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Effect of Lambda Cyhalothrin on the Histoarchitecture of the Female Freshwater Catfish

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ABSTRACT

Pesticides are a crucial element in enhancing agricultural production. If the benefits of pesticides encompass their potential to boost economic prospects through augmented food and fiber production and reduction of vector-borne diseases, then the drawbacks entail significant health consequences for humans and the environment. Fishes play a significant role in aquaculture, serving as an excellent source of protein for humans. Today, the effect of pesticides on fish growth, survival, and reproduction is a significant concern due to their interference with normal physiological processes in these organisms. The application of pyrethroid insecticides for managing insect pests has risen dramatically. The excessive application of synthetic pyrethroids is speeding up environmental and water resource pollution, endangering aquatic organisms and posing an indirect threat to human life. Although pyrethroid compounds show much lower toxic effects on birds and mammals than organophosphates, numerous laboratory studies have shown their impact on arthropods and fish. The USEPA registered lambda cyhalothrin, a widely used agricultural pyrethroid, in 1988 is highly toxic to fishes and aquatic invertebrates. This study was aimed to evaluate histopathological findings of two distinct sub-lethal concentrations of lambda cyhalothrin on freshwater catfish. The liver, muscle, gills, ovary, brain, heart, thyroid, and head kidney (adrenal) tissues were preserved in 10% formalin for histopathological examination and showed marked pathological changes when compared to the control group of fishes.

INTRODUCTION

To sustain the greater food supply needed to feed the growing population in developing countries such as India, pesticides are a crucial element in enhancing agricultural production. If the benefits of pesticides encompass their potential to boost economic prospects through augmented food and fiber production and reduction of vector-borne diseases, then the drawbacks entail significant health consequences for humans and the environment. It appears that the uptake and accumulation of a pesticide by aquatic organisms are more influenced by factors such as habitat, behaviour, life cycle, and exchange equilibria than by food uptake; however, they are influenced by numerous additional factors, including the organism's size, pharmacokinetics, and the physical and chemical characteristics of the pesticide (Rosenberg, 1975).

Fishes play a significant role in aquaculture, serving as an excellent source of protein for humans. Today, the effect of pesticides on fish growth, survival, and reproduction is a significant concern due to their interference with normal physiological processes in these organisms.

In recent years, the application of pyrethroid insecticides for managing insect pests has risen dramatically. In water, pyrethroids are often broken down aerobically and anaerobically at rates comparable to those in soil (Laskowski, 2002).

Due to the overuse of synthetic pyrethroids, pollution of the environment and water resources is accelerating, putting aquatic life at risk and indirectly threatening human life (Hill, 1989). Despite the fact that pyrethroid compounds exhibit significantly lower avian and mammalian toxicities compared to organophosphates, various laboratory studies have demonstrated their effects on arthropods and fish (Siegfried, 1993).

The USEPA registered lambda cyhalothrin, a widely used agricultural pyrethroid, in 1988. Lambda cyhalothrin is highly toxic to fishes and aquatic invertebrates. The fish cultivated in the paddy fields, however, are at risk of being directly exposed to toxic substances employed for pest management in those fields. However, fish farmed in commercial ponds may also be at risk of exposure to various pesticides from adjacent fields, which often contaminate the pond (Nettleton et al., 1990).

Therefore, this study aimed to evaluate the impact of two distinct sub-lethal concentrations of lambda cyhalothrin on freshwater catfish, *Clarias batrachus*, residing in the sediment colloid environmental compartment of agricultural field ditches where they may come into contact with these toxic substances.

MATERIALS AND METHODS:

Freshwater catfish, *Clarias batrachus* locally known as Magur, was selected for the study. The technical grade synthetic pyrethroid, lambda cyhalothrin with 95% purity was obtained from Rallis India Ltd., Bangalore to test its effect on nutritionally important freshwater catfish, *Clarias batrachus*. Healthy female catfishes, *Clarias batrachus* weighing 200-250 g and about 30-35cms in length were chosen and sorted out into three groups of 25 fishes each. The fishes were examined carefully for any pathological symptoms and placed in dilute water containing 0.1 mg/l of potassium permanganate solution to avoid possibility of any dermal infection. They were maintained in tap water under ambient conditions of temperature and photoperiod. Group I served as the control while Group II and III were exposed to the two different sub-lethal concentrations of lambda cyhalothrin for a period of 45 days. For histological studies the liver, muscle, gills, ovary, brain, heart, thyroid and head kidney (adrenal) tissues were collected in 10% formalin. They were processed routinely for paraffin embedding and sectioned to 5μ thickness for staining by haematoxylin and eosin (H&E) method (Luna, 1968) for histopathological examination.

Group I: Control fishes maintained in dechlorinated toxicant free water.
Group II: Fishes maintained in higher sub-lethal concentration of the toxicant (5.768 ppm).
Group III: Fishes maintained in lower concentration sub-lethal concentration of the toxicant (2.884 ppm).

RESULTS:

The histoarchitecture of the liver, muscle, gills, ovary, brain, heart, thyroid, and adrenal (head kidney) tissues of the pyrethroid-exposed fishes showed marked pathological changes when compared to the control group of fishes. All the tissues showed degenerative changes after exposure to the sub-lethal concentrations of pyrethroid.

In contrast to the normal hepatocytes observed in the liver tissue of control group of fishes Figure 1a, the hepatic tissue of the fishes exposed to 5.768 ppm of lambda cyhalothrin showed extensive vacuolization and disruption of hepatocytes Figure 1b. Figure 1c shows the hypermic blood capillary, pycnosis and necrosis of hepatocytes in liver tissue of fishes exposed to 2.884 ppm of lambda cyhalothrin. The degenerated muscle fibres and edema in the muscle tissue of the pyrethroid exposed fishes are shown in figure 2a and 2b.

Fig. 1a: Normal Hepatocytes in Liver tissue

Fig. 1b: Extensive Fatty Change, vacuolated cytoplasm and Necrotic hepatic cells in fishes exposed 5.768 ppm of lambda cyhalothrin

Fig. 1c: Pyknotic nuclei (arrow) necrosis and hypermic blood capillary (BC) in hepatic tissue of fishes exposed to 2.884 ppm of lambda cyhalothrin

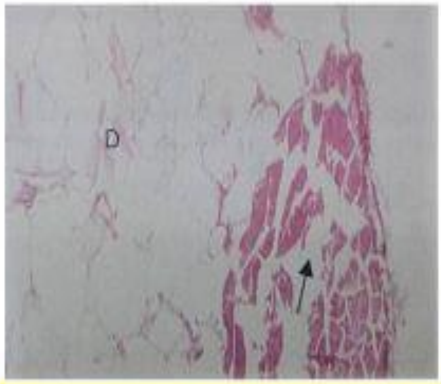
Fig. (2a): Degenerated muscle fibres (D) and edema (arrow) in muscle tissue of fishes exposed to 5.768 ppm of lambda cyhalothrin


Fig. (2b): Degenerated muscle (D) bundles in fishes exposed to 2.884 ppm of lambda cyhalothrin

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The gills of the fishes exposed to 5.768 ppm of lambda cyhalothrin showed atrophy and disruption of lamellae Figure 3a&3b, while fishes exposed to the lower sub-lethal concentration (2.884 ppm) of the pyrethroid showed disruption of lamellar epithelium and curling and curling and fusion of secondary lamellae Figure 3c. Figure 3d show signs of infiltration and inflammation in the secondary lamellae of the gills of fishes exposed to 2.884 ppm of lambda cyhalothrin.

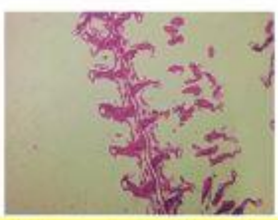
Fig. 3a: Severe atrophy of gills in fishes exposed to 5.768 ppm of lambda cyhalothrin

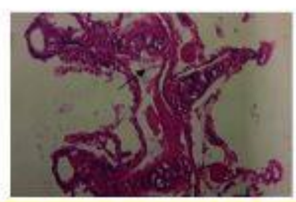
Fig. 3b: A high power photomicrograph showing atrophy and congestion (arrow) in gills of fishes exposed to 5.768 ppm of lambda cyhalothrin

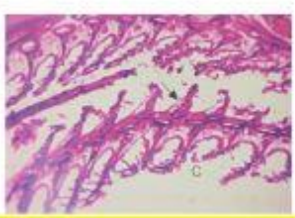
Fig. 3c: Disintegrated lamellar epithelium (arrow), curling (c) of Secondary lamellae in gill tissue of fishes exposed to 2.884 of lambda cyhalothrin

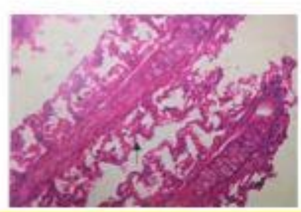
Fig. 3d: Edema and inflammation (arrow) in secondary lamella of the gills in fishes exposed to 2.884 ppm of lambda cyhalothrin

The ovarian tissue of the pyrethroid-exposed fishes also showed degenerative pathological changes, marked necrosis of oocytes along with degeneration of oocytic envelope, edema and loose separation of follicles in fishes exposed to 5.768 ppm of lambda cyhalothrin. Necrosis and loss of connective tissue was observed in the ovarian tissue of fishes exposed to the lower sub-lethal concentration of the pyrethroid.

Focal necrosis and hemorrhage area few pathological changes observed in the neuronal tissue of the fishes exposed to 5.768 ppm of lambda cyhalothrin (Figure 4a) while the fishes exposed to 2.884 ppm of the pyrethroid showed signs of edema, gliosis and congestion in the neuronal tissue (Figure 4b).


Fig. 4a: Focal necrosis and haemorrhage in neuronal tissue of Fishes exposed to 5.768 ppm of lambda cyhalothrin


Fig. 4b: Edema, gliosis and congestion in neuronal tissue of fishes exposed 2.884 ppm of lambda cyhalothrin

The cardiac tissue of the fishes exposed to 5.768 ppm of lambda cyhalothrin showed marked damage with extensive fragmentation of myocardial muscle bundles. The fishes exposed to 2.884 ppm of lambda cyhalothrin showed pathological changes such as inflammation and infiltration of leucocytes in the cardiac tissue. The thyroid tissue of the control group of fishes showed normal follicles filled with colloidal substance.

However fishes exposed to 5.768 ppm of lambda cyhalothrin showed atrophied thyroid follicles with wavy and irregular epithelium and depletion of colloidal substance (Figure 5a). The thyroid tissue of fishes exposed to 2.884 ppm of lambda cyhalothrin also showed hypertrophy and vacuolization of follicles (Figure 5b).

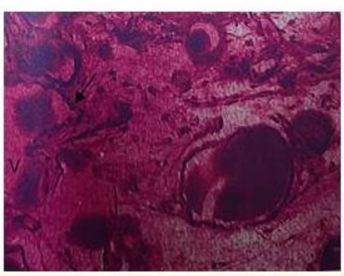
Fig. 5a: Atrophy of thyroid follicles with wavy and irregular epithelium (arrow) and depletion of colloid(V) in thyroid tissue of fishes exposed to 5..768 ppm of lambda cyhalothrin

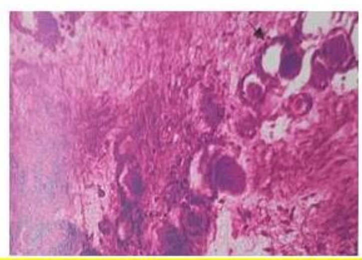
Fig. 5b: Hypertrophy and vacuolization (arrow) of thyroid follicles in fishes exposed to 2.884 ppm of lambda cyhalothrin

The adrenal tissue (head kidney) of the fishes exposed to 5.768 ppm of lambda cyhalothrin showed necrosis, invading lymphocytes and fibrosis (Figure 6a) while fishes exposed to 2.884 ppm of the pyrethroid showed signs of hyperplasia (Figure 6b).

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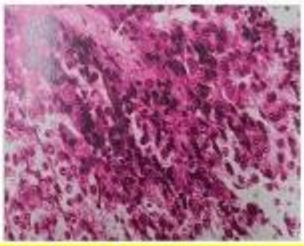

Fig. 6a: Head Kidney showing necrosis, invading lymphocytes and fibrosis (arrow) in fishes exposed to 5.768 ppm of lambda cyhalothrin

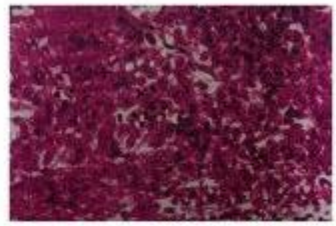

Fig. 6b: Hyperplasia of inter-renal cells in fishes exposed to 2.884 ppm of lambda cyhalothrin

DISCUSSION

In the recent years, the focus of attention of toxicologists has been on the multifaceted studies related to the toxicity of various pesticides. The pollution of aquatic environment by pesticides adversely affects the survival of aquatic organisms including the commercially important fish species which form the dominating group of aquatic system (Radhakrishnan Nair, (2006), Sornaraj et al., (2005). Alterations in the various physico-chemical properties and pH of the medium which the fishes inhabit due to aquatic pollution cause destruction to the membranes of the sub-cellular organelles disrupt the normal functioning of cellular proteins and inhibit the activities of metabolic enzymes and biomolecules (Mehendale, 1987; Tripathi and Shukla, 1990). Chronic exposure studies have also measured effects on the adrenals, spleen, pituitary and testes in mammals (Litchfield, 1985).

Considerable interest has been shown in recent years in histopathological studies while conducting sub-lethal tests in fish. The hepatic tissue is the primary site for detoxification of organic xenobiotics and its metabolites where detoxification takes place in the endoplasmic reticulum. Wide varieties of insecticides and toxic by-products tend to accumulate in high concentration within the hepatic tissue (Jayanth Rao et al., 1985). The present findings gain support of the previous findings of Anitha and Tilak (2003).

Histopathological investigation of the brain tissue in the present study revealed edema, congestion, and necrosis which reveals that lambda cyhalothrin is neurotoxic. The destruction and separation of individual cells, intercellular spaces, configurational changes, disruption of cell membranes and vacuolization may be due to microsomal and mitochondrial dysfunction. Similar changes in the brain tissue have also been reported by Das and Mukherjee (2000) in carp, *Labeo rohita* exposed to hexachlorocyclohexane (HCH). Loss of integrity of brain cells in the present study is supported with the severe inhibition of AChE activity and behavioral changes in the animals.

The degeneration of oocytic envelope and connective tissues dema and necrosis was witnessed in the ovarian tissues of the lambda cyhalothrin exposed fishes. Similar results have been reported earlier by Chatterjee et al., (1997) in carbofuran exposed *Heteropneustes fossilis*. Ram et al., (2001) have reported degenerative changes in the ovarian tissue of fishes subjected to pesticidal stress.

In the present study, severe cardiac changes such as fragmentation of myofibrils and cellular infiltration on exposure of the fishes to the pyrethroid, lambda cyhalothrin was witnessed. Similar degenerative changes have also been reported by Das and Mukherjee (2000) in hexachlorocyclohexane exposed *Labeo rohita*.

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