Monitoring and Forecasting Flight Activity of Orange Wheat Blossom Midge

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INTRODUCTION

The orange wheat blossom midge, *Sitodiplosis mosellana* [Diptera:Cecidomyiidae] (**FIGURE 1**), is an introduced pest of European origin first recorded in North America during 1828 from Quebec, Canada. Economic infestations were infrequent until the mid-1980's when epidemic populations occurred across the western Canadian provinces of Saskatchewan and Manitoba and subsequently during the mid-1990's in North Dakota and Minnesota. In Idaho, orange wheat blossom midge infestations are restricted to Boundary County, our northernmost county which immediately adjoins British Columbia. Yield losses in untreated fields there exceed 40%.

Midge control depends on Lorsban 4E applied as foliar sprays to kill adult flies before they oviposit on flowering wheat heads. Field scouting is critical to midge management because larval control depends insecticide application timing. Once eggs hatch and larvae begin to feed on the developing kernels, insecticide efficacy declines because the glume protects larvae from direct insecticide contact. Midge scouting methods are difficult at best; we currently recommend that wheat growers visually inspect flowering wheat heads with flashlights after sunset when evening temperatures are at least 60°F and wind speed is less than 7.5 mph. Control is warranted if midge density exceeds the economic threshold of 0.20 to 0.25 midges per head at flowering.

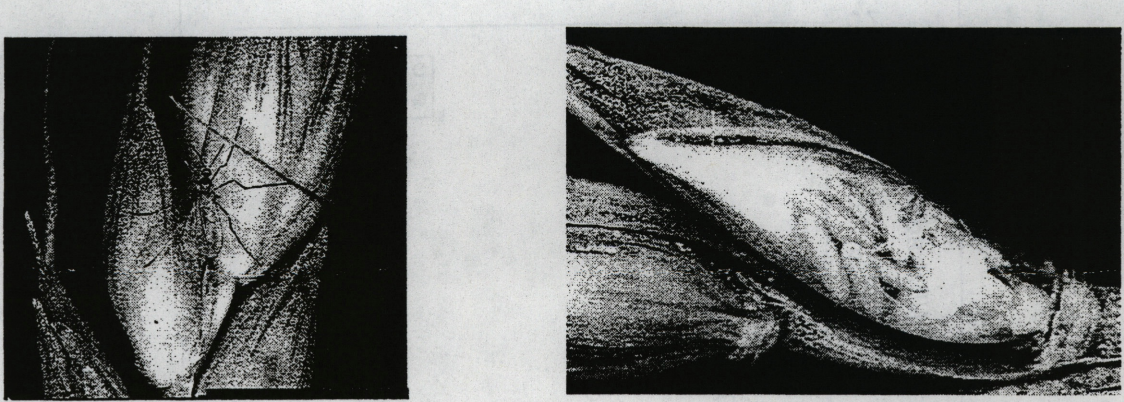

FIGURE 1. *[left] The tiny (1/8-inch), fragile adults only fly at twilight when winds are calm and temperatures are warm. [right] Glume removed to show larvae feeding on the developing kernel. PHOTO CREDITS: Harris et al. 1998*

We began field studies during 1999 to help wheat growers with midge IPM decisions by designing simpler-to-use scouting tools as alternatives to visual counts of adult midges at twilight. Although our 1999 studies showed that sweepnet sampling at twilight was the most accurate [most highly correlated] alternative to visual counts, we also concluded that the degree of confidence that could be placed in a spray:don't spray decision was moderate at best. Here we report our continuing field studies during 2000 to derive a more precise statistical model to calibrate sweepnet samples with absolute midge counts.

We also report our work during 2000 to derive a degree-day model that forecasts periods of midge flight activity. Wheat only is susceptible to wheat blossom midge larval feeding injury when eggs are laid on flowering heads; larvae cannot complete development if oviposition occurs earlier or later than flowering. A model that forecasts when overwintering larvae complete development and emerge from the soil as egg-laying adults could enhance IPM decisions by helping growers schedule field scouting as well as identify high risk fields (fields in flower when seasonal midge activity peaks).

OBJECTIVE 1 — ***refine 1999 statistical model between absolute midge counts and sweepnet sampling at twilight***

METHODS

We compared absolute counts of midges with easier-to-collect relative density estimates from sweepnet sampling at four commercial spring wheat fields in Boundary County. Samples were collected on 2 dates (30 June and 3 July 2000) during wheat flowering. Absolute counts were made at twilight [after 8:30 p.m.] with flashlights by examining 10 randomly selected wheat heads for midge adults. Sweepnet sampling consisted of five 180° sweeps across the canopy at 10 randomly selected sites approximately 50-feet from visual samples.

RESULTS & DISCUSSION — ***we failed to refine the 1999 statistical model***

The relationship between absolute midge density per head and relative midge density per sweep during 1999 and 2000 could not be described by a single model (**FIGURE 2**).

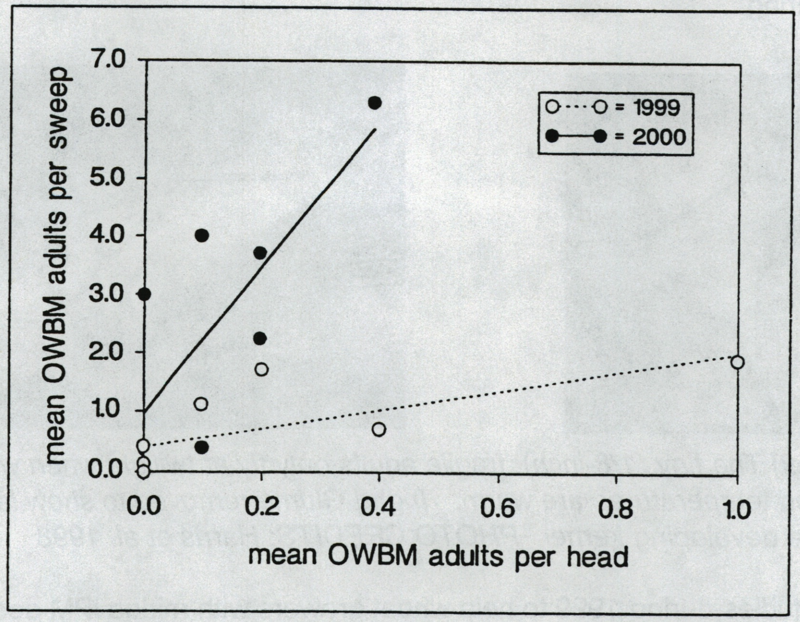

FIGURE 2. *Relationship between adult midge density per sweep during twilight hours and midge density per wheat head during 1999 and 2000; each data point is the mean of 50 sweeps and 10 plant inspections*

Although relative densities during 1999 and 2000 were direct linear functions of absolute densities, regression analyses showed that model parameters differed significantly between years. In particular, 1999 data were described by the linear model (**eq. 1**)

(eq. 1) *mean midges per five 180°sweeps = 0.3929 + (1.6215)(mean midges per head)*
$n = 8, p > F = 0.03, r^2 = 0.56$

In contrast, the 2000 data were described by the linear model (**eq. 2**)

(eq. 2) *mean midges per five 180°sweeps = 0.9531 + (12.3086)(mean midges per head)*
$n = 8, p > F = 0.02, r^2 = 0.60$

As a consequence, it seems that we cannot yet confidently recommend sweepnet sampling to growers for midge management decisions. Current economic thresholds are stated in terms of midges per head, and without a common calibration model for both years, we cannot reliably convert sweepnet estimates into the absolute counts needed for spray:don't spray decisions. In particular, whereas the 1999 linear model (eq. 1) predicts that infestations exceed economic thresholds if sweepnetting exceeds 0.7 to 0.8 midges per five 180° sweeps, the 2000 model (eq. 2) in contrast predicts infestations exceed ET levels if sweepnetting exceeds 3.4 to 4 midges per five 180° sweeps.

We conservatively suggest that growers tentatively adopt the lower set of values (ET = 0.7 to 0.8 midges per five 180° sweeps), with an added cautionary note: r^2 values indicate that the statistical model only accounts for about half of the observed variability in midge sweepnet densities. More precise conversion of sweepnet estimates into absolutes counts depends on unknown factors not measured in these studies. An even more conservative approach is to recommend control action whenever sweepnetting detects any midges in flowering wheat fields.

Objective 2 — derive a degree-day model to forecast midge flight activity

METHODS

We monitored midge flight activity with simple traps consisting of white 8-inch diameter styrofoam dinner plates placed vertically on stakes at plant canopy level (**FIGURE 3**). Plates were coated with a thin film of canola oil, which effectively ensnared the light-bodied midges while allowing heavier-bodied insects to escape. Our 1999 studies had shown these traps to be highly sensitive detectors of adult midges as they emerged from overwintering sites in the soil; traps captured midges when none could be detected by visually examining plants in the field.

Study sites were 3 commercial spring wheat fields located along 32-km north-to-south transect from Bonner's Ferry, Idaho. There were 12 white traps per field (3 facing each cardinal direction). We checked traps at 2-to-3 day intervals on 15 dates between 19 June and 28 July 2000 (from before 1st midge emergence until after last midge capture), scraping traps clean each examination date.

Degree-day summations were calculated from daily max:min air temperatures recorded at a standard weather station 2-km SW Bonner's Ferry, Idaho. The true (biological) lower threshold temperature for midge development is unknown; workers in Europe (Kurppa 1989, Oakley et al. 1998) and Canada (Lamb et al. 1999) arbitrarily had selected 5°C as the lower threshold temperature for midge development and derived degree-day models with accumulation starting dates of 1 January. Hence, for comparison with these published models, we computed degree-days above 5°C since 1 January 2000, using the single sine wave algorithm.

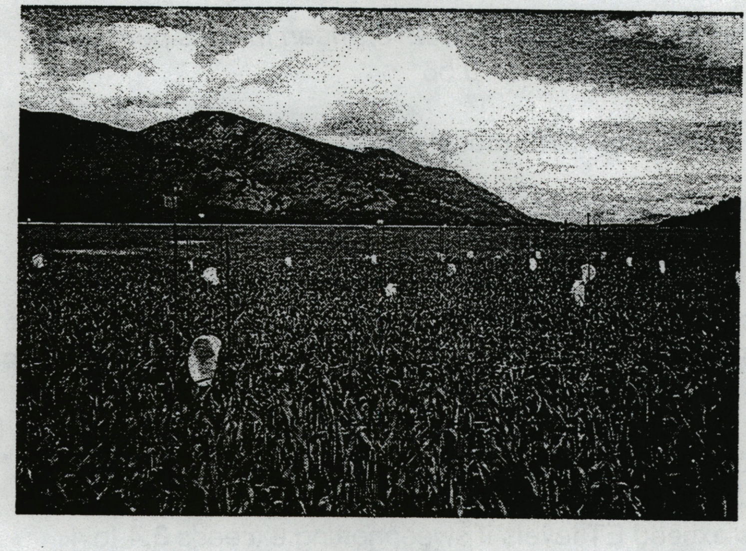

FIGURE 3. Midge trap array in commercial wheat field, Boundary County, Idaho

We described seasonal midge captures as a function of cumulative degree-days by using SAS Procedure PROBIT (SAS Institute 1985) to fit a probit model to our 2000 data. We validated our model by comparing the predicted date of 50% seasonal midge capture from 2000 model with 1999 observed dates.

RESULTS & DISCUSSION *— derived degree-day model*

The probit model adequately described seasonal midge captures as a function of degree-days computed above 5°C since 1 January 2000 (**Figure 4**).

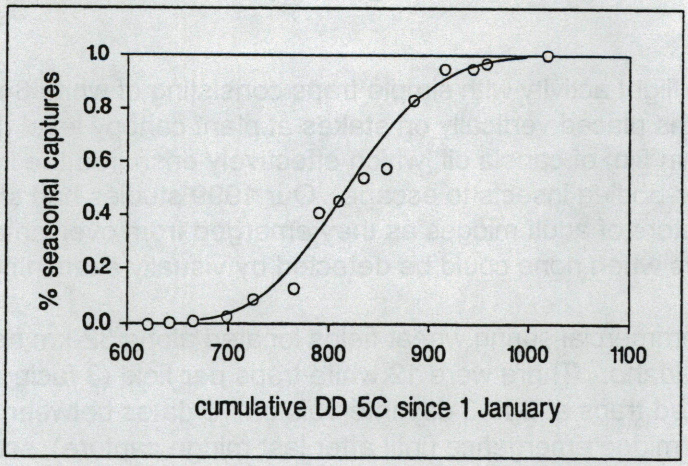

FIGURE 4. *Observed data and best-fit probit model for relationship between seasonal captures of orange wheat blossom midge on white traps during 2000 and degree-day accumulations above 5°C since 1 January 2000, Boundary County, Idaho*

Table 1 lists predicted degree-day requirements for key seasonal midge flight events.

TABLE 1. *Probit model predictions: $DD_{5°C}$ since 1 January required for seasonal midge capture*

event	mean $DD_{5°C}$	lower 95% C.I.	upper 95% C.I.
10% capture	735	720	747
50% capture	820	811	829
90% capture	915	901	932

The model seems to have some promise for predicting midge flight activity. As shown in **Table 2**, comparison of model predictions with our independent data set from 1999 showed that predicted dates of 50% seasonal capture were within 3-to-4 days of observed 50% capture during 1999.

TABLE 2. *Predicted dates of 50% midge capture vs 1999 observed dates of 50% midge capture, Boundary County, Idaho*

1999 data source	model prediction	observed date	error
white traps	5 July	8 July	- 3 days
yellow traps	5 July	9 July	- 4 days

Degree-day models derived earlier by European and Canadian workers were highly variable. Kurppa (1989) observed 1st flight of midges in Finland at 400 $DD_{5°C}$ since 1 January. Oakley et al. (1998) similarly reported 366 $DD_{5°C}$ since 1 January for 1st flight in England, though variation among sites was so high as to call into question the usefulness of forecasts. In contrast, Lamb et al. (1999) reported that 700 and 792 $DD_{5°C}$ since 1 January were required for 10% and 50% seasonal midge captures in suctions traps in Manitoba, Canada. But they too observed high variability and concluded that "*the timing of the flight was not related to growing degree-days.*"

Our model gives predictions most similar to those of our Canadian colleagues. Because both the lower temperature threshold and the accumulation starting date for our models were selected arbitrarily, it remains to be seen if a different threshold or a different starting date might improve predictions. The least-variability method of statistically estimating lower threshold temperatures (Arnold 1959) suggests that modest gains in precision could be made by using a threshold less than 5 °C;; as shown in **FIGURE 5**, error decreased as the lower developmental threshold decreased. As for the potential effect of accumulation starting date on prediction error, Hinks and Doane (1988) reported that diapause termination in overwintering midge larvae requires a minimum of 112-days exposure at 2 °C, suggesting to us that a date later than 1 January might improve predictions. We anticipate at least one additional season of field validation to resolve these questions.

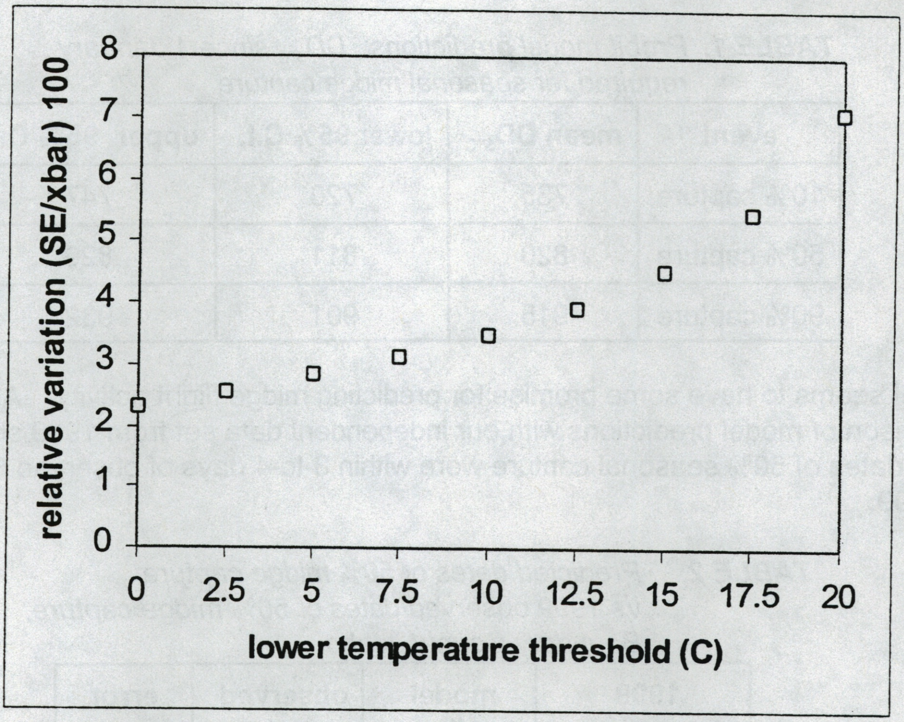

FIGURE 5. *Variability of degree-day accumulations (SE:mean) required for 50% midge capture during 2000 as a function of different lower temperature thresholds, Boundary County, Idaho. The threshold temperature with the smallest variability is the best estimate of the biologically "true" lower developmental threshold.*

ACKNOWLEDGMENTS

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