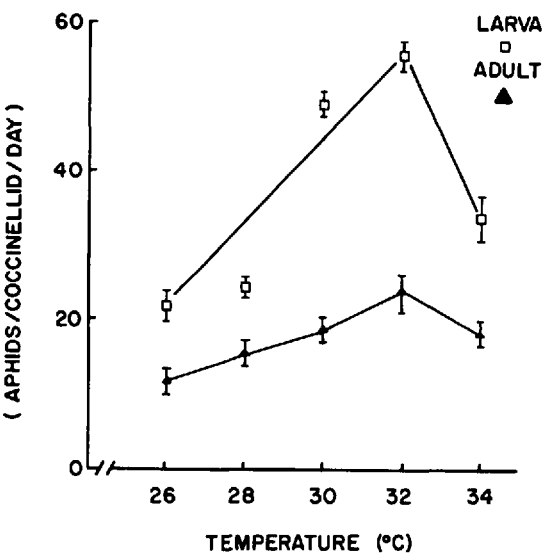

Fig. 3. Influence of temperature on the feeding rates (aphids per coccinellid per day) of larvae and adults of *C. sexmaculata*. Vertical bars represent the SE of the mean.

Table 2. Influence of temperature on fecundity and food consumption of *C. sexmaculata*

Temp (°C)	$\bar{x}$ no. of eggs per ♀ ± SE	$\bar{x}$ no. of aphids consumed per coccinellid ± SE[a]	
		Larvae	Adults
26	347.5 ± 21.9a	323.3 ± 29.1b	121.8 ± 7.3c
28	715.5 ± 37.7b	325.2 ± 16.3b	150.8 ± 6.4e
30	2,611.5 ± 129.8d	614.6 ± 10.2g	174.8 ± 7.3m
32	2,368.5 ± 102.4d	593.3 ± 39.2g	172.2 ± 8.5m
34	356.0 ± 15.1a	329.9 ± 10.4b	119.3 ± 11.4c

RH, 55–60%. Means followed by the same letter are not significantly different ($\alpha = 0.05$).

[a] Aphids consumed by larva and adult during the total duration of the stage.

The percentage of coccinellids surviving to the adult stage ranged from 6.1 at 34°C to 65.7 at 30°C, and the percentage of malformed adults varied from 2.4 at 30°C to 44.7 at 34°C (Table 1). The malformed adults had crinkled elytra that did not lie flat on the abdomen. A majority (>97%) of these adults were infertile and appeared relatively smaller in size than the normal ones.

The feeding rates in both larvae and adults increased linearly with temperature up to 32°C, but then declined by more than 24% (in adults) to 39% (in larvae) at 34°C (Fig. 3). The maximum numbers of aphids per coccinellid consumed by both larvae and adults were at 30 and 32°C, and the minimum at 26 and 34°C (Table 2). The oviposition rate (mean number of eggs per day per female) increased from 33.7 eggs per day at 26°C to 328.9 eggs per day at 32°C (Fig. 1). It then dropped drastically to 54.7 eggs per day at 34°C. The highest number, 2,611.5 eggs per female, was laid at 30°C, and the lowest, 347.5 eggs per female, at 26°C (Table 2).

Discussion

In the present study, a maximum developmental rate of 0.07 per day was observed at 34°C, and a minimum of 0.04 per day at 26°C. Approximately two-thirds of the developmental time was spent in the larval stage and one-third in the pupal stage. The mean developmental time for males was not significantly different from that of females at any of the five experimental temperatures ($P > 0.05$).

According to Bagal & Trehan (1945), the average development time from egg eclosion to adult emergence in field populations of *C. sexmaculata*, fed on a mixture of *Acyrthosiphon pisum* (Harris), *B. brassicae*, and *Siphocoryne indobrassicae* Das, ranged from 18.5 days at 29°C to 26.5 days at 26°C. Highest egg and larval mortality (>95%) was observed at 26°C (Bagal & Trehan 1945), while the hatch rate and the egg viability were lowest (<1%) below 21°C (Modawal 1941). In the present study, the mean development time from egg eclosion to adult emergence was shortest at 34°C. However, at this temperature only a small proportion (6.1%) of the coccinellids was able to reach adulthood, and 44.7% of them were malformed.

Female fecundity, as well as the larval and adult feeding rates, in the present study, were highest at 30–32°C and lowest at 26 and 34°C. The oviposition rate changed in a similar way. Bagal & Trehan (1945) recorded the highest number (2,384 eggs per female) at 29°C, and the lowest (<21 eggs per female) below 25°C. According to Mills (1981), fecundity and growth rates in *Adalia bipunctata* (L.) had a linear dependency on the rate of food consumption, while the maximum feeding rate in *Coccinella trifasciata* Mulsant and *C. californica* Mannerheim was a linear function of the temperature ranging from 15 to 25.5°C (Ives 1981). In the present study, average food consumption in coccinellids increased linearly with temperature from 26 to 30°C, and it was significantly higher in larvae than in adults.

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References Cited

Anonymous. 1985a. SPSS user's guide, 2nd ed., pp. 477–551. SPSS, Chicago, Ill.

1985b. BMD user's guide. Univ. of Pittsburgh, Pa.

Bagal, S. R. & K. R. Trehan. 1945. Life history and bionomics of two predeceous and one mycophagous species of Coccinellidae. J. Bombay Nat. Hist. Soc. 45: 566–575.

Ferran, A. & M. M. Larroque. 1980. Influence des facteurs abiotiques sur la physiologie alimentaire des larvae de la coccinelle aphidiphage, *Semiadalia undecimnotata* Schn. (Col. Coccinellidae). II. Action de la photopériode et de l'humidité relative. Acta Oecol., Oecol. Appl. 1: 215–224.

Ives, P. M. 1981. Feeding and egg production of two species of coccinellids in the laboratory. Can. Entomol. 113: 999–1005.

Matkin, O. A. & P. A. Chandler. 1957. The U.C. system for producing healthy container grown plants. Calif. Agric. Exp. Stn. Man. 23: 1–332.

Mills, N. J. 1981. Some aspects of the rate of increase of a coccinellid. Ecol. Entomol. 6: 293–299.

Modawal, C. N. 1941. A biological note on *Chilomenes sexmaculata* Fabr. Indian J. Entomol. 3: 139–140.

Sharga, U. S. 1948. Biological control of some hemipterous insect pests of crops in India. Curr. Sci. 17: 302–303.

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