

## Section II: Bees and Pollinators

### WHY DO BUMBLE BEES DIE AFTER FORAGING ON LINDEN TREES?

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Linden (*Tilia* spp.; Malvaceae), also known as lime or basswood, is a common ornamental tree in urban landscapes. It produces an abundance of fragrant flowers that draws diverse pollinators. In 2013 and 2014, massive numbers of one bumble bee species, *Bombus vosnesenskii* (Apidae), died after visiting linden trees in western Oregon. Bee deaths were linked to neonicotinoid insecticides applied for control of aphid pests. However, mortality of bees feeding on *Tilia* species has been reported from Europe since the late 1970s, long before neonicotinoids were developed as an insecticide. Investigations by European researchers suggest that the causal factor is the presence of the sugar mannose in the nectar of linden. Mannose is speculated to be toxic to honey bees because it disrupts the glycolysis cycle by competing with glucose for the enzyme hexokinase. However, there is no information on the impact of mannose and other sugars on bumble bees. Information is also lacking on other pollinators that visit linden in Oregon and that were likely affected by the neonicotinoid sprays. The objectives of this study were to: 1) Assess the diversity and abundance of pollinators foraging on linden trees; 2) Determine the impact of mannose and other sugars on honey bees and bumble bees.

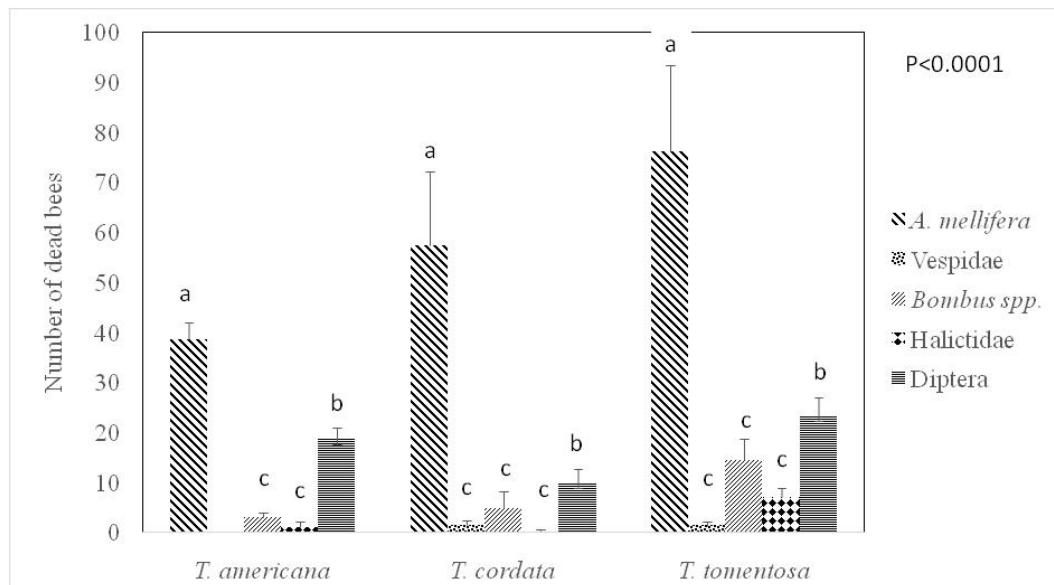
Diversity and abundance of pollinators associated with linden: Three *Tilia* species, *T. americana*, *T. cordata* and *T. platyphyllos* in Corvallis were monitored in the summer of 2014. Bloom in each *Tilia* species lasted for 2-3 weeks with a slight overlap in bloom between *T. americana* and *cordata*. Insect visitors to the trees included European honey bees, bumble bees, halictids, vespids and dipterans. Of these, honey bees and dipterans were the most abundant (Fig. 1).

Impacts of mannose and other sugars on bees: Three laboratory experiments were conducted using honey bees and bumble bees (when available). Sugars were presented to 10 bees per mesh cage for 24 hours at 33° C and 50% RH. The experiments were set up as a randomized block design with 8 replications.

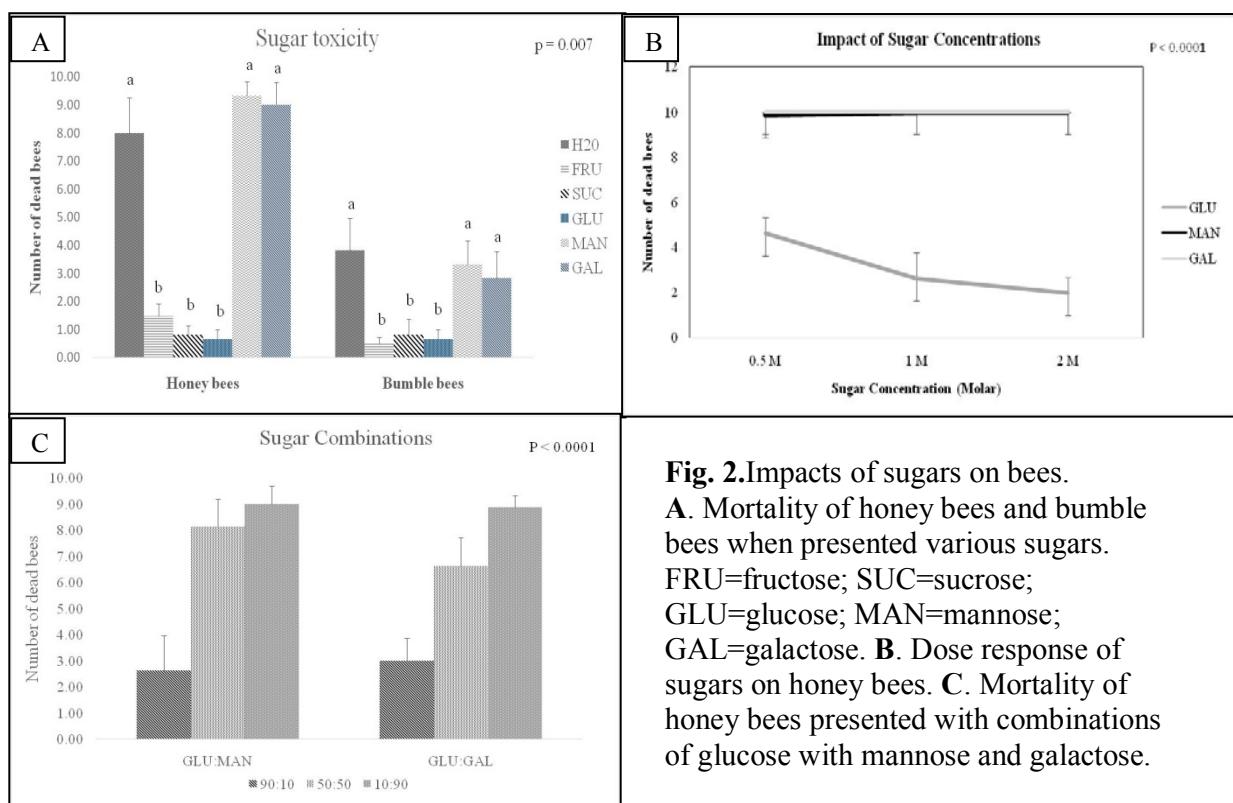
- a) Comparison of impacts of different sugars on honey bees and bumble bees. 1 M solutions of mannose, galactose, glucose, fructose, sucrose, and water (control) were evaluated. Mortality with mannose and galactose was similar to mortality with water (starvation). The impacts of mannose and galactose were greater on honey bees than on bumble bees (Fig. 2A).
- b) Determination of the dose-response of sugars on honey bees. Mannose, galactose, glucose, and water (control) were tested at 0.5, 1 and 2 M concentrations. No difference in mortality was observed for galactose and mannose among the three concentrations tested. Even the lowest dose (0.5 M) for each sugar was highly toxic compared to glucose (Fig 2B).
- c) Determination of the impact of toxic sugars when presented in combination with glucose. The following treatments were evaluated: 1 M solutions of glucose-mannose (GLU:MAN) and glucose-galactose (GLU:GAL) at 90:10, 50:50, 10:90 ratios. Bee mortality was significantly lower with the lowest ratio for each toxic sugar (90:10 GLU:MAN and GLU:GAL) compared to the higher ratios (50:50 and 10:90; GLU:MAN and GLU:GAL) (Fig. 2C).

The results indicate that while bumble bees were the key pollinator that were documented to be affected by the neonicotinoid sprays in Oregon, several other insects also visit linden during bloom. The study documented that mannose and galactose are toxic to honey bees and bumble bees.

However, the impact depended on the amount of non-toxic sugars simultaneously presented to the bees. Based on the results, it is possible that mannose and galactose cause bee mortality by limiting the amount of the enzyme hexokinase available for metabolism of the glucose. Further research is needed for determining the presence of the toxic sugars in the nectar of linden and the biochemical basis for the toxicity.



**Fig. 1** Diversity and abundance of insects that visited linden trees in 2014.



**Fig. 2.** Impacts of sugars on bees.  
**A.** Mortality of honey bees and bumble bees when presented various sugars.  
 FRU=fructose; SUC=sucrose;  
 GLU=glucose; MAN=mannose;  
 GAL=galactose. **B.** Dose response of sugars on honey bees. **C.** Mortality of honey bees presented with combinations of glucose with mannose and galactose.