Japanese Beetle/ Emerald Ash Borer Update

RMRTA 2019 Conference & Trade Show
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CR 207 Credit
Japanese beetle
*Popillia japonica*

**Coleoptera: Scarabaeidae**

First U.S. detection – 1916 near Riverton, New Jersey

The Spread of Japanese Beetle in North America, 1908-1998
Distribution of Japanese beetle in Colorado based on CDA trapping
This is a map of the JB situation in the Denver metro area ten years ago. An area around here now traps more than 2000 per day!
Japanese beetle adults chew on leaves and flowers of many plants.

Japanese beetle damages plants in two distinct ways.
Japanese beetle larvae (grubs) – among the most damaging turfgrass insects in the US

Japanese beetle affects yard/garden plants in two distinct ways
White grubs prune the roots, producing drought stress symptoms.
Skunk digging damage associated with white grub infestations
Managing Japanese beetle in the larval (white grub) stage
Recommendations for Japanese Beetle Larval Control

• Cultural Controls
• Biological Controls
• Chemical Controls
One resource. The Extension Fact Sheet on Japanese Beetle management

COLORADO STATE UNIVERSITY EXTENSION

Japanese Beetle
Fact Sheet No. 5.601 Insect Series | Home and Garden

by W. Cranshaw

For close to a century, the Japanese beetle (Popillia japonica) has been one of the most seriously damaging insect pests of both turfgrass and landscape plants over a broad area of the eastern US. Recently, there have become a few permanent, reproducing populations of this insect in some communities along the Front Range of Colorado. At some of these sites high numbers of Japanese beetles now regularly occur and adult beetles are causing significant damage to leaves and flowers of many susceptible landscape plants.

Figure 2. Japanese beetle damage to leaves of grape.

Body with a dark head and the legs on the thorax are well developed. Normally the body curves into a "C-shape". These features are also typical of other white grubs found in association with turfgrass in Colorado, such as the lesser white grub and the western Corn Rootworm.

Quick Facts

- Japanese beetle adults chew flower blossoms and leaves of many commonly grown plants.
- Japanese beetle larvae are a type of white grub that feeds on the roots of grasses.
- Adults are best controlled by handpicking or by use of certain insecticide sprays.
- Japanese beetle traps can capture many adults have never been shown to reduce damage to nearby plants.
- Japanese beetle larvae can be treated using granular materials or other treatments as recommended by the Colorado Department of Agriculture.
Recommendations for Japanese Beetle Larval (Grub) Control

• Cultural Controls
  – Promotion of root growth to tolerate larval feeding
  – Allowance of some soil drying during critical JB life stages
  – Provision of water to allow tolerance and recovery from root loss
White grubs damage turfgrass by feeding on roots
Grasses with larger root mass are better able to tolerate effects of root pruning insects.

Mowing height greatly affects root mass of turfgrasses!
Recommendations for Japanese Beetle Larval Control

• Cultural Controls
  – Promotion of root growth to tolerate larval feeding
  – Allowance of some soil drying during critical life stages
  – Provision of water to allow tolerance and recovery from root loss
Generalized Life History Sequence of Japanese Beetle

- **JAN**: grub deep in soil
- **FEB**: grub deep in soil
- **MAR**: grub deep in soil
- **APR**: grub root feeding
- **MAY**: grub root feeding
- **JUN**: pupae
- **JUL**: adult egg laying
- **AUG**: grub root feeding
- **SEP**: grub root feeding
- **OCT**: grub deep in soil
- **NOV**: grub deep in soil
- **DEC**: grub deep in soil
Adults burrow into the ground to lay eggs. Eggs are only laid in soil that is suitably moist.
Eggs and 1\textsuperscript{st} stage larvae are very sensitive to drying.
Recommendations for Japanese Beetle Larval Control

• Cultural Controls
  – Promotion of root growth to tolerate larval feeding
  – Allowance of some soil drying during critical JB life stages
  – Provision of water to allow tolerance of and recovery from root loss
White Grub Larval Treatments

- **Insecticides**
  - Imidacloprid (*Merit, Mallet, Zenith, etc.*
  - Clothianidin (*Arena*)
  - Chlorantraniliprole (*Acelepryn, Scott’s GrubEx*)
  - Trichlorfon (*Dylox, Proxol, Bayer Advanced 24 Hour Grub Killer Plus Granules*)

- **Biological Controls**
  - *Heterorhabditis* spp. parasitic nematodes
  - *Bacillus thuringiensis* var. *galleriae* (grubGONE!)
Imidacloprid for White Grubs

- Trade Names(Retail): Merit, Zenith, Mallet, etc.
- Neonicotinoid insecticide
  - Moves systemically in plants
  - Can have hazard to bees exposed through nectar, pollen
- Provides control for month or two
  - Fairly slow moving in soil and into plants

Optimal time for application: Early period of egg hatch – typically late June through mid July
Systemic insecticides and Pollinators – Should we be concerned about their use on turfgrass?
A key risk to pollinators when using insecticides on turfgrass

Application to flowering weeds
Mowing before application greatly decreases hazard to pollinators!
Chlorantraniliprole for White Grubs

- Trade Names: Acelepryn, GrubEx
- Anthranilic diamide insecticide
  - Limited systemic activity
  - Very low hazard to bees
- Relatively slow acting
- Provides control for months

**Optimal time for application:** Early period of egg hatch – *typically mid-late June through mid-July*
Recommendations for Japanese Beetle Larval Control

- Cultural Controls
- Chemical Controls

- Biological Controls
  - Insect parasitic nematodes (*Heterorhabditis* spp.)
  - *Bacillus thuringiensis* var. *galleriae*
  - Milky spore
Insect Parasitic Nematodes ("Beneficial Nematodes", "Predator Nematodes")
Nematodes enter insects through natural openings

*Heterorhabditis* species nematodes can penetrate directly through the body wall
Insect parasitic nematodes enter a host insect and introduce bacteria (*Xenorhabdus* spp.)

The bacteria kill the insect

The nematodes eat the bacteria and the decomposed insect
Grubs turn a reddish color when killed by *Heterorhabditis* nematodes
White Grub Larval Treatments

- Imidacloprid (Hi-Yield Insect & Grub Control, Hi-Yield Grub Control II, Bayer Advance Season Long Grub Control, Merit, Zenith, Mallet, etc.)
- Chlorantraniliprole (Acelepryn, Scott’s Grub-Ex)
- *Heterorhabditis* spp. parasitic nematodes
- *Bacillus thuringiensis var. galleriae*/*Btg* (grubGONE!)
New biological control for Japanese beetle - and other grubs?

BTG - *Bacillus thuringiensis* var. *galleriae*

Perhaps best niche for BTG is to control adults?
Milky Spore for Japanese Beetle?

Used to permanently establish a biological control organism – *not useful for immediate control.*
White grub blast from the past

Lawn Aerator Sandals (a.k.a., “Spikes O’ Death”)
Spikes O’ Death In Action
SPIKES OF DEATH

Oh dear... could you check on the kids. I think I hear them squabbling again!
Question: Does control of larvae in a yard affect the number of adults in a yard?

Answer: Very likely, NO
Some Highly Mobile Insects

Corn earworm (adults)
Grasshoppers
Japanese beetle (adults)
Crucifer flea beetles
Potato/tomato psyllid
Adult beetles feed on both flowers and leaves of many ornamental plants as well as garden vegetables and herbs.
Skeletonizing injuries produced by Japanese beetle adults feeding on leaves
Flowers are often a favored plant part targeted by adult Japanese beetles.
Overlap of adult feeding on flowers – *and use of those flowers by pollinators*

*Issue of unusual concern with Japanese beetle*
Uber-host Plants Favored by Japanese Beetle Adults in CO

- Roses**
- Linden*
- Virginia Creeper*
- Silver lace**
Other Plants Commonly Grown in CO that are Highly Favored by Japanese Beetle

**Ornamentals**
- Hollyhock*
- Gaura**
- Rose-of-Sharon**
- Crabapple
- Japanese maple
- Peking cotoneaster
- Canna lily**

**Food Crops**
- Beans (green, edamame)
- Basil
- Raspberry*
- Grape
- * JB populations overlap with flowering
- ** JB populations overlap >a lot< with flowering
Evaluations of roses at the War Memorial Garden in Littleton, 2016-2019
Japanese Beetle Damage Evaluations on Roses – War Memorial Rose Garden

- Seven observations were made during season
- Damage by Japanese beetle ranked on a 0 to 3 scale (no damage to heavy damage)
Japanese Beetle Damage Evaluations on Roses – War Memorial Rose Garden

- Seven observations were made during season
- Damage by Japanese beetle ranked on a 0 to 3 scale (no damage to heavy damage)
- Observed flower visitation by bees ranked on a 0 to 3 scale (no visitation to high visitation)
Cultivars that will be difficult to maintain in a post-JB world

Cultivars bees do not visit – insecticide options are much greater

Cultivars that JB doesn’t damage in the first place
What should we do about the Japanese Beetle?

We should try to systematically categorize all rose cultivars for susceptibility to Japanese beetle – and use by pollinating bees.
The curious phenomenon of geranium toxicity to Japanese beetle
Geranium Toxicity to Japanese Beetle

• Beetles become paralyzed within a couple of hours after feeding on flowers of zonal geraniums
  – Often recover in lab, rarely outdoors

• Toxin is present in flowers, but not leaves
Recommendations for Japanese Beetle Adult Control

- Physical/Cultural Controls
  - Traps
  - Hand Picking
- Chemical Controls
Japanese beetle controls

Hand Picking
Primary benefit from handpicking

Reduction in volatile attractants produced by plant wounding
Handpicking may be more effective for infestations on foliage versus flowers.

Some flowers (e.g., rose) can produce high levels of volatile attractants - without wounding - and may possess attractive colors.
Can time of day when you hand pick have effects for JB management?

Possibly yes. It may be more effective to *handpick in the evening* than at other times of the day for reducing numbers of beetles on the plants.
Japanese beetle traps are excellent for detecting presence of the insect in an area.
Japanese beetle traps are minimally useful - at best - for control of existing Japanese beetle infestations!
If you insist on using a Japanese beetle trap

• Do not place them anywhere near (at least 30 feet away from) any plant on which Japanese beetles feed

• Avoid placing them in a site where they are likely to draw beetles from long distances
If you insist on using a Japanese beetle trap

• Do not place them anywhere near (at least 30 feet away from) any plant on which Japanese beetles feed
• Avoid placing them in a site where they are likely to draw beetles from long distances

….and preferably give the trap to your neighbor!
Do you have >a lot< of Japanese beetles in your trap??

There are about 836 Japanese beetles per cup.
Chemical Controls Most Effective for Control of Japanese Beetle Adults

- Most pyrethroids (e.g., cyfluthrin, permethrin, bifenthrin)
- Carbaryl
- Acetamiprid
- Imidacloprid
- Chlorantraniliprole

Do not treat plants with flowers in bloom!
Never apply persistent insecticides to plants that are in flower and attractive to pollinators!!
Chemical Controls Most Effective for Control of Japanese Beetle Adults

- Most pyrethroids (e.g., cyfluthrin, permethrin, bifenthrin)
- Carbaryl
- Imidacloprid
- Acetamiprid
  - Ortho Rose and Flower Killer
- Chlorantraniliprole
  - Acelepryn

Do not treat plants with flowers in bloom!
Pollinator hazard warning statement regarding use of Tristar 8.5 SL (acetamiprid)

ENVIRONMENTAL HAZARDS
This product is toxic to wildlife. This product is toxic to bees and other pollinating insects exposed to direct treatment. Do not apply this product while bees or other pollinating insects are actively visiting the treated area. Risk to managed bees and native pollinators from contact with pesticide spray or residues can be minimized when applications are made at dawn or dusk or when temperature is below 55°F at the site of application. Do not apply directly to water, or to areas where surface or ground water runoff can transport the product to surface or ground water. Do not contaminate water when applying or cleaning equipment. Do not dispose of container in or near a water source. Do not permit the product to contact food or food containers. Do not eat, drink, or smoke when handling product.

This type of warning statement allows use of this product on a plant in flower only during times of day when pollinators are not visiting the plant.
Labeled for use on turfgrass and landscape ornamentals.
**Btg - Bacillus thuringiensi**s var. *galleriae*

Sold as **beetleGONE!** in commercial/ag markets

Sold as **beetleJUS** in gardener market

**Btg-susceptible Insects**

- Weevils
- Scarab Beetles
Bacillus thuringiensis (Bt)

- Derived from a widely distributed soil bacterium
- Active ingredient a toxic protein crystal that destroys cells of the midgut
- Used as a stomach poison
- Several different strains – each effective against different insects
Several Bt strains are present, each with specific activity

Caterpillars – kurstaki, \textit{aizawi} strains
Leaf beetles – \textit{tenebrionis} strain
Gnat, mosquito larvae – \textit{israelensis} strain
Scarab beetles – \textit{galleriae} strain
Treated Foliage Consumed
Death (2-5 Days)

- Starvation
- Gut Disruption
New biological control for Japanese beetle - and other grubs?

*Bacillus thuringiensis var. galleriae*

Sold as *beetleGONE!* in commercial/ag markets

Sold as *beetleJUS* in gardener market
Water check

beetleJUS treated
beetleJUS for adult Japanese beetle?

Provides **good reduction in feeding** injury by Japanese beetle.

Provides **fair mortality** of Japanese beetles and mortality is slow.

Persistence of effects probably a few days.
None. You can apply this product to plants in bloom when bees are visiting.
What should we do about the Japanese Beetle?

We should attempt transfers, for permanent establishment in Colorado, of some Japanese beetle natural enemies present in states to the east.
Natural Enemies of Japanese Beetle Exist Elsewhere in the US

- **Paenibacillus popilliae** (Milky spore)
  - Bacterium
- **Istocheta aldrichi**
  - Tachinid fly
- **Tiphis vernalis**
  - Parasitoid wasp
- **Ovavesicula popilliae**
  - Fungus (microsporidium)
Milky Spore for Japanese Beetle?

Used to permanently establish a biological control organism – *not useful for immediate control.*
Natural enemies of Japanese Beetle that were introduced once and now established elsewhere in the United States

- *Paenibacillus popilliae* (Milky spore)
  - Bacterium
- *Ovavesicula popilliae* *
  - Microsporidium (fungus)
- *Istocheta aldrichi* *
  - Tachinid fly
- *Tipha vernalis* *
  - Parasitoid wasp

* Species involved in Colorado Japanese Beetle Biological Control Program
Natural Enemies of Japanese Beetle for Potential Introduction into Colorado?

Ovavesicula popilliae – a fungal disease of Japanese beetle larvae

Ovavesicula infection of Malpighian tubules of Japanese beetle larva

Target stage – larvae in soil
*Ovavesicula popilliae* infects the Malpighian tubules of Japanese beetle larvae and adults.

Normal Malpighian tubules versus infected tubules packed with spores of *Ovavesicula popilliae*.

Source: David Smitley, Michigan State University
Natural Enemies of Japanese Beetle for Potential Introduction into Colorado?

*Ovavesicula popilliae* – a fungal disease that infects Japanese beetle larvae

Main observed effects from infection – reduced winter survival (larvae), shortened life span, reduced fecundity (adults)
Japanese beetles collected from Michigan that were infected with *Ovavesicula popilliae* were shipped to us in late July 2015. The beetles were frozen, so no live beetles were introduced, but spores of the pathogen are still viable.
Dead, frozen Op-infected beetles arrive

Beetles are blended into a slurry

Diluted with water the slurry is poured over sites where high numbers of JB grubs are present, and immediately watered in
Positive infections confirmed in 2017 from both Flatirons Golf Course (Boulder) and Pueblo Zoo release sites!!!
Ovavesicula popilliae as a JB Biocontrol Agent

• Colorado release sites as of today
  – Pueblo (2), Boulder (1), Littleton (2), Cherry Hills (1), Denver (3)

• Characteristics needed for future release sites
  – Site must have high numbers of JB grubs
  – Site must be at least 1 mile from any previous release site
  – Someone must commit to maintaining a JB trap at the site for the first year of the release
*Istocheta aldrichi* – the "winsome fly"

Diptera: Tachinidae

The adult flies glue their eggs onto adult Japanese beetles. The larva tunnels into and kills the beetle.
Hatched egg

Pupa of the fly larva that developed within and killed the Japanese beetle
Istocheta aldrichii as a JB Biocontrol Agent

• Colorado release sites as of today
  – Pueblo (1), Littleton (1), Denver (1)

• Characteristics needed for future release sites
  – Site must have high numbers of JB adults
  – Site must have abundant amounts of suitable flowering plants during July
  – Site must be at least 1 mile from any previous release site
  – Someone must commit to maintaining a JB trap at the site for the first year of the release
*Tipha vernalis* spring tiphia

Hymenoptera: Tiphiiidae

The adult wasps dig into the soil and lay their eggs on late stage Japanese beetle grubs

Photographs courtesy of David Shetlar, the Ohio State University
*Tipha vernalis* as a JB Biocontrol Agent

- **Colorado release sites as of today**
  - Littleton (1), Boulder (1)

- **Characteristics needed for future release sites**
  - Site must have high numbers of JB larvae
  - Site must have abundant amounts of suitable flowering plants during May
  - Site must be at least 1 mile from any previous release site
  - Someone must commit to maintaining a JB trap at the site for the first year of the release
What can we hope for with the Japanese Beetle Biological Control Program?

• One or more of the organisms will establish and reproduce at the release site
• The organism(s) will then spread on their own over time to cover a wide area
• As the organisms establish and increase, populations of Japanese beetle will decrease
  – These reductions will be permanent
Present Situation with Emerald Ash Borer in Colorado
Emerald ash borer (EAB) is a green-colored beetle……

...that develops in ash trees (Fraxinus species)…
In its native range emerald ash borer is insignificant as a species, limiting attacks to very stressed trees.
Emerald ash borer was first detected in North America in the Detroit area in 2002

It is thought to have arrived some time during the early 1990’s

Known distribution in 2006
Damage is done by the larvae that tunnel under the bark, girdling the cambium.
Effects of larval tunneling are cumulative, and damage will accelerate as larval populations increase within the tree.
Symptoms of EAB injury are expressed as progressive thinning of the crop canopy.
EAB larval injuries progress to tree death, if the tree is not effectively treated to control the insect.

EAB injuries produce a progressive and, to some extent, reversible condition.
EAB Will Kill All Unprotected Ash

Thanks to Cliff Sadof of Purdue University for this graphic
Known distribution of Emerald Ash Borer as of about two months ago
How does Emerald Ash Borer compare to the borer we already have in ash - Lilac/Ash Borer?

Lilac/ash borer, a clearwing borer moth

Emerald ash borer, a metallic wood borer/flatheaded borer
Emerald ash borer
*Agrilus planipennis*

Order Coleoptera (beetles)
Family Buprestidae (metallic wood borers, flatheaded borers)

Photograph by Debbie Miller

Photograph by David Cappaert
Lilac/Ash Borer

*Podosesia syringae*

Order: Lepidoptera
(Moths and butterflies)
Family: Sesiidae (Clearwing borers)

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Lilac/Ash Borer: A Common Wood Borer of Colorado’s Street Trees

Fact Sheet No. 5614

by W.S. Cranshaw

Lilac/ash borer (*Podosesia syringae*) is a common wood borer associated with ash throughout Colorado and a species that is native to North America. Damage is caused by the larvae which tunnel into the trunks and lower branches of ash trees. These feeding injuries produce irregular gouging wounds under the bark and tunneling frequently extends deeply into the heartwood.
Emerald ash borer larvae create meandering tunnels in the cambium that produce girdling wounds.

*Note:* Attacks can occur throughout the crown and on the trunk of the tree.
Lilac/ash borer larvae create irregular gouging wounds that extend often into the heartwood.

Attacks are concentrated at the lower trunk of the tree.
EAB adults chew through the bark, producing D-shaped exit holes.
Chewing of the exit hole is done by the larva of the lilac/ash borer – the adult stage cannot chew.
Lilac/ash borer emerges from irregularly round holes. The pupal skin is pulled out when the adult emerges.
After emergence emerald ash borer adults feed on ash foliage for a couple of weeks, and eggs mature.
EAB likely will emerge sometime in midMay.

Most all eggs will be laid in June and into early July.

Photograph by David Cappaert

Photograph by Dan Herms
Adults of the lilac/ash borer are present in mid-late spring. Most eggs are generally laid in May through early June.

Adult stages of the lilac ash borer do not feed on any parts of the ash tree.

Male flying to a pheromone trap
Eggs of both species are laid on the bark of ash trees.
Damage potential to its host

10 – EAB now defines an aggressive tree killing insect in North America.
Damage potential to its host

2, maybe 3 – Lilac/ash borer has far lower ability to seriously damage its host.
Emerald ash borer is devastating to all species of ash that are native to North America.

- Green ash
- White ash
Why is EAB so destructive to ash trees in North America?

NA ash species lack ability to resist EAB
Common question: How is this different from mountain pine beetle? MPB killed a lot of trees.
Chestnut blight – Devastated American chestnut in early 1900s, caused by a fungus

Two tree diseases of exotic origin that have permanently altered North American ecology

Dutch elm disease – Devastated American elm in mid 1900s. Caused by a fungus, vectored by a bark beetle
Colorado EAB
Tree #1

Located near the intersection of 30th and Valmont, Boulder

September 23, 2013

How did it get to Colorado?
This is the known distribution of EAB in North America at the time it was first found in Colorado in 2013.
Emerald ash borer distribution in April 2010
Area of original EAB infestation in Colorado
Important difference with Colorado infestation – Colorado has geography!
Unlike states to the east, Colorado is well compartmentalized due to its geography.

Within Colorado the current infestation is an infestation of the South Platte River drainage, not the State of Colorado.
Within the next five years, emerald ash borer will move out of Boulder into the surrounding counties. This is a slide I have been using since January 2014. The title should now read, “After 6 years, emerald ash borer has moved into the edge of adjacent counties.”
Over time the South Platte River Drainage will be colonized by emerald ash borer
Colorado EAB
Tree #1

Located near the intersection of 30th and Valmont, Boulder

September 23, 2013
Area of original EAB infestation in Colorado
Areas known to be infested with emerald ash borer in Boulder (original site of Colorado establishment)
Reported emerald ash borer distribution in Colorado – four years after Day Zero

- Original Boulder EAB infestation
- 2016 detection of EAB in Longmont
- 2017 detection in Gunbarrel
- 2017 detection of EAB in Lafayette
Sixth Anniversary!
Emerald Ash Borer in Colorado
Reported emerald ash borer distribution in Colorado – Today

- Original Boulder EAB infestation
- 2018 detection Lyons
- 2019 Detection SW of Berthoud
- 2019 detection Broomfield
- 2019 detection Westminster (Adams County)
- 2018 detection Superior
This is the map you can find of EAB distribution on the Colorado Department of Agriculture (CDA) Web Site

The newest findings are outside Boulder County, which has been quarantined for EAB since 2013
This is the map you can find of EAB distribution on the Colorado Department of Agriculture (CDA) Web Site.

The newest findings are outside Boulder County, which has been an EAB quarantine zone since 2013.
How will EAB spread once established?

• Wind-blown dispersal of adults
  – Peak period of adult dispersal is late May through late July

• Butt-heads that move wood containing developing stages
EAB likely will emerge sometime in mid-late May.

Most eggs will be laid in June, egg laying will continue through summer.
Wind Direction from Boulder (with wind speed correction) May-August 2013-2015
Reported emerald ash borer distribution in Colorado – Today

- **2018 detection Lyons**
- **Original Boulder EAB infestation**
- **2018 detection Superior**
- **2019 Detection SW of Berthoud**
- **2019 detection Broomfield**
- **2019 detection Westminster (Adams County)**
Wind Direction from Boulder
(with wind speed correction)
May-August 2013-2015
How far away is emerald ash borer from your community?
How far away is emerald ash borer from your community?

One truckload