# *Trichogramma pretiosum*:[1] Development in Two Hosts in Relation to Constant and Fluctuating Temperatures[2,3]

G. D. BUTLER, JR.[4] AND J. D. LOPEZ[5]

**ABSTRACT**

Ann. Entomol. Soc. Am. 73: 671–673 (1980)

The time of development of *Trichogramma pretiosum* Riley Hym.: (Trichogrammatidae) in *Sitotroga cerealella* (Olivier) (Lep.: Gelechiidae) and *Trichoplusia ni (Hübner) (Lep.: Noctuidae)* eggs was determined at 10 constant and 6 fluctuating temperatures. Development in *S. cerealella* eggs took ca. 1.5 and 0.3 days longer at 17 and 32°C, respectively, than in *T. ni* eggs. At constant temperatures, development times varied from 32 days at 15°C to 6.6 days at 32°C in *T. ni* eggs, but at temperatures >32°C, development times were slightly longer than at 32°C. Development times were similar between tests at constant temperatures and tests at fluctuating temperatures in which average temperatures equalled comparable constant temperatures and maximal temperatures were <32°C. Development times of 3 strains were similar at temperatures between 20 and 30°C. Development required 128.7 heat units above 12.2°C in *S. cerealella* and 131.5 heat units above 11.3°C in *T. ni* eggs.

*Trichogramma pretiosum* Riley is an important naturally occurring egg parasite of *Heliothis* spp. on cotton. Recent progress in mass rearing (Morrison et al. 1978) and in field-release technology (Ables et al. 1979) has greatly increased the practicability of augmentative releases of this parasite for control of *Heliothis* on cotton. In this new technology, knowledge of the developmental age of the immature *Trichogramma* is critical in the production, shipment, programming, and prerelease preparation of the parasites. Temperature is the primary factor available for manipulation to optimize the quality and efficiency of the parasites released in the field. As such, a detailed understanding of the relationship between temperature and development is necessary. Numerous studies have been conducted to determine this relationship in various species of *Trichogramma* (Lund 1934, Stern and Bowen 1963, Stern and Atallah 1965, Bowen and Stern 1966); however, no such information is available for *T. pretiosum*. Therefore, we undertook studies to quantify this relationship under both constant and fluctuating temperatures.

Salt (1940) reported that in *T. evanescens* Westwood, the rate of development is affected by the host upon which the parasites are reared. To explore the possibility that this was the case in *T. pretiosum*, we studied the effect of 2 different hosts, *Sitotroga cerealella* (Olivier) and *Trichoplusia ni* (Hübner), on the rate of parasite development in relation to temperature.

Widespread application of the specialized technology needed for augmentative releases of *Trichogramma* requires knowledge of strain differences in regard to developmental rate. For this reason, and because *T. pretiosum* is available from various commercial and research sources, we also studied the rate of development of different strains of this parasite as affected by temperature. We report here the results of these studies.

## Materials and Methods

Parasitized and nonparasitized *Sitotroga cerealella* (Olivier) egg were received from College Station, TX.[6] From 20 to 40 parasitized eggs from which *T. pretiosum* adults were emerging were put in 50 × 12-mm plastic dishes with a drop of diluted honey on a 5-mm circle of filter paper. After 1 day, 1-$cm^2$ cards with *Sitotroga* eggs or 2-$cm^2$ paper toweling with *T. ni* eggs were placed in the dishes, which were then held in the dark at 25°C for ca. 2 h. The cards and toweling with the eggs were subsequently placed in clean dishes and held at different constant or fluctuating temperatures. At constant temperatures of 17°C or higher, the dishes were examined at 12-h intervals and the number of adult *Trichogramma* counted; at 15°C, dishes were examined at 24-h intervals. Temperature cabinets were modified from household refrigerators or freezers equipped with thermostats that held the temperature to within ± 1°C of that desired. Ten cabinets were held at constant temperatures from 15 to 34°C. Each of 6 additional cabinets had fluctuating temperatures with a gradual change of 16.7°C between maximum and minimum temperatures within a mean range of 13.4–32.3°C. Temperatures were programmed by cams to follow those calculated with the program MACLIM in Stapleton et al. (1974), which estimates mean hourly temperatures from maximal and minimal temperatures. Typical Arizona temperature fluctuations were used for the cams. Vitalite® fluorescent lamps provided a 14-h photophase that began ca. 4 h before the observations were made.

*Trichogramma* adults received from College Station and from 2 commercial insectaries (Rincon-Vitova, Oak View, CA and Biogenesis Inc., Mathis, TX) were used to compare the development rates of different strains in *T. ni* eggs. Eight replicates of dishes of parasitized eggs (20–40 eggs/dish) were held at each of 4 constant temperatures and emergence determined at 24-h intervals. Mean daily emergence and percentage of females emerged were determined for each strain at each temperature.

## Results and Discussion

The duration of the developmental period of male and female *T. pretiosum* at different constant temperatures

[1] Hymenoptera: Trichogrammatidae.

[2] In cooperation with the Ariz. Agric. Exp. Stn. Received for publication June 10, 1980.

[3] Mention of a commercial or proprietary product in this paper does not constitute an endorsement of this product by the USDA.

[4] Research Entomologist, Western Cotton Research Laboratory, Agr. Res., SEA-USDA, Phoenix, AZ.

[5] Research Entomologist, Cotton Insects Research Laboratory, Agr. Res. SEA-USDA, College Station, TX.

[6] We thank R. K. Morrison, Cotton Insects Research Lab., Agric. Res., SEA-USDA, College Station, TX, for providing *T. pretiosum* and *S. cerealella*.

on *Sitotroga* and *Trichoplusia* eggs is given in Table 1. The rate of development increased with temperature from 15 to 32°C; development slowed at temperatures >32°C. Development on *Sitotroga* eggs at temperatures <32°C was slower than on *Trichoplusia* eggs at the same temperatures ($t = 5.66$, $n = 14$, $P = .999$). Development of males and females was simlar in each host species ($T = 0.66$, $n = 18$). Values were determined according to Stinner et al. (1974)[7] for estimating the development rates at temperatures from 15 to 34°C as a sigmoid function in each host with a common optimum temperature (topt) of 32°C

| *Host* | $K_1$ | $K_2$ | $C$ | $R^2$ |
|---|---|---|---|---|
| *Sitotroga* | 4.5168 | −0.1920 | 0.174 | 0.996 |
| *Trichoplusia* | 4.3745 | − .1859 | .182 | .993 |

The duration of the developmental period in *Trichoplusia* eggs at several fluctuating temperatures is given in Table 2. Development at fluctuating temperatures with maximal temperatures below 32°C was similar to that at comparable constant temperatures. As the maximal fluctuating temperature increased above 32°C, development slowed. At the highest temperature tested (40.6°C), survival was zero because the host egg shriveled and died.

Development of the 3 strains of *T. pretiosum* was similar over the 10°C temperature range tested (Table 3). At the higher temperatures, one strain produced more females than the other 2 strains, which could be important because the number of females released in the field is of primary concern.

One might predict development of *T. pretiosum* under different temperatures by the use of heat units (HU). The number of heat units per day or day-degrees is calculated by the substraction of the threshold temperatures from the constant temperature or the average daily temperature. *Trichogramma pretiosum* requires 128.7 HU above a threshold temperature of 12.2°C in *Sitotroga* eggs (or 231 HU above 54°F). Thus, if reared at 30°C, development will take 7.2 days (128.7/(30-12.2)). Development in *Trichoplusia* eggs requires 131.5 HU above 11.3°C (236.7 HU above 52.4°F). Thus, if daily maximal and minimal temperatures for the last 5 days of May in Phoenix are 91–56, 92–61, 91–57, 91–60, and 93–61°F, then the *Trichogramma* will have completed ca. 50% of their development to adults (114.5 HU of the 235.8 needed).

This information can be used when *Trichogramma* have been received by mail for field release. Since the developmental age of the parasites is not known because of the unknown temperature variations during shipment, the parasitized material can be held at 10°C while a small sample is removed, placed at 28°C, and observed for adult emergence. The number of heat units required for the adults to emerge from the sample can be substracted from the total needed for development and the age of the shipment estimated. Then plans can be made for holding the shipment under the proper temperature conditions to program it for field release.

[7] $R_t = C/(1 + e^{k1} + e^{k2\,t'})$, where $R_t$ = rate of development (1/time) at temperature t; C = (maximum developmental rate × ($e^{k1} + {}^{k2}$ topt), i.e., the asymptote; topt = temperature of maximum development rate; $k_1$, $k_2$ = empirical constants $t' = t$, $t \leq$ topt; $t' = 2 \times$ topt $- t$, for $t >$ topt.

**Table 1.—Development of male and female *Trichogramma pretiosum* at indicated constant temperatures in *Sitotroga* and *Trichoplusia* eggs.**

| | *Sitotroga* | | | | *Trichoplusia* | | | |
|---|---|---|---|---|---|---|---|---|
| | Males | | Females | | Males | | Females | |
| Temp (°C) | No. observed | Duration (Mean±SD) | No. observed | Duration (Mean±SD) | No. observed | Duration (Mean±SD) | No. observed | Duration (Mean±SD) |
| 15.0 | | | | | 80 | 32.05±1.61 | 102 | 32.46±1.79 |
| 17.0 | 132 | 25.87±1.79 | 103 | 25.26±1.45 | 281 | 24.13±1.42 | 249 | 23.92±1.16 |
| 20.0 | 617 | 17.93±0.63 | 535 | 18.04±0.58 | 487 | 17.56±0.72 | 608 | 17.71±0.85 |
| 22.5 | 123 | 12.44±0.70 | 144 | 12.50±0.56 | 413 | 11.61±0.58 | 385 | 11.61±0.62 |
| 25.0 | 144 | 9.75±0.51 | 118 | 9.92±0.45 | 468 | 9.17±0.35 | 416 | 9.20±0.37 |
| 27.5 | 123 | 8.27±0.43 | 93 | 8.35±0.46 | 381 | 7.95±0.24 | 266 | 7.95±0.29 |
| 30.0 | 145 | 7.17±0.36 | 116 | 7.16±0.33 | 319 | 6.74±0.38 | 296 | 6.76±0.37 |
| 32.0 | 101 | 7.02±0.19 | 122 | 7.00±0.10 | 212 | 6.70±0.43 | 169 | 6.64±0.46 |
| 33.0 | 324 | 7.06±0.41 | 349 | 7.11±0.44 | 123 | 7.10±0.36 | 106 | 7.17±0.38 |
| 34.0 | 287 | 7.01±0.36 | 324 | 7.11±0.42 | 60 | 7.27±0.46 | 116 | 7.18±0.40 |

**Table 2.—Development of male and female *Trichogramma pretiosum* at indicated fluctuating temperatures in *Trichoplusia* eggs.**

| | | Males | | Females | |
|---|---|---|---|---|---|
| Mean Temp (°C) | Temp Extremes (°C) | No. observed | Duration (Mean±SD) | No. observed | Duration (Mean±SD) |
| 18.4 | 10.0–26.7 | 347 | 17.69±0.46 | 376 | 17.68±0.43 |
| 21.1 | 12.8–29.4 | 709 | 13.43±0.72 | 581 | 13.31±0.64 |
| 23.9 | 15.6–32.2 | 646 | 10.56±0.54 | 612 | 10.63±0.52 |
| 26.7 | 18.3–35.0 | 318 | 9.45±0.59 | 359 | 9.41±0.66 |
| 29.5 | 21.2–37.9 | 172 | 9.34±0.72 | 194 | 9.54±0.81 |
| 32.2 | 23.9–40.6 | no survival | | no survival | |

**Table 3.—Development of 3 strains of *Trichogramma pretiosum* at indicated constant temperatures and percentage of females produced.**

| Temp (°C) | Strain B | | | Strain C | | | Strain V | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. observed | Mean SD | % ♀ | No. observed | Mean SD | % ♀ | No. observed | Mean SD | % ♀ |
| 20 | 191 | 19.51±1.04 | 47 | 311 | 19.55±1.38 | 46 | 824 | 19.47±1.24 | 39 |
| 22.5 | 238 | 12.80±0.78 | 30 | 379 | 12.84±0.81 | 42 | 938 | 13.34±1.14 | 32 |
| 25 | 389 | 10.24±0.80 | 36 | 335 | 10.08±0.71 | 47 | 888 | 10.62±0.92 | 37 |
| 30 | 202 | 7.33±0.54 | 31 | 297 | 7.43±0.63 | 48 | 972 | 7.69±0.68 | 39 |
| Mean | | | 36 | | | 45.8 | | | 36.8 |

## REFERENCES CITED


**Ables, J. R., S. L. Jones, R. K. Morrison, V. S. House, D. L. Bull, L. F. Bouse, and J. B. Carlton. 1979.** New developments in the use of *Trichogramma* to control lepidopteran pests of cotton. Proc. Beltwide Cotton Prod. Res. Conf., Phoenix, AZ. 3 pp.

**Bowen, W. R., and V. M. Stern. 1966.** Effect of temperature on the production of males and sexual mosaics in a uniparental race of *Trichogramma semifumatum* (Hymenoptera:Trichogrammatidae). Ann. Entomol. Soc. Am. 59: 823–34.

**Lund, H. O. 1934.** Some temperature and humidity relations of two races of *Trichogramma minutum* Riley. Ibid. 27: 324–40.

**Morrison, R. K., S. L. Jones, and J. D. Lopez. 1978.** A unified system for the production and preparation of *Trichogramma pretiosum* for field release. Southwest. Entomol. 1: 74–80.

**Salt, G. 1940.** Experimental studies on insect parasitism. VII. The effects of different hosts on the parasite *Trichogramma evanescens* Westwood. Proc. Roy. Entomol. Soc. London (A) 15: 81–95.

**Stapleton, H. N., D. R. Buxton, F. L. Watson, D. J. Nolting, and D. N. Baker. 1974.** Cotton: A computer simulation of cotton growth. Ariz. Agric. Exp. Stn. Tech. Bull. 206.

**Stern, V. M., and W. Bowen. 1963.** Ecological studies of *Trichogramma semifumatum*, with notes on *Apanteles medicaginis*, and their suppression of *Colias eurytheme* in Southern California. Ann. Entomol. Soc. Am. 56: 358–72.

**Stern, V. M., and Y. H. Atallah. 1965.** Ecological studies of *Trichogramma retorridum* and emergence of two *Trichogramma* species from the same host egg. Ibid. 58: 76–81.

**Stinner, R. E., A. P. Gutierrez, and G. D. Butler, Jr. 1974.** An algorithm for temperature-dependent growth rate simulations. Can. Entomol. 106: 519–24.