CHAPTER VIII

GENERAL SUMMARY AND CONCLUSION
Insecticides are the biocidal agricultural chemicals whose direct and indirect effects on wildlife and non-target animals are becoming a matter of serious concern throughout the world. The toxic manifestation of insecticides in animals results from a complex series of interactions between the chemicals and/or its metabolites and various biological systems within the animal. Factors generally affecting toxicities are exposure, uptake, metabolism, distribution, excretion, target interactions etc. Birds in general and raptors in particular are especially susceptible to persistent insecticides, presumably because of their exposure at the top of the food chain and subtle physiological differences. In India organochlorine insecticides are extensively used together with modest amount of organophosphates and carbamates, but no well co-ordinated studies have so far been conducted on birds regarding the physiopathological effects of such insecticides. In the present study, an attempt has been made to explore the physiopathological effects of these biocidal agents with special reference to chlorinated hydrocarbons viz. lindane (γ-hexachlorocyclohexane) on selected species of birds.

The study is primarily divided into two parts. In the first part, comparative hematological responses of six species of birds to organochlorine, organophosphate and carbamate have been studied. Detailed hematological study was conducted in pigeons and ducks with varied duration and doses of insecticides, particularly the organochlorine and also organophosphate. In the other part, toxicological effects of lindane on pigeon and duck have been studied. These include histopathological examination of various organs, liver and kidney function tests, analyses of brain biogenic amine levels and acetylcholinesterase activities and residue analysis of lindane in blood and various organs. The objective of the first part is to study the nature and suitability of use of hematologic response for pesticide toxicity monitoring in birds, while the second part is primarily aimed to assess the toxicity of the most widely used class of pesticides in India. The following conclusions can be drawn from the experimental results of the present study:
1. In the applied doses, no insecticide-induced fatality was observed in any bird species, either during short or long-term experiments. There was no neurological symptoms to suggest any overt toxicity. The general health condition and food intake also remained normal in the experimental birds.

2. Insecticides belonging to different classes produced profound hematological alterations in the experimental birds with varied degrees of intensity. Progressive anemia was the most common hematologic disorder in all the insecticide-fed birds. Heterophilic and eosinophilic leucocytosis together with lymphocytopenia and monocyto­penia were also observed in such birds. Reticulocytosis accompanied by prolonged bleeding and clotting time were the other common hematological abnormalities induced by various insecticides. Increased osmotic fragility of red blood cells was observed in the experimental birds which may be due to membrane dysfunction of such cells. The observed anemia can be attributed to both bone marrow depression and increased hemolysis due to insecticide treatment. Accelerated hemolysis is generally compensated by stimulated erythropoiesis. Since the anemia was persistent, apparently the compensatory production of red cell was either absent or inadequate in the experimental birds. The anemia was further intensified by hemorrhage in liver, spleen, duodenum and lungs. The differential counts of WBC indicate virtual reversal of lymphoid-myeloid ratio in the treated birds. Cellular disorganization, specially of the heterophils accompany hematological disorder, suggesting stress effect. The reduced splenic cellularity and lymphocytopenia and monocyto­penia possibly indicates immunosuppression by the insecticides.
3. Histopathological examinations of some of the vital organs in both lindane-fed pigeons and ducks revealed marked alterations of tissue architecture, specially in the pigeon. These included focal necrosis, hypertrophy, fibrosis and fatty infiltration in the liver parenchyma along with considerable hemorrhage; frequent tubular degeneration, parenchymal alterations, vascular congestion, increased hemorrhage and desquamation of the lining epithelium, particularly of the distal convoluted tubules of the kidney; disorganization of the white pulp area with decreased lymphocyte population, dilatation of the blood vessels and increased hemorrhage in the spleen; hypertrophy along with considerable hemorrhage in the duodenal villi; and marked dilatation of the alveolar structure and accelerated hemorrhage in the lungs.

4. Lindane induced marked alteration of the normal functional capacity of both liver and kidney in pigeons and ducks. The study revealed remarkable increase of serum acid and alkaline phosphatase, GOT and GPT activities, cholesterol, glucose and bilirubin (conjugated and total) contents, followed by subsequent decrease of total lipid, glycogen content and G6PDH activity specially in the high dosed groups of birds. Significant increase of blood urea and non-protein nitrogen content along with subsequent decrease of total protein and RNA content of liver were noted in the experimental birds. The findings indicate both hepato- and renal toxicity of lindane.

5. In pigeons and ducks lindane reduced the dopamine and norepinephrine levels of the whole brain extract while no significant change occurred in the epinephrine and acetylcholine level or acetylcholinesterase activity in such birds. In absence of any neurological symptoms charac-
teristic of insecticide toxicity, it appears that disturbances of CNS by lindane (if any) was not severe and the administered doses of the insecticide are tolerated.

6. Lindane maximally accumulated in the abdominal fat, followed by muscle, kidney, liver and brain in pigeon. In duck (both non-laying and laying), the abdominal fat also contained the highest amount of lindane, while serum seemed to accumulate higher concentration of insecticide compared to kidney, liver or brain, specially at higher doses. The degree of accumulation varied with fat content of the tissue as well as dose and duration of insecticide administration. Though the pigeons accumulated more residue than the ducks, the level of accumulation was not lethal as indicated by absence of any overt toxicity.

On the basis of the above findings, it may be concluded that mild to moderate anemia was a common hematologic disorder of insecticide intoxication in birds. The cause of anemia can be traced to decreased erythropoiesis in the bone marrow and increased hemolysis, possibly due to membrane dysfunction. Absence of compensatory erythropoiesis in other hematopoietic tissue also characterized the anemia in the experimental birds. Increased leucocyte counts and specific cytotoxic effects of heterophils and eosinophils suggest stress effect, while lymphocytopenia, monocytopenia and decreased splenic cellularity indicates a possible state of immunosuppression. The uniform hematological response from two weeks onwards in the insecticide-fed birds together with specific cytotoxic effect on the formed elements of blood suggest the potential to use hematological response for monitoring toxicity of insecticide specially
in the field, where complete diagnostic tests are difficult to perform. Marked changes observed in both liver and kidney functions of lindane-fed birds indicate that this insecticide is both hepatotoxic and nephrotoxic. Histology of these organs also support this view. Though lindane induced some alterations in the levels of dopamine and norepinephrine, it is possibly not a potent inhibitor of brain neurotransmitters and acetylcholinesterase activity. The degree of accumulation of lindane in various tissues of the experimental birds is related to the fat content of the tissues together with dose and duration of insecticide administration. At the administered dose, the accumulated residue is tolerated without inducing any overt toxicity in the experimental birds; but this does not necessarily signify the absence of subtle physiological effects of this insecticide like reproductive adversities or eggshell thinning which are commonly associated with such class of insecticide.