2022 GH IPM BC Workshop: Installing bumblebees and implementing pollinator friendly management



Krischik Lab, Associate Professor, Depart of Entomology, UMinnesota, krisc001@umn.edu

Pollinator Conservation Biocontrol

Welcome. In addition to biocontrols, this website provides how-to instructions, plant lists, helpful links, videos and downloads on beneficial insect and pollinator conservation, insect identification, integrated pest management (IPM), and pollinator best practices for backyards, veggie gardens and parks & open spaces. Find course registration and class materials under resources, courses.

This website contains the following topics:

- Integrated pest management (IPM)
- Pesticides and pollinators
- Best practices for pollinators introduction
- Krischik lab research staff
- Krischik lab at work
- Research projects

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND
Legislative Citizen Commission on Minnesota Resources (LCCMR) Conservation Biocontrol 2017 - 2020

Integrated Pest Management (IPM) for Pollinators

Integrated Pest Management (IPM) › is an approach to solving pest problems that applies knowledge about pests and plants to prevent plant damage early before it becomes a problem. IPM promotes multiple tactics to manage pests and suppress population size below thresholds that cause unacceptable levels of damage to plants or crops.

IPM responds to pest problems with the most-effective, least-risk and least-toxic option. IPM is a science-based decision-making process that includes monitoring and long-term planning. By correcting conditions that lead to pest problems and using approved pesticides only when necessary, IPM provides more effective control while reducing pesticide use and using alternatives to pesticides. The conservation of beneficial insects, which include bees, insect predators, parasitic wasps, and butterflies, is an essential part of IPM.

From backyards to public parks, any individual or organization can adopt an IPM plan; therefore it's important for land managers, farmers and gardeners to learn how to implement IPM. IPM plans should be updated annually, and staff need to be trained on pesticide use and pollinator best practices.

Checking sticky pheromone traps for Plum curculio, photo: L. Schneider

Pollinator Conservation Biocontrol: Bees

More than half of North America's wild bees are in decline, and 1 in 4 at risk of extinction. Native bees, honey bees, wasps and other pollinators are keystone species and provide pollination services for over 30 percent of human food. The best crop pollinators are a combination of honey bees and wild bees.

Bee Conservation Resources

2020 Conserving the rusty patched bumble bee Dr. Vera Krischik, University of Minnesota CFANS.

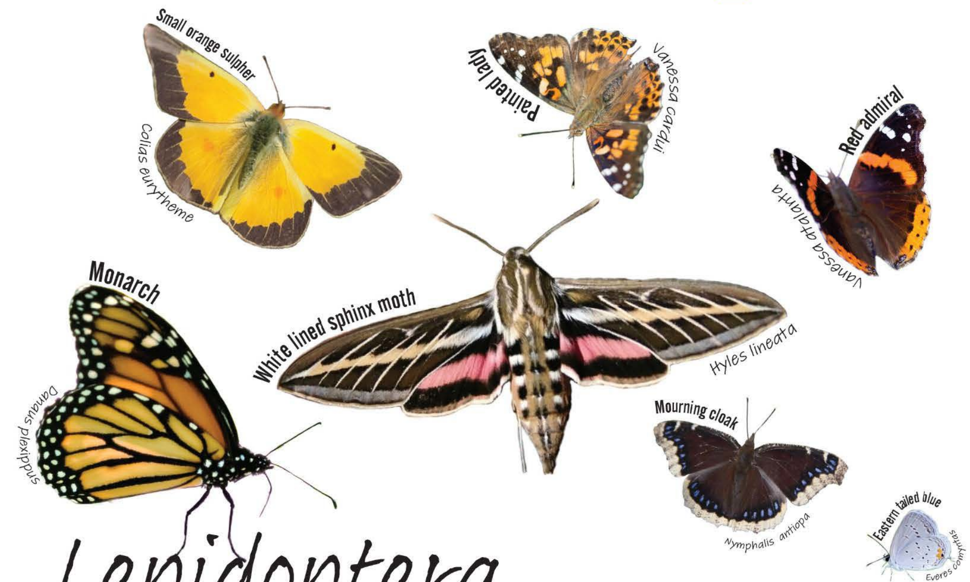
2020 Conservation guide: pollinators, plants, pesticides Dr. Vera Krischik, Laurie Schneider, Emily Tenczar, University of Minnesota CFANS.

2017 Save the bees with flowers and trees poster Dr. Vera Krischik, University of Minnesota CFANS.

University of Minnesota Bee Lab gives valuable information about pollinator diversity.

University of Minnesota Extension provides information for homeowners to attract pollinators to their backyard landscape.

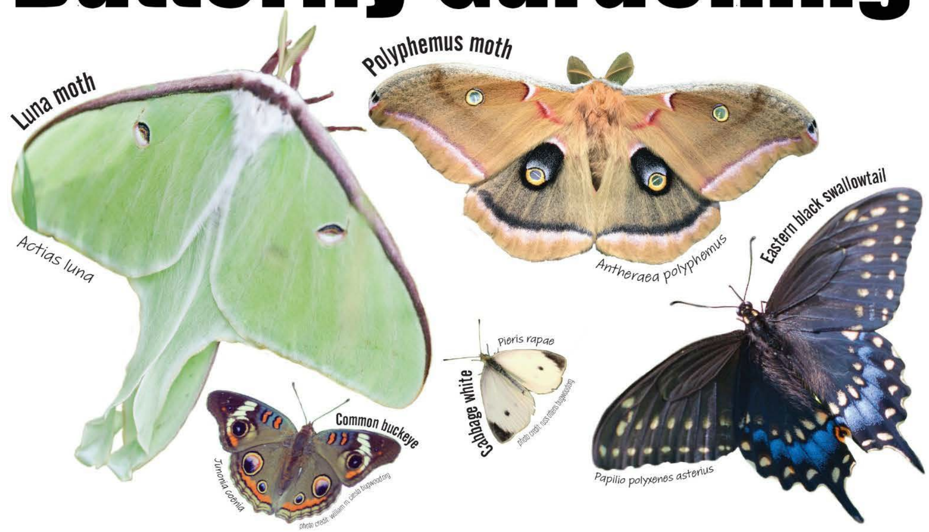
Befriending Bumblebees: A Practical Guide to Raising Local Bumble Bees Elaine Evans, Ian Burns and Marla Spivak, University of Minnesota Extension.



Lepidoptera

by Dr. Vera Krischik, University of Minnesota, Entomology
Center for Urban Ecology & Sustainability, CUES, 2020

Butterfly Gardening



Integrated Pest Management

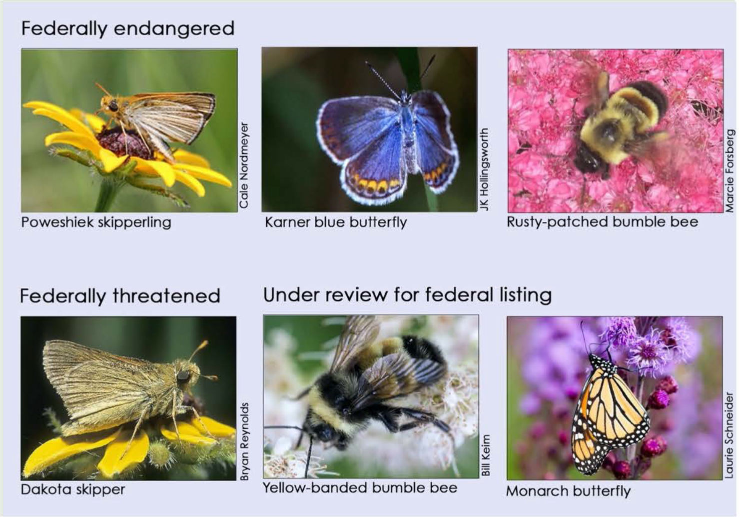
Integrated Pest Management (IPM) is an ecosystem-based approach that employs long-term prevention of pests and pest damage through monitoring of plants, pests and weather to project ahead and plan. IPM addresses the source of the pest problems, whereas pesticides simply respond to pests. IPM minimizes the use of chemicals harmful to pollinators and beneficial insects, and toxic to the environment. The recommended best practice is to use cultural controls to reduce pest populations such as compost, bio fertilizers and aeration instead of pesticides.

Integrated pest management practices include:

1. Inspection and monitoring: Regular and close examination of plants is essential to diagnose pest problems. Monitoring includes devices such as traps, and practices such as observation and recordkeeping.
2. Forecasting: Weather and plant growth cycles (called plant phenology) help predict potential pest outbreaks. Properly timed pesticide applications will be more effective and reduce need for re-application.
3. Thresholds: Set thresholds for pest populations and plant damage. Use hardy plants that are naturally resistant to pests to avoid exceeding pest thresholds. Accept some plant damage.
4. Education: Regularly update the IPM plan and pesticide/treatment list so it remains effective. Stay educated and updated on IPM and best management practices.
5. Recordkeeping: Keep updated records to compare year to year and for decision-making. Track data including weather patterns, when pests appear, number of pests, plant damage, and practices that work and don't work.

Minnesota Threatened and Endangered Species

Excerpt from *Environmental Quality Board, Minnesota State Agency Pollinator Report 2018.*



Endangered: Persius duskywing, Ottoe skipper, Dakota skipper, Assiniboia skipper, Uncas skipper, Karner blue, Poweshiek skipperling, Uhler's artic.
Threatened: Garita skipperling.
Special Concern: Arogos skipper, Disa alpine, Leonard's skipper, Nabokov's blue, Grizzled skipper, Regal fritillary.

In addition to federally-listed species, Minnesota has **8** state-listed endangered pollinator species, **1** threatened, **10** species of special concern, and an additional **19** non-listed species in greatest conservation need.

Think IPM

for pollinator conservation
Integrated Pest Management

BIOLOGICAL CONTROL

is the use of natural enemies to control insect pest populations. Natural enemies include insect predators and parasitoids (such as lady beetles and braconid wasps) plus pathogens including bacteria, fungi and viruses.

PLANT NATIVE & HEIRLOOM

plants that provide pollen and nectar to attract natural predators. Many are attracted to flowering plants and also contribute to pollination services.

INTEGRATED PEST MANAGEMENT

is an ecosystem-based approach that employs long-term prevention of pests through inspection, monitoring, forecasting, thresholds, education and recordkeeping. While pesticides simply respond to the pest, IPM addresses the source of pest problems.

LAWN CARE

Limit insecticide/herbicide use, aerate, mow less often, less grasses grow to 4" or more, add nutrient-rich compost, and plant low growing perennials such as self-heal, clover, creeping thyme, blanket flowers, and pussy toes.

MONITORING

Long term prevention through regular monitoring of plants, pests and weather helps to project ahead and plan. Track and compare year to year to determine what works best.

CHEMICAL CONTROLS

Biorational insecticides are less harmful than conventional insecticides, as they target pests and conserve good bugs (eg. horticultural soaps and oils, corn gluten, spinosad and *Bacillius thuringiensis*).

CONSERVE POLLINATORS

Bees, flies, wasps, beetles and other pollinators are crucial for crops, landscapes, and natural areas. Avoid pesticides, provide nesting areas, and plant pollinator habitat for food sources.

ncipmhort.dl.umn.edu

By Dr. Vera Krischik and Laurie Schneider
University of Minnesota, Dept. of Entomology
Center for Urban Ecology & Sustainability CUES

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND
Legislative-Citizen Commission on Minnesota Resources (LCCMR)
Conservation Biocontrol
2017-2020

Pollinator Friendly Alliance

LACEWING
Predator of aphids. Known as aphid lions.

PIRATE BUG
Adults and nymphs are predators of small insects.

SPIDERS
Arachnids eat many pest insects at any stage from egg to adult.

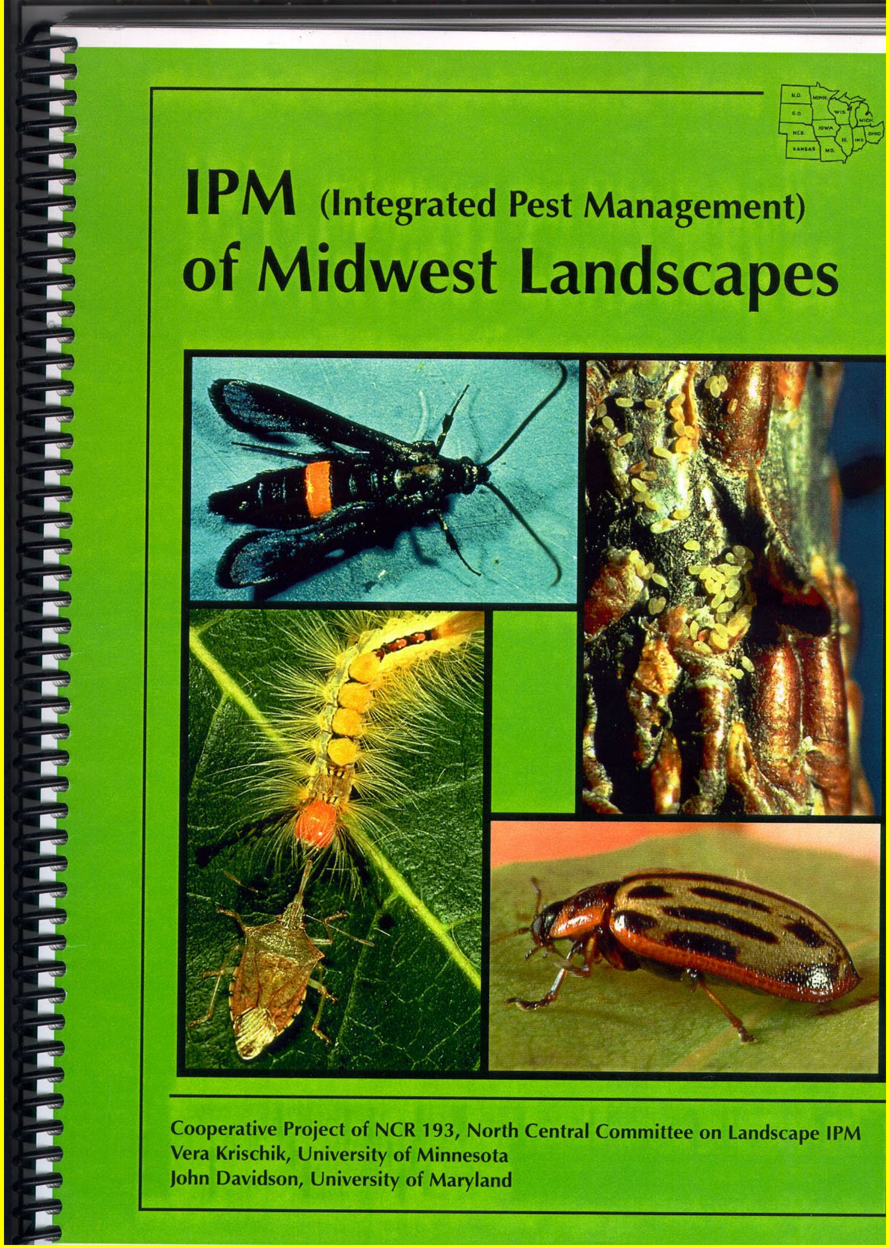
SYRPHID FLY or HOVER FLY
Adults feed on pollen and nectar. Larvae are predators on small insects.

LADY BEETLES
Larvae and adults are predators of small insects.

Turf Insects: white grubs and adults

IPM of Midwest landscapes (2004)

Vera Krischik, UM Entomology



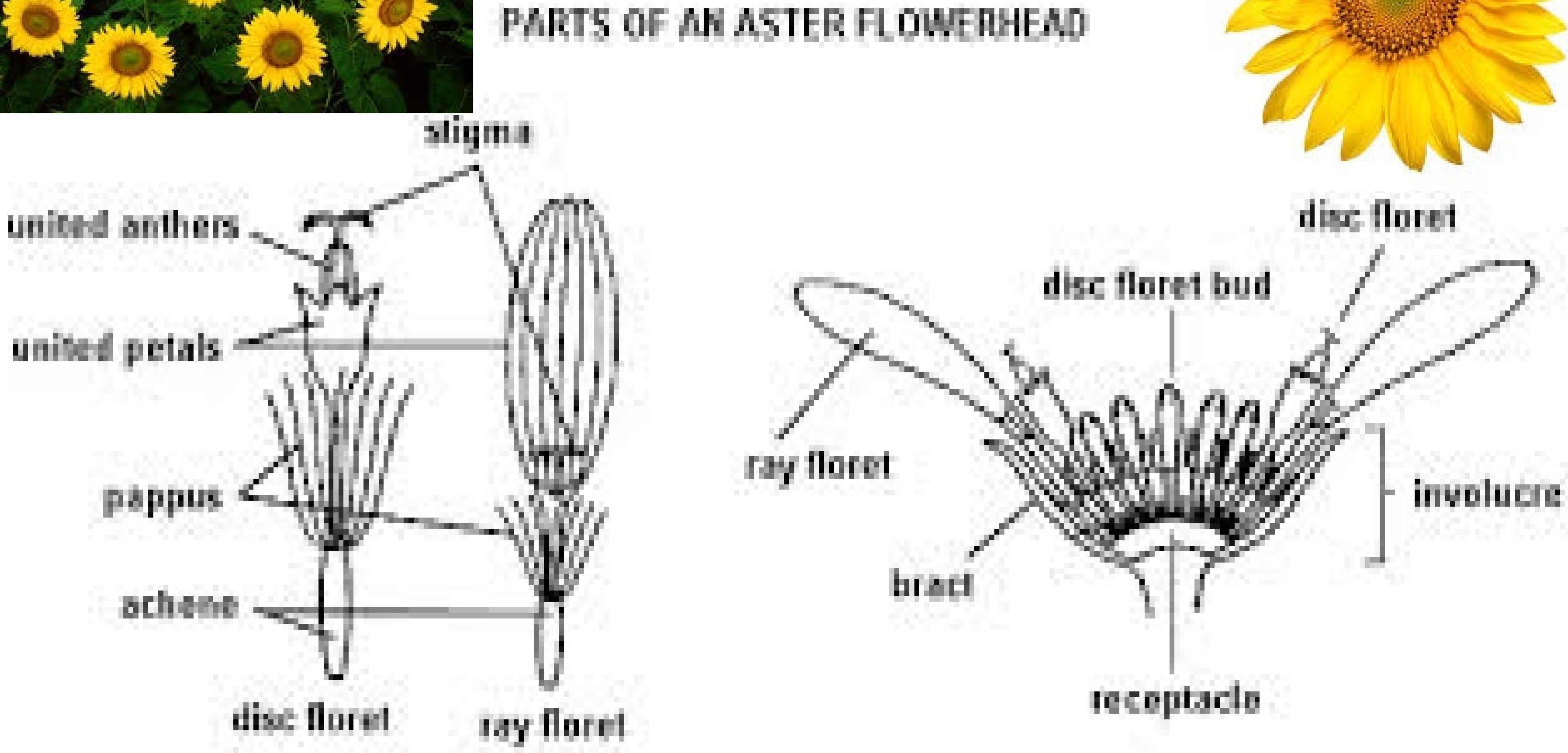
Both Krischiklab websites

IPM of Midwest Landscapes

Pests of Trees and Shrubs

Alder spittlebug	*Clastoptera obtusa*
Ambrosia beetle	*Xylosandrus germanus*
American hornet moth	*Sesia tibialis*
Aphids	Family Aphididae
Apple bark borer	*Synanthedon pyri*
Arborvitae leafminer	*Argyresthia thuiella*
Ash flower gall mite	*Aceria fraxiniflora*
Ash plant bug	*Tropidosteptes amoenus*
Asian longhorned beetle	*Anoplophora glabripennis*
Azalea lace bug	*Stephanitis pyrioides*
Bagworm	*Thyridopteryx ephemeraeformis*
Balsam twig aphid	*Mindarus abietinus*
Banded ash clearwing	*Podosesia aureocincta*
Birch lace bug	*Corythuca pallipes*
Birch leafminer	*Fenusa pusilla*
Black pineleaf scale	*Nuculaspis californica*
Black vine weevil	*Otiorhynchus sulcatus*
Boxelder bug	*Boisea trivittatus*
Boxwood spider mite	*Eurytetranychus buxi*
Bronze birch borer	*Agrilus anxius*
Brownheaded ash sawfly	*Tomostethus multicinctus*
Calico scale	*Eulecanium cerasorum*
Cankerworms	*Alsophila pometaria, Paleacrita vernata*
Clearwing borers	Family Sesiidae
Clover mite	*Bryobia praetiosa*
Cooley spruce gall adelgid	*Adelges cooleyi*
Cottonwood leaf beetle	*Chrysomela scripta*
Cottony maple scale	*Pulvinaria innumerabilis*
Currant borer	*Synanthedon tipuliformis*
Cyclamen mite	*Phytonemus pallidus*
Lesser peachtree borer	*Synanthedon pictipes*
Lilac/ash borer	*Podosesia syringae*
Linden borer	*Saperda vestita*
Locust borer	*Megacyllene robiniae*
Maple bladdergall mite	*Vasates quadripedes*
Maple callus borer	*Synanthedon acerni*
Maple spindlegall mite	*Vasates aceriscrumena*
Maple velvet erineum gall mite	*Aceria aceris*
Mimosa webworm	*Homadaula anisocentra*
Mountainash sawfly	*Pristiphora geniculata*
Mourningcloak butterfly	*Nymphalis antiopa*
Oak borer	*Paranthrene simulans*
Oak clearwing borer	*Paranthrene asilipennis*
Oak cynipid galls	Family Cynipidae
Obscure scale	*Melanaspis obscura*
Oriental beetle	*Exomala orientalis*
Oystershell scale	*Lepidosaphes ulmi*
Pales weevil	*Hylobius pales*
Peachtree borer	*Synanthedon exitiosa*
Pear sawfly	*Caliroa cerasi*
Pin oak kermes	*Allokermes galliformus*
Pine bark adelgid	*Pineus strobi*
Pine engraver	*Ips pini*
Pine needle scale	*Chionaspis pinifoliae*
Pine root collar weevil	*Hylobius radicis*
Pine shoot beetle	*Tomicus piniperda*
Pine spittlebug	*Aphrophora parallela*
Pine thrips	*Gnophothrips* sp.
Pine tortoise scale	*Toumeyella parvicornis*
Pitch mass borer	*Synanthedon pini*

Family Compositae, advanced flower, multiple ray and disc flowers in one head

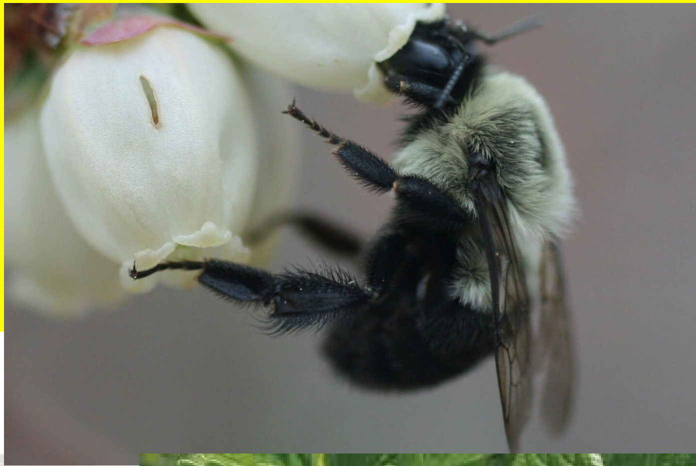


Bumblebees pollinate crop flowers

Where and why use bumblebees in the Greenhouse

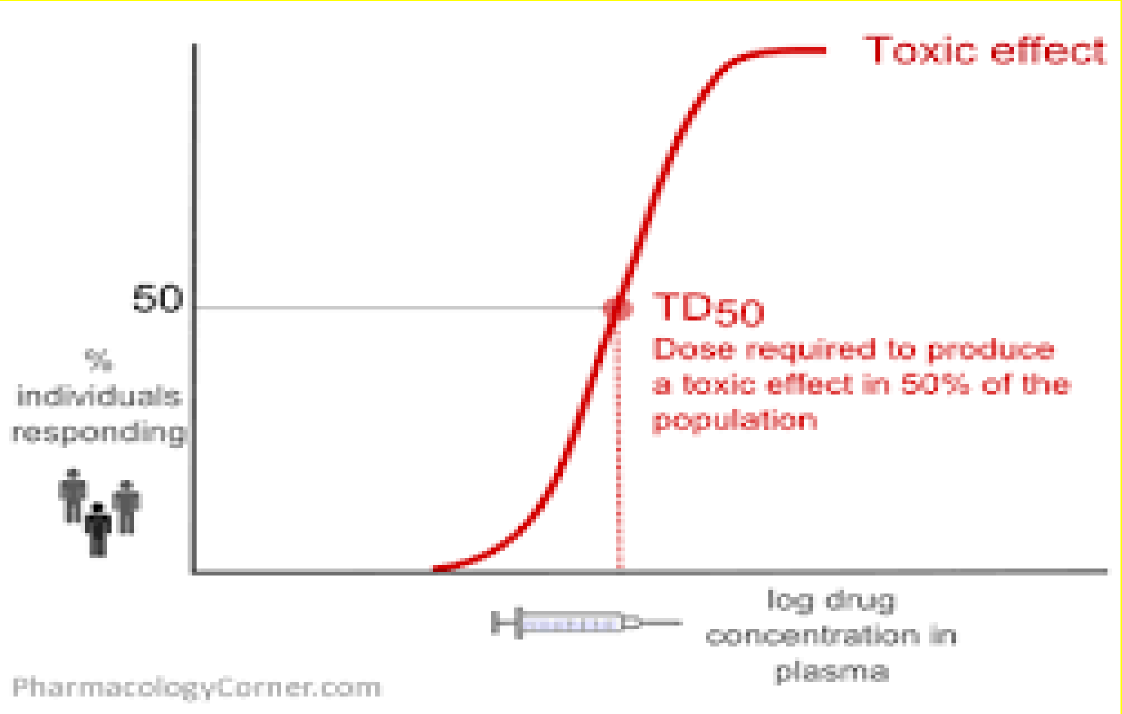
Here to purchase

- **Biobest**
- **Koppert**



Issues with IPM in urban areas:

- **Conserving bumble bees; create habitat and decrease pesticide**
- **Updated Insecticide toxicity to pollinators; are pesticides safe?**



2020 Understanding Pesticide Toxicity to Pollinators

Vera Krischik, Dept. Entomology, University of Minnesota, krisc001@umn.edu, 612.625.7044

Pesticide Toxicity to Pollinators

The active and inert ingredient can be found on the label on the pesticide container. The active ingredient is the chemical registered by the EPA as causing the toxicity of the product to the pest or beneficial insect. Recent papers demonstrate that inert ingredients are highly toxicity to bees as well. Inert ingredients are penetrating agents, odor maskers, stabilizers, preservatives, diluents, surfactants, emulsifiers, propellants, solvents, spreaders, stickers, antifoaming agents, dyes, and drift retardants that modify the physicochemical properties of the spray mixture. Some recent papers demonstrate that the inert ingredient called "organosilicone surfactant adjuvants" increase virus transmission in bees. Also, in recent studies fungicides demonstrated toxicity to bees. Another major issue is that the EPA registers the active ingredient and determines toxicity of the chemical based on short term, 4 day, LD 50 tests (lethal dose to 50% of the population) and not chronic, long term exposure. However, numerous papers are demonstrating that lower, sub-lethal amounts of pesticides affect behavior and alter the ability of insects to find food and survive. For these and numerous other reasons many insecticides are not safe to use around bees and other beneficial insects, such as lady beetles.

IPM: Systemic Compared to Contact Insecticides

The conservation of beneficial insects, that includes bees, insect predators, parasitic wasps, and butterflies, is an essential part of Integrated Pest Management (IPM) programs. IPM promotes multiple tactics to manage pests and to suppress the population size below levels that will damage the plant. Beneficial insects can only manage small, pest populations, when populations of pests are high, conventional insecticides must be used. For most pests that eat leaves, use contact insecticides that sit on the leaf surface and do not move into the plant and the toxicity to pests last for a few days on the foliage. Flowers that open after being sprayed with contact insecticides do not contain insecticide residue. Systemic insecticides move from the leaves or soil into OTHER plant parts as nectar and pollen. Flowers that open after systemic insecticides are sprayed can absorb the insecticide and the residue in leaves and flowers can last for many months.

Systemic, neonicotinoid insecticides are widely used, due to their low mammalian toxicity and the ability of the insecticide to move systemically from soil into the entire plant. However, they often move into pollen and nectar and when fed on by bees alter bee behavior or increase bee mortality. Application methods include seed treatments, foliar sprays, soil and trunk drenches, and trunk-injections. There are six systemic neonicotinoid active ingredients, imidacloprid, dinotefuran, thiamethoxam, clothianidin, acetamiprid and thiacloprid. You will find these active ingredients listed on the insecticide label in small print. Neonicotinoid insecticides are very toxic to bees and beneficial insects, especially as residue in pollen and nectar.

Manage with IPM by using cultural control, sanitation, biological control, using insecticides friendly to beneficial insects (low toxicity in the table). Remember "organic MRI approved insecticides" can be very toxic.

1. Scout for populations of both pest and beneficial insects, such as lady beetles and bees.
Determine if the good bugs are suppressing the pest bugs and no loss to flowering or food production can be found.
2. If beneficial insects are present and the pest population is increasing, then spray CONTACT insecticides on the foliage. Contact insecticides are degraded in a few days by light, water, and microbes.
3. Do not apply insecticides to flowers.
4. Spray contact insecticides on leaves in the evening when bees and lady beetles are not foraging.
5. Use insecticides that are less toxic to bees, such as oils, soaps, neem oil, Acelepryn (chlorantraniliprole), miticides, and insect growth regulators

Toxicity to pollinators of insecticides used in greenhouse, nursery, landscape.
Highlighted in gray are less toxic AI.

			Toxicity to honeybees**			
Chemical class/MOA	**Common name/MOA**	**Trade name**	**LD50* ug/bee**	**Non**	**Moderate**	**Highly**
Carbamates/1A	carbaryl	Sevin	0.014			x
	methomyl	Lannate	0.816			x
Neonicotinoids/4	imidacloprid	Merit, Marathon	0.004			x
	thiamethoxam	Flagship, Meridian	0.004			x
	clothianidin	Arena, Aloft	0.005			x
	dinotefuran	Safari, Venom	0.023			x
	imid+bifenthrin	Allectus	0.004			x
	imid+cyfluthrin	Discus	0.004			x
	flypyradifurone	Altus	1.2			x
	sulfloxaflor+spinetoram	XXpire cancelled	0.02+0.1			x
	acetamiprid	Tristar, Assail Calypso	14.5		x	
	thiacloprid		27.8	x		
Organophosphates/1B	acephate	Orthene	0.1082			x
	chlorpyrifos	Dursban/Lorsban	0.06			x
	dimethoate	Dimethoate	0.038			x
	malathion	Malathion	0.16			x
	phosmet	Imidan	0.1			x
Pyrethroids/3A	bifenthrin	Attain/Talstar	0.1			x
	cyfluthrin	Tempo, Decathalon	0.001			x
	fenpropathrin	Tame	0.05			x
	lambda-cyhalothrin	Scimitar	0.038			x
	permethrin	Astro, Pounce	0.029			x
	resmethrin	foggers	0.065			x
Botanical/3	pyrethrin	Pyganic	0.15			x
Insect growth regulators	diflubenzuron/15	Adept, Dimilin	25	x		
	tebufenozide/18	Confirm	234	x		
	azadirachtin/UN	Aza-Direct, Azatin	2.5		x	
	Neem oil		163	x		
	buprofezin/16	Talus	100	x		
	pyriproxyfen/7C	Distance, Fulcrom	100	x		
	novaluron/15	Pedestal	150	x		
	cyromazine/17	Citation	25	x		
Juvenile hormone /7A	s-kinoprene	Enstar II	35	x		
Anthranilic Diamides/28	chlorantraniliprole	Acelepryn	>104	x		
	cyantraniliprole	Mainspring	0.116			x
Macrocyclic lactones/6	abamectin	Avid, Sirocco	0.009			x
	emamectin-benzoate	Tree-age, Enfold	0.41			x
Miticides	acequinocyl/20B	Shuttle	>100	x		
	etoxazole/10B	TetraSan, Beethoven	200	x		
	fenpyroximate/21A	Akari, Vendex	162	x		

A really big issue understanding systemic compared to contact insecticides.

Imidacloprid residue in plants

Tilia, linden

Calibrachoa, million bells

Ruella, prairie petunia

Whole flower to pollen:

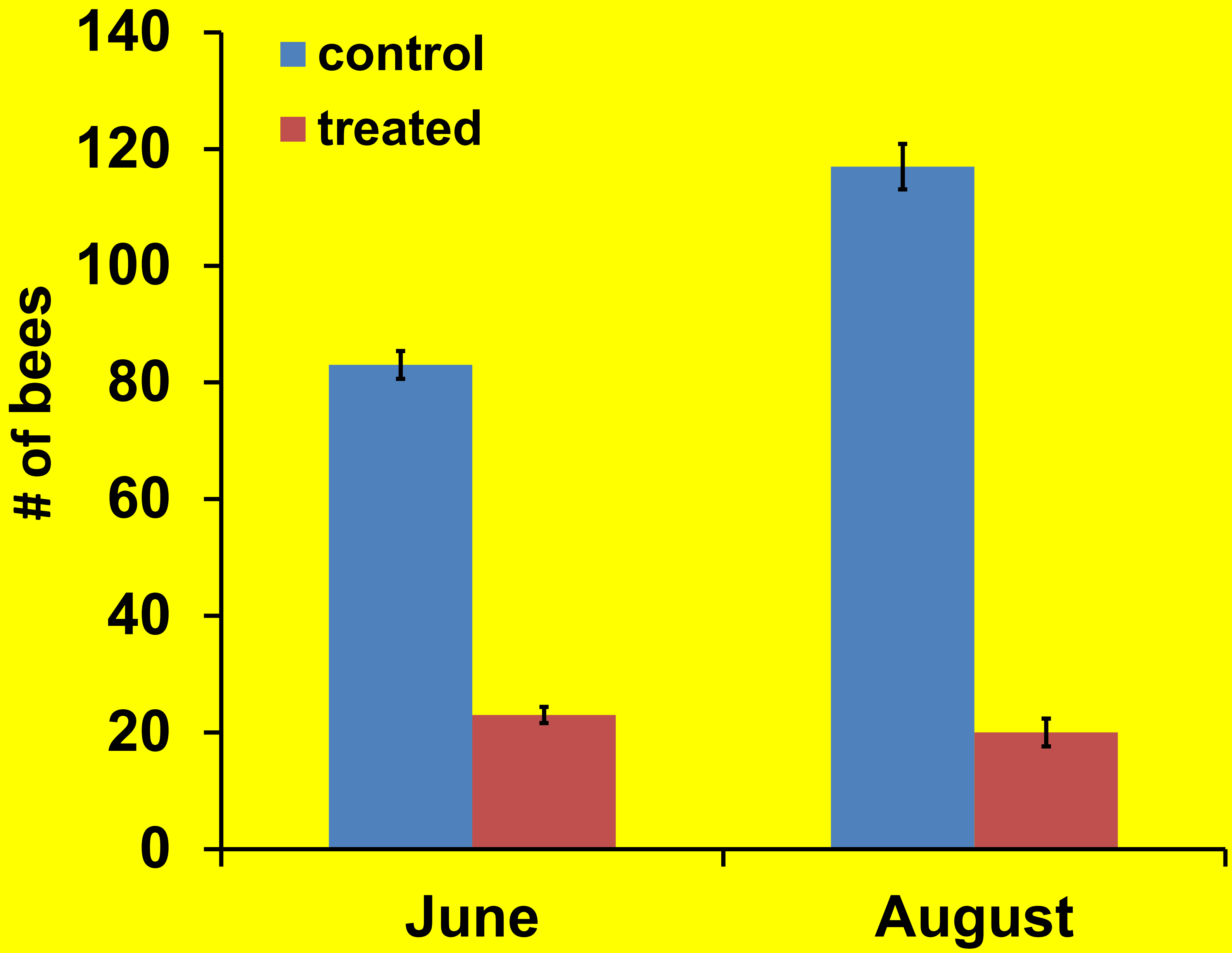
Ruella **imidacloprid pollen = 10-25% flower**

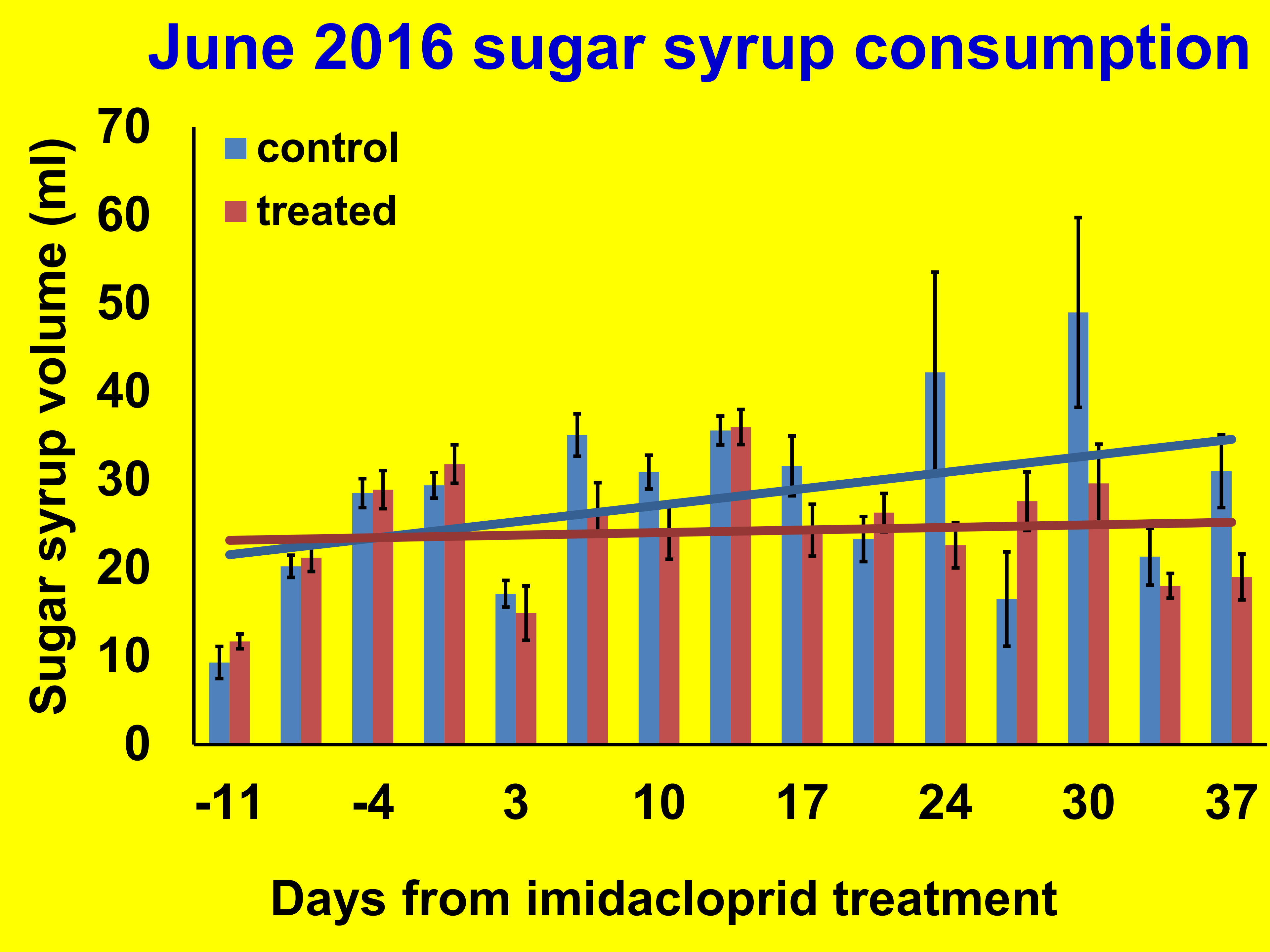
YB imidacloprid pollen = 100% of flower

EPA (13 reports) = maybe 25% of flower

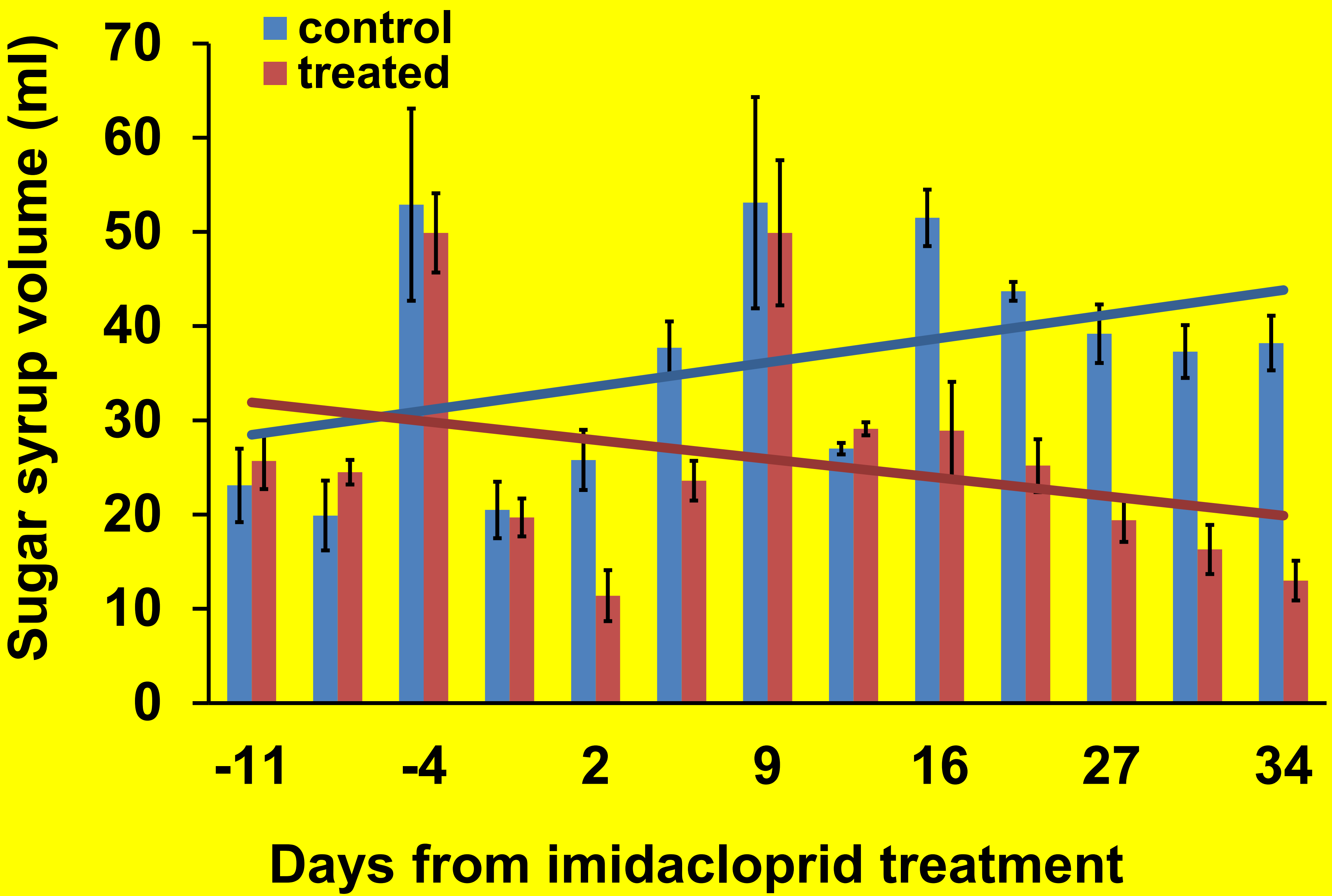
insecticide	5 wks whole flow	5 wks 25% pollen	10 wks whole flow	10 wks 25% pollen
imidacloprid	1,100 ppb	267 ppb	502 ppb	125 ppb, down 46%
dinotefuran	415 ppb	103 ppb	88 ppb	22 ppb, down 22%
pymetrozine	0 ppb	0 ppb	0 ppb	0 ppb
imidacloprid	1,971 ppb	492 ppb	383 ppb	96 ppb, down 20%
dinotefuran	2,993 ppb	748 ppb	386 ppb	96 ppb, down 25%
pymetrozine	126 ppb 1/9	0 ppb	0 ppb	0 ppb
affects on bees		mortality		Behavior, mortality

2016 bee movement

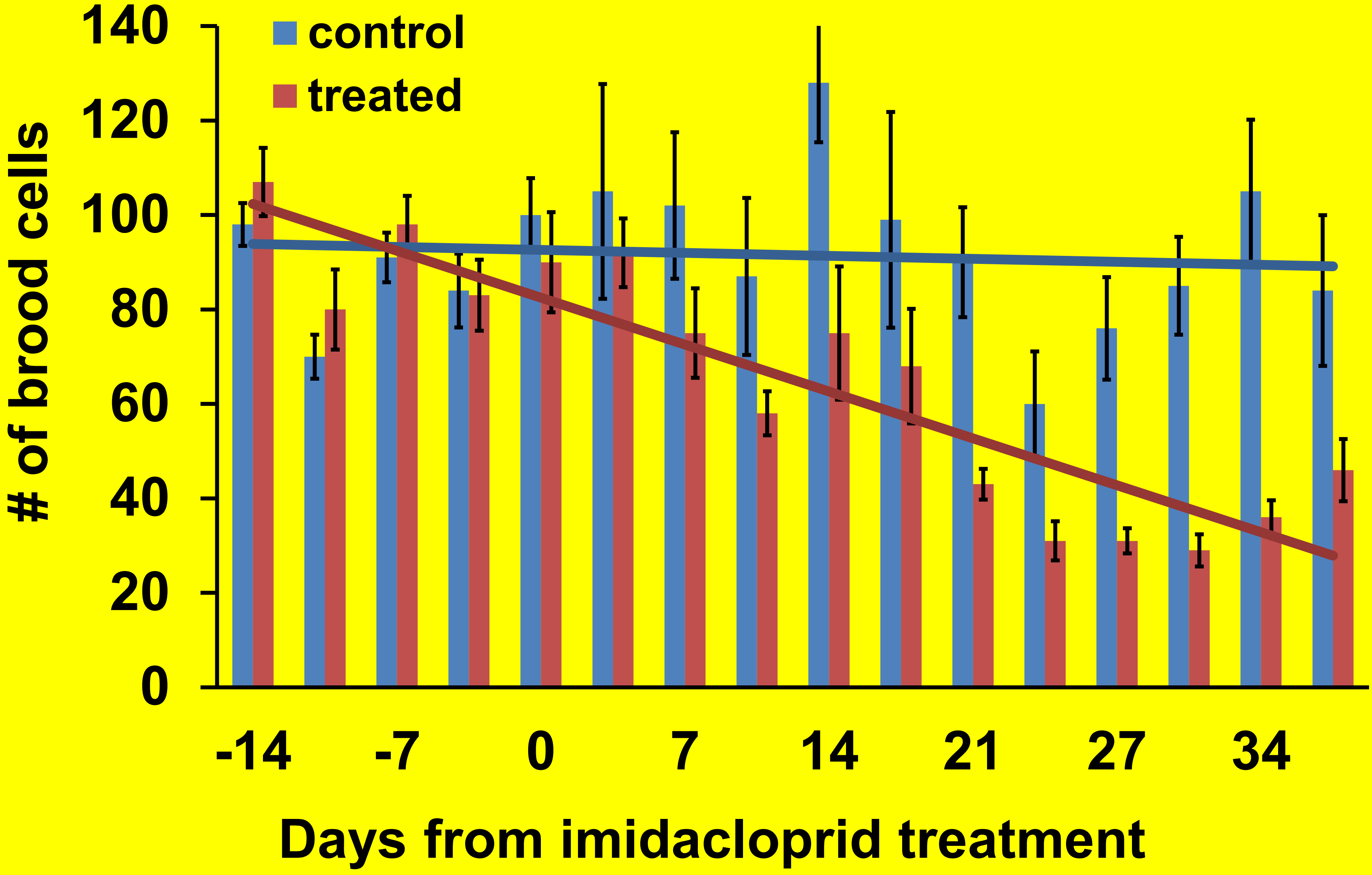


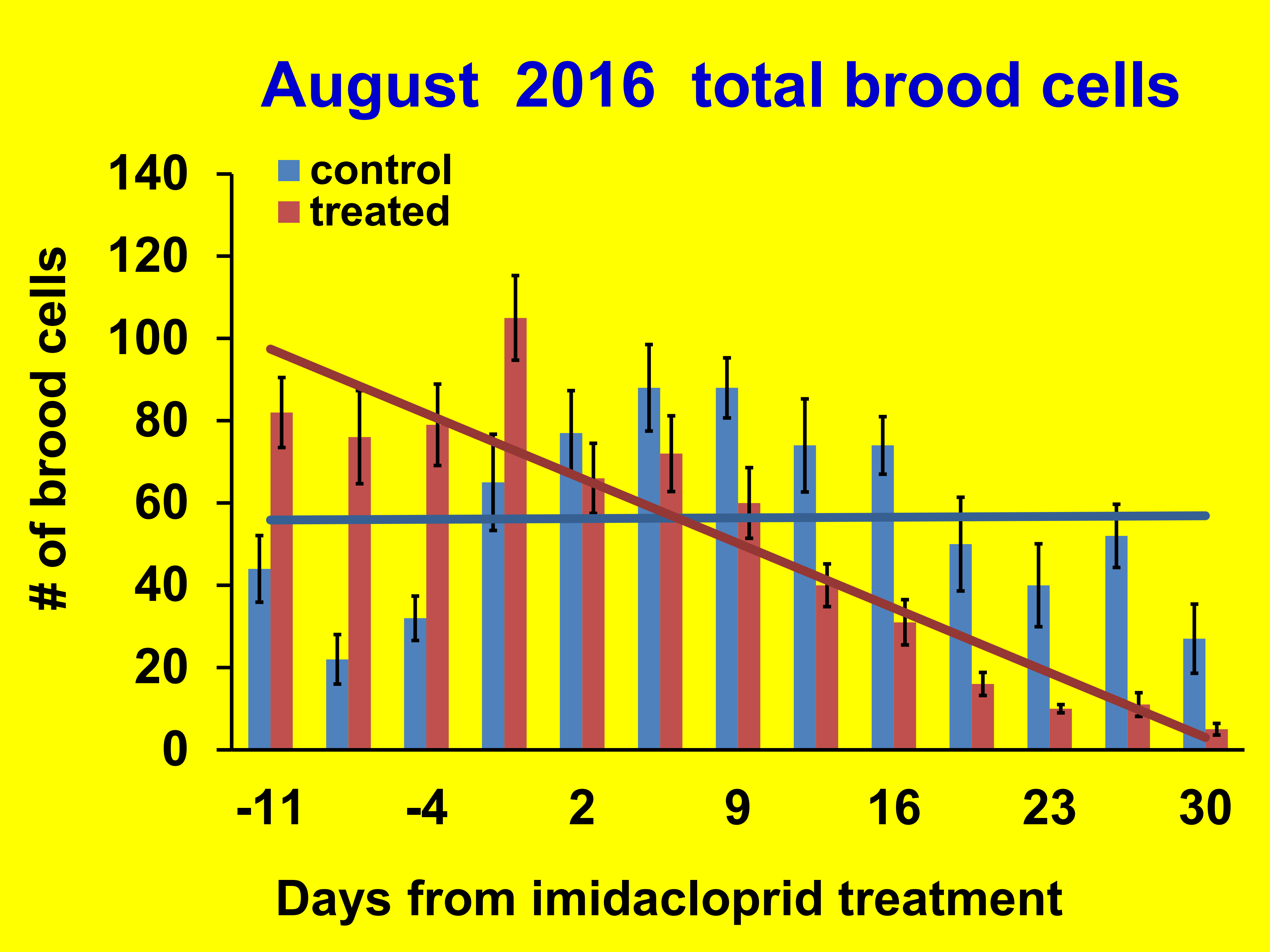

June 2016 sugar syrup consumption
control
treated
Sugar syrup volume (ml)
0
10
20
30
40
50
60
70
-11
-4
3
10
17
24
30
37
Days from imidacloprid treatment

August 2016 sugar syrup consumption



June 2016 total brood cells

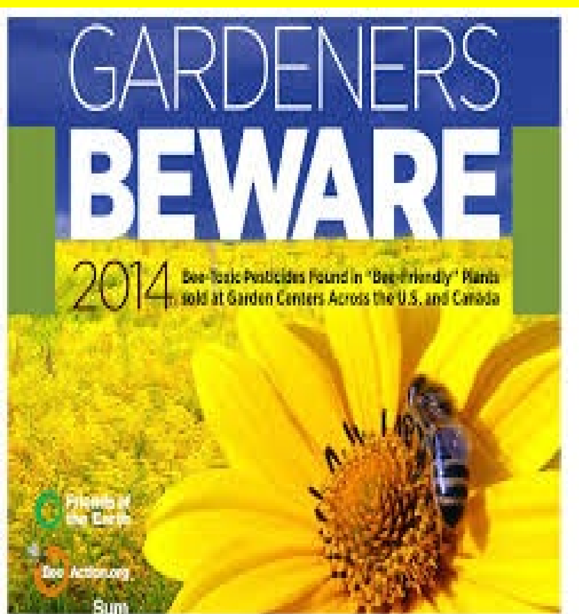



August 2016 total brood cells
control
treated
# of brood cells
140
120
100
80
60
40
20
0
-11
-4
2
9
16
23
30
Days from imidacloprid treatment

GH study with residue in pots

Greenhouse and tree rates are higher than agricultural rates and result in residue that kills beneficial insects.

These data and other published research support the Gardeners Beware reports that showed 62% of purchased plants contained neonicotinoid residue (2 to 879ppb).

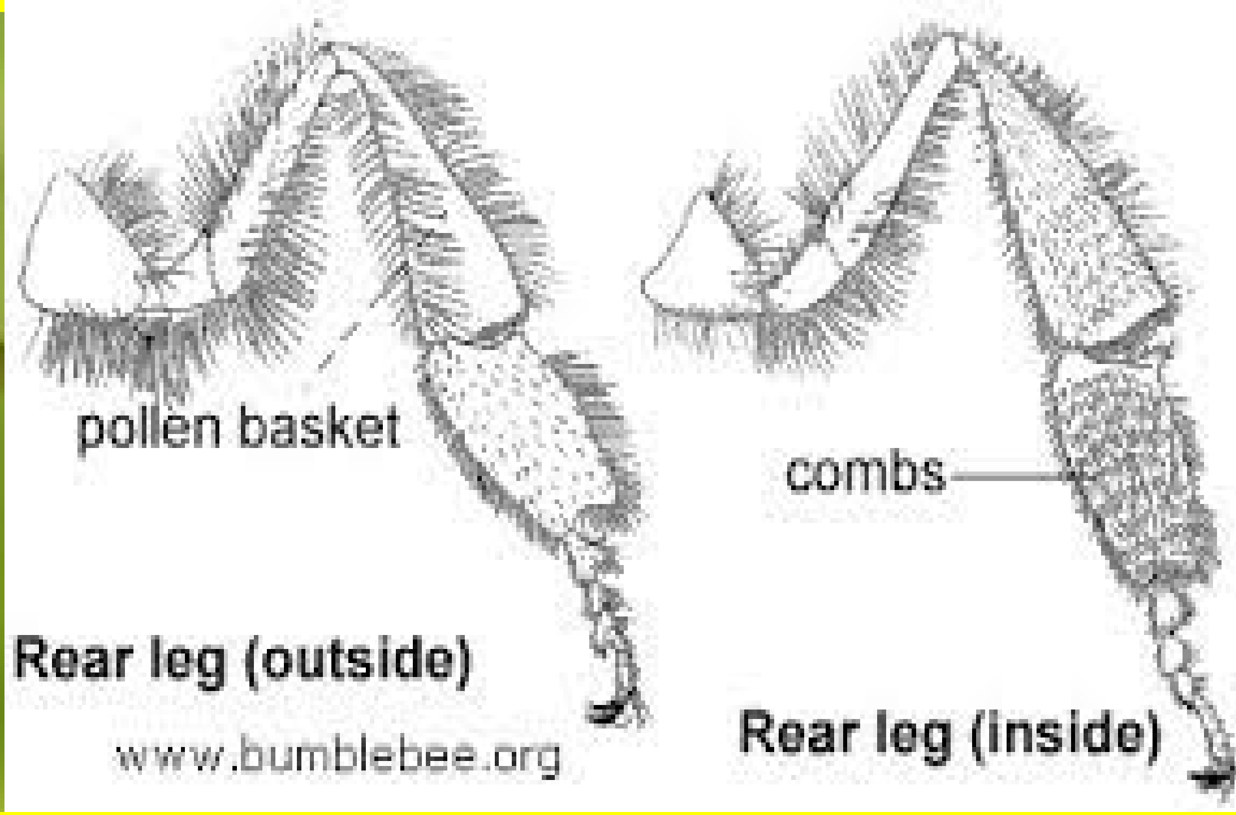


Measuring colony growth

Why use bumblebees? Pollination

How are plants pollinated?

- **Pollen collects on hairs and scales of insects.**
- **Most bees also have specialized structures called combs, corbiculae, scopae to collect pollen.**



Where and why use bumblebees in the Greenhouse

- Bumblebees, BB, pollinate flowers through a method called “buzz-pollination”, a rapid vibrating motion which releases large amounts of pollen onto the bee.
- BB are less likely to leave your crop for more attractive flowers.
- BB forage for pollen rather than nectar, and transfer more pollen to the pistils.
- BB visit more blooms per minute than honeybees.
- BB work earlier in the morning and later into the evening hours.
- BB work better in tunnels
- BB are safer for you and your employees.
- BBs are non-swarming less aggressive than honeybees.

Bumble Bees

Bumble bees are generalist feeders.

- **They are often the first bees active in spring and the last in fall. Since they are active for so many months, they must be able to forage on a wide range of plant species.**
- **When foraging, the female bumble bee carries pollen in a concave, hairless area surrounded by stiff hairs on her rear legs, known as the pollen basket or corbicula.**
- **Bumble bees also differ from solitary bees when feeding their larvae. They provide food gradually, adding it to the brood cells as the larvae need it ("progressive provisioning") rather than leaving all the food in the cell before laying the egg.**
- **Bumble bees store nectar to feed larvae and themselves for a couple of days during bad weather.**

Bumble Bees

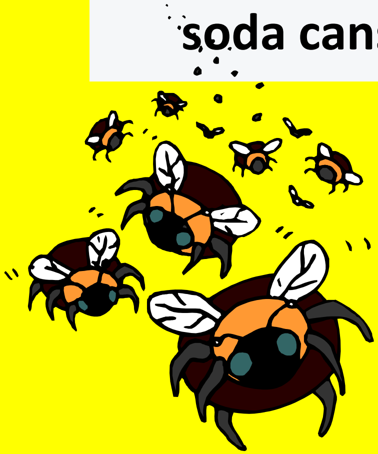
Bumble bees are the only bees native to the US that are truly social.

- Bumble bees live in colonies, share the work, and have multiple, overlapping generations throughout the spring, summer, and fall.
- The bumble bee colony is seasonal. At the end of summer only fertilized queens survive to hibernate through winter. In spring, they start new colonies that may grow to several hundred bees or 200 g.
- Bumble bees nest in cavities (sometimes in hollow trees or walls, but usually underground, such as abandoned rodent holes).
- The queen creates the first brood cells from wax, then provisions them with pollen and nectar and lays eggs. In about a month, they emerge as workers to forage and tend to brood.
- The colony grows through summer. At the end of summer, new queens and drones (males) emerge and mate. By fall, most of the bees and the old queen, will die. New, mated queens will overwinter.

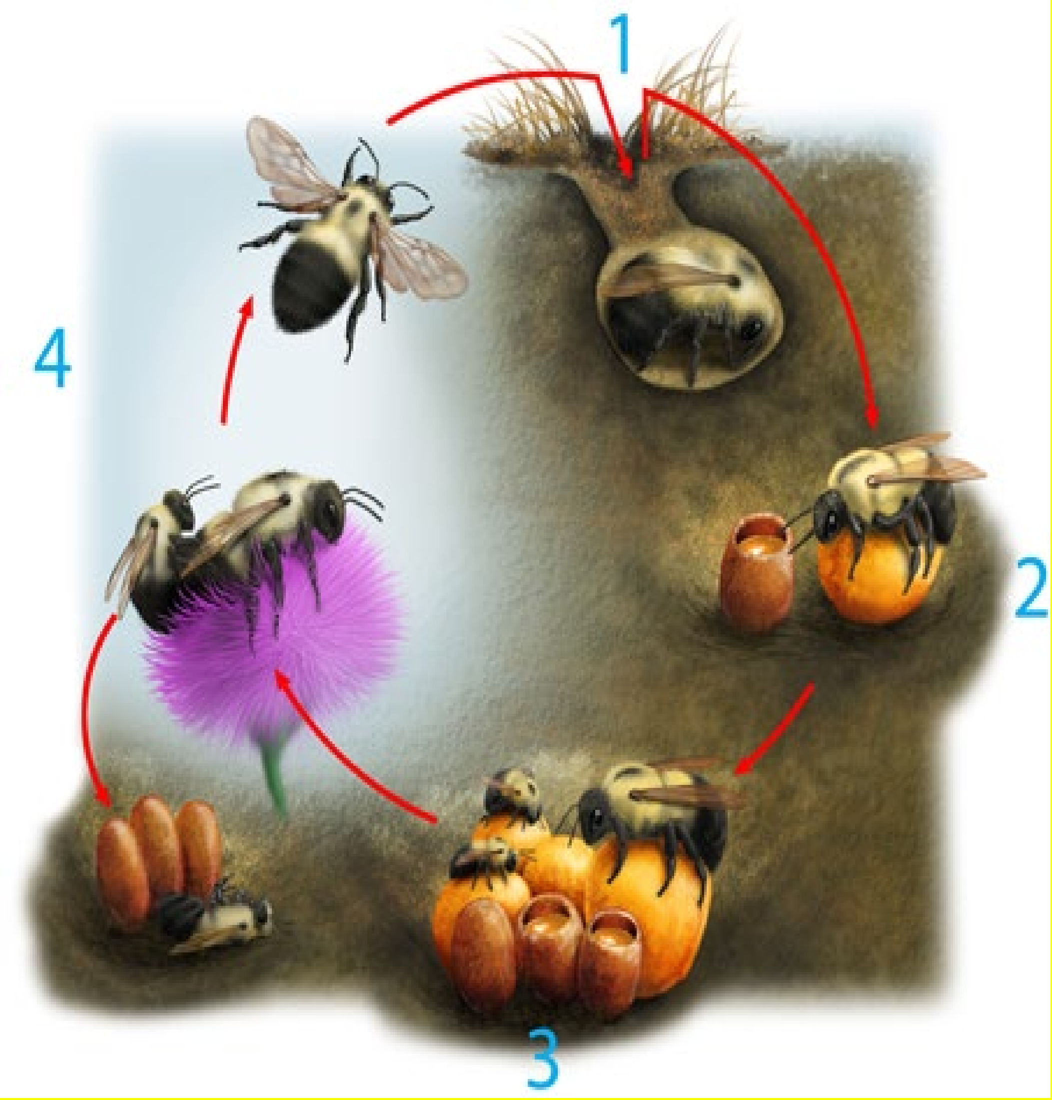
Do all bees sting?

Most bees usually do not sting.

- **Only the bees that live in a colony or hive ("social bees," i.e., honey bees and bumble bees) are likely to sting because they have a colony to defend.**
- **Most native social bees do not defend their hive aggressively.**
- **When foraging away from the nest, no bee is looking for conflict and will only sting as a last resort–perhaps as a result of being swatted or accidentally being caught in someone's clothes.**
- **You are likely to have more problems from the yellowjackets attracted to soda cans or garbage than you will from native bees.**



Bumble bee colony life cycle



Life cycle of a bumble bee colony.
Illustration by David Wysotski, Allure Illustration.

1. A queen emerges from hibernation in spring and finds a nest site, such as an abandoned rodent burrow.

2. She creates wax pots to hold nectar and pollen, on which she lays and incubates her eggs.

3. When her daughters emerge as adults, they take over foraging and other duties.

4. In autumn the colony produces new queens

Bumble Bee Colony

Inside a commercial bumble bee colony. Note capped brood cells, shiny “honey pots” full of nectar, and size difference between workers and two large queens (one is newly produced).

Bumble Bees (*Bombus* spp.)

Order Hymenoptera
Family Apidae

Red-tailed bumble bee (*Bombus ternarius*)
Rob Routledge, Sault College, Bugwood.org

Common eastern bumble bee (*B. impatiens*)
David Cappaert, Michigan State University, Bugwood.org

These large (10 to 23 mm), hairy bees are the only truly social bees native to the United States.

Colonies are annual. Fecundated queens emerge in spring and begin colonies in the ground. Males and queens are produced in fall. New queens mate with unrelated males before overwintering in the ground.

Bumble bees are used to pollinate greenhouse crops such as tomato. Pollen is carried on the hind legs on corbiculae (enlarged areas surrounded by stiff hairs).

A few species invade nests of other bumble bees; these “cleptoparasites” do not collect pollen.

Honey bee (*Apis mellifera*)
David Cappaert, Michigan State University, Bugwood.org

Honey bee products. Different types of honey (clover, buckwheat, orange, etc.) are produced when honey bees forage on specific crops.
Jeffrey W. Lotz, Florida Dept. of Agriculture & Consumer Services, Bugwood.org

Honey Bees (*Apis mellifera*)

Order Hymenoptera
Family Apidae

Honey bees (native to Europe) are used for pollination (almonds, for example) and for honey, beeswax, and propolis production. They are 10 to 15 mm in length and possess corbiculae like bumble bees.

Honey bee colonies are perennial. New colonies form when an old queen swarms with a group of workers. The queen mates with unrelated males. Fertilized eggs become workers; males (unfertilized eggs) are produced prior to swarming. Feral honey bees nest in trees or other cavities.

Honey bees are usually docile. An African subspecies (*A. mellifera scutellata*), present in the south, can be aggressive.

Honey Bee Colony

Inside a honey bee colony. Note capped brood cells containing pupae and open brood cells with larvae (unlike bumble bees, who cap cells immediately after laying eggs).

Solitary Bees

Solitary bees collect pollen and nectar to provision brood cells.

- **Most bees carry nectar in their crop (a sac-like chamber in the digestive tract); how they carry the pollen depends on species.**
- **Most solitary bees have an area of stiff hairs, called a pollen brush or scopa, into which pollen is pushed. The hairs are located either on the underside of the abdomen or along the hind legs.**

Solitary bees can be divided into two loose groups according to their foraging habits:

- **Generalists are bees that gather nectar and pollen from a wide range of flower types and species.**
- **Specialists, on the other hand, rely on a single plant species or a closely related group of plants for nectar and pollen, and are more susceptible to suffer from landscape or habitat changes.**

Solitary Bees

Solitary bees generally live for a year; the adult stage lasts 3-4 weeks.

- **The female bee of most species will mate only once.**
- **She then constructs a nest with mud, plant resins, saps, pebbles, empty snail shells, etc. Bees use abandoned beetle burrows or tunnels in snags, or they excavate nests in stems or in the ground.**
- **Each nest has several (1 to 60+) brood cells in which the female lays eggs. Cells are in a single line filling the hole or in complex tunnels.**
- **Before closing the cells, the bee mixes together nectar and pollen to form “bee bread” to place inside each cell. She then lays an egg, usually on the loaf, and caps the cell. When she has completed and capped all cells, she will seal the nest entrance and leave.**
- **After the eggs hatch, each larva feeds on bee bread until becoming a pupa. After an inactive period, it will emerge as an adult.**

Digger bee (*Anthophora terminalis*)

Laura Gooch, Creative Commons Copyright, http://www.flickr.com/photos/lgooch/7705996856/

Long-horned bee (*Melissodes bimaculata*)

Johnny N. Dell, Bugwood.org

Digger and Long-Horned Bees

Order Hymenoptera
Family Apidae

These bees are sometimes classified in family Anthophoridae along with carpenter bees. These hairy bees are 5 to 25 mm in length and use scopae (stiff hairs) instead of corbiculae to carry pollen on the hind legs.

Most species nest in the ground or in vertical banks, often in sandy soil. Some waterproof their brood cells with secreted waxy or oily material.

Digger and long-horned bees are usually solitary; however, some species aggregate or use common entrances to nesting areas. Each female cares for her own brood.

Small carpenter bee (*Ceratina* sp.)
Steve Nanz, University of Minnesota Extension Gardening Info

Large carpenter bee (*Xylocopa virginica*)
Johnny N. Dell, Bugwood.org

Carpenter Bees

Order Hymenoptera
Family Apidae

Large carpenter bees (*Xylocopa* spp.) are 13 to 30 mm in length and small carpenter bees (*Ceratina* spp.) are 3 to 15 mm. Scopae are located on the hind legs.

In spring, females make or use existing tunnels to lay eggs and insert pollen and nectar. There may be several generations per year. Adults overwinter in the nests.

***Xylocopa* species chew nests in wood (including buildings!) and stems of plants. *Ceratina* species have smaller jaws and utilize softer material, such as dead wood.**

Most species are solitary, but a few species are semisocial (mothers and daughters share nests).

Leaf-cutter bees, Megachilid bees (*Megachile* sp)

Leaf cutter bees use rose leaves to line their nests, add a ball of pollen and nectar and lay an egg. Important pollinators of backyard fruits and crops. Larvae killed by imidacloprid.

Leafcutter bee (*Megachile* sp.) and damage (inset)
Whitney Cranshaw, Colorado State University, Bugwood.org

Blue orchard bee (*Osmia lignaria*)
Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Leafcutter & Mason Bees

Order Hymenoptera
Family Megachilidae

These solitary bees range from 3 to 20 mm. Females collect pollen on scopae on the underside of the abdomen.

Females usually nest in cavities (crevices, beetle tunnels in dead trees, etc.), where they deposit eggs and provision cells with pollen and nectar before sealing each cell. Larvae feed and develop in the cells.

Leafcutter bees (*Megachile* spp.) cut sections of leaves and flowers to line brood cells, while mason bees (*Osmia* spp.) use mud. Other species use pebbles, wood, plant hairs, or other materials.

The blue orchard bee (*Osmia lignaria*) is an important pome fruit pollinator.

Leafcutter bee (*Megachile rotundata*)
Jodelet / Lépinay (Own work) [CC-BY-SA-2.0-fr (http://creativecommons.org/licenses/by-sa/2.0/fr/deed.en)], via Wikimedia Commons

Pupae in cells
Howard Ensign Evans, Colorado State University, Bugwood.org

Leafcutter Bees

Most species nest in above-ground cavities (beetle tunnels in snags, crevices in rocks, etc.) but a few species nest in the ground.

The female cuts pieces of leaves and flower petals to line and divide cells in the nest.

Like other solitary bees, she provisions each cell with nectar and pollen before laying an egg and sealing the cell.

After feeding, the offspring overwinter in the cells as prepupae (mature larvae) or new adults.

Damage caused by adult female leafcutter bees is aesthetic and does not cause significant plant injury.

Houses that work

Butterfly houses do not work

Stem nesting bee houses work, get the right one

Bird houses work, get the right one

Water features work, ponds, fountains cleaned daily

Feed sunflower chips not whole seeds to reduce mess

Most cheap bird foods are not worth the money

BEE LOOKALIKES

Social & Potter Wasps

Order Hymenoptera
Family Vespidae

Paper wasp (*Polistes dominula*)
David Cappaert, Michigan State University, Bugwood.org

Eastern yellowjacket (*Vespula maculifrons*)
Gary Alpert, Harvard University, Bugwood.org

Wasps may be confused with bees but are usually less hairy and have more restricted abdomens.

Yellowjackets, hornets, and paper wasps are large (up to 25 mm) social wasps that nest in cavities, trees, and eaves of buildings. Yellowjackets usually nest in the ground and often sting if disturbed. These wasps also invite themselves to late summer picnics. Colonies are annual.

Potter wasps are solitary vespids that construct nests with mud or utilize cavities or ground tunnels. Vespids are beneficial predators that hunt other insects to feed to their larvae.

BEE LOOKALIKES

Social Wasps

Paper wasps (like this *Polistes dominula*) make open nests; note larvae present in brood cells
Joseph Berger, Bugwood.org

Baldfaced hornets (*Dolichovespula maculata*) make enclosed nests
Steven Katovich, USDA Forest Service, Bugwood.org

The life cycle of social wasps is similar to that of bumble bees, except that wasps are mainly carnivorous.

Among the social wasps, the hornets, aerial yellowjackets, and paper wasps are the species usually found above ground, while most yellowjackets nest in the ground or in cavities . Females chew on wood to make into papery brood cells. Workers hunt caterpillars and other insects to feed the developing larvae.

In fall, drones and queens are produced and mate. The newly fertilized queens overwinter and begin the cycle again in the spring. Colonies do not reused nests.

Cicada killer (*Sphecius speciosus*)
Jessica Lawrence, Eurofins Agroscience Services, Bugwood.org

Solitary Wasps:
Mud-Daubers, Sand, & Digger Wasps
Order Hymenoptera
Family Sphecidae

Spider Wasps
Order Hymenoptera
Family Pompilidae

Solitary wasps nest in the ground or in cavities and provision nest cells with paralyzed insects or spiders. Larvae feed on the paralyzed prey.

One familiar species is the cicada killer (*Sphecius speciosus*), which hunts cicadas. Mud-daubers use mud to construct brood cells and can be found alongside buildings. Solitary wasps usually don't sting humans.

There are also several other families of wasps that are found on flowers.