

Review Article

Impacts of Various Insecticide Forms on Avian Health and Mortality: A Comprehensive Review

Abstract

Different forms of insecticides, such as granular, liquid, and treated seeds, pose significant threats to birds. Granular insecticides, often used in agriculture, are highly concentrated and attractive to songbirds, shorebirds, and waterfowl. Liquid sprays, particularly those used for locust control, can affect bird species beyond agricultural areas due to wide-range applications. Treated seeds can poison birds depending on various factors like toxicity and seed availability. Birds are exposed to insecticides through ingestion, inhalation, and skin absorption, leading to severe health impacts, reproductive issues, and increased mortality. Despite the known dangers, many pesticide-related bird deaths go unreported, highlighting the need for comprehensive studies to understand and mitigate these effects.

Keywords: Agrochemicals, Birds and agriculture, Biodiversity, Insecticides, Pesticide exposure, Chronic effect

Introduction:

The effects of the pesticides are increasing nowadays due to its toxicity and moreover they cause impacts on various trophic levels and it mainly affects the birds and bio accumulates and causes serious effects. In recent years the manufacturing and consumption of agrochemicals (pesticides, insecticides, herbicides) worldwide have been increasing dramatically. The majority of pesticides are not specifically targeting the pest only and also affect non-target plants and animals. Most of the agrochemicals has high persistence ability which resist the degradation mainly persist in the soil and gets leached to groundwater and contaminate the soil and aquatic environment (Mitra *et al.*, 2011).

Most bird species that use agricultural landscapes are in decline as a result of the direct and indirect effects of land use intensification, habitat modification, pesticides and other factors. The pesticide use usually associated with modern agriculture can threaten ecosystem

viability through a reduction in biodiversity (flora and fauna) and pollution of natural resources, such as groundwater, that impact human health and communities, as well as the natural environment. A report estimated between 0.25 and 8.9 birds per hectare of agricultural area are killed each year by pesticides. Due to the severe impact of pesticides approximately 67 million birds die each year (Mitra *et al.*, 2011).

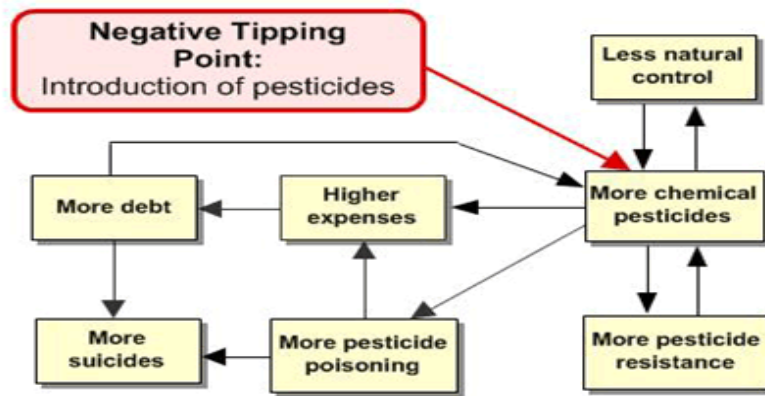


Fig 1. Impact of pesticides

The negative impact of the pesticides had been increasing mainly after the introduction of chemical pesticides which causes increase in the expenditure in agriculture and moreover increase in the pesticide drift by means of air and water. The pesticides not only being toxic to the living organisms and continuous spraying of pesticides leads to increase in the pesticide resistance was developed in the microorganisms. A substance used for destroying insects or other organisms harmful to cultivated plants or to animals.

The pesticides are mainly synthetic compounds which are intended for preventing, destroying, repelling, or mitigating any pest. The Insecticides contribute a major part of agrochemicals used to kill insects. Herbicides are used to kill weeds. The Fungicides are mainly used to control fungal plant diseases. The Rodenticides are also the synthetic compounds used for the killing of rats, mice and other rodents.

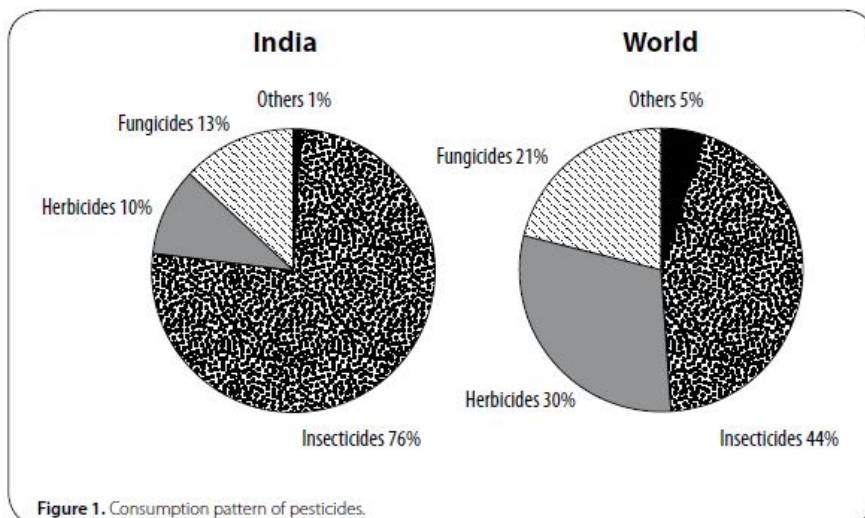
According to the Rachel Carson Council, a study of the unintended economic consequences of pesticides found that the pesticides causes pollination losses to food effects on honey bees and wild bees is \$200 million per year. The natural enemies of pests are being destroyed by the pesticides can cost an estimated \$520 million per year in the U.S. the toxicity of the pesticides causes death of fish population (6-14 million) per year it costs

ranges from \$24 to \$56 million. The agrochemicals toxicity leads to decline of the Wild bird population and it was estimated at 67 million and the value of this bird loss to pesticides is \$2.1 billion annually.

1. Status of usage:

- Currently, India is the largest producer of pesticides in Asia and ranks twelfth in the world for the use of pesticides. In the states consuming higher amount of pesticides Uttar Pradesh ranks first followed by Punjab, Haryana and Maharashtra (Sitaramaraju *et al.*, 2004). Use of chemical pesticides is predominantly followed for the control of pests and diseases.
- Due to the extensive awareness created on the negative aspects of pesticide use, it has been hovering around 480 gms a hectare in India as against the 4.5 kg a hectare in the U.S. and more than 15 kg a hectare in Japan and England.

India, being a tropical country, the consumption pattern is also more skewed towards insecticides (Indian Pesticides Industry; 2011). So the pattern of agrochemical-application in India is not similar to that for the world in general. In India 76% of the pesticide used is insecticide, as against 44% globally (Mathur, 1999). The herbicides and fungicides application is correspondingly less heavy. Crop wise, cotton accounts for the maximum share of pesticide consumption i.e. around 37% followed by paddy (20%). In India together they account for around 57% of the total pesticide consumption. While the wheat and pulses contribute of about 4%, vegetable 9% and the other plantation crops 7% (Ministry of Agriculture, 2009). State wise Andhra Pradesh is the highest pesticides consuming state (23%) followed by Punjab & Maharashtra.



(Wasim *et al.*, 2009)

Fig 2. Consumption pattern in India and world

- In the consumption of agrochemicals in world scenario the insecticides usage was about 44% while the herbicides and fungicides usage are 30% and 21% respectively while other agrochemicals includes 5% of the use. In Indian scenario the utilization of the agrochemicals such as insecticides, herbicides and fungicides are 76%, 10%, 13% respectively while other agrochemicals includes for about 1%.
- The pesticide consumption mainly started after the green revolution which leads to increase in the introduction of high yielding varieties of crops. The pesticide use had its peak in the years of 1988 -1991 and it was about 75000 tonnes while it was greatly reduced to about 45000 tonnes in the years of 2012-2013 was about 45000 tonnes.

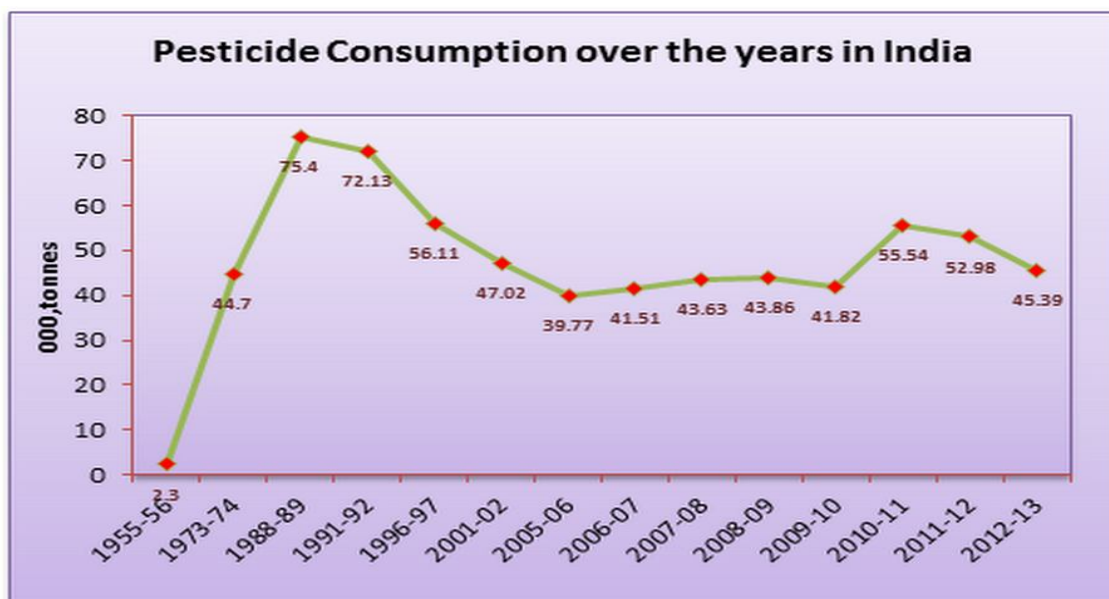


Fig 3. Pesticide consumption over the years in India

3. Role of birds and agriculture:

Birds are more glorious animals for recreational value than others. Birds have always fascinated mankind with their intrinsically beautiful plumage, melodious songs and artistic behaviour (Shrestha 2000). Besides this, birds are valuable for many aspects. They are sensitive indicator of pollution. They also play great role in pest control. According to Robert Van Den Our Nature (2003) 169 Bosch "A pest is a species that, because of its great numbers, behaviour or feeding habit is able to inflict substantial harm on man or his valued resources." Pests have different categories. Insects are key or major pests, which occur perennially and cause serious and persistent economic damage in an ecosystem in the absence of effective control measures. Dead sewer rat, offal, carrion, kitchen scraps and refuse, locusts, termites, fruit, grain and eggs or fledgling birds as the food of House crow (*Corvus splendens*) is described by several workers (Inskipp and Inskipp 1985, Ali 1989, Richard 1993, Thirumurthy and Annamalai 1994). A significant contribution to Nepalese ornithology has been made by Fleming Sr. and Fleming Jr. (1952 to 1980). Permeable of literature about the role of birds in agricultural pests control in Nepal is scanty. In context of Biratnagar, Subba (2001) has published articles on garden birds. The paper deals with the research work carried out in Biratnagar (Latitude N 26° 29', Longitude E 87° 16', altitude 72m), which is the second largest city of the country. It stretches over an area of 760 sq. km.

Human settlement and agricultural lands in the eastern and western sides cover the central part of the Biratnagar. Birds were watched regularly in the agricultural land of Biratnagar, viz. northeast (Kanchanbari), northwest (Air port), southeast (Jatuwa) and southwest (Bakhary) It was done once in a week during Sept. 2001 to Aug. 2002. Binocular, Camera, Field books (Fleming *et al.* 1984, Inskipp and Inskipp 1985, Ali and Ripley 1994, Shrestha 2000) were used to study the feeding behaviour and its role in pest control.

The softer parts of Garden snail (*Achatina fulica*) were found to be eaten by Crow pheasant (*Centropus sinensis*) in large amount in early morning and afternoon. Crabs, destructive to paddy, were seen eaten by House crow (*Corvus splendens*). Cattle egret (*Bubulcus ibis*), Crow pheasant (*Centropus sinensis*), Small green bee eater (*Merops orientalis*), Blue-tailed bee eater (*Merops philippinus*), Common myna (*Acridotheris tristis*), Bank myna (*Acridotheris ginginianus*), Indian tree pie (*Dendrocitta vagabunda*), House crow (*Corvus splendens*) and Red-vented bulbul (*Pycnonotus cafer*) fed on Grasshopper.

Many species of moths and butterflies were controlled by Magpie robin (*Copsychus saularis*), Black drongo (*Dicrurus adsimilis*) and Jungle babbler (*Turdoides striatus*). Weevils were eaten by Indian tree pie (*Dendrocitta vagabunda*). Large-pied wagtail (*Motacillamaderaspatensis*) was found to control the aphid. Owl, Housecrow (*Corvus splendens*) and Jungle crow (*Corvus macrorhynchos*) ate the most destructive pest like rats and mice. Feeding behaviour of birds depends on various environmental factors such as geographical location, habitat, seasons, water quality, competition (intraspecific and interspecific) and scarcity of food etc. List of farmland birds can be seen from table 1.

According to Ali (1990), caterpillars, large insects, lizards, young mice and birds eggs and nestlings are the food of Crow pheasant. Due to the scarcity of food and drastic alteration in environment, food habit of Crow pheasant and House crow was found to have changed. The investigation also revealed the secret of Crow pheasant using Garden snail as food. Besides, the result corroborated the foods and feeding habits of other birds like Cattle egret, Small green bee eater, Blue-tailed bee eater, Common myna, Bank myna, Indian tree pie, Red-vented bulbul, Pied myna, Magpie robin, Black drongo, Jungle babbler, Pied crested cuckoo, Gray-headed myna, King fisher, Flycatcher, Large pied wagtail, Owl and Jungle crow already recorded by earlier workers (Inskipp and Inskipp 1985, Ali 1990, Richard 1993, Subba 2001).

Table 1: Bird species and their population in different land use systems in agro-ecosystem during the year 2012-2013

S.No	Species	CL	WL	PI	FL
1.	Ashy drongo (<i>Dicrurus leucophaeus</i>)	0	11	0	0
2.	Ashy wood swallow (<i>Artamus fuscus</i>)	0	501	0	386
3.	Asian koel (<i>Eudynamis scolopaceus</i>)	18	42	29	55
4.	Asian palm swift (<i>Cypsiurus balasiensis</i>)	240	225	0	461
5.	Asian-paradise flycatcher (<i>Terpsiphone paradasi</i>)	0	0	0	20
6.	Barn owl (<i>Tyto alba</i>)	12	0	0	0
7.	Baya weaver (<i>Ploceus philippinus</i>)	126	0	0	0
8.	Black drongo (<i>Dicrurus macrocercus</i>)	56	63	27	137
9.	Black headed cuckoo shrike (<i>Coracina melanoptera</i>)	0	43	0	26
10.	Black headed ibis (<i>Threskiornis melanocephalus</i>)	0	27	0	0
11.	Black headed munia (<i>Lonchura malacca</i>)	230	0	0	416
12.	Black hooded oriole (<i>Oriolus xanthornus</i>)	0	66	0	44
13.	Black kite (<i>Milvus migrans</i>)	0	0	2	7
14.	Blue-bearded Bee-eater (<i>Nyctornis athertoni</i>)	0	103	0	0
15.	Blue-tailed bee-eater (<i>Merops philippinus</i>)	77	192	0	0
16.	Blyth's pipit (<i>Anthus campestris</i>)	24	0	0	111
17.	Brahminy kite (<i>Haliastur indus</i>)	22	35	18	61
18.	Bronze-winged jacana (<i>Metopidius indicus</i>)	0	62	0	0
19.	Cattle egret (<i>Bubulcus ibis</i>)	0	0	62	42
20.	Chestnut-headed bee-eater (<i>Merops leschenaulti</i>)	0	132	0	257
21.	Common hawk cuckoo (<i>Hierococcyx varus</i>)	0	0	4	23
22.	Common goldenback Woodpecker (<i>Dinopium javanense</i>)	0	0	48	44
23.	Common hoopoe (<i>Upupa epops</i>)	0	0	4	7
24.	Common kestrel (<i>Falco tinnunculus</i>)	7	0	54	44
25.	Common kingfisher (<i>Alcedo atthis</i>)	0	49	11	0
26.	Common iora (<i>Aegithina tiphia</i>)	0	0	57	94
27.	Common myna or Indian myna (<i>Acridotheres tristis</i>)	135	339	192	500
28.	Common sandpiper (<i>Actitis hypoleucos</i>)	0	65	0	0
29.	Common tailor bird (<i>Orthotomus sutorius</i>)	17	0	0	89
30.	Common tern (<i>Sterna hirundo</i>)	0	272	0	0
31.	Coppersmith barbet (<i>Megalaima haemacephala</i>)	0	75	0	144
32.	Cotton pygmy-goose (<i>Nettion coromandelianus</i>)	0	80	0	0
33.	Crimson backed sunbird (<i>Leptocoma minima</i>)	0	0	0	45
34.	Darter (<i>Anhinga melanogaster</i>)	0	74	0	0
35.	Drongo cuckoo (<i>Surniculus lugubris</i>)	0	0	0	8
36.	Great egret (<i>Casmerodius albus</i>)	0	259	611	75
37.	Great goldenback woodpecker (<i>Dinopium benghalense</i>)	0	0	18	18
38.	Green Bee-eater (<i>Merops orientalis</i>)	125	109	85	448
39.	Green sandpiper (<i>Tringa ochropus</i>)	0	8	0	0
40.	Grey francolin (<i>Francolinus pondicerianus</i>)	36	0	18	21
41.	Grey wagtail (<i>Motacilla cinerea</i>)	0	14	0	0
42.	House crow (<i>Corvus splendens</i>)	112	88	146	85
43.	House sparrow (<i>Passer domesticus</i>)	97	0	0	0
44.	Indian golden oriole (<i>Oriolus kundoo</i>)	0	0	0	62
45.	Indian cormorant (<i>Phalacrocorax fuscicollis</i>)	0	256	0	0
46.	Indian cuckoo (<i>Cuculus micropterus</i>)	0	64	44	27
47.	Indian grey hornbill (<i>Ocyrocus birostris</i>)	0	0	0	18
48.	Indian jungle crow (<i>Corvus macrorhynchos</i>)	53	135	148	97
49.	Indian peafowl (<i>Pavo cristatus</i>)	10	0	73	77
50.	Indian pond heron (<i>Ardeola grayii</i>)	0	396	47	0
51.	Indian roller or Blue joy (<i>Coracias benghalensis</i>)	14	74	38	37
52.	Intermediate egret (<i>Mesophox intermedia</i>)	0	113	0	0
53.	Jungle babbler (<i>Turdoides striata</i>)	195	1043	122	660
54.	Jugle bush quail (<i>Perdicula asiatica</i>)	32	0	0	18
55.	Lesser whistling duck (<i>Dendrocygna javanica</i>)	0	177	0	0
56.	Little cormorant (<i>Phalacrocorax niger</i>)	0	288	0	0
57.	Little egret (<i>Egretta garzetta</i>)	0	1299	275	63
58.	Little grebe (<i>Tachybaptus ruficollis</i>)	0	110	0	0
59.	Little swift (<i>Apus affinis</i>)	277	224	0	683
60.	Orange minivet (<i>Pericrocotus flammeus</i>)	0	0	0	30
61.	Oriental magpie robin (<i>Copsychus saularis</i>)	15	0	0	24
62.	Paddy field pipit (<i>Anthus rufulus</i>)	39	0	0	39
63.	Pied bushchat (<i>Saxicola caprata</i>)	63	0	0	117
64.	Pied kingfisher (<i>Ceryle rudis</i>)	0	83	0	0
65.	Plain prinia (<i>Prinia inornata</i>)	48	0	0	63
66.	Purple heron (<i>Ardea purpurea</i>)	0	52	0	0

67.	Purple rumped sunbird (<i>Leptocoma zeylonica</i>)	0	0	0	56
68.	Purple sunbird (<i>Cinnyris asiaticus</i>)	0	0	0	6
69.	Purple swamphen (<i>Porphyrio porphyrio</i>)	0	67	0	0
70.	Red vented bulbul (<i>Pycnonotus cafer</i>)	85	352	0	201
71.	Red wattled lapwing (<i>Vanellus indicus</i>)	0	161	0	54
72.	Rock dove or Rock pigeon (<i>Columba livia</i>)	236	0	0	0
73.	Rose-ringed parakeet (<i>Psittacula krameri</i>)	301	0	140	481
74.	Rufous treepie (<i>Dendrocitta vagabunda</i>)	0	0	91	25
75.	Scaly breasted munia (<i>Lonchura punctulata</i>)	432	0	0	437
76.	Shikra (<i>Accipiter badius</i>)	15	0	17	18
77.	Southern coucal (<i>Centropus [sinensis] parroti</i>)	17	54	60	49
78.	Spotted dove (<i>Stigmatopelia chinensis</i>)	79	183	25	102
79.	Spotted owlet (<i>Athene brama</i>)	18	0	60	49
80.	Stork-billed kingfisher (<i>Pelargopsis capensis</i>)	0	73	0	0
81.	Striated heron (<i>Butorides striata</i>)	0	3	0	0
82.	Tickell's flower pecker (<i>Dicaeum erythrorhynchos</i>)	0	77	0	85
83.	White breasted water hen (<i>Amaurornis phoenicurus</i>)	0	4	0	0
84.	White browed bulbul (<i>Pycnonotus luteolus</i>)	0	87	0	2
85.	White cheeked barbet (<i>Megalaima viridis</i>)	0	0	0	90
86.	White rumped munia (<i>Lonchura striata</i>)	113	0	0	68
87.	White rumped spintail (<i>Zonavena sylvatica</i>)	0	12	0	0
88.	White-bellied drongo (<i>Dicrurus caerulescens</i>)	0	178	0	6
89.	White-browed wagtail (<i>Motacilla maderaspatensis</i>)	29	0	0	73
90.	White-throated kingfisher (<i>Halcyon smyrnensis</i>)	25	156	36	83
91.	Yellow footed green pigeon (<i>Treron phoenicopterus</i>)	0	0	0	4
92.	Yellow wagtail (<i>Motacilla flava</i>)	0	6	0	0
	Total	3430	8661	2562	7572

CL-Cropland, WL-wetland, PI-Plantations, FL-Fallow land

Agricultural land currently occupies approximately 38% of the planet's land surface, or around half its habitable area (Clay 2004). The modification and management of landscapes to produce food or other agricultural commodities for human consumption represents one of the most severe and widespread threats to global biodiversity (BirdLife International 2004; Foley *et al* 2005). The distribution of agricultural land is a better predictor of wildlife threat status than the distribution of people (Scharlemann, Balmford & Green 2005).

Agriculture affects natural ecosystems in more diverse ways, including modifications of landscape, soils, and water supply through deforestation, erosion, channeling, flooding, draining, etc., as well as the elimination or propagation of selected species of plants and animals (Steadman 1996). Agriculture impacts on biodiversity in two main ways. The first is through the clearance of pristine habitats for new planting, with the accompanying pressures of fragmentation of remaining habitats, pollution and disturbance. The second driver of biodiversity decline is the intensification of existing agricultural systems, aimed at increasing crop yields per unit area. This has contributed more to increasing overall

productivity of most commodities over the last 30 years than the planting of new land (Donald and Evans 2006).

Birds patterns of behaviour, distribution, seasonal phenology and demography track closely onto the spatial and temporal scales of agricultural change. Foraging, nest-site selection or breeding performance reflects features within the patchwork of agricultural habitats. The pattern of events in the annual farming calendar interacts with key events in their own lives such as breeding or migration. Their populations or communities vary in ways that reflect local, regional or international variations in land use or management. The effects of year-to-year drift in their demography means that their population trends match the march of agricultural change. Perhaps most importantly of all, the availability of well-organized and geographically extensive data on bird populations over time has drawn our attention to the major environmental changes that have occurred on agricultural land.

When coupled with equally valuable long-term monitoring of land use, these data have special importance in illustrating how ecological trends and agricultural practices are so closely linked (Ormerod & Watkinson, 2000). The possible ecological effects of changing agricultural practice or land conversion are many. Some arise as a direct consequence of structural or composition changes to vegetation and the associated faunal communities. Others are mediated more subtly, for example through the changing phenology of crops. In addition, a wide array of indirect influences arises, for example through changing predator-prey dynamics or the chemical influences of agro-chemicals on species composition. There are also knock-on effects on other ecosystems, for example downstream or in adjacent bordering areas. Moreover, the major restructuring of land surfaces that accompanies agriculture is one of the principal ways through which the remaining semi-natural habitats are fragmented, with consequences for species' populations and dispersal (Ormerod and Watkinson 2000). Negative effects of habitat heterogeneity may occur as a consequence of fragmentation, causing the disruption of key biological processes such as dispersal and resource acquisition. However, there is general consensus that not all species in an ecosystem are equally affected by spatial structures, depending on whether they cause heterogeneity or fragmentation (Tews *et al.*, 2004).

Birds have been widely used as indicators of agricultural environments, and increases in agricultural intensity have been linked with severe declines in farmland bird populations in Europe, North America, Africa and Asia (Donald & Evans 2006). Kati and Sekercioglu (2006) determined that there are 10 specialist species that are highly characteristic and strongly dependent on the habitat types they are found in, as they are found in almost all

sites of that habitat type and rarely in others. When distinct ecosystems, such as forests or wetlands, are destroyed, the ecological roles of birds often disappear with them.

In many cases, however, bird declines occur independent of habitat loss; exploitation, introduced species, pathogens, fragmentation, and other factors eliminate birds and their services from ecosystems. In fact, half of threatened species are threatened by a factor besides habitat loss. This result is particularly the case for scavengers (100%), piscivores (80%), herbivores (78%), omnivores (76%), granivores (56%), frugivores (53%), and birds that weigh 100 g (73%), all of which, except granivores, are groups significantly more threatened than average. Given the momentum of climate change, widespread habitat loss, and increasing numbers of invasive species, avian declines and extinctions are predicted to continue unabated in the near future. By 2100, we expect 6–14% of all historic bird species to be extinct, 7–25% to be functionally extinct, and 13–52% to be functionally deficient (Sekercioglu *et al.* 2004).

4. Mode of poisoning :

First generation insecticides :

The mode of action in birds is generally presented mainly through reproductive effects, such as eggshell thinning, or acute mortality. The common examples of first generation insecticides are organochlorines (DDT, aldrin and dieldrin).

(Review of the ecological effects of poisoning on migratory birds – CMS)

Second generation insecticides:

The mode of action is cholinesterase-inhibiting, which causes neurological effects leading to lethal or sub-lethal effects. The examples of the *Second generation insecticides are organophosphates and carbamates. The avian fauna mainly affected by cholinesterase inhibition are* Barn owls (*Tyto alba*), American kestrels (*Falco sparverius*), Red-tailed hawks (*Buteo jamaicensis*), Great horned owls (*Bubo virginianus*) and Bald eagles (*Haliaeetus leucocephalus*).

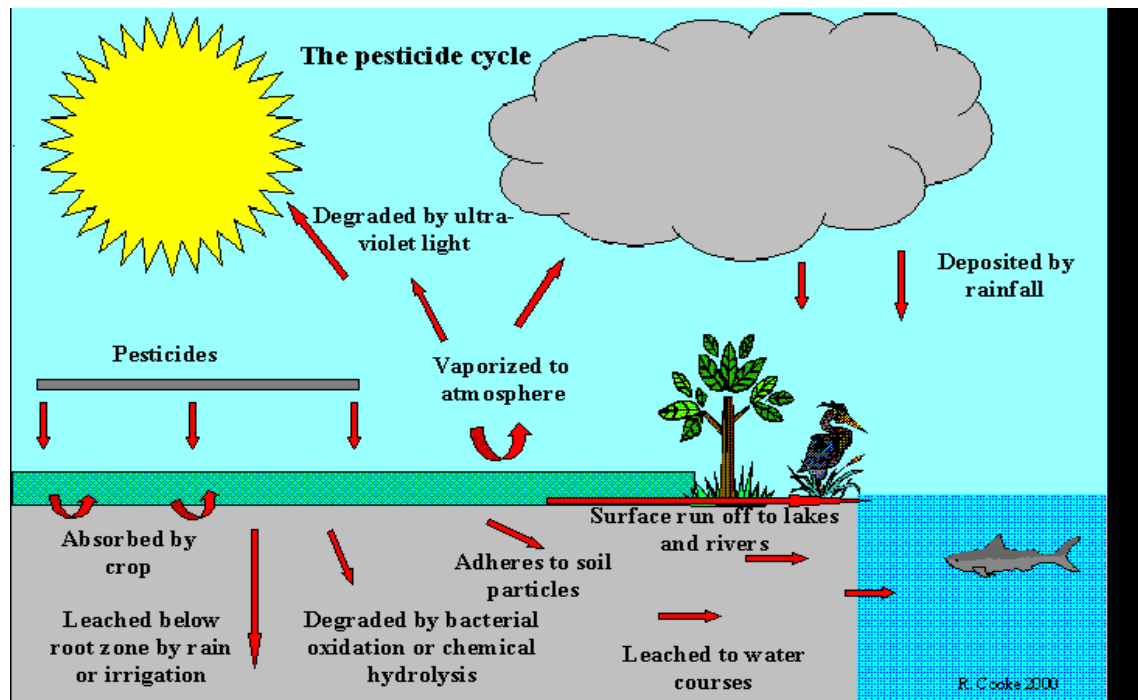


Fig 4. Pesticide cycle

The pesticide cycle is mainly the biotransformation of the pesticides which tends to bio magnify and bio accumulate in biological systems and causes serious effects. After application of pesticides it gets absorbed by the crop and the remains are leached by the rain water or irrigation. Some fraction of pesticides are degraded by bacterial oxidation or chemical hydrolysis while some parts are leached from the soil through surface runoff and leaching and enters into the water bodies. The other route of pesticide transformation was the pesticides gets vaporised to atmosphere and they are degraded by UV light and then comes again to the soil and water bodies as rain and easily enter in to any biological system.

Forms of insecticides that increase risk of exposure

The different forms of insecticide which pose threat to birds are as follows;

Granular forms :

The granular forms are extremely concentrated sources of insecticides, commonly used in agriculture to protect crops from particular pests, and are often implicated in the deaths of songbirds. Eg: Particularly attractive to songbirds, shorebirds and waterfowl (Parsons *et al.*, 2010)

Liquid forms

In the liquid forms of agrochemicals the mortality of birds is dependent on its toxicity and its rate of application. The liquid sprays found sub-lethal effects on the dozens of bird species. The aerial sprays of pesticides for locust control, as discussed above, may affect species other than those who inhabit agricultural areas because of the wide-range of application. (Parsons *et al.*, 2010)

Treated Seeds

The Studies found some seed treatments will poison birds, occasionally under particular circumstances. The poisoning from treated seeds will occur is dependent on the area sown, toxicity of the pesticide, its concentration on the seed, density of the exposed seed, availability of other foods, and ability of the birds to selectively avoid treated seed . Bird population resulting in mortality from treated seed exposure was likely to lie in the range 0-5 per cent.(Hart *et al.*, 1999)

5.Mode of exposure:

The main routes of the agrochemicals exposure by avifauna includes ingestion, inhalation, and absorption through the skin. Pesticides ingested through pesticide soaked granules/seeds, insects and vegetation that sprayed, and drinking contaminated water. Birds ingest pesticides by eating smaller mammals that were previously exposed. Inhalation can occur from chemical spray or treated dust. Skin absorption can occur from bathing in pesticide-affected water, or absorption through the feet by standing in treated soil or vegetation. The volume of seeds eaten by many bird species is large enough to pose a potential risk.

List of chemicals that toxic to birds:

Table 2. List of chemicals that toxic to birds

Active Ingredient Common Name	Trade Names (Not Limited To Only These)	Product Names and Manufacturers (Not Limited to only those)	Toxic to Aquatic Organisms	Toxic To Birds	Toxic to Insects
Insecticides					
Acephate	Orthene	Valent U.S.A. Corp Anti-Scalp™ ORTHENE® Fire Ant Killer Blount Gard ORTHENE® Systemic Insect Control Concentrate		▲	▲
Bendiocarb	Timpan	Piram Turcam	▲	▲	▲
Brodifacoum	Talon Havoc	ICI America, Inc.	▲	▲	▲
Carbaryl	Sevin/Sevin	BUG-BUG-GON Multi-Purpose Garden Dust (bag) ORTHO® Bug-B-Gon® Multi-Purpose Insect Killer Ready-To-Use (Granules)	▲	▲	▲
Chlorpyrifos	Lorsban	ORTHO® ANT-STOP™ Ant Killer ORTHO® Durban® Ready Spray Outdoor Flea & Tick Killer 1 ORTHO® Borer & Leaf Miner Spray ORTHO® Garden Care® Lilly/Miller® Durban® Granules	▲	▲	▲
Diazinon *	Diazinon Isonon Horsal Gardentox Kaysen Knorr Out Nucalin Spectracide	ORTHO® Diazinon Granules ORTHO® Diazinon Seal N' Tight Insect Control ORTHO® Ant-Stop™ Ant Killer (Dust) Bug-To-Go® Ready Spray ORTHO® Lock N' Spray® Bug-B-Gon® Multi-Purpose Insect Killer 1 Chalcoley Corp. Lilly/Miller® Diazinon Granules	▲	▲	▲
Lindane	Isotox Kwell benzene hexachloride or 'BHC'	Drexel Chemical Company Ortho® Isotox (formula IV) Ortho® Lindane Borer/Leaf Miner Spray	▲	▲	▲
Malathion	Cythion Maldathion	ORTHO® Malathion Plus® Insect Spray Concentrate ORTHO® MALATHION 50 PLUS® Insect Spray	▲	▲	▲
Herbicides					
2, 4-D	2, 4-D	Hi-Dep® Weeda® 64 Weed RHAP A-4D® Weed RHAP A Rhône-Poulenc, Inc.	▲		▲
Glyphosate	Roundup	Roundup Weed & Grass Killer1 Ready-To-Use KLEERAWAY™ Systemic Weed & Grass Killer Roundup® Tough Weed Formula	▲		
Trifluralin	Treflan® 4G Treflan® E.C. Trifluralin® 4EC	DowElanco	▲		
Fungicides					
Benomyl	Benlate	Du Pont Agricultural Products		▲	
Chlorothalonil	Bravo	SDS Biotech Corporation Giffin Chemical Company		▲	

6.Impact of Pesticide exposure on bird:

Pesticide exposure severely impacts birds' habitats, mating rituals, territorial defense, and overall health. It causes labored breathing, convulsions, and feather fluffing, increasing risks of predation, accidents, and food scarcity. Reproductive abilities are reduced, with failures in mating, territory defense, and nurturing young. Birds can die within half an hour of exposure. Documented pesticide-related bird deaths are few due to limited scientists, funding, and diagnostic challenges. Many deaths go unnoticed as birds may hide, decay, or be scavenged. Sick birds evade capture, complicating analysis. Comprehensive, well-designed field studies are essential but expensive and time-consuming. Singing bird counts, often used

to estimate populations, may not accurately reflect sublethal effects, necessitating more detailed research to document nonlethal impacts.

Reproduction:

- The pesticide exposure leads to inability to defend territories, disruption of incubation patterns and clutch desertion (the reproductive success was 25 per cent less as a result of two consecutive sprays)
- The Reproductive abilities are reduced by means of failure to find a mate, failure to perform mating rituals, defend territory, and change patterns of attention to their young. Experiments done on red-legged partridges fed with imidacloprid and thiram treated seeds showed adverse reproductive effects at recommended doses after a 10 day exposure. (Scientific advisory Committee 2014)

In England showed delayed chick development and impaired blood cholinesterase activity in tree sparrows in intensively sprayed (organophosphates) area. In organophosphates exposed to mallards hatching success was reduced by 43% in comparison to control due to abnormal incubation behaviour including nest abundant and extended time off nests(Bennett *et al.*, 1991).The predators also gets affected by the pesticides indirectly by consuming prey that contained high residues of the insecticide Eg: DDT. Flies that live just under the skin of cattle. Famphur poured onto cattle was shown to cause subsequent poisoning of magpies, birds that feed on cattle hair for part of their diet. Frogs raised in water containing the insecticide²⁷ Similar problems may occur with other organophosphates.(Caroline Cox., 1991)

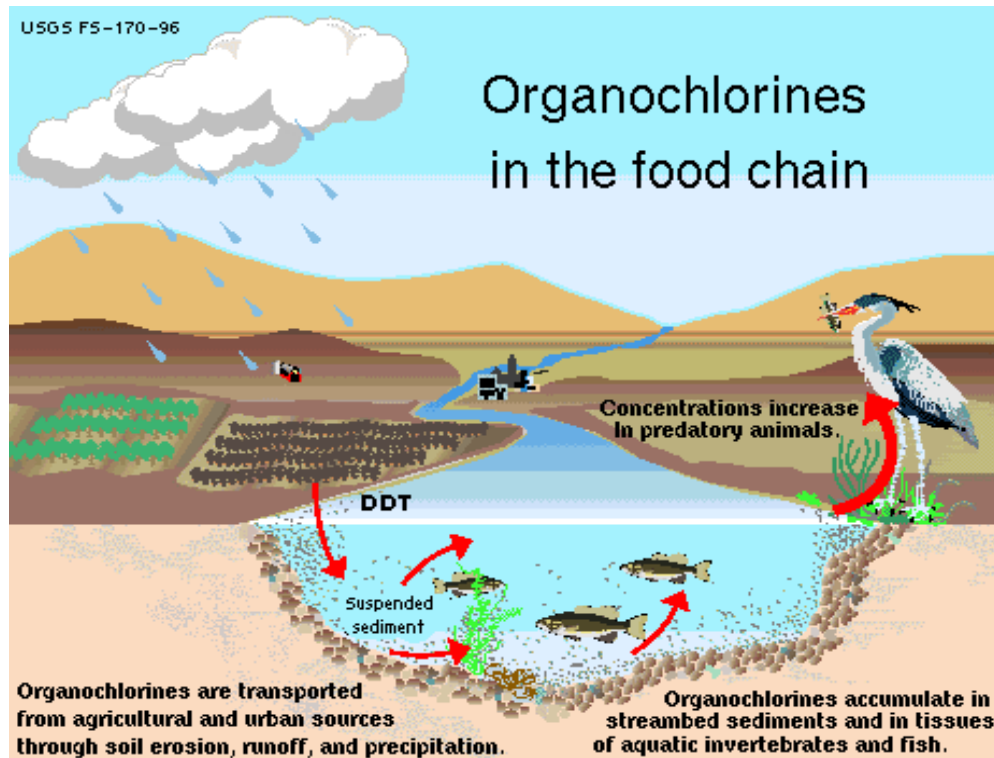


Fig 5. Organochlorines in the food chain

Organochlorine compounds used as agrochemicals which get leached and enter into water bodies and get contaminated in the water at lower levels which thereby biotransform to the phytoplankton-zooplankton-small fishes-Large fishes-predatory birds and they bioaccumulate at all the trophic levels of the food chain which leads to an increase in the concentration of the contaminants called as biomagnification. In each successive trophic level the concentration of the organochlorine compounds increases and causes toxicity.

Organochlorines:

The organochlorine threat to birds did not go away when DDT's registered uses were cancelled. Some organochlorine pesticides (for example, the miticide dicofol which also causes eggshell thinning in birds) are still used in the United States, and uses of others (for example, chlordane) were restricted or cancelled much later than DDT. In addition, DDT and related compounds are still used in many other countries. Birds that migrate to other countries can bring residues stored in their tissues back to the U.S. For example, analysis of great horned owls for organochlorine residues at the Virginia Wildlife Center found high levels of the DDT metabolite DDE, and smaller amounts of dicofol and methoxychlor (another organochlorine insecticide still registered for use in the U.S.). Although the owls do not migrate, the organochlorine residues could have come from the birds' migratory prey,

persistent residues from previous years carried by the long-lived birds, or from current uses of dicofol and methoxychlor. It is not possible to determine the source.

Organo phosphorus:

The insecticidal properties of organophosphorus (OP) and carbamate compounds were first discovered in the 1930s, and the compounds were developed for pesticide use in the 1940s. They have been used increasingly since the 1970s when environmentally persistent organochlorine pesticides, such as DDT and dieldrin, were banned for use in the United States. Organophosphorus and carbamate pesticides are generally short-lived in the environment (usually lasting only days to months instead of years) and, generally, chemical breakdown is accelerated as temperatures or pH or uth increase.

Cause :

The toxicity of OP and carbamate pesticides is due to the disruption of the nervous system of an invertebrate or a vertebrate through the inhibition of cholinesterase (ChE) enzymes. These enzymes are involved in transmitting normal nerve impulses throughout the nervous system. An acute pesticide dose reduces the activity of ChEs, and nerve mpulsescannot be transmitted normally. This can paralyze the nervous system, and it may lead to death, usually from respiratory failure.

Table 3. Toxicity of OP and carbamate pesticides

Compound	Class	Species LD ₅₀		
		Mallard duck	Ring-necked pheasant	Red-winged blackbird
Aldicarb	Carbamate	3.4	5.3	1.8
Carbaryl	Carbamate	>2,000	707	56
Carbofuran	Carbamate	0.5	4.1	0.4
Methiocarb	Carbamate	13	270	4.6
Mexacarbate	Carbamate	3.0	4.6	10
Azinphos-methyl	OP	136	75	8.5
Dimethoate	OP	42	20	6.6
Ethion	OP	>2,000	1,297	45
Phorate	OP	0.6	7.1	1.0
Temephos	OP	79	35	42

Thermoregulation:

The pesticides induced reduction in body temperatures in birds are often associated with decrease in AchEactivity of more than 50% (Clement, 1991). It leads to enhanced mortality in birds is reported at sub lethal doses at thermo-neutral temperatures (Rattner *et al.*, 1984). Interaction between low temperature and pesticides toxicity appears to be resilt of the

impairment of thermoregulation causing inability of birds to withstand the cold (Martinet *et al.*, 1991).

Feeding:

The pesticide exposure leads to direct effects on feeding behaviour including encountering, choosing, capturing and handling of prey. The effects such as loss of coordination, disorientation and convulsions could impair hunting skills. The Low-level acute exposure can produce long-term changes to feeding patterns. Red-winged blackbirds (*Agelaius phoeniceus*) exposed to prey contaminated with parathion developed taste aversion to the prey species even where uncontaminated by the chemical. This could result in reduced food intake and hence body condition, but it could also minimise the risk of poisoning. (Douthwaite *et al.*, 1996).

Exposures to organophosphates and carbamates interfered with the birds ability to discriminate between contaminated and clean food. Reduction in body weight of following sublethal exposure with an average weight loss of 14% was also noted. Such weight loss correlated with single dose of dicotophos (Grue *et al.*, 1984). Lesions in lateral hypothalamus due to pesticide exposure lead to food avoidance and cause a sharp reduction in body weight in birds.

Chronic effects:

The developing chicks showed malformed beaks and skeleton, fluid retention in their heart and problems in sex determination. Congenital abnormalities and defects of feather growth of young terns are reported after pesticide exposure (Bourne *et al.*, 1977) it mainly affects the endocrine system. Birds face high risk due to the consumption of high quantities of seed. Small birds at risk due to their loss body weight. The Endosulfan as an endocrine disrupter while the Lindane affects serum hormonal level which is important in reproduction and metabolism and decreased hormone level resulted in decreased egg production (Herbst *et al.*, 1991).

Effect on haematological and immune system:

Anaemia and decreased haemoglobin concentration have been documented after birds were exposed to lindane (Mandal *et al.*, 1986). Suppression of T-cell mediated immunity in

the wild Caspian terns and herring gulls were found to be associated with high perinatal exposure to pesticides (Grasman *et al.*, 1996).

Starvation:

Indirectly cause birds starvation or force them to leave treated areas because the herbicides destroy the habitat used by the birds prey. For example, synthetic pyrethroids (which, as a group have a relatively low acute toxicity to birds) can destroy birds food supplies. Waterfowl that feed on aquatic insects, small insectivorous birds, and nestlings fed on insects are especially vulnerable.

The Indian subcontinent has had a remarkable geo-tectonic history, especially during the period since the Cretaceous, when the proto-Indian cratonic mass rafted northward from Gondwanan Africa to impact the Eurasian plate (Mani, 1974a; Smith, Hurley & Briden, 1981). This collision produced the Himalayan uplift (Klootwijk, Conaghan & Powell, 1985) and defined the boundaries of the Indian region today as an arc of mountains that ranges from the Andaman Islands (Ripley & Beehler, 1989) north-eastward along the India/Burma border, westward in the easternmost Himalayas to Sikkim, northwestward to Kashmir, and finally southwestward to the Makran Coast of Pakistan.

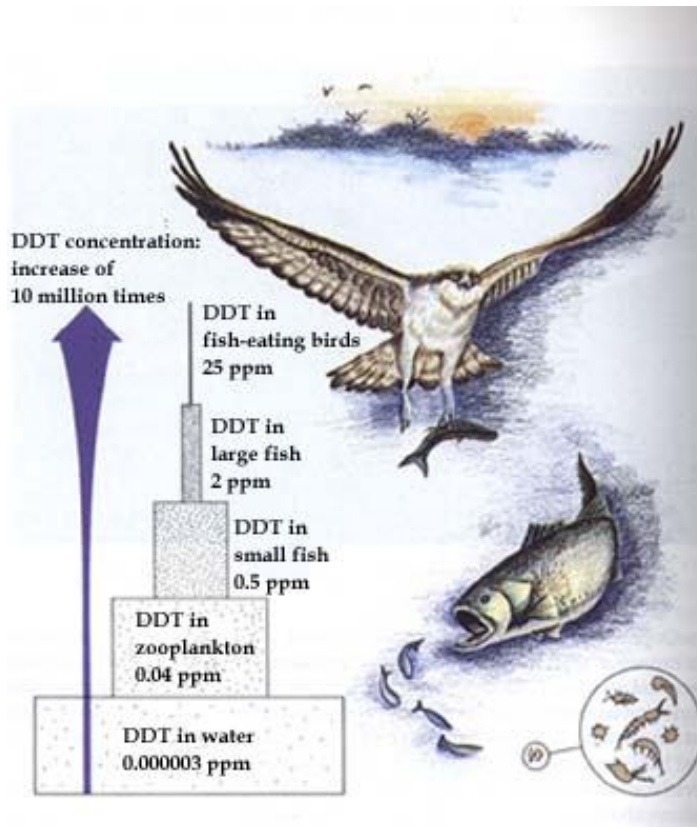


Fig 6. Increase of DDT concentration

The biomagnification and the bioaccumulation were mentioned in the above figure as the water has the lowest level of DDT concentration and it increases tremendously by successive trophic levels and shows a 10 million times increase in the fish-eating birds. (Caroline, 1991)

The forestry application of fenitrothion, an organophosphate insecticide, caused a decrease of almost one-third in the weight of insects available for birds to eat. Pesticides have resulted in the decline in the abundance and diversity of invertebrates and plants. The effects of pesticides on the availability of chick food and thus nestling survival prospects (e.g.) Indirect effects are generally considered to be the greatest threat from pesticides to birds.

Cholinesterase:

Cholinesterase-inhibiting insecticides, which include organophosphates and carbamates, lead to impaired nest attentiveness and predator avoidance. On wading birds productivity in US showed that cholinesterase activity was low in some bird species nesting in an agricultural estuary compared to non-agricultural ones. A review of evidence shows that cholinesterase-inhibiting insecticides can affect a range of physiological and behavioural patterns, potentially

affecting individuals' survival and productivity in the field (Strum *et al.*, 2008).



Fig 7. Bald eagle with clenched talon, a symptom of anti-cholinesterase pesticide exposure

Migratory bird :

The Indian sub-continent is a host to a multitude of birds from western Asia, Europe and Arctic Russia in winter. Hundreds of species of waterfowl, including wading birds such as plovers, terns and sandpipers, migrate each winter to India covering long distances (Grewal, 1990). While concentrations of OC pesticides in whole-body homogenates of birds have been reported elsewhere (Tanabe *et al.*, 1998), concentrations of OCs in prey items and in eggs of Indian birds have not been reported.

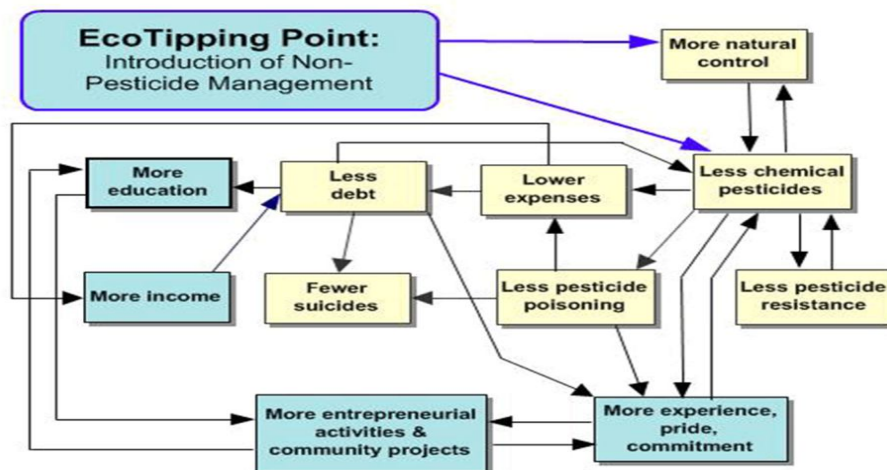


Fig 8. Non-pesticide management positive tips

IPM:

Remedial M Integrated Pest Management, or IPM, is an effective technique to manage pests in your home and garden. By using IPM you can reduce the use of pesticides, have healthier plants, and enjoy your landscape. The seven steps the IPM includes introduction of Resistant varieties, Natural insect predators, Microbial pesticides, Controlling the population, Non toxic naturally occurring substances and Synthetic pesticides in small amounts.

Step 1. Prevention:

- Plant a variety of species
- Build good soil and give plants the sun, water, and nutrients they need.
- Keep garden pathways and beds clean.
- Rotate crops. easures (Dickey *et al.*, 2003)

Step 2. Observation

- Monitor your plants carefully.
- Be realistic. Act only when necessary.

Step 3. Taking Action

- Physical and cultural controls
- Biological controls
- Chemical controls

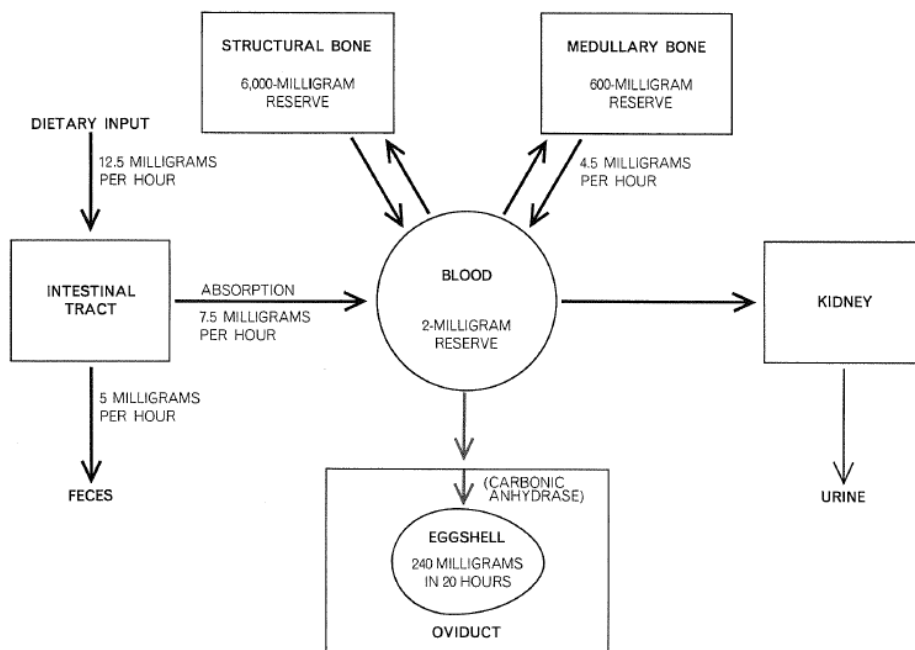
Step 4. Evaluation

7. CASE STUDY:



Fig 9. Pesticides and reproduction of birds

Crushed egg in the nest of brown pelican of the California coast had a thin shell that the weight of the nestinparents body destroyed it. The concentration of DDE in the egg reached 2500 PPM (Peakall, 1970)



CALCIUM FOR EGGSHELL, which is formed around each egg in the last 20 hours before laying, is drawn in part from the bird's food supply and in part from calcium reserves in the bird's bones. The key to shell formation, however, is the enzyme carbonic an-

hydrase, which makes the supply of calcium carried in the ring-dove's bloodstream available to the bird's oviduct at a rate of 12 milligrams per hour. When laying ringdoves are injected with DDE, the action of the enzyme is severely inhibited, causing thin shells.

(Peakall, 1970)

Fig 10. Crushed egg in the nest of brown pelican

Impact of pesticides use in agriculture: their benefits and hazards:

Exposure of eggs to 2,4-D reduced successful hatching of chicken eggs (Duffard *et al.*, 1981) and caused feminisation or sterility in pheasant chicks (Lutz *et al.*, 1972). Herbicides can also adversely affect birds by destroying their habitat. Glyphosate treatment in clear cuts caused dramatic decreases in the populations of birds that lived there (MacKinnon *et al.*, 1993) Effects of some organochlorines (OCs) on fish-eating water birds and marine mammals have been documented in North America and Europe (Barron *et al.*, 1995; Cooke, 1979; Kubiak *et al.*, 1989). (Wasim *et al.*, 2009).

Despite the continuing usage, little is known about the impacts of OCs in bird populations in developing countries. Among the countries that continue to use OCs, India has been one of the major producers and consumers in recent years. As a consequence, wild birds in India are exposed to great amounts of OC pesticides (Tanabe *et al.*, 1998) (Wasim *et al.*, 2009).

Estimating Numbers of Birds Killed by Granular Carbofuran at Seeding in Corn:

The following case study is used to highlight a 'worst-case' impact of pesticides on birds in an agricultural setting. Carbofuran is especially toxic to birds, and its formulation on silica particles (ideal grit material) ensured ample exposure to birds (Mineau 1993). Fortunately, most uses of granular carbofuran formulations have now been discontinued in the US and no granular formulations of this pesticide are permitted in Canada. However, they remain registered on a large variety of crops in most of Latin America where they continue to place our migratory birds at risk. A recent (June 2002) emergency exemption for 10,000 acres of rice in Louisiana and subsequent revocation about a month later shows that the pros and cons of this chemical continue to be the subject of debate. In addition, there are other granular pesticides, although perhaps slightly less toxic, which have similar albeit slower acting effects on birds in agricultural settings.

Organophosphorus and Carbamate Pesticides:

The insecticidal properties of organophosphorus (OP) and carbamate compounds were first discovered in the 1930s, and the compounds were developed for pesticide use in the 1940s. They have been used increasingly since the 1970s when environmentally persistent organochlorine pesticides, such as DDT and dieldrin, were banned for use in the United States. Organophosphorus and carbamate pesticides are generally short-lived in the

environment (usually lasting only days to months instead of years) and, generally, chemical breakdown is accelerated as temperatures or pH or both increase.

Cause :

The toxicity of OP and carbamate pesticides is due to the disruption of the nervous system of an invertebrate or a vertebrate through the inhibition of cholinesterase (ChE) enzymes. These enzymes are involved in transmitting normal nerve impulses throughout the nervous system. An acute pesticide dose reduces the activity of ChEs, and nerve impulses cannot be transmitted normally. This can paralyze the nervous system, and it may lead to death, usually from respiratory failure.

Common routes of exposure of birds to OP and carbamate pesticides include:

Consumption of:

Treated seeds

Vegetation with pesticide residues

Dead or struggling poisoned insects

Granular formulations as grit, food, or coincidentally with other food items

Carrion killed by a pesticide

Food intentionally baited with pesticide

Live animals intoxicated with pesticide

Water contaminated with pesticide from runoff or irrigation

Inhalation

Absorption through the skin

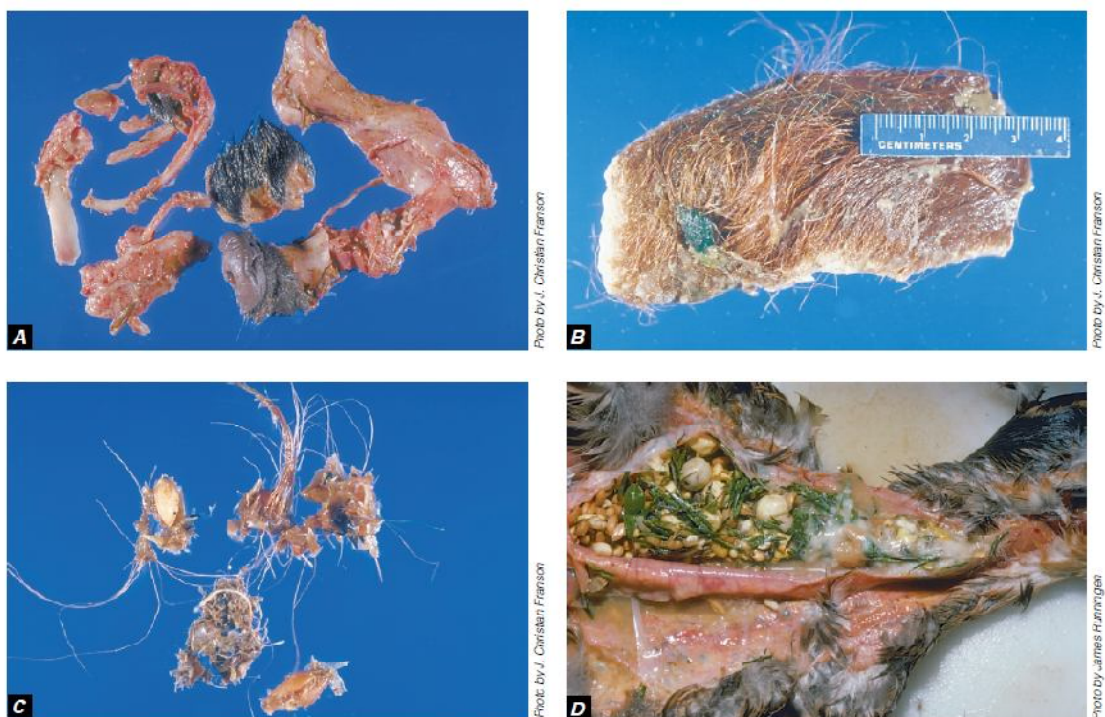


Fig 11. Toxicity of OP and carbamate pesticides

8. Conclusion:

Pesticides and their residues can affect birds and their young directly or indirectly by contaminating food sources. Exposure to pesticides during reproductive stages affects hatching success and fledging survival, as well as increases the chance of reproductive failure. Such problems were reproductive dysfunction, eggshell thinning, metabolic changes, deformities and birth defects, cancers, behavioral changes, abnormal thyroid activities, endocrine dysfunction, immune suppression, feminization of males and masculinization of females. Both acute and chronic exposure to pesticides increase mortality, while sub lethal exposure adversely affects avian population. Legislation at the International and National level regarding the use of pesticide should be strictly followed involving the users. The Alarming rate of avian deaths must be taken serious and alternate control methods such as IPM must be practised for pest control .

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