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ORIGINAL PAPER

The harmful impact of pesticides on Solitary bees

[1]*Kaushik Pramanik, [2]Amit Layek, [3]Rakesh Das and [4]Debashis Mandal

[1,2,3,4] *Ph.D. Research Scholar, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal- 741252, India*

**Corresponding Author: kpramanik.kaushik@gmail.com*

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ABSTRACT

Pollinators provide vital and economically significant ecological services for crops and wild plants. Threats to wild and managed insect pollinators are cause for both ecological and socio-economic degredation. Compared to social bees, most non-Apis bees are solitary, short-lived, and have limited geographic and nutritional ranges. In recent years, multiple anthropogenic pressures may be aggravating pollinator declines. Exposure to chemicals, such as pesticides and other pollutants, is one of the most important factors among all. The ubiquity with which pollinating insects interact with human-dominated landscapes brings them into the frequent intersection with anthropogenic chemicals. Neonicotinoid insecticides have been implicated in dramatic bee diversity and decline of their abundance. It is believed that the widespread use of pesticides to protect our harvested crops poses a substantial risk to agricultural landscapes worldwide, particularly the application of systemic neonicotinoid insecticides, which have grown significantly over the preceding ten years. These pesticides could negatively impact the environment, especially when considering the chance that various species will be exposed to them differently in the wild. These findings suggest that additional research is needed to fully comprehend how variances in toxicokinetics vary between species and chemical mixtures.

Keywords: Pollinator, insecticide, neonicotinoid, sublethal effect, bee decline.

INTRODUCTION

Bees, among other insects, are essential for pollinating wild plants and crops, helping to maintain biodiversity, preserving ecological stability, and providing food. Crop pollination is a crucial aspect of how ecosystems work and how services are provided by bees. Nevertheless, several environmental factors pose a threat to bee populations globally. Recent studies on pollinator reductions worldwide are concerning, especially in light of the high and rising demand for pollination services. Bees come in contact with the chemicals in various situations, whether employed in domestic areas to control mosquitoes, pests in lawns and gardens, or in farming systems to manage weeds, fungi, and arthropod pests. Recent decreases in pollinator populations, particularly in various wild bee and butterfly species, have been strongly linked to both single and cumulative pesticide exposure. It is believed that to protect our cultivated crops, the widespread use of pesticides poses a severe risk to agricultural landscapes, particularly the systemic neonicotinoid insecticide application, which has grown significantly worldwide over the past ten years. Ecotoxicology thus seeks to quantify the effects of chemicals on biological endpoints in order to determine the possible risks of a xenobiotic and serves as a crucial foundation for stakeholders to implement effective mitigation strategies.

Nesting behaviour of solitary bees

Solitary bees create brood cells in reeds, ground crevices, old cracks in woody stems, and the trunk of trees that are present naturally. However, they also readily employ artificial tunnels made by beekeepers. Commercial tunnels are typically constructed of wood or cardboard and positioned inside shelters. Bees will use these shelters to build large artificial aggregations of nests. Each female bee is the only reproductive individual and constructs her own nest, occupying one chamber at a time during egg-laying. To divide up the brood cells inside the nest, solitary bees employ a variety of materials, including soil, chopped, or chewed plant tissue, glue, or a mixture of these (Cane *et al.,* 2007).

In contrast to honeybee colonies, where workers gradually feed the larvae, solitary bee mothers use pollen and nectar she gathers from blossoms to produce a mass quantity in 1 day or less. Then she deposits an egg on the food mass, and the larva grows to adulthood using only this food supply (Bosch and Kemp, 2001). To create several nest cells per cavity, the process is repeated. Brood spends a year in nests developing and overwintering before emerging as adults in the following season. Nesting bees typically live for 4-6 weeks.

Chemical Characteristics of pesticides

The chemical composition of a pesticide affects the capacity of the product to come into touch with or penetrate the target pest, as well as how the pesticide may finally settle in the environment. Three agrochemical properties— hydrophilicity, lipophilicity, and soil adsorption—are essential for comprehending their persistency in the environment and enhancing pesticide exposure pathways for bees foraging freely in an agricultural landscape.

Some pesticides can work systemically because they influence the chemical's buildup for plant uptake and bioavailability in the environment. As a plant develops, systemic pesticides have the potential to spread throughout the entire plant, which means they may be present not only in the vegetative part but also in possible quantities in nectar and pollen. An object's hydrophilicity is its affinity toward the water. The affinity for lipids of a chemical is known as lipophilicity. A pesticide's attraction to lipids enables it to penetrate the lipid layers in the cuticle of both plants and insects, helping to spread the targeted toxin and enhance its impact on pests. In an ecosystem, a pesticide can enter right away through processes like spray application, dust in the soil or air from seed treatments, irrigation system additives, incidental runoff, and spray drift that goes ahead of intended targets (Tsvetkov *et al.,* 2017). However, pesticides can be present in the foraging environments of bees even before they visit a crop in flower because water and soil are the fundamental sinks for pesticides.

Different exposure routes of pesticides in Solitary bees

The solitary bees, particularly the cavity-nesting bees, are susceptible to numerous potential sources of contamination. The various sources of contamination are-

1: Through direct contact with pesticides

The most straightforward and direct exposure pathway for solitary bees is the contact between contaminated food materials and adult bees (Biddinger *et al.,* 2015). Bees can sit on or move through pesticide-infested soil, flowers, grass, leaves, artificial nesting materials, and even water found in treated gardens or fields directly during pesticide applications; the sprayed droplets directly contaminate the bees. When toxins touch the bee cuticle, they may either pass through it directly or enter the body through pores or spiracular holes.

2: Ingestion of the adults

Certain studies also demonstrate that adult bee food, nectar, and pollen can be polluted, which can negatively affect solitary bees (Gill and Raine, 2014). Adult solitary bees that are active frequently take nectar to keep themselves energized, and newborn female bees also do so to aid in pollen consumption for ovarian maturation and egg formation.

Another method of adult pesticide ingestion may involve the manipulation and movement of soil and leaf material with the help of the mandibles and tarsi. Bees like *M. rotundata* females may unintentionally consume chewed contaminated leaf matter and plant juices, while mason bees like *O. lignaria* may consume water or soil particles when building their nests. Bees also groom their bodies, using their mouthparts to clean various body parts, and by doing so, they may ingest toxins or polluted items.

Route 1: Larval Ingestion

The interaction between the bee nesting behaviour and the pesticides available in the environment form the pathways through which pesticides reach the restricted food stores to the larvae of solitary bees. There is no means for the larva to avoid ingesting contaminants (other than to stop feeding). If pollen, nectar, or both carry pesticides due to systemic uptake by the plant, then larval survival or later adult fecundity may suffer. The materials used to create the nest (often leaves or soil) that the mother bee shapes into partitions or cell linings may also expose the larvae via eating. Pesticides' translaminar and systemic activities might cause leaf material to become contaminated on the outside as well as from the inside.

Route 4: Transovarial Transmission

Although the purpose of pesticides is to control the reproduction of insect pests and safeguard a crop, they may also adversely affect pollinators' reproductive success and availability in the future. The solitary bees are suppressed through the transovarial transmission of chemicals, which occurs when pesticides consumed by the mother bee have a negative impact on her young. Pesticides that cause transovarial transmission is either consumed by adult females or seep through their cuticles. The immediate impacts of this exposure approach on reproduction are low or no egg survival or decreased egg output (Hoffmann *et al.,* 2008).

Detrimental effects of pesticides on Solitary bees

Pesticide exposure can have sublethal effects on various physiological and behavioural characteristics, such as biochemical and enzymatic processes, neurophysiology (such as learning and orienting), ontogenesis, immunological functions, or reproductive features. When the *Megachile* and *Osmia* cavity-nesting bees (Hymenoptera: Megachilidae) are exposed to pesticides directly during the application or by gathering and consuming nectar and pollen, they are exposed to pesticides in a manner similar to honeybees. They can, however, differ from honeybees in their exposure to pesticides through plant materials, water, and soil, as well as in their vulnerability to some chemicals and their capacity to recover from contact or ingestion, due to differences in their ecology, physiology, biology, and genetics (Heard *et al.,* 2017). Different pesticide exposure pathways, intensities, and consequences may result from nesting behaviour, habitat kinds and locations, seasonality, immunological responses, and detoxifying processes. Surprisingly, pesticide laws essentially disregard solitary bees. The direct correlation between a female's performance and her ability to reproduce makes solitary bees considerably more practical models for measuring fitness than social bees (honeybees and even bumblebees). Additionally, thorough research into how pesticides affect solitary bees with various life-history attributes (such as flight season, nesting behaviour, habitat, and feeding specialization) would give much-needed and stronger insights into the broader environmental effects of plant protection chemicals.

Effect of neonicotinoids on Solitary bees

Neonicotinoids quickly overtook other insecticides as the most extensively used worldwide after their introduction in the early 1990s. Neonicotinoids differ from conventional pesticides due to a special combination of attributes, including high toxicity, prolonged persistence, high systematicity, and high mobility. Additionally, because they are systemic, they can be discovered in a variety of aquatic and terrestrial compartments, including organic ecological flower strips, and agricultural soils that have been treated previously. As a result, these broad-spectrum insecticides cause a significant threat to creatures that are not their intended targets. Neonicotinoids cause a depolarizing blockade by acting as an agonist of postsynaptic nicotinic acetylcholine receptors, which causes paralysis and ultimately results in the death of the affected organism. Because neonicotinoids are systemic, nontarget pollinating insects may be directly exposed to them in flowering crops by transporting residual trace amounts from vegetative plant parts into nectar and pollen, resulting in harmful sublethal effects (Cresswell e*t al.,* 2012). But when French beekeepers noticed the unusual behaviour, sharp declines in honey output, and catastrophic colony losses in hives close to sunflower and maize fields sprayed with neonicotinoid-coated seeds (Gaucho®), neonicotinoids initially gained attention. Bees were purportedly exposed to the active ingredient's residue through the consumption of pollen and nectar. The abrasion of the coated seeds produced by the pneumatic sowing equipment was contaminating the flowers in the vicinity of cornfields with dust loaded with neonicotinoids. In a semi-field investigation, Whitehorn *et al.* (2012) found that two weeks of neonicotinoid treatment markedly inhibited subsequent colony growth and dramatically decreased daughter queen production. Clothianidin, another neonicotinoid, has recently been shown to have similar effects on bumblebee colony fitness using a similar experimental approach (Larson *et al.,* 2013). Research associated with the agrochemical sector refuted the notion that Gaucho® causes the so-called "French bee malady."

Need for research

All bees are at risk of exposure to pesticides that can easily contaminate nectar and pollen and harm both adult and larval stages. The importance of pesticides expressed in leaves and retained in soils for solitary bee exposure cannot be exaggerated. Systemic and translaminar insecticides (such as neonicotinoids and benzoylureas, respectively) will deliver a pathway of exposure for bees that utilize vegetative materials in nest construction. The soil that orchard bees collect to utilize for nesting may contain persistent chemicals in the soil year-round, such as pyrethroids, spinosyns, and anthranilic diamides.

In some circumstances, using treatments with precise targeting, action on just immatures, or minimal environmental perseverance may lessen the threat to pollinators. In addition to honeybees, certain government organizations (such as those in the European Union, United States, and Australia) are shifting toward pesticide studies for bumble bees and some solitary bees (such as the European red mason bee, *O. bicornis*; EFSA, 2014). Using an ecosystem approach that looks at a representative group of bees to take into account conditions unique to non-Apis wild and managed bees, as well as how ecosystem services may be affected; as a result, additional significant routes may be realized. This extends beyond the paths that have already been researched within the present honeybee standards (Stanley *et al.,* 2015). More practical and useful studies can be conducted to learn more about the direct and indirect factors that could lead to pollinator stress, decline, or extinction. A thorough understanding of how pollinators are exposed to pesticides makes this possible.

CONCLUSION

Finally, the data and prior research indicate that if sublethal parameters and underlying biological mechanisms are ignored, evaluating survival for assessing the risk presented by pesticides may result in insufficient conclusions. Fitness or hints of fitness must be considered early in risk assessments (i.e., to prevent false-negative results), as fitness is ultimately the primary factor governing all-natural populations. In order to lessen the effects of agricultural pesticides and safeguard natural biodiversity, we can take the following measures:

- If at all possible, do not spray blooms directly with pesticides.
- Pesticides come in different formulations-Solutions, emulsifiable concentrates, and granular are the best formulations to use.
- Many of the newer pesticides being marketed today have a faster residual time which is the time required to reduce the activity of the chemical to safer levels for bee activity. When these pesticides are sprayed in the fields, it takes only a few hours for them to degrade as opposed to a few days or weeks.
- The method of application can also change the risk of pesticide poisoning. Aerial applications have the highest potential risk of causing bee kills. Most bee kills occur when the pesticide drifts or moves from the target area into the apiary or onto crops attractive to the bees. The outcome of drift can be catastrophic. Spraying during windy days dramatically increases the risk of drift.

Therefore, agreement on sufficient and adequate test guidelines for solitary bees is urgently necessary to enable the collection of trustworthy and reproducible data.

REFERENCES

Biddinger, D. J., and E. G. Rajotte. 2015. Integrated pest and pollinator management- adding a new dimension to an accepted paradigm. *Curr. Opin. Insect Sci.,* **10**: 204–209.

Bosch, J., and W. P. Kemp. 2001. How to manage the blue orchard bee as an orchard pollinator. Sustainable Agricultural Network, Handbook No. 5, National Agricultural Library, Beltsville, MD.

Cane, J. H., T. Griswold, and F. D. Parker. 2007. Substrates and materials used for nesting by North American *Osmia* bees (Hymenoptera: Apiformes : Megachilidae). *Ann. Entomol. Soc. Am.,* **100**: 350–358.

Cresswell, J.E., Desneux, N. and van Engelsdorp, D. (2012) Dietary traces of neonicotinoid pesticides as a cause of population declines in honeybees: an evaluation by Hill's epidemiological criteria. *Pest Management Science*, **68**: 819–827.

EFSA (European Food Safety Authority). 2014. Towards an integrated environmental risk assessment of multiple stressors on bees: review of research projects in Europe, knowledge gaps and recommendations. *EFSA J.,* **12**: 3594.

Gill, R. J., and N. E. Raine. 2014. Chronic impairment of bumblebee natural foraging behaviour induced by sublethal pesticide exposure. *Func. Ecol.,* **28**: 1459–1471.

Heard, M., S. J. Baas, J.-L. Dorne, E. Lahive, A. G. Robinson, A. Rotais, D. J. Spurgeon, C. Svendsen, and H. Hesketh. 2017. Comparative toxicity of pesticides and environmental contaminants in bees: are honeybees a useful proxy for wild bee species? *Sci. Total Environ.,* **578**: 357–365.

Hoffmann, E. J., S. M. Middleton and J. C. Wise. 2008. Ovicidal activity of organophosphate, oxadiazine, neonicotinoid and insect growth regulator chemistries on northern strain plum curculio, *Conotrachelus nenuphar*. *J. Insect Sci.,* **8**: 29.

Larson, J.L., Redmond, C.T. and Potter, D.A. (2013) Assessing insecticide hazard to bumble bees foraging on flowering weeds in treated lawns. *PLoS One*, **8**: e66375.

Stanley, D. A., M. P. D. Garratt, J. B. Wickens, V. J. Wickens, S. G. Potts and N. E. Raine. 2015. Neonicotinoid pesticide exposure impairs crop pollination services provided by bumblebees. *Nature,* **528**: 548–550.

Tsvetkov, N., O. Samson-Robert, K. Sood, H. S. Patel, D. A. Malena, P. H. Gajiwala, P. Maciukiewicz, V. Fournier, and A. Zayed. 2017. Chronic exposure to neonicotinoids reduces honeybee health neat corn crops. *Science*, **356**: 1395–1397.

Whitehorn, P.R., O'Connor, S., Wackers, F.L. and Goulson, D. 2012. Neonicotinoid pesticide reduces bumble bee colony growth and queen production. *Science,* **336**: 351–352.