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**DEVELOPMENT OF CRANBERRY GIRDLER,  
*CHRYSOTEUCHIA TOPIARIA* (LEPIDOPTERA: PYRALIADAE)  
IN RELATION TO TEMPERATURE**

Sherri L. Roberts and Daniel L. Mahr<sup>1</sup>

ABSTRACT

The development of *Chrysoteuchia topiaria* was studied in controlled-temperature chambers. Estimates of the threshold temperatures for the egg, larval, and prepupal-pupal stages were 9.4, 6.8, and 9.8°C, respectively. An overall threshold temperature for egg to adult development was estimated to be 8.8°C. Degree-day summations above thresholds averaged 107, 484, and 388 for the egg, larval, and prepupal-pupal stages, respectively.

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The cranberry girdler, *Chrysoteuchia topiaria* (Zeller), has been reported as a sporadic but important pest on cranberries (Franklin 1950), commercial grass seed (Crawford and Harwood 1959), and Douglas-fir nursery stock (Kamm et al. 1983). Larvae damage cranberries by feeding on and girdling or severing the subterranean vines, resulting in vine death. The larvae live hidden within and beneath the leaf litter under the aerial portions of the vines, making larval monitoring unfeasible. Adult monitoring can be conducted by sticky traps baited with sex pheromone (McDonough and Kamm 1979, Kamm and McDonough 1982).

Degree-day (DD) accumulation can also be used to monitor development of insect populations, but the developmental thresholds of stages monitored must be determined. The effects of temperature on development of diapausing prepupae and developing pupae of *C. topiaria* were studied by Kamm (1973). Kamm and McDonough (1982) used a prepupal developmental threshold of 5.5°C to investigate seasonal flight of *C. topiaria* in grass fields. No indication was given as to how the 5.5°C value was obtained.

Although pheromone traps are commercially available to growers to monitor seasonal adult flight, additional information is necessary for precise timing of chemical control applications. Adult control is impractical because flight activity occurs during cranberry blossom time, when essential pollinators are active. Therefore, current control recommendations are aimed at the early larval instars. Development of seasonality models to predict life stages of *C. topiaria* in commercial cranberry marshes in Wisconsin conceivably can be based on a consideration of heat accumulation data and pheromone trap catches. For a model to be predictive of egg hatch, it must include heat unit data for egg development as well as adult eclosion.

The study reported here was designed to determine thresholds and thermal constants for the development of all life stages of *C. topiaria*.

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METHODS AND MATERIALS

Developmental studies were conducted on individuals reared from eggs laid by field-collected adult *C. topiaria* moths. Moths were collected in Wood County, Wisconsin, from commercial cranberry marshes by sweep-netting on 24 June, 2 July, and 15 July 1982, and taken to the laboratory. Laboratory studies were conducted in the Department of Entomology, Russell Laboratories, University of Wisconsin, Madison.

Ovipositional cages were constructed using kerosene lantern globes and 1-pt (473-ml) cartons. The small mouth of the globe was covered with a cheesecloth square held in place by a rubber band. A #2 filter paper was placed on the inside of the inverted carton lid. A small hole was perforated in the center of the filter-paper-lined lid to receive a stem of cranberry vine. The large mouth of the globe was placed on the carton and twisted into place to form a seal.

Lighting was provided by four 91.4-cm fluorescent tubes located 15 cm above the tops of the globes. Five unsexed field-collected adults were placed in each cage and eggs were collected daily.

Developmental studies were conducted in controlled temperature cabinets programmed at constant temperatures of 12, 16, 21, 24, and 28°C. All experiments were conducted under a 16:8 photophase:scotophase. Each insect was raised at the same constant temperature through all stages of development.

**Egg development.** Egg development was studied at all five constant temperatures. Eggs were removed daily from ovipositional cages and placed on 9-cm discs of moistened filter paper in petri dishes (100 by 15 mm). The filter paper was remoistened as needed. Table 1 lists the number of eggs tested at each temperature. Eggs were checked daily for hatching.

**Larval development.** Newly emerged first-instar larvae were transferred to 30-ml plastic creamer cups provided with a cube of pinto bean diet (Bioserve diet, Bio-mix #9240). Additional diet was provided as needed. The larvae were observed every second day and instar determinations were made by discarded head capsules; any mortality was recorded. Last-instar larvae were provided with peat moss as a substrate for spinning cocoons. Larval development was considered complete when the cocoon was spun. Numbers of larvae tested at each temperature are shown in Table 1.

**Prepupal-Pupal Development.** In preliminary studies, high mortality occurred after cocoons were opened to determine time of pupation. Therefore, development from cocoon formation to adult eclosion ("prepupal-pupal development") was examined. Cocoons within their 30-ml creamers were held in plastic boxes fitted with raised hardware-cloth bottoms; water was added to help prevent desiccation. Developmental rates were studied at 16, 21, 24, and 28°C. Because of 100% larval mortality at 12°C, prepupal-pupal development was not investigated at that temperature. Table 1 lists the number of cocoons at each temperature. The creamers were observed daily and numbers of emerged moths were recorded.

**Calculation of Developmental Thresholds.** The threshold temperatures for development were estimated using the X-intercept and least-variability methods (Arnold 1959). Experiments were observed every 1-2 days and hatching, cocoon spinning, and adult eclosion were recorded. Average days at each stage were then converted to percent development per day and plotted against respective temperatures. An extrapolation of the computed regression line to X-intercept provided an estimation of the temperature at zero rate of development. This temperature is assumed to be the developmental threshold (X-intercept method).

The second method involved calculation of the coefficients of variability over a range of theoretical bases. Degree-day summations for each temperature were calculated at a number of different base temperatures by using the formula

$$DD = y (xt - bt)$$

where DD = degree-day summation, y = development time in days, xt = mean temperature during development, and bt = base temperature. The coefficient of variability was computed with the formula

Table 1. Temperatures in relation to percent survival, average number of days required for development, average developmental rates (percent development per day), and degree days above calculated thresholds required for development of the egg, larval, and prepupal-pupal stages of *Chrysoteuchia topiaria*.

Stage	Avg. temp. (°C)	No. of viable individuals	% survival	Avg. days for development	% development per day	Degree days	
						Least-variable	x-intercept
Egg						(9°C) <sup>a</sup>	(9.4°C) <sup>a</sup>
	12	352	17	37.0	2.7	111.0	96.2
	16	361	96	18.2	5.5	127.7	120.4
	21	417	65	9.6	10.4	114.8	111.0
	24	398	71	6.1	16.5	90.9	88.5
	28	354	80	6.4	15.7	121.0	118.5
Avg.						113.1	106.9
Larval						(7°C) <sup>a</sup>	(7.3°C) <sup>a</sup>
	12	63	—	—	—	—	—
	16	347	15	52.3	1.9	470.9	455.3
	21	273	35	33.8	2.9	472.6	462.5
	24	283	16	27.5	3.6	468.0	459.7
	28	300	6	27.1	3.7	568.3	560.1
Avg.						494.5	484.4
Prepupa-pupa						(8.9°C) <sup>a</sup>	(9.8°C) <sup>a</sup>
	16	54	43	59.0	1.7	418.0	365.9
	21	97	72	38.8	2.6	469.7	434.8
	24	45	71	25.7	3.9	387.9	364.8
	28	17	12	27.5	3.6	—	—
	Avg.						425.2

<sup>a</sup>Calculated developmental thresholds.

$$CV = s100 / xDD$$

where CV = coefficient of variability, s = standard deviation of sample for DD summations, and xDD = mean of degree-day summations above each base temperature. The base closest to the true threshold temperature for development should have the mean with the lowest coefficient of variability (least-variability method).

## RESULTS AND DISCUSSION

**Embryonic Development.** Percent survival at each of the five temperatures is shown in Table 1. These percentages were calculated from the number of viable eggs, not the total number of eggs tested in the experiment. The low survival at 12°C is similar to that reported by Heinrichs and Matheny (1969), who reported only 3% survival at 10°C. At 25 and 15°C, they reported 93 and 67% survival, respectively.

Extrapolation of the regression equation ( $y = -0.0087 + 0.0094X$ ) for egg development vs. constant temperatures indicated an X-intercept developmental threshold of 9.4°C (Fig. 1). The thermal requirement for embryonic development averaged over all constant temperatures with 9.4°C as a base was 106.9 DD. The least-variability analysis gave a similar estimate of the threshold temperature. The mean with the lowest coefficient

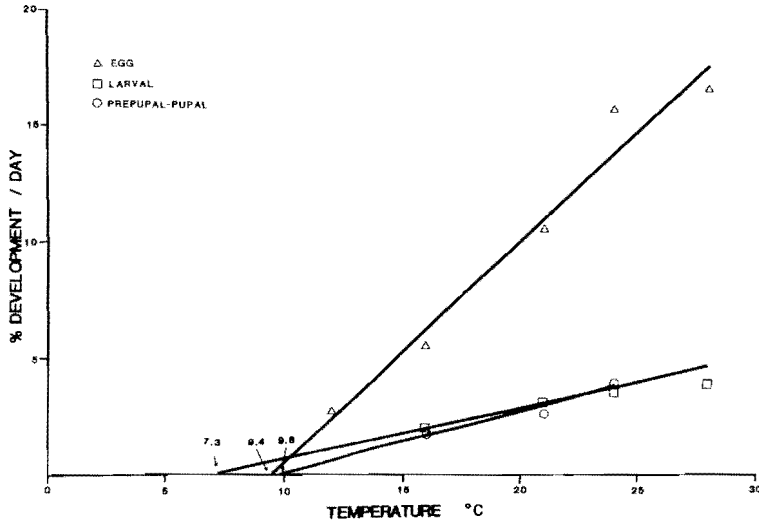


Fig. 1. Developmental threshold temperatures for egg, larval, and prepupal-pupal development of *Chrysoteuchia topiaria*, as determined by the X-intercept method.

of variability (12.33) resulted in a base temperature of 9°C (Fig. 2) and was used to calculate a thermal requirement for development of 113.3 DD. This value was slightly above the 106.9 DD obtained with the X-intercept developmental threshold of 9.4°C.

**Larval Development.** Larval survival at the five temperatures is given in Table 1. High mortality during the first instar at all temperatures resulted from handling of delicate larvae, and from the larvae being caught in the moisture present on the surface of the diet.

Total larval development took an average of 52.3 days at 16°C, 33.8 days at 21°C, 27.5 days at 24°C, and 27.1 days at 28°C (Table 1). The three low temperatures showed a linear increase in developmental rates. This coincides with the linear middle section of a sigmoid developmental velocity curve. At 28°C development took less than one additional day over the time required for development at 24°C.

The X-intercept method, with a linear regression equation of  $y = -0.0153 + 0.0024X$ , yielded a developmental threshold of 7.3°C for the larval stage (Fig. 1). Larval data for instars 6, 7, 8, and 9 were treated together, due to a low number of individuals developing past the sixth instar. A developmental threshold of 7°C was calculated using the least-variable method (Fig. 2). Average degree-day summations were calculated to be 484.4 DD for the X-intercept method and 494.5 DD for the least-variable method.

**Prepupal-Pupal Development.** Survival was 43% at 16°C, 72% at 21°C, 71% at 24°C, and 12% at 28°C (Table 1). At 28°C only two adults eclosed; therefore, the data were not used in calculating threshold temperatures.

Combined prepupal and pupal development took an average of 59.0 days at 16°C, 38.8 days at 21°C, and 25.7 days at 24°C. The X-intercept linear regression equation ( $y = -0.0267 + 0.0027X$ ) resulted in a developmental threshold of 9.8°C (Fig. 1), while least-variable analysis gave a developmental threshold of 8.9°C (Fig. 2). Degree-day summations for the prepupal-pupal stage were 425.2 DD with 8.9°C as a base threshold and 288.5 DD using 9.8°C. These threshold values are significantly higher than the 5.5°C reported for overwintering larvae by Kamm and McDonough (1982).

Developmental thresholds for each stage, egg, larval, and prepupal-pupal, were averaged to obtain a total developmental threshold of 8.8°C for *C. topiaria* and

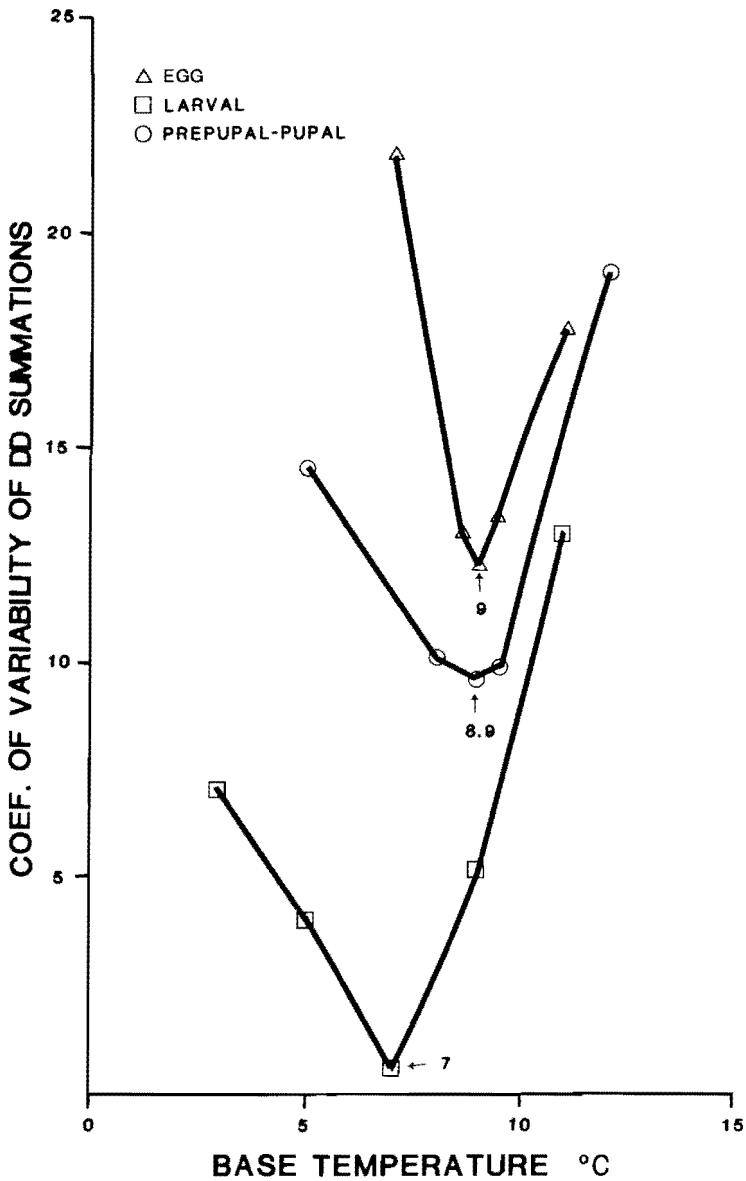


Fig. 2. Developmental threshold temperatures for egg, larval, and prepupal-pupal development of *Chrysoteuchia topiaria*, as determined by the least-variability method.

degree-day summations of 107, 484, and 388 DD, respectively. Total heat units of 979 DD are required for development from oviposition to adult emergence.

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