Reproductive Potential and Development of Rose Leafhopper, *Edwardsiana rosae* (L.) (Homoptera: Cicadellidae), at Constant Temperatures on Apple[1]

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ABSTRACT Reproductive potential and developmental rates for rose leafhopper, *Edwardsiana rosae* (L.), were determined in a constant-temperature study at 13, 17, 23, and 30°C. Developmental rate was faster at progressively higher temperatures, except at 30°C, where there was no egg hatch. Developmental rate was faster for males than for females at each temperature. Regression equations yielded an estimate of 7°C as the temperature threshold for development. The largest number of progeny was produced at the lowest temperature, and survival decreased with increasing temperature. Body length and head capsule width of the five nymphal instars and adult stages of rose leafhopper did not vary among temperatures or between male and female.

Key Words *Edwardsiana rosae,* rose leafhopper, apple, development

The rose leafhopper, *Edwardsiana rosae* (L.), is a common leafhopper found in apple orchards in eastern West Virginia. Adults and nymphs are mesophyll feeders, both feeding on the underside of apple leaves. This produces a white to yellowish stippling visible on the upper leaf surface. Spotting or speckling of fruit from leafhopper excrement is difficult to remove once dry and decreases aesthetic and economic quality for fresh market. When leafhoppers are present in high numbers, they can be annoying to pickers. Day et al. (1995) reported on the biology and management of rose leafhopper on apple in West Virginia.

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Constant-temperature studies have not been conducted on rose leafhopper, but there have been several studies on related species. Childs (1918) reported developmental rates for rose leafhopper at outdoor temperatures. Simonet and Pienkowski (1980) reared newly-hatched potato leafhopper nymphs, *Empoasca fabae* Harris, at six constant temperatures. A developmental study by Hogg (1985) with potato leafhopper simulated field conditions by using three fluctuating temperature regimes, and Sher and Shields (1991) expanded this study with a lower range of fluctuating temperatures. Knight et al. (1991) studied a constant-temperature development of first-generation nymphal stages of white apple leafhopper, *Typhlocyba pomaria* McAtee, using five temperatures.

The objective of this study was to determine rates of development at constant temperatures so that phenological models might subsequently be developed to predict optimal timing of control methods against rose leafhopper.

Materials and Methods

Newly-emerged adults, as determined from daily observations, were collected from cultivated thornless blackberry, *Rubus* sp., plants at the USDA Appalachian Fruit Research Station in Kearneysville, WV in early June 1993. One female and several males were placed on each of 32 caged, potted 'Golden Delicious' apple seedlings that were placed into environmental chambers, eight per temperature, at 13, 17, 23 or 30°C (±1°C) with a photoperiod of 16:8 (L:D) h. Seedlings were monitored every 2 or 3 days beginning with the second week for newly-hatched nymphs; the total number produced by each female was recorded.

As the nymphs emerged, they were removed from the seedlings with a fine camel hair brush and placed individually on apple leaves in shell vials with the petiole of the leaf protruding slightly. A small piece of damp cotton was placed over each petiole to keep the leaf moist and to prevent the nymph from escaping. Each vial was sequentially lettered when the nymph was removed from the tree and placed in a plastic 10 × 10 cm container, numbered the same as the tree from which the nymph was removed. Every other day, each leaf with a nymph was removed from its vial and placed in a Petri dish for microscopic examination. Head capsule width and body length of each nymph were measured with a StereoZoom® microscope (Bausch & Lomb, Rochester, NY) fitted with an eyepiece micrometer, and the leaf was examined for exuviae. Nymphs were transferred to fresh apple leaves every other day. Sex was determined when the nymph molted to an adult. The time in each stadium and total time to reach the adult stage were recorded for each nymph at each temperature. Regressions for growth rate (Wigglesworth 1972) from egg hatch to adult eclosion were calculated using the mean developmental period for males and females at each temperature, while standard errors were calculated for each leafhopper at each temperature separately.

Results and Discussion

Developmental rate for rose leafhopper varied as a function of temperature. Incubation periods for the eggs lessened as temperatures increased. Egg hatch occurred after adults were caged for 6 wks at 13°C, 5 wks at 17°C, and 2 wks at 23°C. No egg hatch was observed at 30°C.

The mean duration (days) to reach the adult stage was shorter for males than for females at each temperature (Table 1). On average, an increase of 4°C (13 to 17°C) reduced developmental time by half, whereas an increase of 10°C (13 to 23°C) reduced developmental time by two-thirds. Fewer days were required for each stadium as temperatures increased, and the fifth stadium required a longer developmental period than each of the earlier stadia.

Table 1. Duration (days) of rose leafhopper development from egg hatch to adult at three temperatures.

	Male		Female	
Temperature (°C)	Mean (SEM)	No.	Mean (SEM)	No.
13	45.2 (3.03)	22	48.8 (3.50)	30
17	22.8 (1.93)	10	25.6 (0.89)	5
23	15.9 (1.60)	56	17.8 (1.47)	5

The growth rate (Fig. 1) for males was significantly faster than for females at each temperature (as determined by 95% confidence intervals). Extending the regression lines to a growth rate of 0 provides a rough estimate of 7°C as the temperature threshold for development for both male and female. This is only an initial estimate, and more research at temperatures lower than we studied needs to be conducted to determine the actual threshold temperature.

The total number of progeny per female on caged apple seedlings averaged 33.20 ± 12.19 at 13°C, 10.30 ± 8.08 at 17°C, and 17.86 ± 5.69 at 23°C. Although 13°C produced the largest number of progeny, it also resulted in the highest nymphal mortality (68%); mortality at 17°C and 23°C was 51% and 22%, respectively.

Rose leafhopper body length increased almost 4-fold from first instar to adult (Table 2). The ratios of growth for body length averaged 1.31 for each instar, including imago. However, head capsule growth was at a constant increment of 0.1 mm for each instar until the imago which was the same width as the fifth instar. Growth in body length approximated Dyar's Rule (Wigglesworth 1972),

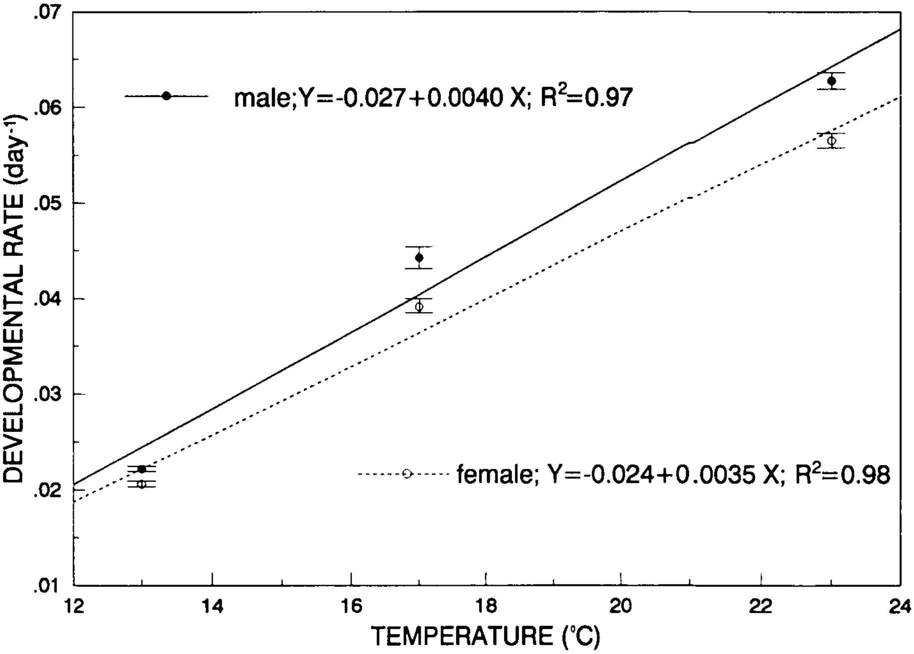

Fig. 1. Developmental rate (mean and SE) as a function of temperature for male and female nymphs of rose leafhopper.

Table 2. Body length and head capsule width of developmental stages of rose leafhopper.

	Body Length (mm) (n = 163)		Head Capsule Width (mm) (n = 163)	
Stadium	Mean (SEM)	Ratio	Mean (SEM)	Ratio
1st	0.8 (0.07)		0.1 (0.01)	
		1.38		2.00
2nd	1.1 (0.08)		0.2 (0.01)	
		1.36		1.50
3rd	1.5 (0.10)		0.3 (0.01)	
		1.33		1.33
4th	2.0 (0.12)		0.4 (0.01)	
		1.25		1.25
5th	2.5 (0.10)		0.5 (0.01)	
		1.24		1.00
Adult	3.1 (0.11)		0.5 (0.01)	

but head capsule growth did not. The relatively constant ratio in body length indicates that no instars were missed and that rose leafhopper has five nymphal instars. Temperature did not affect body length and head capsule width during any stadium for males or females.

Egg developmental time for rose leafhopper decreased with increasing temperatures similar to the findings of Simonet and Pienkowski (1980), Hogg (1985), Knight et al. (1991), and Sher and Shields (1991). A temperature of 30°C may have been to warm for egg development. Simonet and Pienkowski (1980) did not obtain egg hatch for potato leafhoppers at 32°C. They also observed a high nymphal mortality rate at 13°C, similar to our findings.

Temperature may have influenced oviposition (Hogg 1985), thus having some effect on number of progeny produced. It is probable that the number of progeny produced in captivity by each female was lower than normal field oviposition because females may have laid some eggs before collection.

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