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# Effects of Pesticides: A Review

Saira Batool[1]*, Areeba Amer[2], Qammar Shabbir Rana[3], Raja Rizwan Javed[4]
[1*] Centre for Integrated Mountain Research (CIMR),Universityof the Punjab, Lahore
[3,4] National Defense University Islamabad
* Email: Saira.Naqvi@gmail.com

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There has been a rise in the application of pesticides in recent decades to combat plant diseases, weeds, and insects. Insects and other animals that aren't the intended targets of pesticides have been the subject of numerous scientific investigations. The purpose of this article is to summarise and review the literature on the subject of how pesticides affect animal microbiomes. Pesticides have the power to alter the microbiomes of a wide range of animals, including mammals and insects. Examples include the diversity of bacteria, the diversity of bacterial ratios, and the taxonomic composition of bacteria. Pesticide exposure changes an animal's microbiota, which decreases the animal's resistance to infection. If pesticides have unintended consequences, they could be a worldwide issue for pollinators. Pesticides may also have a lethal effect on insects by altering the composition of their gut microbiota, making insects more susceptible to infection from pathogenic microflora. Furthermore, pesticides can alter reproductive success, vitality, and offspring traits. The methods for improving the bees' microbiome are discussed.

**Keywords:** Pesticide, Bacteria, Microbiotic activity.

## Introduction

There has been a rise in the application of pesticides in recent decades [1][2] to safeguard crops from a variety of threats, including insects, diseases, weeds, and so on. Many researchers [3][4][5] have looked into various aspects of pesticide toxicity for unintended species. The study of the microbiome of animals and how it evolves in response to different physicochemical conditions has become increasingly popular in recent years [6] [7]. Because compounds that disrupt the functions of the intestinal microflora produce changes in animal homeostasis, the toxicological significance of the interaction of the intestinal microbiota with contaminants is of major relevance. The effects of different pesticides on the microbiota in the digestive systems of animals used as research models and in agricultural settings are being studied more and more. To that purpose, we set out to gather information on how pesticides affect animals' microbiome, with an emphasis on pollinators. This is a significant problem given the already grave threat that the rapid decline in pollinator populations poses to food sources. This review considers a wide range of topics, including how pesticides affect the types and proportions of bacteria found in animal intestines as well as techniques for restoring the microbiome of helpful insects.

In every instance, xenobiotics have been shown to have a negative impact. Mice and rats are commonly used as study subjects in toxicological research on the effects of pesticides. Broad-spectrum insecticide chlorpyrifos blocks the neurotransmitter acetylcholine's signaling [8]. Because of this, there is a shift in the microbial metabolite level, known as dysbiosis of the microflora [9]. It is prevalent in the food supply and has been shown to disrupt both the endocrine and digestive systems. Rats fed a diet varying in fat content showed this when given the diet orally. Rats were also given injections of chlorpyrifos in conjunction with the new diet. The study provided needed insight into the connection between pesticide exposure and dysbiosis in the gut microbiota [10].

The effects of feeding mice a diet containing chlorpyrifos were also investigated by Liang et al. After that, we did some microflora transplantation and antibiotic treatment [11]. Experiment results showed that chlorpyrifos caused intestinal inflammation by breaching the intestinal barrier and allowing more lipopolysaccharides to enter the body. Mice given microbiota altered with chlorpyrifos also gained weight and had impaired insulin sensitivity.

Mice that were given the fungicide propamocarb had changes to their gut flora and metabolic rate, according to another study [12]. The operational taxonomic unit (OTU) analysis revealed that propamocarb altered 32.2% of the cecum OTUs. Imazalil, a fungicide, was used in a similar study [13]. By sequencing 16S rRNA, researchers were able to show that the fungicide altered the microbial community in the cecum and faeces. It has been shown that the use of the systemic triazole fungicide miconazole reduces both the number and variety of bacteria in the body [14] [15]. Mice that were given miconazole or one of its enantiomers showed shifts in the composition of their cecal microbiota. After being exposed to this substance, the metabolic analysis revealed disturbances in the metabolic profile. This shows that pesticide has negative effects on animals [17].

Antibiotics can change the microbiota in the gut, which may affect how the body processes foreign substances (for the better or worse). Triazine herbicides were tested on rats with antibiotic-modified microbiota to see if there was a correlation between antibiotics and pesticides. Following antibiotic treatment, the relative abundance of bacteria in the genus Bacteroides increased while that of the genus Ruminococcaceae decreased. When taken as a whole, these factors raise the likelihood of bioavailability is increased by triazine herbicide (atrazine, simazine, ametrine, terbuthylazine, and metribuzin) exposure.

Soil bacterial composition has been used as a key indicator of the harmful effects of pesticides in recent studies [18]. [20]. Insecticide monocrotophos has also been studied in relation to earthworms [21]. Higher levels of azoxystrobin stimulated the growth of

Enchytraeus crypticus proteobacteria. Research shows that the use of pesticides like penconazole, carbendazim, Penticton, and fludioxonil can drastically change the makeup of the soil's microbiome.

Trichlorfon is a widely used insecticide in farming and gardening [22]. When it comes to parasitic infections in aquaculture, this compound is a must-have. Since it dissolves easily in water, using it in large quantities can cause pollution [23]. Common carp, Cyprinus carpio, had their intestinal microbiome affected by different concentrations of trichlorfon, and the results were mapped out [24]. Trichlorfon exposure was found to decrease the relative abundance of beneficial bacteria. Due to the widespread application of pesticides, there has been a shift in the fresh algal biocenoses that contribute to water blooms. As a broad-spectrum strobilurin fungicide, azoxystrobin sees extensive use. [25] [26].

The environment in which insects must survive is rife with potentially harmful chemicals (plant toxins, artificial pesticides). It was previously believed that all of these resistance mechanisms were encoded in individual insect genomes. To help the host organism adapt to its surroundings and survive, many different types of symbiotic microbial associations have developed over time.Evidence suggests that some Culex nigripalpus mosquitoes are resistant to pesticides [28], though the causes of this resistance are unknown [27]. Blattella germanica, a type of cockroach, is also notorious for being exceptionally resilient against insecticides. As a result, studies involving these organisms and various pesticides are likely to yield the most useful results. The findings from mosquito research [29] demonstrated resistance to pesticides may originate from the microbiota. Detoxification of xenobiotics, such as synthetic pesticides, was found to involve bacteria from Blattella germanica [30]. As antibiotics have spread throughout the environment, they have increased insect sensitivity to insecticides. Cockroaches that had their microflora disrupted by antibiotics were transplanted into resistant lines, resulting in a dramatic drop in resistance and the deaths of the cockroaches[31].

The silkworm, Bombyx mori, was used to investigate the effects of the insecticide phoxim, an organophosphate. Researchers have discovered that this species is extremely vulnerable to pesticides [32]. Analyses of the intestinal microbiota revealed a decline in the numbers of the dominant bacteria Methylobacterium and Aurantimonadaceae and a rise in the numbers of less dominant bacteria like Staphylococcus. In addition, phoxim upregulated pathogenesis in Enterobacter cloacae and reduced the expression of antimicrobial peptides.

**Results**

Glyphosate is widely used as a herbicide [33]. It has an impact on marine and coastal species because it is widely used on islands close to the coast [34]. [34]. [35]. This evidence suggests that glyphosate has a deleterious effect on the health of the animal as a whole. The pesticide's effect on another species (the Chinese mitten crab) resulted in a reduction in the intestine's antioxidant capacity and an increase in malondialdehyde content [36]. After being exposed to glyphosate, the Chinese mitten crab's intestinal microbiota became much more monophyletic, with a greater abundance of bacteroids and proteobacteria. This was found via data sequencing and analysis. The intestinal microbiota of pollinating insects were exposed to ingested glyphosate. Quantitative PCR shows that a dramatic change in intestinal microflora composition reduces the bee's resistance to pathogens [37]. Among the bacteria tested, glyphosate had a significant impact on the population of Snodgrassella alvi, had a moderate effect on Gilliamella apicola, and had a positive impact on Lactobacillus spp.

Because of its effect on 5-enolpyruvyl shikimate-3-phosphate synthase, glyphosate can stunt the development of gut microbes involved in amino acid synthesis (shikimate pathway) (EPSPS).All genomes of honeybee gut bacteria have the gene encoding the enzyme of the shikimate pathway [38]. This provides evidence that bacteria (and by extension, bees) are especially susceptible to glyphosate's toxic effects. Insects exposed to glyphosate have less of the dominant intestinal microflora. More bees died as a result of this herbicide because they were more vulnerable to the effects of the pathogen Serratia marcescens. As a result, honey bee health and pollination efficiency may be negatively impacted by glyphosate's disruption of the beneficial intestinal microflora[39].

Both adult insects and their larvae are susceptible to death when exposed to glyphosate. [40]. Colonies of young bees are particularly vulnerable to the stresses caused by xenobiotics, while adult bees show no signs of distress. There was demonstrated interaction between the pesticide and vitamin-producing bacteria in the intestines. MAIT cells were found to be activated by Escherichia coli cells but inhibited by Bifidobacterium adolescentis and Lactobacillus reuteri [41]. [42]. Here, proteomic analysis was employed to infer that glyphosate impeded riboflavin and folate biosynthesis. The anti-inflammatory immune response is thereby enhanced by chlorpyrifos and glyphosate [43].

Long-term exposure of rat intestinal microbiota to Roundup herbicide (made from glyphosate) increased Bacteroidetes bacteria and decreased Lactobacillaceae. Different bacteria displayed varying degrees of sensitivity to the herbicide Roundup, demonstrating that it has an immediate effect on the intestinal microbiota as shown by the culture method. So, Roundup buildup in the environment is very dangerous for rats.

There is currently a worldwide trend towards fewer pollinators [44]. The use of toxic pesticides may be to blame for this [45]. Insect population declines and the increased use of pesticides in farming may be linked. An important and steadily dwindling group of pollinators, bumblebee colonies have been shown to be vulnerable to pesticides in recent studies [46]. Thiamethoxam is a neonicotinoid insecticide, and studies have shown that it decreases the number of laying queens in a hive and makes the bees more susceptible to disease [47]. Thus, neonicotinoids have a major impact on pollinator population dynamics. Studies now being conducted look at the target sites for neonicotinoids and the metabolism of neonicotinoids in both harmful and beneficial insects, like bees [48]. The findings aid in the creation of pesticides that specifically target the nicotinic acetylcholine receptors expressed by insects.

Honeybees are known for their unique reproductive behavior, which can shift in response to environmental stresses. Studies show that the widespread use of the insecticide fipronil decreases sperm concentration and viability, while simultaneously increasing the rate of spermatogenesis, resulting in a decline in male bee fertility [49]. Also, another highly effective insecticide was tested in an identical manner. Thiacloprid, a neonicotinoid consumed by bees, altered the wild insect population's behavior. To put it another way, bees' navigation, social interactions, and general demeanor were all thrown off. Thiacloprid, when used at low doses at feeding sites, has been shown to accumulate in the food over time [50]. As a result, honey bees are in danger from pesticides, which can impair their cognitive abilities and cause them to die off [51].

Right now, bees are under constant threat from stress, a variety of agrochemicals, and parasites. Because pesticides alter bees' detoxification and immune responses, they can increase the insects' susceptibility to parasites. Then, we'll think about how different pesticides affect the microbiome of distinct animal groups. Microbiome Alterations Caused by Pesticide Exposure in Honeybees and Bumblebees 3.2. Insight into the microbiota and experimental design in this area is aided by the compilation of all this information [53].

Insects rely heavily on their intestinal microbial communities for their own health. Bumblebees (Bombus terrestris) were collected from both forested and urban areas, and their gut microbiota was studied [54]. Snodgrassella and Gilliamella, two of the main bee-specific bacteria, were found to be significantly more common in urban areas than in the forest zone. Different bumblebee strains elicited unique immune responses following microbiota transplantation [55]. Symbionts Arsenophonus sp. and Phyllobacterium sp. were found in greater abundance in insects infected with the eukaryotic parasite Apicystis bombs. Most of these microorganisms reside in the fat body, and there is a connection between the gut bacteria and the fat body as well [56]. Since the mechanisms by which the body develops protection and resistance to pathogens, such as Crithidia bombi, remain unknown, researchers Näpflin and Schmid-Hempel of Switzerland set out to investigate these questions [57]. It was discovered that infected and healthy people have identical microbial communities. [1]. It has been shown that the microbiota of larval bumblebees is dominated by the Enterobacteriaceae and Lactobacillaceae families, whereas the microbiota of adult bumblebees lacks the typical main intestinal bacteria of bumblebees [58] [59]. There is still no consensus on what role this microbiota plays in the body.

It is well known that insect intestinal symbionts play a role in preventing the spread of disease. The potential functional role of the bumblebee intestinal microbiota can be better evaluated with correctly identified microbial isolates. The use of pesticides has been hypothesised to negatively impact the microbiome of honey bees, as demonstrated above. [60][61]. There was a general decrease in insect health, behaviour (food consumption), and viability. The bees' intestinal microbiota has changed, as shown by 16S rRNA gene sequencing, with fewer microorganisms than usual that help with metabolic homeostasis and insect immunity. Another study looking into how neonicotinoids affect humans and their microbiomes used Bombus terrestris as a test subject [62]. Clothianidin had an inverse relationship (both on an individual basis and at the colony level) with the diversity of microorganisms in the intestine. Although bumblebees' resistance to pathogenic microorganisms does not decrease after being exposed to the xenobiotic clothianidin, the xenobiotic does reduce their size and weight and impair their reproductive ability.

The honeybee's overall health is tied to the composition of its gut bacteria a bug [63]. [65]. In this context, researchers are actively developing new lines of inquiry into how microflora change in response to exposure to pollutants like pesticides. Most pesticide chemicals pose a serious risk to the intestinal microflora [66] and can have deleterious effects on the endocrine and digestive systems as well. These chemicals are a major contributor to metabolic disorders that cause dysbiosis in the intestines.

Proteobacteria, Firmicutes, and Bacteroidetes, the three main classes of intestinal bacteria, were all discovered in honey bees. But as the experiment progressed, a noticeable shift in the insect subjects' species diversity among their intestinal microflora became apparent [68].

As a result, the "probiotic concept" is being actively applied in beekeeping. Probiotics (Lactobacillus salivarius) were found to significantly increase honey production compared to a control group that did not receive probiotics [69]. Feeding probiotics to honeybees has been shown to reduce yeast colonies, which has a knock-on effect on the insects' overall immunity [70].

Bacillus, Bifidobacterium, and Lactobacillus are the predominant probiotic strains in bee intestines. It was suggested that these microorganisms, particularly strains of bee origin, could improve hive health and productivity [4]. In addition to their active use as probiotics, lactic acid bacteria can be found naturally occurring all over the world [71]. Because of their beneficial effects on animal health and reproduction, they are widely used in zoos, apiaries, and poultry farms. Antibiotics weren't working as well on some of these bacteria. It has been determined that hetero-enzymatic lactic acid bacteria predominate in the honeybee's intestinal microflora [72]. In addition, studies with Lactobacillus bacteria demonstrated their probiotic effect [73]. Their use led to increased honey production in part because more bees were producing offspring and laying more eggs [74]. Honey bee deaths due to nosema and warrosis were also reduced by the use of probiotics. Honey bee productivity increased after introduction of a prebiotic preparation containing Lactobacillus johnsonii CRL1649. [75]. Since honey bees can be negatively impacted by an overabundance of pro- and prebiotics in their diet, the study places a strong emphasis on dose selection. could not stop the pathogen from causing disease, but did increase insect mortality by interfering with bee immune system regulation [76].

Similar methods were used to examine Bacillus subtilis subsp. subtilis Mori2, with the same results: the bacterium increases honey production by boosting bee productivity, egg laying, and population growth.

Modulation of the honeybee's intestinal microbiota is seen as a practical and effective solution [77] [78]. Analysis of the hives revealed that the brood population had grown, along with the amount of pollen and honey produced. The insect's normal metabolism is supported by a diverse intestinal microbiota, and research has shown that the number of Acetobacteraceae, and Bifidobacterium species has increased [79].

Seven species of Apis mellifera jemenitica's gut bacteria were studied for their probiotic effects on Paenibacillus-infected bee larvae. The results showed that honey bee larvae mortality could be drastically reduced by supplementing their diet with these probiotic microorganisms. Positive results were greatest when Bacillus licheniformis and Lactobacillus kunkeei were used together.

It is undesirable that antibiotics (like tylosin) are effective against this disease. Finding a probiotic to use as a form of alternative medicine is exciting. For this particular pathogen, lactic acid bacteria proved to be the most effective antagonist. This probiotic was shown to affect the reduction of pathogens in the laboratory, but the results of the experiment did not bear this out in practice [80].

Honey bee larvae can contract a bacterial disease known as European foulbrood. Bees' intestinal bacteria have been shown to be probiotic microorganisms that lower the likelihood of contracting this disease [81]. According to the results of the study, Bacillus, Staphylococcus, and Pantoea isolates make up the vast majority of intestinal bacteria. Bacillus is shown to have an inhibitory effect on pathogenic bacteria when these bacteria are subjected to the influence of Bacillus.

## Conclusions

Animals' intestinal microbial communities are extremely important to their overall health. We found that the microbiome of animals across taxonomic groups was affected by pesticides. It is important to note that insecticides, fungicides, and herbicides can all have an effect on the microbiota found in an animal's intestines. Mammals and pollinators alike suffer serious health consequences from glyphosate's toxic effects on their gut microbiota. Pesticide-induced alterations to the microbiome have far-reaching effects on animal health, including immunity, reproduction, and behaviour. In order to restore a healthy microbiome in pollinators, we need to find a way to fix the problem.

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