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PREDICTION MODELS FOR FLIGHT ACTIVITY OF THE CRANBERRY GIRDLER (LEPIDOPTERA: PYRALIDAE) IN WISCONSIN

Stephen D. Cockfield and Daniel L. Mahr[1]

ABSTRACT

Cranberry girdler, *Chrysoteuchia topiaria*, was monitored with pheromone traps in Wisconsin cranberry farms. Cumulative 50% capture was related to degree-days after first catch using air or soil temperature. An air temperature of 0°C and soil temperature of 2°C were chosen as base temperatures for calculation of degree-days because they yielded estimates with the lowest coefficients of variation. Weibull functions were fitted to the relationship between cumulative percent capture and time or degree-days after first trap catch using air or soil temperatures. The models that predicted the date of 50% capture were evaluated with data from two other farms. Degree-days after first catch using soil temperatures predicted 50% catch with less variability than calendar date or degree-days after thaw of ice, but not significantly less variability than days after first catch or degree-days after first catch using air temperatures.

The larvae of cranberry girdler *Chrysoteuchia topiaria* (Zeller) (Lepidoptera: Pyralidae) feed on many cultivated plants such as turfgrass (Tashiro 1987), lawn grass grown for seed production, conifer seedlings, and cranberries (Kamm et al. 1990). In cranberries, larvae feed on underground runners, eventually causing death of the plants. Outbreaks of cranberry girdler occur infrequently, but when one does occur, the insects can kill large patches of vines that take years to rejuvenate (Eck 1990). Control measures are directed at the young larvae before they cause significant damage. Pheromone traps are used to monitor adult male emergence (Kamm and McDonough 1982, Kamm et al. 1990), and insecticides or biological control products are applied soon after peak flight to coincide with egg hatch (Roberts and Mahr 1986, Kamm et al. 1990). In Wisconsin, one application of soil insecticide is recommended 3 to 4 weeks after peak flight (Mahr et al. 1993).

The time of peak catch of cranberry girdler in Washington has been correlated with annual degree-days (DD) above 5.5°C (Kamm & McDonough 1982). This prediction method has been satisfactory for control of the cranberry girdler on cranberries on the Pacific Northwest coast (Kamm et al. 1990), but has not been evaluated in other cranberry-growing areas. Also, the Washington DD prediction method does not predict events other than peak catch and does not indicate how much of the total catch has occurred. It would be helpful to predict the entire flight activity because of its long duration of up to 8 wks (Kamm et al. 1990). Such predictions could supplement pheromone trap data and allow growers to plan the timing of control measures in advance. The

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purpose of this investigation is to establish and evaluate a method of forecasting pheromone trap catches for use in pest management programs in Wisconsin cranberry farms.

METHODS AND MATERIALS

Flight activity of male cranberry girdler moths was monitored in 1990–1992 on a cranberry farm in Warrens, WI. Data from this site were used to develop additional prediction methods besides the DD method developed in Washington (Kamm and McDonough 1982). At the same time, two other farms, one near Warrens and one near Wisconsin Rapids, were monitored and the data were used to evaluate all the prediction methods. These sites were typical commercial farms and received one or two insecticide applications per year for insect pests other than cranberry girdler. None of the sites had outbreaks of cranberry girdler that needed control. In one bed on each site, three Pherocon II traps were baited with commercial pheromone (Trece, Salinas, CA), and hung just above the cranberry foliage, spaced about 30 m apart, 2 m from the edge of the bed. Starting in mid to late May, traps were checked every 2 or 3 d until first catch, then weekly until beds were flooded in autumn. Lures were changed every 2 wks and traps were replaced weekly or every two weeks. First catch was estimated as midway between sample dates. The cumulative number of males caught during the flight period was calculated, then cumulative weekly catches were expressed as percentage of total caught. The date of 50% of accumulated catch was estimated by linear interpolation from nearest data points. Peak catch is not as clear to determine to the nearest day, but when necessary, peak catch was estimated to have occurred midway between sample dates during the week of greatest catch.

Daily maximum and minimum ambient temperatures were measured in white, ventilated shelters placed 0.5–0.75 m above ground on the edge of a dike next to each bed where traps were monitored. A thermistor recorded soil temperatures in each bed at a depth of 4 cm.

The Washington method of calculating DD was modified for Wisconsin conditions before predicting peak catch. Growers in Wisconsin protect plants during the winter by flooding the beds and covering the vines with ice, whereas those in Washington leave the vines exposed. The earliest logical time to begin accumulating DD in Wisconsin is the first day in spring that the ice is completely melted and foliage is exposed to the air, usually by early April. The original Washington model begins accumulating DD at the start of the year. Alternative prediction methods were sought using the date of first catch as a starting point, or 'biofix' (e.g., Riedl et al. 1976) to begin calculations . We looked for the one most accurate, yet convenient. Three predictor variables were evaluated: the mean number of days from first catch, the mean DD from first catch calculated with air temperatures, and the mean DD from first catch calculated with soil temperatures. Degree-days to 50% catch were computed using ten estimates for base temperature. The base temperature yielding DD with the lowest coefficient of variation (CV) was chosen as best (Arnold 1960). Degree-days were calculated by a sine wave function from daily maximum and minimum temperatures (Arnold 1960, Allen 1976, Higley et al. 1986).

The relationship between accumulation of males in traps and accumulated days or degree-days was fitted to a Weibull function, a method used to represent the distribution of insects completing a developmental stage over physiological time (Wagner et al. 1984):

$$f(x) = 100(1 - e^{-(x/a)^b})$$

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Table 1. Parameter estimates of the Weibull function fit to cumulative percentage of cranberry girdlers trapped and three independent variables after biofix.

Independent variable	Parameter[a]	Estimate	Asymptotic SE	Asymptotic 95% CI
days	a	28.74	1.02	26.65–30.83
	b	1.91	0.19	1.53–2.29
air DD	a	561.8	13.4	534.4–589.1
	b	2.07	0.15	1.78–2.37
soil DD	a	501.2	10.2	480.4–521.9
	b	2.08	0.12	1.83–2.33

[a]Parameters a and b in the following equation: $Y = 100(1-e^{-(x/a)^b})$.

where x = accumulated days or DD from first catch, and a and b are parameters that determine the breadth and skewness of the distribution. Parameters were estimated using nonlinear least squares regression (SAS Institute 1988).

Data sets from other farms were used to evaluate the prediction methods. The difference between the predicted date of 50% or peak catch and the observed date was calculated for each data set, then the standard deviations and variances of the differences were calculated. The prediction method with the lowest variance was judged best. Two variances were determined to be significantly different by an *F*-test of their ratio (Walpole and Myers 1978).

RESULTS

At the first site in Warrens, the mean Julian date of 50% catch was 178. A mean of 23 days elapsed from the date of first catch to the date of 50% catch (Table 1). In a model that used soil temperatures to calculate DD, the base temperature yielding predictions with the lowest CV was 2°C. With that base temperature, a mean of 431 DD accumulated between first catch and 50% catch. In a model that used air temperatures, the base temperature yielding the lowest CV was 0°C and a mean of 477 DD accumulated between first and 50% catch.

Few cranberry girdlers were trapped at the second site in Warrens in 1990, so only five data sets were used for evaluation. The mean calendar date for predicting 50% catch was the least accurate method. The mean error was -5.5 d (range = -15 to +5 d, σ = 78.4 d). The soil temperature model was apparently the most accurate, with a mean error of +0.6 d (range = -1 to +5 d, σ = 6.3 d). The variance associated with the mean calendar date was significantly higher than the variance associated with the soil temperature model (F = 11.9; df = 4,4; P > 0.05). The modified Washington model (Kamm and McDonough 1982) predicted the time of peak catch within a mean error of +6 d (range = -1 to +5, σ = 40.6 d). The variance of the errors was also significantly higher than that of the soil temperature model (F = 4.3; df = 4,4; P > 0.05). The model that used air temperatures was not significantly less accurate than the one that used soil temperatures. That model was in error by a mean of 0.02 d (range = -2 to +5, σ = 8.5). The simplest model, the one that used time and not temperature, was in error by a mean of -0.6 d (range = -5 to +5, σ = 19.3 d). It also was not significantly less accurate than the soil temperature model.

A Weibull function depicted the sigmoid shape and positive skewness of the percentage of males trapped as a function of soil DD (Fig. 1). The function depicted the trends for the sprayed marshes as well (Fig. 2). Because soil

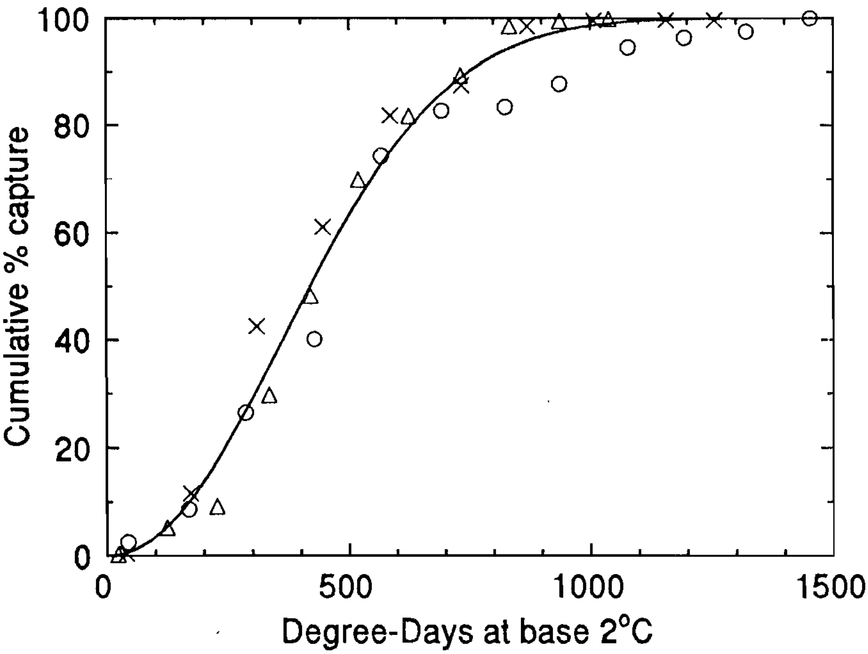

Figure 1. Plot of raw data and fitted model (curve) for the cumulative percent capture of male *Chrysoteuchia topiaria* as a function of soil degree-days, base 2°C, after first catch. Data are from an unsprayed cranberry marsh in Warrens, WI during (○) 1990, (×) 1991, and (Δ) 1992.

temperatures are not often measured on farms, parameter estimates are presented for functions of two other independent variables: time and air DD (Table 1).

DISCUSSION

Consultants and growers can predict pheromone trap catches in a number of ways. On farms where flight is monitored and first catch can be determined, the most convenient method is to predict trap catch far in advance by using the time elapsed after first catch. Then, if air or soil temperatures are available, they can be used to predict catch up to the current date, to supplement the data from the pheromone traps.

The base temperatures of 0 and 2°C do not match any developmental threshold of a stage of cranberry girdler reported by Roberts and Mahr (1986), which ranged from 6.8 to 9.8°C. The DD methods used here are empirical correlations based on field data and may not relate directly to experimentally-derived developmental thresholds or rates. These methods do, however, provide reliable predictions of flight activity in the field in Wisconsin (Fig. 2).

The relationship between flight activity, oviposition, and hatch needs to

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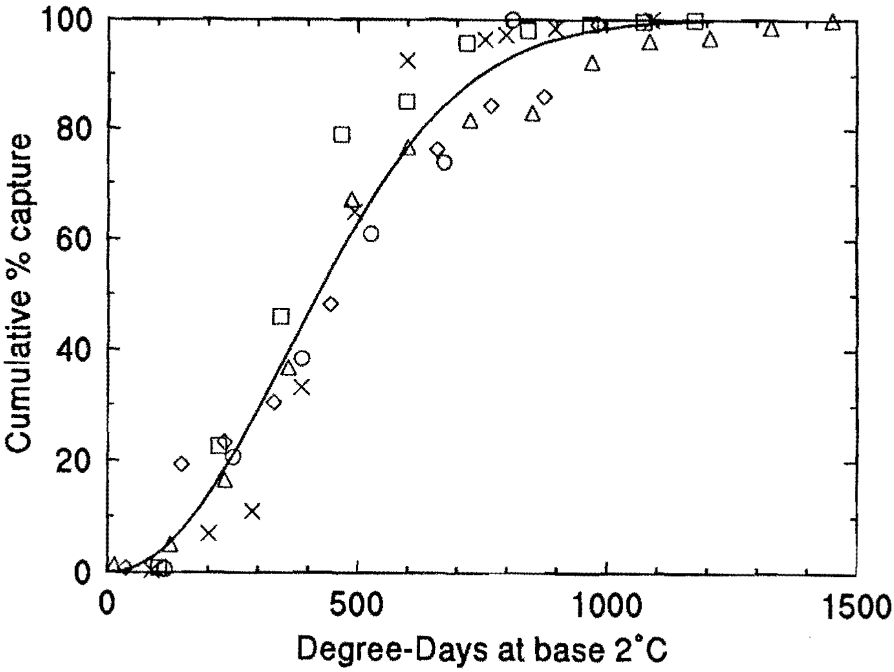

Figure 2. Model prediction (curve) compared to trap catch data of male *Chrysoteuchia topiaria* from sprayed cranberry marshes in Warrens and Wisconsin Rapids, WI, 1990–1992. Data are from farms in Warrens during 1991 (○), 1992 (×), and in Wisconsin Rapids during 1990 (△),1991 (□), 1992 (◇).

be documented for best use of the traps and predictions. It is not known how close peak flight or 50% catch are to peak oviposition, although current pest management practices assume peak oviposition and peak flight coincide (Roberts and Mahr 1986). Until oviposition can be documented, and as long as recommendations rely on observing peak flight, using a predictive model will increase a grower's or consultant's ability to anticipate future dates for applying controls.

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