20 November 2015

Neonicotinoids Induce Negative Side Effects in Bees, Resulting in Colony Collapse

The relationship between neonicotinoids and the decline in pollinators has brought disagreement among scientists. Neonicotinoids are a systematic insecticide that are applied by coating the seed of the target plant, and absorbed and distributed throughout the plant with growth, providing protection from insects. The potent insecticide functions by disrupting the neural transmissions and overstimulating the central nervous system of insects, leading to paralysis and eventual death. As the neonicotinoids are absorbed by the plant, the nectar produced will also be laced with neonicotinoids, hence poisoning the bees that feed upon them. Neonicotinoids affects bees negatively, even in small dosages, reducing memory, homing, foraging, and flower recognition abilities; this accelerates colony collapse disorder, and therefore, its use should be banned, as in European countries such as France, Italy, and Switzerland.

The effects neonicotinoids have on bees varies with the concentration ingested by the pollinator, ranging from decrease in motor, foraging, navigating, memory, and olfactory learning abilities, to paralysis and death (Tan et al., 2015). For acute toxicity to be observed, the concentration in bees must be greater than 3.7 µg/kg (Bonmatin et al., 2005). Henry et al. fed bees a concentration of 67 µg/L and left them to forage; an increase of 10.2-31.6% mortality rate due to homing failure was found. Henry et al. concluded that a forager that consumed 67 µg/L was twice as likely to die in comparison to one that did not consume any neonicotinoids (2012). Decouryte, Lacassie, & Pham-Delègue fed bees 7.5 µg/kg of neonicotinoids, and doubled each dosage until 240 µg/kg. They found that the mortality rate increased from 3.3% to 41%, with the exception at 60 µg/kg, where the mortality dropped 10.5% (Decouryte et al., 2003). While the growth of mortality rate in bees was found to be disproportional to the concentration of neonicotinoids ingested, it can be concluded that an increase in concentration of the toxin led to a higher mortality rate. Apart from physical symptoms, neonicotinoids also causes neural damage. Tan et al. found that the toxin impaired both short-term memory learning and long-term memory retention of bees when fed 20-100 μg/L neonicotinoids; bees that were not treated by the toxin had an improved learning acquisition of up to 420% (Tan et al., 2015). Williamson, Barker, and Wright also found that bees 2.6 μg/L of neonicotinoids had hindered olfactory learning abilities and reduced memory; in contrast to Henry et al. (2012), bees fed 26 μg/L suffered from paralysis and were unable to continue the experiment. (2012). Colony-wise, it was found that the queen production rate was lowered with neonicotinoid usage; colonies treated with 6 μg/kg and 12 μg/kg were only able to produce 14% and 10%, respectively, of the average number of queens produced by the untreated colonies (Whitehorn et al., 2012). However, as the production of queens is affected by the size of the bee colony, it cannot be concluded that neonicotinoids are directly responsible for the lowered rate, but the increased mortality due to the toxin that reduces the bee population may be a more practical explanation. From the data presented by these researchers, it confirms that neonicotinoids are harmful to bees, even if the concentration of the insecticide was not large enough to kill the bee. Neonicotinoids in small doses damages and disrupts the bees' learning and navigation abilities; in large concentrations, neonicotinoids cause paralysis. In both cases, mortality rates are indirectly increased, thus impacting the queen production rate negatively.

As neonicotinoids exist in sub-lethal amounts in nectar and pollen, bees who have ingested the insecticide-laced nectar do not die immediately, thus bringing the toxins back to the hive, spreading neonicotinoids to other bees. The distribution of poison-laced pollen will expose bees that would not regularly come in contact with neonicotinoids, hence causing an increase the mortality within the hive. On average, bees collect 15mg of pollen every trip, therefore containing $5.85 * 10^{-5}$ µg/kg (Winston 117). While no observable side effects will occur until the threshold concentration of 3.7 µg/kg (Bonmatin et al., 2005), the toxins will slowly accumulate within the bees (Rondeau et al., 2014). Over time, due to the circulation of toxic pollen, the threshold of observable level of acute toxicity will be reached, increasing the mortality rate of not only foraging bees, but as well those in the hive. Thus, as the amount of neonicotinoid consumed increases, the mortality rate of the colony will also increase (Decouryte et al., 2003). In combination with the 10-31% of foragers that die due to homing failure, found by Henry et al., the death of bees within the colony due to an excessive buildup of neonicotinoids will cause a dramatic decrease in population (2012). As the rate of queen production is dependent on the size of the colony (Whitehorn et al., 2012), the reduced colony size will therefore cause less queens to be produced, and ultimately, the collapse of the colony.

Most importantly, Kessler et al. suggested that bees are able to distinguish the presence of neonicotinoids, and prefer neonictinoid-laced pollen over non-neonicotinoid-laced pollens. In Kessler et al.'s experiment, bees were given the choice between two food sources: a sucrose solution containing neonicotinoids with concentration of 100nM, and one that was pure sucrose. It was found that the bees were attracted to the neonicotinoid-laced sucrose and consumed less food than the bees in the control group that are only exposed to pure sucrose solutions (Kessler et al., 2015). The results imply that in field-conditions, bees will not only choose neonicotinoid-laced pollen over regular pollen, but as well, refutes the argument that "the actual amount of [neonicotinoids] consumed by individual bumblebees... will be diluted through foraging from other sources" (Godfray et al., 2014). This study is especially significant in determining whether neonicotinoids are safe to be used. As bees would choose to collect pollen from a source containing neonicotinoids, they are more likely to attain the threshold where acute toxicity is observed, resulting in impaired olfactory learning and memory, an increase in homing and foraging failure, and lowered queen production.

An abundance of experiments has been conducted to determine whether the concentration of neonicotinoids found in field conditions is safe for bees; the main rebuttal is that the dosages used in laboratory settings are often greater than the concentration found in field conditions. Whitehorn et al. fed two colonies of bees different dosages of neonicotinoids: one with a dosage of 6μg/kg of neonicotinoids in pollen and the other colony with a dosage of 12 μg/kg. The colonies were treated for fourteen days before left to forage freely in a field environment. When examined in six weeks, Whitehorn et al. observed that there was "no significant differences between treatments were found in numbers of males, workers, pupae, and empty pupal cells", but a large decline in queen production rates (2012). Henry et al. fed bees with a dosage of 67 μg/L and left to forage freely while being monitored, and observed an increase in mortality rate due to homing failure (2012). Conversely, in field conditions, Whitehorn et al. found that the concentration present in pollen and nectar ranges from 0.7μg/kg to 10μg/kg (2012); Schmuck et al. found that the average concentration of neonicotinoids in pollen is 3.9 +/- 1.0 μg/kg (2014); Tan et al. determined the concentration of neonicotinoids found in pollen to be in the rage of 1.9μg/L and 26.7 μg/L (2015). Therefore, as the concentration of the toxin found in pollens were significantly below the concentration administered by both Whitehorn et al. and Henry et al. both experimental results are impractical to be repeated in actual field conditions. However, as bees would choose neonicotinoid-laced pollen over regular pollen, a significant amount of neonicotinoid will accumulate within the pollinators' nervous system (Kessler et al., 2015). Due to the cumulative quality of neonicotinoids (Rondeau et al., 2014), a buildup was observed to occur within three days of treatment, thus regardless of the concentration, bees will be impacted by the toxin (Moffat et al., 2015). Neonicotinoids does exist in very low concentrations in field conditions, however, due to the nature of the toxin, it still poses a threat to bees. The continued use of neonicotinoid treatments will cause a decline in pollinator population.

Neonicotinoids are being more widely used, and are becoming a greater problem for the bee population and the pollinator community. Regardless of the concentration of the insecticide found in actual field conditions, neonicotinoids reduce memory, homing, foraging, and flower recognition abilities, ultimately causing colony collapse disorder, as observed in the various experiments conducted. As well, the experiment by Kessler et al. (2015) confirms the preference bees have for neonicotinoid-laced sources; bees therefore lack the opportunity to dilute the toxin, shortening their lifespan. In addition, the cumulative nature of the insecticide allows the threshold of acute toxicity to be reached even when low concentrations of neonicotinoids are found. The effects of neonicotinoid, en masse, hastens the mortality of bees, thus inducing colony collapse disorder. Therefore, strong scientific evidence has proven that neonicotinoids are damaging to pollinators and causing a decline in bee population; thus, its usage should be banned.

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