Progress in Managing Internal Lepidopteran Pests in Tree Fruit

Deborah I. Breth and Elizabeth Tee
Lake Ontario Fruit Program, Cornell Cooperative Extension, Albion, NY

A resurgence of fruit worms such as codling moth, oriental fruit moth and lesser appleworm that feed on the flesh of apples, pears and stone fruit are threatening the NY fruit industry. More intensive monitoring and better-timed sprays with newer crop protectants has the potential to control this threat.

The NY processing apple market (excluding juice) is worth $33 M, and the fresh apple market is worth $137 million. Profitability of the fruit industry in Western New York is being challenged by a resurgence of codling moth (CM), oriental fruit moth (OFM), and lesser appleworm (LAW) that feed on the flesh of apples, pears, and stone fruit. These insects have been historically controlled by broad-spectrum insecticides applied for control of other pests. There is a "zero" tolerance for these larvae in most fruit markets. Three CM larvae were found in a shipment of apples sent to Taiwan which resulted in the Washington apple industry loosing their $47 M market to Taiwan for five months in 2005. These worms were responsible for over 700 truckloads of fruit being rejected at processors in Pennsylvania, also during 2005, resulting in a loss to growers of over $1M. A 50-bin truckload of Idareds in NY for processing is worth $3,900, but if directed to the juice market due to worm infestation, the value is only $1,600; with 3,400 acres of Idared in NY, that is a potential loss of $7 M.

Extension Effort

The Lake Ontario Fruit Program responded to this problem by developing a pheromone trap network that is maintained across the region of 23 sites including traps for CM, OFM, and LAW. NYS IPM, Mott's, and other grower-supported educational programs have provided funding for this internal lepidopteran pest network in the Western New York region. Traps are monitored weekly and results are reported in newsletters, faxes, emails, and as of 2006, on the web at **http://www.fruit.cornell.edu/lof/** .

The trap catch numbers from the trap network serve as a foundation to run degree day models to predict egg hatch and subsequent spray timings for CM and OFM. The weather data is obtained on the NEWA website **(http://newa.nysaes.cornell.edu/)** using the Degree Day Summaries "Base 45F" for OFM and "Modified base 50F" for CM. This information is also posted in newsletters, faxes and emails.

Internal Lepidopteran pests are the topic for various winter fruit schools, the Empire State Fruit and Vegetable Expo, and special workshops and field meetings where growers and consultants can learn about the biology, identification characteristics, monitoring methods and control of these pests.

Trends

Over the past five years, the Lake Ontario Fruit Program has conducted a survey of infested fruit samples collected at receiving stations in Western New York to quantify and qualify the damage caused by internal lepidopteran pests. The larvae are collected from the wormy apple samples, fixed in 1188 KAAD larval fixative, and identified by presence or absence of an anal comb (Chapman and Lienk), and the number of crochets (hooks) on the bottom of the feet of the caterpillars (G. Krawchyk, unpublished data). The damage in the fruit is also assessed and recorded for use in identifying the pest.

Figure 1 shows that the trend is for warm seasons to result in a greater percentage of infested truckloads of fruit. The years of 2002, 2005 and 2006 were warmer than the cool wet seasons we experienced in 2003-2004, resulting in higher numbers of infested truckloads in '02, '05, and '06. Figure 2 shows that the greater infestation potential for the season, results in more varieties infested by these pests. The most common varieties include Greening, Idared, Rome, Golden Delicious, Crispin and Monroe. In heavy- pressure seasons, Jonagold, Empire, Gala and Cortland also become targets.

The proportion of the larvae found in the fruit has gone from a majority of OFM to a majority of CM since 2002. Table 1 shows the percentage of larvae identified as CM, OFM, LAW, other and unknown. Over the course of three seasons since 2002, our pest complex has trended toward more CM fruit infestations across the region.

In 2005, CM was identified as the key pest in 56% of the larvae identified in infested truckloads of apples in WNY. This is a 100% increase over previous years when the primary pest was OFM. This trend held through 2006 with 49% of larvae identified as CM; however, this number is probably low due to the number of very small, unidentified larvae found in fruit in late October and early November that were more than likely the "suicide" generation of CM, the third brood of larvae that do not survive the winter.

Trap Network Results

The total number of trap locations increased in 2006 due to an increase in

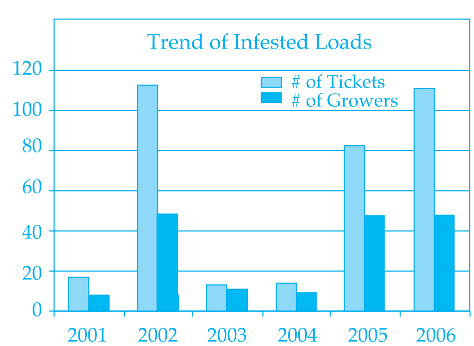

Figure 1. Number of loads of worm infestation over the last 6 years in western New York.

funding from NYSIPM Program. Overall, there was an increase in number of moths caught per trap per season in 2006 compared to 2005 at most sites for both CM and OFM. Figures 3 and 4 show the variation across orchards in the population pressure from each pest. Some orchards had very high populations of OFM and CM, some just a high population of either OFM or CM. Orchards with the highest OFM population were generally located near abandoned apples and peach orchards.

The trap network also showed differences among orchards in determining first trap catch or "biofix" which is used to start the degree-day developmental models. Table 2 shows that OFM trap catch did not typically vary by much more than a week and appears to be more dependent on insect pressure, the higher the pressure, the earlier the catch. But CM first trap catch can vary by as much as two to three weeks, and in some orchards, the recommended action threshold for CM of five moths per trap per week is never reached. The proximity to Lake Ontario appears to be a factor in predicting first trap catch for CM, but not OFM.

This difference in timing raises the question of whether we can make regional recommendations for timing control of CM. The "PETE" model, "Predictive Extension Timing Estimator", developed at Michigan State University in the 70's, has historically been used to time spray applications for control of codling moth. The model predicts adult and egg development, and recommends spray timing based on egg development and hatch. The first spray application is recommended at 250 DD (base 50F) after first sustained trap catch, with a second application to follow in 10-14 days. The second generation spray timing is recommended at 1250-1300 DD (base 50F) with a second application to follow in 10-14 days. If trap catch exceeds 5 moths per trap per week, sprays should continue.

Recent trap data collected in 2005-06 have shown a trend for deviation in spray timing based on the PETE model compared to actual trap catch information in orchards. Figure 5 shows the difference in spray timing recommendations made by the PETE model DD timings compared to the timings that are based on trap data exceeding the 5 moths per trap threshold and timing the first spray for 250 DD50 after the high moth trap catch followed up with a second application in 10 days.

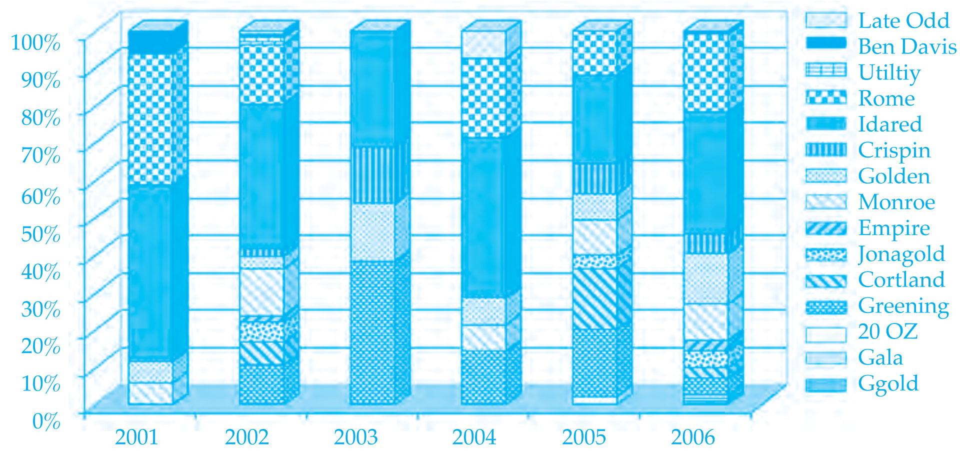

Figure 2. The proportion of infested apple loads by variety by year.

At the Albion 1 site, with a moderate population of CM, using the PETE model would have completely missed the last brood of eggs from the flight of moths that occurred in late August. The Albion 2 site had very high populations of both CM and OFM and if the orchard was not monitored with traps, the grower would not have known how much pressure the orchard was under. This orchard, even though it was on a 10-14 day insecticide schedule, had over 3% fruit infestation. The Waterport location had a low population of CM, with trap catch never exceeding the five moths per trap per week threshold until July 31. Finally, the Rt 272 site had a very high population of CM, which, based on trap numbers, required full season coverage that would have been missed if no traps were present to assess the pressure.

If growers and consultants are relying on historical or regional degree day timings, they may miss very important spray windows resulting in fruit infestation, misinterpret the effectiveness of insecticides, or spray more than they need for control of these pests. More work must be done to re-evaluate the PETE model and its usefulness in Western NY now that we have more significant CM numbers.

TABLE 1

Proportion of various larvae identification by year.

Larval ID	Percent of total worms 2002	2005	2006
CM	21	56	49
OFM	61	20	24
LAW	11	7	6
Other *		1	6
Unknown	7	16	15

* Other include European corn borer, dock sawfly, and fruit fly maggots

This work will continue with funding by the NY Farm Viability Institute in 2007-2008.

Managing Internal Lepidopteran Pests

Compared to five years ago, two things have changed. First, growers and consultants are becoming more aware of the potential for fruit infestation, and have increased the use of pheromone

TABLE 2

First OFM and CM trap catch for sites inland and along Lake Ontario.

	Location	1st OFM Catch	1st CM Catch
>3 miles from Lake Ontario	Albion	28-Apr	15-May
	Medina	28-Apr	29-May
	Albion 2	1-May	15-May
	Knowlesville	1-May	29-May
	Williamson	1-May	15-May
	Brockport	8-May	15-May
	Lockport	8-May	8-May
	Sodus	8-May	5-Jun
	Williamson	8-May	15-May
	Redcreek	no data	22-May
<3 miles from Lake Ontario	North Appleton	1-May	15-May
	Burt	1-May	29-May
	Pultneyville E	1-May	29-May
	Pultneyville W	1-May	29-May
	Waterport	1-May	29-May
	Morton	1-May	29-May
	Youngstown	1-May	29-May
	North Appleton2	8-May	29-May
	North Sodus E	8-May	29-May
	North Sodus W	8-May	29-May
	RT 272 Parkway	8-May	22-May
	North Appleton3	1-May	29-May

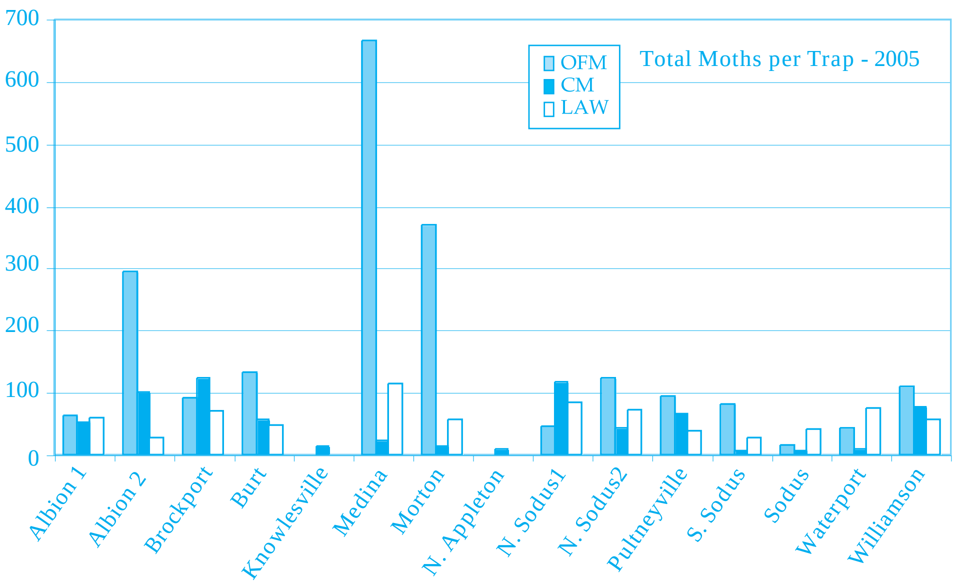

Figure 3. Total CM, OFM, and LAW moths per trap per season for each site in the trap netweork in 2005.

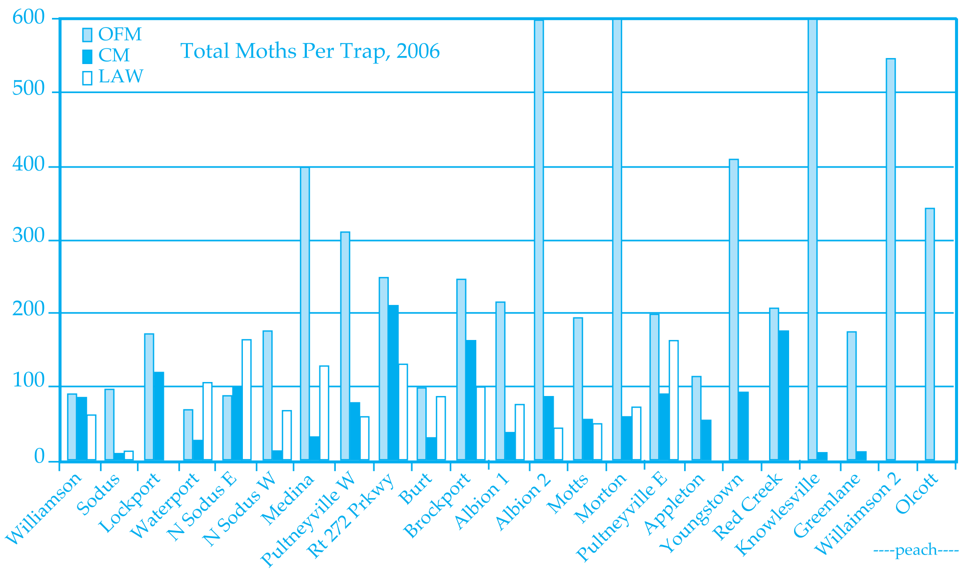

Figure 4. Total CM, OFM, and LAW moths caught per trap per season in each site in the trap network in 2006.

traps for monitoring internal lepidopteran activity in their businesses. Second, growers have increased the number of applications of broad spectrum insecticides such as organophosphates and pyrethroids with internal lepidopteran larvae as the main focus. Prior to this, the challenging pest was obliquebanded leafroller. Although OBLR are still a piece of the pest management puzzle, the internal lepidopteran pests are more of the driving force for now.

There are several materials registered in NY for management of internal lepidopteran pests including two new neonicotinoids (Assail and Calypso), several formulations of pyrethroids, insect growth regulators (Intrepid), and we still have phosmet (Imidan) and azinphos-methyl (Guthion - registered in apples until 2012).

To illustrate the change in insecticide use, Table 3 shows the number of insecticides applied by class in 2006. Of 17 sites for which we have spray records and harvest evaluation data, analysis by regression shows that the % of infested fruit is related to the number of insecticide applicaitons with an R square of 416 (Figure 6).This means that only 41% of the variance in percent fruit damage is attributable to the number of insecticide sprays. This reinforces the idea that the number of sprays is not the total answer to the control of internal lepidopteran pests. The orchards that had fruit damage detected at harvest are processing orchards with a large, dense canopies suggesting that spray coverage plays a significant role in control. Spray timing based on pest development will also contribute to results in controlling the insects.

Mating disruption (MD) is also an option for managing internal lepidopteran pests, especially if OFM is the main pest; insecticides, however are still a necessary part of the equation. Mating disruption has several advantages, including reducing the mating population of OFM by flooding the orchard with female pheromone and making it difficult for the males to find the females to mate with. But there are also disadvantages with MD technology. Given the current state of technology, the pheromones dispensers are generally distributed manually in orchards by farm labor. If you have a ready supply of labor as is generally available in peaches for pruning, this activity will fit in well. But pheromone disruption for CM is a bit more challenging since it is critical to install the pheromone dispensers in the tree tops using poles that reach the tops of the trees or cherry pickers to drive down the row. This can be a difficult proposition in processing orchards. After distributing pheromone dispensers in multiple point sources at 100-200 per acre, trap catch is essentially zero since the male moths cannot find a direct plume of pheromone from the trap. This makes it more of a guessing game as to when to apply sprays. Drs. Art Agnello and W.H. Reissig from the NYS Agricultural Experiment Station have an extensive research program underway to test mating disruption dispensers. There are also large plot trials underway in Western NY to test the efficacy of mating disruption for both OFM and CM using Isomate CM/OFM TT, recently registered in NY.

The best management practices for preventing fruit infestation by CM, OFM, and LAW is to start with a good pheromone trapping program outlined in the *NY Fruit Quarterly* Summer 2005, Vol. 12, No. 2. The second step is to find a source of weather data to calculate degree day accumulations after first trap catch and high trap counts. One source is the NEWA network funded by the NYSIPM program and available on the web at **http://newa.nysaes.cornell.edu/.** The site provides access to weather data and degree day summaries, or you can use the degree day calculator on the NEWA site. Another source of weather data is an on-farm weather station; many of these incorporate software that will calculate degree-day accumulation.

The degree-day developmental models are used to time insecticide applications. Researchers are suggesting that the developmental models are based on the use of older contact insecticides such as pyrethroids and organophosphates. Their trials show that insect growth regulators should be applied at 150 DD base 50F after CM biofix in order to have a greater effect on the eggs. Neonicotinoids should be applied at 150-200 DD after biofix in order to have a greater effect on hatching larvae. Admittedly, there is still a lot of fine tuning of spray application. Finally, the best control will result from the best spray coverage. While this is not an article about spray coverage, spray coverage is important in managing internal lepidopteran pests as well as mites, leafrollers, and more.

Summary

- The trend is for increasing pressure from CM in WNY apple and pear orchards.
- Warm seasons are more conducive to internal lepidopteran pests than cool, wet, seasons.
- The warmer the season, the more varieties will be impacted by internal lepidopteran pests.
- Pheromone traps, if properly maintained, provide information regarding first trap catch of moths to set biofix or the start date for degree-day accumulations; continued maintenance will provide information regarding actual moth activity for the 2nd and 3rd generation.
- Pheromone traps provide information about the amount of pressure in or surrounding an orchard from CM, OFM, or LAW eliminating the risks in relying on "regional" or "historical" information.
- "The more sprays, the better control" does not always hold true; spray coverage and timing are critical components for success.

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Debbie Breth is an area extension educator in the Lake Ontario region who specializes in integrated pest management. Liz Tee is program assistant who works with Debbie.

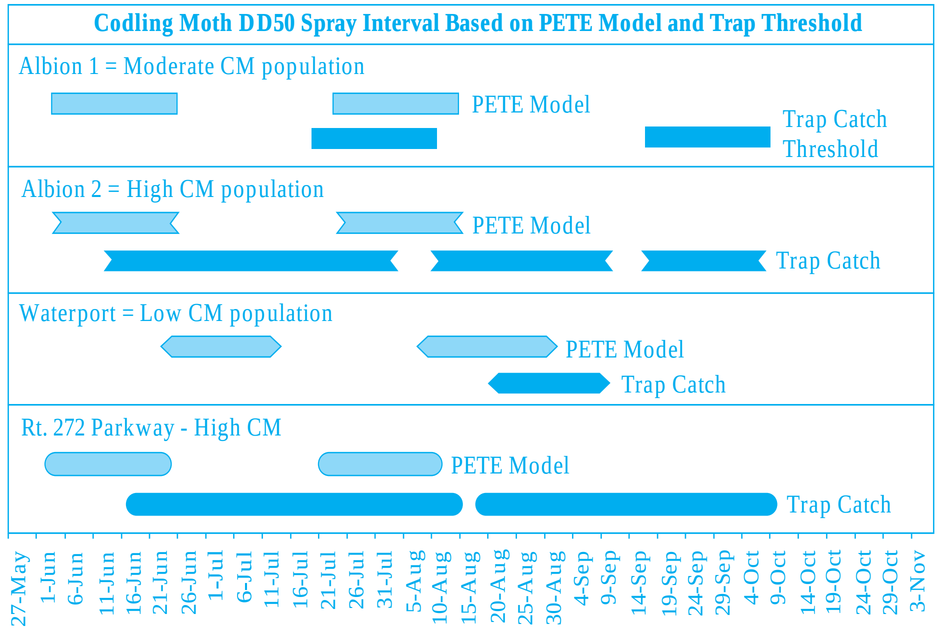

Figure 5. Comparison of spray timing recommendations calculated by the PETE model and those based on exceeding trap threshold with first spray applied at 250DD50 plus 10 days after to cover a 20 day period.

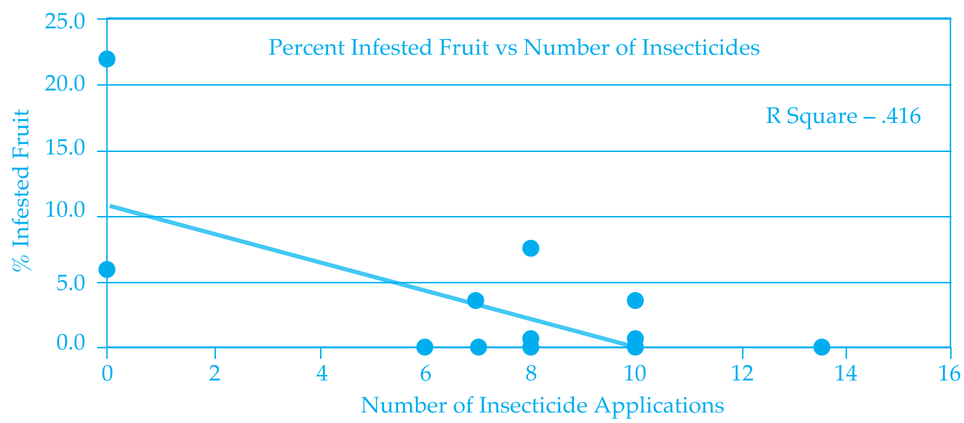

Figure 6. The percent of fruit infestation by internal lepidopteran pests plotted against the number of insecticide applications effective in controlling these pests.

TABLE 3

Number of insecticide sprays by insecticide class and percentage of fruit damaged by internal lepidopteran pests.

	Total Sprays by Insecticide Class				
Location	Insect Growth Regulator	Neonicotinoid	Organo - Phosphate	Pyrethroid	% Lepidopteran n Infested Fruit
Albion 1	1	4	3	2	0.0
Albion 2	-	2	7	1	3.4
Brockport	-	-	4	4	7.6
Burt	-	-	5.5	1.5	0.0
Morton	1	1	5	-	3.6
Lockport	-	2	4	2	0.0
Rt 272 Prkwy	2	2.5	5	4	0.0
Medina	-	-	6	4	0.4
Olcott	-	-	5.5	1.5	0.0
Pultneyville E	1	-	3	3	0.0
Pultneyville W	-	1	5	2	0.4
S. Sodus	2	-	1	3	0.0
Waterport	1	2	3	2	0.0
Williamson	-	3	5	2	0.8
Youngstown	-	-	2	4	0.0
Unsprayed check	-	-	-	-	22.0
Unsprayed check2	-	-	-	-	6.0