From Bloom to Doom: How Pesticides Are Endangering Honey Bees

D. K. Narwade[1]*, B. V. Deore [2], M. Pushpapalatha[1], A. S. Gadge [3], and J. S. Rupali [4]

[1]Department of Entomology, Post Graduate Institute Mahatma Phule Krishi Vidyapeeth, Rahuri, 413-722 Maharashtra, India

[2]All India Network Project on Pesticide Residues, Department of Entomology, MPKV, Rahuri, 413-722 Maharashtra, India

[3]Department of Entomology, University of Horticultural Sciences, Bagalkot 587 104, India

[4]Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India

*Corresponding Author: durgeshnarwade48408@gmail.com

Introduction

If you look at your food plate on the dinner table, have you ever wondered? all the food you eat where it comes from? Well, it might surprise you that, a significant portion of your food comes from pollinators like a honey bee. Pollination is the process by which pollen is transferred from the male parts of a flower (anthers) to the female parts (stigma), enabling fertilization and the production of seeds. This vital biological function is crucial for the reproduction of many plants. Without effective pollination, these plants cannot produce the crops that are integral to our diets, making pollinators like bees, butterflies, and birds indispensable for global food production. Animals are involved in pollination of 90 % of world flowering plants. Worlds 3000 species of agricultural crops required agents for pollination. Pollinator agents include various animal species like birds, bats, insects, etc. Among all animal species insects are the major pollinating agents. But when you think of pollinators, the first thing that comes to mind is a honey bee. Honey bees are called general pollinators because they pollinate most of the flowering plants like sunflower, onion, tomato, potato, cucumber, melon, citrus, grape, mango, etc. The annual value of honey bee pollination in India is 1 lakh corer rupees. Crops are often infested with various pests and weeds, resulting in reduced crop yields and quality. Modern agriculture increasingly depends on the use of agrochemicals to increase crop production. According to statistics, approximately 5.6 billion pounds of various agrochemicals are used in modern agriculture (Topping *et al*., 2020). However, the use of agrochemicals is expected to double by 2050, which would further increase the potential risks and detrimental effects on non-target organisms, especially honey bees. Pollinators pollinate 87% of flowering plants worldwide, delivering environmental health and agriculture services. As one of the most important pollinators, honey bees provide pollination services for crops and many non-crops, such as wild plants (Sillman *et al*., 2020). However, the mass use of pesticides is threatening the economic importance of honeybees and butterflies. Without the honeybee crop yield could decrease by 90%. Moreover, there is a 58% decline risk of the agriculture farmland pollinating butterfly. In this article, we will see how the pesticides are threatening honey bees.

Fig. 1 Honey bee collecting nectar and pollens from flower

The main pathways of pollinator's exposure to insecticides

Foraging honey bees and pollinators can travel up to 15 km from the hive to collect water, pollen, and nectar, which are needed to sustain a colony. During foraging, foragers access agrochemicals through multiple channels. First, pollen and nectar in various crops may contain agrochemicals, leading to oral contact during honey bee foraging (Favaro *et al*., 2019). Second, high concentrations of systemic pesticides may be released into the air, surface water, or guttation water through spray drift or treatment seed, which further increases the risk of pollinator's exposure to agrochemicals (Morrison *et al*., 2018). Worse, honeybees encounter agrochemical pollution from the environment and carry agrochemicals in various forms back to the hive, where the queen, larvae, pupae, and nurse honey bees are susceptible (Johnson, 2015). Notably, in addition to agricultural pesticides, beekeeper-applied pesticides, such as acaricides, exert deleterious effects on honey bees

(Glavan *et al*., 2020). Both beekeeper-applied pesticides and agricultural pesticides can persist for many years in the wax combs of honey bees (Mullin *et al*., 2010), which may further exacerbate their effects on honey bees. As insecticides are one of the most commonly used agrochemicals in agriculture, the pathways by which pollinators are exposed to insecticides are generally the same as those described above.

How insecticides affecting honey bees

Story was started in year 2006, Florida beekeeper Dave Hackenberg was among the first to report a troubling phenomenon that would later be known as Colony Collapse Disorder (CCD). Hackenberg noticed that his hives, which were typically robust, began experiencing severe declines in bee populations with adult bees mysteriously vanishing, leaving behind a queen, eggs, and immature bees. This unexplained mass die-off of honeybees was characterized by the sudden disappearance of foraging bees, leading to weakened hives and reduced pollination. The most important cause of CCC is the negative effects of pesticides on hone bees' health. Among different pesticides, the pesticides that come under the group neonicotinoid are the most toxic to honey bees. These insecticides are highly specific to insects because they act on nicotinic acetylcholine receptors (nAchR) the receptors that are only found in insects. They are nerve poison. The study conducted by Mickael Henry and his co-workers at the French National Institute of Agricultural Research showed that bees intoxicated with neonicotinoid insecticides show 'Homing Failure' which means those bees who went for foraging had not written back to their hives due failure of navigation abilities as a side effect of pesticide poisoning. This accelerates the death rate of bees over a long period. A study conducted by Zhao and his co-workers in 2022 also showed that neonicotinoid affects bees at the molecular level. These insecticides affect the expression of important genes that regulate various crucial mechanisms in honey bees. In response to various protests in Europe to protect bees from the harmful effects of pesticides, the European government banned neonicotinoids in Europe in 2013.

General symptoms of pesticides poisoning in honey bees

- Presence of a large number of dead or dying bees at the hive entrance (Forager bees).
- There is a moist and sticky mass of dead bees at the hive entrance.
- The whole colony may also die instantly.
- Slowing down of activity and crawling of bees around the hive entrance.
- The behavior of bees in the hive changes abruptly. Honeybees in such colonies become more aggressive or agitated.
- Stupefaction, paralysis, aggressiveness and abnormal behavior, jerky, spinning movements.
- They lose their ability to fly and ultimately die 2 or 3 days after poisoning. Poor egg laying patterns or abnormal supercedure of queens.
- Within the hive, a break in the brood cycle (stages of young bees) or a spotty pattern of the brood could also indicate a pesticide problem.

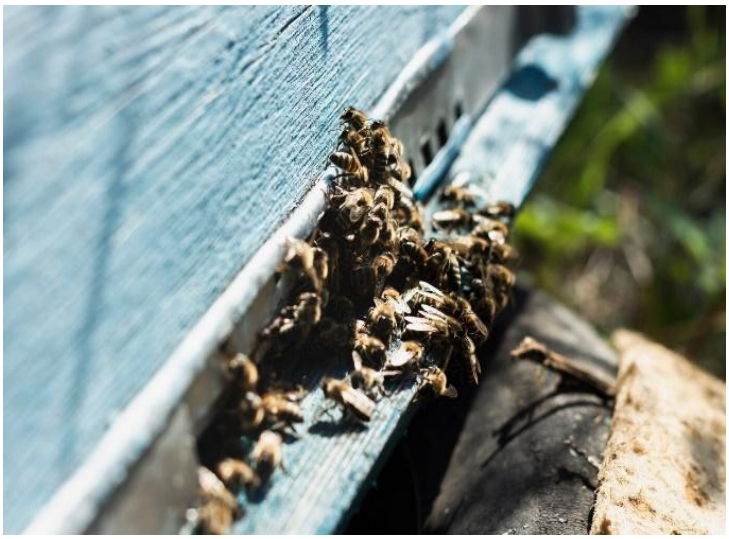

Fig 2. Number of died bees seen at hive entrance due to pesticide poisoning

Management of bee poisoning

1. **Use pesticides only when needed:** Application should be done only after surveying the crop fields for the presence of weeds, pest population or disease incidence for threshold levels.
2. **Do not apply pesticides while crops are in bloom:** use of different pesticides should only be performed only when the crop concerned is not in flowering stages.
3. **Apply pesticide when bees are not flying:** the most pollinators are active during 8 a.m. to 5 p.m. and in such favourable condition's pesticides should not be sprayed to help in protecting the forager bees from coming in the direct contact with pesticide applied. The application can be mostly in the early evening hours.
4. **Do not contaminate water:** contamination of nearby standing water through pesticides run off should be avoided to prevent the bee losses, as the bees collect water from these water sources to cool down the temperature of the colony during the summer season.

5. **Use fewer toxic compounds:** if the situation allows, then the compounds which are less toxic to the bees should be given preference over the highly toxic chemicals. The pesticide labels should notify the possible hazards to honey bees. If no other alternate option remains then the variations in dosages can be applied.
6. **Use fewer toxic formulations:** many pesticides work equally, when prepared in different formulations.
7. **Notify beekeepers:** beekeepers should be notified well before the application, as this time period will allow them to move their colonies to a distance where, pesticidal drift is minimal. Colonies can also be covered with the cloth to confine bees into the box itself to avoid any foraging for 1 or 2 days.

Recommended Policy Strategies

- Enact pollinator-friendly pesticide policies.
- Conserve & enhance pollination habitats.
- Support collaborative research and training

Table 1 Highly Toxic Pesticides to honey bees. This group includes materials that kill bee on contact during application and for one or more days after treatment.

Pesticides by Trade Name	Pesticides by Trade Name	Pesticides by Trade Name
bifenthrin (Capture, Brigade)	Agri-Mek (abamectin)	spinosad (Tracer)
carbaryl (Sevin)	Ambush, Pounce (permethrin)	spinetoram (Delegate/Radiant)
carbofuran (Furadan)	Belay (clothianidin)	spirotetramet (Movento)
cyfluthrin (Baythroid)	Cruiser (thiamethoxam)	Warrior(lambda-cyhalothrin)
cypermethrin (Ammo)	Cygon (dimethoate)	Spectracide (diazinon)
deltamethrin (Delta Gold)	Delta Gold (Deltamethrin)	Savey, Onager (hexythiazox)
dichlorvos (DDVP)	Delegate/Radiant (spinetoram)	Rimon (novaluron)
emamectin (Proclaim)	Diazinon (diazinon)	Poncho seed treatment (clothianidin)
methomyl (Lannate)	Movento (spirotetramet)	novaluron (Rimon)

Table. 2 Relatively non-toxic pesticides. materials in this group can be used with few precautions and a minimum of injury to bees

Pesticides by Trade Name	Pesticides by Trade Name
allethrin (Pynamin)	Altacor/Coragen (chlorantraniliprole)
amitraz (Mitac)	Avaunt (indoxacarb)
azadirachtin (Neemix, Align)	Beleaf (flonicamid)
Bacillus thurgingiensis or Bt (Biobit, DiPel, Full-Bac, Javelin, MVP, etc.)	Belt (flubendiamide)
cyromazine (Trigard)	Dipel (Bacillus thuringiensis)
flonicamid (Beleaf)	Fulfill (pymetrozine)
koalin (Surround)	Kelthane (dicofol)
pymetrozine (Fulfill)	Omite (propargite)
tebufenozide (Confirm)	Pynamin (allethrin)
trichlorfon (Dylox)	Spur (fluvalinate)

Conclusion

Pollinators are essential for ecology, agriculture, the environment, and humanity. They pollinate wildflowers all throughout the world, which helps agriculture and serves as a key indicator of environmental health. Furthermore, they are valuable and contribute to the global economy; nevertheless, their reduction owing to pesticides and the subsequent lack of pollination could result in a tremendous economic loss. As a result, investigations looking into more acceptable insecticide supervision tactics and more practical insecticides are urgently needed, as they will boost the beneficial contributions of insecticides to the agricultural economy while reducing off-target effects on honey bees. Based on these findings, we must continue to investigate eco-

friendly pest control measures as well as the effects of insecticide treatments on their intended and unintended targets in order to control pests responsibly in the future. Additionally, more biological control agents can be prioritized for pest control.

References

Favaro R., Bauer L. M., Rossi M., D'Ambrosio L., Bucher E. and Angeli S. (2019). Botanical origin of pesticide residues in pollen loads collected by honeybees during and after apple bloom. Frontier Science, 10(8), 1069-1072.

Glavan G., Novak S., Bozic J. and Kokalj J. A. (2020). Comparison of sublethal effects of natural acaricides carvacrol and thymol on honeybees. Pesticide Biochemistry and Physiology. 166(12), 1010-1015.

Johnson R. M. (2015). Honey Bee Toxicology. Annual review of Entomology, 60, 1–20.

Mickael H., Maxime B., Fabrice R., Orianne R., Jean-Francois O., Pierrick A., Jean A., Sylvie T. and Axel D. (2012). A common pesticide decreases foraging success and survival in honey bees. Science, 336(6079), 348-350.

Morrison L. M., Renaud J. B., Sabourin L., Sumarah M. W., Yeung K. K. C. and Lapen D. R. (2018). High-throughput quantitation of neonicotinoids in lyophilized surface water by LC-APCI-MS/MS. The Journal of AOAC International, 101(4), 1940–1947.

Mullin C. A., Frazier M., Frazier J. L., Ashcraft S., Simonds R., Vanengelsdorp D. and Pettis J. S. (2010). High levels of miticides and agrochemicals in North American apiaries: implications for honey bee health. Public Library of Science One. 102(4), 230-235.

Sillman J., Uusitalo V., Tapanen T., Salonen A., Soukka R. and Kahiluoto H. (2020). Contribution of honeybees towards the net environmental benefits of food. Science of the Total Environment, 756(5), 780-784.

Topping C. J., Aldrich A. and Berny P. (2020). Overhaul environmental risk assessment for pesticides. Science, 367, 360–363.

Zhao H., Li G., Cui X., Wang H., Liu Z., Yang Y. and Xu B. (2022). Review on effects of some insecticides on honey bee health. Pesticide Biochemistry and Physiology, 188 105219.

* * * * * * * *