No common pesticides detected in snow buntings utilizing a farmland landscape in eastern Québec

Emily Cornelius Ruhs, Oliver P. Love, Louis Drainville and François Vézina

ABSTRACT. Many species of migratory birds are declining worldwide, including throughout North America. Some of the most cited causes of decline are linked to climate change, urbanization, and growth in agriculture. Across eastern Canada, a number of insecticides and herbicides are commonly sprayed before and during the growing season to control pests and foliage competitors. During wintering and migration, a declining Arctic-breeding songbird, the snow bunting (Plectrophenax nivalis), utilizes open farmlands of southern Canada; therefore, this could be a period when the species is most exposed to these pesticides. We tested snow bunting tissues (blood and liver) for the 4 pesticides most commonly used in grain agriculture in Canada: atrazine, chlorothalonil, imidacloprid, and glyphosate, as well as a glyphosate derivative (aminomethylphosphonic acid, AMPA). Although this species is thought to forage in grain fields during autumn through spring, we found no detectable traces of any of the five substances. Wintering buntings may either not be exposed to these pesticides during their presence in agriculture fields or, given the rapid turnover of these pesticides in the blood and tissues, be exposed to doses below detection level in samples.

INTRODUCTION

In Canada, the provinces of Ontario and Québec alone account for 91.9% of total corn production (Hamel and Dorff 2014). Across this crop type, regardless of geographic location, similar insecticides and herbicides are sprayed during the growing season (summer to early fall) to control pests and foliage competitors, respectively (Environment, Energy and Transportation Statistics Division 2015). A review of practices within the agriculture industry is ongoing to determine the biological significance of pesticide exposure on wildlife (Dion 2018, Langlois 2018); however, specific effects of these chemicals on birds, especially following chronic exposure, is generally unknown (but see Evans and Batty 1986, Wilhelms et al. 2006, Mineau and Palmer 2013, Gibbons et al. 2015, McGee et al. 2018). Some pesticides, like neonicotinoids (e.g. imidacloprid and chlorothalonil), atrazine, glyphosate, and glyphosate derivatives, have long-half lives in soil (Wilhelms et al. 2006, Battaglin et al. 2009, Hallmann et al. 2014). For example, imidacloprid has a field dissipation half-life of 26.5 to 229 days (Bacey n.d.), chlorothalonil is field persistent with a half-life of 56.4 to 1155 days (EPA 2005, Bonmatin et al. 2015) and glyphosate has a half-life of 2-197 days (mean 47 days; WHO 1994, Giesey et al. 2000, Vencill 2002). Atrazine has a soil half-life of 35-75 days (Vogue et al. 1994, Workman et al. 1995); however, it has been found in the environment years after application (Jablonski et al. 2010, Jablonski et al. 2011). Therefore, it is possible that birds could still be exposed long after the growing season, like during the wintering period when birds utilize agricultural fields. Some of the most cited causes of declining avian populations are linked to climate change, urbanization, and agriculture intensification (Partners in Flight Landbird Conservation Plan...
In this project, we tested snow bunting tissues (blood and liver) for the four pesticides most commonly used in cereal crops, such as corn, in Canada. We focused on the spring migratory period as this is a time during which the birds accumulate large amounts of body fat for migration through hyperphagia (Le Pogam et al. 2021, Vincent and Bédard 1976, Power 2017) and might therefore be consuming grain-targeted pesticides while migrating along the St. Lawrence shore. The considered pesticides were the four most commonly used in grain agriculture in Canada: atrazine, imidacloprid, chlothianidin, glyphosate, as well as a glyphosate derivative (aminomethylphosphic acid (AMPA)). Our objectives were to (i) assess whether these chemicals were present in tissues that represent short-term (blood) and longer-term exposure (liver) to these pesticides and (ii) if so, at what relative concentrations.

**METHODS**

The eastern Canadian population of snow buntings spends the winter from western Ontario to eastern Québec before migrating north-eastward following the Gulf of St. Lawrence (Macdonald et al. 2012, 2016). Therefore, birds (n=10) were collected in March 2018 as this corresponds to the period of hyperphagia and pre-migratory body mass gain in outdoor captive birds (Le Pogam et al. 2021, Vincent and Bédard 1976, Power 2017). The historic range of snow cover during March in Québec can vary but ranged from 72-136 cm depth in March 2017 (data from 2018 unavailable; https://climate.weather.gc.ca/climate_data). Birds were captured in Saint-Joseph-de-Lepage, Québec, Canada (Lat: 48.575779, Long: -68.169576). All birds were captured on the same day (March 14th) within three hours (9:52 am to 12:20 pm). The capture site was an area with an open cornfield and snow cover. Birds were baited for a few days prior to capture using a certified organic corn product which therefore was not contaminated with the pesticides of interest (Fig. 1). Thus, any level of contamination would have to be resulting from previous exposure. Upon capture, a small blood sample (<1% total body weight) was collected. We then transported birds back to the avian research facilities at the Université du Québec à Rimouski where they were euthanized using CO₂ asphyxiation. Birds were then dissected to retrieve liver tissue samples. Liver was used because it (1) accumulates toxins and (2) is the primary source for metabolizing toxicants (Klaassen and Watkins 2008). A total of ~5 g of tissue was required to analyze for imidacloprid, chlothianidin, and atrazine; however, another ~5 g was required for glyphosate and AMPA. As such, only liver samples were tested for glyphosate and AMPA, as there was not enough blood collected to test for all five pesticides. Samples were then stored at -80°C and prepared for shipment and analysis at Brookside laboratories in Ohio, United States. All procedures were approved by the UQAR Animal Care Committee (CPA-72-18-199) and were conducted under a Canadian Wildlife Services scientific permit (SC-75).

**Laboratory analysis**

To determine the presence and levels of chlothianidin, imidacloprid, and atrazine in samples, each sample was homogenized and weighed into a 50mL polypropylene centrifuge tube, recorded to the nearest 0.001 g. Five mL of water was then added to the tube. Ten mL of acetonitrile was added to the tube and shaken for 2 minutes. A packet of QuEChEERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) salts was added to the tube.
Table 1. Results from the pesticide testing. There were no detectable quantities of atrazine, clothianidin, imidacloprid, glyphosate, or AMPA in any of the birds sampled. Limit of Quantification (LOQ) is the lowest concentration of analyte in a sample that can be detected, all samples for glyphosate and AMPA were between zero and the LOQ (0.8-2.05 mg/kg). Note that the minimal detectable limit (MDL) for the tested pesticides is well below concentration levels known to cause health issues in birds.

<table>
<thead>
<tr>
<th>Type</th>
<th>Blood (mg/kg)</th>
<th>Liver (mg/kg)</th>
<th>MDL or LOQ†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrazine†</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
</tr>
<tr>
<td>Clothianidin</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
</tr>
<tr>
<td>Imidacloprid</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>0.8-2.05 mg/kg</td>
<td>ND</td>
<td>0.8-2.05 mg/kg</td>
</tr>
<tr>
<td>AMPA</td>
<td>0.8-2.05 mg/kg</td>
<td>ND</td>
<td>0.8-2.05 mg/kg</td>
</tr>
</tbody>
</table>

†indicates an herbicide derivative

Previous studies focusing on the effects of pesticides in birds have been either experimental (Evans and Batty 1986, Mineau and Palmer 2013, Eng et al. 2017) or conducted during the crop growth (and pesticide application) season (Boutin et al. 1999). For example, a study in southern Ontario identified numerous farmland bird species that were at risk of pesticide exposure during the breeding season due to their high occurrence near agricultural landscapes and to the timing of that occurrence with pesticide application (Boutin et al. 1999). Our study aimed to determine whether snow buntings were contaminated during spring, long after the crop growth season. This period could be a very sensitive portion of their annual cycle due to important physiological changes occurring at that time for migration (Le Pogam et al. 2021, Vincent and Bédard 1976, Power 2017), but also due to pesticide contamination, which could increase as pre-migratory buntings become hyperphagic (Vincent and Bédard 1976, Laplante et al. 2019) and begin fattening for their long-distance flight (Le Pogam et al. 2021).

While our results are encouraging for this declining species, the lack of detection of these compounds during late winter is not necessarily a sign that these birds are not being exposed during other times of the year or in areas with higher pesticide use (e.g.,

Fig. 1. Snow buntings feeding on organic (pesticide-free) corn bait during the winter in Québec, Canada. Photo by François Vézina.
Warner et al. 2019). For example, in eastern Canada, snow buntings are wintering in a gradient of agriculture intensity, from southern Ontario (intense) to Newfoundland (low; Hamel and Dorff 2014) and are faced with increasing pesticide use over time (Agriculture and Agri-Food Canada 2016). Further studies are needed to determine whether snow buntings are contaminated in areas of greater agricultural intensity. More research is also required to define the potential effects of these toxicants and the ecological impacts long after the crop growing season, especially during sensitive life-history stages like pre-migratory fattening. More precisely, future studies should also aim to sample populations that (1) are from other wintering locations where pesticide use is more extensive and (2) across a wider geographical scale varying in their pesticide use intensity.

Since the implementation of this project, both clothianidin and imidacloprid have been restricted, but not for grain crops like corn (PMRA a and b 2019, Environment et Lutte contre les changements climatiques Québec 2021); while glyphosate has been reapplied for the next 15 years. Given that locations for growing grain will increase as temperatures continue to climb and growing seasons get longer (Almaraz et al. 2008, Kucharik and Serbin 2008), understanding the long-lasting effects of pesticide application to wildlife is paramount. Several migratory bird species are declining throughout North America (North American Bird Conservation Initiative Canada 2012) and agricultural expansion could be a factor in this decline, especially in birds associated with open farmland landscapes. Therefore, whether agricultural intensity and pesticide exposure impact population decline is a question of utmost importance.

Responses to this article can be read online at: https://www.ace-eco.org/issues/responses.php/1979

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Ethical approval All applicable international, national and institutional guidelines for the care and use of animals were followed. Procedures were institutionally approved by the UQAR Animal Care Committee (CPA-72-18-199). Funding This research was funded through a Natural Sciences and Engineering Research Council of Canada (NSERC) Engage grant awarded to O.P.L. Conflict of interest The authors declare that they have no conflict of interest.

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