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Do neonicotinyl insecticides affect birds as they do bees?

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Background

Neonicotinoids are a family of insecticides commonly used for pest treatment in agricultural and horticultural applications. They are applied through soil drenches, seed coatings, foliar sprays, and tree trunk injections. Systemic in nature, the insecticide will move from the application site through the plant to the leaves, pollen, nectar, seeds, and fruits following application.

In bees, neonicotinoids have been shown to be lethal in high doses. Sub-lethal doses can cause deleterious effects on foraging, navigation, and colony health. With growing concern of their usage, introductory research has begun on the effects of neonicotinyl insecticides on bird populations.

This study may serve as a foundation for further research into non-target effects of these insecticides.

Objectives

- Objective 1: Determine residue levels in leaves and seeds of green ash trees, (*Fraxinus pennsylvanica)* following an Imidacloprid (neonicotinoid) soil drench.
- Objective 2: Determine lethal and sub-lethal effects of neonicotinyl insecticides on birds.

Methods

- We collected samples of leaves and seeds from ash trees treated with Imidacloprid insecticides.
- We performed meta-analysis of published research to find the LD50 (lethal dose) and the negative effects of neonicotinoids on birds.
- Using the results of our meta-analysis, we calculated how many treated ash seeds would need to be eaten for lethal and sub-lethal effects to occur.

Results

Imidacloprid and other neonicotinyl insecticides have been found in the bodies of wild birds. These studies show that there are lethal and sub-lethal effects of neonicotinyl insecticides, observed in both field and lab experiments.

We found that ash trees, following an Imidacloprid soil-drench, had a mean residue of 35 ppb in the seeds.

We have determined how many treated ash seeds must be ingested to see deleterious effects on birds, using known LD50 levels and our residue analysis for the amount of imidacloprid in an ash seed.

Table 1: Lethal and Sub-lethal effects on birds

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Bird Species	*LD50 (mg/kg)	Lethal and Sub-Lethal Effects	References
Field Surveys			
Many species	unknown	Correlation between bird population declines and neonicotinoids in water	Hallmann 2014
Many Species	unknown	Nervous disorders present in 29.6% of 103 deaths with neonicotinoid residues detected. Primarily pigeons/partridges	Millot 2016
American Robin	unknown	Poisoning after ingesting grubs from a treated lawn	Gibbons 2014
Rufous Hummingbird Anna's Hummingbird	unknown	Neonicotinoids (thiamethoxam, clothianidin, and imidacloprid) were measured in cloacal fluid with a concentration of 3.63 ppb	Bishop 2018
Eurasian Eagle-Owl	unknown	Imidacloprid residue in blood after exposure was measured at a concentration of 3.28 ppb	Taliansky-Chamudis 2017
White-crowned Sparrow	unknown	Imidacloprid residue was found in the blood of 78% of wild sparrows tested	Hao 2018
European Honey Buzzard	unknown	Neonicotinoid residue was present in 80% of the blood samples taken from both adult and juvenile buzzards	Byholm 2018
Greater Prairie-Chicken	unknown	Neonicotinoids were found in 67% of prairie-chicken livers tested (imidacloprid: 8.3 ppb, clothianidin 4.2 ppb, thiamethoxam 1.1 ppb)	Roy 2019
Sharp-tailed Grouse	unknown	Neonicotinoids were present in 89% of grouse livers tested. (Max levels measured: imidacloprid: 84.5 ppb, clothianidin: 3.58 ppb, thiamethoxam: 1.18 ppb)	Roy 2019
Wild Turkey	unknown	43% of turkeys tested were positive for one or more neonicotinoid present in liver samples	MacDonald 2018
Experimental Studies			
Brown-headed Cowbird	unknown	Impaired coordination, retching, reduced consumption of imidacloprid-treated seeds	Millot 2016 Avery 1993
Red-winged Blackbird	unknown	Impaired coordination, retching, reduced consumption of imidacloprid-treated seeds	Millot 2016 Avery 1993
Red Munia	31	Thyroid disruption interfering with seasonal reproductive stages gonad development	Pandey 2017
Canary	35	Incapacitation at 10mg/kg	Mineau 2013
House Sparrow	41	Ingestion of 1.5 beet seeds can result in death, reduced coordination, inability to fly	Gibbons 2014 Mineau 2013 Millot 2016
White-crowned Sparrow	41	4 imidacloprid-treated canola seeds, or 0.2 treated corn seeds can result in death, respiratory distress, reduced body mass	Eng 2017 Goulson 2013
Red-legged Partridge	31-53	The highest dose (0.14-0.7mg/g) of wheat seeds treated with imidacloprid killed 100% of partridges in 21 days Low dose resulted in reduced fecundity	Gibbons 2014 Lopez-Antia 2014 Lopez-Antia 2016
Grey Partridge	13.9	5 maize seeds, six beet seeds or 32 oilseed rape seeds will reach LD50. Sub-lethal effects include failed eggs	Gibbons 2014 Millot 2016 Goulson 2013
Japanese Quail	31	Imidacloprid: Severe signs at 6mg/kg Clothianidin: clinical signs at 25 mg/kg; Incapacitation at 100 mg/kg	Mineau 2013 MacDonald 2018
Mallard	283	Severe clinical signs at 25mg/kg; mortality 8 days post dose	Mineau 2013 Millot 2016
Northern Bobwhite	152	Slight clinical signs at 25 mg/kg; incapacitation 50-100 mg/kg	Mineau 2013 Ertl 2018 MacDonald 2018
Rock Pigeon	25	50% mortality with the ingestion of <4 treated wheat seeds Severe clinical signs at 12.5 mg/k	Millot 2016, Mineau 2013, MacDonald 2018, Berney 1999
Chicken	104	Chick embryo mortality due to malformed crest and neural cells; mortality in 5-24 hours	Wang 2016 Kammon 2010 Liu 2016

*LD50 amounts are the lethal dose of ingested imidacloprid

Table 2: Imidacloprid residue in leaves and seeds of Ash Trees treated annually via soil drench

Ash tree (number)	Imidacloprid Residue	Recovery
July leaves (6), no residue (2)	94ppb	100%
July seeds (2) no residue (2)	36 ppb	119%
July leaves control (3)	0 ppb	100%
July seeds control (3)	0 ppb	132%
August leaves (6) no residue (2)	66 ppb	95%
August seeds (6) no residue (2)	34 ppb	105%
August leaves control (3)	0 ppb	91%
August seeds control (3)	0 ppb	107%

Table 3: Number of ash seeds (5g) with a residue of 35 ppb imidacloprid that must be eaten to reach the LD50

Bird Species and Weight	Ash Seeds Ingested for Lethal/Sub-lethal Effects
Rock Pigeon 900 g	Lethal: 24,545 seeds Sub-lethal: 4,909 seeds
Mallard 1,500g	Lethal: 32,706,818 seeds
Japanese Quail 100 g	Lethal: 14,090 seeds
Northern Bobwhite 150 g	Lethal: 10,227 seeds
House Sparrow 30 g	Lethal: 5,590 seeds
Canary 20 g	Lethal: 27,272 seeds
White-crowned Sparrow 26 g	Lethal: 5,590 seeds Sub-lethal: 1,363 seeds

Conclusion

The amount of imidacloprid residue in an ash seed after treatment is 35 ppb, not enough to kill birds. Seeds of treated crops, such as corn, canola, sunflower, and beets carry a greater risk. These have around 1-2 mg applied per seed compared to those of ash trees which have 35 ppb, a much smaller amount.

A meta-analysis of papers showed that neonicotinoids are found in free-ranging birds, resulting in detrimental or fatal effects. The residue we've found in ash seeds is not enough to constitute a risk to normal behaviors or physiological functions.

Further research is needed to determine lethal and sub-lethal amounts of neonicotinoids in birds including clothianidin, thiamethoxam, etc. Research is also needed to measure neonicotinoid residues in treated vegetation and seeds.