April 29 2017, Sat, 9:10-9:35am, Healthy Hives, Healthy Live, Healthy Lands, Effects on neonicotinoids on beneficial insects, and of course bees

Vera Krischik, Associate Professor, Depart of Entomology, UMinnesota and others

20 years of neonicotinoid issues

- 2018 France complete ban being discussed
- 2016 “How neonicotinoids can kill bees”, Xerces Society for Invertebrate Conservation, Dec 14
- 2016 EPA states 25 ppb is NOEL for bees (research)
- 2016 Health Canada use of imidacloprid not sustainable due to effects on insects and aquatic organism; considering a ban
- 2016 Ontario reduce seed treatment use by 2018
- 2016 EFSA may request ban of some neonicotinoids
- 2016 EU moratorium being reviewed
- 2013 EFSA confirmed imidacloprid, thiamethoxam, and clothianidin were toxic to bees.
- 1996 French beekeepers protest use of imidacloprid seed dressing and effects on honeybees

Mark Dayton, Governor Minnesota, August 28, 2016

1. Established an Interagency Pollinator Protection Team to develop cross agency policies and programs.

2. The Governor's Committee on Pollinator Protection was created to advise the Governor, the Environmental Quality Board, the Interagency Pollinator Protection team.

3. DNR, MNDOT, BSWR, and MPCA shall develop an integrated pest management strategy to minimize pesticide use on public lands.

4. The Commissioner of Administration will not use neonicotinoid applied plants and neonicotinoid pesticides on the State Capitol Complex and other state sites.

Soil-applied imidacloprid alters survival + behavior

1.*Coleomegilla maculata* (Coleoptera: Coccinellidae) (Smith + Krischik 2001)
2. *Anagyrus pseudococci* (Hymenopter: Encyrtidae) (Landmark et al 2007)
3. *Chrysoperal carnea* (Neuroptera: Chrysopidae) (Rogers et al 2007)
4. *Bombus impatiens* (Hymenoptera: Apidae) (Scholer + Krischik 2013 GH, Krischik et al. 2017 field)
5. Ladybeetles + monarch +painted lady (Krischik et al. 2015)

Talk summary: Neonicotinoid residues

1. **Seed treatments result in the low residue of neonicotinyl insecticide in nectar and pollen (less than 7.6 ppb).**

2. **Few studies demonstrate that seed treatments reduce honeybee colony health.**

3. **Bumblebees are more affected by neonicotinoid insecticides due to queen foraging, no bee bread for queen and larvae, and small colony size.**

Talk summary: Neonicotinoid residues

4. Many papers demonstrate that neonicotinyl insecticides affect foraging, learning, and orientation at sublethal dose starting 6 ppb below the lethal dose of 40-185 ppb.

5. Bees have 40% more n-nicotinic ACH receptors compared to other insects that are used in orientation, navigation, and learning.

6. Only 1% of insects are pests, but insecticides kill all insects, pollinators, beneficial insects, and pest insects

Summary from research

1. Residue in linden flowers from soil drench and trunk injection will kill/alter behavior of bees. Residue in flowers growing underneath trees treated with a soil drench will kill bees.

2. Residue in flowers from small and large GH pots will kill bees at 5 and 10 wks.

3. In a field study with bumblebees 20 ppb imidacloprid in sugar syrup, the EPA NOEL, resulted in decreased movement, sugar consumption, brood, and queen production.

Summary on what YOU can do to save bees and beneficial insects by planting flowers and trees

1. Use IPM. Do not use systemic insecticides. Instead use contact insecticides.
2. Plant a seasonal phenology of native and garden plants for nectar and pollen.
3. Only single-flowered plants, not double flowers, provide pollen and nectar.
4. Provide overwintering habitat for bees.
5. Do not kill queen bees in the spring/fall, they will not sting.
6. Understand the different types of bees and wasps so you can conserve them.

Rising Toxicity of pesticides 1945-2003

Pesticide	Brand Name	Use	LD50 (ng/bee)	Toxicity DDT = 1
DDT	Dinocide	Insecticide	27,000.0	1
Amitraz	Apivar	Acaricide	12,000	2
Coumafos	Perizin	Acaricide	3,000	9
Taufluvalinate	Apistan	Acaricide	2,000	14
Metiocarb	Mesurol	Insecticide	230	117
Carbofuran	Curater	Insecticide	160	169
Lambda-cyhalothrin	Karate	Insecticide	38	711
Deltamethrin	Decis	Insecticide	10	2,700
Thiametoxam	Cruiser	Insecticide	5	5,400
Fipronil	Regent	Insecticide	4.2	6,429
Clothianidin	Poncho	Insecticide	4.0	6,750
Imidacloprid	Gaucho	Insecticide	3.7	7,297

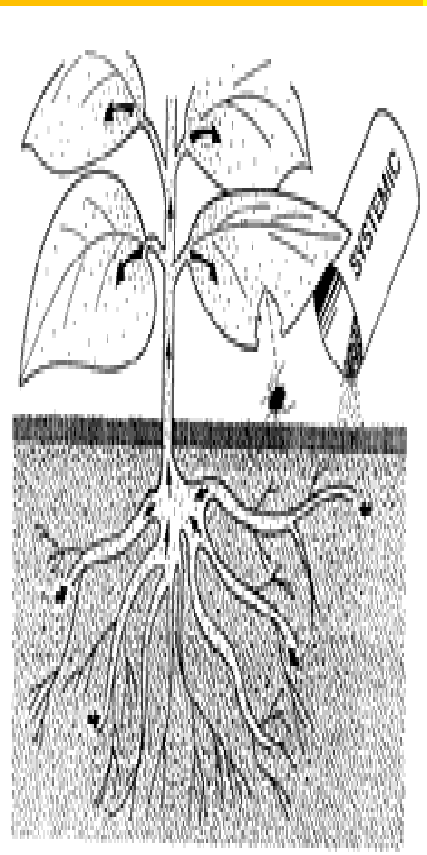
Source: Dr. J.M. Bonmatin, CNRS (France)

1945 to 2003 imidacloprid is 7,000X more toxic than DDT to bees

LD50 DDT … 27,0000ng/bee
LD50 neonicotinoid insecticides
Imidacloprid ……..4 ng/bee….40 ppb
Clothianidin ……..4 ng/bee….40 ppb
Dinotefuran ……..4 ng/bee….40 ppb
Thiamethoxam …..5 ng/bee….50 ppb

aspirin 80mg=80,000microg=80,000,000ng

Contact and systemic insecticides



Contact insecticides:

- Many, sprayed on foliage
- Eat leaf or walk on leaf to be killed
- Toxicity lasts 1-3 weeks
- Flowers that open after spraying do not contain insecticides.

Systemic insecticides:

- Treated-seed, soil drench, trunk-inject
- Eat leaf, pollen, or nectar to be killed.
- Toxicity lasts 2-12mos, unknown
- Flowers that open will have the insecticide

Imidacloprid rates vary among sites

Agricultural field

0.1 mg imid/canola seed (Gaucho)

1.2 mg imid/corn seed (Gaucho)

4 mg imid/sg ft ag field (soil, Admire Pro)

2.5 mg imid/sg ft ag field (foliar, Admire Pro)

Nursery/greenhouse

300 mg /3 gallon pot (~1 sg ft surface) (Marathon1%G)

Landscape

3.7 mg/sg ft turf (Bayer Adv Season Long Grub)

122 mg rose @ 4 times/yr (Bayer Adv Rose Fl)

10.2mg/sg ft beds @ 4 times/yr (Bayer Adv Rose Fl)

Why do plants make flowers?

- 150 million years, Angiosperms evolved, flowering plants coevolved with insects to pollinate flowers.
- Flower color, shape, nectar and pollen rewards are due to insects.

Why do plants make leaves that are aromatic?

- Plants evolved chemical defenses against insects and insects evolved mechanisms to deal with plant toxins.
- Insects used these toxins for protection from predators.
- Insects advertise their toxicity using warning colors.
- Over time, this led to coevolved species.

American ash, rose, apple, family Rosacea, rose family, pollinated by bees and fruits dispersed by birds

Catalpa, family Bigoniaceae coevolved with bumblebees

Formerly family Asclepiadaceae, are coevolved with Monarch butterflies

Native flowers advertise pollination by turning a new color. Breeding removes this trait.

In double flowers the stamens become petals, and flowers provide no pollen or nectar.

Effects on neonicotinoids on beneficial insects, and of course bees

Objective 1. How much imidacloprid is found in flowers from a soil treatment.

Objective 2. Lab study: Determine the effects of 0, 10, 20, 50, and 100 ppb imidacloprid and clothianidin on bumble bees. Field Study: 20 ppm imidacloprid

Objective 3. Determine the effects of 0, 50, 100, and 200 ppb imidacloprid on honeybees.

Objective 1. How much imidacloprid is found in flowers from a soil treatment .

***Agastache*, Anise hyssop**

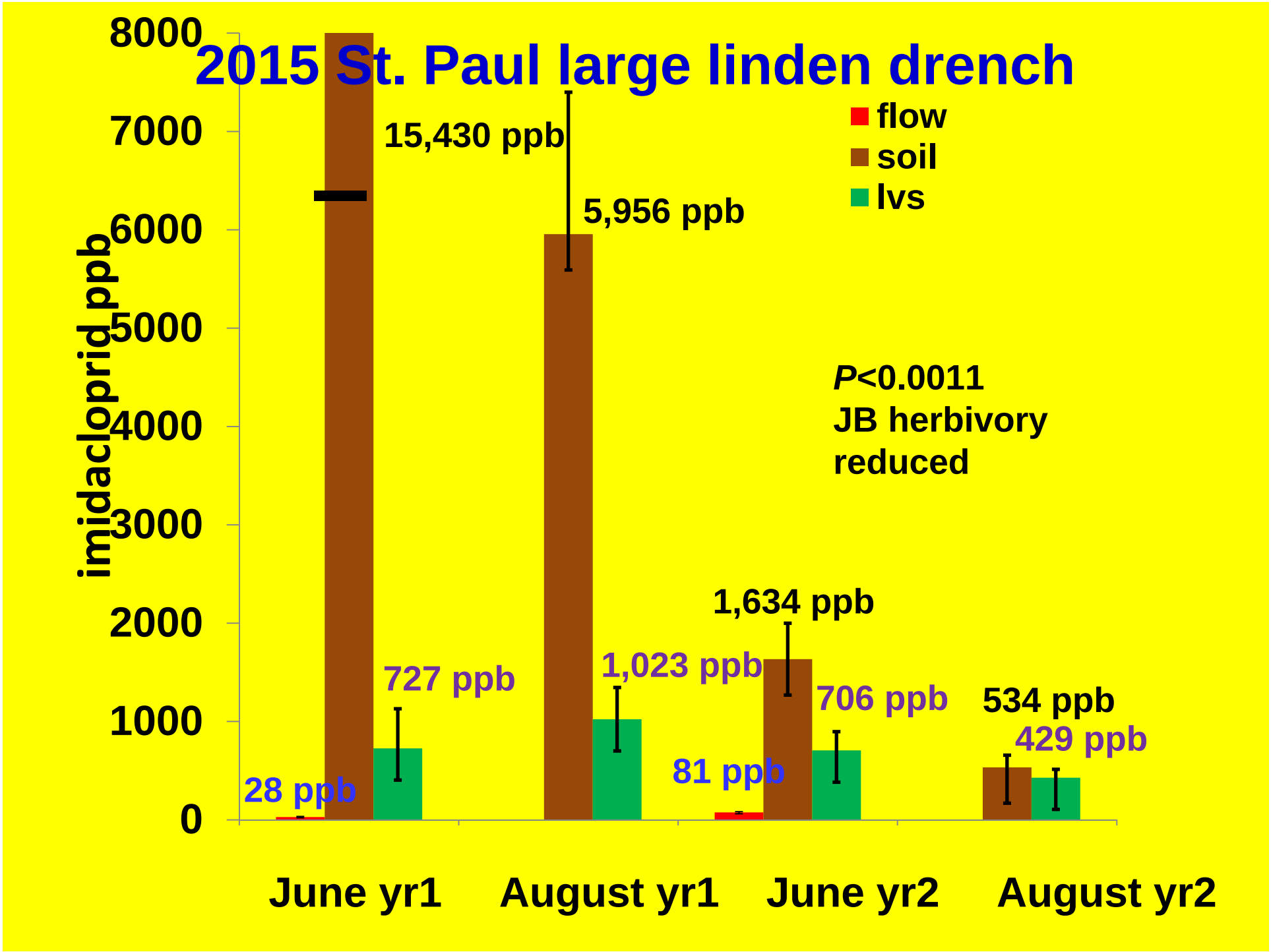
***Asclepias*, tropical milkweed**

***Rosa*, rose**

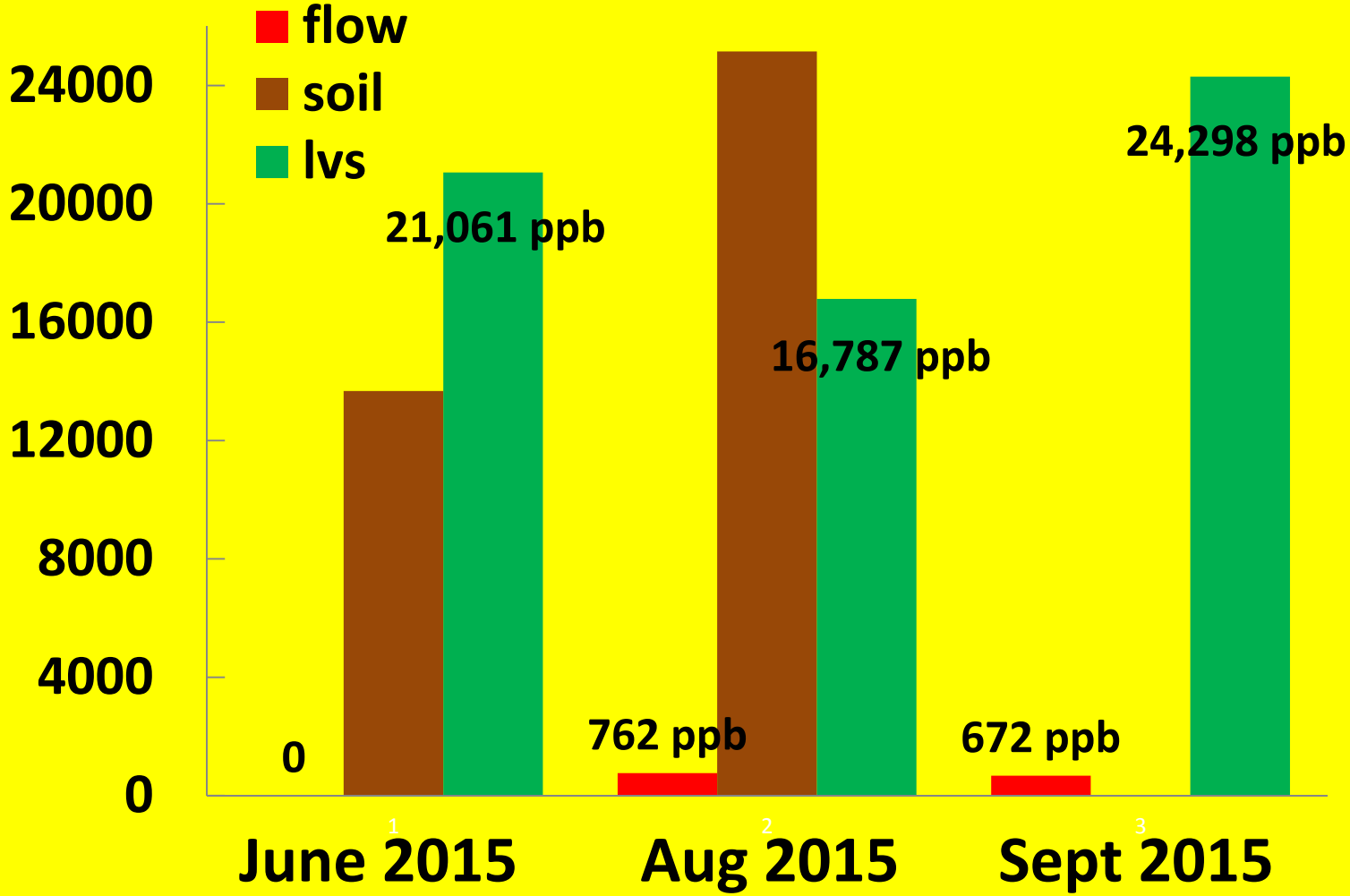
***Brassica*, canola**

***Tecoma*, Yellow bells, YB**

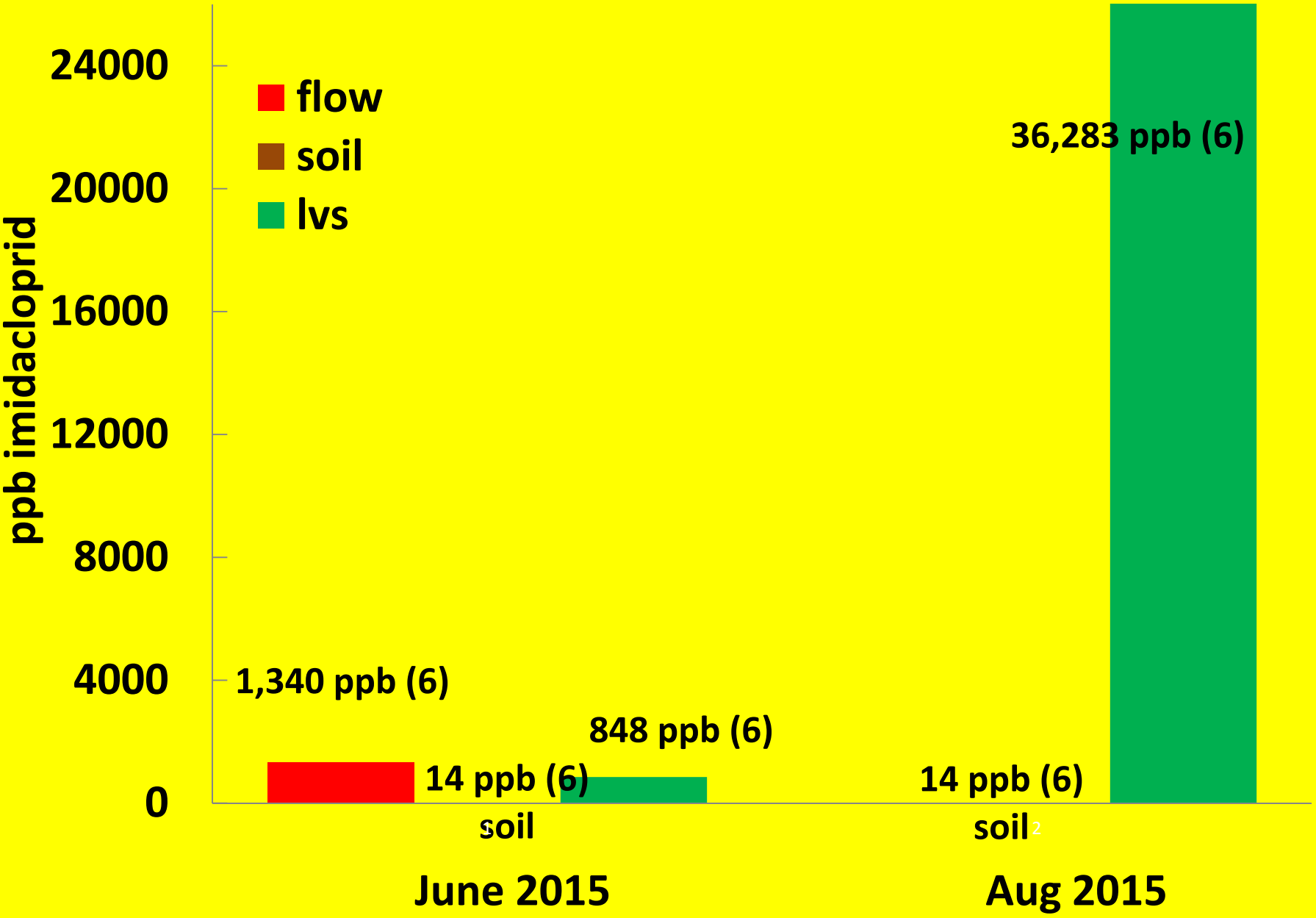
mg/soil	Dead Hbees hyssop	Hyssop wflow ppb	Milkw wflow ppb	Canola pollen ppb	YB pollen ppb	Rose pollen GH ppb	Rose pollen Field ppb
0	0.4	6	0	0	0	15	9
25	0.8	52*	79*	14	8	36	
50	1.7	133*	186*	461*	21	30	
160				2072*			
300-1X	4.0*	1973* (197)	1568* (156)		106*	95	812* Marathon
600-2X	6.5*	5265*	2774*		276*	332*	1175*1X consumer
1200-3X	7.5**	9335*	8337*		9162 *	720*	1648*2X consumer


2015 St. Paul large linden drench
flow
soil
lvs
imidacloprid ppb
8000
7000
6000
5000
4000
3000
2000
1000
0
15,430 ppb
5,956 ppb
1,634 ppb
1,023 ppb
727 ppb
706 ppb
534 ppb
429 ppb
81 ppb
28 ppb
P<0.0011
JB herbivory
reduced
June yr1
August yr1
June yr2
August yr2

2015 UM small linden drench, dogwood below



2015 UM small linden trunk injection



Summary residue

Objective 1. How much imidacloprid is found in flowers from a soil treatment.

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

Objective 2. Lab study: Determine the effects of 0, 10, 20, 50, and 100 ppb imidacloprid and clothianidin on bumble bees.

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10 ppb = pollen from seed treatments
20 ppb = NOEC Bayer, alters behavior
50 ppb = Field pumpkin study
100 ppb = Lower level in landscape plants

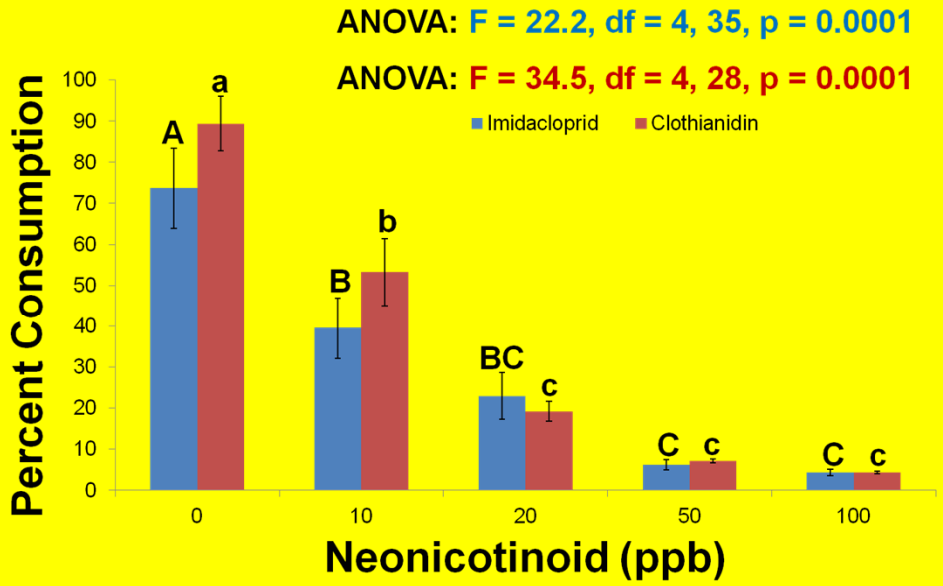
LD50 imidacloprid 4-40 ng/bee = 40-400 ppb
LD50 clothianidin 4 ng/bee = 40 ppb

Objective 2. Lab study: Determine the effects of 0, 10, 20, 50, and 100 ppb imidacloprid and clothianidin on bumble bees.

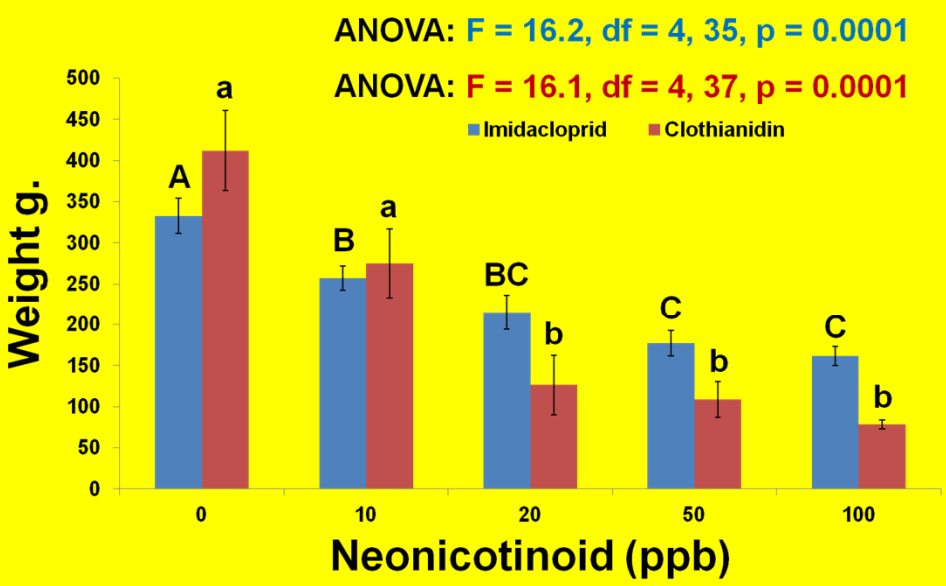
Brood box **Flight box**

Measuring colony growth

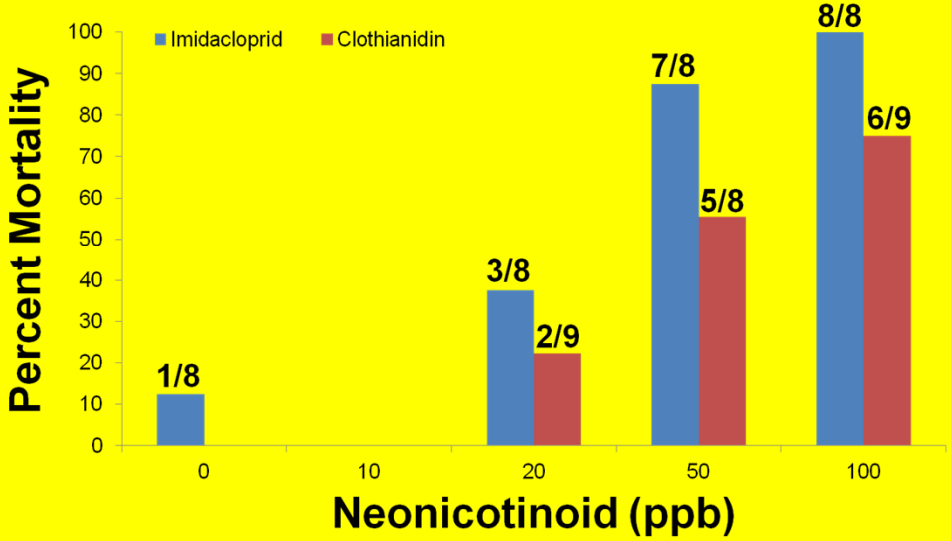
Sugar Consumption



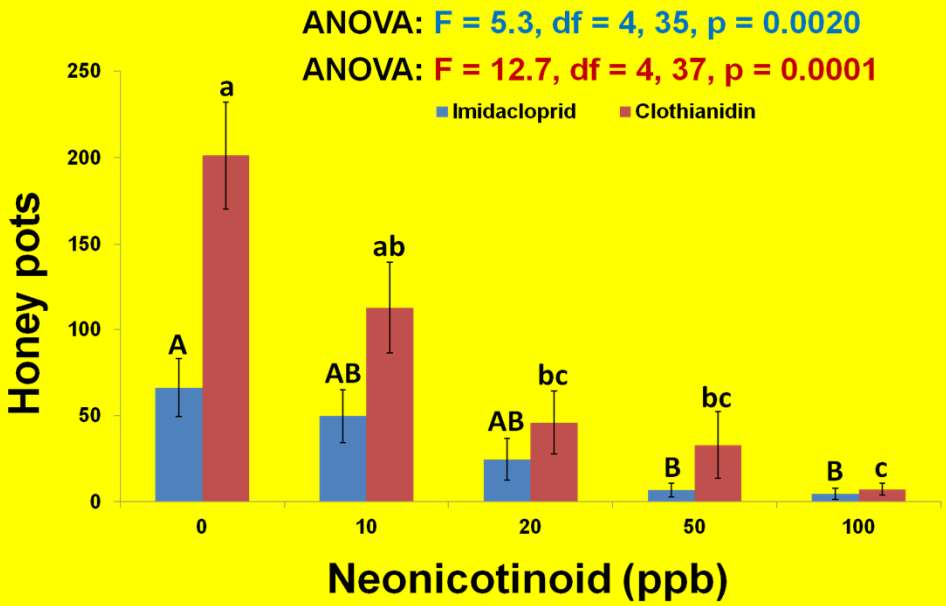
Colony weight



Queen mortality



Number of honey pots



Summary

Objective 2. Lab study: Determine the effects of 0, 10, 20, 50, and 100 ppb imidacloprid and clothianidin on bumble bees.

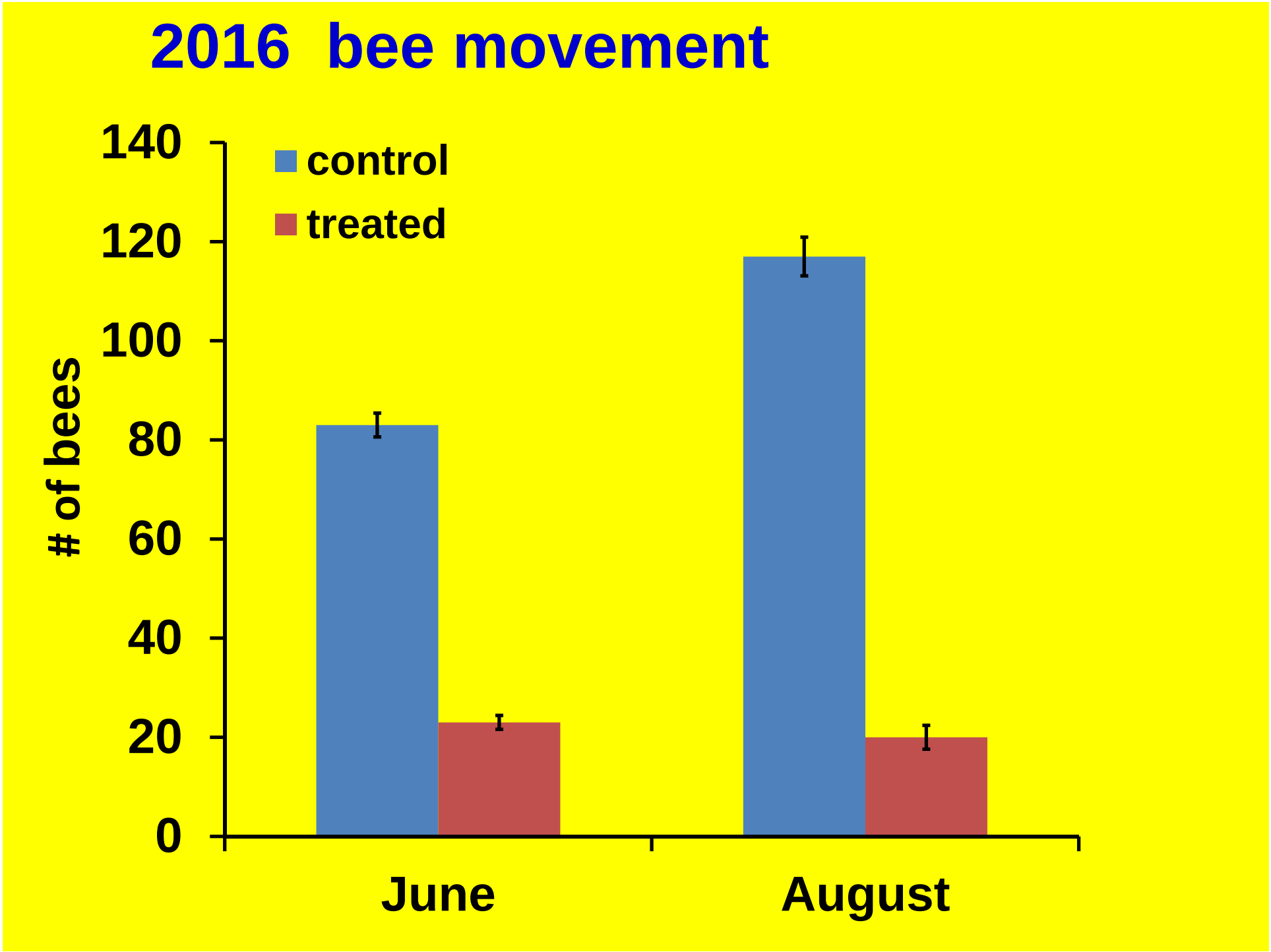
In a lab study with bumble bees, colonies starting at 20 ppb had:
higher queen mortality,
less stored nectar,
lower consumption, and
lower colony weight.

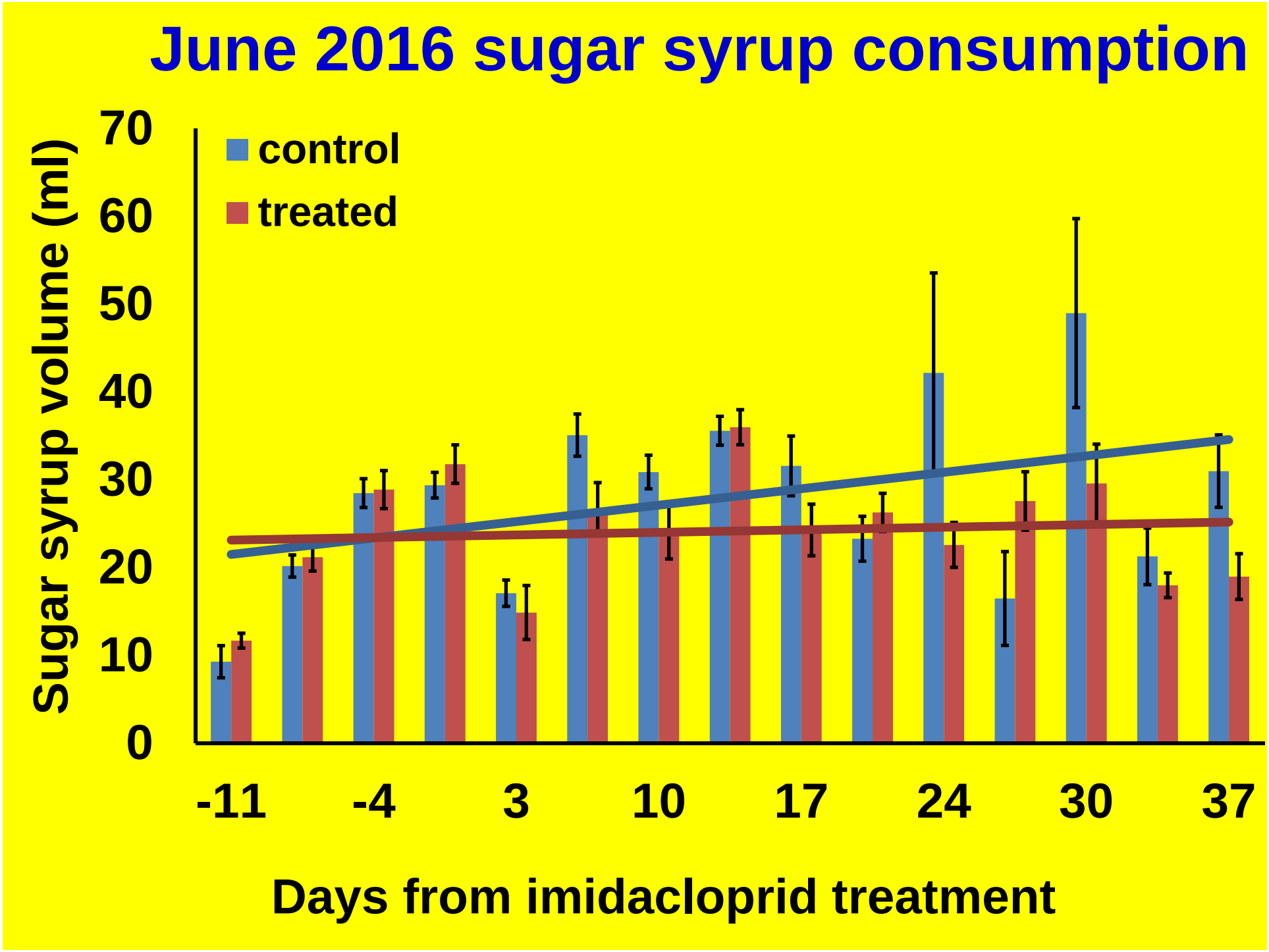
Objective 2. Field study: Determine the effects 0 and 20 ppb imidacloprid on bumble bees.

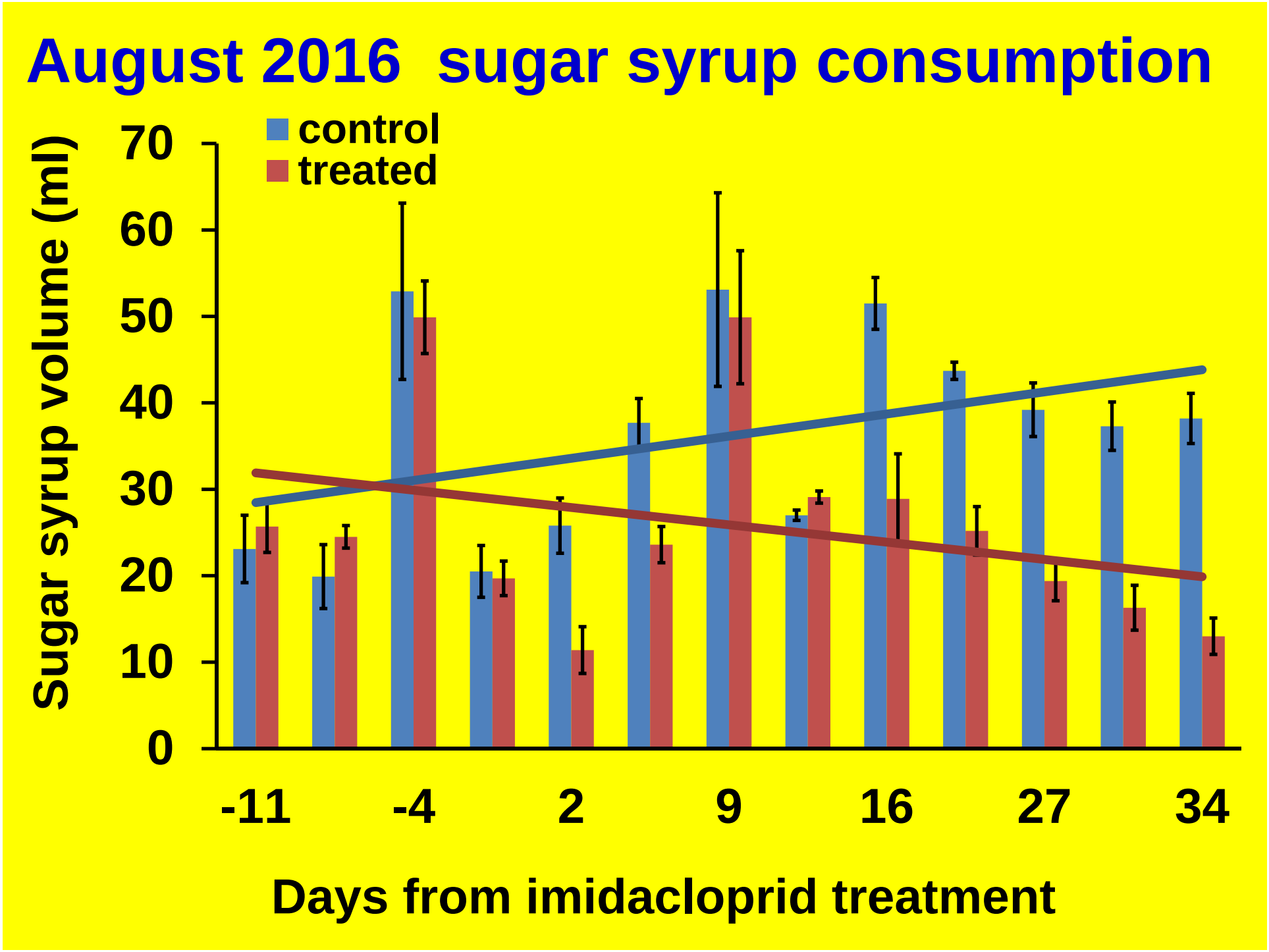
20 ppb in syrup, NOEL <25ppb EPA March 2016

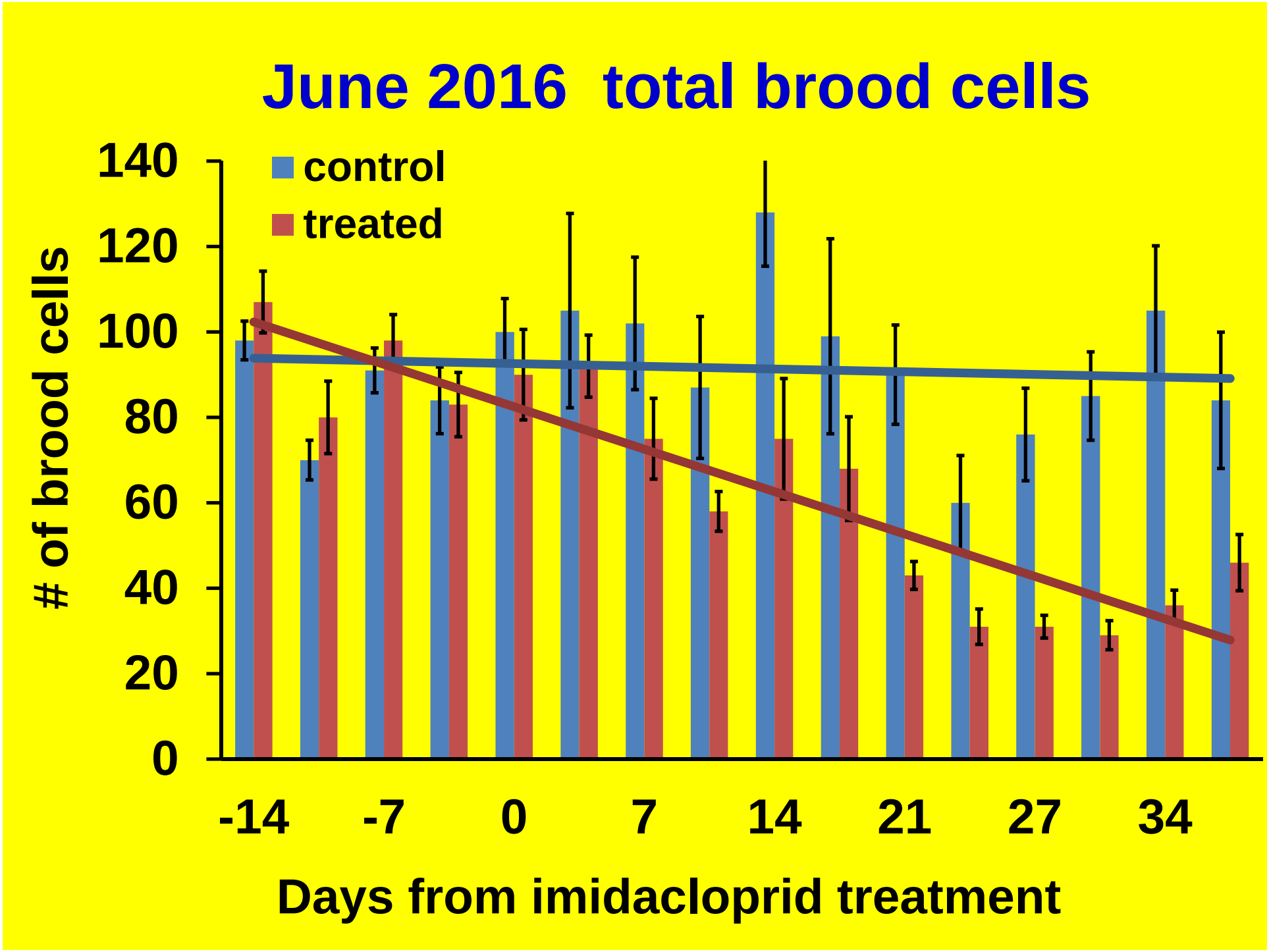
Plot 1, June and August

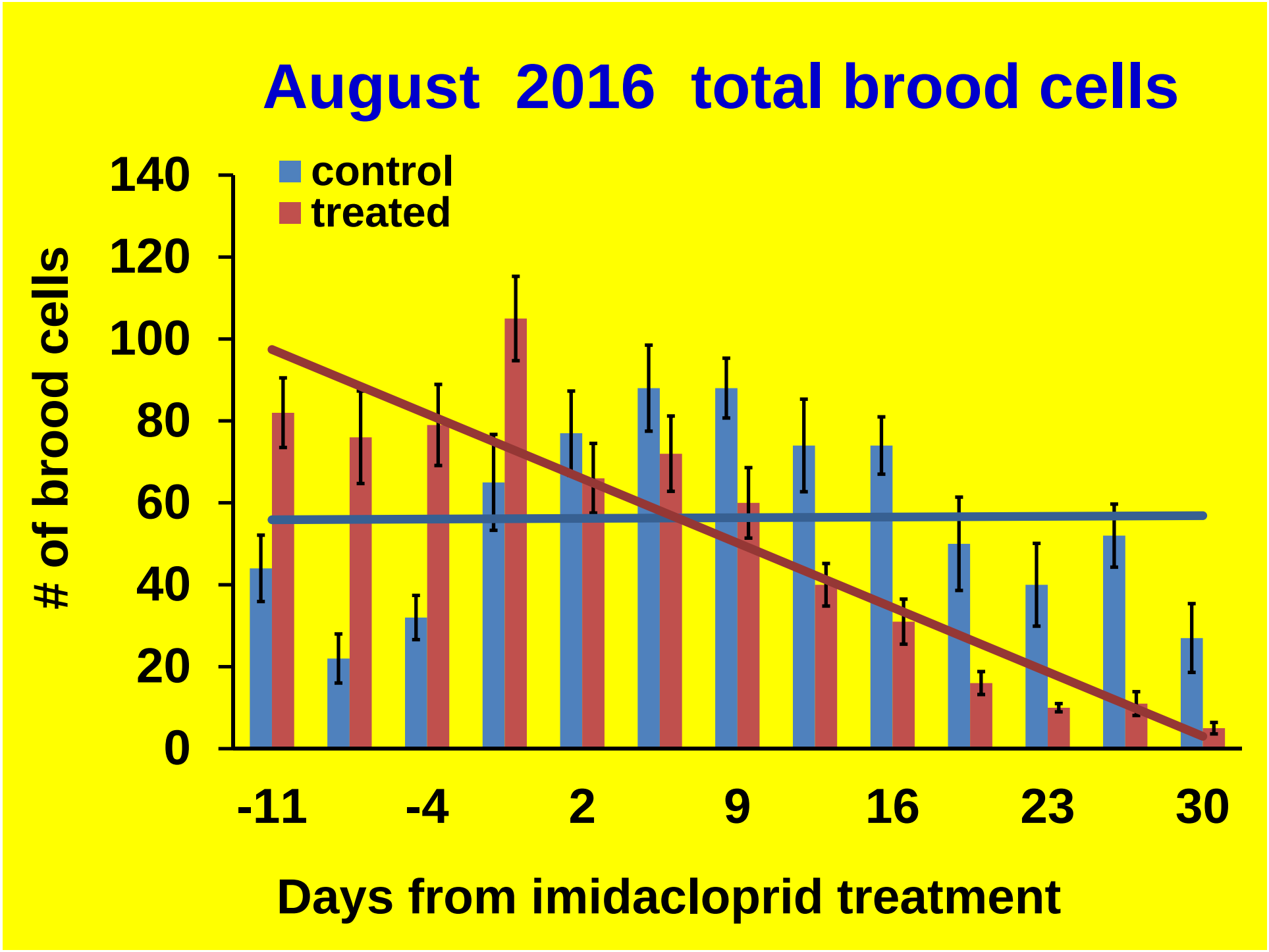
Plot 2, June and August


2016 bee movement
control
treated
# of bees
140
120
100
80
60
40
20
0
June
August


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


August 2016 sugar syrup consumption
control
treated
Sugar syrup volume (ml)
70
60
50
40
30
20
10
0
-11
-4
2
9
16
27
34
Days from imidacloprid treatment


June 2016 total brood cells
control
treated
# of brood cells
140
120
100
80
60
40
20
0
-14
-7
0
7
14
21
27
34
Days from imidacloprid treatment


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

Summary field study

In a field study with bumble bees at 20 ppb imidacloprid in sugar syrup resulted in decreased movement, sugar consumption, brood, and queen production.

The NOEL (no observable effect level) stated by the EPA in March 2016 was 25 ppb. Bumblebee colonies are negatively affected by 20 ppb imidacloprid and 25 ppb is NOT the NOEL.

Objective 3. Lab study: Determine the effects of 0,10, 20, 50, and 100 ppb imidacloprid on honeybees.

Honey Bee Frame 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).

Objective 3	
June-Sept, 5 assessments **June 8, July 6, Aug 3, 31, Sept 22**	**F df, P** **Treatment**
Adult population bees	(1.43 3, 34). 0.2362
Sealed brood area pupae	**(4.95 3, 34), 0.0028, lower Sept 200 ppb**
Open brood area 1-5th instar	(0.59 3, 34), 0.6224
Pollen area	**(11.38 3, 34), <0.0001, Sept 100, 200 ppb**
Mean missing cell area	**(3.06 3, 34), 0.0412, Sept 200 ppb**
Brood pattern	(2.35 3, 34), 0.0901
***Nosema* spp. levels**	**(4.85 3, 34), 0.0065, higher Sept 200 ppb**
***Varroa destructor* levels**	(1.49 3, 34), 0.2358
Total returning foragers	(1.79 3, 34), 0.1670
Percent return pollen foragers	**(6.42 3, 34), 0.0015, lower Aug 200 ppb**
Dead bees	(0.90 3, 34), 0.4528
Consumption 48 hours	**(2.98 3, 34), 0.0450, lower Aug, Sept 200 ppb**
Consumption 1 week	**(3.07 3, 34), 0.0407, lower June 100 ppb**
Queen replacement Date:	70% in control in July and August
Virus	**higher DWV 50, 100, 200 ppb; BQV 200ppb**

Summary field study

Objective 2. Determine the effects imidacloprid at 0, 50, 100, and 200 ppb imidacloprid on honey bees.

In a field study with honeybees, few effects were observed on 15 parameters of colony health, except in Sept decreased brood cells, consumption, stored pollen, and pollen foraging and increased virus at the higher imidacloprid levels of 100 or 200 ppb.

Why are bumblebee more susceptible to neonicotinoids?

- Honeybee queens never forage.
  Bumble bee queens forage in fall + spring.
- Honeybee colonies have 50,000 workers
  Bumble bee colonies have 30 workers.
- Honeybee forager is the last stage in lifecycle.
  Bumble bee workers forage at any age.
- Honeybee bread=pollen+ nectar+ saliva+ +hypo pharyngeal secretion, detoxifies
- Bumble bees do not make bee bread.

Summary of research

1. **Residue in landscape plants higher than crop residue from ag field treatments.**

2. **Honeybees in colony studies are less susceptible to imidacloprid.**

3. **Bumblebees in lab and field studies very sensitive starting at 20 ppb, a field realistic dose for landscapes. The EPA NOEL is wrong.**

4. **Read for more information from research papers 2016 “How neonicotinoids can kill bees”, Xerces Society Invert Conservation.**