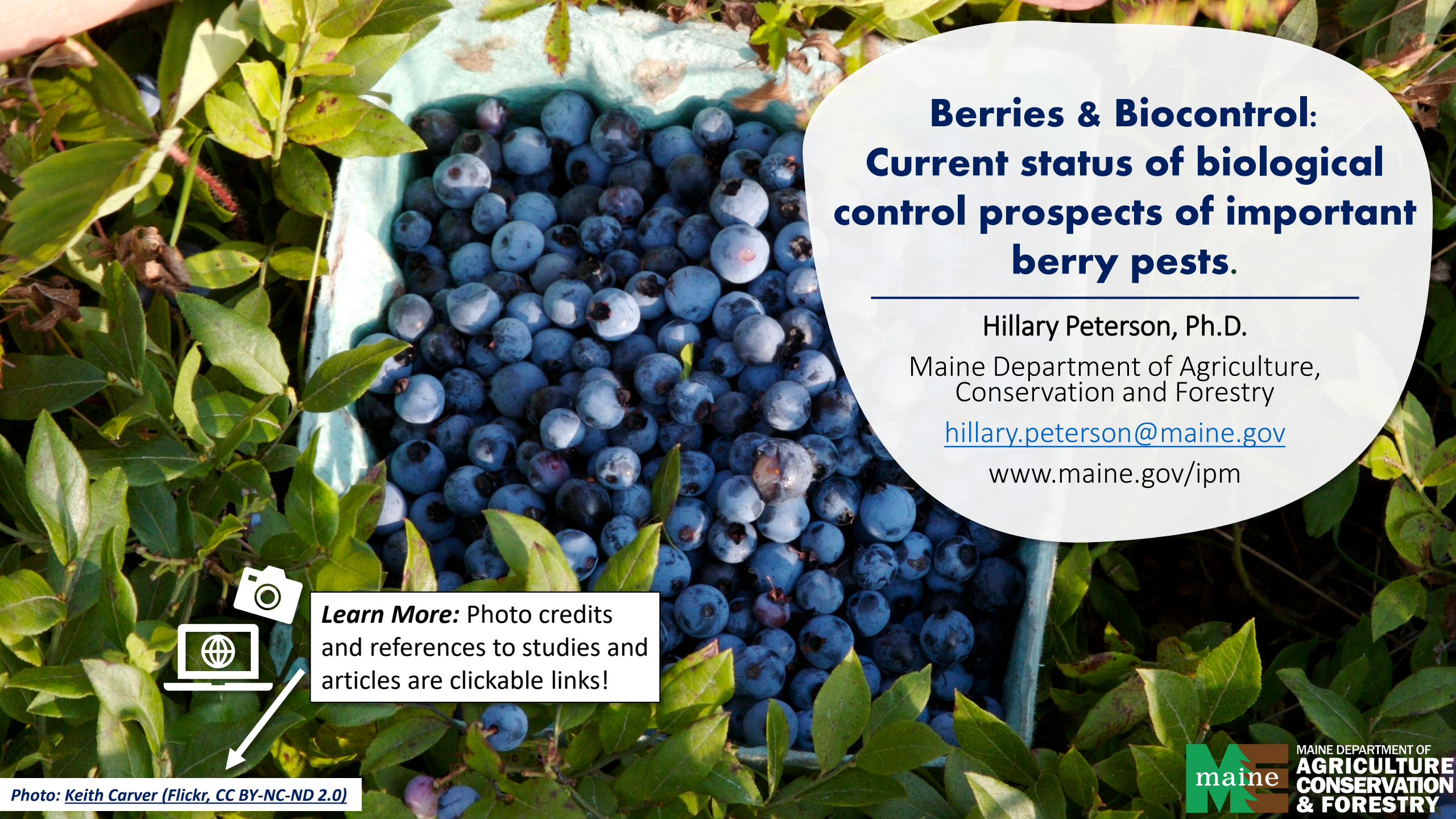


Berries & Biocontrol: Current status of biological control prospects of important berry pests.

Hillary Peterson, Ph.D.

Maine Department of Agriculture, Conservation and Forestry

hillary.peterson@maine.gov

www.maine.gov/ipm

Learn More: Photo credits and references to studies and articles are clickable links!

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Common Insect Pests of Berries

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Highbush Blueberry

Blueberry Maggot Fly

Special Section:

Spotted Wing Drosophila (SWD)

Raspberries & Blackberries

Candy-striped Leafhopper

Black Vine Weevil

Strawberries

Tarnished Plant Bug

Strawberry Bud Weevil

Strawberry Rootworm

Lowbush Blueberries

Blueberry Spanworm

Blueberry Thrips

UMaine Extension:

- Grasshoppers
- Flea beetles
- Blueberry Leaf Beetle
- Blueberry Sawfly
- Blueberry Tip Midge
- Red Striped Fireworm
- Winter Moth

Photos: Michigan State University; Hannah Burrack (NC State); UMaine Extension Tom Murray (bugguide.net); Matt Bertone; Charlie Armstrong; Jim Dill

Gotpests.org > fruit

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Maine.gov Agencies | Online Services | Help Page Tools GO State Search: GO

Got Pests? Maine Integrated Pest Management Council

Home | Contact Us Site Index | Search Got Pests: Go

GOT PESTS?
- About Got Pests?
- Is It Really a Pest?
- Pest Solutions
- A Word About Pesticides
- Want to Know More?

ASK the EXPERT

Home > Pests of Fruit

Pests of Fruit

Bugs
Diseases
Other Critters
Weeds

Bugs

Apple Maggot


Leafhoppers and Spittlebugs


Plum Curculio

QUICK FIND
- Bed Bugs
- Invasive Pests
- Late Blight of Potatoes/Tomatoes
- Mosquitoes
- Ticks
- What's New?

LINKS
- Maine Integrated Pest Management Council
- Maine Board of Pesticides Control
- Maine Natural Areas Invasive Plants
- Maine Center for Disease Control & Prevention
- Maine Department of Agriculture, Conservation and Forestry
- Maine YardScaping Partnership
- University of Maine Cooperative Extension IPM for Maine Homeowners
  - Have Your Pest Identified (Diagnostic Lab)
- USDA APHIS Wildlife Services

UMaine Extension > Home & Garden > Fruit Pests

Photo Gallery: Fruit Pests

Apple Maggot Fly

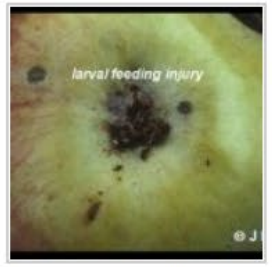
Apple Maggot Fly (closer view)

European Apple Sawfly (larvae plus damage)

Round-headed Apple Tree Borer

Larval stage of a longhorned beetle (such as the Round-headed Apple Tree Borer at left)

Codling Moth (apple pest)

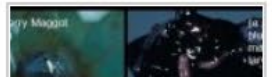


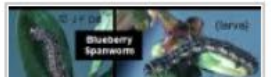
An apple with codling moth larval feeding injury

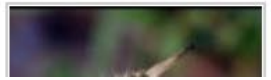
Black Vine Weevil (*Otiorhynchus sulcatus*) (strawberry, raspberry and cranberry pest; rhododendrons are also a host)

Raspberry Weevil (also known as the Clay-colored Weevil) (*Otiorhynchus singularis*) (very similar to the Black Vine Weevil) (this one was found feeding on a rhododendron in central Maine; 5/16/2021)

Blueberry Flea Beetle





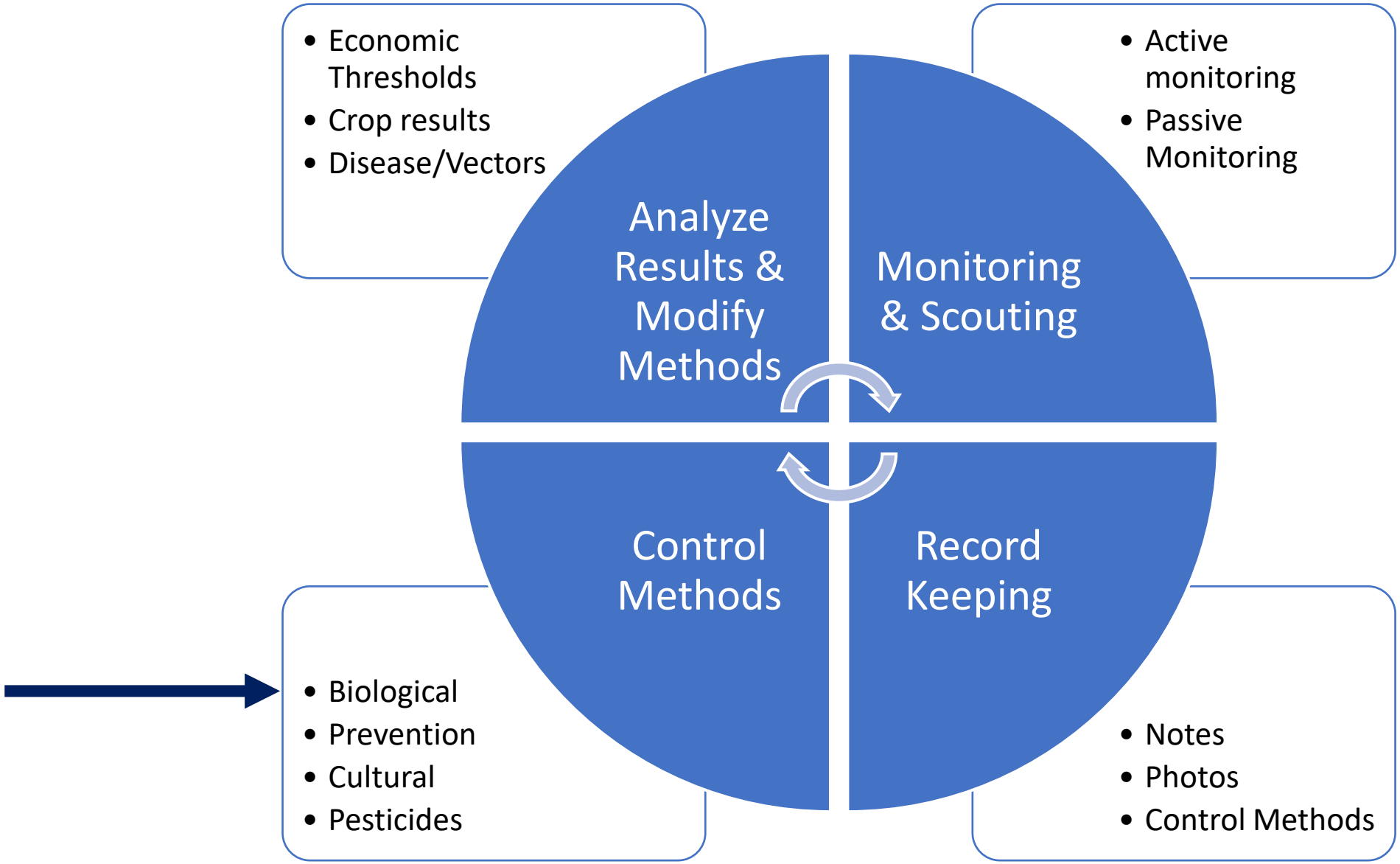


Additional Photos and Information:

- Apple Maggot
- Apple Mealybug
- Black Vine Weevil
- **Blueberry Insect Pests** (specific to Maine low-bush blueberry):
  - Blueberry Flea Beetle
  - Blueberry Maggot Fly
  - Blueberry Spanworm
  - Blueberry Thrips
  - Red-striped Fireworm
  - **Spotted-wing Drosophila (invasive) (*see* Fruit Flies)**
- Candy-striped Leafhopper (pest of blackberries and raspberries)
- Codling Moth
- **Cranberry Insect Pests:**
  - Blackheaded Fireworm
  - Cranberry Fruitworm (cranberry and highbush blueberry pest)
  - Cranberry Weevil
  - Cranberry Tipworm

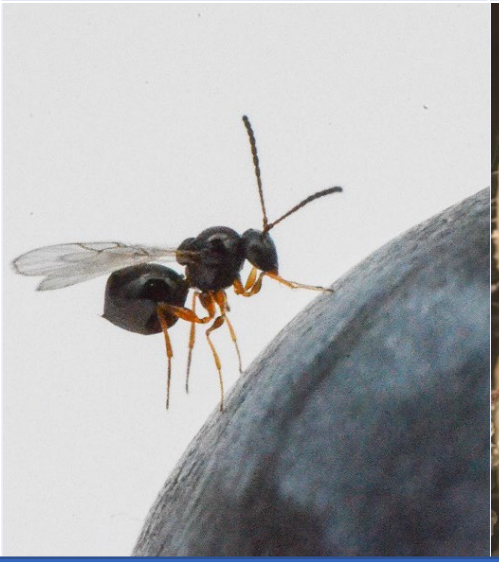
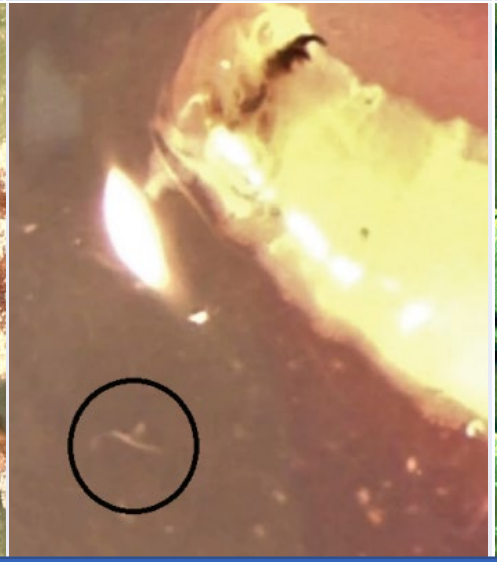
TOP

Biological Control within the IPM Cycle



Introduction to Biological Control Organisms

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Often Insects or Other Non-Insect Arthropods		Entomopathogens		
Predators *e.g., rove beetles*	**Parasitoids** *e.g., larval parasitoids*	**Fungi** *e.g., Beauveria bassiana*	**Nematodes** *e.g., Oscheius onirici*	**Bacteria & Viruses** *e.g., Bacillus thuringiensis (Bt)*
				

Generalist → **Specialist**

Photos: Machi (iNaturalist); Tim Haye; Surendra Dara; Foye and Steffan 2019; Scimat

Introduction to Biological Control Types

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Conservation Biocontrol	Augmentative Biocontrol	Classical Biocontrol
		

Photos: Sarah Foltz (Xerces.org); Victor Fursov; Tim Haye

Raspberries & Blackberries

Photo: Allagash Brewing (CC by 2.0)

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Two-Spotted Spider Mite Biocontrol

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Pest and Fruit Damage

- Two-Spotted Spider Mite
- Foliage injury to the fruiting spurs

Biocontrol option: Predatory Mites

- Naturally occurring and for-purchase
- Avoid pesticides with high toxicity to predatory mites

Examples of where to purchase:

- Association of Natural Biocontrol Producers

Learn More

- Raspberry & Blackberry Production Guide for the Northeast, Midwest, and Eastern Canada

Spider mite damage to leaf

Predatory mite

Table 8.3 **Relative toxicity of pesticides to beneficial mites.**

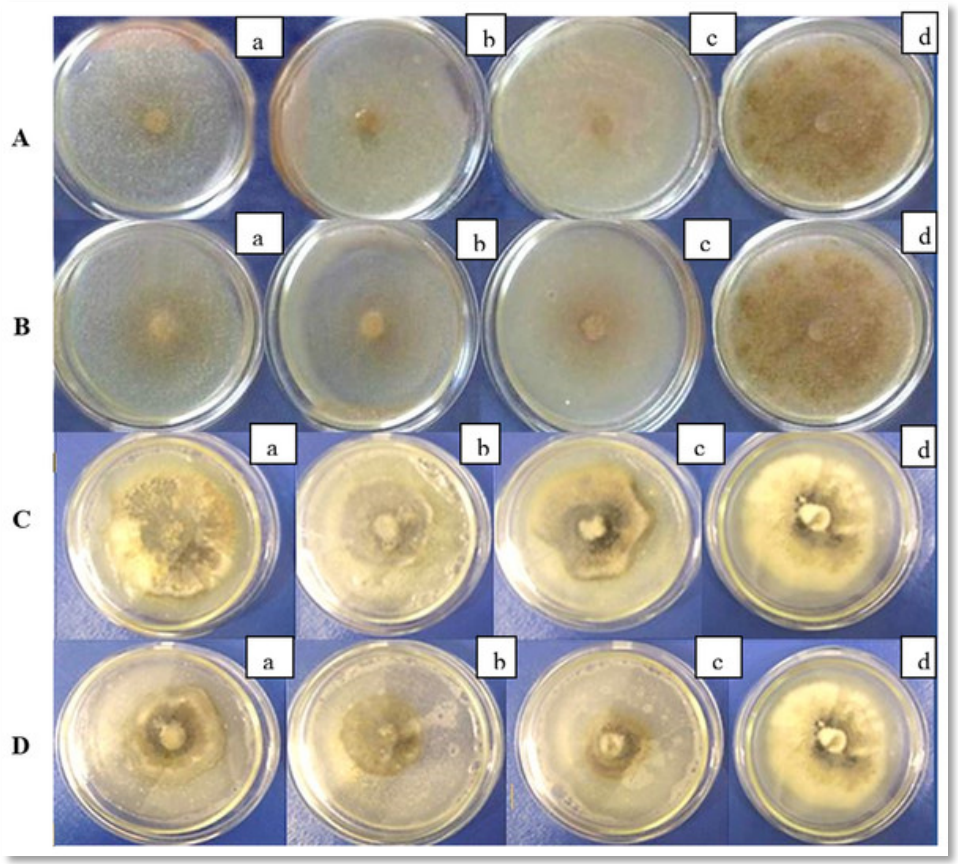
Chemical	Toxicity
Benlate (benomyl)	medium
Brigade (bifenthrin)	high
Captan	low
Guthion (azinphosmethyl)	low
Kelthane (dicofol)	medium
Lorsban (chlorpyrifos)	medium
Morestan (oxythioquinox)	low
Ronilan (metalaxyl)	low
Sevin (carbaryl)	high
Vendex (hexakis)	low

Any organisms to be released in Maine must be on the IF&W unrestricted list.

***Photos:** Washington State University; **Table:** Raspberry & Blackberry Production Guide;*

Recent Studies from Around the World

Western Siberia: Raspberry spur blight (*Didymella applanata)* controlled by two bacterium strains (*Bacillus velezensis*) in raspberries led to higher yield.



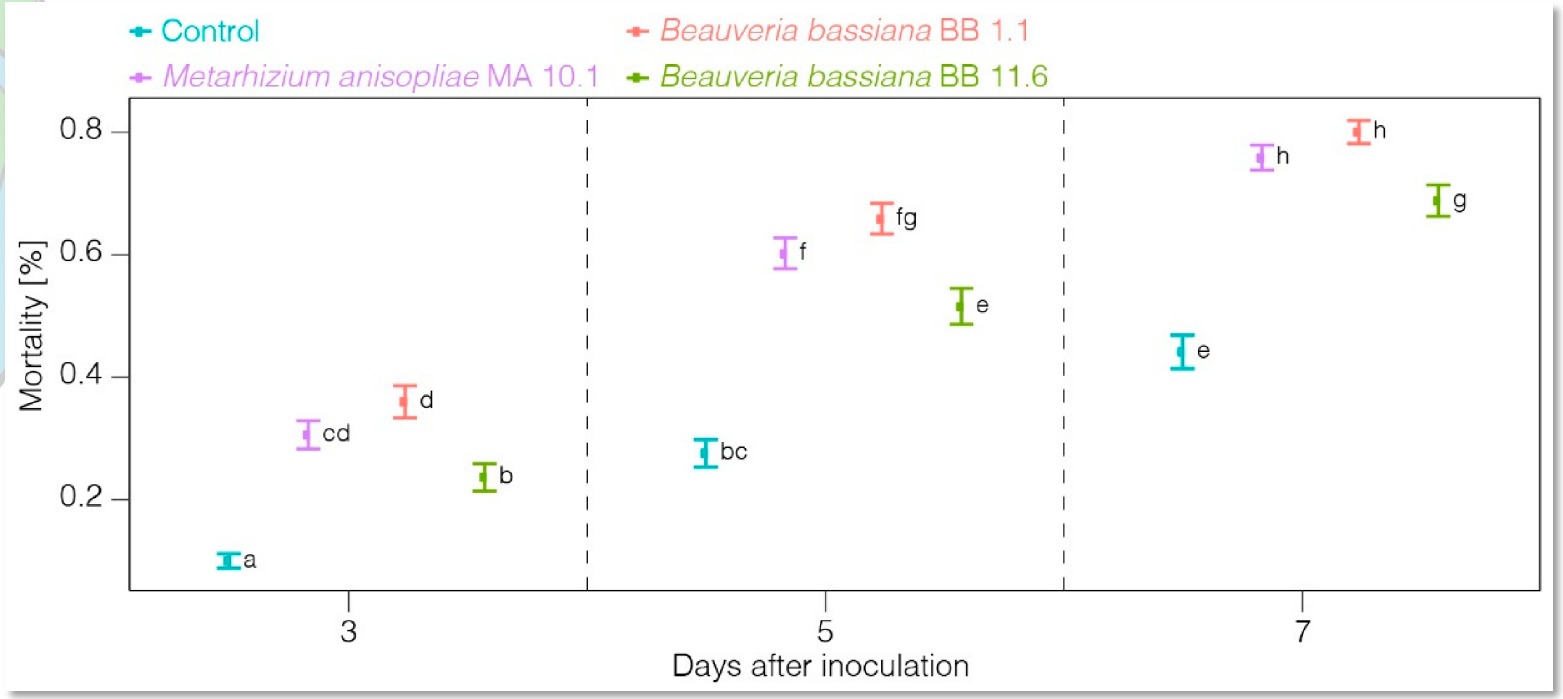
Learn More: Asaturova et al. 2021

Photos: Ohio State Extension; Asaturova et al. 2021

Recent Studies from Around the World

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Switzerland: Eriophyoid mite (*Phyllocoptes gracilis*) controlled by entomopathogenic fungi *Beauveria bassiana* (strain BB 1.1) and *Metarhizium anisopliae* (strain MA 10.1)



Learn More: Minguely et al. 2021

Photos: Plant Parasites of Europe; Figure: Minguely et al. 2021

Strawberries

Photo: Andrew Malone (CC by 2.0)

maine MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

History: Classical Biocontrol in Maine Strawberries

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Beneficial Organism

- *Peristenus digoneutis* (European origin)

History of Release

- Released in Maine in 1984
- Aimed at tarnished plant bug in alfalfa
- Reduced populations in strawberries too

Current Status

- Tarnished plant bug populations are up
- May be worth investigating further

Learn More

- USDA Report (2003)
- Tarnished Plant Bug in Strawberries (NC State)

Tarnished Plant Bug
Lygus lineolaris

Tarnished Plant Bug
Strawberry Deformation

Peristenus digoneutis
prepares to lay an egg in a
tarnished plant bug nymph

Photos: Hannah Burrack (NC State); Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Strawberry Root Weevil Biocontrol

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Pest and Fruit Damage

- Strawberry root weevil
- Weak and stunted plants

Biocontrol option: Nematodes

- Mid-late May optimal timing
- *Heterorhabditis bacteriophora* (Hb)

Examples of where to purchase:

- Association of Natural Biocontrol Producers

Learn More

- UMaine Extension Newsletter (2021)

Any organisms to be released in Maine must be on the IF&W unrestricted list.

Photo: David Handley (UMaine Extension)

Blueberries

Photo: Keith Carver (Flickr, CC BY-NC-ND 2.0)

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AGRICULTURE
CONSERVATION
& FORESTRY

Conservation Biocontrol in Blueberries

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Beneficial Organism

- Dung beetles

Summary of Ecosystem Services

- Pathogen (*E. coli*) suppression
- Wildlife pest suppression
- Nutrient cycling in the soil
- Increased soil permeability

Conservation Biocontrol Practices

- Reduction in pesticide inputs

Learn More

- UMaine Factsheet

Onthophagus nuchincornis

Onthophagus hacate

Photos: UMaine Factsheet; Swamp Cartoons

Conservation Biocontrol in Blueberries

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Beneficial Organism

- Allegheny Mound Ant

Summary of Ecosystem Services

- Voracious predators:
  - red striped fire worm
  - blueberry flea beetle larvae/pupae
  - blueberry leaf beetle
  - grasshoppers

Conservation Biocontrol Practices

- Weed control of tall vegetation
- Reduction in pesticide inputs

Learn More

- UMaine Factsheet

Allegheny mound ant worker

Allegheny mound structure in wild blueberry field

Photos: wycraig1 (iNaturalist, Maine); Alex Wild; UMaine Factsheet;

Conservation Biocontrol in Blueberries

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Beneficial Organism

- Ground Beetles

Summary of Ecosystem Services

- Voracious predators of *many* pests
- Weed management (feeds on seeds)

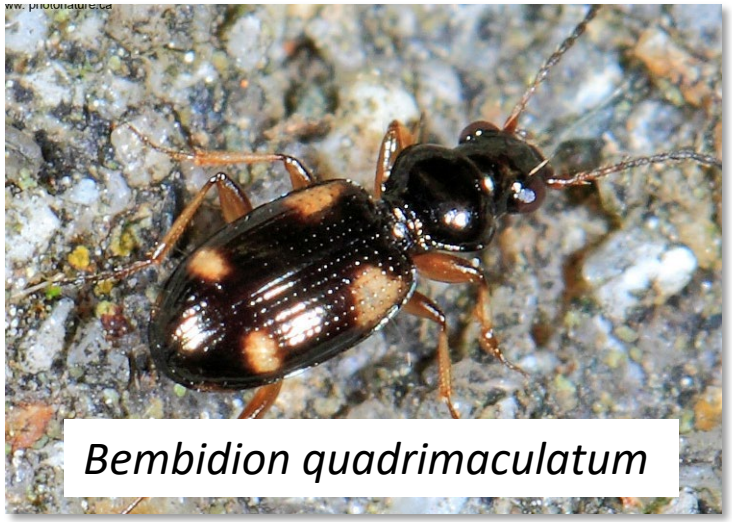
Conservation Biocontrol Practices

- Unmanaged refuge areas & beetle banks
- Reduction in pesticide inputs

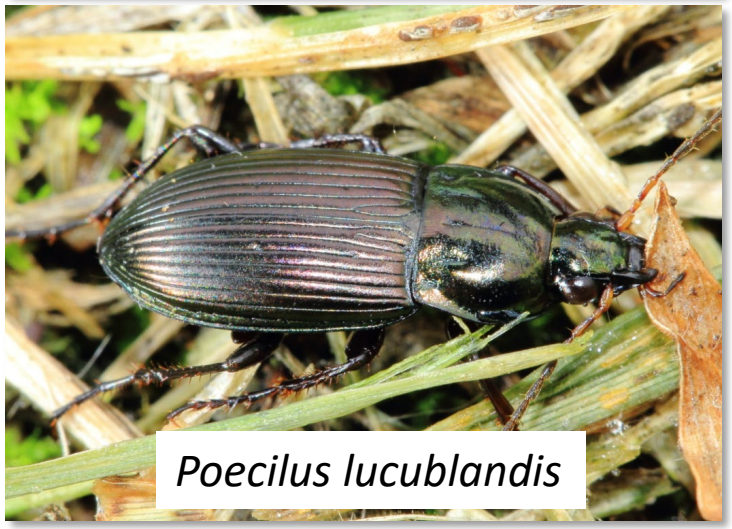
Learn More

- UMaine Factsheet

Particularly good predators of blueberry spanworm and blueberry flea beetle:


Bembidion quadrimaculatum


Harpalus rufipes


Poecilus lucublandis


Pterostichus melanarius

Photos: alainhogue (iNaturalist); Jesus Tizon (flickr.com; (CC BY-NC-ND 2.0)); stephenluk (iNaturalist)

Entomopathogens of Blueberries in Maine

Researchers: Frank Drummond (Umaine) and Eleanor Groden (UMaine)

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Pest and Fruit Damage

- Key pests of lowbush blueberry

Report contains:

- Key native parasitoids and predators
- Options for entomopathogen control

Learn More

- UMaine Technical Bulletin (2000)

Table 1. Key pests of lowbush blueberry, their current and potential microbial control agents (those field tested), application rates, and selected references.

Key Pests	Microbial Agent	Application Rate	References
blueberry spanworm	Btk (Javelin, Dipel Agree, Biobit)	1133.9 g/ha (16 oz/acre), but depends upon formulation and product.	Yarborough and Collins 1997
blueberry spanworm	Mycotrol ES *(B. bassiana)*	2.4 l/ha (32 fl oz/acre)	Collins and Drummond 1998
blueberry flea beetle	Mycotrol ES	2.4 l/ha (32 fl oz/acre)	Collins and Drummond 1998

This does not constitute an endorsement or a recommendation by the State of Maine or the Board of Pesticides Control to use these products in the production of blueberries. Any products without an EPA registration number have not been reviewed or registered by the EPA. The label must be strictly followed.

Table: Drummond and Groden 2000,

Upcoming Research: Blueberry Gall Midge (BGM) Parasitoids

Researchers: István Mikó (UNH), Jeff Garnas (UNH), Elijah Talamas (Florida Dept. Ag), Philip Fanning (UMaine), Monique Raymond (UNH)

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Pest and Fruit Damage

- Blueberry gall midge complex
- 2004: First identified in ME
- Blueberry flower bud loss
- Difficult to control with pesticides

Objectives of Study

- Provide information about parasitoids of blueberry gall midge for IPM
- Create user-friendly identification tools
- Determine biocontrol options

Learn More

- BGM Factsheet (UMaine)
- BGM Factsheet (Oregon State)

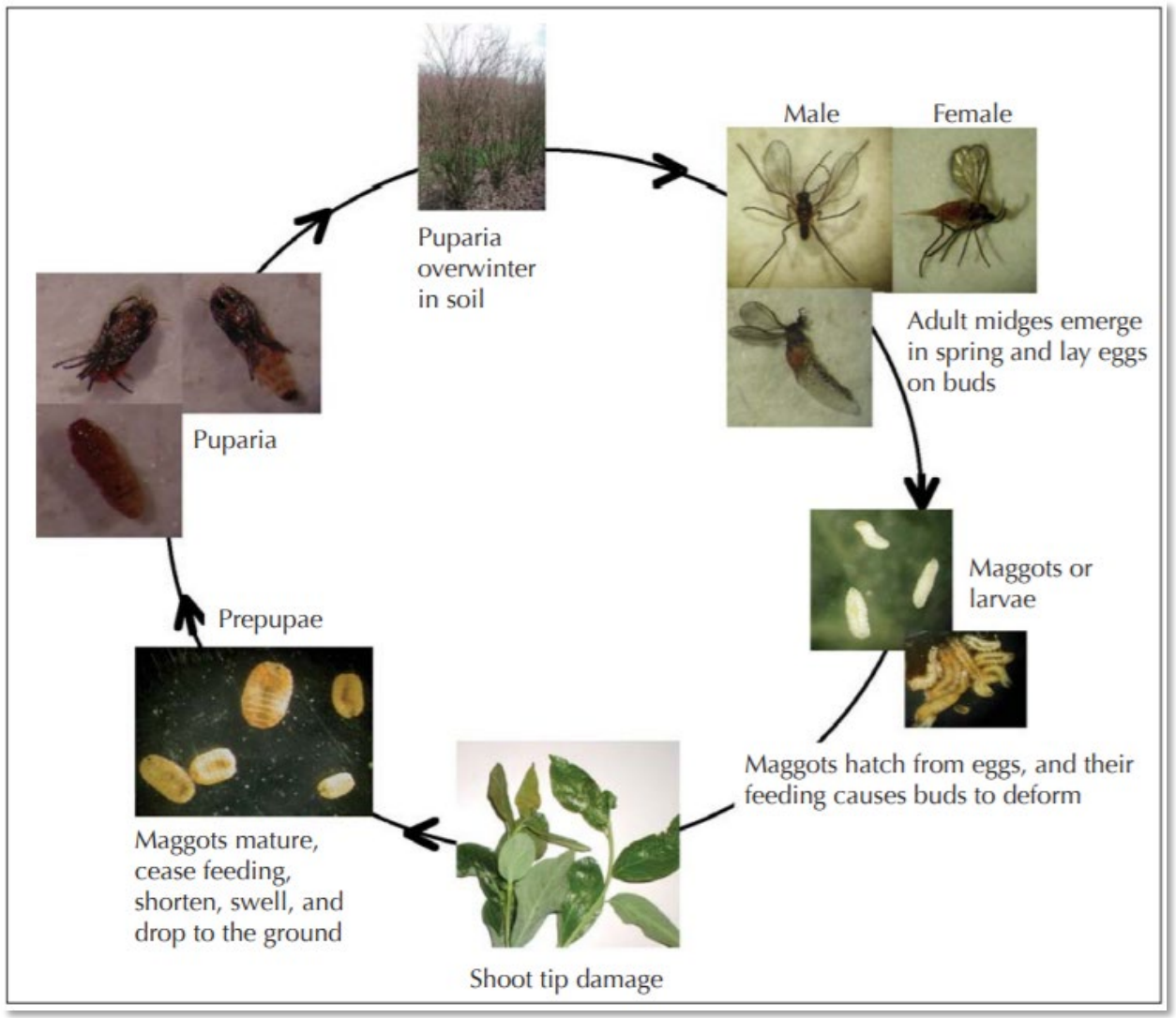


Figure: Oregon State University Factsheet

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MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

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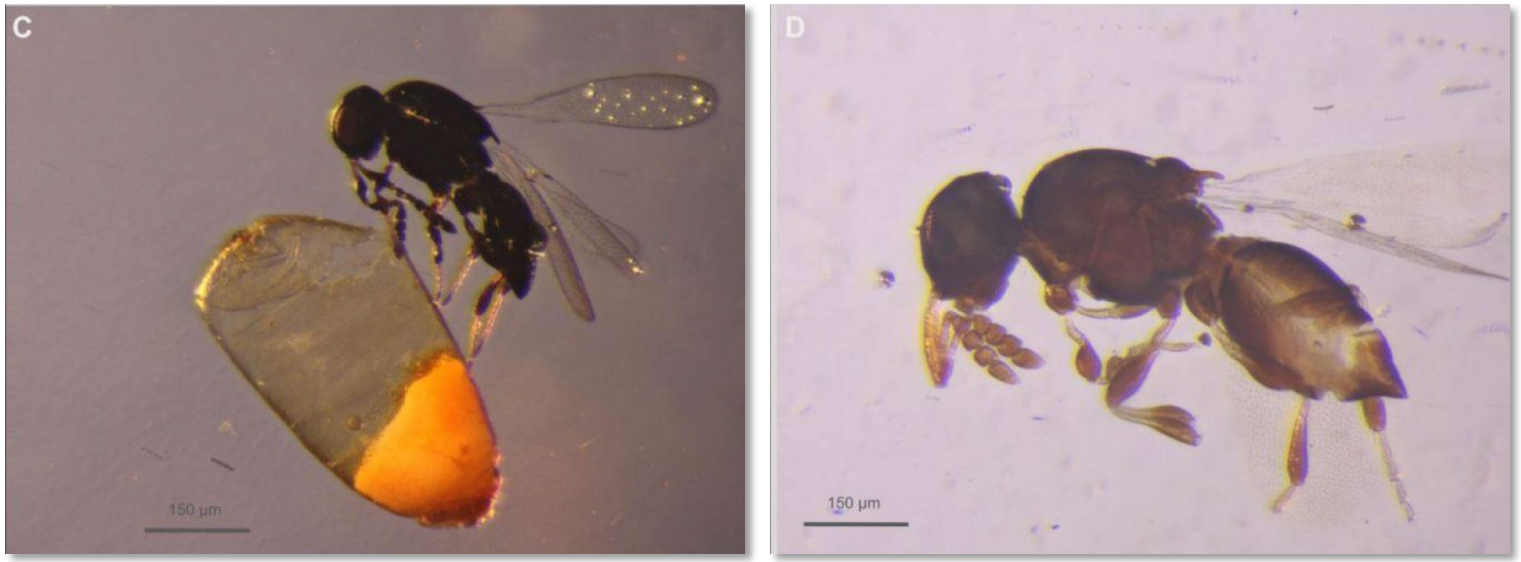


Parasitoids reared from blueberry gall midge in Maine June/July 2021

Photos: Mikó et al. grant proposal

Special Section:

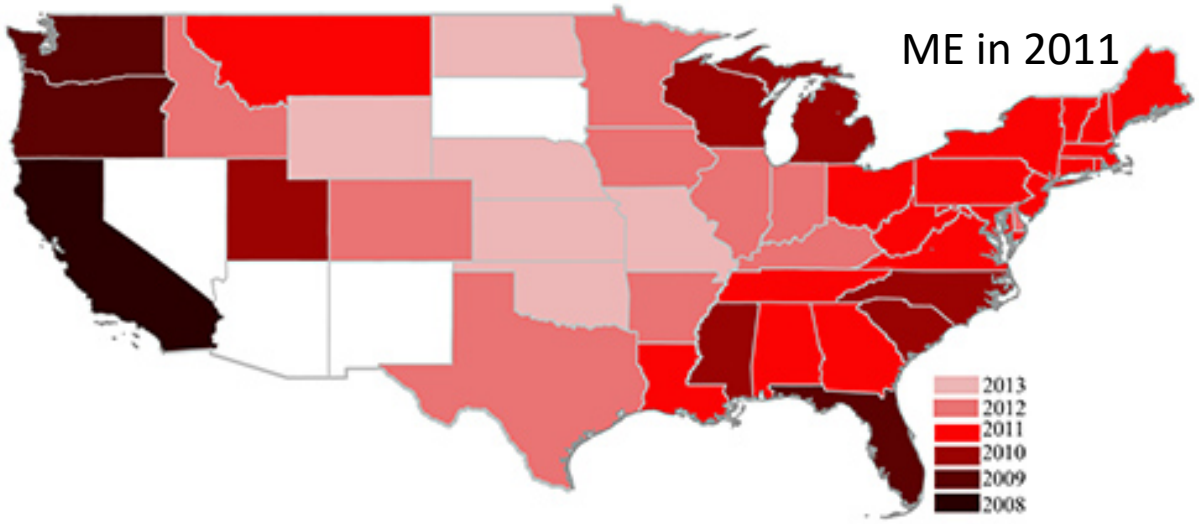
Spotted Wing Drosophila (SWD)

Photo: Matt Bertone (CC by 2.0)

maine
MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

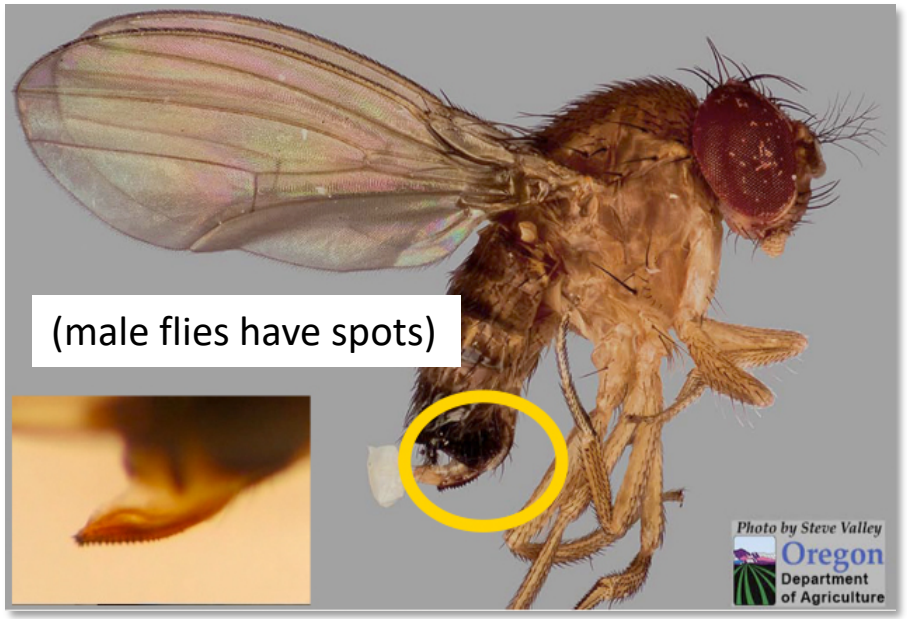
Introduction to Spotted Wing Drosophila (SWD)

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY



Native to Southeastern China, North and South Korea, and Southern Japan

Major concern to Maine agriculture: wild blueberries, highbush blueberries, day-neutral strawberries, and fall raspberries.



Photos: Matt Bertone; NYS IPM Program; UMaine Factsheet

Spotted Wing Drosophila (SWD) Biocontrol

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Recent Review Paper: Summarizes many studies since spotted wing drosophila was first detected

Journal of Economic Entomology, 114(5), 2021, 1950–1974
https://doi.org/10.1093/jee/toab158
Advance Access Publication Date: 13 September 2021
Review

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Review

Drosophila suzukii (Diptera: Drosophilidae): A Decade of Research Towards a Sustainable Integrated Pest Management Program

Gabriella Tait,[1] Serhan Mermer,[1] Dara Stockton,[2] Jana Lee,[3] Sabina Avosani,[4,5] Antoine Abrieux,[6] Gianfranco Anfora,[5,7] Elizabeth Beers,[8] Antonio Biondi,[9] Hannah Burrack,[10] Dong Cha,[2] Joanna C. Chiu,[6] Man-Yeon Choi,[3] Kevin Cloonan,[11] Cristina M. Crava,[12] Kent M. Daane,[13,14] Daniel T. Dalton,[15] Lauren Diepenbrock,[16] Phillip Fanning,[17] Fatemeh Ganjisaffar,[6] Miguel I. Gómez,[18] Larry Gut,[19] Alberto Grassi,[20] Kelly Hamby,[21] Kim A. Hoelmer,[22] Claudio Ioriatti,[20] Rufus Isaacs,[19] Jimmy Klick,[23] Laura Kraft,[10] Gregory Loeb,[24] Marco Valerio Rossi-Stacconi,[5] Rachele Nieri,[4,5] Ferdinand Pfab,[25] Simone Puppato,[20] Dalila Rendon,[1] Justin Renkema,[26] Cesar Rodriguez-Saona,[27] Mary Rogers,[28] Fabiana Sassù,[29,30] Torsten Schöneberg,[21] Maxwell J. Scott,[10] Michael Seagraves,[23] Ashfaq Sial,[31] Steven Van Timmeren,[19] Anna Wallingford,[32] Xingeng Wang,[22] D. Adeline Yeh,[17] Frank G. Zalom,[6] and Vaughn M. Walton[1,33]

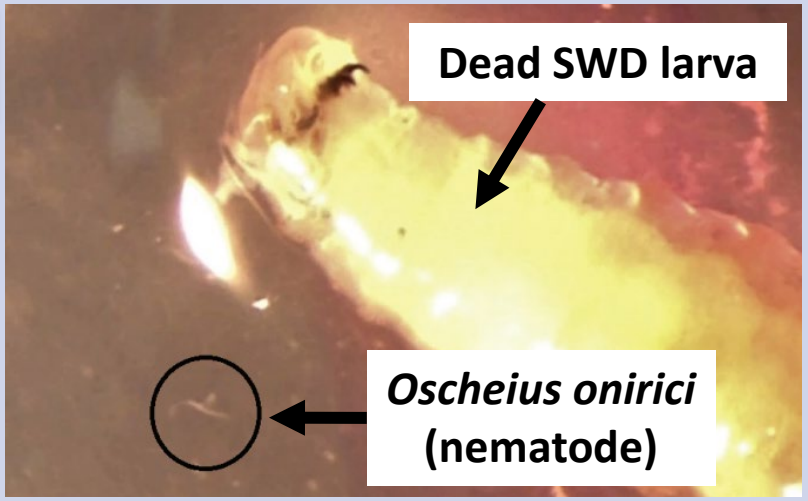
[1]Department of Horticulture, Oregon State University, Corvallis, OR, USA, [2]USDA-ARS Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, Hilo, HI, USA, [3]USDA-ARS Horticultural Crops Research Unit, Corvallis, OR, USA, [4]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy, [5]Research and Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige, Italy, [6]Department of Entomology and Nematology, University of California, Davis, CA, USA, [7]Center Agriculture Food Environment, University of Trento, San Michele all'Adige, Trentino, Italy, [8]Tree Fruit Research & Extension Center, Washington State University, Wenatchee, WA, USA, [9]Department of Agriculture, Food and Environment, University of Catania, Catania, Italy, [10]Department of Entomology and Plant Pathology, North Carolina State University, Raleigh, NC, USA, [11]Trécé Inc., Adair, OK, USA, [12]Institute of Biotechnology and Biomedicine (BIOTECMED), University of Valencia, Valencia, Spain, [13]Kearney Agricultural Research and Education Center, Parlier, CA, USA, [14]Department of Environmental Science, Policy & Management, University of California Berkeley, Berkeley, CA, USA, [15]Faculty of Engineering & IT, Carinthia University of Applied Sciences, 9524, Villach, Austria, [16]Citrus Research and Education Center, Entomology and Nematology Department, University of

Paper & Figure: Tait et al. 2021 (Open Access Review Paper)

Spotted Wing Drosophila (SWD) Biocontrol

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Recent Review Paper: Summarizes many studies since spotted wing drosophila was first detected

Predators	Parasitoids	Entomopathogens
 **Minute Pirate Bugs** **Rove Beetle** **Lacewing**	***Ganaspis brasiliensis***  **A promising parasitoid of SWD larva from China and Japan**	 ***Oscheius onirici*** **(nematode)**
• Challenge in control of larvae • SWD pupae attacked in soil • Conservation biocontrol	• Native parasitoids struggle • Parasitoids from Asia show promise • Field cages for rearing	• Field conditions = challenge • Lure-and-infect devices • Promising new nematode discovered

Photos: Raupach et al 2014; Udo Schmidt (CC BY-SA 2.0); Buffington et al. 2016; Foye and Steffan 2019; Paper: Tait et al. 2021 (Open Access Review Paper)

Spotted Wing Drosophila (SWD) Parasitoid Update for Maine

Collaborators: Philip Fanning (UMaine), Phillip Demaynadier (ME Dept. Inland Fisheries and Wildlife)

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Pest and Fruit Damage

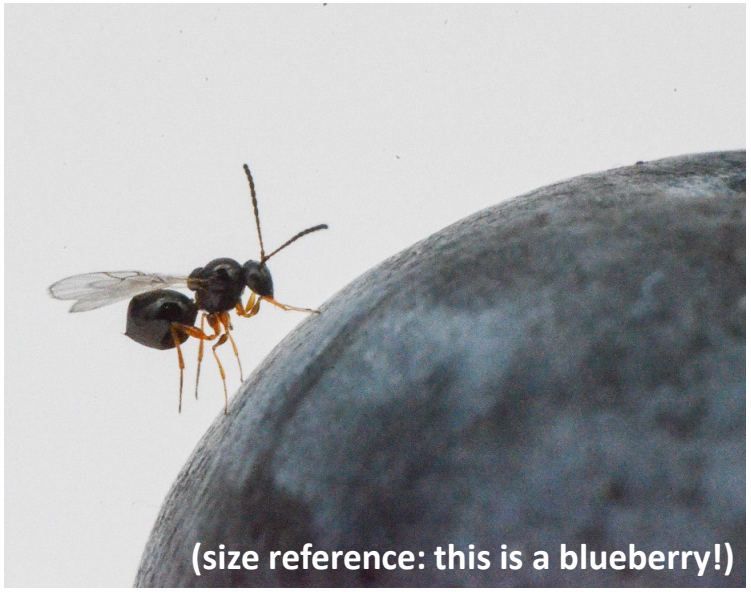
- Spotted wing drosophila (SWD)

Objectives of Study

- Work on releases of a specialist parasitoid of SWD
- Permit has been approved for the state of Maine
- Difficult to rear & release

Learn More

- USDA APHIS Release Permit News
- Biocontrol Factsheet (Oregon State)



Ganaspis brasiliensis

A parasitoid approved for release for control of SWD in Maine

Photos: Matt Bertone; Buffington et al. 2016; Tim Haye

Spotted Wing Drosophila (SWD) Parasitoid Update for Maine

Collaborators: Philip Fanning (UMaine), Phillip deMaynadier (ME Dept. Inland Fisheries and Wildlife)

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Pest and Fruit Damage

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Learn More

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- Biocontrol Factsheet (Oregon State)

Rearing these parasitoids is challenging – research will take place to figure it out for Maine Growers!

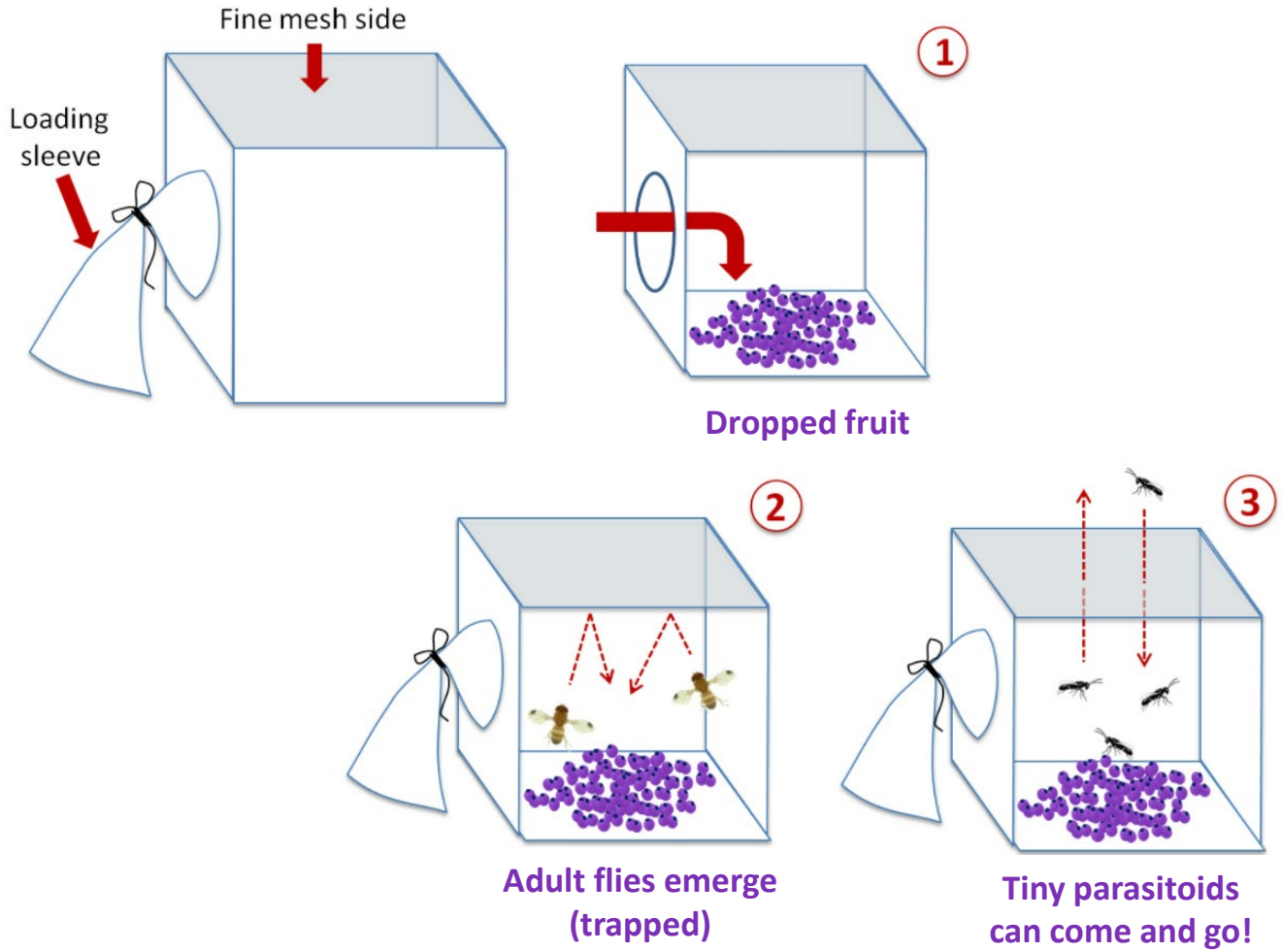


Photo: Matt Bertone; Figure: Rossi-Stacconi et al. 2019

Spotted Wing Drosophila (SWD) Biocontrol

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

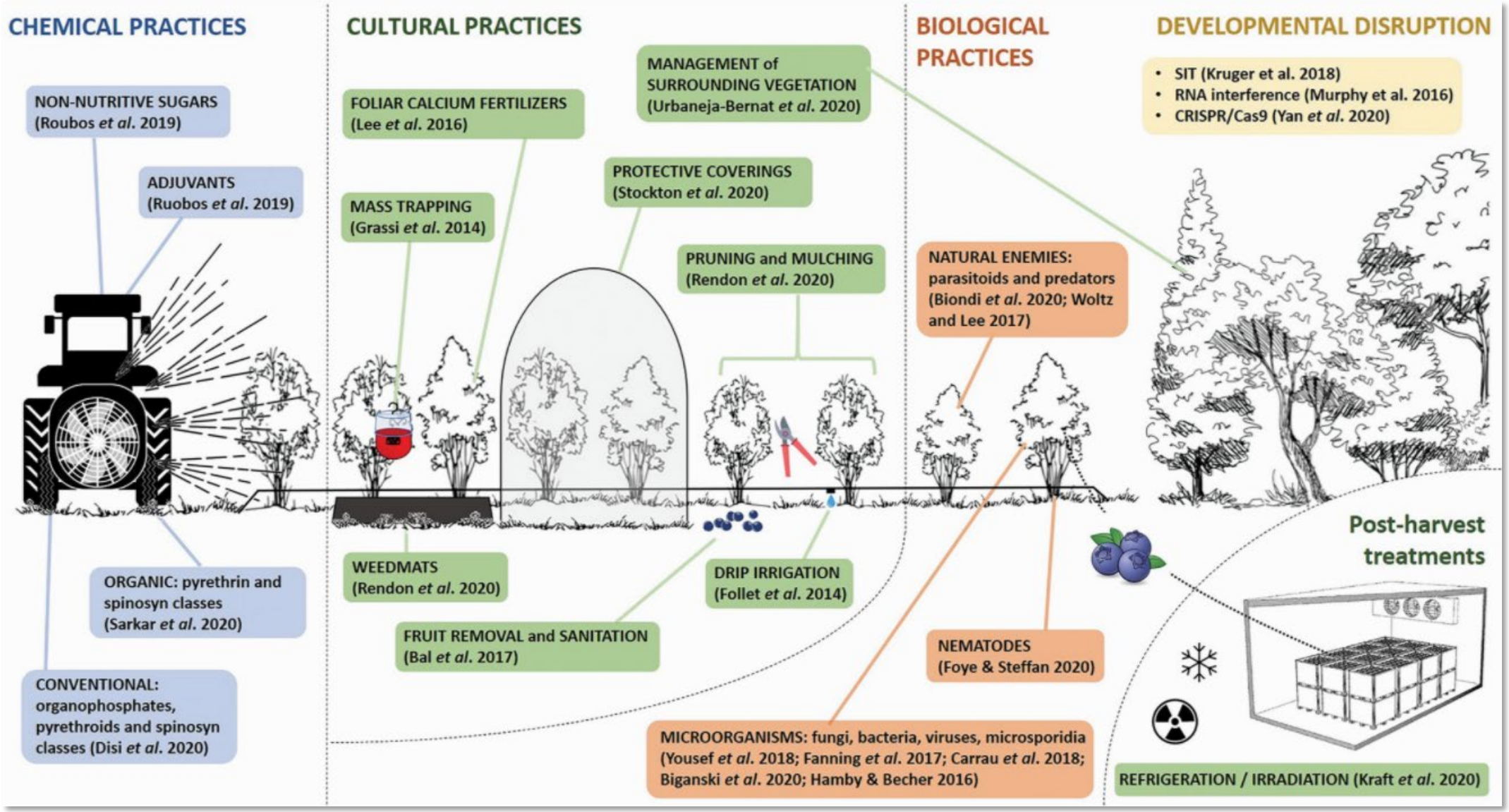
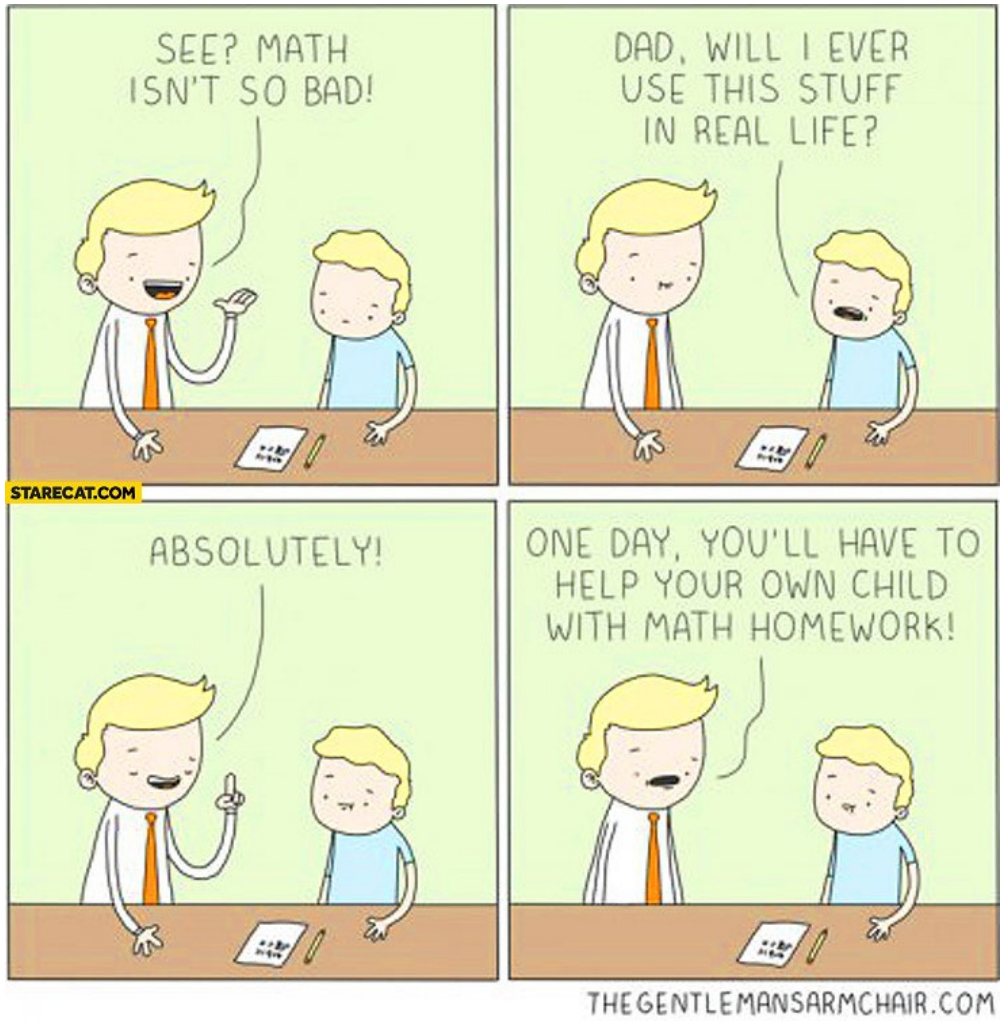


Figure: Tait et al. 2021 (Open Access Review Paper)

Modeling: Understanding biology for more effective biocontrol releases

MAINE DEPARTMENT OF AGRICULTURE CONSERVATION & FORESTRY

Researchers are working on building complex mathematical models that have the potential to become useful tools



Seasonal environment

Temperature

Fruits or suitable medium

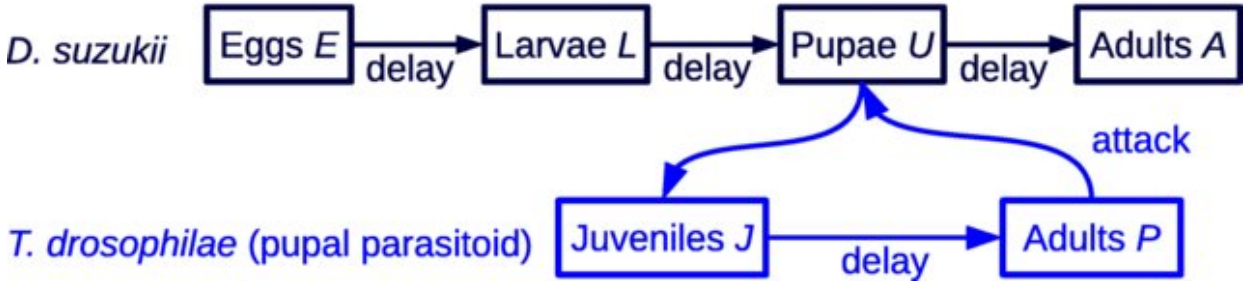
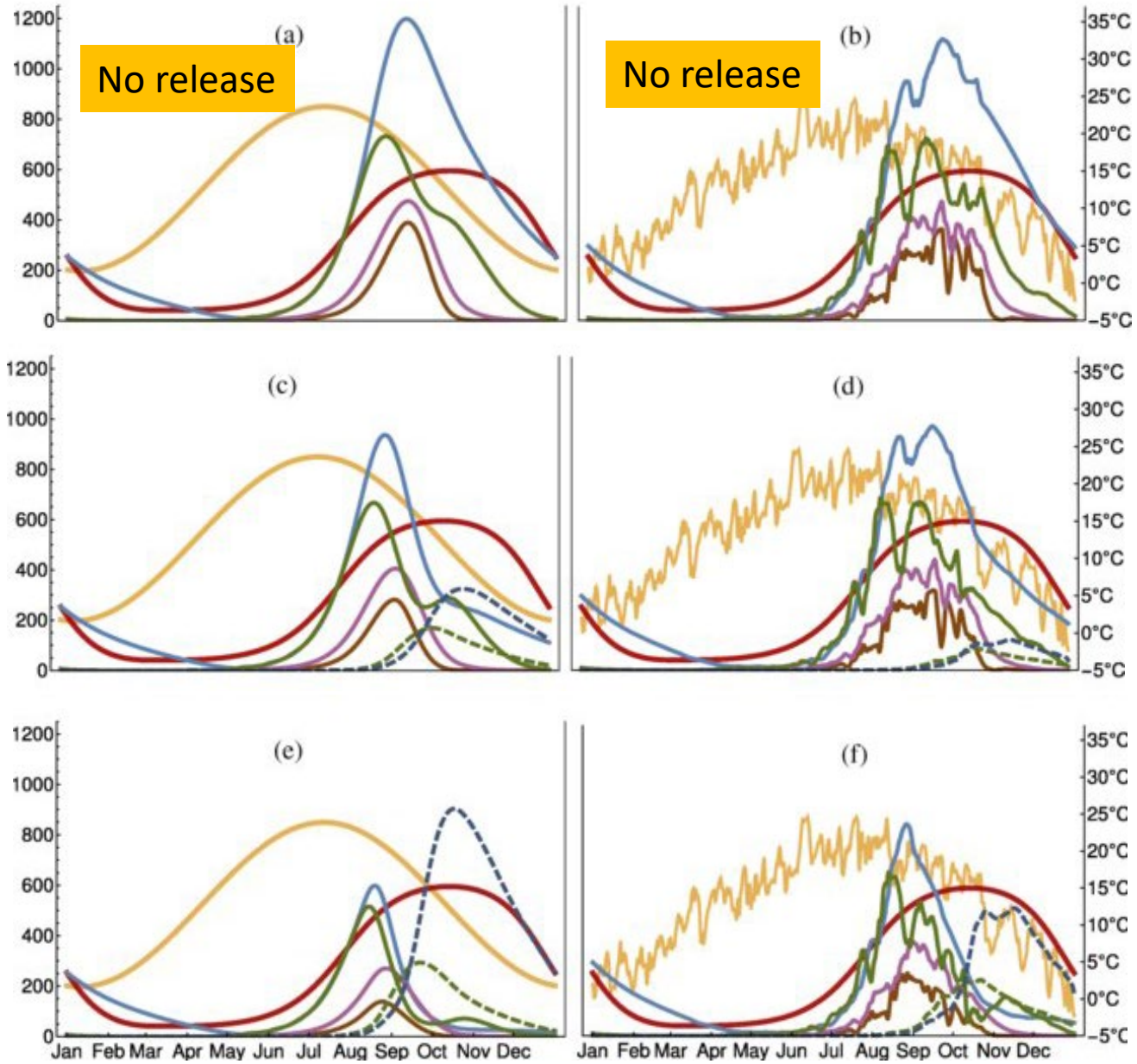


Photo: bioplanet; Figure: Pfab et al. 2018

Modeling: Understanding biology for more effective biocontrol releases



Predicted if released on April 1st

Predicted if released on June 1st

Photo: bioplanet; Figure: Pfab et al. 2018

Recent Study: Spotted Wing Drosophila (SWD) Parasitoid ID

Researchers: Abram et al. 2022

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Pest and Fruit Damage

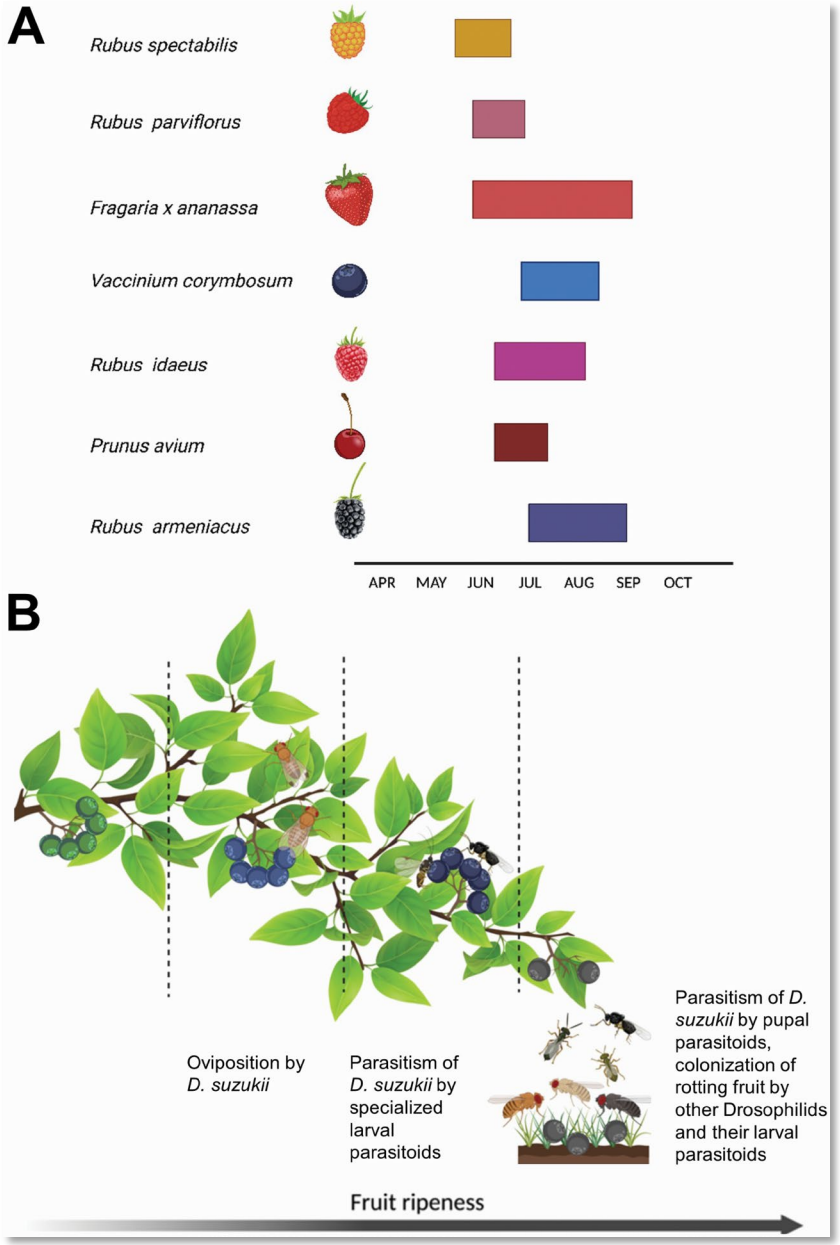
- SWD across cultivated and wild fruit

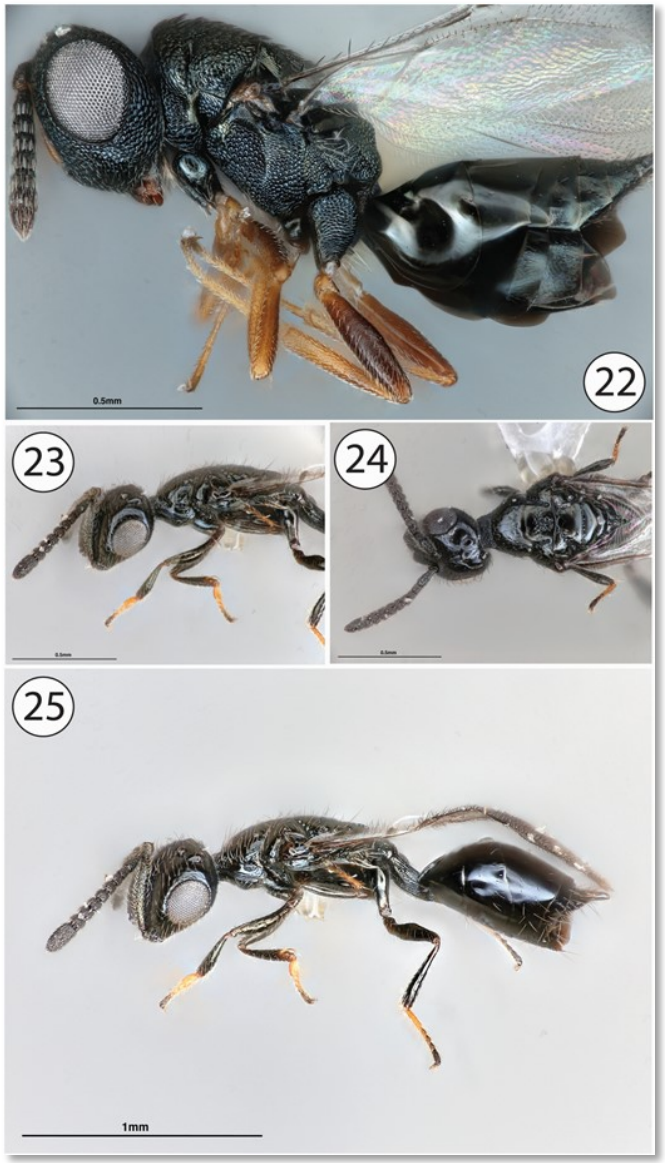
Outcomes of Study

- Demonstrated importance of various sampling methods
- Created parasitoid sampling protocols
- Provided new identification tools

Learn More

- Open-access (free) journal article





Figures: Abram et al. 2022

Ways you can use biological control this upcoming season

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Conservation Biocontrol	Augmentative Biocontrol	Classical Biocontrol

In most scenarios for Maine berry growers, conservation biocontrol is the most practical recommendation.

Practicing IPM is the way to go!

Photos: Sarah Foltz (Xerces.org); Victor Fursov; Tim Haye

Questions?

References

Tait, G., et al. (2021). *Drosophila suzukii* (Diptera: Drosophilidae): A Decade of Research Towards a Sustainable Integrated Pest Management Program. *Journal of Economic Entomology*, *114*(5), 1950–1974. https://doi.org/10.1093/jee/toab158

University of Maine Cooperative Extension Factsheets (linked throughout presentation)

Shane Foye, Shawn A Steffan, A Rare, Recently Discovered Nematode, *Oscheius onirici* (Rhabditida: Rhabditidae), Kills *Drosophila suzukii* (Diptera: Drosophilidae) Within Fruit, *Journal of Economic Entomology*, Volume 113, Issue 2, April 2020, Pages 1047–1051, https://doi.org/10.1093/jee/toz365

Pfab, F., Stacconi, M.V.R., Anfora, G. *et al.* Optimized timing of parasitoid release: a mathematical model for biological control of *Drosophila suzukii*. *Theor Ecol* **11,** 489–501 (2018). https://doi.org/10.1007/s12080-018-0382-3

Paul K Abram *et al.* A Coordinated Sampling and Identification Methodology for Larval Parasitoids of Spotted-Wing Drosophila, *Journal of Economic Entomology*, 2022, https://doi.org/10.1093/jee/toab237

Photo: Keith Carver (Flickr, CC BY-NC-ND 2.0)

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