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LIFE IN A CONTAMINATED WORLD: THE PESTICIDES AND THE BIRDS POPULATION DECLINE

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All the authors contributed to the design of the study. Authors SB and PS wrote the first draft of the manuscript. Author BD analyzed the data and Author JD contributed to the management and execution of the study. All authors read and approved the final manuscript.

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ABSTRACT

Background: The extensive use of pesticides has been increasing with the modernization of agricultural system, vector borne disease control, pest control, etc. Pesticides not only affect the environment, but also affect the wildlife including birds. Generally the chemical pesticides which are tremendously used in the agricultural fields fall under three major groups, which are organochlorine, organophosphate and carbamate [1].
Aim: To review the effect of pesticides in population decline of birds.
Materials and Methods: The related data on pesticide's contribution to the bird's decline were obtained from digital data bases like Google Scholar, PubMed/ Medline, the Google Search Engine, Science Direct, Research gate, and NCBI (National Center for Biotechnology Information) .
Result: After reviewing many research papers, we can say that though use of pesticides increases agricultural production and control the vector borne diseases, but it has a severe effect on the bird's metabolism, the nervous system, endocrine system, development, behavior, etc.
Conclusion: When birds are exposed to pesticides for a long time it causes continuous health hazard for the population. To overcome this situation, intensive research should be carried out at molecular level, genetic level, etc. Rigid legal plans should set up against the extensive use of pesticides and concerned authorities shall look into its implement as well.

Keywords: Birds; pesticides; organochlorine; organophosphate; carbamate.

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1. INTRODUCTION

Birds are the important element of the natural system and have many ecological values. They play a vital role in controlling pests, helps in plant pollination, seed dispersal, helps in control of insects and rodents etc. Many birds keep our surroundings clean by eating death organisms, thus birds are benefits to people in various ways and maintain ecological balance in the ecosystem. Though birds are very important for the ecosystem but from some decades the population of the birds are declining rapidly. More birds than ever before were placed on the Red list of greatest conservation concern in the latest report, published in 2021 [2]. At 70 species long, the Red list is nearly double the length of the one in the first report in 1996, showing that even more of our birds are in trouble [2]. Cancun, Mexico, 8 December 2016 (IUCN) – over 700 newly recognized bird species have been assessed for the latest update of the IUCN Red list of threatened species, and 11% of them are threatened with extinction. The update also reveals a devastating decline for the birds, driven by habitat loss, civil unrest, illegal hunting [3] [4] and also by using pesticides in farmlands. Among the major reasons of the bird's decline is the use of pesticides in farmlands. Pesticides have been used in farmlands from ancient times, findings suggest that more than 4,500 years ago the Sumerians were using sulfur compounds to control insects and mites [5] [6] [7]. Then the use of the plant based pesticides simultaneously started in ancient Chinese, Greeks and Romans. The use of chemical pesticides revolutionized by the Second World War by the discovery of dichlorodiphenyltrichloroethane (DDT) in the USA and manufactured in Switzerland [8], followed by chlorinated hydrocarbons . In Germany, another equally toxic group of chemical synthetic pesticides were developed named organophosphates [7] and at the same time Swiss workers also discovered a third group of synthetic organic insecticides, the carbamates [7]. The initial targets of the organic insecticides were the vectors of human disease, but after the war, there was a rapid expansion in the agricultural sector [7]. As the time passes the use of pesticides is also rises in agricultural farmlands. Many farmers do not know what amount of pesticides should be used against a particular quantity of crop due to lack of knowledge about scientific farming, so there is always a large amount of pesticides remains on the farmlands. These remaining pesticides enter and contaminate water through direct application, runoff and atmospheric deposition, etc. The contamination effects the ecosystem of water body by affecting aquatic organisms, plants and the other organisms which depends on these water bodies for their living, like birds. Agricultural pesticides have been shown to affect 87% of the bird species that are threatened globally [9]. In this review paper we will discuss about the commonly used synthetic chemical pesticides and their effects on bird's population.

2. MATERIALS AND METHODS

Several research papers and studies on pesticides and their adverse effect on bird's population decline were reviewed for this paper. The related data for review paper on pesticides contribution to bird's decline were recouping from the digital data bases like Google Scholar, Pub med.

Medline, Science Direct, Research Gate, Google Search Engine and NCBI (National Center for Biotechnology Information). 64 articles including both research papers, review papers and other relatable articles from authentic websites have been incorporated to curate this review paper.

3. RESULTS

As the uses of pesticides are increasing with the agricultural product demand, the effect of these pesticides on birds is also increasing swiftly. Most commonly used chemical synthetic pesticides like Organochlorines; organophosphates, etc. have the adverse effect on birds. A few examples are given to support the fact that pesticides have tremendous effect on birds -when Mallard Duck fed with high amount of Dieldrin, it affect their aggressive behavior [10], when the Ring doves exposed to DDE for longer duration, the courtship behavior gets effected [11] , high dose of DDE cause severe eggshell thinning of American Kestrel, Peregrine Falcon, Sparrow Hawks and Gannets [12], in White-Throated Sparrow DDE interrupt nocturnal activity [13], sub lethal doses of dieldrin affect the breeding as well as the social behavior of Bobwhite Quail and different type of effects Pheasant [10], a group of organophosphate insecticide named Parathion, can kill American Kestrels that feed on frogs raised in water containing the insecticide, another organophosphate insecticides named Famphur kill Red- Tailed Hawks and similar secondary poisoning have also been reported for Barn Owls, Great Horned Owls and Bald Eagles [14],administration of neurotoxic pesticide, named Endosulfan cause lethargy, weakness and diarrhea in Japanese quail [15] Parathion poisoning of geese was attributed to spray drift in 1950s [16] , pesticides at high concentration are lethal and hence cause density-

mediated indirect effects [17] and at sub-lethal concentrations, it can harm immune system, physiology, morphology and behavior including predator detection and swimming ability [18] Few studies have examined heritable genetic variation. Birds may get effected by pesticides when they consume contaminated seeds, pesticides treated grain, contaminated water and even contaminated fish and insects. This contamination caused by the use of a large amount of pesticides in garden, lawns and farmlands. We have reviewed some research papers related to the effect of pesticides on the bird's population. The collected outcomes of the research papers are given below in tabulated form.

Table 1. The Effect of Organochlorine or Chlorinated hydrocarbon on birds

Pesticide	Effects on birds
Organochlorine (OC) or Chlorinated HydroCarbon	• The effect on behavior ➢ Reduce the reproductive success of birds [1]. ➢ The affected birds ignore territorial barriers and decrease the extent of their home range [19]. ➢ Change their reproductive behavior [1]. ➢ Show less attentiveness to young ones [19]. ➢ Affects on feeding behavior [10] . ➢ Affects on aggressive behavior [10]. ➢ Affects on social and breeding behavior [10]. ➢ Avoidance of predation [10]. ➢ Affects courtship behavior as well as nocturnal activity [11] [20]. • The effect on development ➢ Deformity in beaks and skeleton [21]. ➢ Fluid retention in heart [21]. ➢ Congenital abnormalities [22]. ➢ Effected birds reproduce young ones with defected feathers [22]. • The effect on endocrine ➢ Affect serum hormone level, which is important in reproduction and metabolism [1]. ➢ Increase the level of insulin and estradiol [21] [23]. ➢ Decrease in the level of basal luteinizing hormone and thyroid hormone level [23] [21]. ➢ The high concentration of DDT through biological magnification disturb calcium metabolism in birds, which causes thinning of eggshell and their premature breaking [24]. ➢ Reduction hormone level results in decreased egg production [25]. • The effect on the hematological and immune system ➢ Decreases hemoglobin concentration and cause anaemia [26]. ➢ Decrease the number of T and Blymphocytes along with their atrophy and decrease in size of the follicles [27]. ➢ Decrease in hemorrhages in thymus [27]. ➢ Suppression of T- cell mediated immunity [28]. • Neurotoxicity ➢ The DDT act upon the voltage sensitive Na ion channel of the axonal membrane. Pesticides slow down the inactivation of Na ion channels when an action potential is developed. Consequently, repetitive discharge from nerve is caused, thereby disrupting the transmission of action potential [29]. ➢ The Cyclodienes compound which is a group of organochlorine act as an inhibitor of GABA receptor and reduce the flow of chloride ions which leads to

	neurological disorders like tonic convulsion and clenched claws in predatory birds [29].

Table 2. Effect of oganophosphates and Carbamates on birds

Pesticides	Effects on birds
Organophosphates (OP) and Carbamates (CM)	• The effect on behavior ➢ The effect on feeding behavior includes anorexia, gastro- intestinal stress, and it even interferes with the bird's ability to discriminate between contaminated and clean foods [30] [31] [32]. ➢ Pesticide exposure lead to food avoidance [32]. ➢ Increases aggression in both the sexes [33]. ➢ Reduce in singing and displaying behavior in birds [34]. ➢ The decrease in egg laying capacity due to abnormal egg incubation behavior, thus hatching success also reduce [35] [26]. ➢ Effects on reproductive behavior [30]. • The Effect on the physiology ➢ Effects thermoregulation [30]. ➢ Cause a sharp reduction in body weight in birds [1]. ➢ OP results in short term hypothermia [33]. ➢ OP and CM results in reduction in body temperature [36]. ➢ OP and CM cause inability of birds to withstand the cold [37]. • Effect on the endocrine system and reproductive behavior [38] [39] [40] ➢ Alteration in reproductive behaviour and gonadal development [32]. ➢ Delayed in development and degeneration of the spermatogenic cell [1]. ➢ Decrease level of cholinesterase activity in testis and brain in male birds is directly related to decreased in the number of degenerated germ cells in the seminiferous tubule [41]. ➢ Reduced in testicular function [42]. ➢ Alteration in the secretion of LH and testosterone and decreased progesterone level [43]. ➢ Effect on feedback mechanism of hormones. • The effect on the hematological system and immune system ➢ Destroyed the cell's and organs of the immune system, reduce the immune function [44] [35]. ➢ Decreased in WBC, neutrophils and lymphocytes count [45] . ➢ Altered maturation and change in lymphocytes and functional alteration to immune-competent cells [35] [44]. • The effect on genetic level ➢ Effect in proteins and DNA that eventually leads to effect in genetic level [46]. • Neurotoxicity ➢ Organophosphates and Carbamates both inhibits the Acetylcho linesterase (AChE) by forming a phosphorylated enzyme derivative, making it more resistant to hydrolysis than the normal acetylated derivative. This inhibition leads to the accumulation of neurotransmitter acetylcholine at the synaptic cleft in the sympathetic and parasympathetic nervous system in neuromuscular junctions, thus disrupting transmission across cholinergic synapses. In irreversible inhibition of AChE results in continuous transmission and leads to seizures, respiratory failure and eventually death [47]. ➢ Inhibits fatty acid amide hydrolase which effects limb immobility in OP induced neuropathy [47] [1].

Pesticides	Effects on birds
	➢ It causes impaired foraging, learning and chick rearing [1] [47]. • Effects on enzyme activity ➢ Enzyme inactivation, induced by organophosphorus pesticides leads to acetylcholine accumulation, hyper stimulation of nicotinic and muscarinic receptor and disrupted neurotransmission [47]. • Acute toxicity of OP and CMs includes adverse effects on the birds mortality [47].

Besides these major pesticides, there are also some pesticides like neonicotinoids, different fungicides, rodenticides, herbicides, acaricides, nematicides etc which affect birds in different ways. These pesticides can have an effect for years after birds consume them.

4. DISCUSSION

In today's farming processes, the use of chemical pesticides is very common. Due to increase in the human population, the demand for agricultural products are also increasing rapidly, to cope up farmers' overuse pesticides to save their crops from destruction by the pest. As chemical pesticides are easy to use, cheap, shows result in a short period of time and easily available, so farmers choose chemical pest controlling methods over cultural or mechanical pest controlling methods. Many research papers suggest that, out of the various pesticide's farmers use in farmlands, 125 of them have tested contamination or eco-toxicological effects. In 2016, pesticides use reached 1763 million Kg per year in mainland China, 407 in the USA, 377 in Brazil, and 368 in the European Union according to Food and Agricultural Organization Corporate Statistical Database [48]. Worldwide India ranks 2nd in agricultural production and 12th in pesticide use [49]. These pesticides affect our entire environment and environmental components. Among all the environmental components, toxic pesticides mainly effects bird's, which is a major biotic component. Many species of farmland bird worldwide have shown huge declines in numbers and range over the past four decades [50]. These have been linked to agricultural intensification, which has taken the form of a suite of changes in farmland practice. One of these is increased use of pesticides [50].

A study published in 'Nature' by Dutch researchers have found a correlation between bird population declines in the Netherlands and neonicotinoid pesticide. According to this study the declines in bird population is happening due to the higher concentration of the common neonicotinoid pesticide named imidacloprid in surface water [51]. The researchers posit that the pesticide affects these birds by killing off their bug and insect food supply. Surface water quality measurement across the Netherlands from 2003 to 2010 gave the researchers concentration data for imidacloprid by mapping those data they concluded that in areas with imidacloprid higher than 19.43 nanograms per liter, bird populations were declining rapidly [51]. The average rate of decline was 3.5 % annually that makes more than 30% decline over 10 years [51].

According to a study published in 'Nature' sustainability by Madhu Khanna, a study co-author and associate director of research at the Institute of Sustainability, Energy and Environment at the University of Illinois at Urbana-Champaign, said a 100Kg increase in the use of seed coating pesticide in one US country was linked with the 2.2% decrease in Grassland birds , whereas non- neonicotinoid pesticides causes 0.05% decrease [52]. Thus, US and Canada have lost 29% of its birds since 1970, due to farmland expansions and pesticides use [53].
From 2008 to 2014, researchers estimate that the populations of grassland birds declined 4% and insect-eating birds 3% annually [53]. More than half of the US countries studied lost more than 10% of their grass land birds due to neonicotinoid use over that time period [53].

Recent research has uncovered similar trends across Europe, bird populations have dropped by more than 400 million in 30 years. Despite of a government plan to cut pesticide use in half by 2020 [54]. Bird populations across the French countryside have fallen by a third over the last decade and a half. With the rise in use of pesticides in the farmlands, gardens, and in the field of agriculture has caused unforeseen consequences and threatens too many forms of life including birds as well as the environment.

5. CONCLUSION

Pesticides toxicity is one of the major reasons of the bird population decline of the present day world. By reviewing different research papers of various researchers, we found that pesticides such as organochlorine, organophosphates and carbamates are mostly use in agricultural fields, which effects the

birds in various levels such as physiological, neurological, behavioral, developmental, hematological, immunological etc. Even if many researchers have worked to explain the effect of pesticides on birds and their population decline, but the study of the effect of pesticides at the molecular level is still unclear. Researchers need to find out if there is any chance of mutation or already mutation occurred on the bird's genetic material due to the use of a large amount of pesticides. If the birds decline continuous at this rate, our entire ecosystem will collapse causing ecological imbalance. To overcome this situation, we need to shift from artificial and chemical pest control methods to ecofriendly cultural and traditional methods of pest control. In the cultural and traditional methods, we can use bio-pesticides and Integrated

Pest Management (IPM). And if we have to use the chemical pesticides then it must be limited to absolute necessary. The use of pesticides in farmlands near wildlife areas or species rich areas should be avoided strictly. Moreover, we can educate citizens regarding the harmful effect of pesticides use.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation, but for the advancement of knowledge. The authors have funded to the research at their own personal interest.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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