Latest research: Neonics vs. pollinators

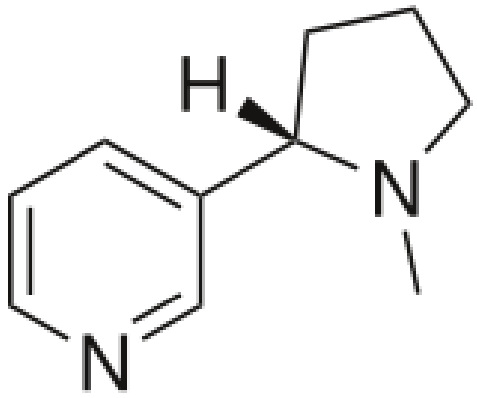
Richard Cowles, CT Agric. Expt. Station, Valley Lab

Overview

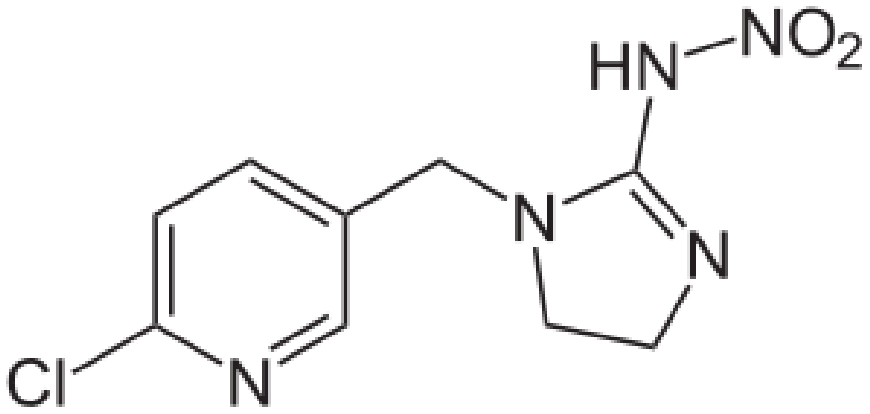
Neonicotinoids
Neonics vs. bees
Exposure through ornamental nursery crops
Mitigating risk: Best management practices

What are neonicotinoid insecticides?

Nicotine



Imidacloprid



Others:	dinotefuran	Safari
	thiamethoxam	Flagship
	clothianidin	Arena (landscape only)
	acetamiprid	TriStar

Systemic insecticides have advantages:

When presented within tissues, target pests in hard-to reach areas can be affected

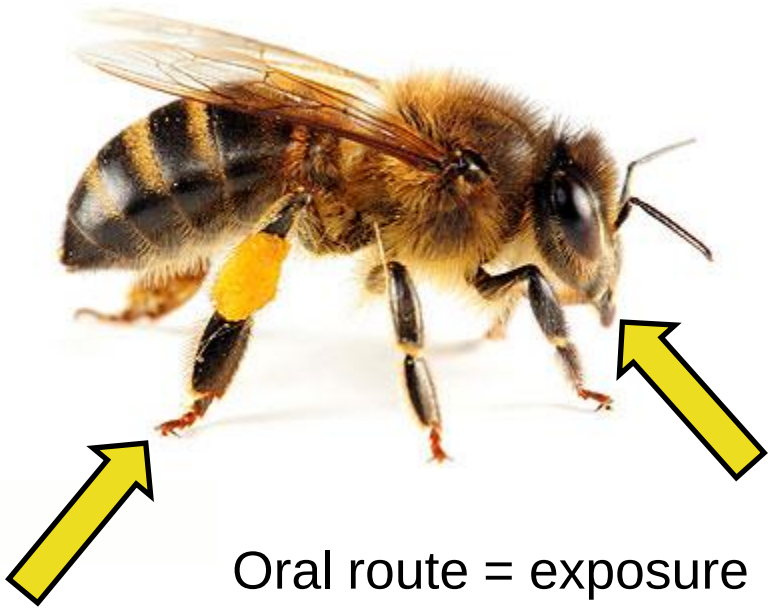
Exposure of parasites and predators can be minimized

Unintended effect of systemic insecticides

Any insect feeding on plant tissues can be exposed.

This includes bees, butterflies, and other pollinators feeding on nectar or pollen

Are they really at risk?



"Dermal route" = contact toxicity from foliar applications

Usually short residual with neonics
Short period of high risk

Reason why application during bloom is prohibited

Oral route = exposure from systemic presence

Can be from foliar spray, but longer-term potential exposure from root uptake from soil

Photo: Wonderville Media

Slide photos shared by David Smitley

June 20, 2013 Wilsonville, Oregon

- 25,000 dead bumble bees and honey bees found in the parking lot of the Wilsonville Target Store

- Linden trees in full bloom had been illegally sprayed with Safari (dinotefuran)

What do neonicotinoids do to bees?

Interfere with foraging behavior

Maladaptive behaviors occur at concentrations far lower than required to kill insect outright

Colony collapse disorder of honey bees: 2006

Most bees (not the queen) leave from the hive

Dead bees are not found at hive apron

photo: 21stcentech.com

Why imidacloprid does not fit CCD pattern

CCD started to occur before imidacloprid was in widespread use!

Isle of Wight Disease, dating to ~1906
Autumn Collapse, 1961 – 62
Disappearing Disease, 1979
Colony Collapse Disorder, 2006 – 2008 (?)

Source: P. L. Borst, 2015. American Bee Journal

Why imidacloprid does not fit CCD pattern

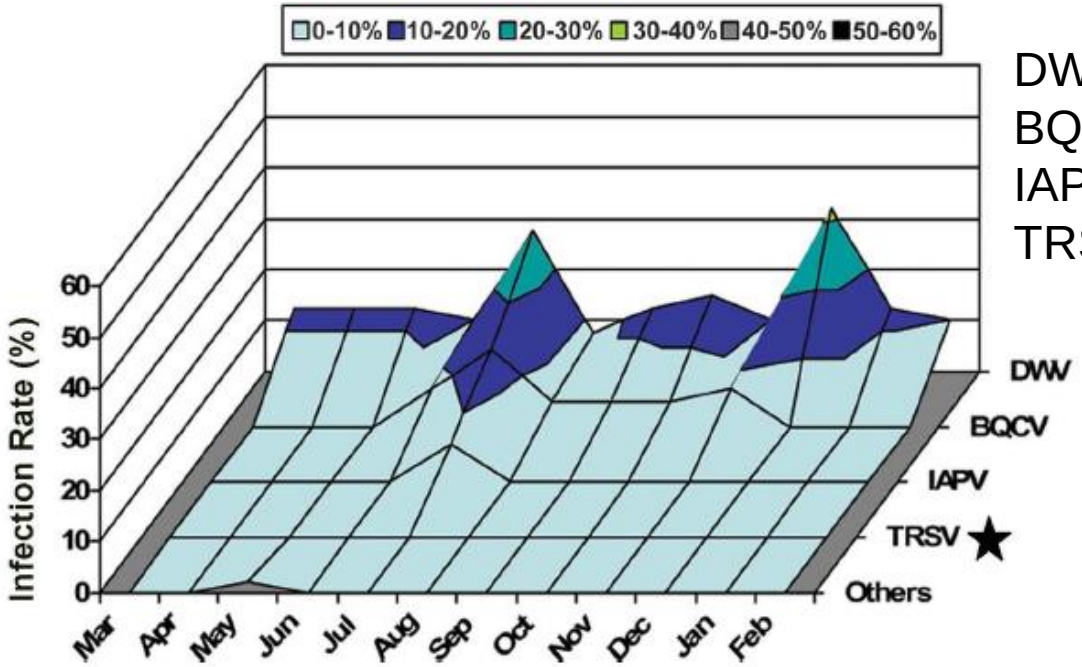
CCD-causing agent can be removed from hive equipment with irradiation

Therefore, a pathogen is probably involved

Why imidacloprid does not fit CCD pattern

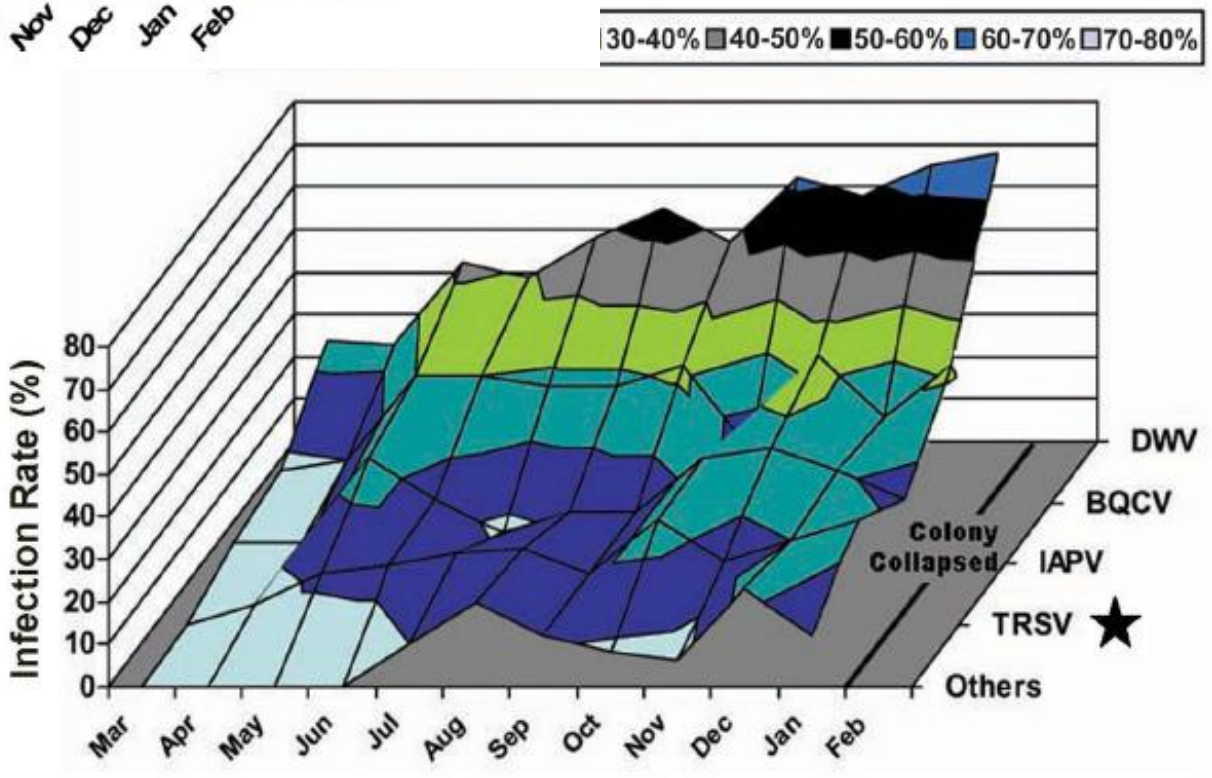
Countries banning neonicotinoids have seen no decrease in colony losses.

Australia, which uses neonicotinoids, does not have varroa mite and also does not experience the colony loss syndrome.



DWV, deformed wing virus
BQCV, black queen cell virus
IAPV, Israeli acute paralysis virus
TRSV, tobacco ringspot virus

Li, et al. 2014. mBio 5(1): e00898-13



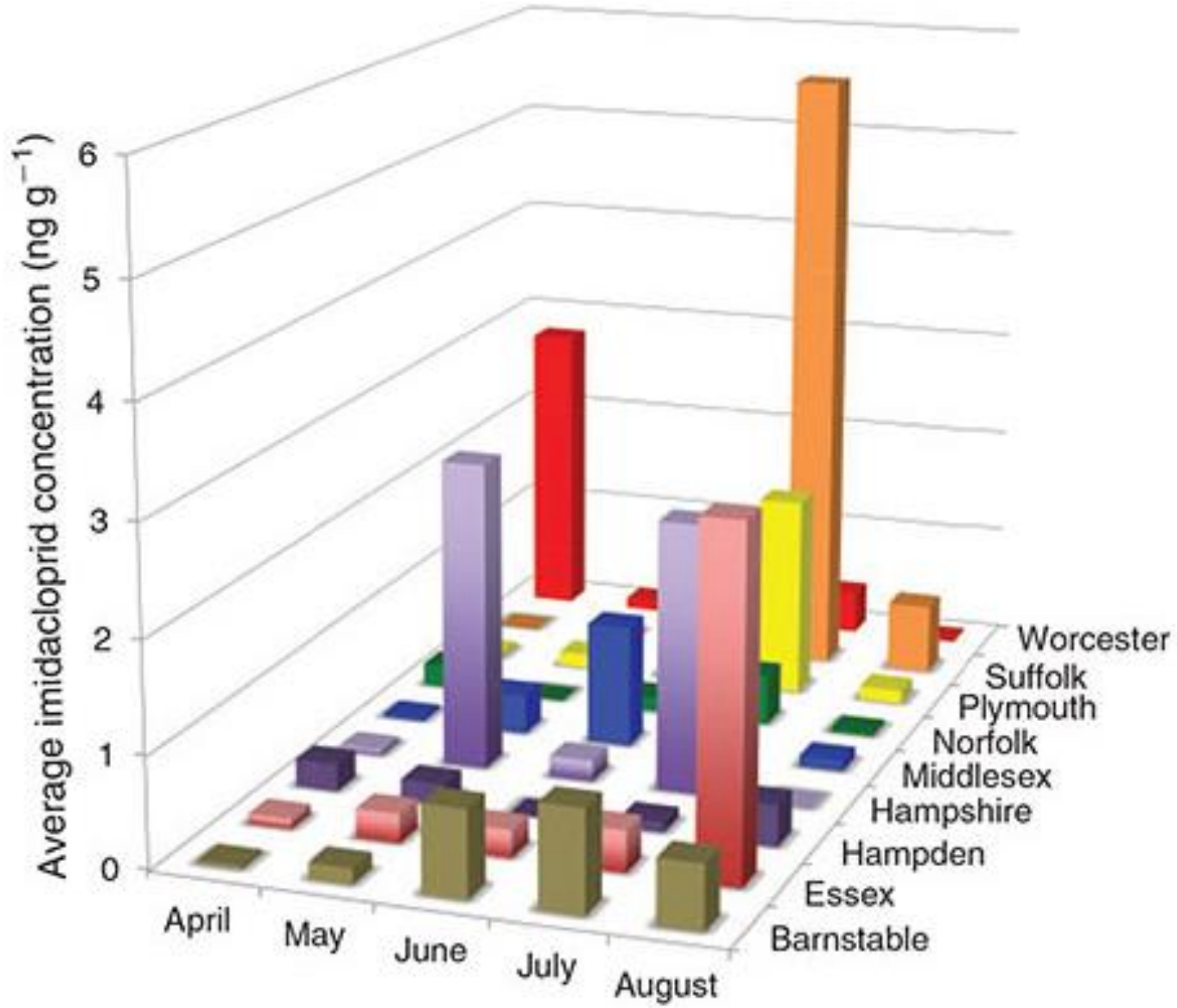
The causes of colony losses shouldn't really be considered controversial any longer.

Bees leave the colony when they are sick and about to die. "Altruistic suicide" protects the colony.

Varroa mites plus a complex of viruses caused CCD. Other stressors are poor nutrition, genetics, and excessive exposure to pesticides used in the hive, or applied during bloom of crops.

Evidence related to CCD*	neonics	diseases
Geographical correlation	-	+
Temporal correlation	-	+
Dosage response	+/-	+
Other experimental evidence	-	+

* and overwintering mortality

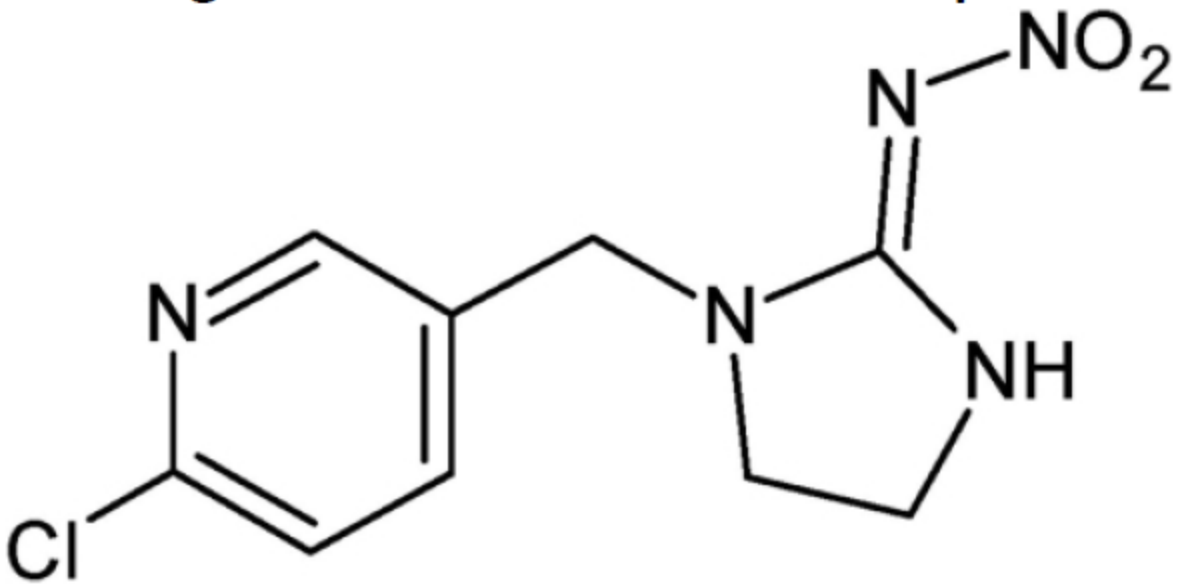


Lu, et al., 2015. *Environmental Chemistry* - http://dx.doi.org/10.1071/EN15064

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY AND
POLLUTION PREVENTION

Preliminary Pollinator Assessment to Support the Registration Review of Imidacloprid



January 4th, 2016

305 page document, specific to of risks to honey bees from use of imidacloprid in agriculture

Field-level exposure with current practices are about one-tenth the concentration threshold for detecting any adverse effects on honey bees.

Hazardous use (to bees) of these products in vegetable and fruit production would be expected to be obvious due to drunk bees, poor pollination, and crop failure.

What is the exposure level specifically from ornamental plants?

Data from red maples

Josephine Johnson, Ph.D. dissertation

Leaves	10,000 ppb
Flowers	200
Pollen	5
Nectar	not detected

Systemic insecticides travel with xylem sap

Leaves continuously accumulate solutes, flowers less so

Study by Mach, et al., 2017 (Dan Potter's lab, UK)

Imidacloprid residues (ppb)

	leaves	nectar
Ilex	21,000	280
Clethra	25,000	500

Dose
1 g a.i. per ft.

Dinotefuran residues (ppb)

	leaves	nectar
Ilex	13,000	1,200
Clethra	8,500	450

Imidacloprid

Labeled dosage for shrubs = 0.75 – 1.5 g per foot of shrub height.

Approximately 10% of this amount may be effective for aphids and lace bugs.

Dosages on flowering shrubs and herbs need to be fine-tuned to protect pollinators

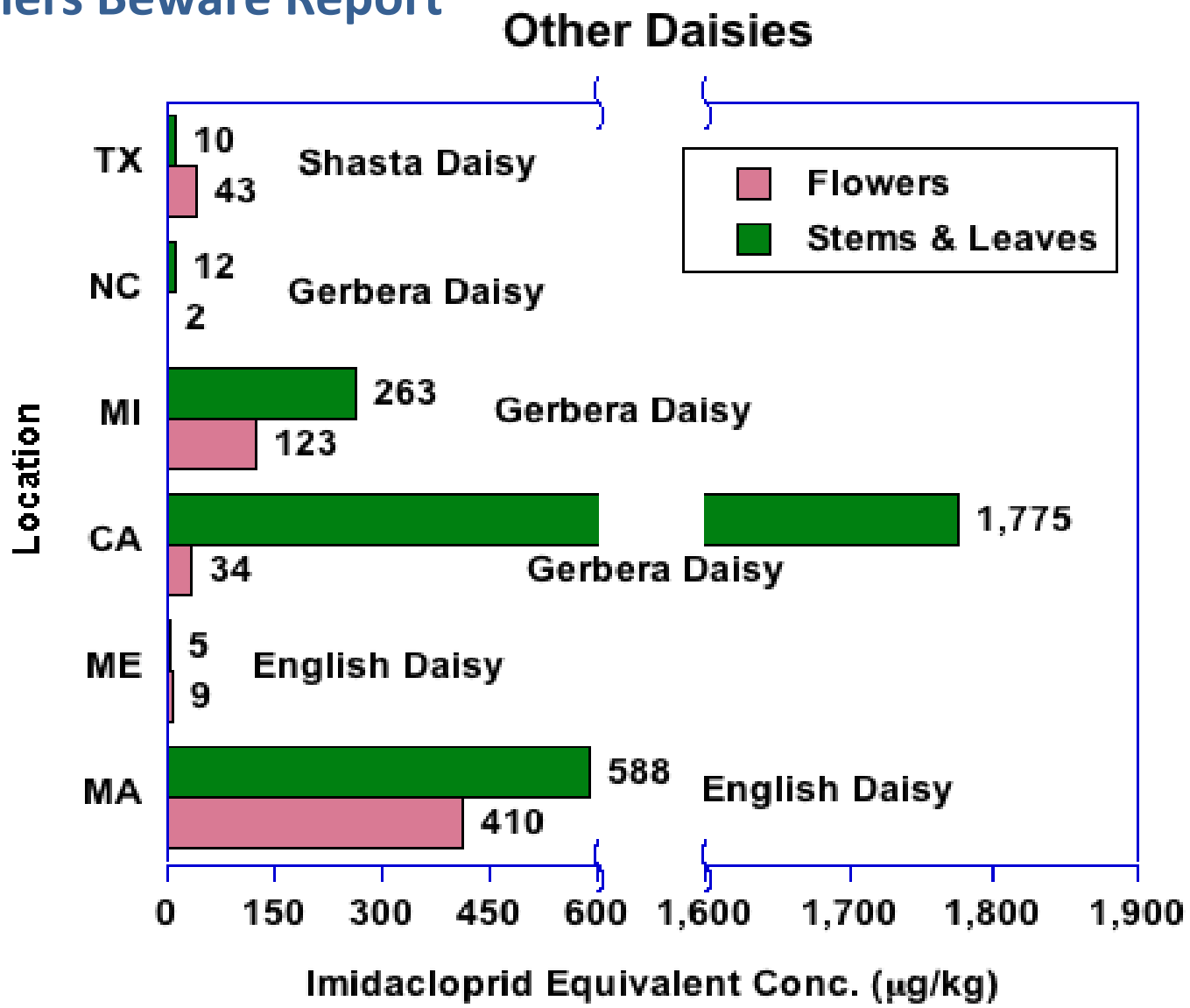
June 2014

Gardeners Beware 2014: Bee-Toxic Pesticides Found in "Bee-Friendly" Plants Sold at Garden Centers Across the U.S. and Canada

Report Summary

- Plants purchased from retail nurseries in 18 cities across the U.S., Canada.
- Laboratory measured the presence and concentration of pesticides.
- Testing showed that **51 percent of store-bought plants** had levels of a group of harmful pesticides known as neonicotinoids that were high **enough to kill honey bees, bumble bees, and other pollinators "outright."**

Gardeners Beware Report



Applications in ornamental hort pose risk due to relatively high application rates

Trees 2.88 g a.i. per inch dbh (EAB)
two 32 inch dbh trees = one acre

3-ft tall shrubs, 1.44 g a.i. per foot
42 shrubs = one acre

Nursery pots, greenhouse rate, 0.05 ml/pot
about 12x agronomic use rate

NRDC

A FORCE FOR NATURE

BEES CAN'T BAYER IT! AND NEITHER SHOULD WE.

America's bees are dying at some of the highest rates ever recorded, struggling to survive a deluge of next-generation pesticides unleashed by multinational chemical giants.

We can't afford to lose bees – not when one out of every three bites of food we take depends on them! Swift action is needed. That's why the Natural Resources Defense Council (NRDC) is taking on Bayer, the German aspirin maker and the world's #1 manufacturer of bee-killing pesticides.

Please join us by signing the enclosed Petition to Bayer's CEO and demand that he pull his company's bee-toxic pesticides from the American market now.

Dear Friend,

I'm sure you've seen the headlines: a shocking 44 percent of the nation's honeybee colonies collapsed over the past year!

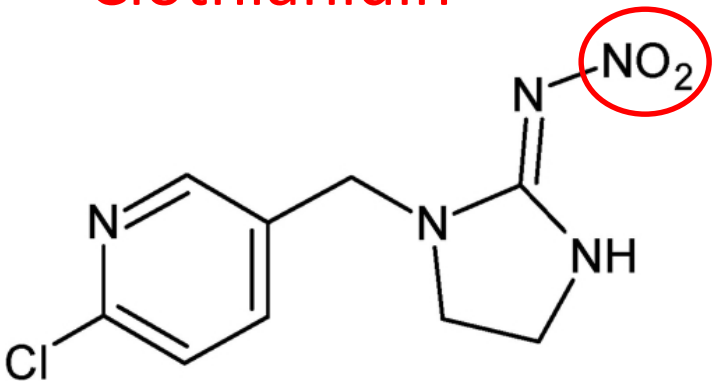
March 2014

Buyers from Home Depot and Lowes contact nursery and greenhouse growers

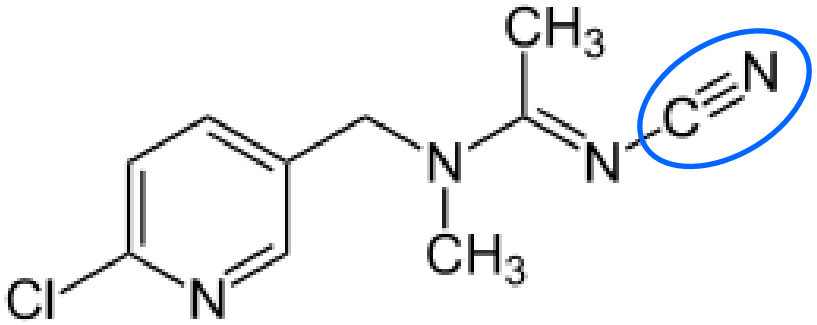
Lowes and Home Depot will be neonic free in 2019

Relative toxicity to bees

Product	Oral LD50 (ng/bee)
Acetamiprid	7,100
Imidacloprid	3.7
Dinotefuran	7.6
Clothianidin	3.5

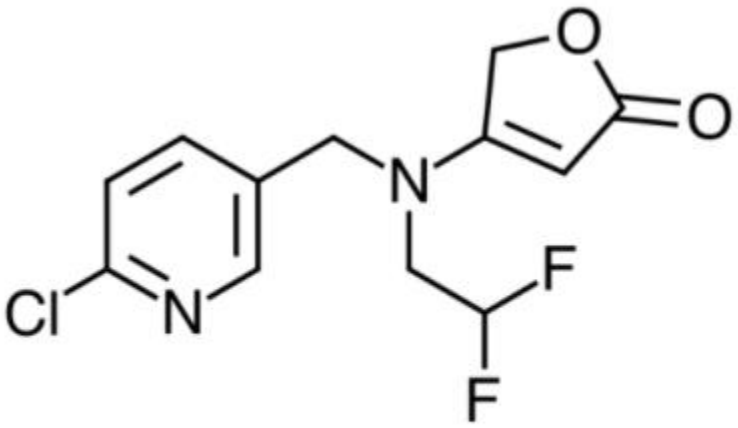


Nitroguanidine, highly toxic

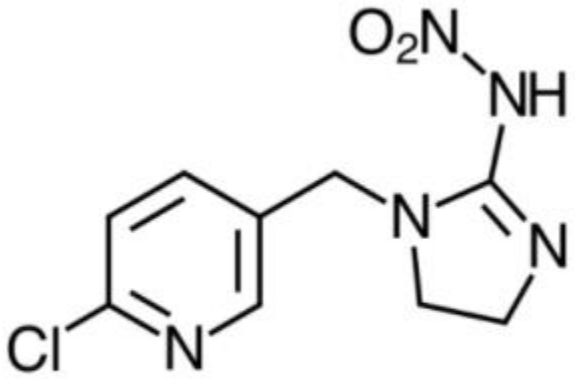


Cyano-substituted, not so toxic

Flupyradifurone (Altus, from Bayer)



Flupyradifurone



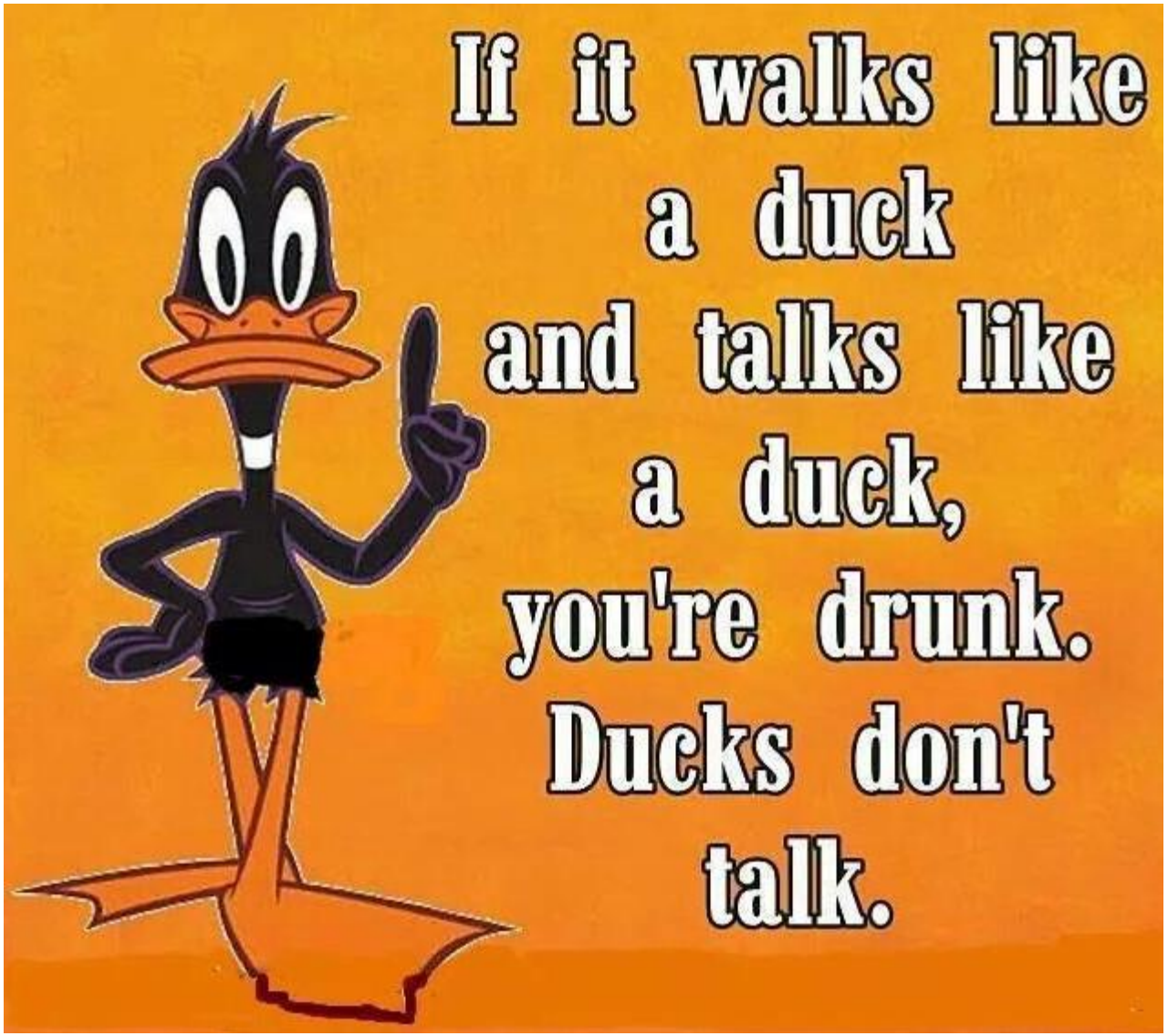
Imidacloprid

Chemical	Oral LD50 (ug/bee)	Water Solubility (mg/L)	Average Aerobic Soil Half-life (days)
Imidacloprid	0.004	514	997
Clothianidin	0.004	259	214
Thiamethoxam	0.005	4,100	229
Dinotefuran	0.02	39,800	51
Flupyradifurone	1.2	3,200	144
Acetamiprid	14.5	3,600	10

LD50 = dose lethal to 50% of test bees; ug/bee = micrograms per bee

Insecticide	acute oral LD50 (µg/bee)
Flupyradifurone	1.2 *
Flupyradifurone + DMI fungicide	0.2

* Any value < 2 ug/bee is classified as highly toxic to bees



Bayer pulled a sneaky trick in classifying flupyradifurone as NOT being a neonicotinoid.

Don’t count on consumers accepting this classification.

There are a few specific uses of these products that may lead to hazardous exposure to honey bees.

Bumble bees and solitary bees may be more sensitive than honey bees, though.

What about bumble bees?

Table 1. Landscape variables predicting *N. bombi* presence in four declining US *Bombus* species (*B. affinis*, *B. occidentalis*, *B. pensylvanicus* and *B. terricola*) as selected by LASSO and stability selection analyses.

variable	LASSO coefficient[a]	stability selection π_{thr}[b]	*p*-value[c]	ΔAIC[d]
log developed area	−0.315	**1.00**	0.002	8.5
latitude	0.033	**1.00**	0.091	0.9
log chlorothalonil	1.825	**0.94**	<0.001	107.0
longitude	−0.013	0.60		

clothianidin influence insignificant

fungicides, specifically chlorothalonil, highly associated with *Nosema bombi* infection

McArt, et al., Proc. Royal Soc. B, Jan 2, 2018

Efforts by CAES to understand risk to bees from nursery use of neonicotinoids

R. Cowles and Brian Eitzer
Hort Research Institute

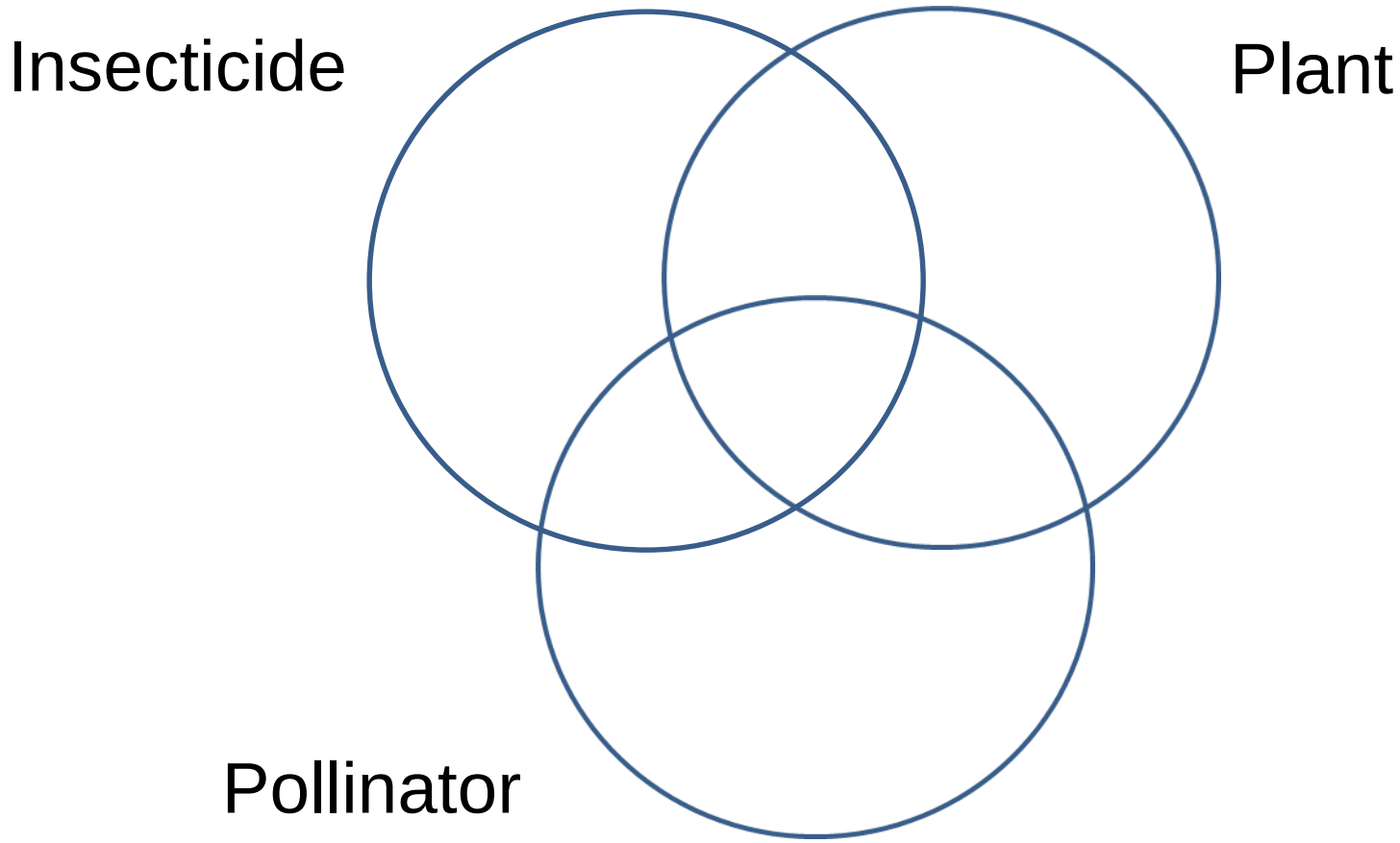
Kim Stoner, Brian Eitzer, and R. Cowles
CT DEEP-funded study

Goals

Determine whether current practices may pose risk to bees

Identify approaches that will limit this risk

Systemics principles and pollinator risk



Use of model plants to study contamination of nectar and pollen

- easier to obtain gram quantities
- inappropriate to treat with bee-toxic systemics in the real world

From Krischik, UMinn: Nursery plants treated with Marathon soil app.

2011 Imidacloprid residue plants

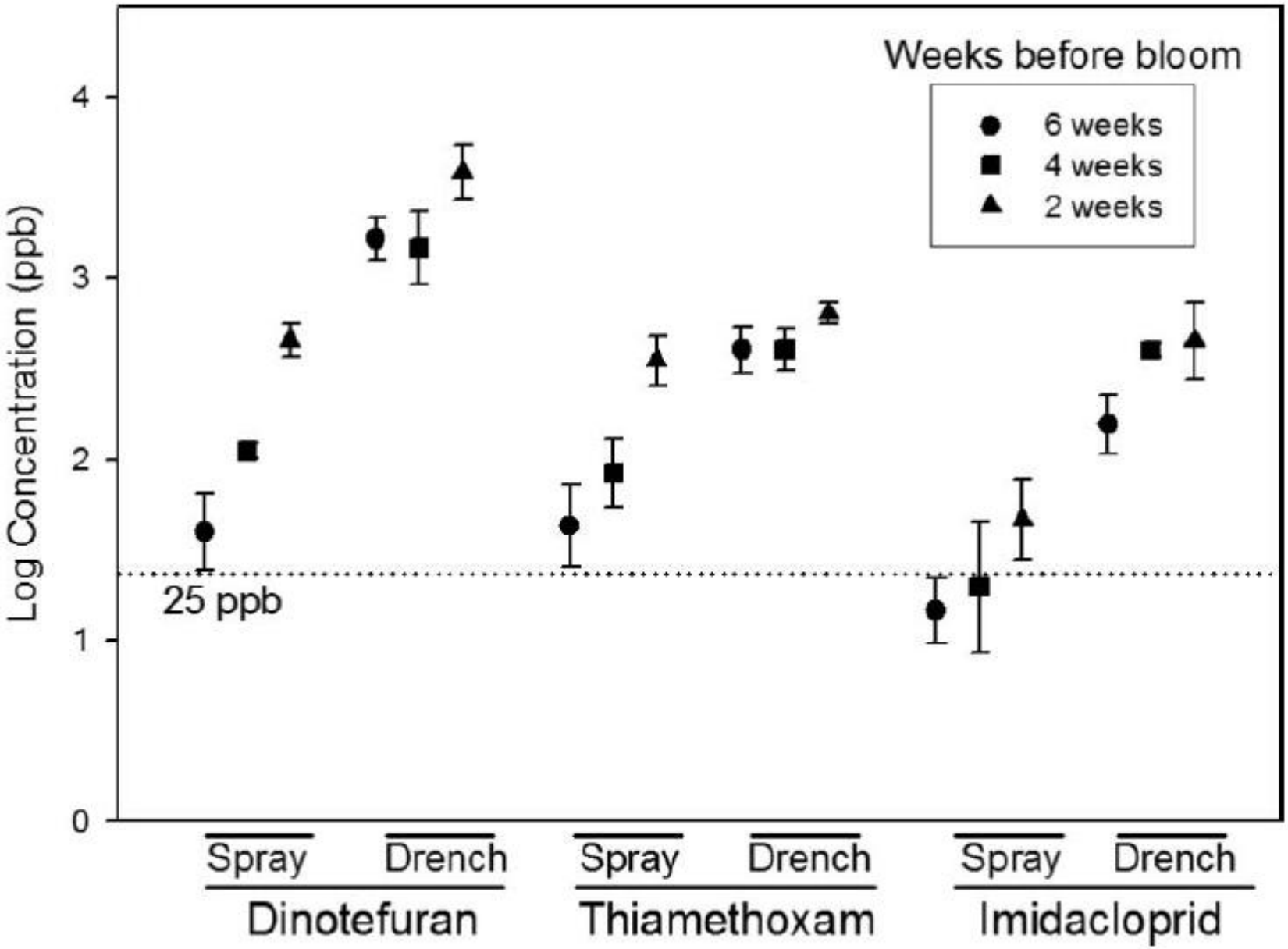



Dose in mg/soil	Dead bees on Agasatche	*Agastache* spp. nectar ppb	*Asclepias* spp. nectar ppb	*Esperanza* spp. nectar ppb	*Rosa* spp. pollen ppb
0	0.6b	6b	3c	0c	26b
25	0.6b	52b	80c	8c	36b
50	0.5b	133b	175bc	21c	30b
300 1X 3 gal pot	1.1ab	1973b	1568bc	106c	95b
600 2X 3 gal pot	2.4a	5265ab	2950b	276b	332b
1200	2.4a	9335a	8337a	9162a	720a
	F=3.2, 0.01	F=3.7, 0.017	F=25.8, 0.0001	F=166, 0.0001	F=5.7, 0.0025

Please don’t apply systemic insecticides to milkweed!

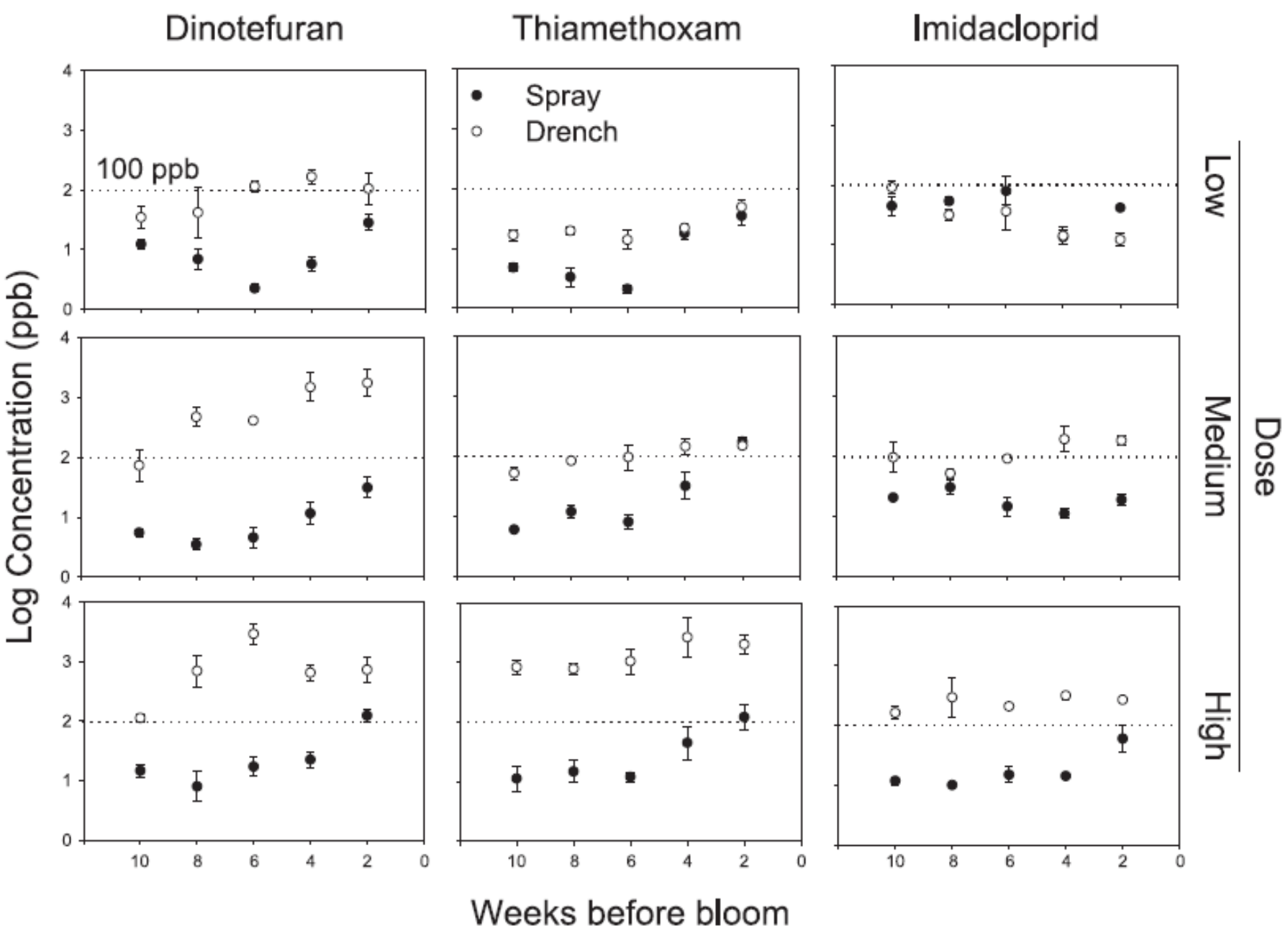

TD33


SORVALL
RC2-B



Paper available as pdf from my web page


Cat. No. 09-016
Fisher Scientific



Paper available as pdf from my web page

Nectar concentrations

3 gal, 1.6 ppb

5 gal, 0.4 ppb

without bagging, 12 ppb

Pollen average 14 ppb

Date	Hive	Thimethoxam (ppb)	Clothianidin (ppb)
8/3/2015	A	2.5	2
	C	43	78
8/10/2015	A	1	1.2
	B	1.4	2
8/17/2015	B	81	20
	C	305	31
8/24/2015	A	41	4.5
	C	7.8	16

Table 3. Relationship of neonicotinoid concentration and estimated honey bee toxicity to percentage of *Spiraea* pollen in trapped pollen samples sorted by color from Nursery C, Hive C, Aug. 17, 2015 (pollen sample with the highest neonicotinoid concentration and honey bee toxicity).

Color category	% *Spiraea* pollen	Concentration of thiamethoxam (ppb)	Concentration of clothianidin (ppb)	Estimated % of honey bee LD_{50} (includes other pesticides)
Bulk sample	**29%**	**305**	**31**	**70.5%**
Sorted colors:				
Mahogany rose	99%	680	143	180%
Warm sand	70	703	202	202
Almond buff	21	472	79	118
Mustard gold	2.4	15	0	3.6
Sunflower	1.2	14	0	2.8
Straw	0.7	8	0	1.6
Grape Leaf	0.6	6.8	0	1.4
Freesia	0.3	0	0	0
Butterscotch	0.1	8.3	0	1.7
Yolk yellow	0	6.1	0	1.2
Cathay spice	0	0	0	0

Like linden, other plants may be very efficient at transporting systemic insecticides to nectar or pollen.

“Risky” plants by family:

Rosaceae, Malvaceae, Aquifoliaceae, Lamiaceae, Fabaceae, Boraginaceae, Crassulaceae

Pest groups

Matching the most appropriate pesticide to the pest

Aphids

Alternatives to nitroguanidine neonics

Insecticidal soap
Aria
Applaud
TriStar, Altus
Mainspring
Oil

Biocontrol: *Beauveria*, wasps

For All Ornamental Plants:

What are the biggest potential problems for bees if neonicotinoids are used?

- Spraying open flowers (with almost any insecticide).
- Soil drenches with imidacloprid, clothianidin, or dinotefuran

Summary

Poor pollinator health has other major causes

Dust liberated from treated seed, landscape use, and some treated ornamental horticulture crops present risk from neonicotinoids.

Plants highly attractive to pollinators should not be treated with nitroguanidine neonicotinoids

Low bee-toxicity alternatives exist

Selling plants that provide floral resources is a good opportunity to improve pollinator health.

?


Michael Durham (Oregon Zoo)