MORTALITY OF BUMBLE BEES ASSOCIATED WITH LINDEN: A REVIEW

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Globally, there have been reports of declines in populations of bumble bees which have been attributed to changes in land use that have led to loss of foraging resources and nesting habitats, diverse pathogens, and pesticides associated with agricultural crop production. Other factors may also be responsible for bumble bee mortality but these have received little attention. For minimizing future losses, it is critical that bee mortality factors are determined. Risks associated with foraging behaviors are particularly critical as bees spend considerable time seeking food resources. Bees forage on multiple plants, and hence species that pollinate crops are affected by negative factors across the landscape.

In 2013, over 50,000 bees died after foraging on linden (*Tilia* spp.; Malvaceae) trees in one location in Oregon, and there were concerns about impacts on cropping systems in surrounding areas. The sudden and dramatic reduction in pollinators impacted crops with blooming periods succeeding the linden-bee kill in the same year, and crops requiring bee pollination the following year. Linden is a common, profusely flowering, bee attractive ornamental tree, and since 2013, linden-associated bee mortality has been observed annually, in Oregon and nationwide. Based on investigations by the Oregon Department of Agriculture, neonicotinoid insecticides accounted for the bee deaths at some locations but, at others, no insecticide residues were detected.

While linden-bee deaths are a new phenomenon in the US, mortality of bees feeding on linden has been reported from Europe since the late 1970s (Crane 1977). Also, linden-bee deaths in Europe were reported many years before neonicotinoids were developed as an insecticide in the mid-1980s. Clearly, factors besides neonicotinoids are responsible for mortality of bees associated with linden. Two hypotheses have been proposed to account for the bumble bee deaths:

1. **Mannose Hypothesis**: Under drought conditions, the sugar mannose is produced, and this is toxic to bees.

Von Frisch (1928) documented the toxicity of mannose to honey bees, while Argoti and Rao (2015) documented its toxicity to bumble bees. Mannose is a monosaccharide that is very similar in structure to glucose (Figure 1) which is used by bees as a carbohydrate source. Hence, the toxicity of mannose was speculated to be due to disruption of glucose metabolism resulting from imbalance between enzymes associated with the glycolysis cycle that provides energy for bees (Sols et al. 1960). However, subsequent studies refuted the competitive inhibitor of glycolysis hypothesis (Saunders et al. 1969). The basis of mannose toxicity to bees remains unknown.

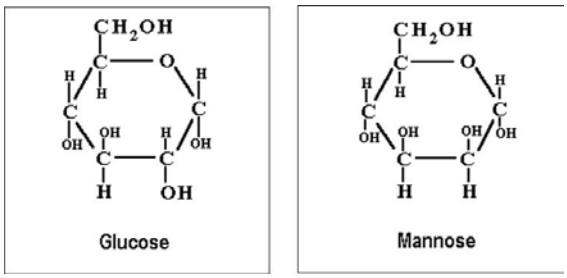

Figure 1. Structure of glucose and mannose.

2. **Starvation Hypothesis:** Massive bloom in linden draw bumble bees which forage even when nectar flow is low, and hence die out of starvation.

In a study by Baal et al. (1992), when bumble bees under linden trees that were still alive but unable to fly were exposed to fresh linden flowers before they died, the bees revived. No further supporting evidence was provided for this hypothesis.

Interestingly, while greater numbers of honey bees than bumble bees forage on linden, only bumble bees deaths have been associated with linden. Honey bees are susceptible to neonicotinoids and yet few dead honey bees were observed under linden in the 2013 incident. Researchers have speculated that the differential response is because honey bees are better able to access nectar levels and hence they do not die due to starvation. Also, honey bees have, on occasion, been observed to be deterred by pesticides applied to plants. The hypothesis that when honey bee worker recruiters die after foraging on linden no further workers are recruited has little support from honey bee researchers.

Other factors associated with nectar may be toxic to bees (Adler 2000). Bees are not deterred by naturally occurring levels of nectar toxins and thus succumb to the toxicity. Nectar toxins kill fewer bees than the massive neonicotinoid-associated bee kills observed in 2013. However, they are likely to occur more widely, and remain undocumented in most instances.

The linden-bumble bee mortality phenomenon is intriguing; future research is critically needed for addressing the various unanswered questions for minimizing future losses.

Key References:

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