# University of Minnesota

# Residues in landscape plants and effects on bumblebees and two species of butterflies

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## Introduction

Neonicotinoid insecticides are commonly used in landscapes and agriculture in the US, but levels of residue in ornamental plants are rarely measured. Neonicotinoid research showed lethal and sublethal effects on bee behavior and colony health (Scholer & Krischik 2014, Baron et al. 2017, Arce et al. 2017) and on butterfly survival, development, and behavior (Pecenka & Lundgren 2015, James 2019, Peterson et al. 2019, Krishnan et al. 2020).

## Objective 1: Materials & Methods

**Objective 1: Comparing neonicotinoid residues in ornamentals and agriculture.** Plants were treated with label rates of imidacloprid, harvested at 5-10 wks, and residue was quantified by HPLC GC at the USDA lab in Gastonia, NC

## Objective 1: Results

**Objective 1.** Imidacloprid is common in ornamentals and residues are significantly higher compared to clothianidin residues near ag fields. The $LD_{50}$ is around 4 ng/bee for both and was shown to have similar colony affects on bumblebees (Scholer and Krischik 2014).

**Table 1. Neonicotinoid residues in urban and ag plants.**

| Species/ label application | Flowers imid ppb | Leaves imid ppb | Many cloth ppb | Ref |
|---|---|---|---|---|
| Neonicotinoid residues in agricultural fields (4mg/sqft) | | | | |
| *Asclepias syriaca* | | | 1.14<br>0.71 | 1,2 |
| *Brassica napus* pollen | | 0.09<br>0.10 | | 3 |
| *Brassica napus* Wildflowers pollen | 1.4<br>0.16 | | | 4 |
| Bee Urban<br>Bee Rural pollen | 20 | | 5<br>35 | 5 |
| *Taraxacum* pollen | 2.9 | | 6.3 | 6,7 |
| Neonicotinoid residue in ornamentals (pot 300 mg/sqft) | | | | |
| *Tilia cordata*<br>25 cm DBH trunk inj | 1,340<br>yr1<br>45 yr 2 | 36,283<br>yr1<br>680 yr 2 | | 8 |
| *Tilia cordata*<br>25 cm DBH soil dr | 34 yr 1<br>38 yr 2 | 290 yr 1<br>680 yr 2 | | 8 |
| *Tilia cordata*<br>70 cm DBH soil dr | 30 yr1<br>88 yr2 | 554 yr1<br>737 yr2 | | 8 |
| *Cornus racemosa*<br>4 cm DBH soil dr | 762 | 21,062 | | 8 |
| Rosa<br>soil dr | 812 | na | | 8 |
| *Asclepias incarnata*<br>soil dr | 86 | 132 | | 8 |
| *Agastache*<br>soil dr | 94 | 561 | | 8 |
| *Calibrachoa hybrid*<br>Pot dr, 1L pot | 333 | 25, 933 | | 8 |
| *Ruellia humilis*<br>Pot dr, 1L pot | 502 | 2,086 | | 8 |
| *Asclepias incarnata*<br>pot dr, 6L pot | 1568 | | | 8 |
| *Agastache*<br>Pot dr 6 L pot | 1973 | | | 8 |

1. Pecenka and Lundgren 2015, 2.Olaya-Arenas and Kaplan 2017, 3. Blacquiere et al. 2012, 4. Botías et al. 2015, 5. David et al.2016, 6. Krupke et al. 2012, 7. Krupke et al. 2017, 8. Krischik unpublished

## Objective 2: Materials & Methods

**Objective 2: Flight cage studies on lethal and sublethal doses on bumblebees.** Bumblebees, *Bombus impatiens* (Koppert Biological Systems, Howell, MI), colonies were fed untreated Koppert Bee Happy syrup (35%) for 3 weeks after which clothianidin (20 ppb) or chlorantraniliprole (4 ppm) were dissolved in the syrup and fed ad libitum for 5 weeks (10 colonies/trt). Colonies were measured weekly for weight (g), syrup consumption (ml), and movement (sec). Photos were taken bi-weekly to measure brood numbers, brood cell age (1-3), worker numbers, and disease. Movement is the time for a worker to cross the brood.

## Objective 2: Results

**Objective 2:** *Bombus impatien*s fed 20 ppb of clothianidin ($LC_{50}$ 100 ppb, Scholer and Krischik 2014) in syrup had reduced brood production and movement. At 4 ppm chlorantraniliprole ($LC_{50}$ 7 ppm, Smagghe et al. 2015) caused no effects

**Figure 1. Clothianidin (20 ppb) had lower colony weight and brood.**

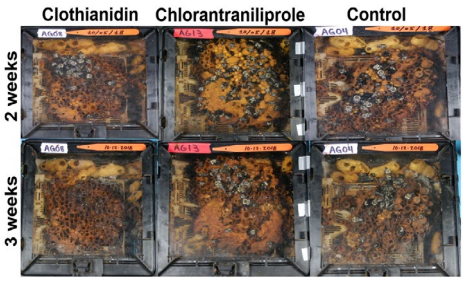
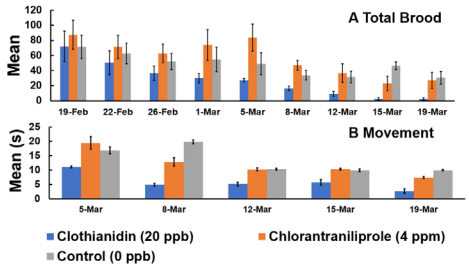



**Figure 2. (A) Brood numbers (mean ± SE) and (B) movement (mean ± SE) , both were lower for clothianidin (20 ppb).**




## Objective 3: Materials & Methods

**Objective 3: Lab studies on lethal and sublethal doses on butterflies** For $LC_{50}$ bioassays, larvae were fed swamp milkweed, *Asclepias incarnata (Danaus plexippus)* or common mallow, *Malva sylvestris (Vanessa cardui)* dipped in insecticides. Adults in 3 m cages were fed Bee Happy syrup at eclosion. On day 1 adults (30/trt) were force fed syrup containing bifenthrin, (0.1 ppm), clothianidin (10 ppm), imidacloprid (0.05 ppm), or chlorantraniliprole (0.001 ppm). Butterflies were dropped and the ability to open wings was measured on 3 days (day 1, 8, 10).

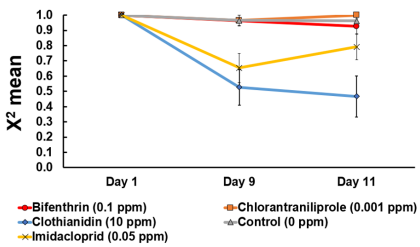
## Objective 3: Results

**Objective 3:** For clothianidin, larval *D. plexippus* had an $LC_{50}$ of 4 ppm and *V. cardui* 96 ppm and for chlorantraniliprole 0.20 ppm and 0.03 ppm. Sublethal effects of clothianidin (10 ppm) reduced flight (wing opening), but did not lower fecundity

**Table 2. $LC_{50}$ ppm values for *D. plexippus* and *V. cardui***

| Insecticide | n | $LC_{10}$ | $LC_{50}$ | $LC_{90}$ | Slope ±SE | $X^2$ | *P* |
|---|---|---|---|---|---|---|---|
| $LC_{50}$ fifth instar painted lady larvae, *Vanessa cardui* | | | | | | | |
| clothianidin | 180 | 28.9 | 96.2 | 801 | 0.6 ± 0.1 | 2.8 | 0.6 |
| imidacloprid | 180 | 43.3 | 256 | 1309 | 0.8 ± 0.1 | 3 | 0.4 |
| bifenthrin | 180 | 7.1 | 9 | 70 | 0.6 ± 0.1 | 0.5 | 0.9 |
| chlorantraniliprole | 180 | 0.004 | 0.03 | 0.2 | 0.7 ± 0.1 | 0.06 | 0.9 |
| $LC_{50}$ fifth instar monarch larvae, *Danaus plexippus* | | | | | | | |
| clothianidin | 262 | 0.15 | 3.7 | 89 | 0.4 ± 0.05 | 8.1 | 0.2 |
| imidacloprid | 99 | 0.19 | 1.1 | 6.24 | 0.7 ± 0.18 | 1.2 | 0.3 |
| bifenthrin | 191 | 0.18 | 1.5 | 12.49 | 0.6 ± 0.08 | 4.2 | 0.4 |
| chlorantraniliprole | 300 | 0.02 | 0.2 | 2.8 | 0.5 ± 0.07 | 2.0 | 0.8 |
| $LC_{50}$ adult painted lady adults, *Vanessa cardui* | | | | | | | |
| clothianidin | 100 | 6.0 | 13.2 | 28.9 | 1.6 ± 0.4 | 1.5 | 0.5 |

**Figure 3. Proportion of *D. plexippus* adults that did not fly.**

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## Discussion & Conclusion

Two butterfly species had higher $LC_{50}$ for the neonicotinoids clothianidin (4, 96 ppm) and imidacloprid (1, 256 ppm) than bumblebees (100 ppb imidacloprid, clothianidin). $LC_{50}$ for butterflies was lower for chlorantraniliprole (30, 200 ppb) than bumblebees (7 ppm). Clothianidin (10 ppm) reduced flight in monarch butterflies. The 20 year decline of endangered Rusty patched bumblebee, *B. affinis,* may be correlated to ubiquitous neonicotinoid residues and bumblebee sensitivity (20 ppb).