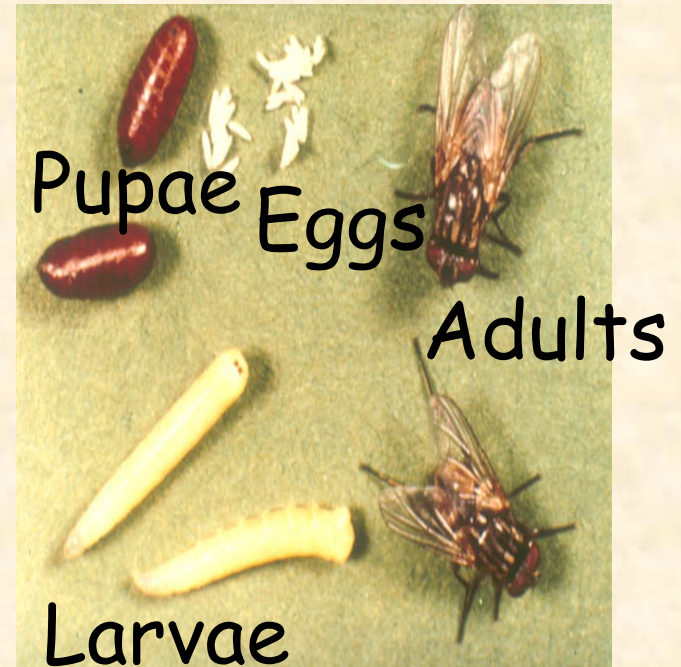
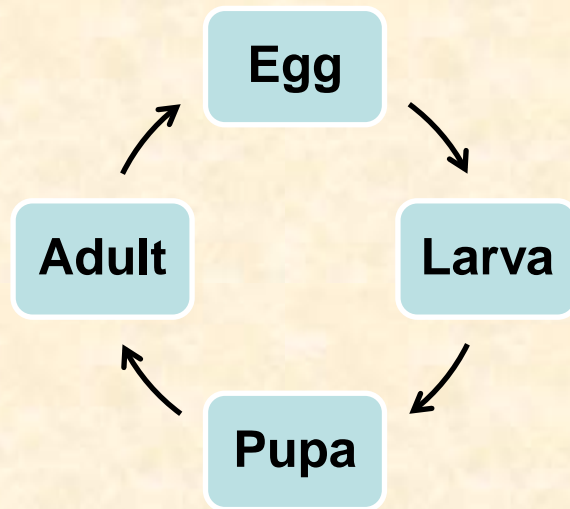


Ecology & Management of Vegetable Insect Pests

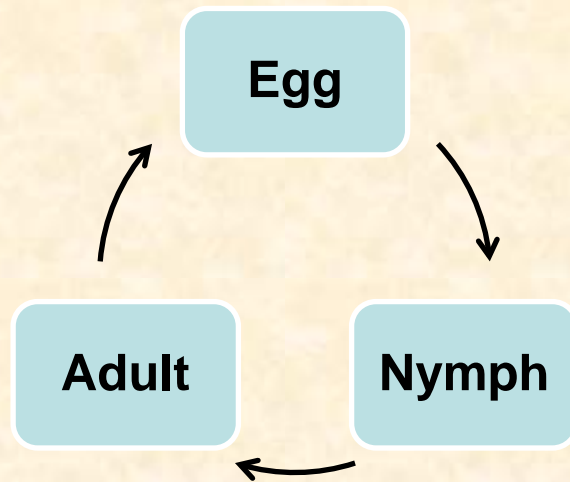
Donald R. Lewis
Iowa State University
Department of
Entomology



Insect Development Complete Life Cycle



Insect Development Simple Life Cycle



Tomato hornworm

Squash bug

Squash vine borer

Cucumber beetles

Japanese beetle

Colorado potato beetle

Corn earworm

**Brown marmorated stink
bug**



Tobacco & Tomato Hornworms

- Well-known
- Only occasionally require special control



Tobacco & Tomato Hornworms

Tobacco



Tomato



**Tobacco hornworm is more common
in Iowa.**

**In spite of species differences, in Iowa
both are called tomato hornworm**

Also feed on eggplant, pepper, potato

Tobacco & Tomato Hornworms

- **Life cycle: Egg, larva, pupa, adult**



Adults appear in mid to late summer
4 – 5 inch wing span
Active at night (dusk)



Eggs laid individually on underside of leaves

Tobacco & Tomato Hornworms

- **Life cycle: Egg, larva, pupa, adult**



Eggs hatch in one week into tiny, first instar caterpillar



Caterpillars are fully grown in 3 – 4 weeks

Tobacco & Tomato Hornworms

- Life cycle: Egg, larva, pupa, adult



Univ of Ohio

Caterpillars pupate in the soil and spend the winter



Univ of Toronto

There is only 1 generation per summer.

Tobacco & Tomato Hornworms

Control

- **Handpicking**
 - (large caterpillars after damage is done)
- **Spraying**
- **Bt (only effective against small caterpillars)**



Tobacco & Tomato Hornworms



Tobacco & Tomato Hornworms




NCSU



NCSU



 University of Nebraska
Department of Entomology

- **Biological Control**
- **Tiny wasp**
- **Interesting but not limiting**

Cucurbits



Squash Bug

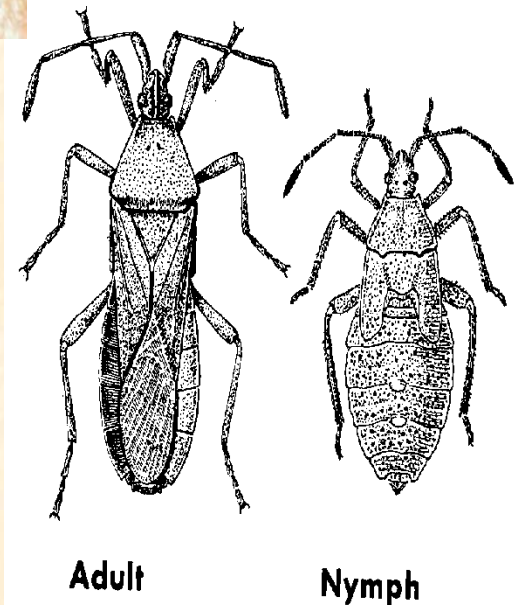


- **Simple Life Cycle**
- **Sucking Mouthparts; Sap feeding**
- **Leaves wilt and turn black and crisp**



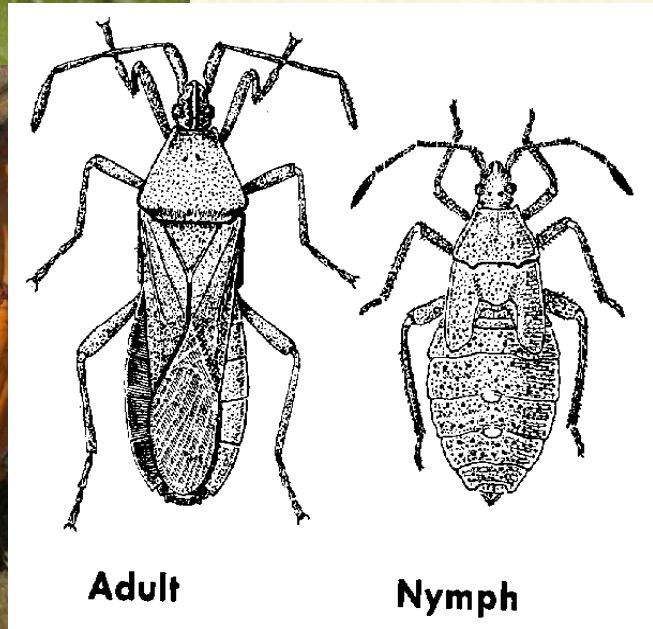
Squash Bug

- 1-inch long
- gray-black or brown
- elongate oval
- pointed
- overwinter in protected locations



Squash Bug

- Adults become active in spring
- After mating females lay eggs until midsummer
- 5 nymph instars take 4-6 weeks to develop into adults
- typically 1 generation per year



Squash Bug

Crop rotation

Remove crop residue

Remove eggs

Treat when eggs begin to hatch

Large nymphs and adults are difficult to control



Insecticides for nymph control

- **Neem**
- **Pyrethrum**
- **Azera®**
(azadirachtin + pyrethrins)
- **Actara® (RR)**
- **Assail® (RR)**
- **+ 14 others**

Squash Vine Borer



- **Clearwing moth**
- **Day-flying moth;
noisy**
- **Complete life cycle**
- **Winter as pupae in
soil**
- **Moths appear in mid-
June**
- **Eggs laid at base of
plant**

Squash Vine Borer

Larvae tunnel in vines

Holes & frass

Wilting, collapse,
death

Larvae in squash



Squash Vine Borer

- Usually 1 generation per year
- Spray when moths are flying
- Need insecticide on stalks and vines when caterpillars hatch (spray not dust)
- - Bt kustaki; +? Bt aizaiwi (XenTari)
- +? Spinosad (Entrust)
- Others
- Once caterpillar is in the vine it is usually too late, though excision may work in small plantings



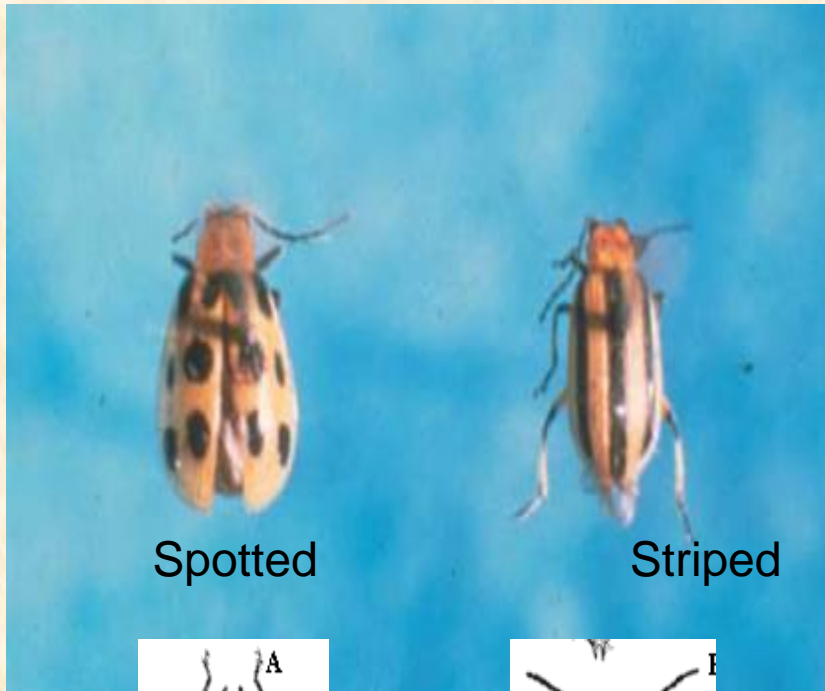
Squash Vine Borer

Floating row cover until flowering

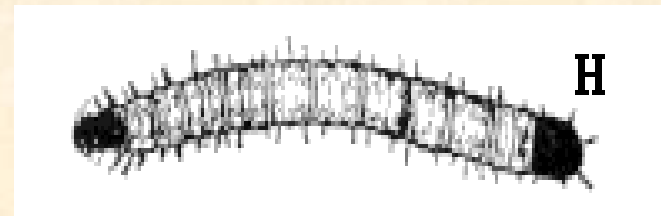


Cucumber Beetles

Spotted and Striped



- Complete life cycle
- Adults overwinter
- Eggs laid in spring
- Larvae in soil (no damage)
- New adults appear in July



Cucumber Beetles



- **Seedling damage**
- **Bacterial Wilt disease**



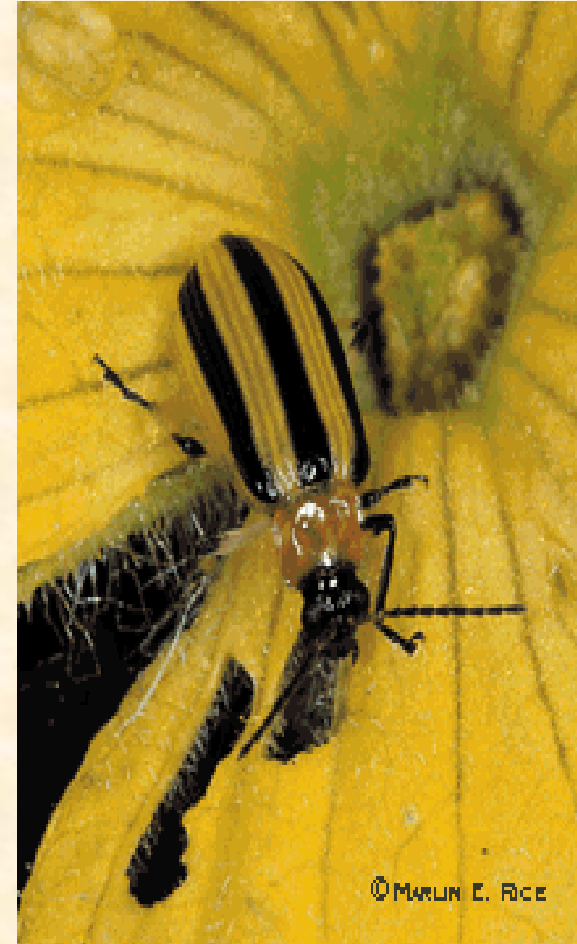
Cucumber Beetle Management

- **Crop rotation ??**
- **Floating row covers**
- **Trap crop**
 - **Blue Hubbard squash planted early around the perimeter of the cash crop**
- **Kaolin clay (Surround)**
- **Pyrethrum**



Monitoring – Visual Inspection

- **Check weekly**
- **Consider yellow sticky traps**
- **Begin immediately after transplanting**
- **Between 11 AM and 3 PM**
- **Count beetles every 2 or 3 days**
- **Spray when average > 1 beetle per plant**



Which one is not a cucumber beetle?



Which one is not a cucumber beetle?



Which one is not a cucumber beetle?



Western Corn Rootworm
Sloppy stripes
Black tibia



Striped Cuc Beetle
Perfect stripes
Yellow tibia

Japanese Beetle





**Multicolored
Asian Lady
Beetle**



Japanese Beetle

1/2-inch long, metallic green head and thorax, bronze wing covers, 5 tufts on white hair at edges of abdomen

Japanese Beetle

Japanese Beetle Life Stages



egg

1st

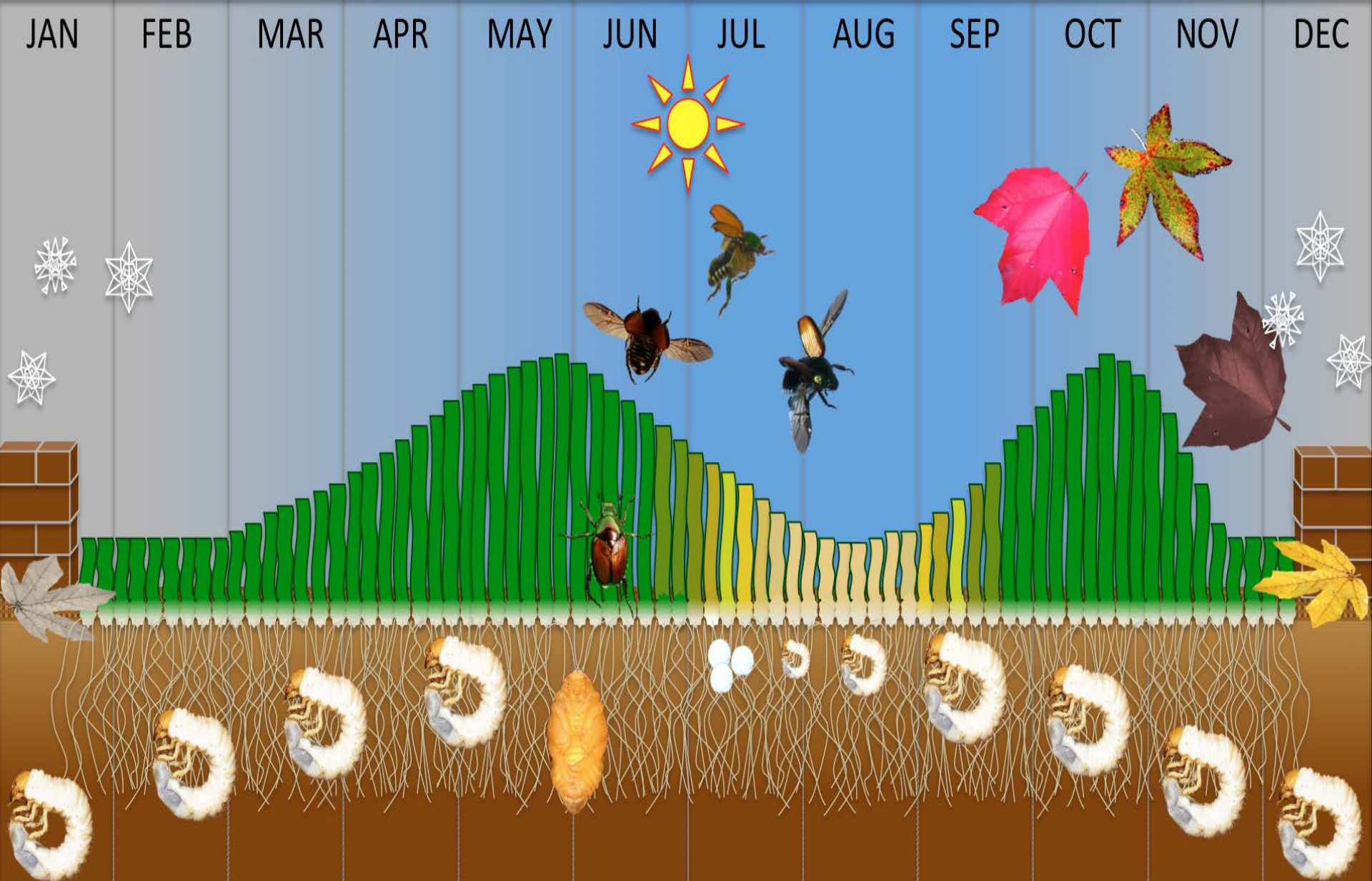
2nd

3rd

pupa

adult

instar larva



Adults present from late June to early August

Japanese beetle

- **Adults – foliage, fruit, flowers**
 - **Over 350 plant species**



Japanese beetle - Vegetables

Asparagus

Beans

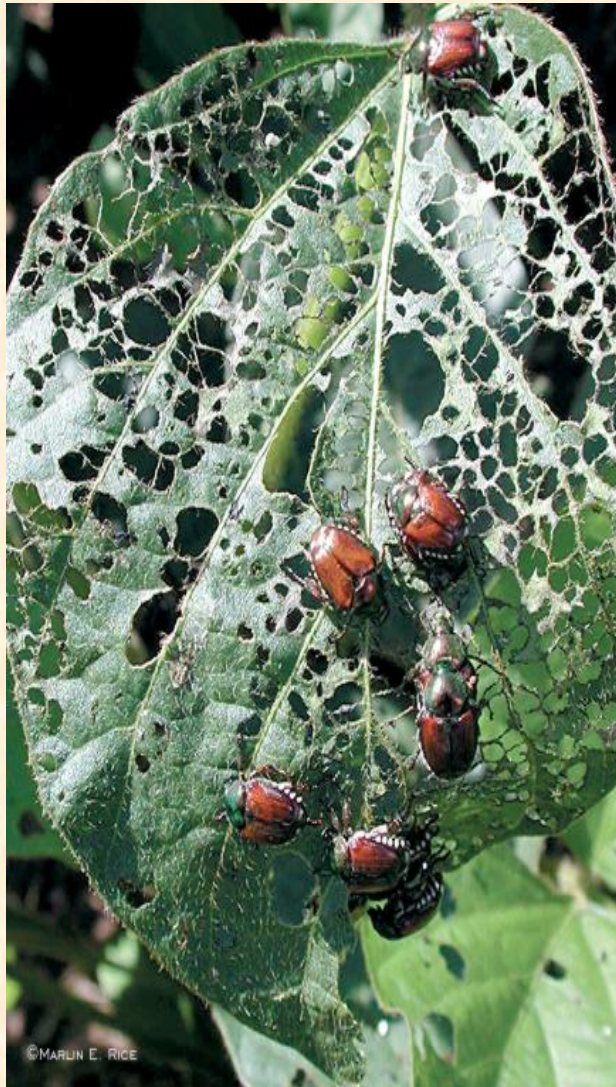
Eggplant

Herbs

Okra

Sweet corn

Other



Japanese beetle - Fruits





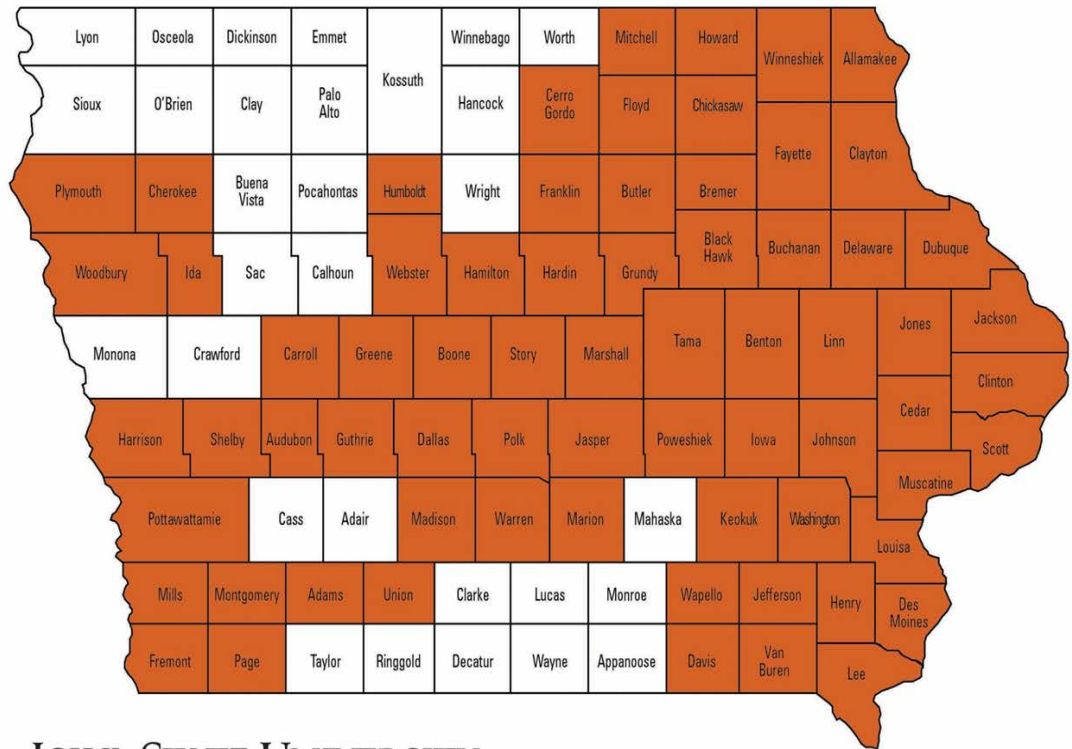
Japanese Beetle eating Aronia

Japanese Beetle

1994 - 2017



REPORTED DISTRIBUTION OF JAPANESE BEETLE IN IOWA



IOWA STATE UNIVERSITY
Extension and Outreach

JUNE 28, 2017

Japanese Beetle Controls

- **Tolerate the damage**
- **Screening / handpicking**
- **Spray early and spray often**



Japanese Beetle Controls

- **Adults appear over an extended period of time**
- **2 to 4 to continuous insecticide sprays**
- **Repellents**
 - **Kaolin clay (Surround)**
 - **Azadirachtin (Neem)**



Linda Naeve



**Trapping =
bailing the
ocean**

**Emotionally
satisfying, but will
attract more than
are caught**

Not recommended



Conclusions about JB

- **Controlling JB grubs in the soil WILL NOT prevent damage to crops and ornamentals the following year. Beetles are highly mobile!**
- **And vice versa**



White grub biological control

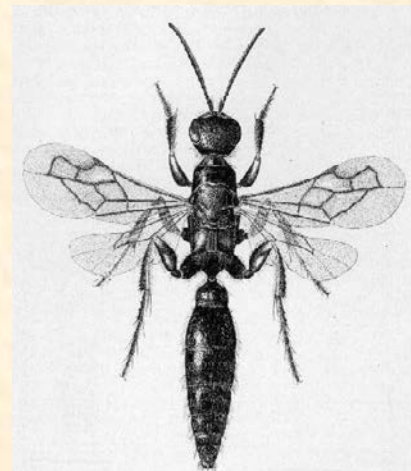
- Pathogens
- Nematodes
- Parasitoids



http://www.pueblo.gsa.gov/cic_text/housing/japanese-beetle/jbeetle



www.hort.uconn.edu/ipm/homegrnd/htms/wgrbpics.htm



<http://www.oardc.ohio-state.edu/biocontrol/tiphia.htm>

Entomopathogenic Nematodes



- Need warm, moist soil
- May need 1 to 2 billion per acre
- Efficacy debatable
- Efficiency debatable

Steinernema feltiae
10 million nematodes sold
on Amazon for \$16 will
cover 200 sq ft

White grub biological control

- Pathogens
 - *Paenibacillus popilliae*
 - Formerly *Bacillus popilliae*
 - Milky Spore




Counterpoint to the dogma about milky spore that persists in the consumer literature and on the Internet

“... field studies performed by USDA from the 1940s and 1950s .. yielded less than 25% control with a few exceptions in the 50 to 100% control.”

Dave Shetlar, Ohio State Univ

White grub biological control



Biological Insecticide Granule Controls Annual White Grubs in Turf and Ornamentals

ACTIVE INGREDIENT: *Bacillus thuringiensis* subsp. *galleriae*, Strain 2S5-202 fermentation solids, spores and insecticidal toxin* 9.0% w/w

OTHER INGREDIENTS: 91.0% w/w

TOTAL: 100.0% w/w

*Contains a minimum of 1 x 10¹⁰ CFU per gram.

KEEP OUT OF REACH OF CHILDREN

CAUTION:

EPA Reg. No.: 88947-2 Net Weight: 10 lb 40 lb

EPA Est. No.: 9198-09-1 or 9198-09-2 Batch Number:

FIRST AID	
If on skin or clothing:	<ul style="list-style-type: none">Take off contaminated clothing.Rinse skin immediately with plenty of water for 15-20 minutes.Call a poison control center or doctor for treatment advice.
If inhaled:	<ul style="list-style-type: none">Move person to fresh air.If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth to mouth if possible.Call a poison control center or doctor for further treatment advice.
If swallowed:	<ul style="list-style-type: none">Call a poison control center or doctor immediately for treatment advice.Have person sip a glass of water if able to swallow.Do not induce vomiting unless told to by a poison control center or doctor.Do not give anything by mouth to an unconscious person.

HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or when going for treatment. For non-emergency information concerning this product, call the National Pesticide Information Center (NPIC) at 1-800-858-7378, Monday through Friday, 8:00 am to 12:00 pm Pacific Time (NPIC Web site: www.npic.orst.edu). For emergencies, call your poison control center at 1-800-222-1222.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION

Harmful if absorbed through the skin, inhaled, or swallowed. Avoid contact with skin, eyes, or clothing and breathing dust. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and handlers must wear:

- Long-sleeved shirt and long pants
- Waterproof gloves
- Shoes plus socks

A NIOSH-approved particulate respirator with any R or P filter with NIOSH approval number prefix TC-814, or a NIOSH-approved powered air purifying respirator with an HE filter with NIOSH approval number prefix TC-21C. (Repeated exposure to high concentrations of microbial proteins can cause allergic sensitization.)

Follow the manufacturer's instructions for cleaning/maintaining PPE. If no such instructions are available for washables, use detergent and hot water. Keep and wash PPE separately from laundry.

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling the product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

For terrestrial uses: Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsate.

No manual application can be made within 200 feet of any threatened or endangered Lepidoptera or Coleoptera.

Manufactured for: **Phyllom BioProducts**

Phyllom BioProducts, Inc.
8800 East Broadway, Suite 202
Denver, CO 80231
954-829-1020
www.phyllombio.com

Target the pest!

31714-2

- GrubGone™
- *Bacillus thuringiensis* strain *galleriae*
- Phyllom BioProducts
- 50 - 75% reduction of JB larvae compared with control
- Differences in activity among various batches of Bt-g.

beetle **GONE!** *Target the pest!*

BIOLOGICAL INSECT CONTROL **tlc** WATER DISPERSIBLE FORMULA

Selectively Controls Japanese Beetle and other Invaders in Residential, Commercial, Public Landscapes or Farms including on Edible Plants

ACTIVE INGREDIENT: *Bacillus thuringiensis* subsp. *galleriae*, Strain 505-502 fermentation solids, spores, and insecticidal toxins*76.5% w/w
 OTHER INGREDIENTS:23.5% w/w
 TOTAL:100.0% w/w
 *Contains a minimum of 0.85 x 10⁸ CFU per gram.



KEEP OUT OF REACH OF CHILDREN

CAUTION: See additional documentation for First Aid, Precautionary Statements, Directions for Use, Product Information, Application Information, Warranty and Storage & Disposal Instructions.

EPA Reg No.: 88347-3

EPA Est. No.: ☐ 70051-CA-001, ☐ 87448-0H-01, ☐ 48458-CA-2, ☐ 002375-WI-002, ☐ 63416-MI-1, ☐ 084544-MI-1, ☐ 0669431-0H-001, ☐ 84760-LA-1

FIRST AID

If in eyes:	<ul style="list-style-type: none"> Hold eyes open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
If on skin or clothing:	<ul style="list-style-type: none"> Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.
If swallowed:	<ul style="list-style-type: none"> Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to by a poison control center or doctor. Do not give anything by mouth to an unconscious person.



HOT LINE NUMBER

Have the product container or label with you when calling a poison control center or doctor, or when going for treatment. For emergency information concerning this product, call the National Pesticide Information Center (NPIC) at 1-800-458-7378 seven days a week, 6:30 am to 4:30 pm, Pacific Time (NPIC website: www.npic.orst.edu). During other times, call your poison control center at 1-800-222-1222.

Manufactured for:
Phyllom BioProducts



Phyllom BioProducts Corp.
484 Lake Park Ave #23
Oakland, CA 94610
Tel: 650.322.5000
Email: products@phyllom.com

- beetle**GONE**® tlc
- *Bacillus thuringiensis* strain *galleriae*
- Phyllom BioProducts
- “Good reduction of JB adult until the first rainfall”
Stanton Gill, U MD
- "Do not apply or allow to drift to plants that are flowering”
SH Dreistadt, UC-Davis
- \$130 - \$150 for 5 pounds covers 2 acres. 100 gal water / acre

Japanese beetle



Colorado Potato Beetle

- **Oval, convex. 9 to 14 mm long**
- **Yellow-brown with ten longitudinal black stripes on wing**



- **Soft, humpbacked. Up to 10 mm.**
- **Red > yellowish-red > orange**
- **Black head and legs**
- **Two rows of black spots on sides**

CPB – Life Cycle





www.ag.umass.edu



UGA5381089

CPB – Life Cycle

- Overwinter as adults in the soil
- Emerge in May and fly to fields
- Feed on emerging plants
- Lay eggs on underside of potato leaves
- Larvae feed for 2 – 3 weeks
- Larvae burrow into the soil to pupate
- New adults emerge in 2 – 3 weeks
- At least 2 full generations per year

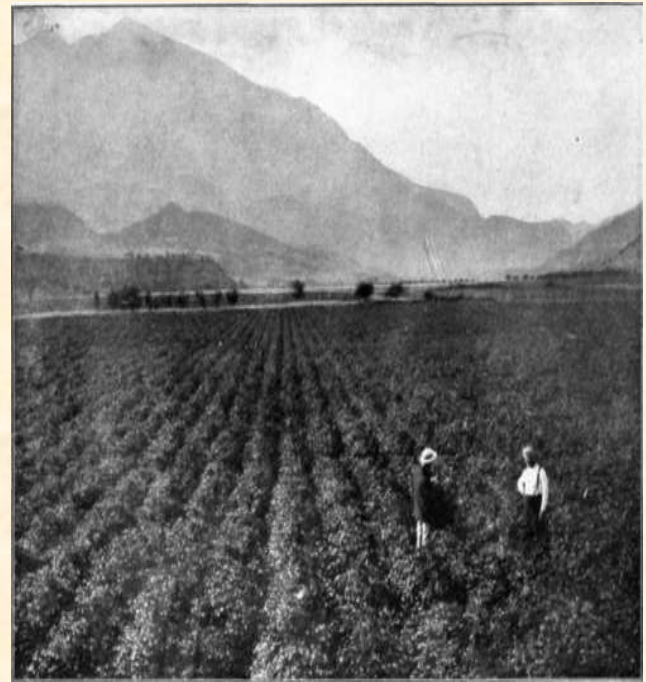
CPB -- History

- Originated in central Mexico
- First collected in USA in 1811 (Missouri River Valley) and described in 1824
- Feeding on buffalo-bur, *Solanum rostratum*
- No practical significance for 4 decades



CPB -- History

- European settlers brought potato to Great Plains
- First found destroying potato crops *Solanum tuberosum* about 100 miles west of Omaha, Nebraska in 1859
- Named “Colorado potato beetle” in 1867 by C.V. Riley
- Spread rapidly eastward, reaching the Atlantic coast by 1874



CPB - Management

- **Tolerate Defoliation**
- ~~Resistant varieties~~
- ~~Biological control~~
- **Crop rotation**
- **Trap Crop**
- ~~Flaming~~
- ~~Vacuum suction / hand picking~~
- **Systemic insecticides**
- **Biological insecticides**
- **Foliar chemical insecticides**



Allowable Defoliation From Colorado Potato Beetle*

- Preflowering: 20-30%
- Flowering: 5-10%
- Tuber Formation: 30%



Midwest Vegetable Production Guide for Commercial Growers

2018

Illinois

University of Illinois Extension
C1373-18

Indiana

Purdue Extension
ID-56

Iowa

Iowa State University Extension and Outreach
FG 0600

Kansas

Kansas State University Research and Extension
MF3279

Michigan

Michigan State University Extension
E0312

Minnesota

University of Minnesota Extension
BU-47094-S

Missouri

University of Missouri Extension
MX384
Lincoln University of Missouri
Cooperative Extension and Research
LUCER 01-2017

Ohio

Ohio State University Extension
Bulletin 948



* Midwest Vegetable Production Guide for Commercial Growers, 2018. 240 pages

CPB - Management

- **Crop rotation - Plant fields as far as possible* from last year's potato fields to reduce potato beetle damage.**
 - **“As far as possible” > ¼ mile**
 - **Adult dispersal in spring is random**
 - **Delays infestation in the spring by 2 – 3 weeks**
- **Trap Crop**
- ~~Flaming~~
- ~~Vacuum suction / hand picking~~
- **Insecticides**

CPB - Management

- Trap Crop
- ~~Flaming~~
- ~~Vacuum suction / hand picking~~
- Systemic insecticides
- Biological insecticides
- Foliar chemical insecticides
- Plant early potatoes on field border
- Between current and previous year field
- Destroy by spraying, flaming or disking before larvae mature



CPB - Management

- **Insecticides**
 - **Systemic insecticides**
 - **Biological insecticides**
 - **Foliar chemical insecticides**
- **Scout at least weekly from emergence to determine necessity for treatment and to improve treatment timing**



CPB – Chemical Management

- **Foliar Applied Insecticides**
 - Eggs are not susceptible to insecticides
 - Timing is a tough issue to solve
 - Target 3rd instar larvae
 - Staggered adult arrival
 - Extended egg hatch
 - Scouting !!
 - Control 1st generation larvae for best result



CPB – Reduced Risk Insecticides

- **Spinosad**
 - SpinTor 2SC®
 - Entrust®
- **Rimon 0.83EC®**
 - Novaluron
 - IGR
- **Novodor®**
 - *Bacillus thuringiensis tenebrionis* (Btt)
- **Prokil Cryolite 96® or Prokil Cryolite 50D®**
 - Sodium aluminofluoride

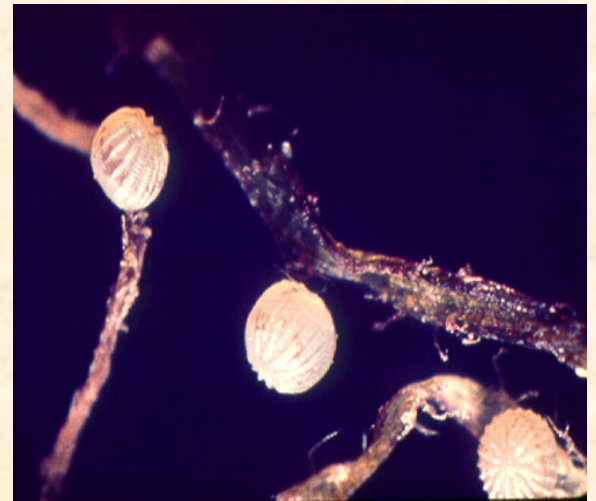
Corn Earworm



**AKA Tomato
Fruitworm &
Cotton Bollworm**

Corn Earworm

- **CEW does not survive the winter this far north**
- **New moths blow in from southern USA every spring**
- **Arrival time varies**
- **Moths are attracted to and lay eggs on green corn silks (7 – 10 day period of vulnerability)**



Corn Earworm

- Eggs hatch in 2 – 6 days
- Tiny larvae follow silks down to tip of ear
- Larvae feed on ear tip
- Grow in 21 to 30 days



Corn Earworm Management

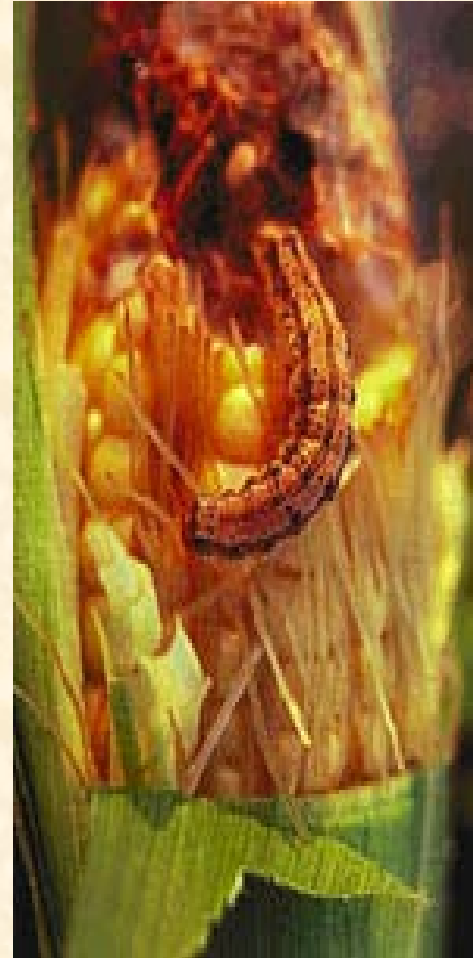
- **Plant early**
- **Use short season varieties**
- **Apply insecticide to silks while they are green and moths are present**
- **Organic treatments into the silk channel are time consuming.**
- **“Zea-Later” manual applicator to deliver a Bt and oil mixture (or other treatment) directly into the silk channel**





Corn Earworm

- **Insecticides must be sprayed when moths are flying and silks are green to prevent caterpillar entry into the silk channel at tip of ear**
- **To protect new silk, spray the day after the tassels appear**
- **Repeat in 2 – 3 days and again 5 days later**





Corn Earworm

- **“Some level” of pyrethroid resistance in upper Midwest**
- **Corn Earworm = Cotton Bollworm**
- **Keep very accurate records of insecticide applications**
- **If one pyrethroid fails to give control because of resistance, other pyrethroids are very likely to fail as well.**
- **Pyrethroids: Ambush, Pounce, Warrior, Capture, Baythroid, Mustang-Max, Decis, Proaxis, and Discipline**
- **Non-Pyrethroids: Sevin and SpinTor**

Corn Earworm Monitoring

- **To limit applications, spray only if silks are fresh and green and if moths are present.**
- **Monitor moths with pheromone traps**
- **Adjust sprays according to moth presence**



Bt Sweet Corn

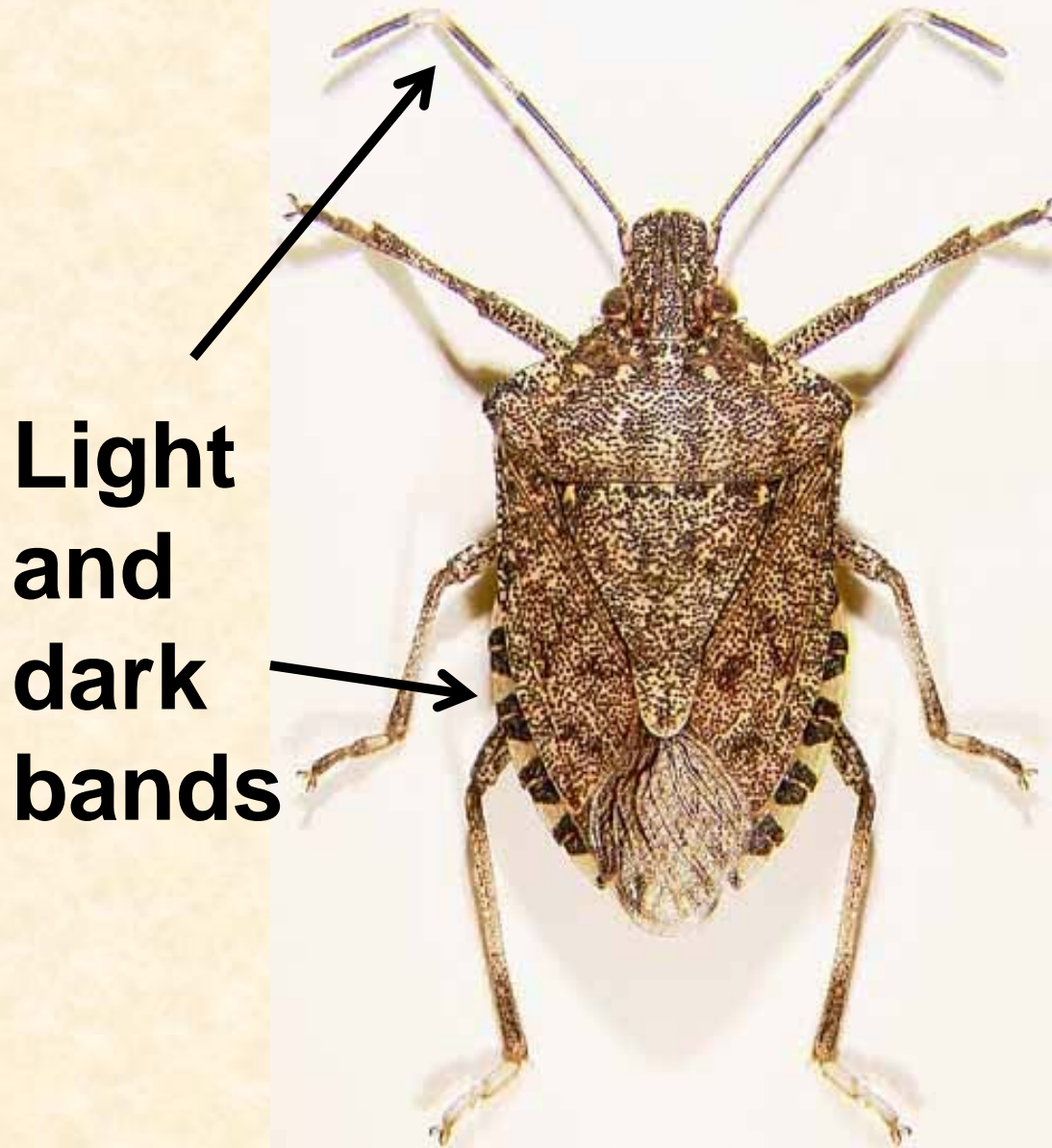
- Genetically modified sweet corn**
- Contain genes of the Bt bacterium**
- Several varieties are available**
- Corn plant produces Bt toxin**
- Effectively controls all the major caterpillar pests, including corn earworm**
- Consumer concerns may limit market**
- Higher seed price**
- Not "bullet proof"**

Brown Marmorated Stink Bug

- Pennsylvania, 1998
- Plant feeding stink bug
- Native range China, Japan, Korea
 - An agricultural pest



Brown Marmorated Stink Bug



- 17 mm long
- Brown
- Shield-shape
- Bands on antennae and dorsal abdomen

Brown Marmorated Stink Bug



1998 – First found in Pennsylvania

2010 – Reported in 22 eastern states

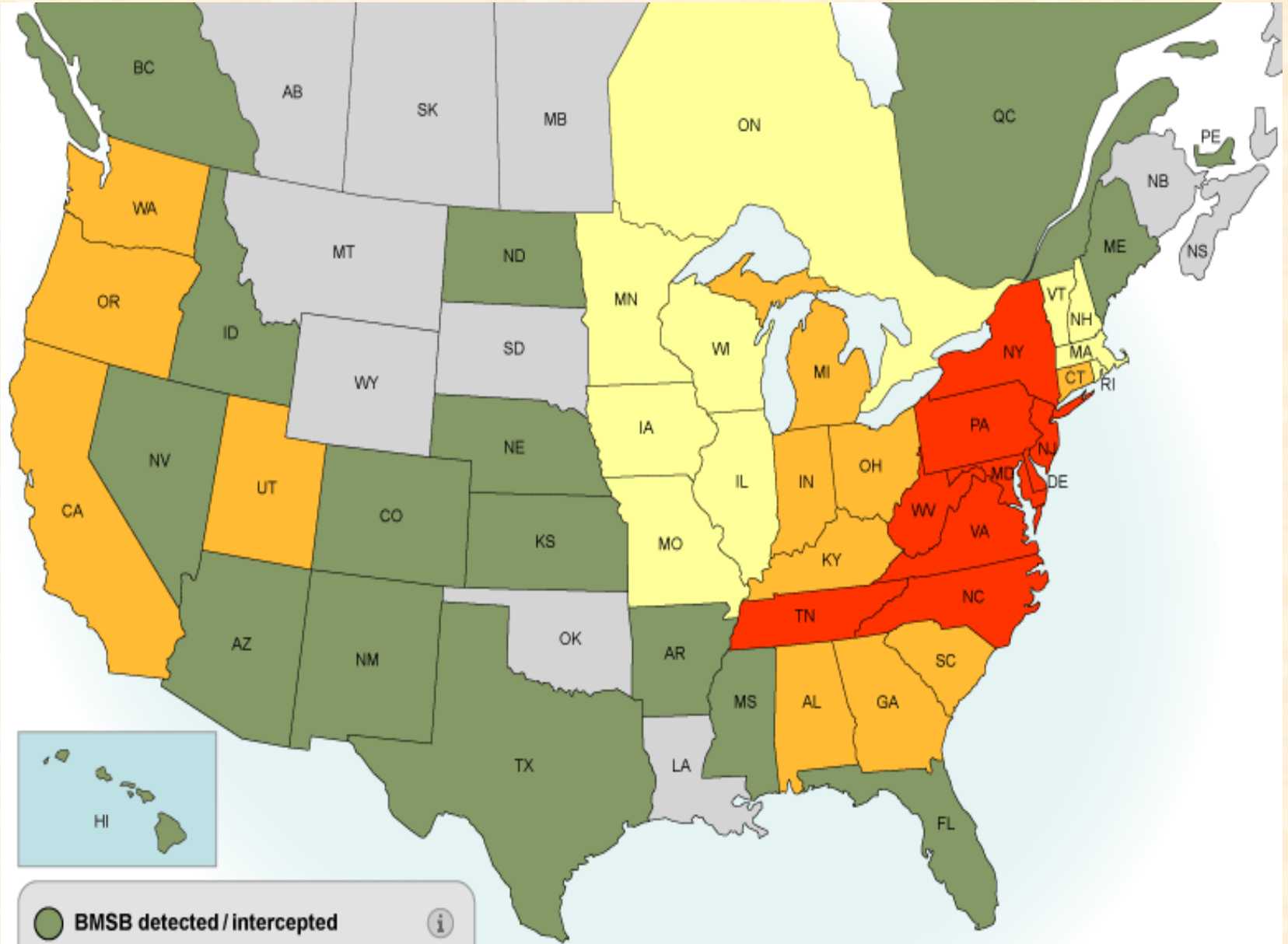
Population explosion

Damage to plants severe

2017 – Reported in 44 states

The future – BMSB will continue to spread

Population cycles and plant damage unknown



- BMSB detected / intercepted** (i)
- Nuisance problems only** (i)
- Agricultural and nuisance problems** (i)
- Severe agricultural and nuisance problems reported** (i)



Not BMSB!



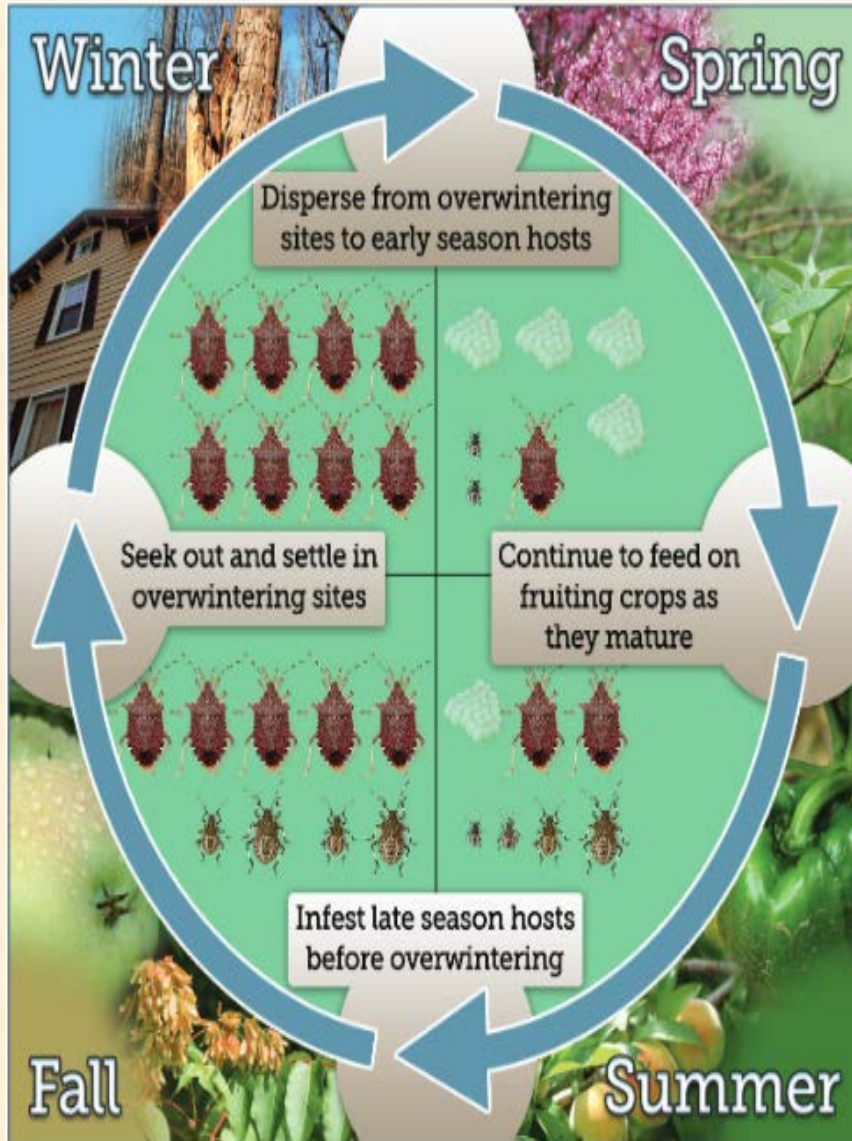
- **Brown Stink Bug (left)**
- **Spined Soldier Bug (center)**
- **Green stink bug (right)**

Squash Bug is Not a Stink Bug

- 1-inch long
- Gray-black or brown,
- Elongate oval
- Pointed at the head end
- Common on foliage and fruit of pumpkins and squash in late summer
- Hide in winter under old vines, and other debris
- Rarely found indoors



Brown Marmorated Stink Bug



- Adults emerge from protected overwinter sites in May & June
- Mate >> Lay eggs
- Nymph feeding damage in early summer
- Adult feeding damage in fall



BMSB Feeds on:

- **Fruit crops**
- **Vegetables**
- **Corn and soybeans**
- **Trees and shrubs**





**...then it comes
indoors**



<http://graphics8.nytimes.com/images/2010/09/27/us/STINKBUG-2/STINKBUG-2-articleLarge.jpg>

and it stinks.



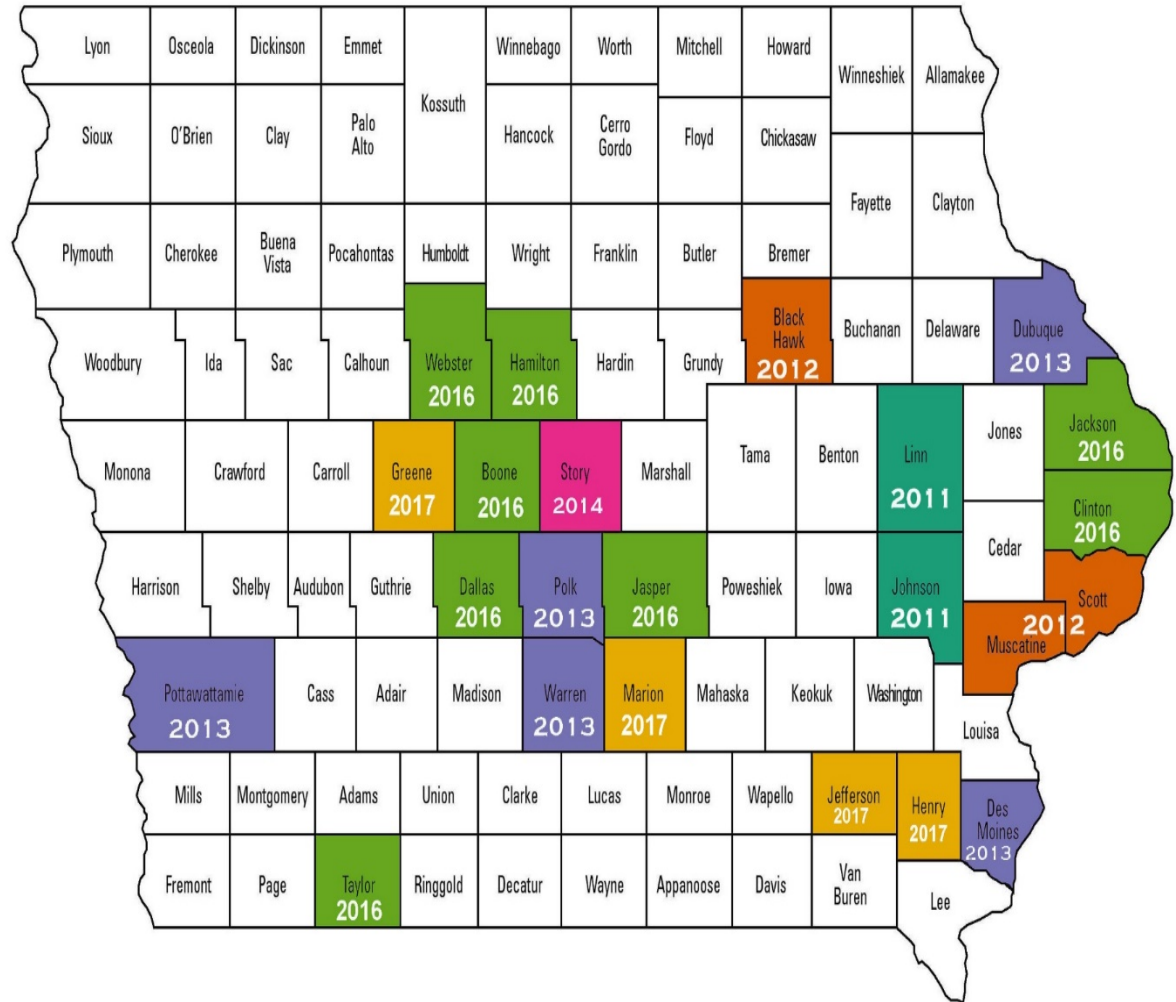
Paul Bedard, Washington DC

- **Do NOT cause harm**
- **But, annoying as heck!**





Brown Marmorated Stink Bug Reports in Iowa

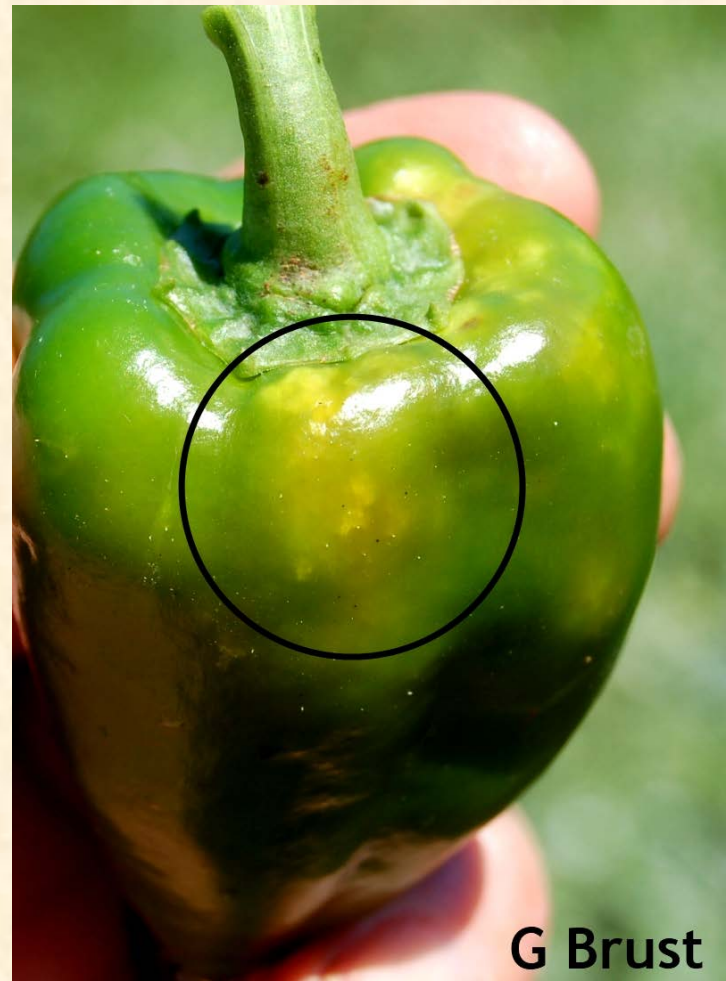


- **Household accidental invader**
- **September - October**

IOWA STATE UNIVERSITY
Extension and Outreach

Status in Iowa

- Reports of damage to fruit or vegetables?
- Keep looking
- Keep in touch



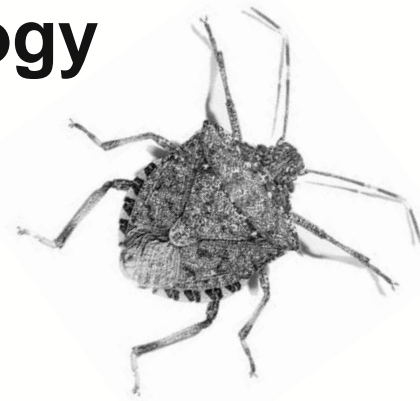
G Brust

Brown Marmorated Stink Bug



Discussion

Donald Lewis
Department of Entomology
Iowa State University
515-294-1102
drlewis@iastate.edu



Spotted wing drosophila



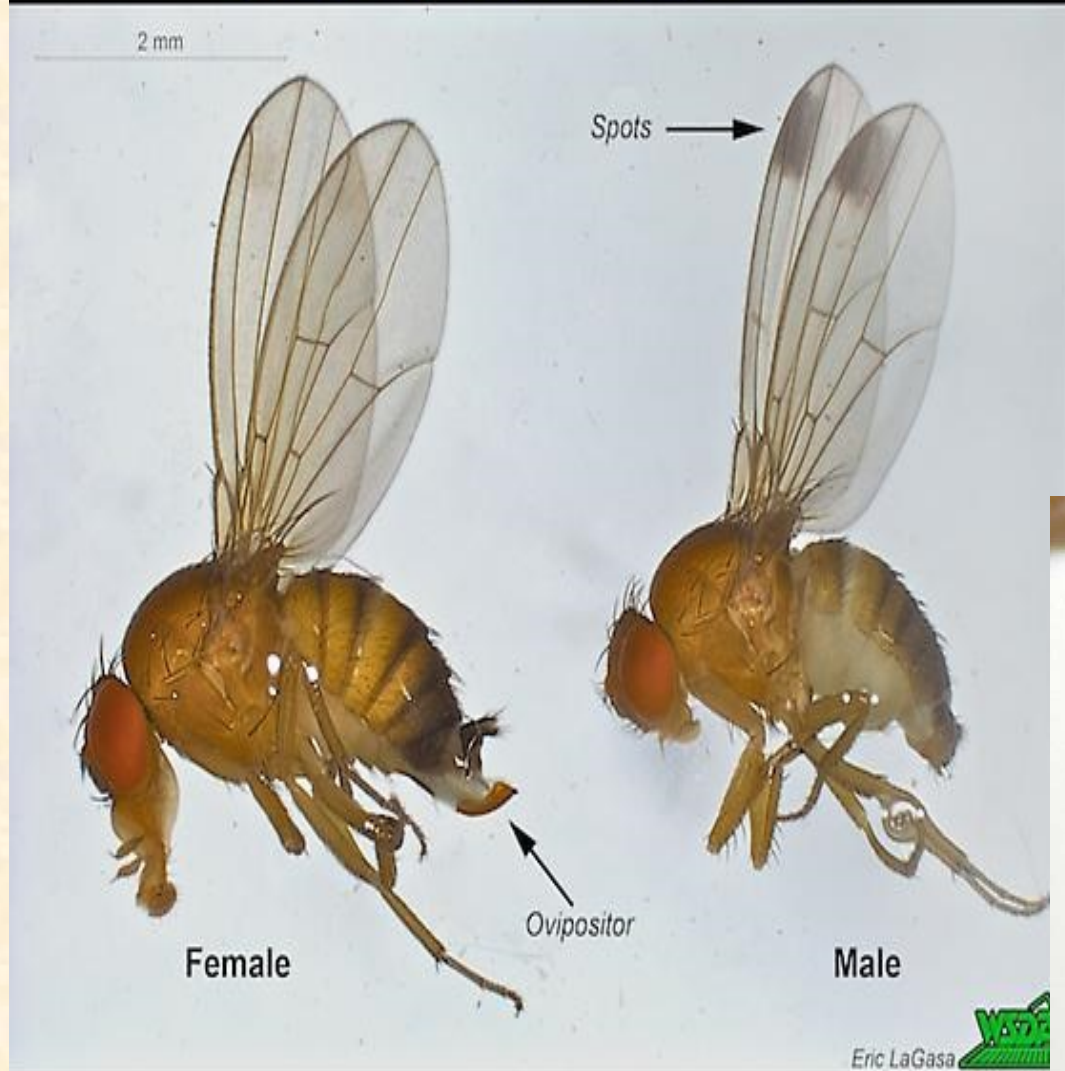


Spotted Winged Drosophila

- *Drosophila suzukii*
- Native to Japan, China, India, Thailand, Korea
- Primary pest of thin-skinned fruit
 - Fruit does not need to be damaged or rotting
 - Attacks healthy fruit on the plant



Spotted Wing Drosophila (*Drosophila suzukii*)



**2 – 3 mm (1/8th inch)
Striped abdomen; Red eyes**



Host Range

- Raspberry and blackberry
- Blueberry
- Strawberry
- Cherry
- Apple
- Peach
- Plum



UC Statewide IPM Program

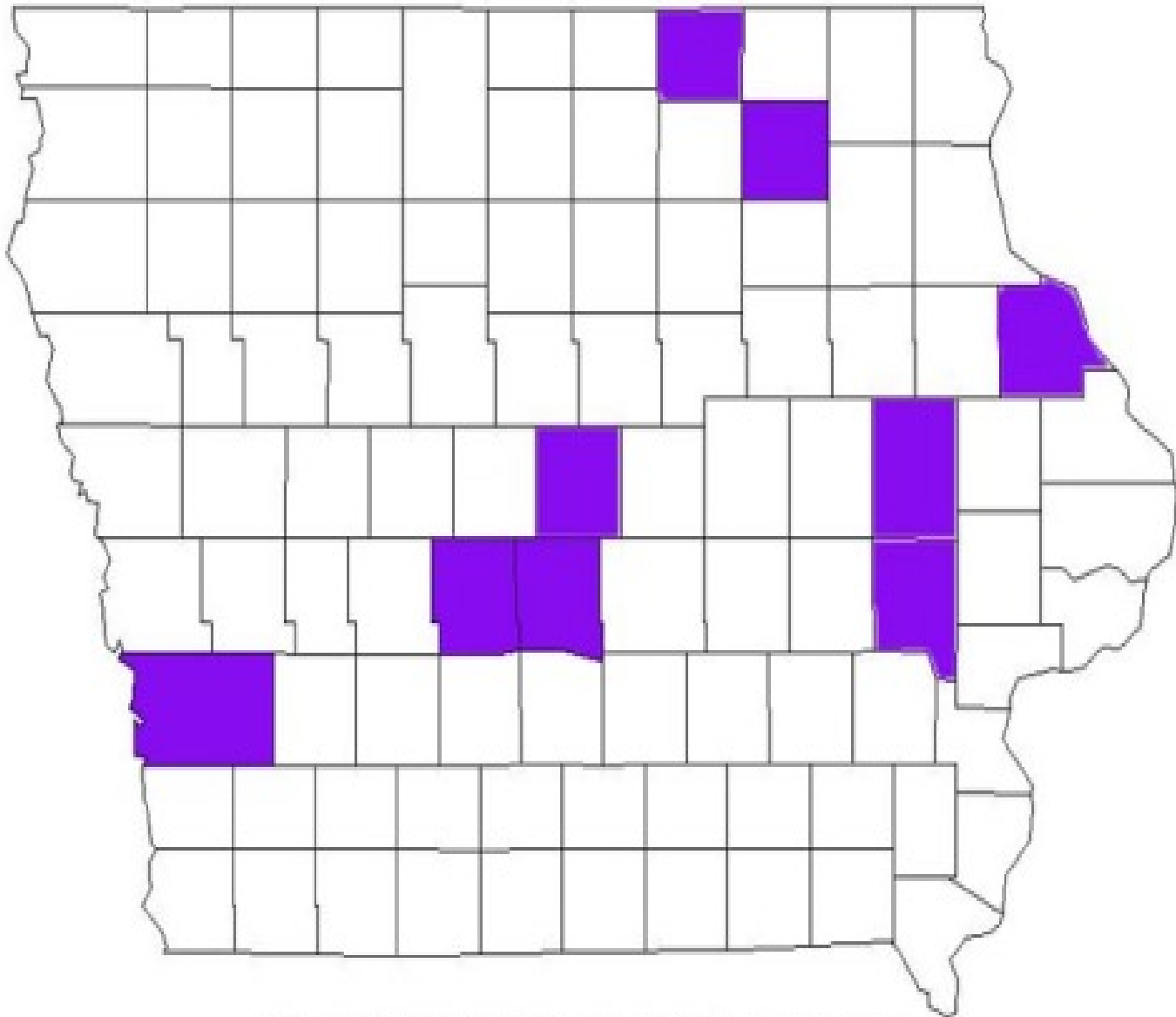




Host Range

- **Wild hosts**
 - Crabapple
 - Pokeweed
 - Autumn olive
 - Nightshade
 - Amur honeysuckle
 - Wild grape





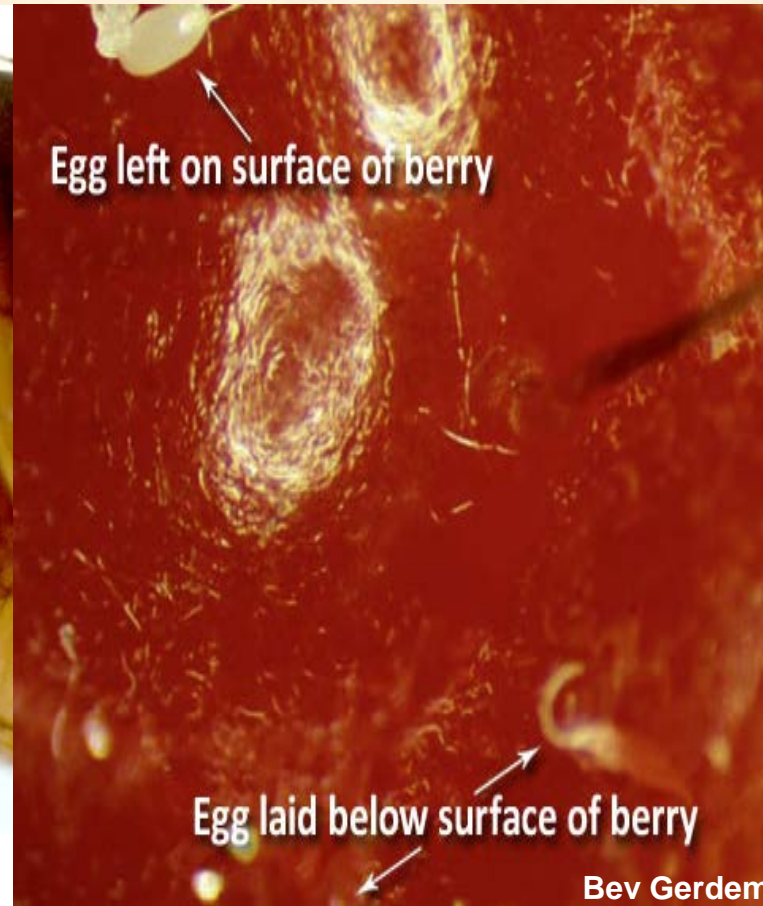
SPOTTED WING DROSOPHILA REPORTS - 10.01. 2013

SWD Ovipositor

Serrated ovipositor allows it to attack pre-harvest healthy fruit



Photo by Martin Hauser, CDFA



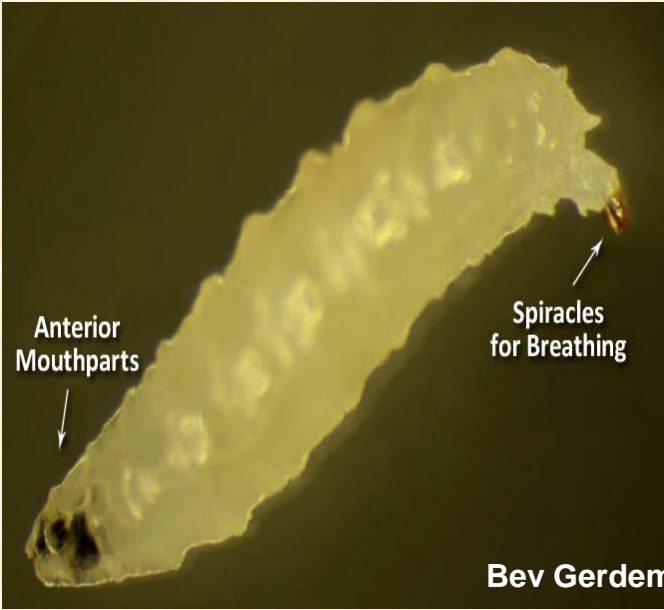
Bev Gerdeman

Spotted Wing Drosophila

- Raspberries are susceptible to injury when they start to turn color



Larvae in Fruit



SWD

Management

- **Monitor**
 - For adults
 - Check fruit for larvae
- **Sanitation**
- **Insecticide**



Efficacy rating	Active ingredient ¹	Residual activity (days)	Pre-harvest interval (PHI) ²						
			raspberry, blackberry	blueberry	strawberry	grape	cherry	peach	plum
Very effective	bifenthrin	7-10	3 days	X	X	X	X	X	X
	cyfluthrin	7-10	X	X	X	3 days	X	X	X
	permethrin	7-10	14 days	14 days	14 days	X	X	7 days	X
	esfenvalerate	7-10	21 days	14 days	X	X	14 days	14 days	14 days
	gamma-cyhalothrin	7-10	X	X	X	X	14 days	14 days	14 days
Effective	malathion	5-7	1 day	1 day	X	X	3 days	7 days	X
	spinosad	3-5	3 days	3 days	1 day	7 days	14 days	7 days	7 days
Moderately effective	carbaryl	10	7 days	7 days	7 days	7 days	3 days	3 days	3 days
	acetamiprid	1-3	1 day	1 day	1 day	7 days	7 days	7 days	7 days
Unrated but likely to be effective	pyrethrins + PBO	1-3	0 days	0 days	0 days	0 days	0 days	0 days	0 days

Horticulture & HomePest News

Spotted Wing Drosophila Update 11/1/2013

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Garden Insect Controls

1. **Bt-k**: early instar caterpillars only
2. **Spinosad**; effective on larvae, not effective on adults
3. **Neem** (azadirachtin): feeding deterrent or insect growth regulator
4. **Insecticidal soap**: soft and slow insects, direct contact only
5. **pyrethrins (pyrethrum)**: very short residual; pyrethrin + piperonyl butoxide (PBO) or canola oil (e.g., Pyola®)
6. **pyrethroids**: esfenvalerate, cyfluthrin, permethrin, bifenthrin
7. **carbamate**: carbaryl (Sevin)

