Field Evaluation of Thermal Models to Predict Blackheaded Fireworm Egg Hatch

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Blackheaded fireworm remains a major pest in many of the cranberry growing regions in the United States and Canada. In both annual generations, adults and larvae can be monitored in an IPM program, but the very young larvae are difficult to detect. Since these larvae are the desired targets, a model of egg hatch would be useful to anticipate the optimum time of control measures.

Rose Kachadoorian and Daniel Mahr have developed models for the hatch of over-wintering and summer generations based on laboratory studies. The purpose of this paper is to evaluate the linear degree-day models with field data. Specifically, the objectives are (1) to determine what information can be gathered in a commercial cranberry marsh for the model, and (2) to evaluate the degree-day models for both generations.

Overwintering Eggs

As cranberry marshes are flooded to protect the plants from desiccation, flooding alters the environment for overwintering eggs as well. To understand the environment surrounding over-wintering eggs, temperature was monitored in a marsh from the time of egg laying until the end of hatch. Daily maximum and minimum air or water temperatures were recorded, depending on which matched the environment of the eggs. By scientific convention, all measurements in this and other experiments were made in degrees Celsius. Values in degrees Celsius and their equivalents in degrees Fahrenheit are presented at the end of the text (Appendix A).

Judging from the stability of the temperatures measured during the winter (Fig. 1), ice protects eggs from exposure to extreme cold or untimely warmth. In spring when the ice melts, eggs are exposed to air temperatures suitable for development. The date when all the melted ice is drained, what can be called the Water Free Date, becomes a logical time to begin measurement of air temperatures for a hatch model. If the marsh is reflooded, that period of reflood is disregarded in degree-day calculations.

We monitored egg hatch for the overwintering generation at four commercial cranberry marshes in 1990. After the flood was removed, 30 to 100 eggs were located and daily maximum and minimum sheltered air temperatures were recorded near the eggs. Eggs were checked approximately three times per week until all had either hatched or desiccated.

Because of differences in management and climate between sites, the distribution of hatching was unique in each marsh (Fig. 2). On all marshes, hatching lasted for many weeks.

A linear model for hatch of overwintering eggs generated from laboratory results predicted the date of 50% hatch. Degreedays were computed with the sine wave method using a lower threshold of 10°C (50°F) and an upper threshold of 31°C (88°F)

In general, the actual date of 50% hatch occurred much sooner than the predicted date of hatch (Table 1). Probably the low temperatures during the spring fell within the area of poorest fit for a degree-day model. Also, simply indicating a date of hatch is not useful for an activity completed over several weeks. A non-linear distribution model based on laboratory results may fit the data better.

As an alternative to laboratory-generated models, a model of the distribution of hatching can be constructed directly from field data. Such a model was constructed and is presented with the data (Fig. 3). In the future, we will test if this alternative model is a better predictor than the laboratory model has shown to be.

Summer Eggs

To evaluate the summer model, we established groups of eggs to sample. Egg-laying moths were caged over uninfested cranberry vines for 24 hours. Three groups of eggs were started a week apart, then 30 to 100 eggs from each group were located and monitored as in the other experiment.

In the summer generation, hatch occurred within a few days because of the warm temperatures (Fig. 4). There were differences in time of hatch for the three groups of eggs because of differences in temperature between the three weeks.

We evaluated the linear degree-day model for summer eggs by comparing the predicted date of hatch to the date of 50% hatch. The summer egg model had a base temperature of 8°C (47°F), an upper threshold of 31°C (88°F), and required 79 Celsius Degreedays (174 Fahrenheit Degree-days) until hatch. There was a small deviation from the predicted date of hatch and the date of 50% hatch (Table 2). On average, the deviation was one day, which means the model is as reliable as possible.

Conclusions

The maximum and minimum daily temperatures after the water is removed in the spring are the most practical measurements to use in a model of egg hatch. A laboratory model for summer egg hatch works very well. Practical application of the summer model will depend on a companion model that correlates egg laying and pheromone trap catches. A field-generated model for hatch of over-wintering eggs will be evaluated in 1991 in Wisconsin and other cranberry growing regions.

Acknowledgments

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Appendix A. Temperatures in degrees Celsius and their equivalents in degrees Fahrenheit.

Degrees C	Degrees F	Degrees C	Degrees F
-20	-4	5	41
-15	5	10	50
-10	14	15	59
-5	23	20	69
0	32	25	77
		30	86

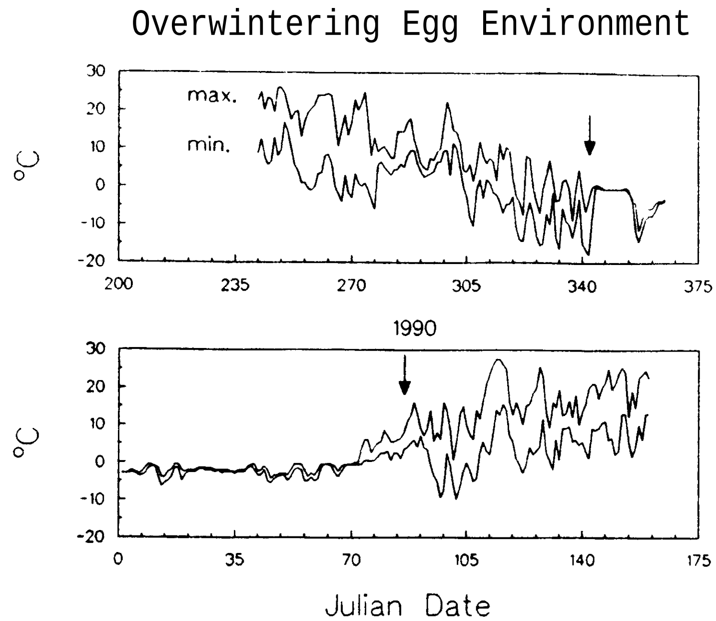

Figure 1. Daily maximum and minimum air or water temperatures in a cranberry marsh when overwintering blackheaded fireworm eggs are present. Julian dates are the order of days in a year starting with January 1. Arrows indicate the start of winter flood and removal of flood.

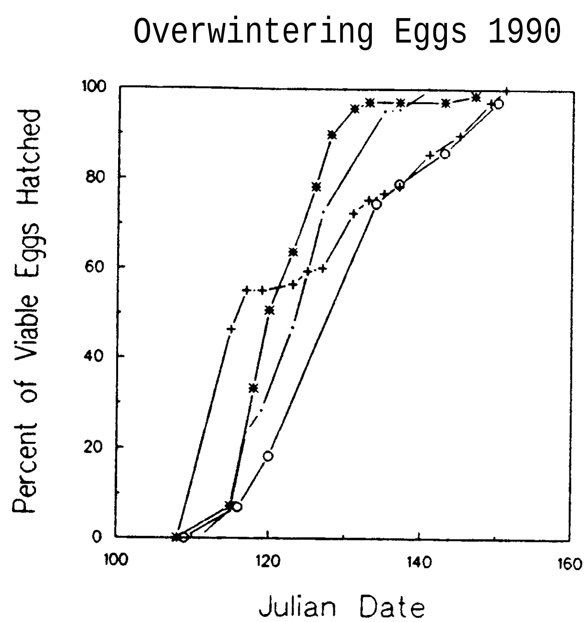

Figure 2. Percent hatch of overwintering eggs at four marshes in 1990. Data for each marsh is represented by a different symbol. Julian date 110 is April 20, 120 is April 30, 130 is May 10, and 140 is May 20.

Table 1.

Comparison of date of 50% hatch for four overwintering cohorts and predicted date of mean hatch.

Site	Date of 50% hatch[1]	Predicted hatch date[2]	Deviation (days)
Monroe co.	4 May	8 May	4
Wood co.	26 April	25 May	29
Portage co.	30 April	14 May	14
Rusk co.	8 May	23 May	15
Mean			15.5

1 Estimated by extrapolation.
2 Degree-day model, Kachadoorian and Mahr.

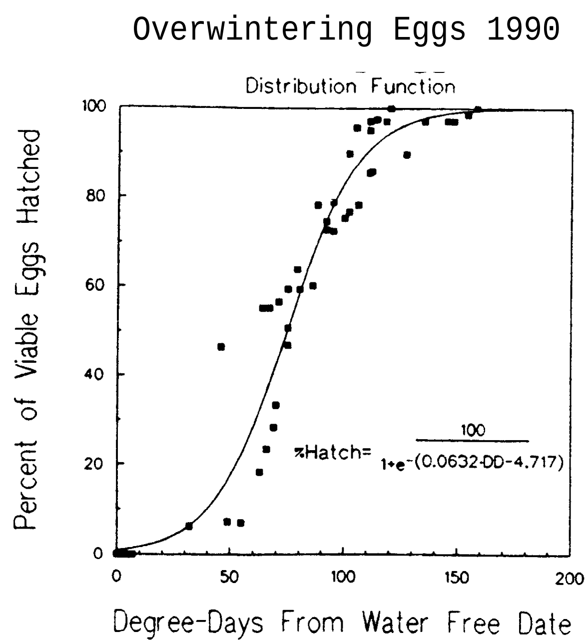

Figure 3. Alternative model for hatch of overwintering eggs generated from field data. The equation is an s-shaped curve, which approximates the measurements of egg hatch represented by squares. Degree-days are in degrees Celsius and are calculated the same as the laboratory-generated model.

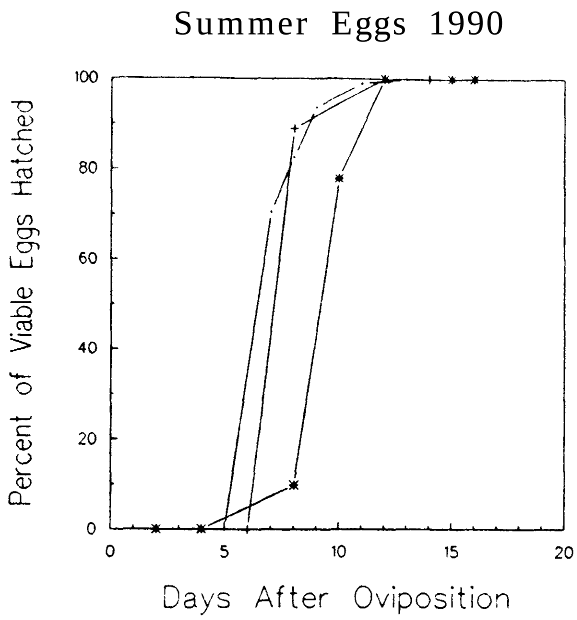

Figure 4. Percent hatch of summer eggs starting from the day of oviposition. Three groups of eggs are represented by different symbols.

Table 2.

Comparison of date of 50% hatch for three summer cohorts and predicted date of mean hatch.

Oviposition date	Date of 50% hatch [1]	Predicted hatch date [2]	Deviation (days)
28 June	4 July	3 July	1
6 July	13 July	13 July	0
10 July	19 July	17 July	2
Mean			1

[1] Estimated by extrapolation.

[2] Degree-day model, Kachadoorian and Mahr.