Spotted Lanternfly & Other Invasive Fruit Pests

David Biddinger, Greg Krawczyk, Julie Urban, & Heather Leach

Penn State University Entomology

djb134@psu.edu

DJB 2019

Major Tree Fruit Pests

PENNSTATE 1855

Invasive

CM

OFM

TABM

OBLR

IPM Research in PA from 1972 – to Present

SUCCESS OF IPM

STAIRCASE OF IPM FOR TREE FRUITS

Pheromone Mating Disruption

Insecticides
Selectivity: Ecological, Physiological

Cultural Controls

Sampling Schemes

Economic Thresholds & Injury Levels

Natural Enemies Biology and Behavior

Pests Biology and Behavior

Pesticide Efficacy & Calendar Spraying

Ecologically-Based IPM

-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0

Exotic Species in the US

- **Invasive insects & weeds cost the US over $122 billion/yr**
- **adding about 11 new species/year (7 important pests)**
- **Approx. 1,500 species currently.**
- **Make up 39% of the 600 major arthropod pests.**
- **Responsible for up to 50% of crop losses in CA.**

Light brown apple moth

Omnivorous Leafroller

Light brown apple moth

possible US distribution map

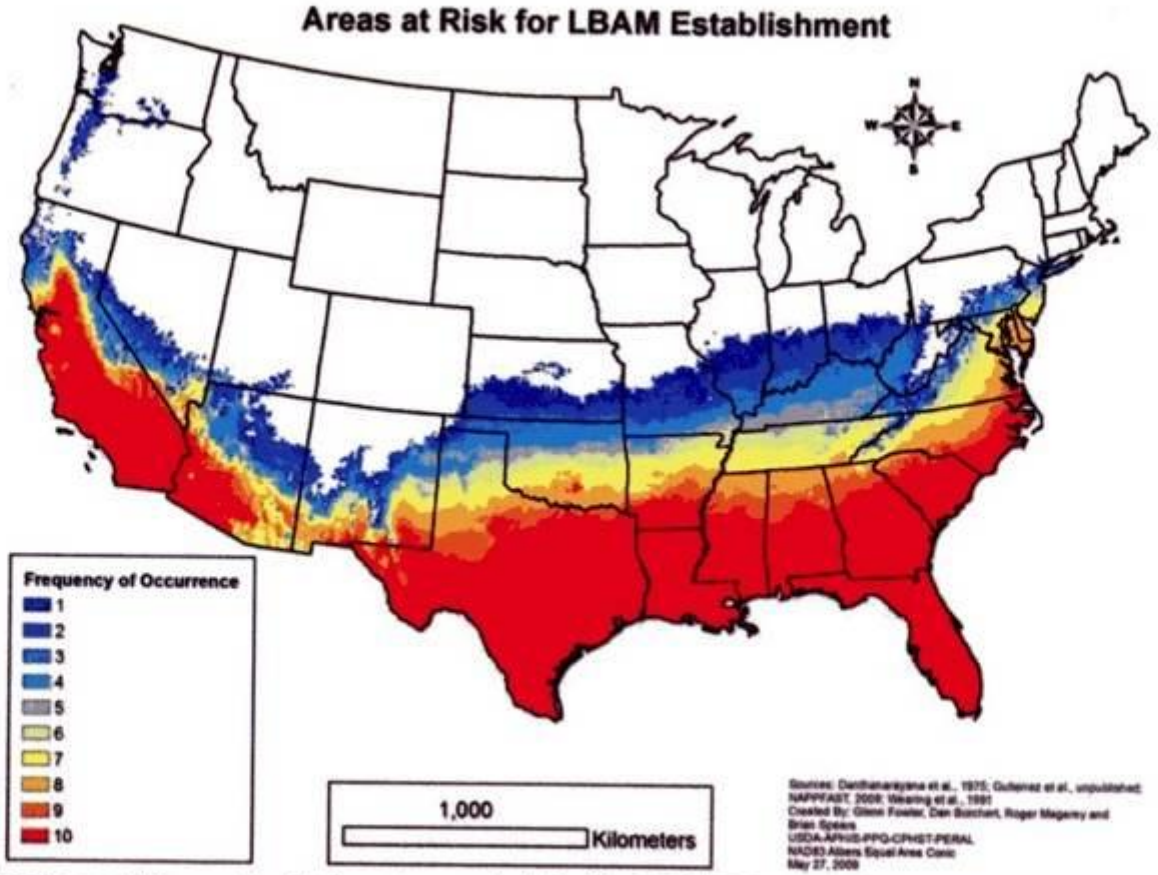
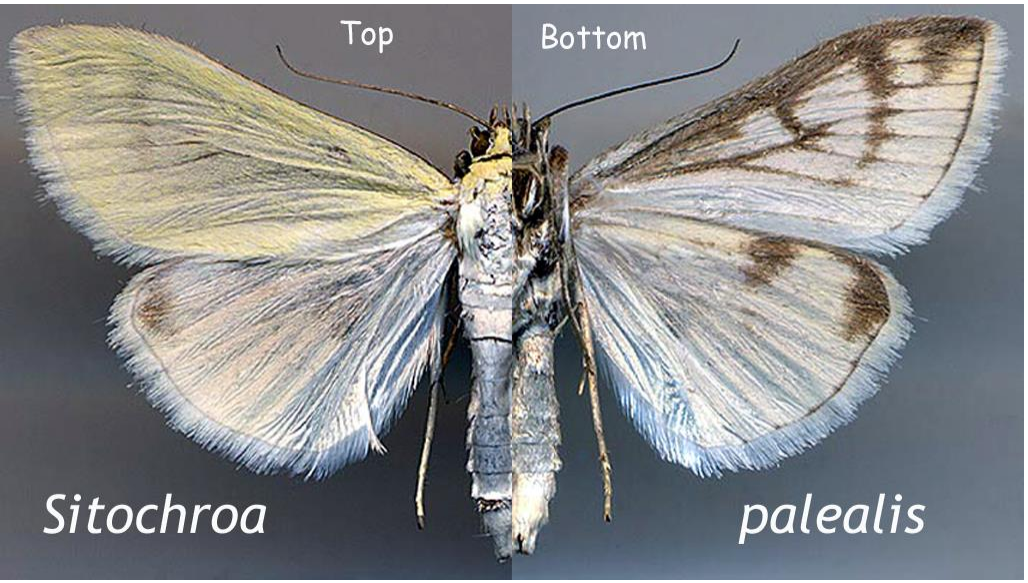


Figure 2. Climate match analysis for areas at risk for LBAM establishment. The results are reported in terms of frequency of years from 1999 to 2008 where enough degree days accumulated for LBAM to complete ≥ three generations and non-lethal minimum daily temperatures >-16°C occurred.

http://www.aphis.usda.gov/plant_health/plant_pest_info/lba_moth/downloads/lbameconomicanalysis.pdf



Carrot Seed Moth - Pyralidae

African Fig Fly – Zaprionus indianus

Spotted Wing Drosophila

Multi-Colored Asian Lady Beetle

Apple

Soybean

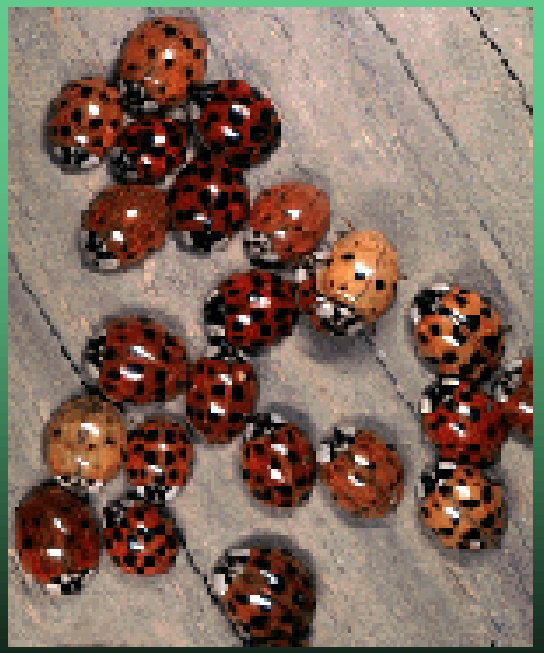
DJB 2006

Agricultural Perspective

DJB 2006

Brown Marmorated Stink Bug
2010
$37 million loss in apple alone!

Social Perspective



Economic Loss

Some growers have experienced 50-60% loss of peach crops and 20% loss of apple crops.

2010 BMSB caused over $37 million in damage to Mid-Atlantic apple production

Fresh injuries on stone fruit occurred during season (May, June, July)

Stink Bug injuries on apples during late summer

Greg Krawczyk, 2010

Brown marmorated stink bug (*aka Asian stink bug*) is not your usual insect pest

- **Hundreds of available host plants**
- **Long distance movement ability (2 km)**
- **Undefined biology/monitoring issues**
- **Inconspicuous initial injury on fruit**
- **Spends 80-90% of life outside of orchards**
- **No current effective biological control**

BMSB CONTROL

The impact of BMSB on seasonal insecticide applications; apple

Mating disruption against codling moth and Oriental fruit moth

2009

Before BMSB

Im. As. Del. Alt.

4 insecticide appl.
4 active ing.

2012

with BMSB

As. As. Im. As. Ln. Del. Ln. Del. Ac. Ln. Ln. Del. Bl. Ln. Ac. W. Bl. As. Br. Sc.

PC PC **BMSB** LR/**BMSB** **BMSB** **BMSB** **BMSB**

April May June July August September

11 insecticide appl.
8 active ing.

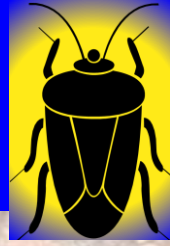
BMSB - Complete spray

Fruit Research & Extension Center

Insecticides:

Im. – phosmet; As. – acetamiprid; In. – methoxyfenozide;
Ln. – methomyl; Del – spinetoram; Alt. – rynaxypyr;
Sc. – dinotefuran; Bl. – clothianidin; Dn.- fenpropathrin;
Ac.- thiametoxam; W. – lambda cyhalothrin; Br - bifenthrin

Brown Marmorated Stink Bug
How we manage this pest?



Effective chemicals to date:
Pyrethroids and Methomyl –
Toxicity of Dinotefuron to NE's?

Photo by A. R. Biggs

40 + years of IPM

Systems Affected

- San Jose Scale
- Wooly Apple Aphid
- Mites

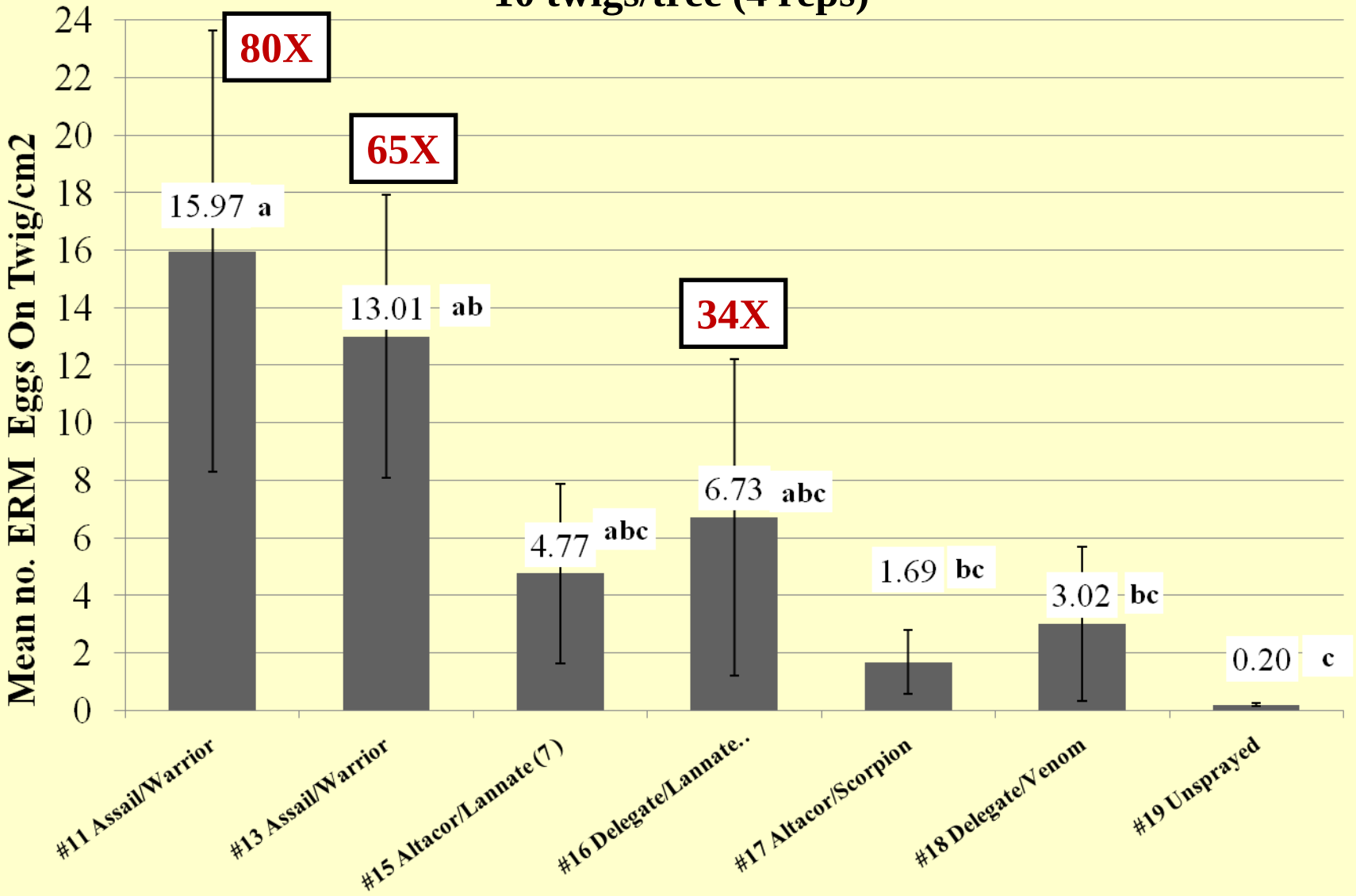
Quadraspidiotus perniciosus

Woolly Apple Aphid Parasitoid
Aphelinus mali

Typhlodromus pyri

Raff Block Overwintering ERM Eggs

10 twigs/tree (4 reps)



* Means followed by the same letter(s) are not significantly different (Fisher's Protected LSD, P≤0.05)

D. J. Biddinger 2013

Most effective insecticides against BMSB

PYRETHROIDS

IRAC Group 3A

- bifenthrin **(Brigade)**
- fenpropathrin **(Danitol)**
- λ-cyhalothrin **(Warrior)**
- cyfluthrin **(Baythroid)**

NEONICOTINOIDS

IRAC Group 4A

- dinotefuran **(Venom, Scorpion)**
- thiametoxam **(Actara)**
- clothianidin **(Belay)**
- imidacloprid **(Provado, Admire Pro)**
- acetamiprid **(Assail)**

OTHER

(IRAC Groups 1A, 1B, 2A

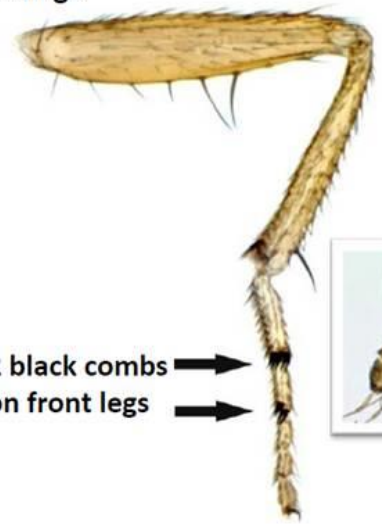
- methomyl (carbamate) **(Lannate LV and SP)**
- endosulfan (organochlorine) **(Thionex)**
- acephate (organophosphate) **(Acephate)**

Mixes such as Endigo or Leverage

SWD Identification – key characters

Male

Black spot on wings



2 black combs on front legs

Female

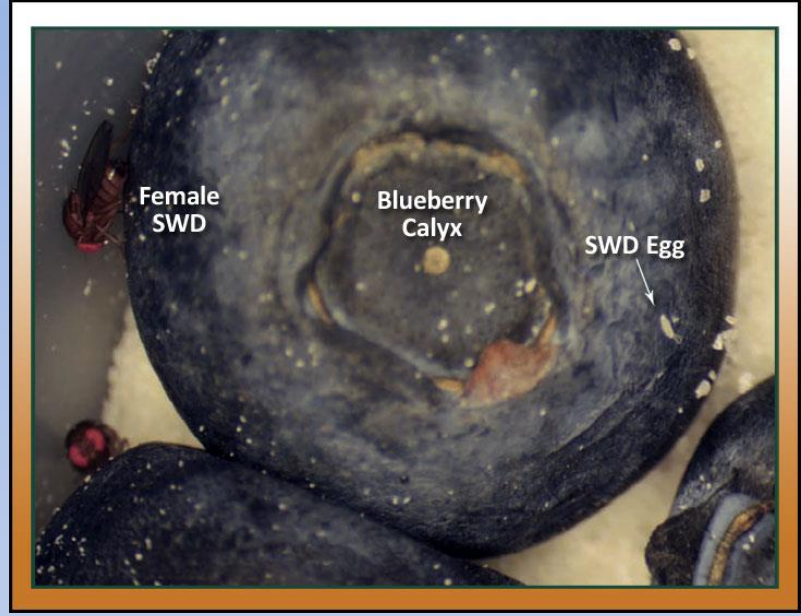
She inserts saw-like device (ovipositor) into fruits and lays eggs

by Alex Surcică

NE IPM – Urgent IPM Grant 2011

Male SWD with wings that exhibit faint spots. About 15% of SWD males have either faint spots or lack them altogether. Note that the front leg (upper right corner) has the two black bands. This characteristic is exhibited by all SWD males.

This picture showcases the saw-like ovipositor of a female SWD. This allows the SWD females to lay eggs in ripening fruit. SWD females do not have wing spots or black bands on their legs like males do.


Female
SWD
Blueberry
Calyx
SWD Egg


UC Statewide IPM Program
© 2009 Regents, University of California

SPOTTED LANTERNFLY IN PENNSYLVANIA

Sven-Erik Spichiger, Entomology Program Manager

pennsylvania
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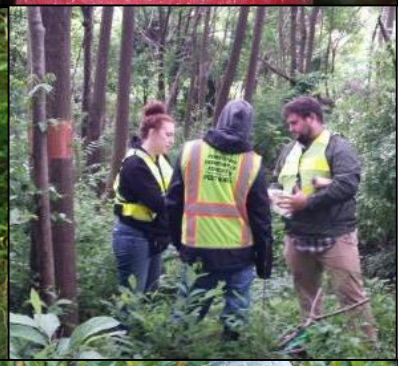
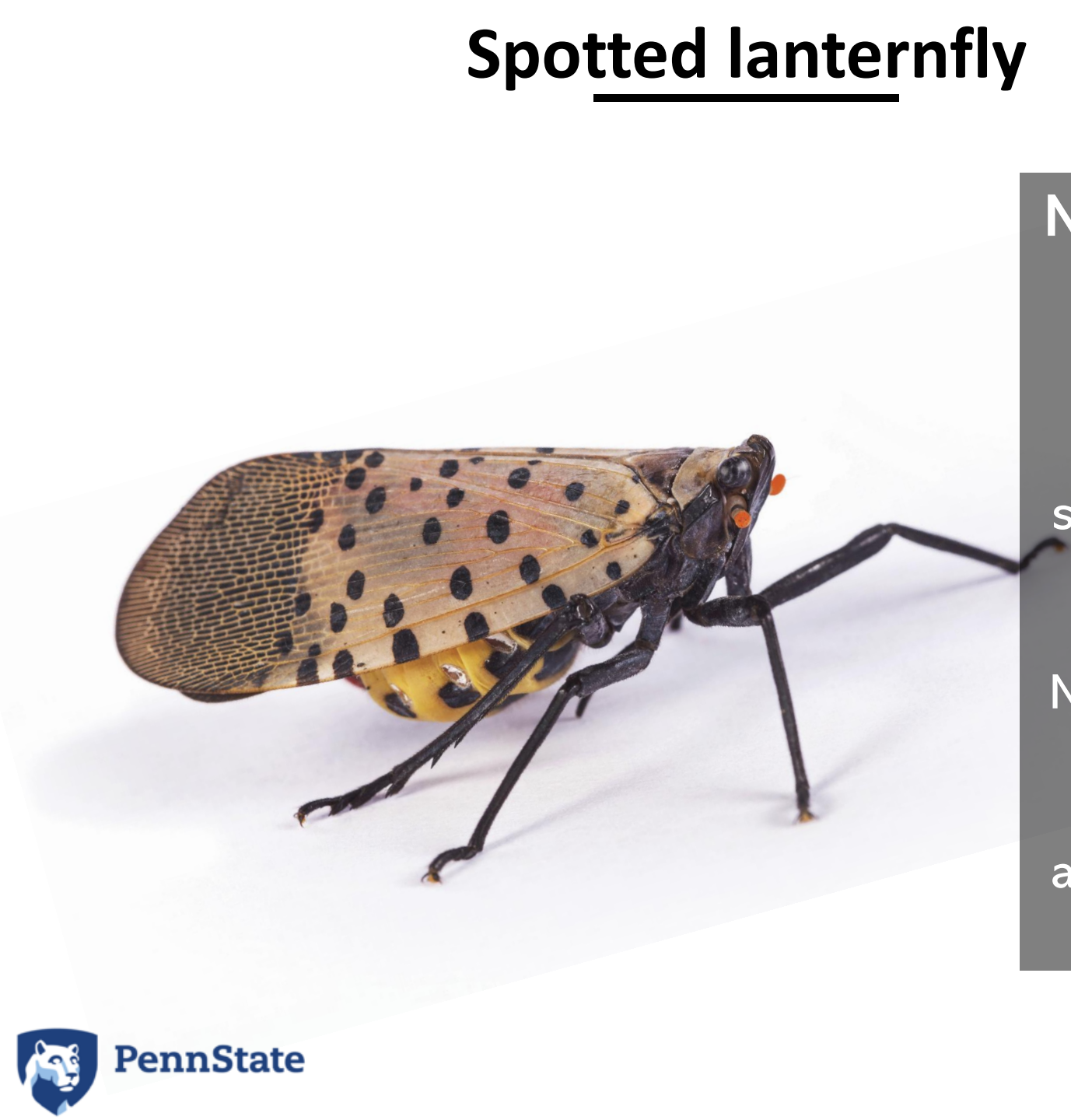


Spotted lanternfly



NEW INVASIVE PEST

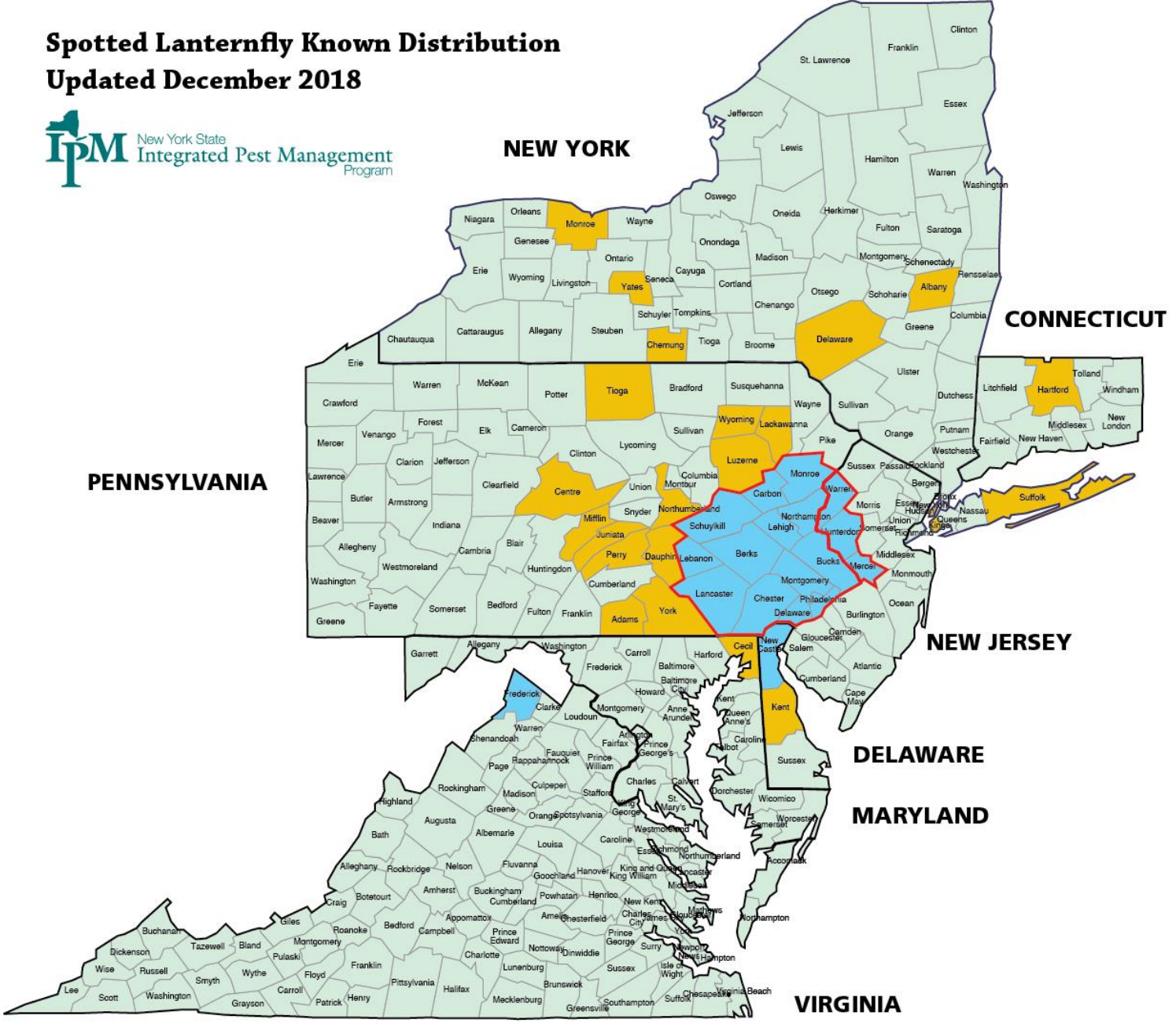
Native to Asia, found in southeastern PA in 2014

Now **spread to 4 states** and detected in 3 additional states

PennState

Spotted Lanternfly Known Distribution
Updated December 2018

New York State Integrated Pest Management Program



SPOTTED LANTERNFLY IN PENNSYLVANIA

Sven-Erik Spichiger, Entomology Program Manager

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Adults: July - December

Egg Laying:
September - November

Eggs: October - June

Fourth Instar:
July - September

One Generation Per Year

Hatch and 1st Instar:
May - June

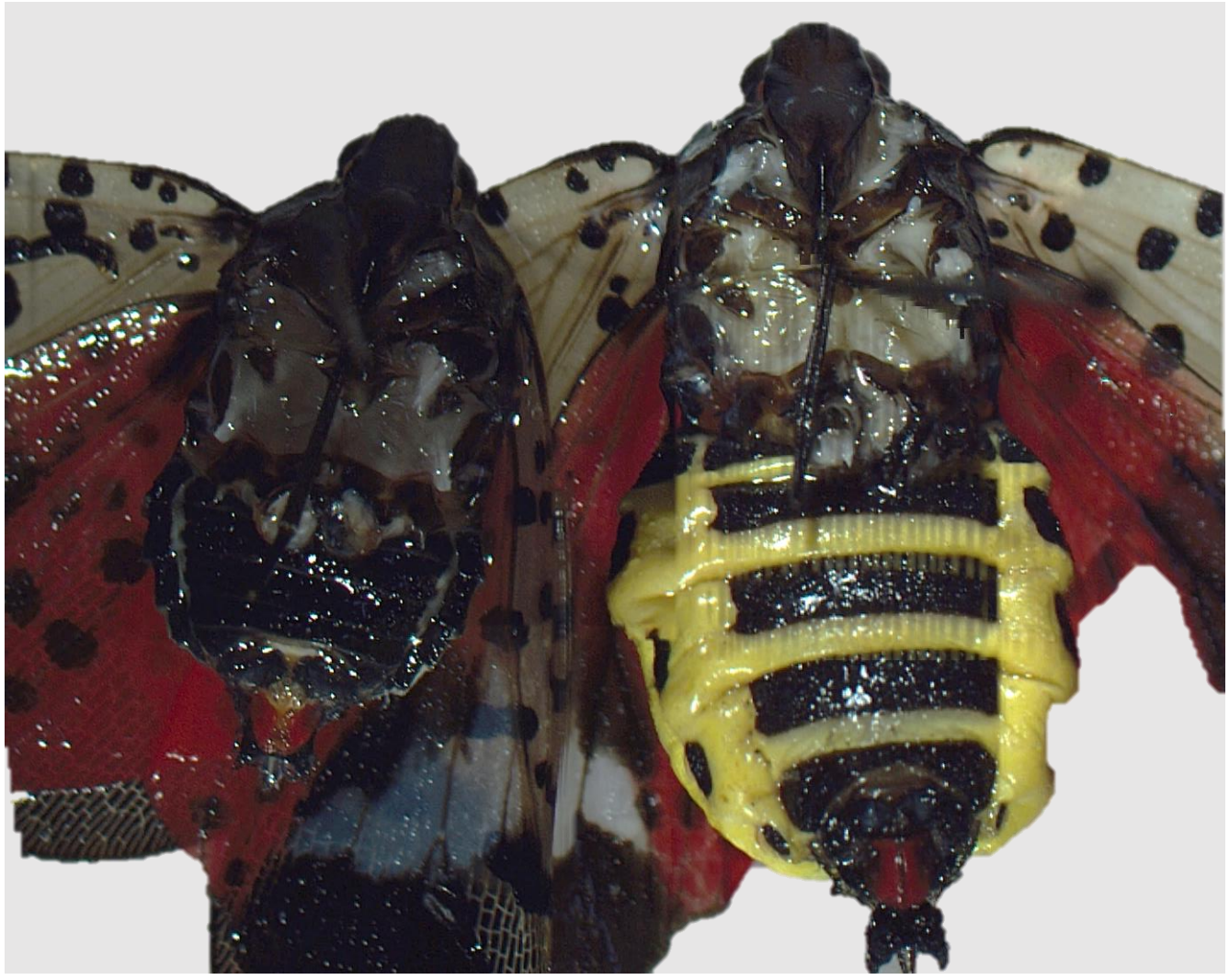
Third Instar: June - July

Second Instar: June - July

Early versus Late Season Females

-- Adults appear: late July

-- Females lay eggs: October - November



SLF is a Hemipteran

PennState

How does SLF feed?

SPOTTED LANTERNFLY

Feeds on plant sap through a **piercing-sucking** mouthpart

Excretes **honeydew** (sugar water) as it feeds

PennState

Honeydew and sooty mold

SLF are serious troublemakers

High populations of SLF in SE PA

Video by Christopher Jordan

SLF in backyards and chimneys

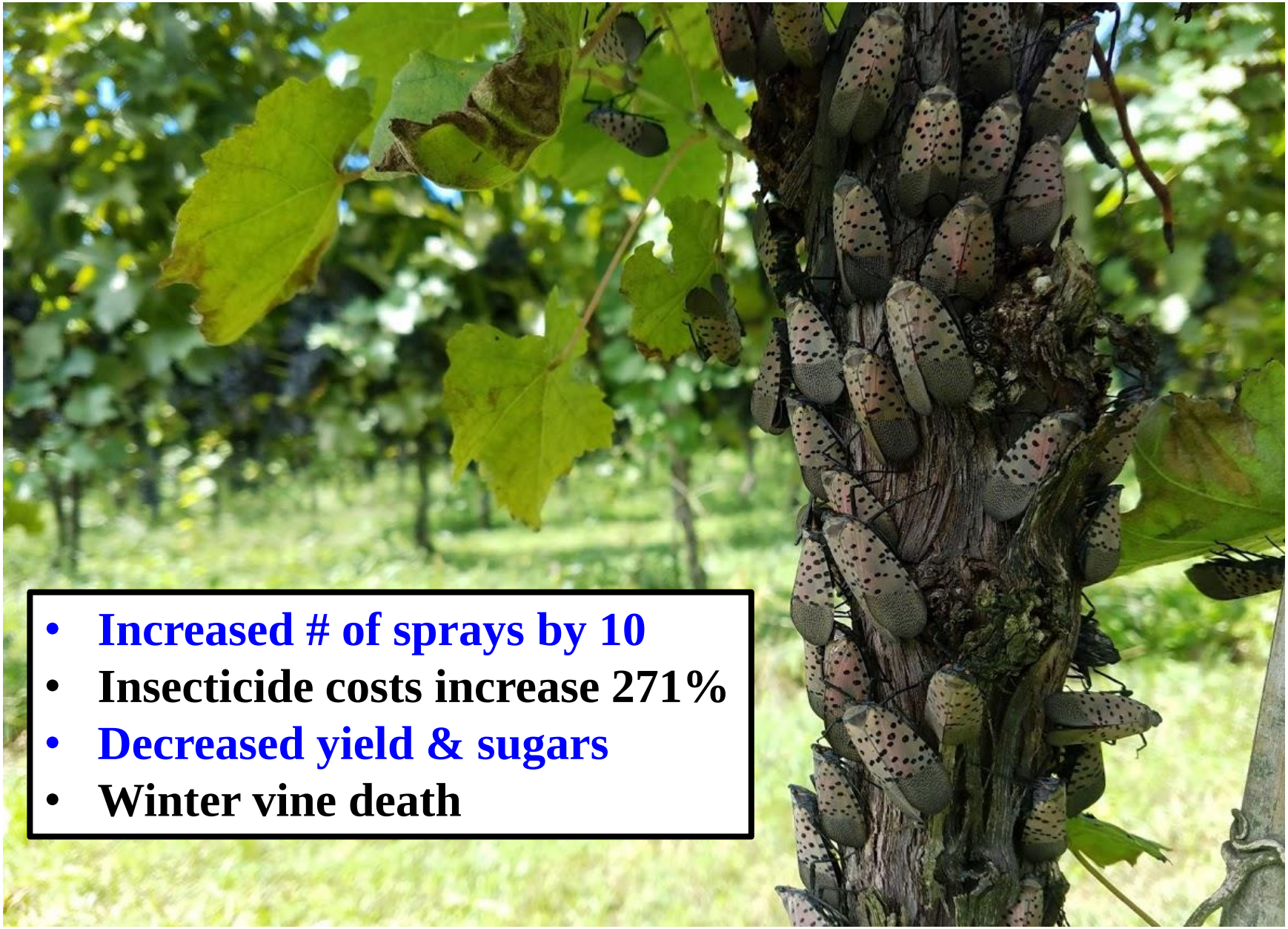

PA Department of Agriculture


G. Krawczyk

Sooty mold – a nuisance problem

SLF in orchards

SLF in vineyards



- **Increased # of sprays by 10**
- **Insecticide costs increase 271%**
- **Decreased yield & sugars**
- **Winter vine death**

As the population of spotted lanternfly grows, and the insect adapts, new threats to multiple industries emerge.

Biggest threat is to forestry & ornamentals.

In tree fruit, peach appears to be most at risk, but will attack apple.

Need insecticide efficacy & residual data to develop control programs & integrate into IPM.

SLF host range

HOSTS

Preferred host is invasive tree, **tree-of-heaven**

Feeds on over **70+ hosts**, including hardwoods, vegetables, tree fruit, hops, and grapes

Feeding not recorded on **conifers**

Identification of tree-of-heaven

TREE of HEAVEN

Male and female trees

Reproduces by seed (samaras) or by **"clones"**

Bark has appearance of **cantaloupe** skin

Few other animals are recorded on tree-of-heaven

Identification of tree-of-heaven

TREE of HEAVEN

Pinnately **compound leaves**

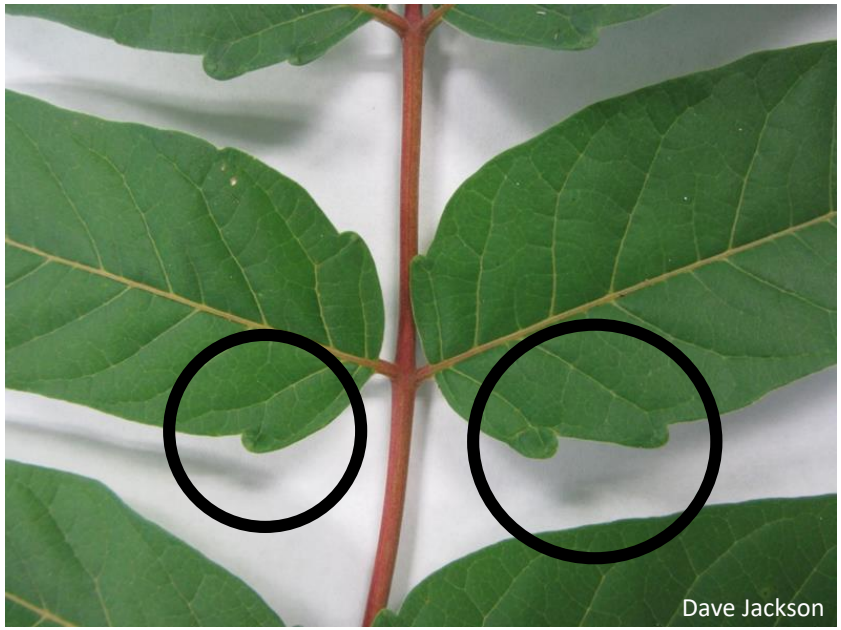
1-4 feet in length

10-40 leaflets

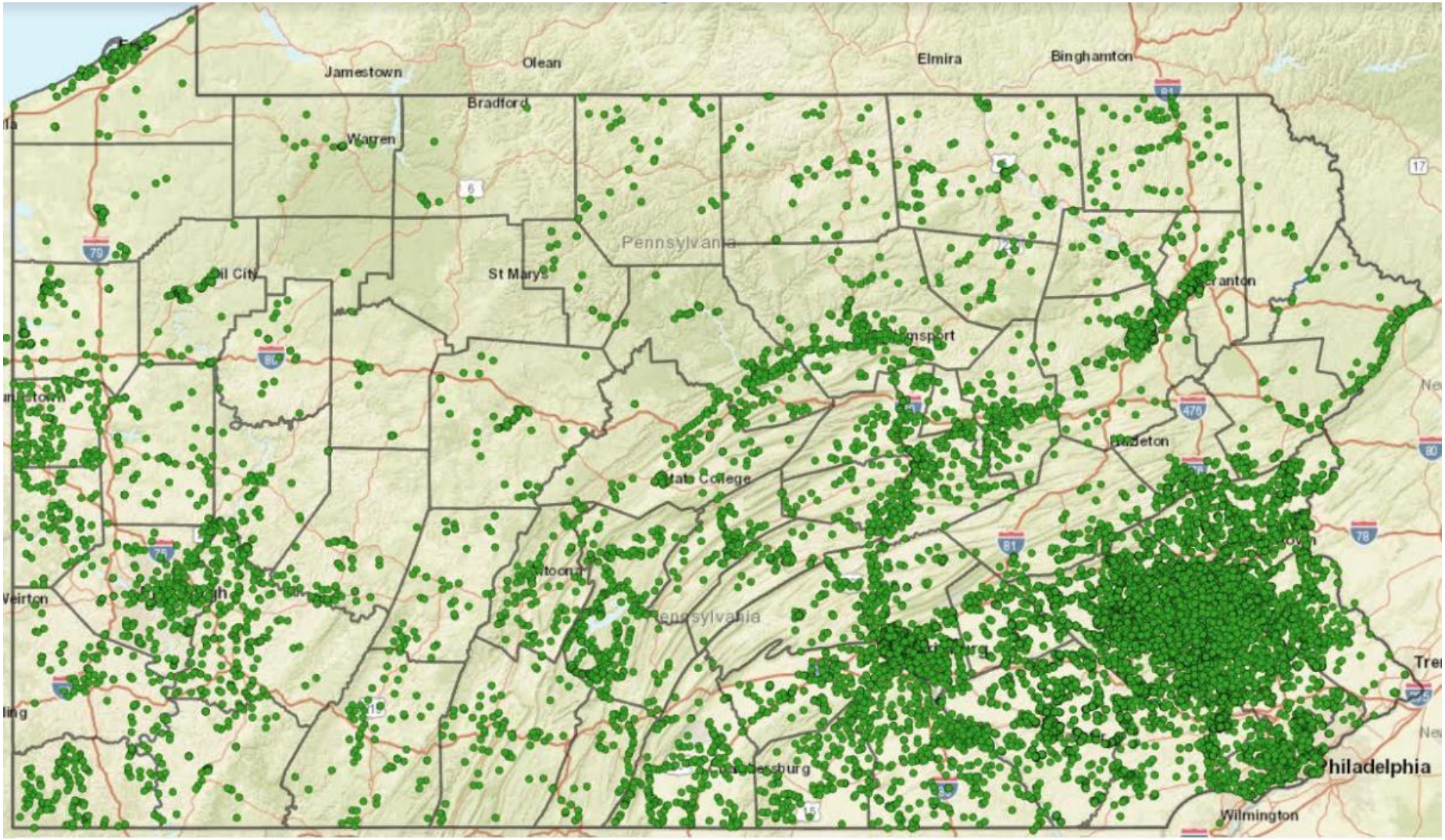
1-2 **teeth** at base of leaflet

Smooth leaf margin

Rotten **peanut butter odor** when crushed



Tree-of-heaven populations in PA



Data courtesy of Dr. Dennis Calvin (Penn State) and Pennsylvania Department of Agriculture

SPOTTED LANTERNFLY IN PENNSYLVANIA

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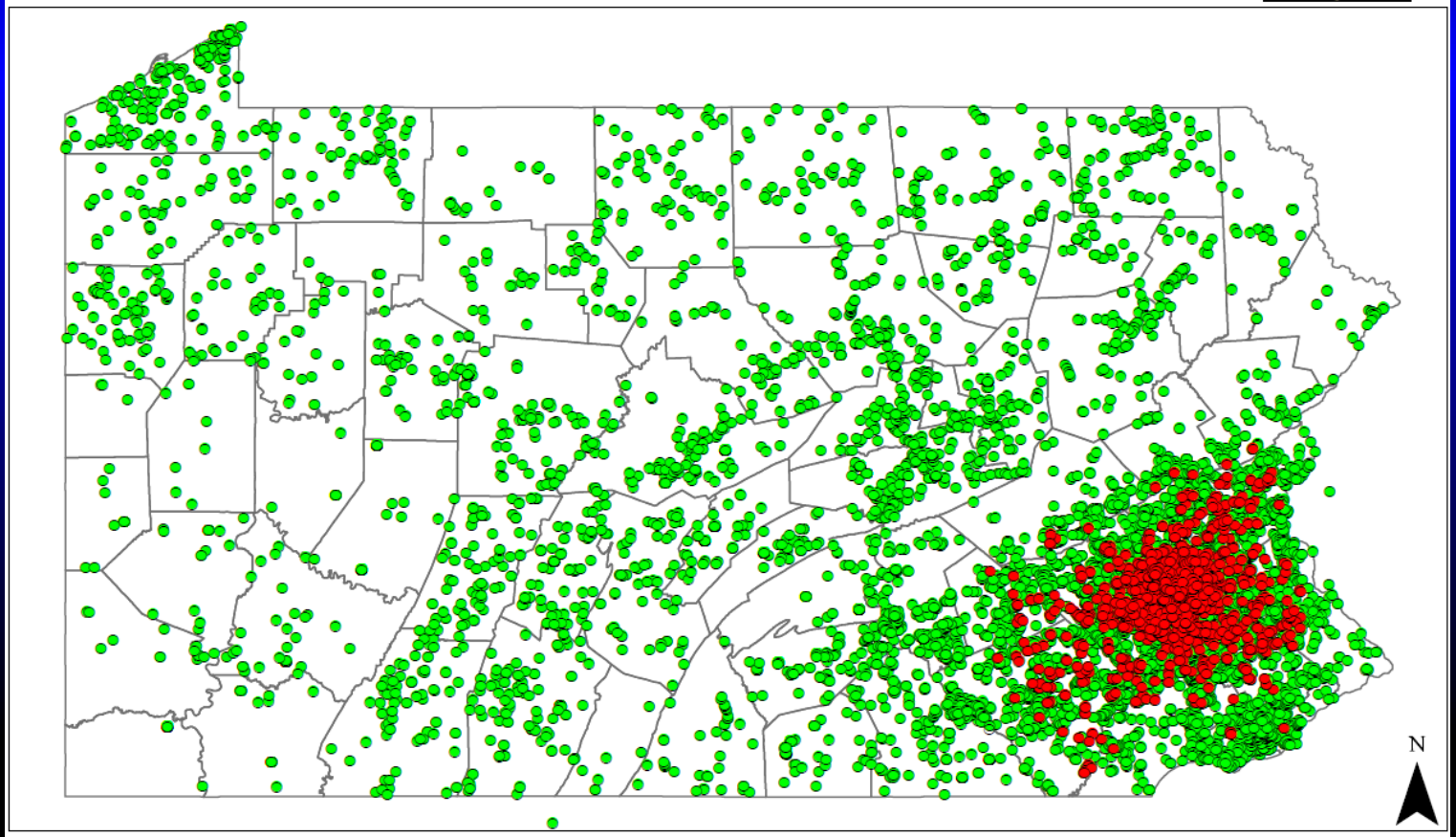
Current Distribution:

2014 -- 2017 Lycorma Detection Survey
Results through 21 November 2017



Spotted Lanternfly Presence

- Positive
- Negative

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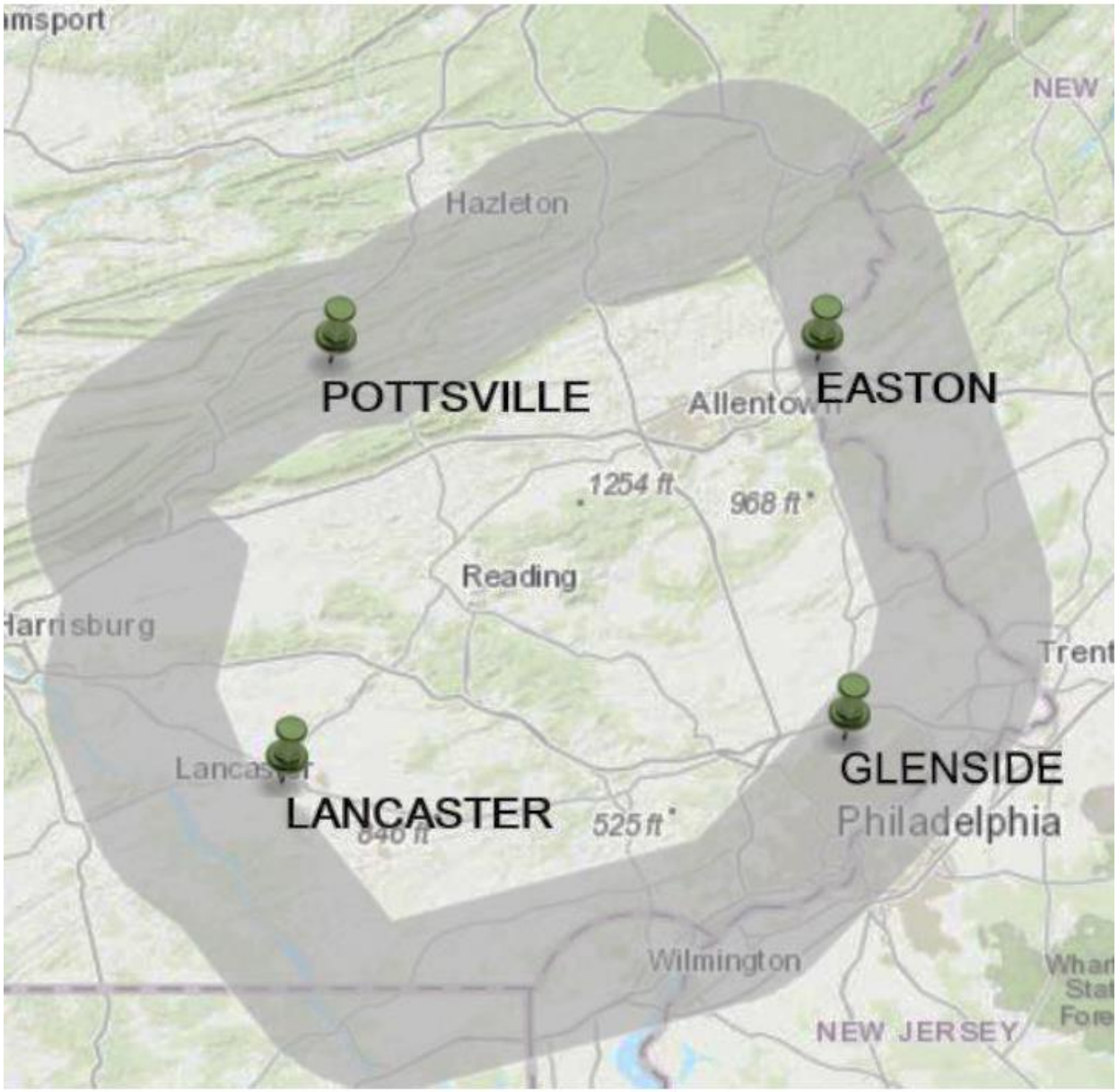
What's being done to control SLF?



CONTROL

PA Dept. Agriculture focusing in "**core**" of population

USDA focusing on 18-km **buffer** outside of core population

What's being done to control SLF?

CONTROL

Tree-of-heaven being utilized as trap tree

Majority of trees killed, remaining trees are treated with **systemic insecticide**

What's being done to control SLF?

SPREAD

All businesses transporting material within or in and out of the PA/NJ quarantine counties are **required to have SLF permit**

SLF egg masses

EGG MASSES

Eggs are laid on any **hard surface** (vines, trunks, posts, stones, houses, lawn furniture, etc.)

They are laid in fall, overwinter, and hatch in the spring

In PA, average number of eggs per mass was **37.3**, while the maximum was 78 (E. Smyers data)

Old egg masses

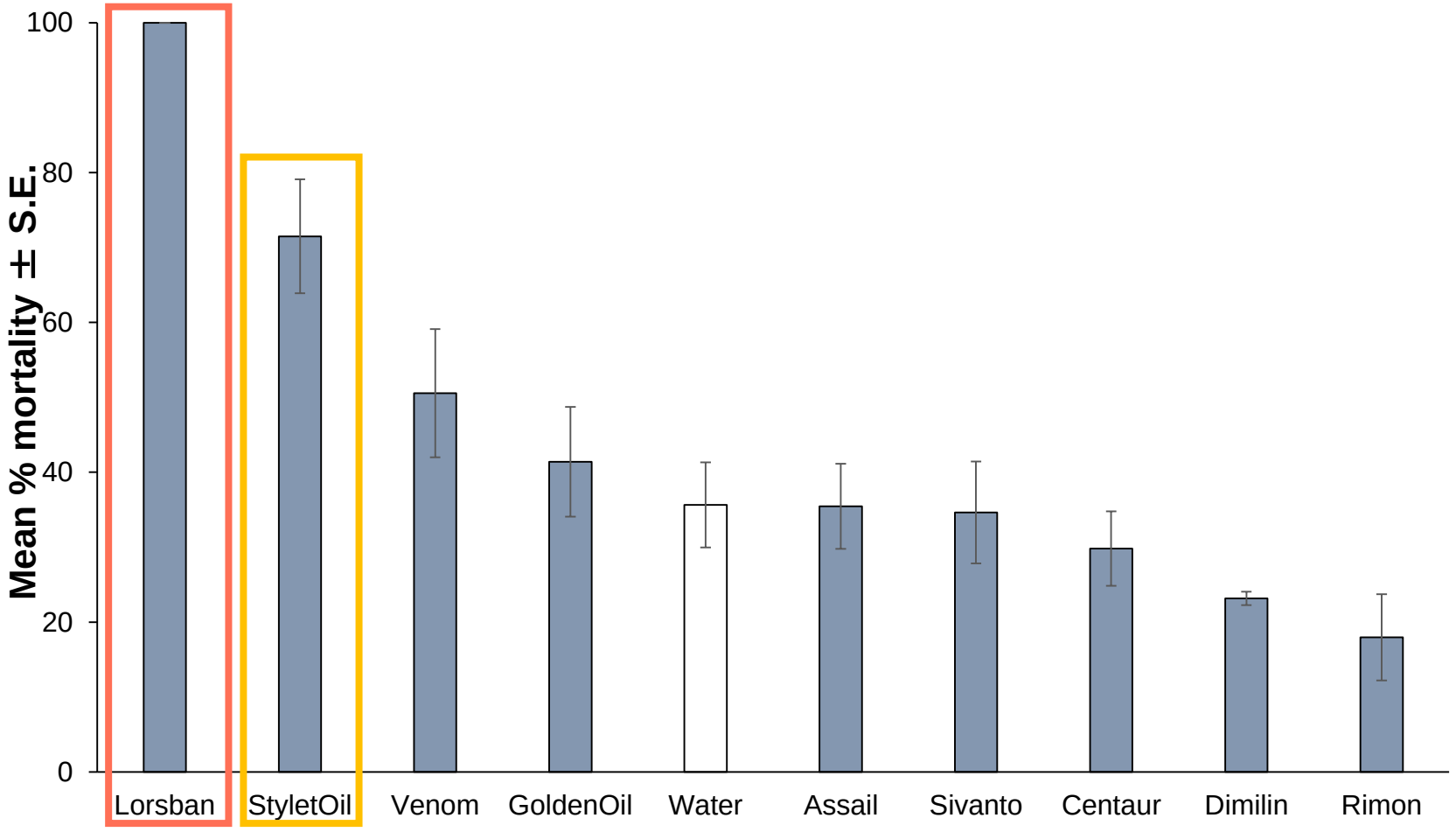
New egg masses

SLF egg masses

SLF Egg Masses on Red Maple Trees

SLF egg masses on Christmas trees

Field ovicide assays



Data provided by Greg Krawczyk

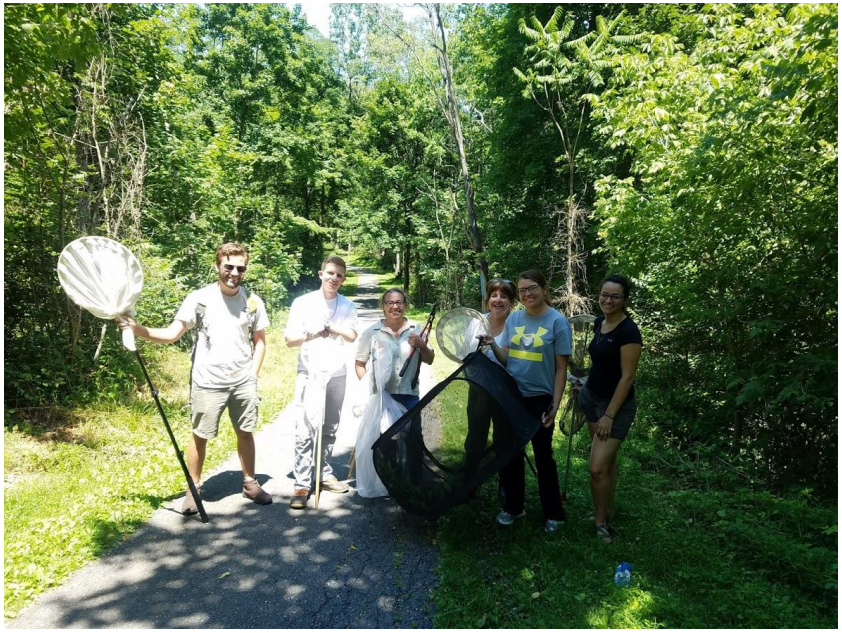
SLF insecticide trials, homeowners

Active Ingredient	Mode of Exposure	Available Products	Legal Use	Activity Against SLF	Residual Activity
bifenthrin	contact	Talstar P	ornamental and landscape plants and trees	excellent	excellent
carbaryl	contact	Garden Tech Sevin Ready-to-Spray Bug Killer (note: new formulation is sold with zeta-cypermethrin)	vegetable and ornamental plants and trees under 10 feet tall	excellent	good
dinotefuran	systemic/contact	Safari 20SG, Transect 70 WSP, Zylam Liquid	ornamental and landscape plants and trees	excellent	excellent
insecticidal soaps*	contact	Garden Safe Insecticidal Soap	vegetables, fruit trees, ornamentals, shrubs, flowers, and gardens	good	poor
malathion	contact	Spectracide Malathion Insect Spray	flowers and bushes, fruit, and vegetables	excellent	poor
natural pyrethrins	contact	Garden Safe Multi-Purpose Garden Insect Killer, Natria Insect Mite and Disease Control	vegetables, ornamentals, trees, shrubs, and flowers	excellent	poor
neem oil*	contact	Bonide Neem Oil	flowers, ornamental trees and shrubs, fruit, nuts, and vegetables	good	poor
spinosad*	systemic	Bonide Captain Jack's Deadbug Brew	outdoor ornamentals, fruit, and vegetables	fair	poor
tau-fluvalinate, tebuconazole	contact/systemic	BioAdvance 3 in 1, Insect, Disease and Mite Control	nonedible plants only, groundcovers, vines, ornamentals, shrubs, and trees	excellent	good
zeta-cypermethrin	contact	Amdro Quick Kill Outdoor Insect Killer Concentrate	lawns, trees and shrubs, roses, and flowers	excellent	excellent

*Recommended for organic production.

Note: The listing of products in this table is not an endorsement or specific recommendation of the product or the company. Other products with the same active ingredient should also work in the same way, but they may have different rates or formulations.

SLF insecticide trials



Nymph SLF insecticide trials (on peach)

Trade name	Active ingredient	Class	Rate per acre	Systemic, Contact, Ingestion	PHI (days)	REI (hrs)	Days of activity	Labeled for SLF?	SLF activity
Imidan 70WP	phosmet	Organo-phosphate	2 1/8 lb	C, I	14	336	14	Yes, 2(ee)	Exc.
Scorpion 35SL	dinotefuran	Neonicitinoid	5 fl oz	S, C, I	1	12	7	2(ee) pending	Exc.
Brigade 10WSB	bifenthrin	Pyrethroid	16 oz.	C, I	30	12	14	Yes, 2(ee)	Exc.
Mustang Maxx 0.8EC	zeta-cypermethrin	Pyrethroid	4 fl. oz.	C, I	1	12	<7	Yes, 2(ee)	Exc.
Closer 2SC	sulfoxaflor	Sulfoximine	5.75 fl oz.	S, C, I	7	12	7	2(ee) pending	Good
Actara 25WDG	thiamethoxam	Neonicitinoid	3.5 oz	S, C, I	5	12	7	Yes, 2(ee)	Exc.
Assail 30SG	acetamiprid	Neonicitinoid	5.3 oz	S, C, I	3	48	<7	Yes, 2(ee) on nymphs only	Good
Carbaryl 4L	carbaryl	Carbamate	2 qt	C, I	7	12	7	No	Exc.
Avaunt 30DG	indoxicarb	Oxadiazine	6 oz	C, I	7	12	7	Yes, 2(ee)	Exc.
Movento 2SC	spirotetramat	Ketoenol	9 fl oz	S, C, I	7	24	7	No	Poor
Danitol 2.4EC	fenpropathrin	Pyrethroid	21.33 fl oz	C, I	21	24	7	No	Exc.
Entrust 80WP	spinosad	Spinosyn	2.5 oz	C, I	7	4	<7	No	Poor
Sivanto Prime 1.67SC	flupyradifurone	Butenolide	14 fl oz	S, C, I	0	4	<7	No	Poor

Adult SLF insecticide trials (on grape)

Trade name	Active ingredient	Class	Rate per acre	Systemic, Contact, Ingestion	PHI (days)	REI (hrs)	Days of activity	Labeled for SLF?	SLF activity
Imidan 70WP	phosmet	Organophosphate	2.125 lb	C, I	14	336	0	Yes, 2(ee)	Poor
Imidan 70WP	phosmet	Organophosphate	1.33 lb	C, I	7	336	0	Yes, 2(ee)	Poor
Scorpion 35SL	dinotefuran	Neonicitinoid	5 fl oz	S, C, I	1	12	<14	Yes, 2(ee)	Exc.
Brigade 10WSB	bifenthrin	Pyrethroid	16 oz.	C, I	30	12	21	Yes, 2(ee)	Exc.
Mustang Maxx 0.8EC	zeta-cypermethrin	Pyrethroid	4 fl. oz.	C, I	1	12	<7	Yes, 2(ee)	Good
Closer 2SC	sulfoxaflor	Sulfoximine	5.75 fl oz.	S, C, I	7	12	0	2(ee) pending	Poor
Actara 25WDG	thiamethoxam	Neonicitinoid	3.5 oz	S, C, I	5	12	<21	Yes, 2(ee)	Exc.
Assail 30SG	acetamiprid	Neonicitinoid	5.2 oz	S, C, I	3	48	0	Yes, 2(ee) on nymphs only	Poor
Carbaryl 4L	carbaryl	Carbamate	2 qt	C, I	7	12	<14	No	Exc.
Avaunt 30DG	indoxicarb	Oxadiazine	6 oz	C, I	7	12	0	Yes, 2(ee)	Poor
Admire Pro	imidacloprid	Neonicitinoid	1.4 fl oz	C, I	0	12	<7	No	Poor
Venerate XC + Nu-Film P	*Burkholderia spp.* strain	Other	4 qt	C, I	0	4	0	No	Poor
Entrust 80WP	spinosad	Spinosyn	2.5 oz	C, I	7	4	0	No	Poor
Sivanto Prime 1.67SC	flupyradiferone	Butenolide	14 fl oz	S, C, I	0	4	0	No	Poor

Conclusions

1. **SLF adults appear to be harder to kill w/ insecticides than nymphs, but less tolerant of heat, so higher control mortality.**
2. **The lower rates for grapes are less effective and give shorter residual.**
3. **Need to integrate efficacy, residual, PHI, REI and varying rates into control recommendations for each crop and generate more 2(e) label amendments.**
4. **Test slower acting compounds (esp. IGRs) that can disrupt development and affect reproduction, but are more IPM compatible and bee safe.**

https://extension.psu.edu/spotted-lanternfly

SLF endemic parasitoids

Brown Marmorated SB (*Halyomorpha halys*) vs. Predatory SBs

DJB-2005

White bands on antennae & legs, white striping on abdomen edges. Pronotum smooth.

4,700 species
300 are predatory

Predator w/ no White bands, pronotum toothed.\

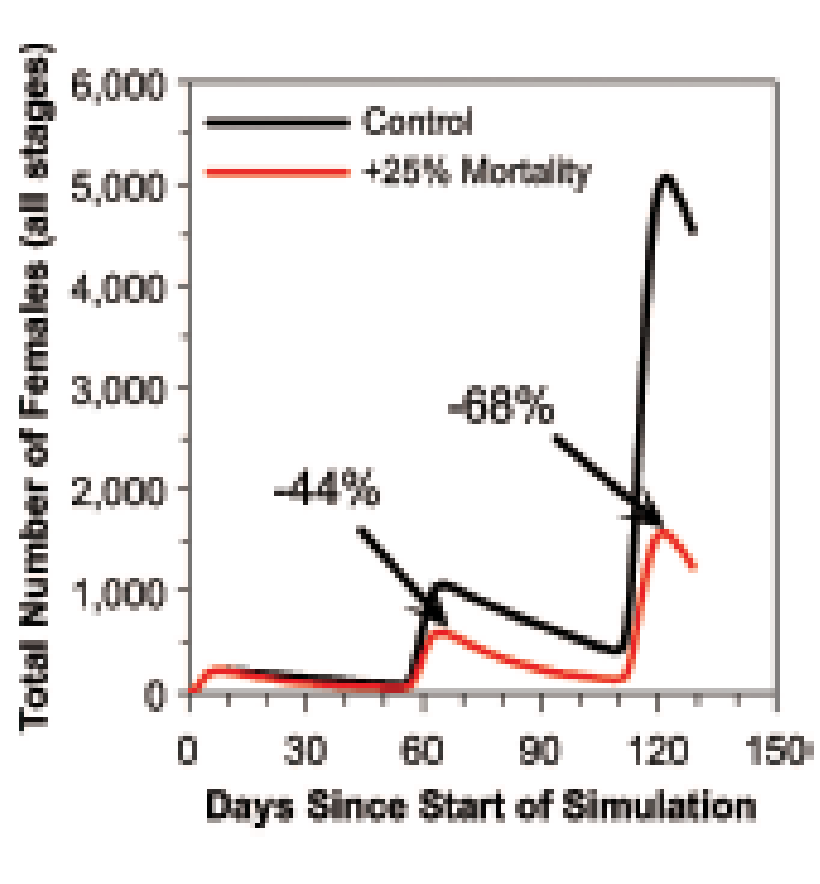
Management of Invasive Pests Begins with a Reliance on Insecticides, but there is hope of native biocontrol!

FIGURE 1 The effect of low levels of mortality on population growth

The population model is started using 16 fertile female codling moths. We ran the model twice, the first time using mortality rates observed in the laboratory (the control) and the second time using the same mortality rates but with an additional 25 percent mortality at the larval stage, to simulate natural-enemy induced mortality. We then plotted the size of the control population and the one with the additional larval mortality.

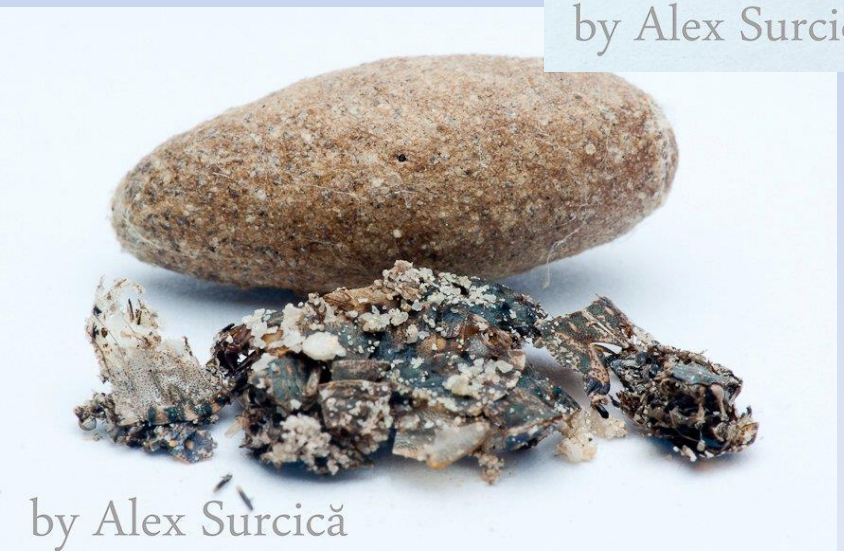
Both populations increase rapidly, but the one with 25% morality added increases slower than the control population. After a single generation, there are 44% fewer individuals in the population and after two generations 68% fewer in the 25% mortality treatment compared with the control.

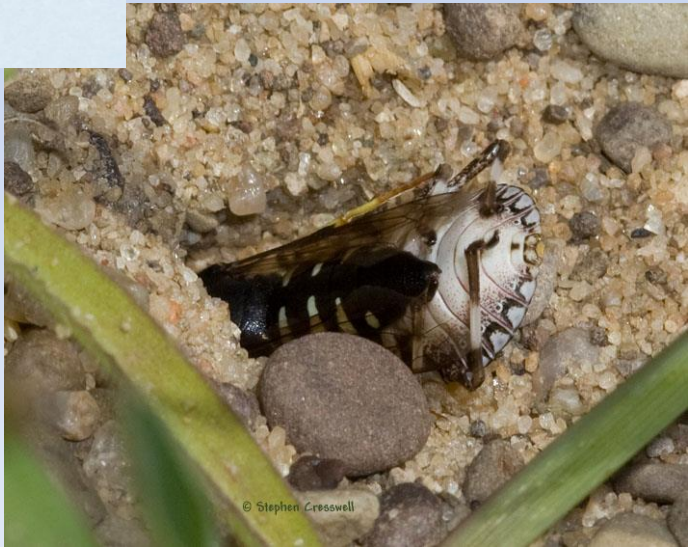
The effect in each generation is the result of not only killing the additional 25% of larvae, but also eliminating all the progeny of those individuals. Another way to think of this is that the additional mortality acts similarly to compound interest in a savings account. As the savings grow because of interest paid, the greater the interest earned the following period.



* V. Jones, T. Unruh, D. Horton, & J. Brunner. Improving Apple IPM. Good Fruit Grower. Dec. 2006.

Bicyrtes quadrifasciata – Sand Wasp



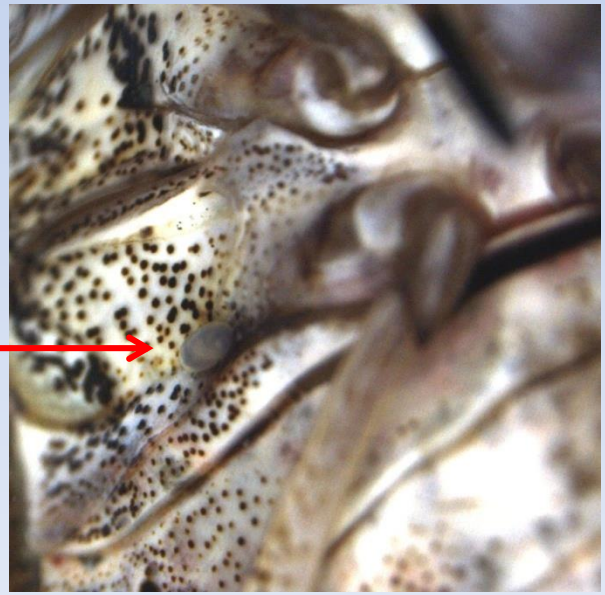


Tachinid Parasitoids of Adult Stink Bugs

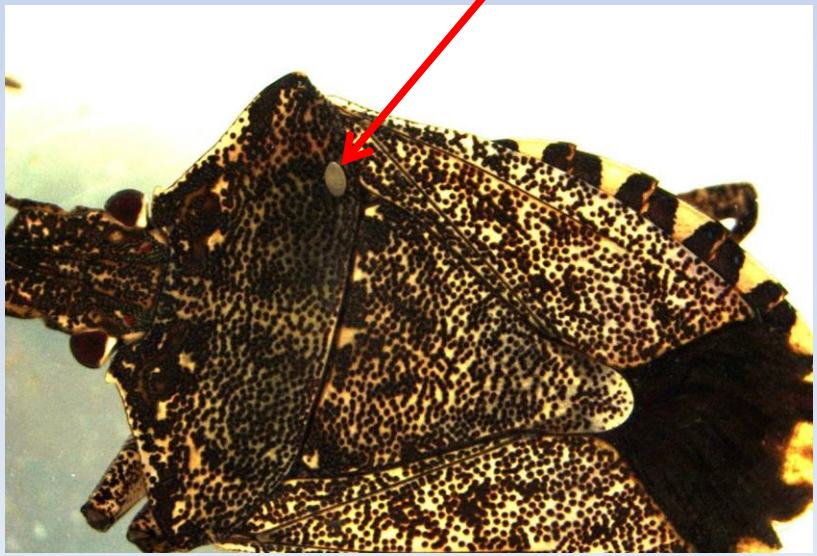
Trichopoda sp.

Gymnosoma sp.

Tachinid Egg



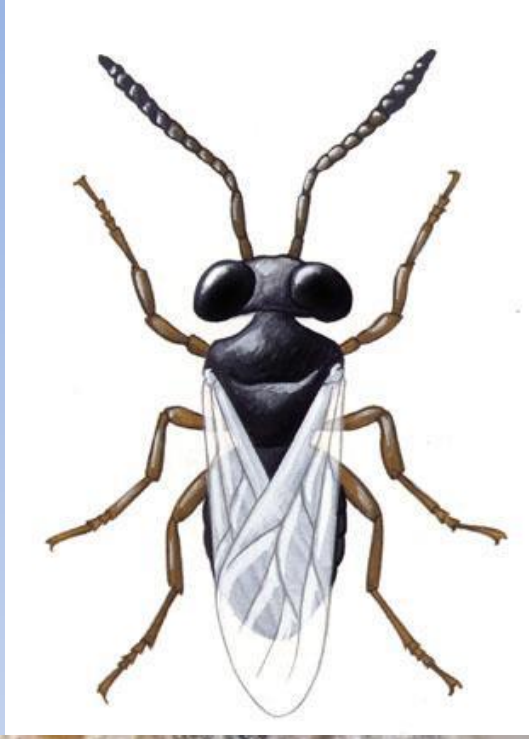
Tachinid Egg



D Biddinger 2011

Trissolcus basalis
Scelionidae

Stink Bug Egg Parasitoid



SPOTTED LANTERNFLY IN PENNSYLVANIA

Sven-Erik Spichiger, Entomology Program Manager

pennsylvania
DEPARTMENT OF AGRICULTURE

Christopher Marley Planthopper Formation

Lycorma delicatula (WHITE):

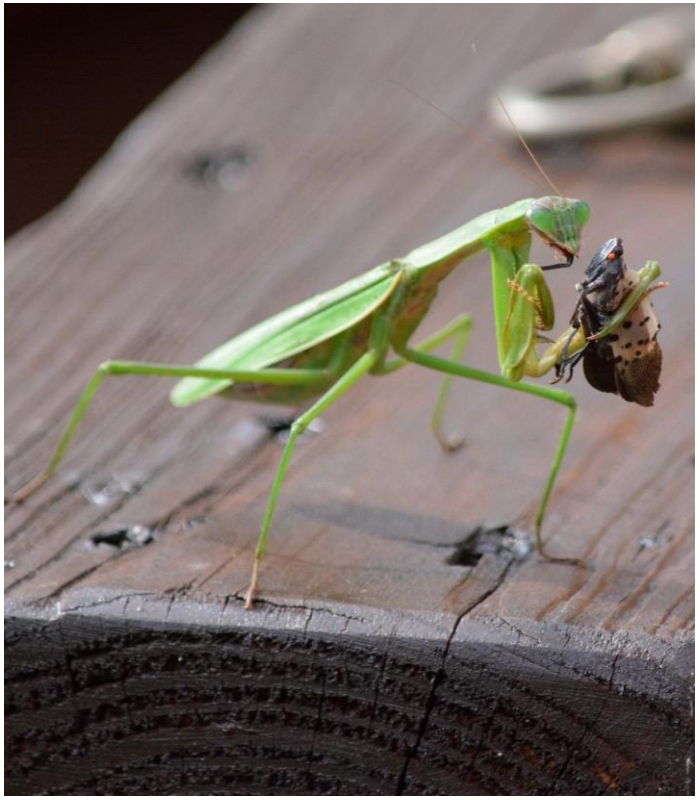
A Planthopper in the Family Fulgoridae

696 Species of Lanternflies in the world

Only 17 species in North America

Like most planthoppers, Lycorma pierce the stems of plants, trees, and vines and feed on phloem.

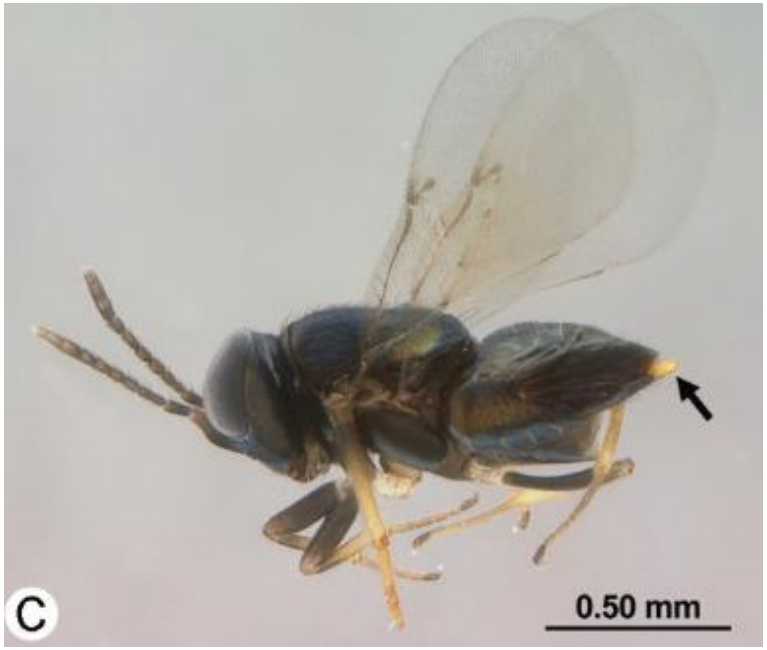
SLF predators

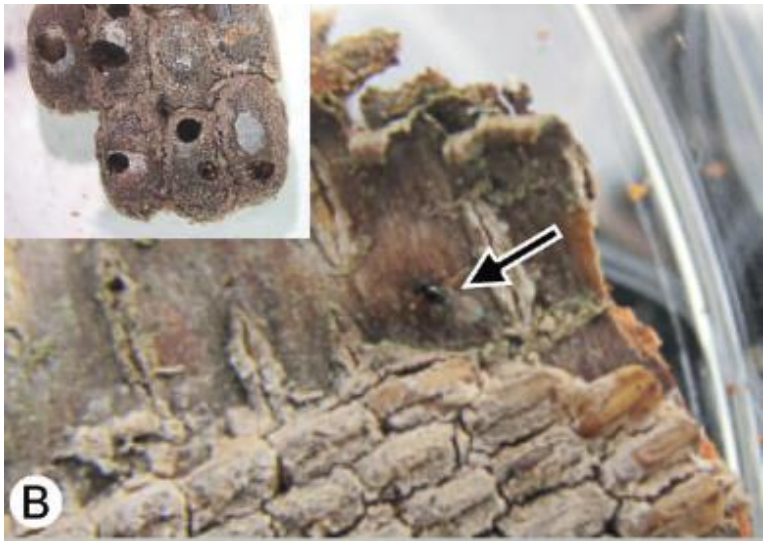


Generalist predators are attacking SLF in the U.S.

This is unlikely to control the SLF population

SLF endemic parasitoids





Ooencyrtus kuvanae

Gypsy moth parasitoid, introduced in 1908

Not reported on SLF in China

Found **~7%** parasitism of available egg masses

~20% of egg mass parasitized

Only found in some locations

Liu & Mottern (2017) **J. Insect Sci.**

Fungal pathogens on SLF

FUNGAL PATHOGENS

***Beauveria* sp.** found attacking SLF nymphs and adults in PA population

Too early to determine species or use as a control method

Dr. Ann Hajek

Eric Clifton

Eric Clifton

Fungal pathogens on SLF

FUNGAL PATHOGENS

Fungi closely related to ***Entomophaga* sp.** found attacking SLF adults in PA population

Species is unknown, but believed to be related to gypsy moth fungal pathogen

Dr. Ann Hajek

PENNSTATE

Classical Biological Control

- actively practiced in the US for about 100 years.
- about 2300 introductions worldwide have provided complete control in about 100 cases.
- Success in about 16-34% of attempts.

Foreign exploration for parasitoids in China

Anastatus orientalis

Only egg parasitoid recovered (to date)

A. orientalis is widely distributed throughout China

Parasitism ranged from **0-92%** of egg masses (those with any eggs attacked) and from **0- 26%** total eggs

In quarantine at APHIS (Otis, MA)


M-Y. Choi


Male


Female

Data courtesy of Kim Hoelmer & Juli Gould

Foreign exploration for parasitoids in China

Dryinus sp. nr. *browni*

Attacks **2nd and 3rd instars**

Late stage parasitoid larvae make protective sac in nymph

Overwinter in cocoon

40% parasitism reported in Chinese literature

June 2018 collection in China; **now at ARS quarantine lab**

Data courtesy of Kim Hoelmer & Juli Gould

Spotted Lanternfly ⟹ one word


THANK YOU!
https://extension.psu.edu/spotted-lanternfly
pennsylvania
DEPARTMENT OF AGRICULTURE
PennState