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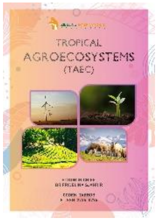

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*RESEARCH ARTICLE*

# INSECTICIDAL EXPOSURES MODULATES THE BENEFICIAL INSECT'S BIODIVERSITY IN AGROECOSYSTEM

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**ABSTRACT**

Beneficial insects have inevitable contributions for pollination and natural pest control in agriculture. But farmers are struggling to boost up the crop production with chemical application in controlling insect pests enormously without knowing the ultimate consequences. Asia covers 59% of the world's total insecticide usage. Insecticidal exposures share different modes of action with parasitoids and predators. They affect the survival of insects, reduce the capacity of reproduction, change insect behavior, alter the host's availability for parasitism or predation, and sometimes cause direct death. Among the different pesticides, clothianidin and pyridaben recorded in decreasing 86.44% and 83.54% of the honeybee population (86.44 and 83.54%) indicating their toxicity to the bee pollinators reduction. Dimethoate causes the total mortality of aphid parasitoid *Aphidius ervi*. while Azadirachtin showed 40.43% emergence rate at the dose of $LC_{25}$ for both the male and female insects, and pyrethrum insecticides have sublethal effects on the lifespan of *Chelonus oculator*. The nicotinoids, pyrethroid, and organophosphorus groups have a residual impact on the nectar and pollen biology. Residues of imidacloprid @ 19.7μg/kg found in pollen and 6.0μg/kg in honey those potentially affecting on the bee activity. Moreover, sulfoxaflor exposure has extensive sub-lethal effects on wasps, especially available as beneficial insect in the crop fields. This study findings revealed the necessities for future research on the harmful effects of synthetic and natural insecticides on the beneficial insects. Furthermore, it has been suggested that Integrated pest management (IPM) that involves sustainable ecosystem-based pest management techniques Might be an effective and efficient alternative of the insecticides for conserving the beneficial insects in the agroecosystem for the betterment of our future generations.

**KEYWORDS**

Agroecosystem, beneficial insect, insecticides, residues, sub-lethal.

## 1. INTRODUCTION

Insects are one of the most significant components for the ecosystem management in agriculture, some of them are beneficial insects, and some are recognized as pests (Ndakidemi et al., 2016). Insects that cause economic damage to crop production are insect pests, whereas insects that help crop production are beneficial. Pollinators, many predators, and parasitoids are all beneficial insects in agriculture. Beneficial insects like bees, wasps, lacewings, and other natural enemies are diverse insects that provide valuable services like pollination and pest control. Pollinators are responsible for around 35% of the world's food production through pollination process (Potts et al., 2016). Beneficial insects and natural enemies are efficient biocontrol agents and crop pollinators to our agroecosystem (Siviter and Muth, 2020).

Every year, pests are causing substantial economic losses all over the world. Insecticides have a variety of chemical classes that are toxic to insects, and they are prone to change throughout time. Insecticides that are engaged in agriculture have chemical and biological origins. Almost every insecticide has the capability of dispersing habitats. Many insecticides are hazardous to insects and people, and some become more concentrated as they are transportable to the food chain. Chemical insecticides are actively used in crop production (Karise and Raimets, 2017). Insect pest control has always been a persistent issue for agricultural production and producers worldwide (Khan et al., 2017).

Insect pests and beneficial insects of many orders live in agroecosystems, subjected to agricultural techniques, particularly chemical treatments (Zibaee and Malagoli, 2020). Insecticides are a diverse collection of compounds used in agroecosystems that have multiple impacts on insect biodiversity. However, insecticides used in agricultural ecosystems significantly impact beneficial insect populations, altering insect physiology, development, and insect biodiversity (Olivares et al., 2021). Beneficial insect fatalities will endanger biodiversity and crop production practices, ecosystem, and food production (Goulson et al., 2015). Insecticide applications help to mitigate insect pests, but this chemical control may also alter the biodiversity of helpful insects. This alteration can cause crop production loss in agriculture.

Insecticides have recently been used in today's agriculture owing to the development of pests and pathogens. Insecticides for pest control are popular with farmers worldwide because of their excellent crop-protection capabilities and consistency (Ahmed et al., 2011; Fan et al., 2015). But the negative side is that the number of species, species

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composition, and physiological activity of beneficial insects is disrupted due to insecticidal exposures. The majority of commercial field agricultural pesticides (insecticides) have broad-spectrum action. It can kill both beneficial insects and pest species. Chemical insecticides, like other pesticides, hurt non-target species like bees, wasps, lacewings, hoverflies, etc., mainly when applied as an aerial spray (Susphire, 2021). Insecticides sometimes leave polluting residues, which can cause direct or indirect impacts on individuals (Zhang, 2018).

Insecticides help in providing the opportunity for timely treatment. On the other hand, it will destroy natural enemies and pollinators. Many regions of the world have seen a reduction in wild pollinators, especially natural enemies and bees (Buchori et al., 2020). One of the causes of such drop is insecticidal use, and their residues direct and indirect detrimental consequences on beneficial insect biodiversity (Ndakidemi et al., 2016). However, their impact has frequently been overlooked or underestimated. In most developing countries, there is a lack of knowledge on the effects of insecticidal exposure on the biodiversity of natural enemies and pollinators. Farmers need proper awareness of insecticidal treatments' impact on beneficial insects in agricultural areas, predominantly natural enemies and pollinators. This review aims at the recent status of insecticides usage, documenting the impacts of insecticidal exposures, and conservation and augmentation approaches of beneficial insects. This information would be helpful to figure out the importance of optimization the pesticide usage as per the IPM protocols that is the most desirable approach for sustainable agroecosystem.

## 2. Materials and Methods

This review paper prepared using the information available in the secondary sources such as books, research articles, proceedings, newsletter and personal communication with the expertise of the Bangabandhu Sheikh Mujibur Rahman Agricultural University. The recent most relevant information were retrieved from the various online platform through internet browsing. After collecting all the related information, it was compiled and arranged chronologically for better understanding the objectives and made necessary interpretation. to understand better and clarify its main objectives.

## 3. Results and Discussions

### 3.1 Beneficial insects and their values in agroecosystem

The global challenge is maintaining quality and maximum yields while ensuring ecological balance in agriculture production. Pest insects can cause damage to crops and food production and create health hazards to humans (Jankielsohn, 2018). Insects are mainly regarded as pests when they reach to the economic injury level (EIL). However, their ecological importance is frequently underestimated. Ecosystem cycle, pollination, predation, or parasitoids are the vital ecological roles of insects in the agroecosystems. This natural process is environmentally sound and provides long-term management in agricultural systems (Pywell et al., 2015). In agricultural arrangements, natural enemies are responsible for 33% of the world's crop productions (Getanjaly et al., 2015; Chowdhury et al., 2017).

**Table 1:** Beneficial insects and their importance

| Beneficial insects | Importance |
|---|---|
| Honeybee | Produce honey, bee wax, royal jelly |
| Lac insects | Produce shellac, which is used as dyes, polishes, and sealing |
| Ladybirds | Adaptable to various prey and effective on insect pests (e.g., aphids, mites, thrips, etc.) |
| Hoverfly | Larvae pierce aphids and suck off their internal contents using their mouths |
| Lacewings | Consume the insects by predation |
| *Trichogramma* sp. | Tiny wasps that parasitize to Lepidopteran insects |
| Parasitic wasps | Female deposits eggs in host pupae, which causes the pupa to die while the parasitoid larvae develop in the host |

(Source: Modified from Getanjaly et al.,2015)

### 3.2 Insecticidal influences in agriculture

Insecticide usage influences our agroecosystems (e.g., beneficial insects) and the environment. Insecticidal use and their residues in agroecosystem have resulted in widespread and persistent biodiversity loss in many pollinators or natural enemies (Newton, 2004). The environmental effects of insecticidal exposures constitute a significant concern. Insecticides are most commonly linked with environmental harm because their ultimate purpose is to kill the pests. They have deadly or sub-lethal effects on organisms those pollinate crops and feed on pest species. They diminish or pollute food sources for organisms at trophic levels as well (Devine et al., 2007).

#### 3.2.1 *Trends in worldwide insecticidal use*

The first effective pesticides were introduced in the middle of the twentieth century. The research of new insecticides has shifted exclusively to synthetic organic compounds in recent years. In 1892, chemical insecticide was possibly used for the first time. In 1932, the first large-scale application of synthetic insecticides took place (Banglapedia, 2021). Today's technologies, which rely heavily on chemical inputs, notable insecticides have followed the agricultural output extension process (Aktar et al., 2009). As a result, rather than reducing pest problems, uncontrolled use of insecticides and their residues often worsens and poses severe threats to beneficial insect biodiversity (Chirinos et al., 2020). Agrochemicals are used throughout the globe at a rate of around five billion kg per year, that can have substantial consequences for non-target species and create significant environmental threats (Calliera et al., 2013; Verger et al., 2013). From 2014-2019, Asia covers 59% of the world's total insecticide usage (Figure 1).

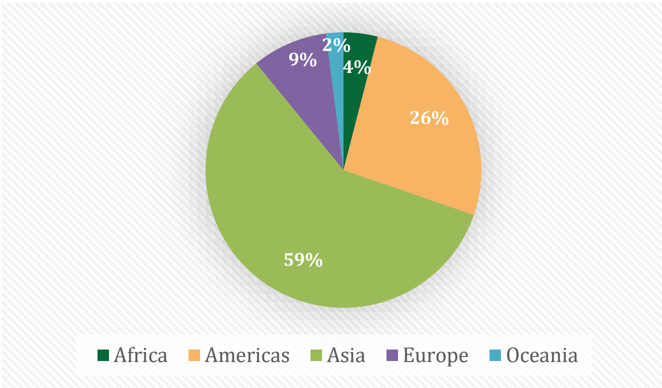


**Figure 1:** Insecticide's utilization pattern worldwide (2014-2019). (Source: "FAOSTAT", 2021)

#### 3.2.2 *Insecticidal usage pattern in Bangladesh*

Insecticides were not introduced in Bangladesh until 1956. The government encouraged farmers to be using pesticides by offering them a full subsidy till 1974. After that, the government cut the contribution by 50 percent. In 1979, the government phased out the donations, and the pesticide industry was turned over to the private sector (Banglapedia, 2021). In Bangladesh context, the pesticides utilization pattern was alarming that denoted increasing trend from 2014 to 2019. In 2014, the amount of insecticides used was 1596 ton whereas it was remarkably peak to around 2184 ton in 2017-2019 (Figure 2).

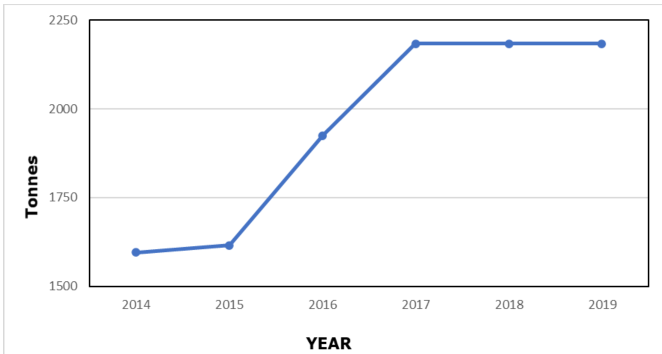


**Figure 2:** Insecticides used in Bangladesh. (Source: "FAOSTAT", 2021)

Agrochemicals were found to be overused by 47 percent of farmers in Bangladeshhowever, 70% of pesticides were marked as "highly dangerous" (Dasgupta and Meisner, 2005). But without knowing their detrimental impacts, Bangladeshi farmers are applying insecticides because the economic returns are essential for their living, and they have no other choices for crop protection.

### 3.3 Direct effects of insecticides on beneficial insects

Beneficial insects are killed by insecticidal application, both at the time of applying and those that will move into the spraying zone where direct death being the most common deadly impact of such activities. Suppose the insecticides do not kill the exposed pest species immediately after application. In that case, there is a chance that they will accumulate to fatal amounts, which can cause deadly impacts to the beneficial insects (Bacci et al., 2007). Higher Sulphur insecticide residues in agricultural fields enhanced adult parasitoid wasp *Trichogramma* sp. mortality and lowered emergent wasp survival (Thomson et al., 2000).

#### *3.3.1 Indirect effects of insecticides on beneficial insects*

Insecticides have indirect effects such as weakening insects (predators and parasitoids), altering their behavior, and increasing the development time of larval stages. All of which result in lower prey intake and reproductive potential (Dent and Binks, 2020).

The followings are some of the indirect effects:

1. Limited capability to catch prey: Cypermethrin dosages lowered predators' ability to detect and capture prey. In a study, it was found that parasitoids treated with carbamates reduce the guiding capacity of parasitoids to the aphid-infested plants (Fernandes et al., 2010).

2. Predators, parasitoids, and pollinators have fewer food options: Insecticides can reduce the number of insects that provide food for other beneficial insects. Through insecticidal effects, the eradication of hosts or prey would result in a shortage of food supplies for beneficial insects and natural enemies. This scarcity can cause forcing them to migrate in search of new prey or hosts. For instance, imidacloprid doses reduced the ability of bumblebees and honey bees to move in food sources (Ndakidemi et al., 2016).

3. Damage to the development of parasitoids and predators: *Aphidius ervi* is a significant parasitoid of the aphid. Insecticidal residues can cause sub-lethal effects. Insecticides affect the mortality and lifespan of *Aphidius ervi* (Table 2).

**Table 2:** The survival rate of adult *Aphidius ervi* after exposure to insecticides

| Treatments | Surviving Males | Surviving Females | Surviving Adults |
|---|---|---|---|
| Dimethoate | 0.00 ± 0.00a | 0.00 ± 0.00a | 0.00 ± 0.00a |
| Imidacloprid | 8.70 ± 0.30c | 8.10 ± 0.24d | 22.00 ± 0.41b |
| Pirimicarb | 6.64 ± 0.19b | 5.15 ± 0.54b | 22.75 ± 0.25c |
| Spinosad | 6.89 ± 0.15b | 6.40 ± 0.29c | 23.00 ± 0.00c |
| Control | 9.95 ± 0.19d | 8.55 ± 0.38d | 23.00 ± 0.00c |

(Source: Araya et al., 2010)

There were notable changes among treatments after 24 hours of exposure. Dimethoate showed the highest toxicity, causing total death of all insects at the end of 24 hours. Pirimicarb followed by spinosad treatments showed the less mortality than dimethoate while also being more harmful than the control. Spinosad had the same results as the control group. The average lifespan of males and females was almost similar (Table 2).

Reproductive loss of parasitoids and predators: Insecticides were found to gather in the ovaries of some of the parasitoids. It can reduce the size of an insect, cause infertility, and affect the longevity of the insects like the common green lacewing *Chrysoperla carnea* (Schneider et al., 2004). Insecticidal ingestions in females may also cause ovary distortions (Medina et al., 2006).

#### *3.3.2 Effects of botanical insecticides*

Compared to synthetic insecticides, botanical insecticides also had harmful impacts on natural enemies. Higher doses of the botanical insecticides mainly influence on the beneficial insects' ability to establish populations, restrict the ability to consume prey, impact parasitism or consumption rates, lower reproduction, and impair the ability to detect prey. Azadirachtin and pyrethrum significantly impact on the development time, emergence ratio, and longevity of *Chelonus oculator*. (Table 3 and Table 4).

**Table 3:** Response of azadirachtin toxicity on *Chelonus oculator* development

| Sex | Concentration | Development time (day) | Emergence rate | Longevity (day) |
|---|---|---|---|---|
| Female | $LC_{25}$ | 27.23 ± 0.26b | 40.43b | 10.23 ± 0.32b |
| | $LC_{50}$ | 36.81 ± 0.31a | 33.46c | 6.81 ± 0.32c |
| | Control | 21.30 ± 0.33c | 53.96a | 18.56 ± 0.37a |
| Male | $LC_{25}$ | 22.65 ± 0.27b | 40.43b | 5.91 ± 0.23b |
| | $LC_{50}$ | 31.76 ± 0.31a | 33.46c | 5.23 ± 0.21b |
| | Control | 18.70 ± 0.30c | 53.96 a | 13.63 ± 0.30a |

$LC_{25}$: Lethal concentration 25;
$LC_{50}$: Lethal concentration 50

(Source: Modified from Tunca et al., 2014)

It has been revealed that the development time of *C. oculator* female was 27.23 and 36.81 days, and the male was 22.65 and 31.76 days at the rate of $LC_{25}$ and $LC_{50}$ accordingly which was higher than that of the control. On the other hand, azadirachtin lowered the emergence rate at LC25 and LC50 and the values were 40.43 and 33.46, respectively (Table 3).

**Table 4:** Response of pyrethrum toxicity on *Chelonus oculator* development

| Sex | Dose | Development time (day) | Emergence rate | Longevity (day) |
|---|---|---|---|---|
| Female | $LC_{25}$ | 35.08 ± 0.41a | 33.30b | 8.00 ± 0.27b |
| | $LC_{50}$ | * | * | * |
| | Control | 21.30 ± 0.33b | 53.96a | 18.56 ± 0.37a |
| Male | $LC_{25}$ | 28.88 ± 0.37a | 33.30b | 4.11 ± 0.26b |
| | $LC_{50}$ | * | * | * |
| | Control | 18.70 ± 0.30b | 53.96a | 13.63 ± 0.30a |

$LC_{25}$: Lethal concentration 25; $LC_{50}$: Lethal concentration 50; *: Total mortality (Source: Modified from Tunca et al., 2014)

The pyrethrum harms the development time, emergence ratio, and longevity of *Chelonus oculator* (Table 5). The table indicates that the pyrethrum has highly hazardous effects. The concentration of $LC_{50}$ value caused total death in *C. oculator.* The emergence rate had dropped significantly by 33.30 percent at the concentration of $LC_{25}$ (Table 4).

### 3.4 Residual effect of insecticides on honeybee

The honeybee is the most important species and effective pollinator globally among all beneficial insects. Insecticides make honeybees more vulnerable (Sadd et al., 2015). Insecticidal exposures were evident as one of the leading causes of honeybee extinction (Sanchez-Bayo and Goka, 2014; Zhu et al., 2014). Residues from the insecticides can reduce the growth and reproduction of honeybees (Figure 3). Methods of applying insecticides have an impact on honeybees' biology and reproduction system. They can harm honeybees directly or indirectly from contaminated pollen and nectar consumed by bees (Fairbrother et al., 2014; Park et al., 2015). Insecticidal residues can be observed in nectar and pollen of flowers (Table 5) (Kasiotis et al., 2014; Wallner, 2009).

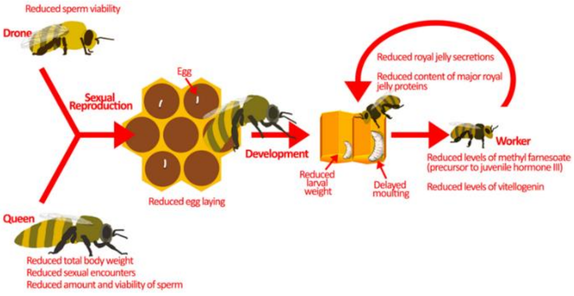


**Figure 3:** Insecticidal exposure inhibits the reproduction and development of honeybees. (Source: Chmiel et al., 2020; Maori et al., 2019)

| **Table 5:** Insecticidal residue levels in pollen and honey | | |
|---|---|---|
| **Insecticide's name** | **Residues (μg/kg)** | |
| | **Pollen** | **Honey** |
| Thiamethoxam | 28.9 | 6.4 |
| Clothianidin | 9.4 | 1.9 |
| Imidacloprid | 19.7 | 6.0 |
| Cypermethrin | 13.9 | 18.1 |
| Dinotefuran | 45.3 | 13.7 |
| Methiocarb | 1.4 | 15.0 |
| Carbaryl | 58.9 | 23.4 |
| Dimethoate | 2.3 | 4.8 |
| DDT | 31.2 | 44.2 |
| Diazinon | 8.5 | 17.0 |
| Malathion | 17.1 | 98.0 |

(Source: Modified from Sanchez and Goka 2016; Samson et al., 2014)

The Carbaryl, a carbamate group insecticide, showed the highest residue of 58.9 μg/kg in pollen and malathion 23.4 μg/kg in honey. The lowest residue value was found in pollen and honey is 1.4 μg/kg and 1.9 μg/kg with the application of methiocarb and clothianidin, respectively. Necotionoid, pyrethroid, and the organophosphorus group also showed the residual effects on pollen and nectar (Table 5). It is necessary to understand insecticides' direct and indirect impacts on beneficial insects and natural enemies. Insecticidal residues have exposed them to less than lethal dosages, implying their actions impact on physiological changes. As a result of insecticidal exposure, insect species would have established linkages with behavioral changes (Gómez et al., 2019). For saving beneficial insects from residual effects, it is necessary to determine the influence of insecticidal side effects on beneficial insects. Insecticide's exposure and possible detrimental effects on bee colonies challenge beekeepers who rent their colonies for pollination or make honey on or near the crops. This comprises sublethal effects on forager efficiency that are more difficult to detect (Frazier et al., 2015).

Insecticide exposure decreases bees foraging as an immediate toxic outcome (Table 6). Nevertheless, evidence of insecticides' sublethal effects and related adjuvants has been increasing in the literature. Lower lifespan, reduced immunological function, learning effects, poor orientation, foraging, and motor coordination are some of the consequences (Ciarlo et al., 2012; Oruc et al., 2012; Garrido et al., 2013). Honeybee colonies pollinating or working near the crops were exposed to a wide range of insecticides (Frazier et al., 2015). In practical evident for almost all the crops, field force numbers varied dramatically over time, with changes varying wildly depending on the harvest and the time of the year. The subsequent fall of returning foragers at crop fields cannot be attributed to the residues of insecticides. Honey bee colonies, particularly those employed for agricultural pollination, are unquestionably exposed to a wide range of agrochemicals, including several bee-toxic insecticides (Mullin et al., 2010; Orantes-Bermejo et al., 2010; Krupke et al., 2012).

| **Table 6:** Effect of different insecticides on the population of foraging honeybee | |
|---|---|
| **Treatments** | **Percent decrease/increase (+) of honeybee population after treatment** |
| Clothianidin | 86.44 |
| Fenpyroximate | 60.74 |
| Pyridaben | 83.54 |
| Methoxyphenozide | 41.28 |
| Fenpropathrin (water spray only) | 65.25 |
| control | (+)2.43 |

(Source: Modified from Dutta et al., 2017)

### 3.5 Insecticidal impacts on Syrphid fly

Syrphid flies are significant pollinator species (Rader et al., 2015). The adult Syrphid fly is valuable in mustard. Adverse effects were observed in adult Syrphid flies due to insecticidal treatments (Table 7).

| **Table 7:** Insecticidal effects on the adult Syrphidfly population | | |
|---|---|---|
| **Insecticides used** | **Average population per plot (5 min)** | |
| | **1 DBS** | **7 DAS** |
| Methoxyphenozide | 12.25 | 6.85b |
| Fenpyroximate | 12.84 | 4.87c |
| Fenpropathrin | 11.65 | 4.04c |
| Clothianidin | 12.05 | 2.01d |
| Pyridaben | 11.82 | 2.42d |
| control | 12.12 | 12.45a |

DBS= Day before spray; DAS= Day after Spray

(Source:Modified from Dutta et al., 2017)

The Syrphid fly population in different treatments showed significant results. Among the treated insecticides, the lowest Syrphid fly population was found in clothianidin at 7 Days after spray. Also, the less population was found in pyridaben and fenpropathrin. Fenpropathrin has similar data to fenpyroximate. Compared to other values Syrphid adult population found in methoxiphenozide was relatively high after treatment compared to the other insecticides used (Table 7).

### 3.6 Insecticidal impacts on predatory insects

Insecticides have different effects on predators based on the species, treatment method, and growth level. Insecticides harm a wide range of insect species, notably Hymenoptera, Coleoptera, and Hemiptera. Sulfoxaflor, for example, is harmful at excessive amounts to beneficial insects like wasps. Sulfoxaflor lowers parasitoid wasps' (*Trichogramma* spp.) parasitism potential and increases mortality (Jiang et al., 2020). Many insecticides reduce the number of predatory beetles (Tran et al., 2016). Insecticidal residue in Lacewings (*Chrysoperla carnea*) can lower fertility (Garzón et al., 2015).

### 3.7 Insecticidal contamination to the insect food sources

Insecticidal residues can reach insects' food sources in different ways. It can be through direct spraying of insecticides or by the plant where contamination has already occurred by residues. Honeydew is a more abundant source than nectar and pollen in many agroecosystems (Tena et al., 2016). Contaminated food sources like honeydew showed effect on mortality of hoverflies' and parasitic wasp (Figure 4). Pymetrozine and flonicamid have different modes of action. The toxication has a dangerous effect on the parasitic wasp *Anagyrus vladimiri* and hoverfly *Sphaerophoria rueppellii* (Calvo-Agudo et al., 2019).

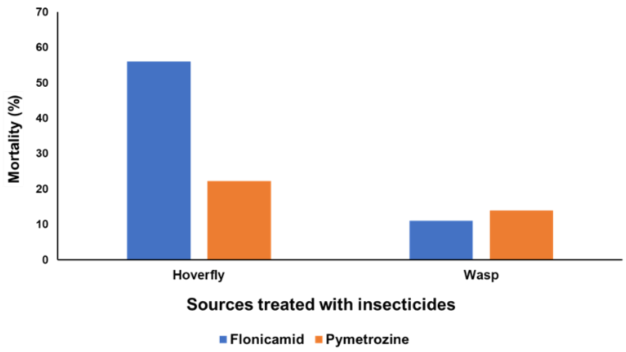


**Figure 4:** Mortality rate of hoverflies and wasps. (Source: Calvo-Agudo et al., 2020)

The hoverfly's mortality rate in flonicamid was 56 ± 10%, and pymetrozine was 22.2 ± 8% in the treatments. Mortality of the parasitic wasp was 11 ± 4.8% in flonicamid treatment and showed 14 ± 3.4% in pymetrozine treatment when it fed on the food source like honeydew emitted by mealybugs (Figure 4).

### 3.8 Conservation of beneficial insects

It is everyone's responsibility to protect beneficial insects. Beneficial insects can control pest species without the need for human intervention. When selecting plants, insect and disease-resistant varieties are considerable. Pruning, hand-picking, proper irrigation, nutrition management, and netting are examples of non-chemical approaches to avoid insecticidal use (LCCMR, 2021). Planting diverse flowers and plants around cultivated areas can attract pollinators to visit and keep the pest below the economic injury level (EIL). Providing nesting sites for beneficial insects can secure their biodiversity. If we minimize the use of broad-spectrum insecticidal use, then beneficial insects will be secured in an agroecosystem. Where insecticides are needed, in that case, the rational bioproducts that have less impact, such as horticultural mineral oils, clove oil, cottonseed oil should be used as an alternative to the insecticides.

Minimum concentrations of insecticides application will also be helpful. And it is better to spray when pollinators are less active, mainly in the early evening. To overcome such problems of exposing to the insecticides, we can adopt Integrated Pest Management (IPM) practicesthrough providing proper knowledge and training to the farmers regarding IPM plans, preparations and application strategies (Krischik et al., 2020). Insecticides are frequently used in agricultural production to combat insect pests. Pest management is unavoidable in modern farming practices. It's impossible to say whether or not an insecticide that reduces pest species without affecting the beneficial insects.

Carbamates, Nicotinoids, Organophosphate, Organochlorine, Pyrethrins, etc., are typical chemical insecticides commonly used in the agricultural fields. Excessive use of such insecticides causes the decline of beneficial insect populations worldwide. However, pollinators and natural enemies have significant role for the maintenance of the agroecosystems. Methoxyphenozide was demonstrated to be the safest insecticide in both of syrphid fly and honeybee safety. Meanwhile, clotheaianidin and pyridaben, were extremely poisonous to both syrphid flies and foraging honeybees.

## 4. Conclusion

From the above details, it has been revealed that insecticidal exposures directly or indirectly impact on the growth, development, immunity, and behavior of the beneficial insects. The regulatory process is not changed to incorporate the sub-lethal effects of insecticides. In that case, the cycle of insecticides being licensed for use without complete knowledge of their potential impact on beneficial insects will continue. IPM programs that encourage insecticide reduction that is detrimental to pollinators and agriculture should promote as an ecological friendly approach for successful reduction in insecticidal usage. Farmers should be encouraged in using an IPM method as pest management strategy for securing the beneficial insect's biodiversity and strengthening the agroecosystem services for the safe world's food supply in the future.

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