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Chapter 10

Pesticide applications in agriculture and their effects on birds: An overview

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Chapter contents

Abstract

Avifauna is one of the successful diverse and evolutionary groups and occurs in the tropics in large numbers as compared to temperate zone. Fluctuation in the diversity of birds provides early warning of environmental problems. The threats to their community structure due to various reasons. Agricultural pesticides have been shown to affect 87 percent of the bird species that are threatened globally. Over the past four decades, many farmland avian species have shown alarming declines in numbers and/or range. Approximately five million plenty of pesticides are used annually in the world, of which about seventieth is used for agriculture causing decline in avian population in the agro-agriculture ecosystem. In this review an attempt has been made to focus on the effects of pesticide applications on birds. The possible health effects of pesticide applications on avifauna has been discussed as well.

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Introduction

Agriculture has always been India's backbone and has helped advance the country. With population growth and diminishing agricultural land, this sector has been subjected to severe stress. Pesticides and fertilizers have come to rescue in the past by acting as a catalyst in stabilizing the higher yields gained by using hybrid seeds. According to the Directorate of Plant Protection, Quarantine and Storage, the use of pesticides have reduced in recent years because of practices of IPM (Integrated Pest Management), use of biopesticides (Neem) and few others (Yadav, 2010). There are several types of organisms which are useful for farming and therefore pesticides have to be very specific about their targets like insecticides, fungicides, rodenticides, herbicides and a few others. In the 1960s the circumstances were such that country needed Green Revolution and as early as possible since food security was need of the hour but today circumstances have changed perhaps that is why MS Swaminathan, father of green revolution feels that there is a need of evergreen revolution since "Green revolution has some repercussion like overuse of pesticide and now focus should be given on continuous improvement of productivity without harming ecology (Swaminathan, 2017). The rising cases of brain ailments and another acute chronic disease in recent years are also due to the adverse effect of pesticides (Abdollahi *et al.,* 2004). Avian species play an important role in the ecosystem. Avifauna is one of the diverse and evolutionary successful groups and occurs in large number in the tropics. The threats leading to their population decline are due to different reasons but agriculture pesticides alone affect 87% of the globally threatened bird species (BLI, 2008). Substantial information on them is available which is largely lacking for other groups. Fluctuation in the population of avian species in an ecosystem provides early warning of environmental problems and the healthy avian populations are indicators of ecological integrity. The decline in avian population shows a collapsing ecosystem (US FWS, 2002). This should be better to prevent birds from avicides with pesticide use directly or indirectly. Nowadays this should be better to resolve by using biodiversity ecofriendly pesticides. (Weldemariam and Getachew, 2016). Figure 10.1 shows a schematic diagram showing how pesticide application affects the survival of avifauna.

Many species of farmland birds have shown alarming declines in numbers and/or range over the past four decades (Baillie *et al*., 1997, Fuller *et al*., 1995, Marchant and Gregory, 1994, Siriwardena *et al*., 1998), and these declines have been attributed to changes in farming practice (Chamberlain *et al*., 2000). Agriculture has become increasingly intensive in the UK since the Second World War, and particularly since 1973 when the UK joined the EC (Donald *et al*., 2002). This intensification has taken place as a suite of changes in farming practice, such as loss of mixed farming, the switch from hay to silage, the switch from spring to autumn sowing of cereals and associated loss of over -winter stubbles, increased agrochemical input and loss of unfarmed structures such as hedgerows and ponds (Evans *et al*., 1995; O'Connor and Shrub, 1986).

Pesticide use in agriculture

In the Republic of India, Currently one hundred forty-five pesticides are registered to be used at this time. Pesticide production began in 1952 from a BHC plant close to the metropolis, West Bengal. India currently stands the second largest manufacturer of pesticides in Asia and twelfth globally. In India, seventy-six of the pesticides are used as pesticides, whereas globally the percent stand at forty-four (Mathur, 1999). Use of chemical was reduced in the Eighties because of the introduction of a recent chemical compound. During the DDT era regarding eighty-fifths of the farmers of used an organochlorine chemical at the speed of 0.39 kilogram/ha covering 282 million hectares of agricultural land. Now, the consumption of chemical pesticides is highest in Andhra Pradesh (33%), followed by Punjab, Karnataka, Tamilnadu, Maharastra, Haryana, Gujarat, Uttar Pradesh, and the remaining states account less than 9.5 percent of the total. Nearly seventieth of the chemicals consumed in India is reported to be utilized for cotton (45%) and rice (22%) and such quantity of pesticide use has remained virtually unchanged during the last five decades (Vyas, 1998). In India, chemical use has accrued dramatically and currently, it's turning into a worldwide drawback. Recent findings recommend that chemical utilization was negatively related to the scientific orientation. (Mukherjee *et al*., 2006). Pesticides such as aldrin, aromatic hydrocarbon hexachloride, calcium cyanide, chlordane, copper acetoarsenite, bromochloro-propane, endrin, ethyl mercury chloride, heptachloride, menazone, nitrogen, paraquat dimethyl sulphate, pentachloronitrobenzene, pentachlorophenol, phenylmercury acetate, sodium methane arsenate, tetradfone, toxafen, DDT, dieldrin, diazinon, parathione, aldicarb, atrazine, paraquat,

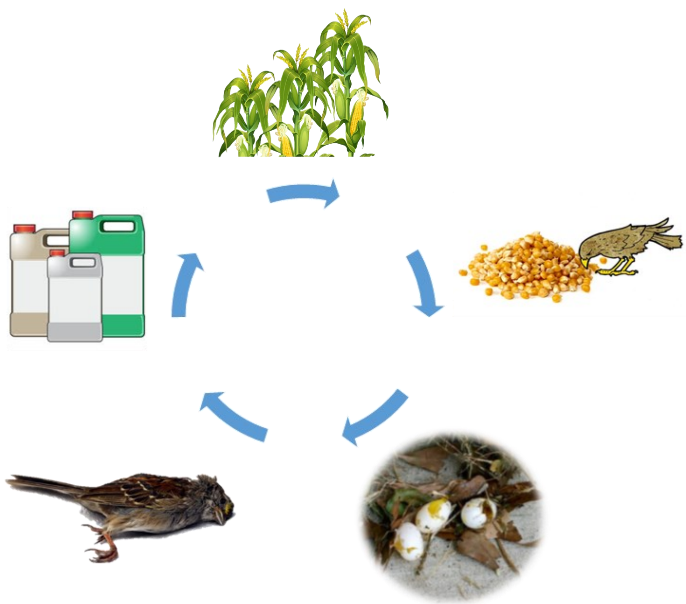

Figure 10.1. *A schematic diagram showing how pesticide application affect the survival of avifauna.*

and glyphosate are some of the most important hard pesticides. About five million plenty of pesticides are applied annually within the world, of that seventieth is employed for agriculture and the remainder by public health and Government agencies for vector control and by some owners (Yadav, 2010).

Effects of organochlorines (OCs) or chlorinated hydrocarbons on birds

The OCs are divided into three groups, *viz*. the dichlorodiphenyltrichloroethane connected compounds, the cyclodiene pesticides (aldrin, dieldrin, endrin, heptachlor, and endosulfan) and isomers of hexachlorocyclohexane (HCH). The acute toxicity of p, p'-DDT affect action on nerve fiber voltage-dependent Na^+ channels. Normally once Na^+ current is generated throughout the passage of a nerve impulse, the signal is quickly concluded by the closure of the metal channel. In dichlorodiphenyltrichloroethane poisoned nerves, the closure of the channel is delayed inflicting disruption of impulse regulation which may result in repetitive discharges (Walker, 2008). Dichloro-diphenyl-dichloro-ethylene (DDE) is responsible for the severe egg cover thinning of Yankee kestrel, Falco peregrinus, sparrow hawks and gannets. Regarding bioaccumulation of organochlorines pesticide, Tanabe *et al*. (1998) studied the migratory birds of South India and concluded that resident birds had the highest residues of HCHs and moderate to high residues of DDTs.

Acute toxicity of chlorinated hydrocarbon

DDE residues found in eggs of birds were nearly 10 ppm (Peakall, 1993). DDT has moreover caused local mass death of birds. LD50 of DDT in birds is <500 mg/Kg (Edson *et al*., 1966). Cyclodiene pesticides over stimulate the inside nervous system and clinical signs of their vigilant poisoning include salivation, hyperactivity, respiratory distress, diarrhea, tremors, hunching and convulsions (WHO, 1989). Cyclodienes have an increased potential effect than DDT to land vertebrates. The LD50 of dieldrin is 67 mg/Kg in the pigeon (WHO, 1989). Residues of dieldrin, heptachlor epoxide and other OCs in the tissues of British sparrow hawk and Kestrel from 1963 to the 1990s were recorded (Newton and Wyllie, 1992). The cyclodiene endosulfan is extremely toxic to birds (Kidd and James, 1991). It transported over long distances through the air and has been found within the Arctic aloof from any sources of use (Sang *et al*., 1999). Endosulfan stays deposited within the upholstered tissue and in stressed conditions. Acute oral studies conducted in mallards treated with endosulfan resulted in birds exhibiting wings crossed high over their back, tremors, falling and alternative symptoms when 10 minutes of oral alimentation dose administration.

Sublethal toxicity of chlorinated hydrocarbon

Effect on behavior: Chronic low-level OC exposure affects the fruitful success of birds and changes their sexual union behavior. The affected birds ignore territorial barriers, exhibit less attentiveness to young and reduce the extent of their home territory (Fry, 1995). Once fed with DDE for extended length, wooing behavior in ring doves (Haegele and Hudson, 1977) and nocturnal activity in *Zonotrichia albicollis* were disturbed. Sub fatal doses of dieldrin have an effect on the aggressive behavior of duck, social and breeding behavior of bobwhite and a spread of effects within the pheasant (Peakall, 1985).

Effect on development: The developing chicks showed deformed beaks and skeleton, fluid retention in their heart and issues in sex determination when chronic sub fatal OC exposure (Gilbertson and Fox, 1977).

Effect on the endocrine system: Most of the grainrous birds are exposed to pesticides through contaminated seed consumption. Some small birds are significantly in danger because of their low weight. The birds face high risk due to the consumption of high quantities of seed. Insecticide affects bodily fluid internal secretion level that is very important in reproduction and metabolism. The reduced hormone levels resulted in decreased egg production (Herbst and van Esch, 1991).

Effect on the hematological and immune system: Anaemia and reduced Hb concentration is documented when birds were exposed to insecticide (Mandal *et al*., 1986). Suppression of T-cell mediated immunity within the wild Caspian terns and herring gulls were found to be related to high perinatal exposure to OC compounds (Grasman *et al*., 1996). After administration of two ppm endosulfan in chicks for eight weeks, there was a major decrease within the range of T and B lymphocytes and total leucocytes along with atrophy and reduction in size of the follicles and hemorrhages within the thymus (Garg *et al*., 2004).

Effects of organophosphates (OPs) and carbamates (CMs) on birds

OPs and CMs are most typically used pesticides throughout the planet due to their low bio-accumulation properties as compared to OCs. These pesticides inhibit acetylcholinesterase (AChE) at the postsynaptic membrane of cholinergic synapses (Bishop *et al*., 1998) within the central and peripheral nervous systems of all vertebrate species. Ops inhibit AChE by forming a phosphorylated catalyst derivative, making it a lot of resistant to chemical reaction than the normal acetylated by-product (Taylor, 1990). Birds seem to be a lot of sense to acute exposure to anticholinesterase pesticides because of a reduced level of anticholinesterase detoxifying enzymes (Parker and Goldstein, 2000). While recovery from CMs typically happens within 1-2 h, acute OP exposure causes avian mortality within twenty-four h (Hill, 1992). The metabolism of latent inhibitors in the brain, quantity, and frequency of exposure and the sensitivity of brain AChE to inhibition are 3 most significant causes of OP toxicity (Hill, 1992).

Acute toxicity of OPs and CMs

The U.S. Department of Interior's National wildlife medical institution reported that fifty of the documented cases of lethal poisoning of birds are caused by ops and CMs (Madison, 1993). The possible route of exposure of these pesticides is the consumption of seeds or insects contaminated on their surface with lethal amounts of pesticide (Prosser and Hart, 2005). Organophosphates are involved in 335 separate mortality events inflicting the deaths of about birds in the USA between 1980 and 2000 (Fleischli *et al*., 2004). Worldwide, over 100,000 bird deaths caused by monocrotophos, the worst organophosphate, are documented (Hooper, 2002). Application of diazinon, another widely used OP pesticide, to lawns, golf courses, and turf farms have killed thousands of birds in the U.S (Tattersall, 1991). Although many reports are available on the short-term changes of behavior in birds, after exposure to sub fatal doses (Grue *et al*., 1997) reports on the long changes in the behavior of birds appear to be few (Grue *et al*., 1991).

Sublethal toxicity of OPs and CMs

Effect on feeding behaviors: OP and CM intoxication are usually related to anorexia and symptoms of gastrointestinal stress (Grue *et al*., 1991). Long-term effects of a very small amount of OP have an effect on the feeding behavior of breeding Red-winged Blackbirds (Nicolaus and Lee, 1999). Reduction in body weight following sublethal exposure with an average weight loss of 14% was also noted in previous studies (Grue and Shipley, 1984).

Effect on the endocrine system and reproductive behavior: Alteration in the reproductive behavior and gonadal development in birds (Kuenzel, 1994) have been noticed following acute sublethal exposure to OPs and CMs because of ventromedial neural structure lesions. Delayed development and degeneration of spermatogenic cells have occurred when domestic and semi-domestic birds were exposed to OPs. Alteration in the migratory behavior (Vyas *et al*., 1995), sexual behavior (Grue and Shipley, 1981; Hart, 1993), litter and clutch size (Bennett *et al*., 1991) and parental care (Grue, 1982), are because of reduced levels of reproductive hormones which results from chemical pesticide exposure. Reduction in singing and displaying in the European starling (Hart, 1993) and raised aggression in each sex (Grue *et al*., 1991) are powerfully correlated with brain AChE inhibition. In OP exposed mallards, hatching success was reduced by forty-third as compared to controls because of abnormal incubation behavior including nest abandonment and extended time of nests (Bennett *et al*., 1991). OP and CMs decreased egg laying capability. Reduction in food consumption alone is accounted for reductions in egg laying in Northern Bobwhites fed a diet contaminated with methamidophos for fifteen days (Stromborg, 1986). In female bobwhite quail, an important decrease in plasma titers of LH, progesterone, and corticosterone (Rattner *et al*., 1982) were noted following the short term ingestion of parathion.

Effect on thermoregulation: OPs and CMs have an effect on thermoregulation also in birds. Acute sublethal exposure to OP results in pronounced, short-lived hypothermia (Grue *et al*., 1991). OP and CM-induced reductions in body temperatures in birds are often related to decreases in AchE activity of more than five hundredths (Clement, 1991). The interaction between low temperatures and pesticide toxicity appears to be the result of the impairment of thermoregulation, inflicting inability of birds to withstand the cold (Martin and Solomon, 1991).

Effect on the hematological system and immune system response: Exposure to high doses of OPs will cause direct injury to cells and organs of the immune system and reduce the immune function (Voccia *et al*., 1999; Ambali *et al*., 2010). Different effects include direct injury to proteins and deoxyribonucleic acid. OPs interfere with immune system response in animals through antcholinergic and non-cholinergic pathway (Barnett and Rodgers, 1994). Sublethal exposure to chloropyriphos and methidathion to young chickens results in a reduction in WBC and neutrophils (Obaineh and Matthew, 2009).

Conclusion

In the light of the above information it can be concluded that the chemical pesticides cause serious sub-lethal effects during the reproductive stages of birds. Sub lethal exposure could contribute to other causes of mortality like trauma. Some bird species are highly susceptible to the pesticide in which breeding season coincide with the most important application of pesticides. Exposure to pesticides during reproductive stages affects hatching success and fledgling survival, as well as increase the possibility of reproductive failure. The preying birds like the peregrine falcon, whooping Crain, and bald eagle are subjected to secondary poisoning when they consumed prey. Pesticides and their residues have an effect on birds and their young directly or indirectly by contaminating food sources. Alteration of feeding behavior compromised the immune system, and increased predation further reduces the ability of these birds to maintain healthy populations.

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