

Project Summary

This is a joint research/extension project requesting \$99,039 in PL89-106 funds and \$75,961 in Smith-Lever funds.

Wine and juice grape production in the northeastern US is centered in the lakeshore regions of Pennsylvania, and New York and in the New York Finger Lakes region. The most serious pest of viticulture in the northeast is the grape berry moth, *Paralobesia viteana* (GBM). In recent years, this insect has become more difficult for growers to control using the traditional risk assessment protocol of applying insecticides at ten days post bloom, early August and late August. This protocol, although widely used, was developed in a time when most insecticides were broad spectrum contact poisons and is calendar based rather than phenology based. We propose to test and operationalize a degree day model for GBM to enable better timing of insecticide applications, especially to enable the effective use of new, low risk compounds that must be ingested in order to cause pest mortality. Our goals are to compare the efficacy of phenology model based spray timings to the traditional risk assessment timings, to identify user friendly biofix(es) for starting the degree day accumulations within each growing season, and to deliver these new timings by taking advantage of the NEWA network of weather stations. Pennsylvania will join this network by purchasing and installing two weather stations and linking them into NEWA and New York will add two stations to their existing network. This project responds to a regional stakeholder-organized meeting that developed priorities for addressing insect management issues

Improved Timing of Control for the Grape Berry Moth, *Paralobesia viteana*, Using a Degree-Day Model

Problem Statement:

The grape berry moth (GBM) *Paralobesia viteana*, is the key arthropod pest of grapes grown in the eastern US, requiring control in many regions to avoid significant economic injury. This injury is typically loss of berries due to GBM feeding, but additional significant losses can occur as a consequence of fruit rots brought on by the GBM damaged berries that can extend to entire clusters resulting in major crop losses. However, population size and potential for doing damage varies widely within vineyards on the same farm, from region to region and year to year (Martinson et al. 1991). Hence, growers need reliable and effective methods for assessing risk from GBM, both in space and time, to make appropriate management decisions. One tool, originally developed in the 1970s and 1980s, is a trap baited with synthetic sex pheromone (Roelofs et al. 1971) that attracts and captures male GBM. Pheromone-baited traps have been developed for a number of important moth pests and can be useful for understanding pest phenology, determining the need to apply an insecticide and timing of control measures. Unfortunately, the pheromone based lure, as currently employed, is only marginally useful for indicating the first flight of overwintered male GBM and not useful at all for indicating subsequent generations (Weigle et al. 1999). Hence, there is a critical need for an alternative method to reliably time management decisions for GBM.

Background:

Because insects are poikilotherms, their rates of development are a function of temperature. As temperatures increase during the summer, the time frame required to complete a generation – to progress from egg to adult – decreases. However, this temperature-dependent development process changes drastically as fall approaches, which enables the insect to develop into a stage capable of overwintering: the diapausing stage. Insects that successfully overwinter well exhibit a strong diapause, and the timing of initiation of diapause in late summer or early fall is strongly influenced by photoperiod. The following spring, temperature influences the termination of diapause, returning the insect into a process of development as a function of temperature. Thus, the interaction of temperature and photoperiod can be used to predict the number of generations that an insect population will complete. Winter and spring temperatures can accurately model when the population will break diapause, and temperatures following that enable us to model the number of generations that will be completed until diapause initiation cues (decreasing photoperiod) cause diapause initiation.

GBM diapause as pupae, and emerge as adults in the spring, approximately when wild grapes are in bloom (ca. 10 days to two weeks prior to bloom in Concord vineyards). Recent research conducted on GBM has led to an improved understanding of this pest's seasonal habits and voltinism. Studies have elucidated 1) the minimum base temperature threshold for GBM development (Tobin et al. 2001), 2) the degree day requirement for the emergence of adults from diapausing pupae (Tobin et al. 2002), 3) the degree day requirement for development from egg to adult (Tobin et al. 2001), 4) the critical photoperiod for induction of diapause (Nagarkatti et al. 2001), and 5) that the egg is the GBM life stage that makes the decision to diapause (Nagarkatti et al. 2001).

The picture we now have of GBM seasonality is that adults will emerge in the spring, mate and oviposit approximately 20 individual eggs directly on the surface of grape berries. The egg will hatch and the larva will eat its way into the berry within which it will feed until larval development is complete. The mature larva will exit the grape and pupate either in a rolled leaf or in bark crevices or in the soil. After pupation is complete, adults will emerge, mate and initiate another generation. This pattern will continue until late summer, when the GBM egg, which triggers diapause when the individual GBM reaches the pupal stage, perceives shortening day length. The pupa will over-winter and emerge the following spring to begin the cycle anew. At the latitude of Pennsylvania's grape growing belt along Lake Erie, a GBM egg that is laid on July 22 (photoperiod of 14H 45M), has a 50% chance of diapausing when it reaches the pupal stage. An egg laid on August 3 (photoperiod of 14H 21M) has a 90% chance of diapausing when it reaches the pupal stage.

One possible explanation for recent GBM control failures could be climate change. If the climate warms significantly, it would be possible for the second generation of GBM to complete development earlier than in the past and to oviposit before the critical photoperiods that induce diapause. As a consequence, the eggs that would be deposited by the second generation GBM will not elect to diapause when they reach the pupal stage, but instead continue development through to the adult stage which would then mate and initiate another generation.

We conducted a study to explore this possibility (Tobin et al 2008) in which we considered GBM voltinism under different climate scenarios. We illustrated that increases in mean surface temperatures $>2^{\circ}\text{C}$ can have dramatic effects on GBM voltinism by causing a shift in the ovipositional period that currently is subject to diapause-inducing photoperiods. This will result in an additional and later generation of GBM. Early season berry loss is usually offset by an increase in the size of the remaining healthy berries. Late season berry loss will be a genuine yield loss. In addition, GBM damage will be readily apparent at harvest. With a current USDA harvest rejection standard of 2% or more damaged berries, it is apparent that this increase in GBM voltinism will result in significant losses to the northeastern USA grape industry.

Presently, the grape berry moth risk assessment protocol (GBMRAP) (Martinson et al. 1991) is the primary tool used by grape growers in the east to estimate timing of GBM management. For a high risk vineyard the protocol calls for an insecticide application at ten days post bloom (first generation GBM), early August (second generation), and if necessary, late August (third generation). As is true of other insects (and grapevines), development of GBM is temperature dependent. Although the recommended first spray is tied to bloom time, which in turn, is driven by temperature, the other timings are based solely on calendar date irrespective of temperature. In an average year the GBMRAP timings for control (using contact insecticides) may work fairly well but in cool years they may be applied early and in warm years they may be applied late. Hence, what is needed is a temperature based development or phenology model to provide growers with a more reliable method to time management actions. Such a model has been developed for GBM (Tobin et al. 2001, 2003) in which the number of degree-days (DD) for GBM to develop from eggs to egg-laying adult females is approximately 810 DD ($^{\circ}\text{F}$) (450 DD ($^{\circ}\text{C}$)) using a base developmental threshold of 47°F (8.4°C).

During the 2006 and 2007 growing season, female GBM were trapped with either malaise or light traps. Data from these trap catches have laid the framework for validation of

the degree-day model (Figure 1). More data however, are needed to substantiate the model including local variations. However, the peaks of emergence indicated by trap catch data, coincide nicely with the peaks generated by using Tobin's model to estimate generational peaks by degree-day calculations and represent a significant advance over the information provided by the sex pheromone trap catches of males.

Finding a reliable and practical biofix for initiating the phenology model is key to successful implementation. Our previous research has shown that trapping adult female moths, either with light traps, malaise traps, or panel traps baited with synthetic host volatiles, provides fairly clear information on female flight activity. Peak captures of females in the spring flight (see background section) were good predictors of flight activity in subsequent generations. However, these trapping techniques are not grower friendly at this time.

Justification:

The grape berry moth is the most destructive direct pest of grapes in that the larvae feed internally on grape berries resulting in loss of crop and often initiating bunch rot diseases. New York is the second largest and Pennsylvania is the fifth largest grape producing state in the US, and the vast majority of the grapes are grown along the shore of Lake Erie and in the Finger Lakes region of New York. In recent years, late season infestations of GBM have caught grape growers unaware, resulting in numerous load rejections at juice processing plants. These late season infestations have caused considerable consternation to grape growers and to the grape industry (see appendix document "GBM Summit II" for a summary of National Grape Cooperative sponsored workshop on this problem). Speculation as to why we are now experiencing problems with this insect in the late summer has considered the loss of broad-spectrum contact insecticides and/or insecticide resistance. It is apparent that the newer compounds available for GBM management are not contact poisons, but must be ingested in order to kill. Preliminary studies carried out at PSU have demonstrated that GBM larvae within grape berries are protected from insecticide sprays. Therefore, the only window of opportunity available for the control of GBM using insecticides that must be ingested is the brief time during which neonate GBM larvae are chewing their way through the grape skin and into the berry. Ensuring that active insecticide residues are covering the grape berry when the newly hatched GBM larvae are attempting to chew their way in requires a precise method for anticipating and timing insecticide applications. Without the intervention of this project, grower loads will continue to be rejected at the processing plants, the economic well being of grape growers will be negatively impacted, and insecticides will continue to be misapplied with concomitant non-target impacts including effects on biodiversity, ecosystem services, and human health.

. We propose to validate the use of the temperature-driven phenology model in field settings, evaluate the suitability of natural biofixes that can easily be employed for initiating the counting of degree days, and develop a delivery method for widespread use and adoption of this GBM management approach in New York and Pennsylvania. Therefore, our specific objective for the next three seasons are:

Objectives:

1. **Research:** Compare effectiveness of GBM control with insecticide when timing is based on grape berry moth risk assessment protocol verses a degree-day phenology model.
2. **Research and Extension:** Investigate use of alternative methods to determine first flight of female moths as a biofix for degree-day phenology model.
3. **Extension:** Incorporate the phenology model into a Cooperative Extension NEWA system for use by growers

Anticipated Impacts

Economic benefits: Grape growers and extension educators throughout the region have been seeking a new method to better time GBM management decisions, especially for the second and third generations. A temperature based phenology model will represent a major improvement over the calendar-based approach currently being employed that will lead to more cost efficient, less wasteful, and more efficacious use of insecticides for GBM control.

Safeguarding human health and the environment: Grape growers will transition from the remaining broad spectrum insecticides to more targeted, and less environmentally damaging compounds through the adoption of this more accurate method for calculating spray timings. Reduction in the use of broad spectrum compounds will reduce grower/applicator risk, non-target impacts, and issues associated with pesticide residues and human health.

Implementation of IPM: This study is focused on refining and advancing our understanding of GBM phenology and the direct implementation of these findings into a regional IPM strategy for management of this important pest. Growers will be exposed to this approach with regular Coffee Pot meetings (ca. 5/season, 25 growers/session), a revised GBM-IPM extension brochure (ca 200 growers in PA/NY, field demonstration projects and associated grower meetings (ca. 100 growers/meeting), as well as via the regular summer and winter grower Extension conferences (ca. 100-200). We anticipate that growers educated via these venues will readily adapt to this improved approach.

Approach and Procedures

Objective 1. Compare effectiveness of GBM control with insecticide when timing is based on grape berry moth risk assessment protocol verses a degree-day phenology model.

In year 1, we propose to establish a series of replicated small plots (2 to 4 panels = 6-12 vines, 5 replicates per treatment per site) in the Finger Lakes region of New York, and in the Lake Erie grape belt in both New York and Pennsylvania. In each of these three regions, we will identify at least 2 sites where GBM pressure is high and vineyard size permits multiple, replicated small plots for assessment of different spray timings. In each location, one treatment, called Late Phenology, will consist of timings based on the GBM phenology model with the first treatment being applied at the predicted second flight. The second treatment, called Early Phenology, will also use the GBM phenology model, but will include a treatment timed for the first flight of

GBM (i.e. those that emerged from diapause). This treatment is to determine the necessity of taking any action to control early season GBM. The third treatment, called Risk Assessment (GBMRAP), will consist of timings recommended by the current risk assessment protocols (10 days post bloom, end of July, end of August). The fourth treatment will be an unsprayed control. These trials will be applied by the researchers. We would assess berry moth activity using light traps, and/or Malaise traps in order to identify the 50% emergence date of the various flights of female GBM. Each treatment will be monitored for GBM damage approximately 2 weeks after applications. In each treatment replicate plot, fifty clusters will be examined for berry damage (percent damaged clusters). Clusters will be examined to determine rate of damaged berries (percent damaged berries) and incidence of fruit rots.

For the Early Phenology treatment, the timing of the first flight of GBM will be determined by accumulating 189C degree days (Tobin et al. 2002) from January 1. This spray timing will be compared to the date of the 50% emergence of female GBM as determined by the Malaise and light trap data to assess the accuracy of the degree day prediction. For both the Early and Late Phenology treatments, control of the second flight of GBM will be applied approximately 450° C degree days after 50% emergence of the first flight. This spray timing will be sufficiently early that spray residue will be in place prior to oviposition for that flight. Approximately 400cDD after the 50% emergence of the second flight, an application of insecticide will be administered for the third flight. If population pressure appears to be high, this process will be repeated for the fourth flight of GBM as well.

In the second year, the most efficacious Phenology timing will be compared to the Risk Assessment treatment (GBMRAP) in larger vineyard block trials. In each of the three regions, at least two vineyards with high GBM pressure will be selected and complete vineyard blocks (approximately 2 to 5 hectares) will be treated using either the Phenology or GBMRAP treatments. These larger blocks will permit a more robust comparison of the two treatment timings and lay the groundwork for the demonstration projects detailed in objective 3. The block treatments will either be applied by the researchers or by grower cooperators. GBM damage estimation will be conducted as in year one, with vineyard block edges examined separately from block interiors.

Results of the comparison of the risk assessment timing of Martinson et al. 1991, the phenology model driven timings, and the untreated controls will be statistically analyzed and reported via Extension meetings, newsletters, and in the refereed literature.

Objective 2. Investigate use of alternative methods to determine first flight of female GBM moths as a biofix for degree-day phenology model.

Finding a reliable and practical biofix for initiating the phenology model is key to successful implementation. Our previous research has shown that trapping adult female moths, either with light traps, malaise traps, or panel traps baited with synthetic host volatiles, provides fairly clear information on female flight activity. Peak captures of females in the spring flight (see background section) were good predictors of flight activity in subsequent generations. However, these trapping techniques are not grower friendly at this time. As a consequence, for this objective we propose to compare several, more grower friendly approaches to determine which is the best indicator of first flight of females and could be used as a substitute biofix. The alternative indicators are 1) peak male capture in pheromone traps, 2) bloom date of river bank

grape *V. riparia*, the most common species of wild grape in the Northeast, 3) bloom date of common cultivated grapes: concord, cayuga white, and chardonnay.

Objective 2a: Correlate female GBM captures with other bio indicators at multiple vineyard sites. At multiple sites (9-10 total) in the Finger Lakes and Lake Erie regions we propose to monitor female captures using light traps, male capture using standard pheromone traps, bloom date (50% bloom) of *V. riparia* and bloom date of concord, Cayuga white and chardonnay when present through the first half of the growing season. All sampling will begin by 1 May. At least three battery-powered mosquito type light traps (Bioquip Products) will be deployed at the vineyard edge at each site and checked at least every other day. Two wing traps (Suterra model) baited with commercial GBM sex pheromone (Suterra) will be placed at the vineyard edge of each site as well and checked for males at the same time as light traps are checked. To assess 50% bloom of *V. riparia* and cultivated grapes we will mark off five individual vines of each and examine five clusters per vine (second cluster on shoots) every other day and record flowering status (buds or % florets).

We will determine, retrospectively, date of peak capture of females in light traps at each site during the spring flight and correlate with 1) date of peak male captures, 2) date of 50% bloom of *V. riparia*, and 3) date of 50% bloom of cultivated grape. Each vineyard site represents a data point. We will also estimate number of degree-days between each of the indicator dates and each other and peak capture of females in light traps subsequent flights. Data will be collected for two growing seasons.

Objective 2b. Quantify bloom date for V. riparia, concord, cayuga white, and chardonnay at single planting site. The goal of this objective is to obtain data on the relationship between bloom date of commonly grown grape cultivars, one of which will likely to be present at most commercial vineyards and *V. riparia*. Although *V. riparia* appears to be well matched with GBM phenology, there are limitations to its use by commercial growers. It is not always present near commercial vineyard sites, genotype and environment (e.g. sun exposure) affect bloom date, and its not always simple to distinguish it from other wild grape species. We propose to establish growing degree day (GDD) relationships between bloom date of *V. riparia* and cultivated grapes to be used to adjust GBM phenology model predictions based on biofix of grape cultivar used. For example, in 2008 and 2009 we assessed bloom date for several individual *V. riparia* vines and concord at Geneva (2009 only) and at a commercial vineyard near Rushville, NY (08 and 09). The average difference in bloom date, using a base lower threshold of 8.4 ° C was 103° C DD. Hence, a grower with concord vines would use concord vine bloom date and the model would predict second flight at $450 - 103 = 347$ ° C DD after concord bloom and the third flight at $347 + 450 = 797$ ° C DD.

Using a common garden planting of multiple grape species and cultivars located in Geneva, NY, we will evaluate 50% bloom date for multiple accessions of *V. riparia*, concord, cayuga white, and chardonnay. Individual vines will be evaluated every other day, starting the last week of May, recording the flowering status (% open florets) for 5 clusters (second cluster on shoot). This will be done for 2010-2011. Degree day estimates of bloom date for the different grape species or cultivars will be compared to trap catch data of GBM at nearby commercial vineyard. Similar determinations will be made at all sites described under Objective

2a, although in most cases, one or several of the grape species or cultivars will not be available at a specific site.

Objective 3. Demonstrate, Implement and Educate Growers in the Degree-Day Model for timing of applications for grape berry moth.

This objective will begin in Year 2 as a transition from the research phase of small blocks used in Objective 1 to larger blocks in grower vineyards classified as being at high risk for grape berry moth infestation. A minimum of two vineyard pairs per region will receive the treatments. If the vineyards are of sufficient size, they will be divided into two blocks, one block will have insecticide applications timed using the new degree-day model and the other using the grower standard of the Grape Berry Moth Risk Assessment (GBM RA). The degree-day model developed and placed on the NEWA website will be used to time insecticide applications in both research and demonstration vineyards using the closest available NEWA weather station <http://newa.cornell.edu/>. In the event suitably large vineyards are not available vineyard pairs consisting of two vineyards with similar high risk for grape berry moth infestation will be used. The three sets of paired high-risk vineyard blocks that will be added in year two research objectives will be used as demonstration vineyards with researchers conducting the spray operations in both. Information obtained from research blocks will be used to assist growers in implementing correct timing of GBM control in demonstration blocks. Cooperative Extension project personnel will work directly with growers in their demonstration vineyards to assess growing degree-day, pheromone trap catches, biofix and GBM cluster damage. Collection of data in both the GBM and Phenology Growing Degree-Day blocks will allow for a comparison of efficacy of both GBM Management strategies. Assessments will be conducted on a weekly basis starting at bloom and running through the preharvest evaluation in mid September to track timing and incidence of GBM cluster infestation. Preharvest evaluation will include both incidence and severity evaluations.

In Year 3 the transfer of research to grower vineyards will be completed with a minimum of five paired blocks (one assigned to GBM RAP and the other to degree-day model) in participating grower vineyards in each region being used to demonstrate, implement and compare the degree-day model for timing of insecticide applications for grape berry moth with the GBM RA. Growers will conduct insecticide applications in each block timed according to the degree-day model and the GBM Risk Assessment. Growers will use the most effective and convenient biofix identified in objective 2 during the first two years of the project, in combination with the model made available using NEWA Temperature data will be obtained from the nearest weather station as part of the NEWA system. Data collection will be identical to the demonstration vineyard evaluation procedures in Year 2 with Cooperative Extension project personnel again working with participating growers.

In years 2 and 3 growers across New York State and Pennsylvania will be instructed on the use of the Degree-Day model and use of the NEWA website through small group meetings, large group twilight meetings and annual winter conferences as well as hard copy and electronic newsletters and web pages. In year 3 a survey using Turning Technologies audience polling software will be conducted during small group meetings to determine the willingness to change spray practices to incorporate growing-degree model information in their grape berry moth management strategy.

Project Timetable:

Year 1: a. Small plot trials will be conducted in three grape growing regions in PA and NY and evaluated for assessing the efficacy of phenology based timing of GBM insecticides vs. GBMRAP. Assessments will include quality of GBM control and disease incidence.

Completion by end of 2010.

b. A grower friendly biofix will be determined to assist growers in identifying the start date for initiating the accumulation of GBM growing degree days. **Completion by end of 2011.**

Year 2: a. Large vineyard block trials (using the year 1 biofix determination) will be conducted in three grape growing regions in PA and NY to demonstrate efficacy at large, grower oriented scales. **Completion by end 2011**

b. Extension meetings (Phase 1) will be held at these large block sites to introduce growers to the concept of GBM phenology based timings. Coffee pot meeting topics will include this topic, and growers will be informed of upcoming demonstration projects. Cooperative Extension project personnel will work directly with growers in these demonstration vineyards to assess growing degree-day, pheromone trap catches, biofix and cluster damage from GBM and bunch rots. **Completion by March 2012.**

c. Weather stations will be added to the NEWA system (2 in PA, 2 more in NY) and the GBM phenology model will be incorporated into the programming of the NEWA system. **Completion by March 2012**

d. Complete programming for NEWA to add GBM model. **Completion by March 2012**

Year 3: a. Transfer of research to grower vineyards will be completed with a minimum of five paired blocks (one assigned to GBM RAP and the other to degree-day model) in participating grower vineyards in each region being used to demonstrate, implement and compare the degree-day model for timing of insecticide applications for grape berry moth with the GBM RAP.

Completion by end 2012.

b. Extension outreach (Phase 2) Growers across New York State and Pennsylvania will be instructed on the use of the Degree-Day model and use of the NEWA website through small group meetings, large group twilight meetings and annual winter conferences as well as hard copy and electronic newsletters and web pages. **Completion by March 2013**

c. A survey using Turning Point Technologies audience polling software will be conducted during small group meetings to determine the willingness to change spray practices to incorporate growing-degree model information in their grape berry moth management strategy. **Completion by March 2013**

d. Re-write the GBM risk assessment protocols, adopting the phenology model, and make available to stakeholders via pdf and web sites. **Completion by March 2013**

Evaluation Plans (by objective)

Objective 1: Standard statistical analyses including ANOVA and mean separation tests will be conducted to determine the significance of treatment differences between the four treatments.

The most efficacious of the phenology driven timings will be used in year 2 when we transition to large block trials. In the large block trials, standard statistical analyses including ANOVA and mean separation tests will be conducted to determine the significance of treatment differences.

Objective 2a. We will determine, retrospectively, date of peak capture of females in light traps at each site during the spring flight and correlate with 1) date of peak male captures, 2) date of 50% bloom of *V. riparia*, and 3) date of 50% bloom of cultivated grape. Each vineyard site represents a data point. We will also estimate number of degree-days between each of the indicator dates and each other and peak capture of females in light traps subsequent flights. Data will be collected for two growing seasons.

2b. Using a common garden planting of multiple grape species and cultivars located in Geneva, NY, we will evaluate 50% bloom date for multiple accessions of *V. riparia*, concord, cayuga white, and chardonnay. Individual vines will be evaluated every other day, starting the last week of May, recording the flowering status (% open florets) for 5 clusters (second cluster on shoot). This will be done for 2010-2011. Degree day estimates of bloom date for the different grape species or cultivars will be compared to trap catch data of GBM at nearby commercial vineyard. Similar determinations will be made at all sites described under Objective 2a, although in most cases, one or several of the grape species or cultivars will not be available at a specific site.

Objective 3. In years 2 and 3 growers across New York State and Pennsylvania will be instructed on the use of the Degree-Day model and use of the NEWA website through small group meetings, large group twilight meetings and annual winter conferences as well as hard copy and electronic newsletters and web pages. In year 3 a survey using Turning Point Technologies audience polling software will be conducted during small group meetings to determine the willingness to change spray practices to incorporate growing-degree model information in their grape berry moth management strategy. We anticipate that > 30% of growers will agree to adopt this new GBM spray timing. This should equate to approximately 9000 acres of vineyards in PA and NY that will be treated using this new protocol. Success of this approach will also be evaluated by examining the load rejection rates at juice grape procession plants. We anticipate a significant reduction in rejections following the completion of this project which will be reported in the literature and at grower Extension meetings.

Key Personnel:

Michael C. Saunders and Greg Loeb: Lead investigators for the research portions of this project. Saunders and Loeb will design and implement the small and large block trials for comparison of phenology based timings with GBMRAP based timings. Saunders and Loeb will also conduct studies of biofixes for initiating the accumulation of GBM degree days. These individuals will also serve as speakers at Extension talks, twilight meetings, coffeepot meetings, and will assist in the implementation of the GBM phenology model into the NEWA system.

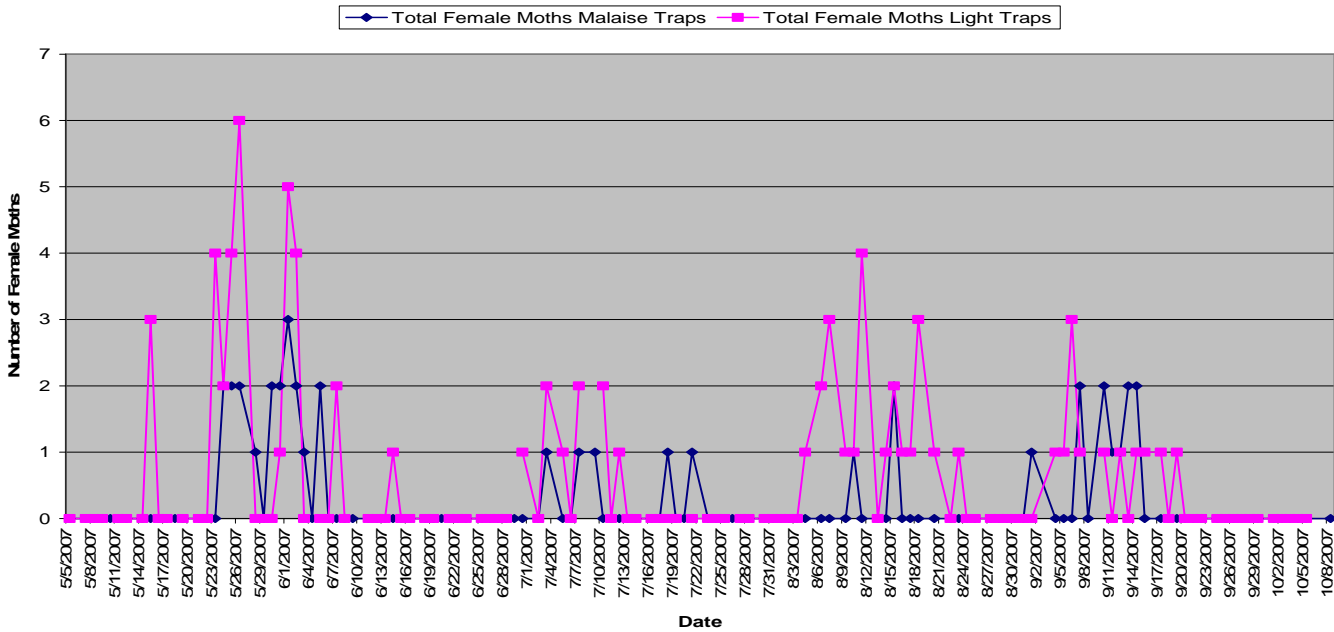
Andrew Muza and Tim Weigle: Lead Extension specialists responsible for grower meetings, Extension literature preparation, establishment of NEWA system and the incorporation of GBM model into NEWA system.

Additional personnel:

Bryan Hed: He is a research plant pathologist who will assist in the evaluation of bunch rot incidence in the various field treatments for GBM control.

Figure 1. Total female GBM captures in light and malaise traps. Note the four distinct emergence periods. The degree day accumulation between the median points of each peak conforms very closely to the phenology model predictions.

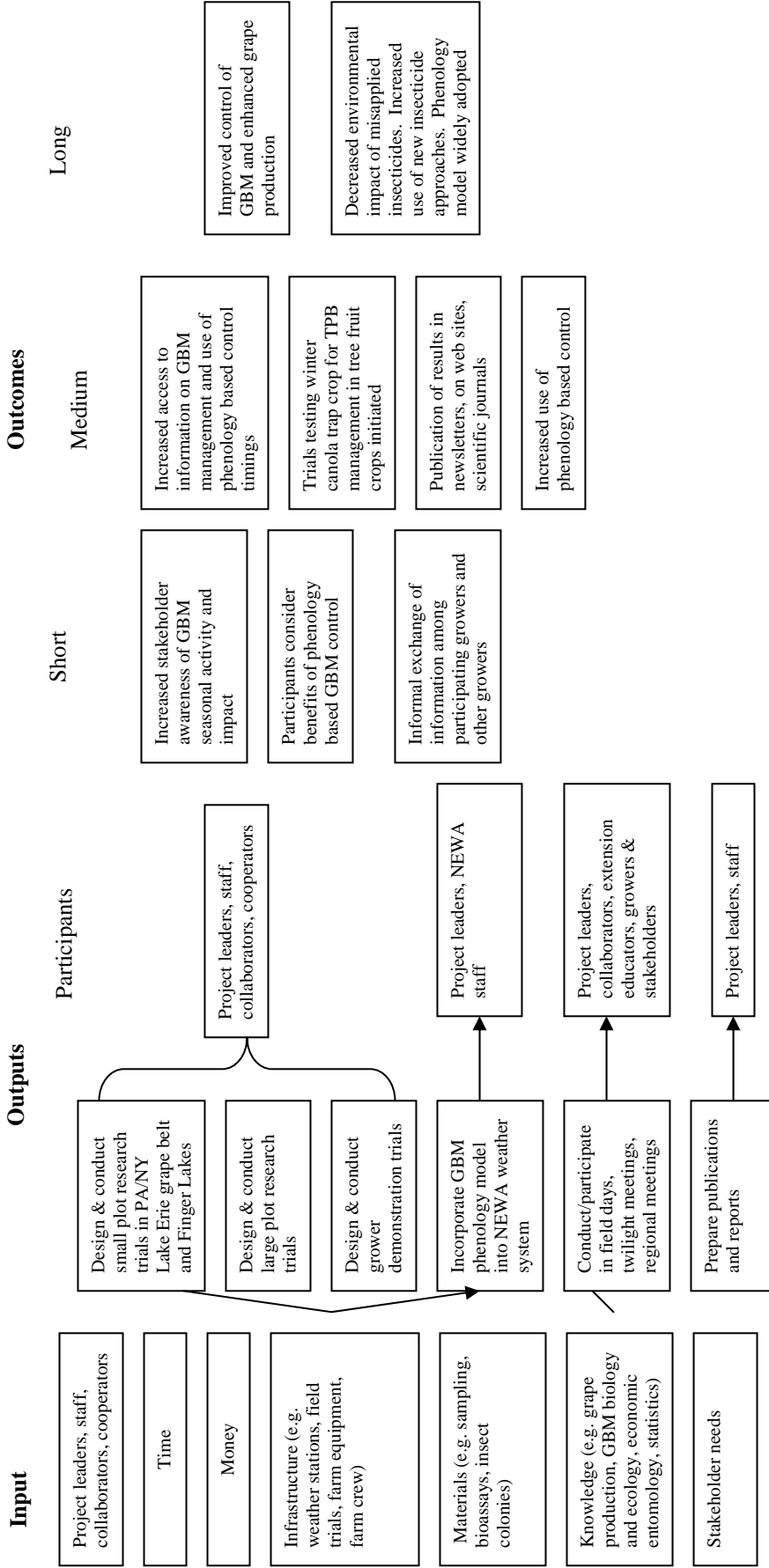
2007 Total Female GBM Captures in Light and Malaise Traps



SITUATION:

Control of the grape berry moth, *Paralobesia viteana* (GBM) has become problematic in recent years with considerable crop loss and load rejections at grape processing plants. We propose to refine the timing of control through the use of a temperature driven phenology model. This model will be incorporated into a regional weather system and will employ a grower friendly biofix. Growers will be trained in the use of this approach via an assortment of outreach programs and demonstration projects

PROGRAM ACTION-LOGIC MODEL



External Factors

1. Costs of pesticide, fuel, and other inputs
2. Value of grape crop
3. Climactic conditions as affect GBM phenology

Assumptions

1. Vineyards for management available
2. GBM populations sufficient to assess efficacy of field trials
3. GBM important pest of grapes

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GRAPE BERRY MOTH SUMMIT II
December 12, 2002
Minutes

At the Summit, the attendees agreed to evaluate the GBM problem based upon the following criteria:

- Defining the Problem
- Identifying the Causes of GBM Damage
- Defining an Action Plan for Research, Extension, and Industry on How to Reduce GBM Damage In 2003

Defining the Problem:

- Load rejections – Processor representatives from the region indicated that there were more load rejections in 2002 than in previous years, and some processors experienced substantially more than others. One processor indicated that after October 1, 2002, load rejections were primarily due to mold & decay as a result of earlier GBM larvae damage. Current USDA standards allow a maximum of 1% insect damage, and a maximum of 3% for mold & decay.
- Field losses – Several participants indicated that field losses were also substantial this year, albeit highly variable within most vineyards. Some vineyards that were considered low risk in the past had high amounts of late season GBM damage in 2002. Reports were given that field losses were as much as 60% or more in parts of many vineyards throughout the New York, Pennsylvania, Ohio and Michigan grape producing areas. Reports from Ontario, Canada, indicated that GBM losses were low this year in most vineyards. A study conducted in Michigan comparing a sprayed vineyard to an un-sprayed vineyard showed that the un-sprayed vineyard with GBM damage had a 1.5-ton/acre lower crop than the sprayed vineyard. A report from New York indicated that .75-ton/acre was gathered on the vineyard floor due to primarily GBM larvae damage to the berries.
- Overall, the group consensus was that damage due to GBM was on the increase and that most of the fruit damage resulting in load rejections and crop losses were due to late season (mid-August to mid-September) larvae damage. It was noted that one larvae can damage 3-5 berries or more. One participant raised the question of whether GBM damage results in deterioration in juice and wine quality. According to the processor and winery representatives, this has not been evaluated.

Causes of the Problem:

- Some growers with frost damage to their vineyards reduced their pest management applications this year in anticipation that they would not be harvesting their vineyards. However, in many vineyards, especially in Michigan and Erie County, New York, there was a much larger crop than had been anticipated. This resulted in most of the vineyard acreage in these areas being harvested. Some of the harvest vineyards had not had adequate pest control measures applied for GBM.

- Poor spray coverage is a major issue when trying to control late season generations of GBM. With the increasingly larger, denser canopies in many vineyards, penetration of these canopies in late July and forward becomes very difficult. The situation is exacerbated by the lack of highly efficacious, broad-spectrum insecticides. These newer chemistries require thorough coverage of the fruit and direction ingestion of the material by the GBM larvae in order to be effective. In many instances, growers have poor coverage because they are traveling too fast, using too little water and spraying every other row.
- Traditionally, growers put their sprayers away by mid-August. With most of the crop damage coming from late season GBM infestations, spray applications made in late July or early August will not provide needed late season control.
- Lack of thorough and timely scouting to identify the potential for late season infestations was also identified as a cause.
- Lack of understanding by growers on what life stage of GBM (adult, eggs, larvae) should be the primary target. This is coupled with a lack of understanding on what materials are effective on a particular stage in the life cycle of GBM. The loss of broad-spectrum insecticides, such as methyl parathion and azinphos methyl, has exacerbated the problem making it more difficult to control late season GBM populations.
- Resistance development to currently registered insecticides was also identified as a potential problem. Some growers are not alternating chemistries and that is of particular concern with fenpropathrin (Danitol) and some of the other newer chemistries coming along.
- Lack of spray equipment specifically designed for use in grapes was also identified as a cause of the problem directly associated with the difficulty in getting thorough coverage late in the season. Most grape spraying equipment was developed primarily for fruit tree crops and is not effective in labrusca grapes, which typically have large leaves and multiple leaf layers within the canopy.
- Lack of knowledge on where GBM populations are coming from as being primarily endemic within the vineyard, or as migratory populations that for each generation move into the vineyard from the surrounding flora. If migratory populations are a key factor, the percent of the females that have already mated in the wild prior to moving into the vineyard is also not known.

Defining an Action Plan for Research, Extension and Industry to Reduce GBM Damage in 2003:

- The major cause identified by the participants that must be addressed is inadequate spray coverage. The issue includes such factors as the need for better timing of the less efficacious materials, the difficulty in penetrating the dense labrusca canopies late in the growing season, and inadequate sprayer design. This was identified as primarily an issue to be addressed by extension and industry. To address the issue, it was suggested that demonstration plots be established in 2003 to show growers how to get better coverage. This should be done on farms of highly credible growers who would serve as models for others to follow. We will

also encourage growers to thoroughly scout their vineyards and to have their sprayers available to spray later in the season, if necessary.

- Industry and extension will, in their 2003 communications with grape growers, place emphasis on the economic impacts of GBM damage as defined earlier in the minutes. This is needed to bring home the message about the need to control this pest in relation to losses in the field and the cost of additional spray applications.
- There is the need for improved information on the relationship between GBM adults, egg and larvae numbers, and yield loss potential. This was identified as primarily a research question. This information is particularly important in regard to mid-July GBM damage and potential crop loss.
- Research is also needed to quantify pesticide efficacy in relation to the various life cycle stages of GBM. This understanding would help growers determine what material should be used when targeting to either adults, eggs, or larvae.
- There should be a better understanding of the basic biology of GBM. We need to know more about the biology and what triggers outbreaks of this insect in order to more effectively control GBM. This has implications for research, extension and processors. Certainly, the growers need to understand more about what we know on the biology of GBM, and research needs to learn more about the changing population dynamics.
- Extension and the processors need to educate the growers on resistance management of the few remaining efficacious materials remaining to control GBM. Too many growers are using a single chemistry for the entire season. If this continues, resistance to fenprothrin (Danitol) and other emerging chemistries will occur quickly and potentially leave the industry without adequate controls for GBM.
- It has been demonstrated in Canada that mating disruption pheromones have been used effectively there to control GBM. Additional research in the U.S. and Canada needs to further evaluate the effectiveness of pheromones and other alternatives, such as trichogramma for control of GBM. It would also be useful to know the proportional distribution of vineyard populations of GBM that are endemic versus those that migrate in from outside the vineyard. The potential role of beneficials in augmenting control of GBM should also be investigated.
- Further research is needed on the relationship between the timing of diapause and late season population levels of GBM.

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Project Title: Improved Timing of Control for the Grape Berry Moth, *Paralobesia viteana*, Using a Degree-Day Model

Project Type: Joint Research-Extension

Project Summary: This is a joint research/extension project requesting \$99,039 in PL89-106 funds and \$75,961 in Smith-Lever funds.

Superscripted numbers refer to the 14 specific criteria of the Northeastern Region (NE-IPM)

Wine and juice grape production in the northeastern US⁴ is centered in the lakeshore regions of Pennsylvania, and New York and in the New York Finger Lakes region⁶. The most serious pest of viticulture in the northeast is the grape berry moth, *Paralobesia viteana* (GBM). In recent years, this insect has become more difficult for growers to control using the traditional risk assessment protocol of applying insecticides at ten days post bloom, early August and late August^{11,12}. This protocol, although widely used, was developed in a time when most insecticides were broad spectrum contact poisons and is calendar based rather than phenology based. Indeed, in preliminary research we have shown that peak flight and egg-laying can occur several weeks earlier than the timing prescribed by GBMRAP. We propose to test and operationalize a degree day model for GBM to enable better timing of insecticide applications, especially to enable the effective use of new, low risk compounds that must be ingested in order to cause pest mortality^{5,7,9,10,14}. Our goals are to compare the efficacy of phenology model based spray timings to the traditional risk assessment timings, to identify user-friendly biofix(es) for starting the degree day accumulations within each growing season, and to deliver these new timings by taking advantage of the NEWA network of weather stations. Pennsylvania will join this network by purchasing and installing two weather stations and linking them into NEWA and New York will add two stations to their existing network. This project responds to a regional stakeholder-organized meeting that developed priorities for addressing insect management issues.^{13,14}

Problem: The grape berry moth (GBM) *Paralobesia viteana*, is the key arthropod pest of grapes grown in the eastern US, requiring control in many regions to avoid significant economic injury. This injury is typically loss of berries due to GBM feeding, but additional significant losses can occur as a consequence of fruit rots brought on by the GBM damaged berries that can extend to entire clusters resulting in major crop losses. However, population size and potential for doing damage varies widely within vineyards on the same farm, from region to region and year to year (Martinson et al. 1991). Hence, growers need reliable and effective methods for assessing risk from GBM, both in space and time, to make appropriate management decisions.

Background: Presently, the grape berry moth risk assessment protocol (GBMRAP) (Martinson et al. 1991) is the primary tool used by grape growers in the east to estimate timing of GBM management. For a high risk vineyard the protocol calls for an insecticide application at ten days post bloom (first generation GBM), early August (second generation), and if necessary, late August (third generation). As is true of other insects (and grapevines), development of GBM is temperature dependent. Although the recommended first spray is tied to bloom time, which in turn, is driven by temperature, the other timings are based solely on calendar date irrespective of temperature. In an average year the GBMRAP timings for control (using contact insecticides) may work fairly well but in cool years they may be applied early and in warm years they may be

applied late. Hence, what is needed is a temperature based development or phenology model to provide growers with a more reliable method to time management actions. Such a model has been developed for GBM (Tobin et al. 2001, 2003) in which the number of degree-days (DD) for GBM to develop from eggs to egg-laying adult females is approximately 810 DD (°F) (450 DD (°C)) using a base developmental threshold of 47 ° F (8.4 °C). Finding a reliable and practical biofix for initiating the phenology model is key to successful implementation. Our previous research has shown that trapping adult female moths, either with light traps, malaise traps, or panel traps baited with synthetic host volatiles, provides fairly clear information on female flight activity. Peak captures of females in the spring flight were good predictors of flight activity in subsequent generations. However, these trapping techniques are not grower friendly at this time.

Justification: The grape berry moth is the most destructive direct pest of grapes in that the larvae feed internally on grape berries resulting in loss of crop and often initiating bunch rot diseases. New York is the second largest and Pennsylvania is the fifth largest grape producing state in the US, and the vast majority of the grapes are grown along the shore of Lake Erie and in the Finger Lakes region of New York. In recent years, late season infestations of GBM have caught grape growers unaware, resulting in numerous load rejections at juice processing plants due to high GBM infestations and associated cluster diseases⁸. These late season infestations have caused considerable consternation to grape growers and to the grape industry. Speculation as to why we are now experiencing problems with this insect in the late summer has considered the loss of broad-spectrum contact insecticides and/or insecticide resistance. It is apparent that the newer compounds available for GBM management are not contact poisons, but must be ingested in order to kill. Preliminary studies carried out at PSU have demonstrated that GBM larvae within grape berries are protected from insecticide sprays. Therefore, the only window of opportunity available for the control of GBM using insecticides that must be ingested is the brief time during which neonate GBM larvae are chewing their way through the grape skin and into the berry. Ensuring that active insecticide residues are covering the grape berry when the newly hatched GBM larvae are attempting to chew their way in requires a precise method for anticipating and timing insecticide applications⁵.

Grower groups in NY, PA, MI, OH and other leading grape production states have consistently placed development of new pest management approaches that reduce environmental impact of viticulture^{1,3,5,9} (while retaining profitability¹⁰) as high research priorities. National Grape Cooperative growers in Michigan have listed "*Grape berry moth biology and management alternatives*" as a top priority (http://northeastipm.org/regu_regional.cfm), and the Regional Guidance Committee of the Viticulture Consortium East has listed "*Develop integrated crop management programs for specific grape production regions that are economically-feasible, environmentally sound, and socially acceptable*" as a top research priority. As a measure of the importance of grapes in the eastern US, crop profiles for wine and juice grapes are online for 10 eastern states at <http://pestdata.ncsu.edu/cropprofiles>. In 2002, a "Grape Berry Moth Summit" was organized by the main eastern US grape processor, and attended by processors, growers, commodity leaders, extension specialists, and researchers from across the eastern US states, including the PD's of this proposal.^{3,5,6,7,10,12,13} Without the intervention of this project, grower loads will continue to be rejected at the processing plants, the economic well being of grape growers will be negatively impacted, and insecticides will continue to be misapplied with concomitant non-target impacts including effects on biodiversity, ecosystem services, and human health.

Project Objectives:

1. **Research:** Compare effectiveness of GBM control with insecticide when timing is based on grape berry moth risk assessment protocol verses a degree-day phenology model.
2. **Research and Extension:** Investigate use of alternative methods to determine first flight of female moths as a biofix for degree-day phenology model.
3. **Extension:** Incorporate the phenology model into a Cooperative Extension NEWA system for use by growers

Anticipated Impacts

Economic benefits: Grape growers and extension educators throughout the region have been seeking a new method to better time GBM management decisions, especially for the second and third generations. A temperature based phenology model may represent a major improvement over the calendar-based approach currently being employed that will lead to more cost efficient, less wasteful, and more efficacious use of insecticides for GBM control, as well as a reduction in late season bunch rots⁸.

Safeguarding human health and the environment: Grape growers will transition from the remaining broad-spectrum insecticides to more targeted, and less environmentally damaging compounds through the adoption of this more accurate method for calculating spray timings. Reduction in the use of broad-spectrum compounds will reduce grower/applicator risk, non-target impacts, and issues associated with pesticide residues and human health.^{1,9}

Implementation of IPM: This study is focused on refining and advancing our understanding of GBM phenology and the direct implementation of these findings into a regional IPM strategy for management of this important pest. Growers will be exposed to this approach with regular Coffee Pot meetings (ca. 5/season, 25 growers/session), a revised GBM-IPM extension brochure (ca 200 growers in PA/NY, field demonstration projects and associated grower meetings (ca. 100 growers/meeting), as well as via the regular summer and winter grower Extension conferences (ca. 100-200). We anticipate that growers educated via these venues will readily adapt to this improved approach.^{7,5,11,13,14}