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Conservation of Pollinator Diversity in the Era of Neonicotinoids

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More than 80 per cent of the approximately 350,000 species of flowering plants in the world depend partially or completely on insects, mostly bees, for sexual reproduction. This interaction between plants and bees is the basis for sustaining much of the biodiversity on Earth. Pollinators are vectors of genetic exchange.

Although honey bees constitute major pollinators of several cultivated crops, they are always considered as important in managed pollination. However, several species of cultivated crops depend on non-*Apis* bees, which are solitary. In fact, there are more than 800 species of non-*Apis* bees in India (~20,000 species in the world), which are wild pollinators of several crops and wild plant species. The survival of many species of plants in the wild, in short the plant diversity itself, depends on visits to their flowers by these bees.

In recent years, there has been a concern about decline in pollinator populations at the global level. The possible reasons attributed for this are, loss of habitats – including nesting sites for bees, loss of flora that sustain bee populations, monocropping, mismatch between flowering phenology and bee activity and excessive use of chemicals in agriculture (Potts *et al*., 2013). Of these, indiscriminate use of herbicides and insecticides has been considered to be major.

Beginning of the Era of Neonicotinoids

Use of insecticides has been a more common method of pest control. By 1980s many insect pests had developed resistance to the then available chemicals in the market belonging to organophosphates, carbamates and pyrethroid groups (Alyokhin *et al*., 2008). Against this background, insecticides belonging to neonicotinoid group were projected as having several advantages, including selective toxicity to arthropods, high persistence, systemic nature, versatility in application (especially as seed treatments), high water solubility, and assumed lower impacts on fish and other vertebrates. Understandably, neonicotinoids have been the most widely used class of insecticides worldwide since the 1990s. Their application ranges from plant protection and veterinary pest control to invertebrate pest control in fish farming. Neonicotinoids are systemic insecticides. Irrespective of the mode of application and route of entry, they translocate to all parts of the plant, making the entire plant toxic to the insects that feed on it. The discovery of imidacloprid by Shinzo Kagabu, followed by its introduction to the market in 1991, started the era of neonicotinoid class of insecticides (Tomizawa and Casida, 2011). Soon other insecticides followed – thiamethoxam and Clothianidin in 1999 (Maienfisch *et al*., 2001). By 2010, neonicotinoids ruled the market and became the most widely used insecticides globally (Casida and Durkin, 2013) with a few more insecticides of the same group quickly added (acetamiprid, thiacloprid, dinotefuran and nitenpyram). Of all these, imidacloprid became more popular since it was available in several formulations as foliar sprays, soil application and seed treatment, and became a panacea for almost all pest problems on a variety of crops. No wonder this insecticide became most popular among farmers worldwide, and probably also resulted in over use or misuse of the formulations. Today there are over half-a-dozen multinational pesticide companies formulating insecticides of this group and competing in the market. Neonicotinoids have been registered in more than 120 countries. With a global turnover of over €1.5 billion, they represent more than 25% of the global market for insecticides.

Are Neonicotinoids harmful to bees?

Though many insecticides are known to be unsafe to bees, more recently, the use of neonicotinoids has been specifically pointed out as a factor that might contribute to declines of both managed and wild bees (Goulson, 2013). Neonictotinoids are used on crops in three ways. There are formulations that are used for seed treatment,

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some are used for soil application and as foliar sprays on several crops. Even when they are used for seed treatment, low concentrations are subsequently found in the nectar and pollen of the crop, which is in fact surprising. Thiamethoxam used for seed dressing was present in all pollen samples and a majority of nectar samples collected from oilseed rape (3.26 ± 2.16 ng/g in pollen, 3.20 ± 4.61 ng/g in nectar) (Bonmatin *et al*., 2014; Botias *et al*., 2015). Studies have also found that foraging bees brought back to the nest pollen and nectar contaminated with on average 71.8 ng of neonicotinoids/ day (Botias *et al*., 2015).

What is the effect on bees?

Neonicotinoid contamination need not always result in death of bees. More often bees get sublethal doses. Sub-lethal doses of 1-24µg/kg and 0.1 - 20 ng/bee have been shown to impair navigation, foraging behaviour, feeding behaviour, and olfactory learning performance in honeybees (Decourtye, 2004). The result is that a foraging bee will not be able to navigate and find its way back home leading to a sudden decline in the population of a bee colony. Further it has also been shown that the foraging bees do not avoid visiting neonicotinoid sprayed plants (Kessler *et al*., 2015).

Are neonicotinoids responsible for CCD?

Colony Collapse Disorder is the sudden disappearance of worker bees from their hives, resulting in collapse of the colony. In the US, between 2005 and 2015, millions of colonies were affected. One of the reasons for CCD is attributed to the extensive use of neonicotinoids. Though there has been a lot of debate on the issue (Lundin *et al*., 2015), several developed countries have banned or brought neonicotinoids under restricted use. And, there is hardly any data on the effects of neonicotinoids on Indian bees.

Conservation of pollinator diversity

Conserving pollinator diversity is important for our own survival, because we depend more directly on this ecosystem service, as many agricultural crops rely to some degree on pollinators for setting seeds that we use for our consumption. Nearly 70% of 1330 tropical crops have shown improvement in fruit or seed quality and quantity with bee visitation (Roubik, 1995) and it is estimated that about one-third of our food is derived from pollination service provided by bees (Klein *et al*., 2007). Globally the annual value of pollination service by insects to cultivated plants is estimated to be around €153 billion (Gallai *et al*., 2009). Wild pollinators are as important as managed bees in terms of the economic value of their role (Kleijn *et al*., 2015) and hence it is necessary to take suitable measures to conserve both *Apis* and non-*Apis* bees. Conservation measures should include identifying and protecting nesting habitats, development of floral calendars and making available resources after the cropping periods for sustaining populations and of course identifying and popularizing safer pesticides or pest control methods.

We do not know whether the era of neonicotinoids will continue or whether the bees will survive the era.

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