

Project Title: Biological Mite Control in Pennsylvania apple Orchards Through the Distribution and Conservation of the Predatory Mite, *Typhlodromus pyri*.

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Institution or Agency Conducting the Research: Pennsylvania State University Fruit Research & Extension Center

Proposal Number: PDA ME 444201

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Introduction

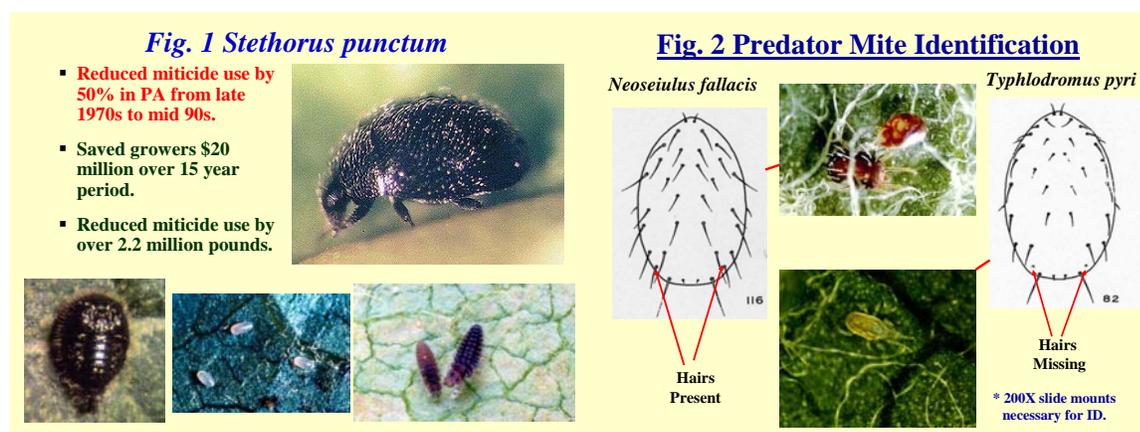
Pennsylvania was known internationally for a very successful IPM program based on biological control of mites in apple orchards by the lady beetle, *Stethorus punctum* from about 1978 – 1998 (Fig. 1) The introduction of several new classes of insecticides toxic to *Stethorus* (some neonicotinoid and IGR chitin inhibitors) and cheaper, more effective miticides practically eliminated this predator from orchards. The replacement of one of the older very toxic carbamate insecticides (methomyl) with some of these new pesticides allowed the survival of beneficial mites of the family Phytoseiidae. The discovery in 2003 of the new predatory mite, *Typhlodromus pyri* (Scheuten) in apple orchards in a USDA-RAMP program using only reduced risk insecticides (Fig.2) was a perfect replacement for *Stethorus*. If conserved using nontoxic insecticides, *T. pyri* is at least 10 times more effective than *Stethorus* in reducing pest mite injury.

Objective 1: Survey predatory mites throughout the major fruit growing regions of Pennsylvania.

During the grant, 45 grower sites in four counties have been evaluated for predatory mite diversity. *T. pyri* was detected in 31 of these sites, but the abundance and importance of this predator mite varied widely according to the pesticide use patterns. Surveys are now being limited to growers that are establishing *T. pyri* in orchards through the Agricultural Management Assistance (AMA) Program. This Natural Resource Conservation Service (NRCS) program has been supporting growers that are either conserving existing populations in their orchards that this project has identified or by augmenting populations from ‘seed’ orchards.

Predatory mite data was taken in 2005 to 2007 in the 6 paired plots of reduced risk (RAMP) and conventionally managed apple orchards (5-10 acres in size). The RAMP sites have not received broadspectrum OP, carbamate, or pyrethroids sprays since 2001 and have transitioned away from the ecology found in conventional grower orchards. Pest and predator mite counts were made 3-6 times during the 2006 season and were intensified in 2007 to every 2 weeks. We have slide mounted a sub-sample of about 8,000 specimens for identification from the RAMP and conventional orchards for both years and found *T. pyri* to be the dominant predator in 5 of the 6 sites. We also found an introduced Mediterranean species, *Amblyseius andersonii* Garman to be the dominant predator in the State College site where it apparently escaped from greenhouses and became established in the apple orchards. Both species were giving complete biological mite control of spider mites in all 6 sites in all of the RAMP and most of the grower conventional sites.

We are continuing the evaluation of 11 new sites with 8 new growers who are participating in a 900 acre Area-wide Pheromone Mating Disruption Approach to Control Two Major Fruit Pests in Pennsylvania Orchards (PDA Contract ME 445577) by Hull and Krawczyk. In 2006 & 2007, mite and predatory mite leaf counts were made twice during the season in at least one MD block of all participating apple growers and in the conventional orchards of each of the four main sites. Since pesticide use patterns were not altered for the project in 2006, these counts and predator identifications will serve as a baseline for developing IPM spray programs in 2007 and for comparison of changes in predator species composition and abundance in subsequent years of management. A subsample of 800 predatory mites have been saved from the 2006 & 2007 leaf counts and slide mounted for identification to species under a compound microscope. *Typhlodromus pyri* (Scheuten) is the dominant Phytoseiid predatory mite in nine of the eleven orchards sampled and the unreliable *Amblyseius fallacis* (Garman) is dominant in only two sites. During the course of the grant, approximately 15,000 specimens of phytoseiid predator mites were individually slide mounted, cleared and identified under a specially adapted phased contrast compound microscope.



Objective 2: Conserve T. pyri in sites where it already exists.

We have developed a very good data base of pesticide impacts on predatory mites in general which is now available through the *Pennsylvania Tree Fruit Production Guide* for growers and the public alike either as a hard copy or free in electronic format from the Penn State Fruit Research and Extension Center website (<http://frec.cas.psu.edu/>). In order to continue the spread

and conservation of *T. pyri* in PA apple orchards, we continue field testing and bioassays with all pesticides, especially those newly registered, to inform growers of the impacts their management choices will have on what should be a completely sustainable biological mite control. While fruit growers currently have a large number of miticides available, resistance has developed in the European red mite to many of these in less than 3 seasons and the cost of these products for many growers is approximately 30% of their total insecticide budget. The use of miticides alone is clearly not a sustainable practice. We have determined that a unique insect growth regulator type of miticide known as Envidor® (spiridiclofen) is very effective in controlling pest mites without harming *T. pyri* populations. This makes it an ideal tool to control pest mites when *T. pyri* is being established into new orchards or to supplement mite control when predator/prey ratios have shifted negatively due to the use of harmful pesticides. Further establishment of *T. pyri* in areas outside of Adams County and with new growers, would move these values closer towards complete biological mite control in PA apple orchards (Fig. 5).

In order to continue the spread and conservation of *T. pyri* in PA apple orchards, we continue field testing and bioassays with all pesticides, especially those newly registered, to inform growers of the impacts their management choices will have on what should be completely sustainable biological mite control. In 2006 we determined in large plot trials that the miticide Zeal which was thought to be safe to *T. pyri* was actually moderately toxic. In 2007 we completed 3 grower demonstration large block trials with two commonly used miticides and determined the class of miticides that Nexter (pyridabin) belongs to is very harmful to phytoseiid predator mites in general, but that an insect growth regulator type of miticide known as Envidor (spiridoclofen), is very effective in controlling pest mites without harming *T. pyri* populations. This makes it an ideal tool to control pest mites when *T. pyri* is being established into new orchards or to supplement mite control when predator/prey ratios have shifted negatively due to the use of harmful pesticides. The success of the *T. pyri* program is such that we will continue testing the effects of new miticides, insecticides and selected fungicides as part of our normal pesticide testing programs to determine effects on *T. pyri* populations for the future. The results will be incorporated into the PSU recommendations for apple production and to NRCS protocols for the conservation of biological mite control.

Occasional flare ups of pest mites due to the introductions of new pesticides, movement of other mites from the ground cover during drought years and the need for dormant oil applications to control occasional outbreaks of San Jose Scale will mean that complete elimination of miticides and dormant oil will probably never occur. Biological control with *T. pyri* in PA apples is a model for sustainability and has the potential to work in other crops such as peaches/nectarines, grapes, Christmas trees, and small fruits. But only if reduced risk IPM programs can also be developed for these crops and the use of broadspectrum insecticides such as organophosphate and pyrethroids are eliminated and *T. pyri* populations established through similar conservation programs.

Objective 3: Introduce or augment T. pyri populations in sites where they are currently absent or present at very low levels.

We have now assisted in 26 transfers of *T. pyri* from seed sites (Table 1) and established them into 22 new sites totaling 297 acres with 20 growers in 3 states (Table 2). *T. pyri* is more mobile than originally thought. It appears to be able to immigrate (by wind or transfer of bulk bins) into adjacent blocks and become established within a season or two if the pesticide

program is benign. After becoming established, they become the dominant mite predators within a season and give complete pest mite control. We now estimate that approximately 8,000 of Pennsylvania's 22,000 acres of apple have or are in the process of transitioning to *T. pyri* as a sustainable component biological mite control. Our predatory mite program has been so successful, that fruit research stations from Rutgers's University, Michigan State University, West Virginia State University, and Virginia Tech have all started field sites with *T. pyri* from the Penn State Fruit Research & Extension Center at Biglerville in 2007 and North Carolina State University has requested to start a program in 2008.

Table 1. Pennsylvania university and grower "seed" sites available for the introduction and/or augmentation of the predatory mite, *T. pyri*, populations into commercial apple orchards.

Block	County	Acreage
Lerew Orchards	Adams	500
S. Slaybaugh	Adams	200
D. & S. Slaybaugh	Adams	500
D. & J. Wenk	Adams	500
Pullig Greening Block	Adams	30
E. Diveley Jr.	Adams	45
E. Diveley Sr.	Adams	25
W. Schulteis	Adams	20
Doc Oyler	Adams	20
PSU Biglerville	Adams	40
PSU Arendtville	Adams	20
		Total: 1,900 acres

Table 2. *T. pyri* introduction or augmentation sites in Pennsylvania apple orchards from 2005 to July 2007.

Block	County	Date	Source	Acreage
2005				
Boyer RAMP	Bedford	5/27, 6/14	Diveley Sr. Greening Bl.	5
D. Slaybaugh RAMP	Adams	5/26	Diveley Sr. Greening Bl.	10
D. Slaybaugh IPM, Adams Co.	Adams	6/1, 6/7	Diveley Sr. Greening Bl.	10
S. Slaybaugh RAMP	Adams	6/7	Lerew RAMP Bl.	6
S. Slaybaugh IPM	Adams	6/2, 6/7	Diveley Sr. Greening Bl.	7
D. Wenk RAMP	Adams	5/24	Lerew RAMP Bl.	5
D. Wenk Weaner Mtn.	Adams	5/24	Diveley Sr. Greening Bl.	7
J. Wenk Trellis Bl.	Adams	6/10	Lerew RAMP Bl.	7
Harner Farms RAMP	Centre	7/20	Lerew RAMP Bl.	5
2006				
A. Hale	Adams	5/19	E. Diveley Jr.	20
D. Garretson	Adams	6/1	PSU Biglerville #1	30
W. Schulteis	Adams	6/13	Diveley Sr. Greenings	20
M. Rice	Adams	6/18	PSU Biglerville #1	10

PSU Arendtville Orchards	Adams	6/15, 6/23	E. Diveley Jr.	10
PSU Biglerville #4A	Adams	6/15	PSU Biglerville #1	5
WV University Station – H. Hogmire	Kearneysville, WV	6/30	Diveley Sr. Greenings	5
2007				
Neil Starner	Adams	6/26, 6/28	Aville #1, D. Wenk	50
James Duffy	Adams	6/19, 6/21	Aville #1	50
Brad Hollabaugh	Adams	7/1	PSU Station Raff Bl.	5
Rutger’s University Fruit Research Station – P. Shearer	New Jersey	7/5, 9/12	PSU Station Raff Bl.	10
Michigan State University Fruit Research Station – John Wise	Fennville, Michigan	7/20	PSU Station Raff Bl.	10
Virginia Tech Fruit Research Station – Chris Bergh	Winchester, Virginia	9/12	PSU Station Raff Bl.	10
Number of Sites: 22		Transfers: 24		Total: 297 acres

The success of *T. pyri* in the first RAMP program in giving complete control of European red mite combined with NRCS IPM incentives through the Agricultural Management Assistance (AMA) Environmental Quality Incentives Program (EQIP) from 2004-7 has greatly encouraged growers to adopt practices that will conserve this predator in both conventional and reduced risk orchards. Because *T. pyri* is organophosphate resistant, by eliminating pyrethroid and carbamate sprays as outlined in the NRCS AMA 595 specification (<http://paipm.cas.psu.edu/1218.htm>) by Biddinger, most of the participating RAMP growers and some of the AW mating disruption plots now have established populations of *T. pyri* in conventional orchards. These ‘modified’ conventional tactics indicate that fruit growers are learning and listening to what we have to say about the biological control of mites, but it is blurring the differences in mite control between reduced risk and conventional types of IPM programs.

Objective 4: Evaluation of success.

Objective 1. We consider our survey efforts to have been completed. We will discontinue further survey efforts except in support growers that have signed up for the NRCS AMA cost share program and in support of the developing mite biological control in the Areawide Mating Disruption project. The discovery of two new predator mite species during this survey demonstrates how little we know about the orchard ecology of Pennsylvania apple orchards. The fact that *A. andersoni* may prove to be even a better biological control agent for our weather conditions than *T. pyri* demonstrates how important it is to continuously look for suitable biocontrol agents. The ecology of orchards can change rapidly due to major changes in pesticide use such the elimination of organophosphate (OP) insecticides due to the FQPA process and the introduction of new classes of pesticides which may be more toxic to beneficials or have a different spectrum of activity on pests. The development of OP resistance in codling moth in the last decade has greatly changed pesticide use patterns as the industry has shifted from leafrollers

as their the primary insect pest. The accidental or intentional introduction of a foreign species such as *A. andersoni* or the Asian ladybird beetle can also quickly shift biological control programs away from native species or long-term residents (*T. pyri* was probably introduced from England over 100 years ago).

Objective 2. We have a very good data base of pesticide impacts on predatory mites in general which is now available through the *Pennsylvania Tree Fruit Production Guide* that is readily available to growers and the public alike either as a hard copy or free from the Penn State Fruit Research and Extension Center website (<http://frec.cas.psu.edu/>). Specifications on how to conserve biological mite control with predatory mites are also available for growers participating in the AMA program through their local or regional Natural Resources and Conservation Service office. We will continue to update pesticide impact ratings, predator to prey ratios for spray thresholds, and identification guides through these websites. This information is now available through the PA IPM program website (<http://paipm.cas.psu.edu/>).

Objective 3. We have made a good start mostly through the AMA/EQIP NRCS IPM incentives program to get growers to establish or conserve *T. pyri* for biological mite control, but the number of growers participating so far is somewhat disappointing. Some of this is due to the small size and difficulty in identifying predatory mites for the average grower. Its predecessor, the ladybird beetle *Stethorus punctum*, was much easier for growers to see and attribute successful mite control. Growers are for the most part unable to tell if they have the 1:10 predator to prey ratio necessary for biological mite control because they can't see the mites readily. When in doubt it is sometimes easier to spray rather than count, despite the cost. The fact that the pesticide industry has developed a multitude of new acaricides available for mite control for the first time in 20 years does not help this situation. Some growers also don't like the real and perceived limitations on which pesticides they can use without impacting the predatory mites. As FQPA is implemented and older classes of pesticides are replaced with the more expensive reduced risk pesticides, these limitations will be less important.

The AMA incentive program at only \$6/acre was too low for most growers to get excited about this program in comparison to other higher value incentives and barely covered the labor costs of transfers from the "seed" sites. To date NRCS has paid approximately \$18,000 to apple growers (at \$6/A over a 3 year contract for AMA) to establish and conserve *T. pyri* for biological mite control. The cost share was increased to \$18/A through the EQIP program starting in 2007 and several new growers signed up for this IPM option for the next 3 years. The money available for IPM in EQIP remains much lower than it was for the now defunct AMA program and this will probably not change until more money is allocated for IPM and specialty crops under the new Farm Bill in late 2007.

In Figs. 1 & 2 below, we see the miticide use for Pennsylvania apple orchards in 2005 according to the NASS estimates. More recent estimates are not available, but are probably miticide use has probably increased since then. If our estimate of a third of the PA apple orchards are under biological mite control due to *T. pyri*, miticide usage should also be reduced proportionately, although dormant oil is also used to control scale insects. Roughly this should be a reduction of about 700 lb ai/year of miticide and 18,500 gallons of dormant and summer oil/year worth \$233,000/year. If all 22,000 acres of apple in PA were under biological mite control with *T. pyri*, most of the \$700,000 dollars would be eliminated each season and most of

the 2,200 lb ai of miticide and 56,000 gallons of oil would not be applied to impact the environment.

Fig. 1 Miticide Use in PA Apple Orchards 2005
% of 22,00 Acres Treated

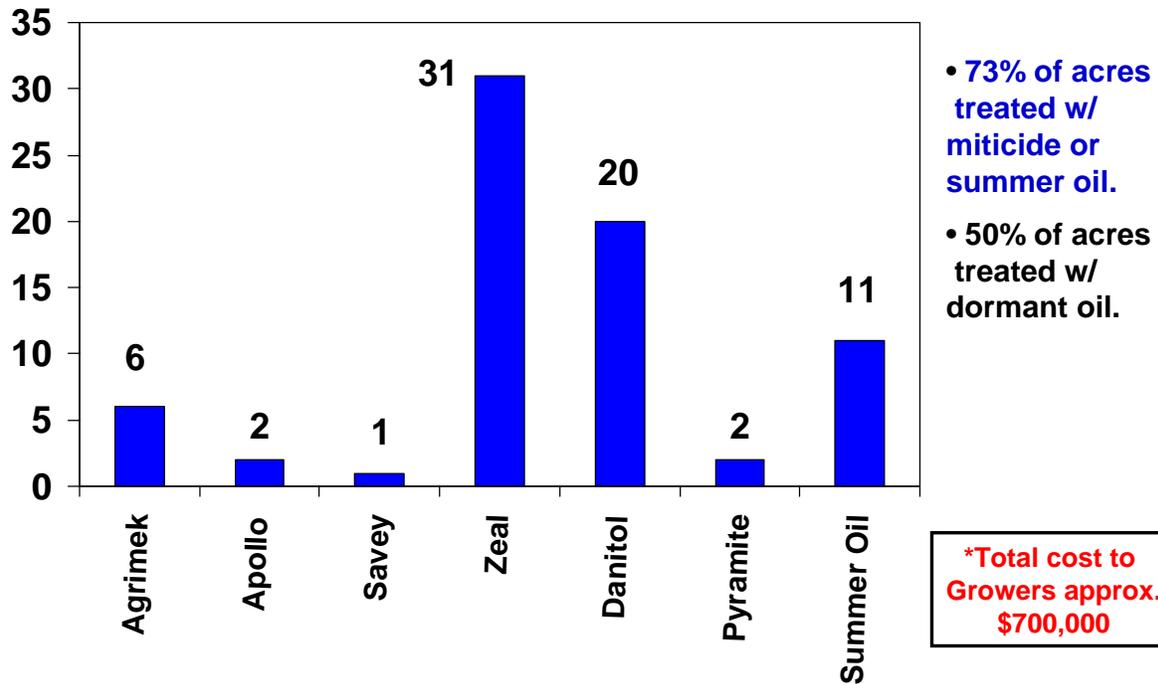
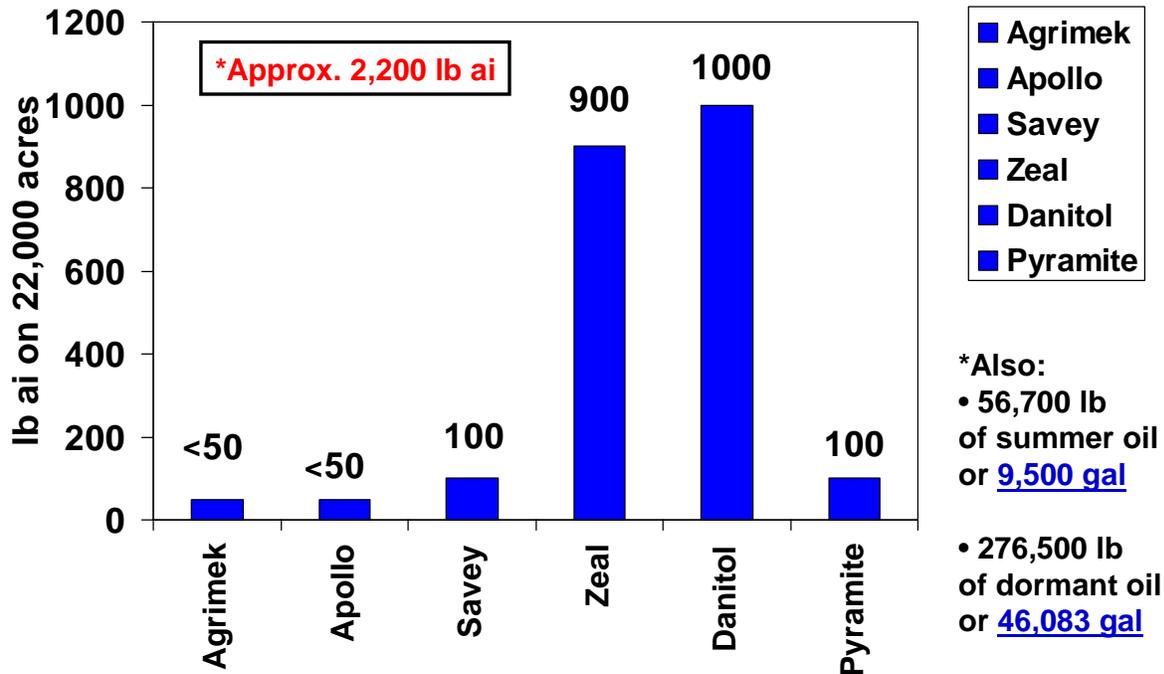


Fig. 2 Miticide Use in PA Apple Orchards 2005
Amount Applied



To date NRCS has paid approximately \$30,000 to growers (at \$6-18/A over a 3 year contract) through the AMA& EQIP programs on approximately 3,000 acres (Attachment 1). Using the NAAS data, we developed Table 3 which shows an annual cost of almost \$700,000/year on miticides and oil for mite control. The cost of miticides and especially oil has greatly increased since 2005, but we will use the 2005 figures as a baseline for comparison. Figs. 3-4 indicate that approximately 2,200 lb active ingredient (ai) of miticide and almost 55,000 gallons of oil are applied each season to the 22,000 acres of PA apples.

Table 3. Miticide use and cost based on data from National Agricultural Statistics Survey Data for PA in 2005.

Miticide	% A Treated in 2005 (22,000 A)	Total Acres	Rate/A	Cost/A	Total Cost
Agrimek	6%	1,320	10 fl oz	\$51.34	\$67,769
Apollo	2%	440	4 fl oz	\$42.45	\$18,678
Savey	1%	220	3 oz	\$47.25	\$10,385
Zeal	31%	6,820	2.5 fl oz	\$57.38	\$391,322
Danitol	20%	4,400	12 fl oz	\$13.92	\$61,28
Pyramite	2%	440	4.4 oz	\$26.62	\$11,713
Summer Oil	11%	2,420	1 gal	\$4.40	\$10,648
Dormant Oil	50%	11,000	3 gal	\$10.41	\$114,510
				Total	\$686,293

Fig. 3 Miticide Use in PA Apple Orchards 2005
% of 22,00 Acres Treated

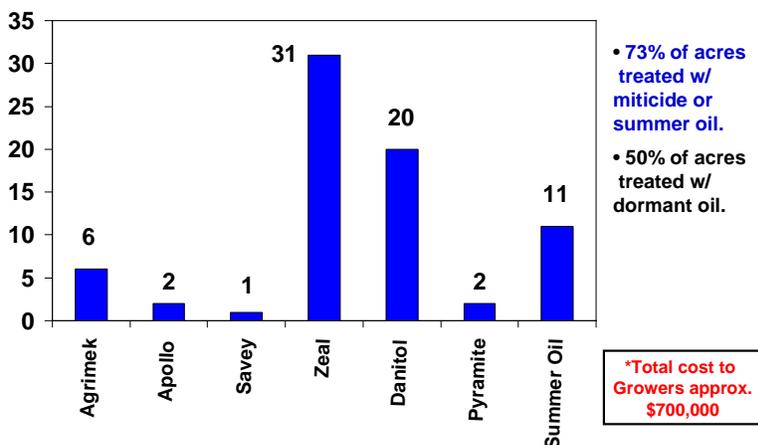
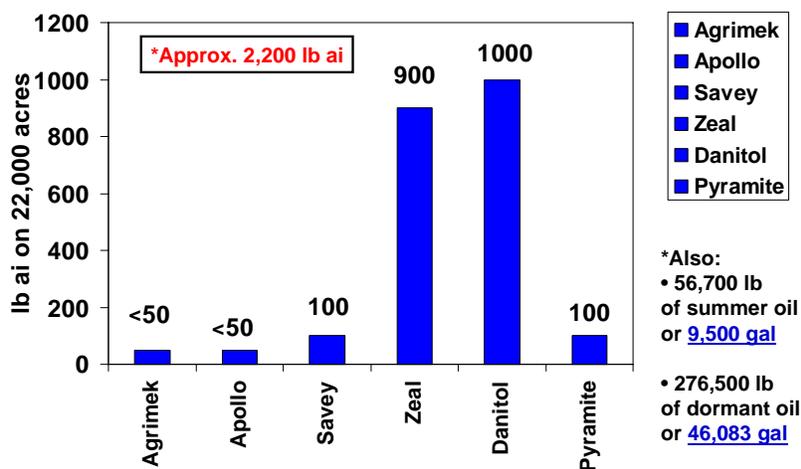


Fig. 4 Miticide Use in PA Apple Orchards 2005
Amount Applied



Once established and the guidelines for pesticide use are followed, *T. pyri* is a completely sustainable biological control agent capable of reducing the use of miticide and oil use by at least 90%. Based on these figures, it can be extrapolated that the \$30,000 that NRCS invested on 3,000 acres in this program, actually saved growers \$117,000 in miticide/oil costs and reduced miticide use by 310 lb ai and oil by 4,900 gallons (Fig. 5). As stated earlier, the acreage established with growers has expanded to at least 8,000 acres in the state. At this level, growers are reducing miticide use by 800 lb ai/year and oil by 12,700 gallons/yr for a savings of approximately \$300,000/year (Fig.6).

Fig. 5 Bottom Line To PA Apple Growers

<u>Presently w/o <i>T. pyri</i></u>	<u><i>T. pyri</i> Conserved/Introduced</u>
<ul style="list-style-type: none"> • Miticides and oil represent about 30% of arthropod control costs on 22,000 acres. <ul style="list-style-type: none"> – 2005 cost for miticides on 22,000 acres was about \$561,000. – 2005 cost for dormant & summer oil is about \$125,000. • Over 1 ton of miticide AI/ year & about 55,000 gallons of dormant & summer oil. • Resistance to most current miticides & non-target effects. 	<ul style="list-style-type: none"> • Only a dormant oil application is necessary to supplement <i>T. pyri</i> & scale control every other year. <ul style="list-style-type: none"> – total cost is \$50,000/year. • Almost no miticide AI & only 10,000 gal of dormant oil. • Sustainable long-term. <ul style="list-style-type: none"> – No resistance. – Basis for RR & organic IPM. – Applic. to stone/small fruits.

Fig. 6 NRCS Program Metrics for *T. pyri*

<u>NRCS IPM Acres</u>	<u>NRC Grower Expanded IPM Acres</u>
<ul style="list-style-type: none"> • Invested \$31,000 on 3,100 acres at \$6/A - later \$18/A. • Reduced miticide use by 310 lb ai on those acres worth \$99,000. • Reduced 4,900 gallons of oil worth \$18,000. 	<ul style="list-style-type: none"> • Grower/PSU transfers & natural migration to 8,000 acres in 3 years. • Reduced by 800 lb ai worth \$250,000/yr each season. • Reduced oil by 12,700 gallons worth \$45,000/yr.

Objective 5: Grower education and project implementation.

The information related to practical implementation of biological mite control was presented to Pennsylvania fruit growers during educational meetings held in all Pennsylvania major fruit growing regions. The advantages of the program and program constraints were stressed and explained to growers. Numerous growers interested in the project received additional instructions on program implementation and requirements. Recommendations were provided on non-disruptive insecticide program, which would protect beneficial mites in commercial apple orchards. Also, recommendations about biological mite control were presented during monthly

meetings organized for organic fruit growers at Fruit Research and Extension Center in Biglerville. Various scientific presentations were made of aspects of *T. pyri* biological mite control in both the mid-Atlantic region and the West Coast as can be seen by the publications and abstracts listed below.

Considerable work has been done on the PA IPM website to provide information on IPM cost-share programs from NRCS. This website development has been supported by a 1 year state level NRCS Conservation Innovation Grant and a cooperative agreement between PSU/PDA (PA IPM program under Ed Rajotte) has established between both parties to continue to provide technical and web support to NRCS IPM programs including the *T. pyri* biological control specification <http://resources.cas.psu.edu/ipm/nrcs/amabcspec07.pdf>. A press release by the PA IPM program concerning *T. pyri* can be found at: <http://paipm.cas.psu.edu/1236.htm>.

Publications:

- Hull, L. A., G. Krawczyk, E. Bohnenblust, & D. J. Biddinger. 2008a. Expansion of an area-wide pheromone mating disruption approach to control two major fruit pests in Pennsylvania orchards – year 2. *Penn Fruit News* 87(1): 50-60.
- Hull, L. A., G. Krawczyk, & D. Biddinger. 2008b. Large plot lepidoptera reduced risk insecticide study, 2007. *Arthropod Management Tests*. (in press).
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- Hull, L. A., G. Krawczyk, & D. Biddinger. 2007a. Large plot Lepidoptera study, 2006. *Arthropod Management Tests*. 32: A15. <http://www.entsoc.org/pubs/index.html>
- Hull, L. A., G. Krawczyk, & D. Biddinger. 2007. Efficacy of new insecticide chemistries against internal fruit feeding Lepidoptera and leafrollers on apple in Pennsylvania. (Abstract). Proceedings – 81st Ann. Western Orchard Pest Management and Disease Conference, Portland, OR. <http://entomology.tfrec.wsu.wopdmc/proceedings.php>
- Hull, L. A., G. Krawczyk, E. Bohnenblust, & D. J. Biddinger. 2007b. Management of CM and OFM through the implementation of an area-wide mating disruption program in Pennsylvania. (Abstract). Proceedings – 81st Ann. Western Orchard Pest Management and Disease Conference, Portland, OR. <http://entomology.tfrec.wsu.edu/wopdmc/proceedings.php>
- Hull, L. A. and **D. J. Biddinger**. 2006. Mite threshold airblast study 2005. *In: Arthropod Management Tests*, Vol. 31: A19. <http://www.entsoc.org/Protected/AMT/AMT31/AMT.aspx?Report=A19>.
- Biddinger, D. J. 2005. Predatory mites benefit apple growers in Pennsylvania. PA IPM, Fall 2005, Vol. 8, No. 4. <http://paipm.cas.psu.edu/newsletter.html>.
- Biddinger, D. J. & L. A. Hull. 2005. Survey of Pennsylvania apple orchards for a mite predator to give effective and sustainable control of spider mites. *Penn Fruit News*, 85: 23-28.

Biological Mite Control In Pennsylvania Apple Orchards (Updated PA IPM Press Release from 2006)

Pennsylvania tree fruit growers could potentially save up to one million dollars per year in miticide applications, reduce their pesticide usage by over one ton of active ingredient, reduce horticultural oil use by up to 40,000 gallons, as well as receive federal conservation payments, thanks to a predatory mite discovered in 2003 by a Penn State researcher. Pennsylvania's tree fruit industry ranks #4 in the nation and is worth \$69 million a year. At one time, the state was internationally known as a model system for the biological control of mites from the black lady beetle, *Stethorus punctum*, which was resistant to organophosphate insecticides. Conservation of *Stethorus* as a biological control agent reduced miticide use by 50 percent (an estimated 2.2 million pounds) over a 15 year period, saving growers an estimated \$20 million. However, the introduction of new classes of synthetic insecticides and miticides used to control orchard pests decimated populations of the black lady beetle but not all of the predatory mites.

The use of biological controls, such as predatory mites, is one component of a grower's integrated pest management (IPM) program. IPM aims to manage pests -- such as insects, diseases, weeds and animals -- by combining physical, biological and chemical tactics that are safe, profitable and environmentally compatible. According to Dr. David Biddinger, biocontrol specialist at the Penn State Fruit Research & Extension in Biglerville, Pa., it was a surprise to find high numbers of the predatory mite *Typhlodromus pyri* (*T. pyri*) in a commercial apple orchard in Adams county because, despite numerous survey in Pennsylvania and other mid-Atlantic states, it had never been found south of New York. "With the implementation of the Food Quality Protection Act, growers can no longer use some of the more toxic compounds in their orchards to control pests and more selective pesticides are being developed and applied," explains Dr. Biddinger. "As a result, we are starting to see new beneficial insects and mites in orchards."

Before the introduction of synthetic pesticides just before World War II, pest mites such as European red mites and the two-spotted spider mites were kept under control by predatory mites similar to *T. pyri*. According to Dr. Biddinger, it is very important to keep these pests at bay, because they feed on the leaves of apple trees and can reduce fruit quality, color and yield. As broad-spectrum insecticides were introduced to control insect pests, naturally occurring mite predators were also killed. This necessitated the use of pesticides to control the pest mites (miticides). "Miticides are expensive and pest mites quickly developed resistance (immunity) to them, forcing the pesticide companies to produce new products and pass related costs onto the grower," he says. Unfortunately, resistance in predatory mites develops much slower.

Armed with the observation that *T. pyri* were present in Pennsylvania and a grant from the Pennsylvania Apple Marketing Board in 2004, Dr. Biddinger surveyed approximately 20 apple orchards for the presence of the predator, usually only detected in orchards in New York and New England. He found that about one half of all surveyed orchards in Adams County contained populations of the predatory mite. "The survey confirmed what we already suspected, that *T. pyri* is capable of tolerating the hotter summers of Pennsylvania and can exist throughout the state," says Dr. Biddinger.

A four-year USDA Risk Avoidance and Mitigation Program (RAMP) grant allowed Dr. Biddinger and other researchers to work with seven apple growers and four peach growers in Adams, Bedford and Centre counties using only reduced risk insecticides to manage pests. Many of these new insecticides, such as the insect growth regulators, are not broad-spectrum in activity, meaning that they target only specific pests and are not harmful to predatory mites. "Unlike other predatory mite species, *T. pyri* never leaves the tree, even when pest mite populations decline. They are able to subsist on pollen and fungal spores until the pest mites return," Dr. Biddinger explains. "This close association with fruit trees allows them to respond to pest mite populations before the pests can cause injury, but makes them very susceptible to pesticides. Just one spray of a toxic compound can reduce predatory mites for the following three growing seasons or even wipe them out." *T. pyri* has the potential to be an effective mite predator on other tree fruit (e.g. peach, cherry and pears), small fruits (e.g. raspberries, blackberries & grapes) and

even Christmas trees, but those crops have not yet developed softer pesticide programs that would allow *T. pyri* to survive.

From 2005-7, a three-year Pennsylvania Department of Agriculture grant allowed Dr. Biddinger and other researchers at Biglerville to work specifically with fruit growers throughout the state to conserve or introduce *T. pyri* into apple orchards. "We transplanted *T. pyri* into new orchards with growers from various regions by transferring in the spring apple shoots from *T. pyri* "seed" orchards to almost 300 acres with over 20 growers," Dr. Biddinger says. "We've been having great results so far; the predatory mites seem to adapt well and are building up quickly in new orchards." The mites spread much more quickly from the original introduction site to other blocks on a farm more quickly than originally estimated. Spring introductions usually will increase to detectable levels by the same fall and often by the next season are abundant enough to give sustainable mite control alone. Currently, he estimates that about 8,000 of the 22,500 acres of Pennsylvania apple orchards now have *T. pyri* populations established and they could eventually spread throughout the state. Their effectiveness, however, is dependant on the pesticide programs used by the fruit growers. Other mid-Atlantic states including Virginia, West Virginia, New Jersey and North Carolina are developing similar biological mite control programs using *T. pyri* from the PSU Fruit Research & Extension Center.

Through the PDA grant, Dr. Biddinger is also working with growers to conserve *T. pyri* in sites where it already exists and advising them how to maintain sustainable mite control. Since there is often a lag period of 6 months to a year before the predator population become abundant enough to regulate pest mites alone, other measures may be needed to keep the pest mites under control in the meantime. "We are advising growers to use non-toxic dormant oil sprays to augment mite control or to use non-toxic miticides to control only the pest mites and to avoid using toxic insecticides such as pyrethroids to control other pests. Pesticide impact ratings for *T. pyri* and other beneficial insects are an integral part of the PSU *Tree Fruit Production Guide*.

Not only do growers benefit from reduced pesticides and production costs, but they may also receive government payments as an incentive for adopting these practices. Dr. Biddinger encourages interested growers to participate in this incentive program aimed at supporting this transition to environmentally friendly pest management and pesticide handling tactics. The program, Environmental Quality Incentives Program (EQIP), is administered through the USDA - National Resources Conservation Service (NRCS). The program partially reimburses growers for the introduction of various conservation practices into their farm operations, including biological controls in an IPM program. According to Barry Frantz, assistant state conservationist for programs with the USDA in Pennsylvania, NRCS, EQIP provides cost-share assistance to agricultural producers to voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation into their farming operations. "Producers may construct or improve water management structures or irrigation structures, plant trees for windbreaks or to improve water quality, mitigate risk through production diversification or resource conservation practices, adopt integrated pest management tactics, or transition to organic farming," Frantz explains. Currently, Dr. Biddinger says they are testing new low-toxicity pesticides to see how they will affect *T. pyri* and are looking to expand the program to other areas of the state. For more information on the project, contact Dr. David Biddinger at (717) 677-6116 or by e-mail at djb134@psu.edu.