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Hatching of Sod Webworm[1] Eggs in Relation to Low and High Temperatures[2]

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Abstract
Eggs of 12 species of sod webworm were exposed for various periods to temperatures of 0, 10, and 45°C. Hatchability was compared with control eggs kept at 25°C. Short exposures to any temperature did not significantly affect percent hatch. Prolonged exposure resulted in a significant decrease in hatchability for several species at 0° and for all species at 45°C. There was a significant difference in hatchability between the 3 generations of *Crambus teterrellus* (Zincken) and of *Pediasia trisecta* (Walker) at extreme temperatures. Populations of *Agriphila ruricolella* (Zeller), collected at 2 elevations, differed significantly in hatching percentage and developmental rate.

Sod webworm eggs are deposited in the thatch area of sod where they may be subjected to a wide range of temperatures. Eggs laid in spring and early fall may be exposed to near freezing or subfreezing temperatures at various locations in Tennessee (U.S. Department of Commerce 1969). Temperatures taken at the University of Tennessee indicate grass surface and sod thatch may exceed 45°C for several hours on mid-summer afternoons.

We have studied the effect of low temperatures on eggs of 3 sod webworm species (Heinrichs and Matheny 1969). Investigators working with other species have found that short exposures to low temperatures (Lindsay 1954, Watters 1966) and high temperatures (Guerra and Ouye 1968) did not affect hatch. However, high temperatures for longer durations significantly decreased percent hatch (Guerra and Ouye 1968), but the effect varied among the species tested. Data concerning the effect of high temperatures on sod webworm eggs are not available.

This study was conducted to determine the response to high and low temperatures of eggs from: (1) various Crambinae species, (2) generations of the same species, and (3) populations of the same species collected at different elevations.

Materials and Methods

Eggs of 12 species of sod webworm were obtained from field-collected moths. Females were allowed to oviposit in plastic jelly cups[5] held at room temperature. All eggs were less than 1 day old when tests were begun. There were 3 replicates of each treatment with 10 eggs/replicate. Eggs for each replicate were placed in desiccators and subjected to the following treatments: 0, 10, and 45°C temperatures for durations of 8 hr, 1, 2, and 5 days, and then moved to 25°C to determine if development and hatching would occur. Exposure to the constant 45°C temperature for 1–5 days is ecologically unrealistic. However, this exposure period was purposely used to provide sufficient stress to bring out physiological differences which might occur among species and between populations. High viability at 25°C in previous experiments was the criterion for selecting this temperature as a control. Eggs were examined daily to determine the effect of exposure temperatures on duration of hatch.

Saturated salt solutions (Winston and Bates 1960) were used to maintain desired relative humidities at each temperature in an attempt to keep the water-vapor pressure deficit (saturation deficiency) as small as possible (Table 1); therefore, all eggs were exposed to a similar degree of drying. Earlier workers (Buxton 1931, Evans 1934) noted the importance of expressing humidity in terms of saturation deficit and its role in governing mortality over a wide range of temperatures.

Table 1. Saturated salt solutions used to obtain desired water-vapor-pressure deficit at selected temperatures

Compound g/100 ml H_2O	Temp °C	% RH	Actual water-vapor pressure (mm-Hg)	Water-vapor pressure (mm-Hg) at 100% RH	Water-vapor pressure deficit
39.12 NaCl	0°	75	3.44	4.58	1.14
39.12 NaCl	10°	76.5	7.00	9.21	2.21
56.70 KCl	25°	85	20.20	23.76	3.56
24.10 K_2SO_4	45°	96	69.00	71.88	2.88

Two species, *Crambus teterrellus* and *Pediasia trisecta*, occur simultaneously and throughout most of the summer in Knoxville, Tennessee. Light-trap records (Heinrichs and Matheny 1970) indicated each of these species may have 3 generations/year. The hatchability of these species was compared to determine whether the late spring and early fall generations might be more resistant to colder temperatures and the mid-summer generation more tolerant to heat.

Percent hatch and developmental rate of *Agriphila ruricolella* found in the Appalachian Mountains near Roan Mountain, Tennessee, (elevation 5,600 ft) were compared with *A.*

ruricolella taken from Crossville, Tennessee, (elevation 2,000 ft). Development was determined by the following formula:

$$\begin{array}{c}\text{\% development}\\ \text{each exposure day}\\ \text{in relation to}\\ \text{development at}\\ \text{control (25°)}\end{array} = \frac{\begin{array}{c}\text{Mean days to}\\ \text{hatch at control}\\ \text{(25°)}\end{array} - \begin{array}{c}\text{Mean days to}\\ \text{hatch at control}\\ \text{(25°)}\\ \text{(after exposure)}\end{array}}{\text{No. exposure days}} \times 100$$

Results and Discussion

Species

Table 2 indicates mean hatch of sod webworm species at each temperature (including all durations). Percent hatch at the control temperature (25°C) was 96.7% or above in all species except *Agriphila vulgivagella*, *Microcrambus elegans*, and lst-generation *C. teterrcllus*, which had a percent hatch of 73.3, 83.3, and 90.0, respectively. High temperature (45°C) including all durations resulted in a significant decrease in hatchability for all species. Only *Crambus alboclavellus*, *M. elegans*, and 1st- and 3rd-generation *P. trisecta* hatched significantly less at 0° in comparison with 10 and 25°C temperatures. Thus, for most species of Crambinae whose eggs were studied, few significant differences were observed between percent hatch at 0, 10, and 25°C.

Table 2. Mean percent hatch (including all durations) of Crambinae species at various temperatures[a]

Species	Control temperature (25°C)	Exposure temperatures (0°C)	(10°C)	(45°C)
Crambus albaclavellus Zeller	96.7 abed	75.8 ghi	98.3 ab	38.3 klmno
C. laqucatellus Clemens	100.0 a	95.0 abcd	99.2 ab	49.2 jkl
C. teterrellus (Zincken) 1st generation	90.0 abcde	85.0 cdefgh	84.2 defgh	30.8 no
C. teterrellus 2nd generation	100.0 a	95.0 abcd	98.3 ab	50.8 j
C. *teterrellus* 3rd generation	100.0 a	99.2 ab	100.0 a	50.0 jk
C. praefectellus (Zincken)	100.0 a	95.8 abcd	95.0 abcd	33.3 mno
C. pascuellus floridus Zeller	96.7 abcd	86.7 bcdefg	90.8 abcde	37.5 lmno
Pediasia trisecta (Walker) 1st generation	100.0 a	76.7 fghi	100.0 a	30.0 no
P. trisecta 2nd generation	100.0 a	88.3 abedef	95.8 abcd	36.7 mno
P. trisecta 3rd generation	100.0 a	73.3 hi	97.5 abc	29.2 no
P. mutabilis (Clemens)	96.7 abcd	89.2 abcde	92.5 abcde	40.0 jklmn
P. caliginosella (Clemens)	100.0 a	90.0 abcde	95.0 abcd	38.3 klmno
Microcrambus elegans (Clemens)	83.3 efgh	13.3 p	80.8 efghi	26.7 o
Agriphila ruricolella (Zeller) Roan Mt.	96.7 abcd	90.0 abcde	88.3 abcdef	30.0 no
A. ruricolella Crossville	96.7 abcd	87.5 abcdefg	91.7 abcde	50.8 j
A. vulgivagclla (Clemens)	73.3 hi	69.2 i	71.7 i	45.0 jklm
Chrysoteuchia topiaria (Zeller)	96.7 abcd	96.7 abcd	95.8 abcd	39.2 jklmn

[a]Means followed by the same letter do not differ significantly at the 0.01% level of probability.

Figure 1 shows total mean hatch for all species at all temperature and duration levels. Durations of 8 hr (at all temperatures) did not significantly affect hatch. Increasing the exposure time, however, resulted in a sharp reduction in hatchability at 45°C, the total hatch at 1, 2, and 5 days being 60.0, 2.6, and 0.2%, respectively. Most eggs completely shriveled and collapsed after 2 days at 45°C; only a single *Pediasia caliginosella* larva hatched after 5 days' exposure to this temperature. It appeared physically deformed and died shortly after being placed on a meridic diet.

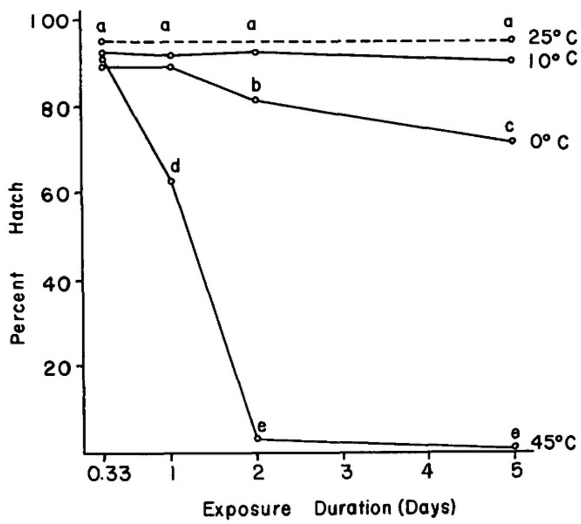

Figure 1. Total mean hatch for all species at all temperature and duration levels. (All points below the same letter do not differ significantly at the 0.01% level of probability.)

Prolonged exposure to 0°C temperatures (2 and 5 days) also resulted in significantly lower hatch than did the 10 and 25°C treatments (Fig. 1). There is a slight but nonsignificant decrease in egg hatch after 5 days' exposure to 10°C. We (Heinrichs and Matheny 1969) have shown that longer exposure (30 days) at 10°C significantly lowered the hatch of sod webworm eggs.

Generations

The 3 generations of *C. teterrellus* and *P. trisecta* did not differ significantly in percent hatch at 25°C (Table 2). At 0 and 10°C, lst-generation *C. teterrellus* had lower hatch than did succeeding generations. *P. trisecta* (1st and 3rd generations) had significantly lower hatch at 0° than at 10°C. Thus, these spring and fall generations are apparently no more cold tolerant than the 2nd (midsummer) generation.

According to Dr. A. B. Klots of the American Museum of Natural History in New York (personal communication), *C. teterrellus* is of neotropical origin whereas *P. trisecta* is essentially Boreal and closely related to Palearctic species. Therefore, it would be expected that *P. trisecta* eggs might be more resistant to cooler temperatures; but in this study, *C. teterrellus* eggs had better percent hatch at low temperatures than those of *P. trisecta*. Hatching percentage at 45°C indicated that *C. teterrellus* is also more heat tolerant than *P. trisecta*. Thus, eggs of *C. teterrellus* can withstand a wider range of temperatures at a similar saturation deficit.

Populations

Populations of Roan Mountain and Crossville *A. ruricolella* differed significantly in hatching percentage at 45°C; the latter having a higher percentage hatch (Table 2). Significant differences in hatchability between the 2 populations did not occur at low temperatures. However, there was a significant difference in the effect of low temperature on developmental rate (Table 3). At 0 and 10°C, daily development of Roan Mountain eggs ranged from 4 to 50% of that of the control (25°). Development of Crossville eggs ranged from 0 to –35% of that of the control. In all except 1 treatment (10° for 5 days) Crossville eggs exposed to low temperatures required more developmental days before hatching, after moving to 25°C, than those placed directly in 25° (control). Thus, development of Roan Mountain eggs was less severely affected by low temperatures. These eggs are, therefore, apparently more tolerant to low temperatures than eggs from Crossville moths.

Table 3. Mean days to hatch and daily percent development[a] for *A. ruricolella* eggs after exposure to various temperature and duration levels

Location	Mean days to hatch at control (25°)	Exposure temp °C	Exposure duration (days)	Mean days to hatch at 25° after exposure period	% development[b] per exposure days in relation to control (25°)
Roan Mountain	11.0	0	1	10.5	+ 50 a
			2	10.5	+ 25 abc
			5	10.8	+ 4 bcd
		10	1	10.7	+ 30 ab
			2	10.5	+ 25 abc
			5	9.5	+ 30 ab
		45	1	13.3	– 230 f
Crossville	10.5	0	1	10.8	– 30 d
			2	11.2	– 35 d
			5	10.7	– 4 bcd
		10	1	10.7	– 20 cd
			2	10.7	– 10 bcd
			5	10.5	0 bcd
		45	1	12.0	– 150 e
			2	13.0	– 125 e

[a]Means followed by same letter do not differ significantly at the 0.01% level of probability. Data transformed to (x + 300).

[b] + = development during exposure period; – = development delayed after return to control (25°) temperature; 0 = no development during exposure period

Development of Roan Mountain eggs was more severely affected by the 45° temperature than the development of Crossville eggs. After exposure to 45° for 1 day, development of Roan Mountain eggs was delayed 2.3 days, while development of Crossville eggs was delayed 1.5 days. In addition, no Roan Mountain eggs hatched after 2 days' exposure, while some of the Crossville eggs did hatch.

This study indicates that eggs of the 2 populations of *A. ruricolella* exhibit physiological differences in their response to extreme temperatures. In recent communication, Dr. A. B. Klots indicated that the adults of the 2 populations exhibit morphological differences and that they may be taxonomically distinct.

Notes

1. Lepidoptera: Pyralidae: Crambinae
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