Honey bees, Pesticides, and Friendly Fire

By: Fynn Mitchell

A look at how the accidental exposure of honey bees to pesticides affect their behaviour and our agricultural yields

- Pollinators, such as bees, play crucial roles in maintaining environmental welfare, and improving the crop yield of agricultural industries[1].
- Pesticides are commonly used in the agricultural industry to discourage pests from disrupting crop growth, however, pesticides also impact pollinators which can, in turn, reduce crop yields[2].
- Pesticide impacts on bees in particular are not only limited to increased mortality, but also deleterious modifications to numerous behaviours necessary for survival, such as foraging[3,4,5,7,9].

What was found

- Phenyl-pyrazole insecticides, such as fipronil, neonicotinoids, such as acetamiprid, thiamethoxam, clothianidin, and imidacloprid, and organophosphorus insecticides, such as methyl parathion had the most impact on honey bee behaviour[3,4,5,6,7,8,9,10].
- Thiamethoxam was found to cause the least dramatic impact on behaviour, clothianidin was found to have the most dramatic impact on behaviour, and was the most harmful to bees as a whole[5,8].

What are honey bees?

- *Apis mellifera*, or the honey bee, is a variety of insect, and is one of the quintessential pollinators throughout most of the world[1].
- Bees use hives as reproductive sanctuaries and food storage facilities[9].
- The bee hive has a hierarchical structure dividing hive members into roles such as queens or workers[2].
- Forager bees acquire food using flowers which provide nectar and pollen[2].
- Reproduction centers around the queen who mates with male drones[2].

How behaviours are tested

- Bees were exposed to a given insecticide orally via the mouth or topically via application to the thorax.
- Pesticide effects on bee mobility used open-field-like apparatuses to observe vertical displacement[3].
- Pesticide effects on sucrose and water sensitivity or responsiveness were evaluated based on the propensity for bees to display their proboscis extension reflex upon exposure to water or sucrose[5].
- Pesticide effects on olfactory learning and behaviour involved Pavlovian conditioning with a drop of sucrose acting as an unconditioned stimulus, and another odour such as coffee beans acting as a conditioned stimulus[3].

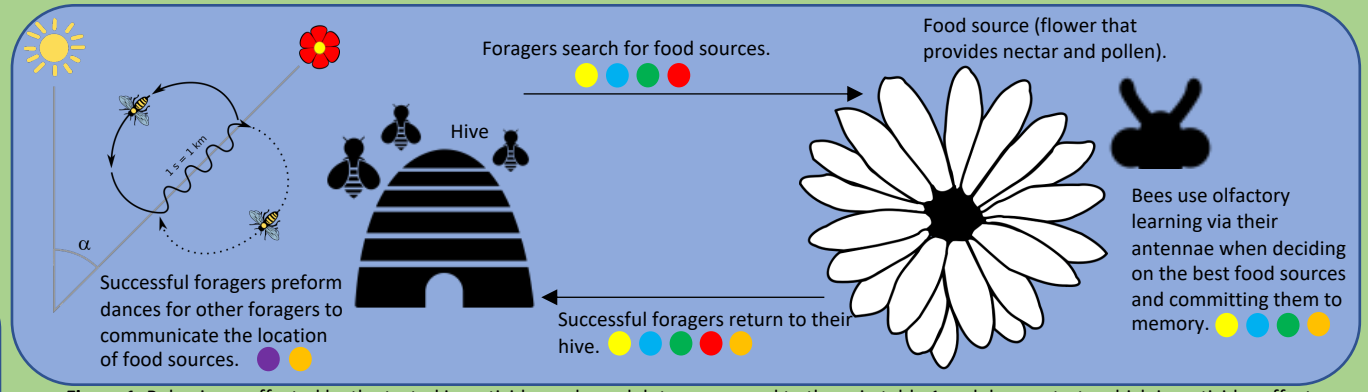

Figure 1: Behaviours affected by the tested insecticides, coloured dots correspond to those in table 1 and demonstrate which insecticides affect which behaviour[1,2,3,4,5,6,7,8,9,10].

Table 1: A collection of experimental study results detailing the effects of fipronil, acetamiprid, thiamethoxam, clothianidin, imidacloprid, and methyl parathion on honey bee behaviour[3,4,5,6,7,8,9,10].

Insecticide Class and Type	Insecticide effects
Phenyl-pyrazole Class	
Fipronil	- Reduced olfactory learning and memory performance - Reduced sucrose responsiveness
Neonicotinoid Class	
Acetamiprid	- Reduced olfactory learning and memory - Reduced sucrose responsiveness - Increased water consumption
Thiamethoxam	- Reduced olfactory learning and memory - Reduced sucrose responsiveness - increased water consumption
Clothianidin	- Reduced time foraging despite longer foraging flights
Imidacloprid	- Reduced time foraging despite longer foraging flights - Reduced learning performance
Organophosphorus Class	
Methyl parathion	- Reduced time spent in hive - Reduced tendency to perform dances

What that means

- The deleterious effects of these pesticides impact foraging behaviour and, in turn, the ability of entire hives to survive
- Olfactory learning and memory are important to recalling the location of substantial food sources for communication to other foragers[7].
- Communication amongst foragers in the form of dances are critical to maximizing the hive's foraging efficiency[10].
- Sucrose sensitivity is vital to role allocation of hive members, and differential impediments can result in bees with poor sensitivity foraging more, reducing foraging efficiency[3].
- Mobility and activity is the foundation of foraging, reductions in mobility impede proper foraging[8].

Making a difference

Three methods could mitigate the harmful effects of pesticides, and are as follows;

1. Insecticides of relatively low toxicity could be substituted for existing ones, such as changing out clothianidin for thiamethoxam[1],
2. Applying insecticides toxic to honeybees during plant blooming could cease[1],
3. Legislatively approved application methods could be more widely used[1].

These methods, alongside better law enforcement and improved training amongst farmers, can help to curb the dangerous possibility of a world with too few pollinators[1].

1. Fikadu, Z. (2020). Pesticide use, practice and its effect on honey bee in Ethiopia: A review. *International Journal of Tropical Insect Science, 40*, 473-481. https://doi.org/10.1007/s42690-020-00114-x 2. Poquet, Y., Vidau, C., & Alaux, C. (2016). Modulation of pesticide response in honey bees. *Adipologie, 47*, 412-426. https://doi.org/10.1007/s13592-016-0429-7 3. El Hassani, A.K., Dacher, M., Gauthier, M., & Armengaud, C. (2005). Effects of sublethal doses of fipronil on the behaviour of the honey bee (*Apis mellifera*). *Pharmacology Biochemistry and Behavior, 82*(1), 30-39. https://doi.org/10.1016/j.pbb.2005.07.008 4. Aliouane, Y., El Hassani, A.K., Gary, V., Armengaud, C., Lambin, M., & Gauthier, M. (2009). Subchronic exposure of honeybees to sublethal doses of pesticides: Effects on behaviour. *Environmental Toxicology and Chemistry, 28*(1), 113-122. https://doi.org/10.1897/08-110.1 5. El Hassani, A.K., Dacher, M., Gary, V., Lambin, M., Gauthier, M., & Armengaud, C. (2008). Effects of Sublethal doses of acetamiprid and thiamethoxam on the behavior of the honeybee (*Apis mellifera*). *Archives of Environmental Contamination Toxicology, 54*(4), 653-661. https://doi.org/10.1007/s00244-007-9071-8 6. Decourtye, A., Armengaud, C., Renou, M., Devillers, J., Cluzeau, S., Gauthier, & Pham-Delegue, M. (2004). Imidacloprid impairs memory and brain metabolism in the honey bee (*Apis mellifera* L.). *Pesticide Biochemistry and Physiology, 78*(2), 83-92. https://doi.org/10.1016/j.pestbp.2003.10.001 7. Decourtye, A., Lacassie, E., Pham-Delegue, M. (2003). Learning performances of honey bees (*Apis mellifera L*) are differentially affected by imidacloprid according to the season. *Pest Management Science, 59*(3), 269-278. https://doi.org/10.1002/ps.631 8. Schnider, C.W., Tautz, J., Grünewald, B., Fuchs, S. (2012). RFID tracking of sublethal effects of two neonicotinoid insecticides on the foraging behaviour of *Apis mellifera*. *PLoS ONE, 7*:e30023. https://doi.org/10.1371/journal.pone.0030023 9. Lambin, M., Armengaud, C., Raymond, S., & Gauthier, M. (2001). Imidacloprid-induced facilitation of the proboscis extension reflex habituation in the honey bee. *Archives of Insect Biochemistry and Physiology, 48*(3), 129-134. https://doi.org/10.1002/arch.1065 10. Guez, D., Zhang, S.W., & Srinivasan, M.V. (2005). Methyl parathion modifies foraging behaviour in honey bees (*Apis mellifera*). *Ecotoxicology, 14*, 431-437. https://doi.org/10.1007/s10646-004-1348-3