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Challenges of Pesticides to Pollinator

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Human population growth and industrial development have led to increased and unsustainable consumption of natural resources. The resulting interrelated environmental pressures threaten global biodiversity and jeopardize the provision of crucial ecosystem services. Pollination is a high-profile example which mediates the transfer of pollen between flowers, aiding in production of fruits and seeds in approximately 88% of flowering plants. Among insects, Social and solitary bees, wasps, flies, beetles, butterflies, and moths comprise the vast majority of the world's pollinators for the pollination of fruit, vegetable, oil, seed, and nut crops. In insects bees are uniquely specialized for pollen transport and account for the bulk of pollination.

The widespread use of pesticides has emerged as a major concern for pollinator populations. Insecticides, herbicides, and fungicides are commonly used in agricultural practices, urban settings, and even home gardens to control pests and weeds. However, the unintended consequences of pesticide use on pollinators have become increasingly apparent. Usage of chemical fertilizers and pesticides reached at alarming situation. Honey bees and beekeepers are suffered more prominently due to practices used in agricultural development. It has been analysed that decline of honeybee population is due to application of insecticides like organochlorine, carbamate, organophosphorus, pyrethroid and neonicotinoids**.** Exposure to pesticides can occur through various routes, including direct contact with sprayed surfaces, ingestion of contaminated pollen and nectar, and the accumulation of pesticide residues in soil and water sources. These chemicals can have detrimental effects on pollinators, both in the short term and over extended periods. Acute toxicity can occur when pollinators are exposed to high concentrations of pesticides, leading to immediate adverse effects such as disorientation, paralysis, and even death (Chreil and Maggi, 2023). For example, certain insecticides target the nervous systems of insects, disrupting their ability to navigate, forage, and communicate effectively. This can result in pollinators being unable to find food sources or return to their hives or nests, ultimately impacting their survival. Furthermore, chronic exposure to sublethal doses of pesticides can have subtle but significant impacts on pollinators. Prolonged exposure weakens their immune systems, making them more susceptible to diseases and parasites. It can also impair their reproductive capabilities, including reduced fertility, altered mating behaviors, and decreased brood production. Over time, these effects can lead to population declines and ecological imbalances.

Routes of exposure of pollinators to pesticides

The various types of pesticidal formulations employ distinct pathways to traverse through plants, safeguarding them from diverse threats like weeds, pathogens, insect pests or rodents. Depending on the characteristics of the pesticides involved, three primary application techniques commonly employed for crop treatment include direct spray (commonly utilized in residential and garden settings), soil applications, and seed applications (typically employed in larger agricultural systems). These varied application methods significantly

influence the exposure of these chemicals to insect pollinators that visit crops. Some of routes include 1. Direct exposure when bees forage on treated plants 2. Particles from dust formulations adhering to foraging bees or the entire colony due to wind drift 3. Runoff from treated fields reaching nearby water reservoirs 4. Drift of pesticides onto non-treated plants growing adjacent to treated crops and 5. The presence of pesticide residues in pollen resulting from seed treatment**.**

Pesticides on pollinators

Intense crop management practices necessitate use of various types of pesticides which are harmful to pollinators**.** Instances of pollinator kills associated with pesticide use have been documented since the late nineteenth century, but the discovery in the mid2000s of parallel declines in wild pollinators and plants depending on pollinators along with widespread losses of managed pollinators raised the possibility that the effects of pesticides on pollinators might be more than merely episodic.

A) Direct toxicity: Direct exposure to either drift droplets, which are scattered during the foliar spraying of crops, dust from seed drilling at planting, or inhalation of volatile pesticides during or after application to the crops results in death of pollinators immediately or weaken the pollinator, making it more susceptible to other stressors or diseases. (Aoun *et al.,* 2020). Mostly systemic pesticides like neonicotinoids spread throughout plant tissues and can accumulate in plant nectar and pollen which are carried to colony impairs the nutritional quality of food and also brood death**.**

B) **Sub lethal effect:** Sublethal neonicotinoid exposure can impair brain function and the learned ability of foraging workers to relocate the hive in honey bees. Recognizing the potential risks posed by neonicotinoids and other pesticides, some countries and regions have implemented restrictions on their use, especially for certain crops known to attract pollinators.

C) **Acute toxicity:** Acute toxicity describes the immediate or short-term effect of pesticides, typically within one exposure event. Acute toxicity to bees can cause death on contact, disorient the bee, or otherwise prevent it from returning to the hive**.**

D) **Chronic toxicity:** *Chronic toxicity* occurs when bees are exposed to a pesticide with a low level of toxicity over a longer period of time. The effects may be subtle and become apparent gradually, affecting bees' growth, susceptibility to disease, and memory as well as colony longevity and reproduction, i.e., production of new queens. Since bees visit many different flowers throughout a day of foraging, they can be exposed to a combination of pesticides that may pose varying degrees of risk.

E) Loss of Habitat and diversity: Managing plant pests at the time of flowering period is very crucial to achieve maximum yield in agriculture. Pesticide use at this time lead to habitat degradation and loss of floral resources for pollinators. Mono-cropped agricultural landscapes often lack diverse plant species, reducing the availability of food for pollinators and making them sensitive to pesticides (Challa *et al*., 2019).

Management of pesticide toxicity on pollinators

Integrated Pest and Pollinator Management (IPPM): Embracing IPPM practices allows for the integration of various pest management strategies, such as cultural practices, biological control, and targeted pesticide applications while minimizing impact on pollinators. By reducing reliance on pesticides and incorporating alternative methods, the overall use of chemicals can be minimized, and pollinators populations can be conserved.

Use pesticides only when needed: Insect pests, pathogens, or environmental factors may infest or infect specific crops at various growth stages. Therefore, pesticide application should occur only after conducting thorough surveys of the crop fields to assess the presence of weeds, pest populations, or disease outbreaks, ensuring that these factors have reached threshold levels. This approach is essential for protecting the populations of insect pollinators and beneficial insects (Kumar et *al.,* 2020).

Pesticide labels and restrictions: Pesticide labels commonly provide detailed guidance to reduce potential harm to pollinators. These guidelines might advise applying pesticides during periods of reduced pollinator activity or refraining from spraying during flowering stages. Furthermore, some regions have imposed regulations limiting the use of pesticides harmful to pollinators in order to safeguard these essential species.

Avoid applying pesticides to plants during flowering: Do not apply insecticides that are highly toxic to bees at any time during flowering. The risk to pollinators is too great. If applying an insecticide is necessary, choose the least toxic product and plan to apply it well before or after the plants flower. Avoid applying systemic neonicotinoid insecticides to the soil around bee-attractive plants any time before bloom in the spring. Wait until the petals have dropped or use a bee-friendly product.

Habitat Conservation: Conserving and restoring pollinator habitat, such as native wildflower meadows and hedgerows, plays a crucial role in mitigating the impacts of pesticides (Aizen et al., 2019). By providing alternative forage sources and nesting sites, pollinators can access pesticide-free areas, reducing their exposure and promoting their overall wellbeing.

Use less toxic chemicals and formulations: Dust formulations are more toxic to bees as they drift more. Micro encapsulated granules which are in almost size of pollen may mislead bees as they carry it to the hive where it is mixed with pollen. Among insecticides Pymetrozin, *Beauveria bassiana* are considered safe to bees than others.

Conclusion

In nutshell, the challenges posed by pesticides to pollinators are multifaceted and demand urgent attention. The evidence overwhelmingly suggests that pesticides, particularly neonicotinoids and other systemic insecticides, contribute significantly to the decline of pollinator populations worldwide. These chemicals disrupt crucial behaviors such as foraging, navigation, and reproduction in bees, butterflies, and other pollinators, ultimately jeopardizing global food security and ecosystem stability.

Addressing these challenges requires a comprehensive approach that balances agricultural needs with environmental preservation. Implementing stricter regulations on pesticide usage, promoting integrated pest and pollinator management practices, and investing in research for safer alternatives are critical steps. Furthermore, enhancing public awareness and education about the importance of pollinators and the risks associated with pesticide use can foster widespread support for conservation efforts.

Ultimately, safeguarding pollinator populations is not only a matter of ecological preservation but also essential for human well-being. By mitigating the adverse effects of pesticides on pollinators, we can strive towards a sustainable future where agriculture thrives in harmony with the natural world.

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