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Research Paper

CHANGES IN HAEMATOLOGICAL PARAMETERS OF SILVER BARB (*Barbonymus gonionotus*) DUE TO EXPOSURE OF PESTICIDES, LAMDA-CYHALOTHRIN AND DIMETHOATE

Md. Mahabubur Rahman and Md. Rakibul Hasan

Department of Fisheries,
University of Rajshahi, Rajshahi-6205,
Bangladesh.

Abstract

The study was carried out to investigate the changes in haematological parameters of silver barb (*Barbonymus gonionotus*) due to exposure of pesticides, lamda-cyhalothrin and dimethoate in glass aquaria. In this study, three batches of fish were kept in clean water treated as control fish (T1); six batches of fish were exposed to two concentrations of lamda-cyhalothrin as 0.001 ml/L (T2) and 0.003 ml/L (T3); and six batches of fish were exposed to two concentrations of dimethoate as 0.001 ml/L (T4) and 0.003 ml/L (T5) for 96 hours. During this study, physico-chemical parameters (temperature, oxygen and pH) of test water, behaviour and haematological parameters (WBC, RBC, Hb, PCV, MCV, MCH and MCHC) of the fish were analyzed. Physico-chemical parameters of test water were within the productive ranges. When the fish exposed to pesticides, they showed less activity, loss of equilibrium, motionlessness, erratic swimming and loss of appetite. WBC, RBC, Hb, PVC and MCV were found significantly decreased and MCHC insignificantly increased. MCH was found decreased insignificantly in lamda-cyhalothrin exposed fish but significantly in dimethoate exposed fish. Therefore, the study stated that lamda-cyhalothrin and dimethoate pesticides produce an adverse effect in haematological parameters which might affect normal physiology and immunity of fish.

Key words: *Changes, haematological, parameters, exposure, lamda-cyhalothrin, dimethoate.*

INTRODUCTION

A variety of agricultural chemicals such as pesticides, insecticides, fungicides, herbicides and other biocides are used to control crop pests in agricultural production [2]. In Bangladesh, more than 300 types of pesticides and insecticides are used for agricultural crop protection. Due to injudicious and indiscriminate use of these pesticides, water

bodies like ponds, lakes, river and low lying water areas are continuously getting polluted through surface run off, sediment transportation from treated soil and direct application as spray for controlling pests [33]. Pollution of surface water caused by pesticides used in agriculture and their effects on non-target organisms are problems of global importance [25]. Pesticides may be directly toxic, deteriorate the water quality and cause ecological imbalance leading to health hazards to aquatic flora and fauna [23]. In acute cases, there are records of catastrophic mortality of the entire aquatic biota [33].

Pyrethroid pesticides are widely used for controlling the insect pest all over the world. Pyrethroid pesticides are extremely toxic to fish [21] and other aquatic animals due to impaired metabolism. Lambda-cyhalothrin is a synthetic pyrethroid used for the eradication of insects in agricultural fields [22]. Like all pyrethroids, lambda-cyhalothrin is a neurotoxin [5] insoluble in water and very toxic to fish [39]. It reduces packed cell volume, red blood cell count and haemoglobin concentration in fish [56]. Organophosphorus pesticides are extensively being used in agriculture and account for approximately 50% of the global pesticides use [29]. Occurrence of organophosphates into water bodies causing acute and chronic toxicity to fish fauna [1 and 42]. Dimethoate is an organophosphorus pesticide possessing contact and systemic properties [26] that is used in worldwide agriculture. The haematological effects of dimethoate reported are reduction of erythrocyte counts and haemoglobin concentration [3].

There are many reports available related to the toxicity of pesticides on different fish species [18]. Toxicity of pesticides in aquatic organisms can be studied by evaluating the changes in the haematological parameters [49]. Haematological studies are procedures frequently and routinely applied in the diagnosis of diseases in aquaculture [45]. However, a numbers of studies have been conducted on the effect of pesticides on the haematological parameters throughout the world [7, 11, 14, 17, 48, 55 and 57] but in Bangladesh, such studies are much limited in number [4, 27, 31 and 40]. However, the knowledge on the pesticide's pollution and health condition of fish still needs to be expanded to provide data for different fish species that will be helpful for fish health management in promising aquaculture practices in Bangladesh. As the information on the health conditions of silver barb related to lamda-cyhalothrin and dimethoate pesticides

pollution are not available in Bangladesh, therefore, the study was conducted to find out the effects of lamda-cyhalothrin and dimethoate pesticides on haematological parameters of silver barb as a model test organism and a candidate species for rice-fish culture in Bangladesh.

2. MATERIALS AND METHODS

2.1. Experimental unit and site

The study was conducted in glass aquaria in the wet laboratory of the Department of Fisheries, University of Rajshahi, Bangladesh. The aquaria were rectangular in size (90×40×45 cm) containing 90 liters of water and providing aeration facilities. Fine meshed nets were used to cover of aquarium to avoid jumping of fish.

2.2. Test pesticides

Two pesticides, Fighter 2.5 EC, a commercial pyrethroid pesticide contains lamda-cyhalothrin and Tafgor 40 EC, a commercial organophosphorus pesticide contains dimethoate were used.

2.3. Experimental design

The study was carried out for a period of 96 hours. In this study, three batches of fish (12 fish in each batch) were kept in clean water (without pesticides) treated as control fish (T1); six batches of fish were exposed to two concentrations of lamda-cyhalothrin as 0.001 ml/L (T2) and 0.003 ml/L (T3); and at the same time, six batches of fish were exposed to two concentrations of dimethoate as 0.001 ml/L (T4) and 0.003 ml/L (T5).

2.4. Collection and maintenance of test fish

The test fish, *B. gonionotus* (Body weight 80.93±11.43 g) were collected from local fish farm and were transferred in the aquaria in the laboratory for acclimatization. During the period of acclimatization and experiment, the fish were fed with a commercial pellet feed twice daily to satiety for avoiding the effects of starvation. Tap water was used throughout the course of the experimental period. The aquarium water was aerated continuously. Constant amount of the test chemical and test water were renewed every

24 hours to remove fecal matter and waste metabolites of fish and also for maintaining constant concentration of test pesticides.

2.5. Physico-chemical parameters

The physico-chemical parameters, viz., water temperature, dissolved oxygen and pH were monitored regularly with a Centigrade thermometer, HACH Kit and pH meter, respectively.

2.6. Behaviour of fish

Behaviour of the test fish was monitored by eye observation and taking video.

2.7. Blood samples collection and analysis

At the end of the experiment, blood samples from the fish were collected in a haeamatocrit tube containing anticoagulant agent (EDTA). During the study, total count of White Blood Cells (WBC) and Red Blood Cells (RBC), Haemoglobin (Hb), Pack Cell Volume (PCV) or Hematocrit (Ht), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC) were analyzed. Total WBC and RBC were counted by using an improved Neubaur Haemocytometer [51]. Hb concentration was determined by the cyanmethemoglobin method [35]. PVC (%) was determined by the microhematocrit method [24]. The value of MCV was calculated from the haematocrit value and the erythrocyte count [19]. MCH value was calculated from the haemoglobin value and the erythrocyte count [54]. MCHC value was calculated by dividing the haemoglobin content in g/dl by the PCV % of red blood cell [54].

2.8. Statistical analysis

The data were analyzed using one-way ANOVA test. The mean values were compared to see the significant difference from the Duncan's Multiples Range Test (DMRT) set as $P \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1. Physico-chemical parameters of water

When physico-chemical parameters of water are affected by toxicants then any physiological changes may be reflected in the values of one or more of haematological parameters [58]. During this study, the observed physico-chemical parameters of test

water did not showed any significant variation among the treatments and were recorded as water temperature 22.7 to 22.8^{o}C and 22.2 to 22.3^{o}C; dissolved oxygen 6.3 to 6.8 mg/L and 6.4 to 6.8 mg/L and pH 7.5 to 7.8 and 7.6 to 7.9 in lamda-cyhalothrin and dimethoate treated aquaria, respectively. The values of observed parameters were within the productive ranges for fish growth according to the different research reports [6, 10 and 28].

3.2. Changes in behaviour of test fish

Behaviour is an appropriate index in toxicological studies, because behaviuoral changes in fish are good index of organism response toward the aquatic pollutants [60]. Presence of pesticides in water can affect the behaviour of fish and can be used as an index of stress [16]. In the present study, the fish showed some abnormal behaviours when they exposed to lamda-cyhalothrin and dimethoate pesticides. The abnormal behaviours were decrease in food intake primarily, restlessness, asymmetrical swimming activities, loss of equilibrium, motionlessness and lethargic movement. Similar behavioural changes have been reported due to cypermethrin exposure in *Poecilia reticulate* [36], in *Cyprinus carpio* [55]. Identical behaviours have also been reported in *L. rohita* due to cypermethrin and diazinon exposure [31] and due to difenoconazole and thiamethoxam exposure [27]. Absorption of pesticides in gills with respect to the lipophilic nature of them can cause respiratory limitations [39] that consequently might be resulted in abnormal behaviour of the fish [53].

3.3. Changes in haematological parameters due to lamda-cyhalothrin exposure

The changes in hematological parameters of silver barb due to lamda-cyhalothrin exposure are shown in Table 1. Compared to the control fish, the hematological response of silver barb exposed to lamda-cyhalothrin was a significant decrease in WBC, RBC, Hb, PVC, MCV and an insignificant decrease in MCH and insignificant increase in MCHC. These results are more or less consistent with the findings of other studies investigating hematological response of different fish species exposed to other pyrethroid pesticides.

Decrease in total WBC count in the present study might be due to the role of lamda-cyhalothrin as a potential environmental stressor. Decrease in WBC counts have been reported by Masud and Singh [37] in *Cyprinus carpio* and by Khatun *et al*. [31] in *Labeo*

rohita using cypermethrin pesticide which are consistent to the present study. The total count of RBC in present study decreased with the increase in concentration of lamda-cyhalothrin (Table 1). Significant decreases in total RBC counts have also been reported in *Channa punctatus* by Saxena and Seth [50] and in *Labeo rohita* by Khatun *et al.* [31] when treated with cypermethrin. These reports are supportive to the results of the present study. Lowering of RBC count might be due to the disruptive action of pesticides on the erythropoietic tissue [34]. According to Kocabatmaz and Ekingen [32], use of pesticides had a negative effect on haemoglobin concentration which is supportive to the present study. Decreased concentration of Hb in different fishes due to pyrethroids pesticides exposures have also been reported by Deka and Dutta [15], Khatun *et al.* [31] and Jasmin *et al.* [27]. The decreased concentration of Hb in the present study might be due to either increase in haemoglobin destroyed or decrease in haemoglobin synthesis [38].

Blood cell indices like MCV, MCH and MCHC seem to cause changes that are more sensitive and can cause reversible changes in the homeostatic system of fish. Fluctuations in these indices correspond with RBC count, hemoglobin concentration and PCV [9]. A similar response was noted in the present study, when the fish exposed to lamda-cyhalothrin pesticide. A significant decrease in PCV value has been reported in the difenoconazole exposed fish [27, 43 and 55] and in the cypermethrin exposed fish [31]. These reports are consistent to the present study. MCV values decreased significantly whereas MCH decreased insignificantly in lamda-cyhalothrin exposed fish. These findings are more or less supported by the report of Khatun *et al*. [31] and Chandrasekar and Jayabalan [12]. Moreover, the increased value of MCHC in the lamda-cyhalothrin exposed fish is supported by the report of Jasmin *et al*. [27] who described the increase in MCHC value for *Labeo rohita* when exposed to difenoconazole. Increase in MCHC value due to pesticide exposure is also supported by the report of Fransesco *et al*. [20]. The changes in MCHC value in the fish might be due to the stress condition created by the pesticide [13].

Table 1: Changes in haematological parameters due to lamda-cyhalothrin exposure

Parameters	Treatments		
	T1	**T2**	**T3**
Total WBC (10^4× mm^{-3})	5.78±0.21[a]	5.39±0.14[b]	4.63±0.18[c]
RBCs (10^6×mm^{-3})	1.53±0.08[a]	1.33±0.11[b]	1.27±0.09[b]
Hb (g/dl)	3.20±0.19[a]	2.75±0.23[b]	2.58±0.19[b]
PCV (%)	8.67±0.27[a]	7.29±0.18[b]	6.71±0.23[c]
MCV (fl)	56.67±1.10[a]	54.88±1.03[b]	52.83±1.05[c]
MCH (pg)	20.91±0.38[a]	20.67±0.43[a]	20.31±0.57[a]
MCHC (g/dl)	36.90±1.85[a]	37.72±1.64[a]	38.45±1.67[a]

* T1 assigned the fish didn't expose to lamda-cyhalothrin (treated as control). T2 assigned the fish exposed to 0.001 ml/L of lamda-cyhalothrin; and T3 assigned the fish exposed to 0.003 ml/L of lamda-cyhalothrin. Values are mean of triplicate determination. Values in the same row with different superscripts are significantly different (*P≤0.05*).

3.4. Changes in haematological parameters due to dimethoate exposure

The changes in haematological parameters of silver barb due to dimethoate exposure are shown in Table 2. Compared to the controlled fish, the hematological response of silver barb exposed to dimethoate was a significant decreases in WBC, RBC, Hb, PVC, MCV and MCH whereas insignificant increased in MCHC. These results are consistent with the findings of other studies investigating hematological response of different fish species exposed to other organophosphorus pesticides.

The decrease in the leukocyte counts in the present study due to dimethoate pesticide exposure is supported by the reports of Rostami *et al.* [46], Pourgholam *et al.* [44], Far *et al.* [17], Khatun *et al*. [31] and Jasmin *et al.* [27] using different organophosphorus pesticides. Decreased RBC count have also been reported in *Heteropneustes fossilis* by Singh and Srivastava [52], in *Cyprinion watsoni* by Khattak and Hafeez [30], in *Piaractus mesopotamicus* by Tavares *et al.* [57] and in *Labeo rohita* by Khatun *et al*. [31] due to

exposure of various organophosphorus pesticides. The decrease found in Hb concentration might be due to either an increase in the rate of Hb destroying or a decrease in the rate of Hb synthesis. This assumption is supported by Matkovies and Witas [38]. Decreased Hb concentration in *L. rohita* has also been reported by Jasmin *et al*. [27] due to exposure of an organophosphorus pesticide, thiamethoxam.

Significant decreased PCV value has been reported by Svoboda *et al.* [55] in *Cyprinus carpio* and Khatun *et al.* [31] in *Labeo rohita* due to diazinon exposer which is supportive to the present study. The reduction of PVC might be due to the fish suffers from haemodilution [59]. Significantly decreased values of MCV and MCH in dimethoate exposed fish in the present study are supported by Far *et al.* [17] and Khatun *et al*. [31]. More or less similar results have also been reported by Binukumari *et al*. [8] Mostakim *et al*. [40] and Muralidharan [41]. Moreover, the increased value of MCHC in the present study is consistent with the finding of Jasmin *et al*. [27] who recorded increased MCHC value in *L. rohita* due to thiamethoxam exposure. Increased values of MCHC have also been reported by Khatun *et al*. [31] in *L rohita* due to diazinon exposure and Chandrasekar and Jayabalan [12] in *C. carpio* due to endosulfan exposure. The changes in MCHC value might be due to the decrease in Ht % caused by haemolysis or stress condition [47].

Table 2: Changes in haematological parameters due to dimethoate exposure

Parameters	**Treatments**		
	T1	**T4**	**T5**
Total WBC (10^4× mm^{-3})	5.78±0.21^a	3.41±0.46^b	2.48±0.21^c
RBCs (10^6×mm^{-3})	1.53±0.08^a	1.17±0.17^b	1.06±0.13^b
Hb (g/dl)	3.20±0.19^a	2.25±0.21^b	2.05±0.35^b
PCV (%)	8.67±0.27^a	6.02±0.46^b	5.29±0.34^c
MCV (fl)	56.67±1.10^a	51.45±1.78^b	49.91±1.52^b
MCH (pg)	20.91±0.38^a	19.23±0.39^b	19.33±0.26^b
MCHC (g/dl)	36.90±1.85^a	37.37±1.43^a	38.75±1.87^a

* T1 assigned the fish didn't expose to dimethoate (treated as control). T4 assigned the fish exposed to 0.001 ml/L of dimethoate; and T5 assigned the fish exposed to 0.003

ml/L of dimethoate. Values are mean of triplicate determination. Values in the same row with different superscripts are significantly different (*P≤0.05*).

From the results of this study, it can be said that both pesticides, lamda-cyhalothrin and dimethoate are hazardous to silver barb and resulted significant changes in haematological parameters. More significant changes were observed in dimethoate exposure than lamda-cyhalothrin exposure. These changes might be potentially disruptive to the health of silver barb in their natural environment.

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REFERENCES

[1] Aker W G, Hu X, Wang P and Hwang H M. 2008. Comparing relative toxicity of malathion and malaoxon in blue catfish *Ictalurus furcatus*. *Environ. Toxicol*., **23**: 548-554.

[2] Alam M N. 2002. Toxicity of Kadett-36 to an air breathing fish *Clarias batrachus* (L). *Nat. Env. Pollut. Tech.,* **1(4)**: 427-430.

[3] Anees M A. 1978b. Haematological abnormalities in a fresh-water teleost *Channa punctatus* (Bloch) exposed to sub lethal and chronic levels of three organophosphorus insecticides. *Int. J. Ecol. Environ. Sci.,* **4**: 53-60.

[4] Ashaduzzaman, Huda M D, Haque E, Khan A R, Hossain M M, Rahman M A, Sultana S, Akther S, Neela F A and Rahman M H. 2014. Effects of insecticide on morphological changes of red blood cells of *Channa punctatus* (Bloch). *J. Life Earth Sci.,* 9: 85-89.

[5] Beat G, Andres W, Gunter S and Marc S. 1997. The pyrethroids permethrin and cyhalothrin are potent inhibitors of the mitochondrial complex 1. *Pharm. Exp. Therapeut*., **281**: 855-860.

[6] Bhuiyan B R. 1970. Physico-chemical qualities of some ancient tanks of Sibsagar, Asam. *Environmental health,* **12**: 129-134.

[7] Binukumari S, Anbalagan M and Vasanthi J. 2013. A Study on the effect of an insecticide encounter (Herbal Plant Extract) on the haematology of the freshwater fish *Labeo rohita*. *International Journal of Pharmacy and Biological Sciences,* **8**: 92-94.

[8] Binukumari V, Sudhasaravanan R and Mohankumar M. 2015. Impact of the Pesticide Endosulfan 35% EC on the Haematological Parameters of Fresh Water Fish, *Cirrhinus mrigala. Int. J. Curr. Microbiol. App. Sci.,* **4(2)**: 55-58.

[9] Binukumari S and Vasanthi J. 2013. Impact of the Pesticide Dimethoate 30% EC on the Haematological Parameters of Fresh water fish, *Labeo rohita*. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* **7(2)**: 63-65.

[10] Boyd C E. 1990. Water Quality in Ponds for Aquaculture. Birmingham Publishing Co. Birmingham, Alabama, USA.

[11] Cakmak M N and Girgin A. 2003. Toxic effect of synthetic pyrethroid insecticide (Cypermethrin) on blood cells of Rainbow Trout (*Oncorhynchus mykiss*). *Biological Sciences,* **3**: 694-698.

[12] Chandrasekar S and Jayabalan N. 1993. Haematological responses of the common carp, *Cyprinus carpio* exposed to the pesticide endosulfan. *Asian Fish. Sci.,* **6**: 331-340.

[13] Chen X, Yin D and Hou S. 2004. Immunotoxicity of pentachlorophenol on macrophage immunity and IgM secretion of the crucian carp (*Carassius auratus*). *Bulletin* of *Environmental Contamination and Toxicology,* **73**: 153-160.

[14] David M, Sangeetha J, Shrinivas J, Harish E R and Naik V R. 2015. Effects of deltamethrin on haematological indices of Indian major carp, *Cirrhinus mrigala* (H). *International Journal of Pure and Applied Zoology,* **3(1)**: 37-43.

[15] Deka C and Dutta K. 2012. Effects of cypermethrin on some haematological parameters in *Heteropneustes fossilis*. *The Bioscan,* **7**: 221-223.

[16] Dobsikova R, Velisek J, Wlasow T, Gomulka P, Svobodova Z and Novotny L. 2006. Effects of cypermethrin on some haematological, biochemical and histopathological parameters of common carp (*Cyprinus carpio*). *Neuro Endocrinology Letters,* **2**: 91-95.

[17] Far M S, Roodsari H V, Zamini A, Mirrasooli E and Kazemi R. 2012. The effects of diazinon on behaviour and some haematological parameters of fry rainbow trout (*Oncorhynchus mykiss*). *Fish and Maine Science,* **4**: 369-375.

[18] Farombi E O, Ajimoko Y P and Adelowo O A. 2008. Effect of Butachlor on Antioxidant Enzyme Status and Lipid Peroxidation in Fresh Water African Catfish, (*Clarias gariepinus*). *Int. J. Environ. Res. Pub. Hlth.*, **5(5)**: 423-427.

[19] Feldman B F, Zinkl J G and Jai N C. 2000. Schalm's Veterinary Haematology, 5th Ed. Lippincott Williams and Wilkins, pp: 1120-1124.

[20] Francesco P, Mathieu P and Senechal D. 2012. Conformal Field Theory. Springer Science & Business Media.

[21] Haya K. 1989. Toxicity of pyrethroid insecticides to fish. *Environmental Toxicology and Chemistry*, **8**: 381-391.

[22] He L-M, Troiano J, Wang A and Go K. 2008. Environmental Chemistry, Ecotoxicity and Fate of Lambda-cyhalothrin. In: Reviews of Environmental Contamination and Toxicology. Whitacre D M (ed.). Springer. pp. 71-91.

[23] Hemmer M J, Hemmer B L, Bawman C J, Croll K J, Formar L C, Marcovich D, Hoglund M D and Denslow N D. 2001. Effect of pnonylphenol, methoxychlor and endosulfan on vitellogenin induction and expression in sheephead minnow (*Cyprinodon variegates*). *Environmental Toxicology and Chemistry,* **20**: 336-343.

[24] Hesser E F. 1960. Methods for routine fish hematology. *Progress Fish Culture,* **22**: 164-170.

[25] Hill I R. 1985. Effects on non-target organisms in terrestrial and aquatic environments. In: Lehey JP, editor. The Pyrethroid Insecticides. London: Taylor & Francis, London, UK. pp: 165-181.

[26] Jackson G A. 1968. Biological half-life of endrin in channel cat fish tissues. *Bull. Environ. Contam. Toxicol.*, **16**: 505-507.

[27] Jasmin J, Rahman M M and Rahman M M. 2017. Haematological Changes in *Labeo rohita* (H.) due to Exposure of Pesticides, Difenoconazole and Thiamethoxam. *International Journal of Contemporary Research and Review*, **9(1)**: 20199-20205.

[28] Jhingran V C. 1991. Fish and Fisheries of India. 3rd edition, Hindustan Publishing Corporation, India.

[29] John P J. 2007. Alteration of certain blood parameters of freshwater teleost *Mystus vittatus* after chronic exposure to Metasystox and Sevin. *Fish Physiol Biochem*., **33**: 15-20.

[30] Khattak I U and Hafeez M A. 1996. Effect of malathion on blood parameters of the fish, *Cyprinion wabsoni. Pakistan Journal of Zoology,* **28**: 45-49.

[31] Khatun M A, Rahman M M and Islam M S. 2014. Effects of cypermethrin and diazinon on haematology of *Labeo rohita* (H.). *International Journal of Development and Research,* **4**: 953-957.

[32] Kocabatmaz M and Ekingen G. 1984. The standardization of blood sampling and haematological methods in different species of fish. *Doga Bilim Dergisi,* pp. 149-157.

[33] Kumari S B and Subisha M C. 2010. Haematological responses in a freshwater fish, *Oreochromis mossambicus* exposed to chlorpyrifos. *The Ekol.,* **10(1-2)**: 83-88.

[34] Larsson A, Haux C and Sjobeck M L. 1985. Fish physiology and metal pollution: results and experiences from laboratory and field studies. *Ecotox. Environ. Safe.,* **9(3)**: 250-281.

[35] Lee R G, Foerster J, Jukens J, Paraskevas F, Greer J P and Rodgers G M. 1998. Wintrobe's-Clinical Hematology, 10th Ed. Lippincott Williams and Wilkins, New York, USA.

[36] Li X, Ping S, Xiumei W, Zhenbin and Liqiang X. 2005. Toxicity of cypermethrin on growth, pigments and superoxide dismutase of *Scenedesmus obliquus*. *Ecotoxicology and Environmental Safety*, **60**: 188-192.

[37] Masud S, Singh I J. 2013. Effect of cypermethrin on some hematological parameters and prediction of their recovery in a freshwater Teleost, *Cyprinus carpio. Afr. J. Environ. Sci. Tech.,* **7**: 852-856.

[38] Matkovics B and Witas H O. 1981. Paraquat as an agent affecting antioxidant enzymes of common carp erythrocytes. *Comparative Biochemistry and Physiology*, 87: 217-219.

[39] Mergel M. 2010. Lamda-cyhalothrin, http://www.toxipedia.org/display/toxipedia/Lambda-Cyhalothrin. Accessed December 4th 2016.

[40] Mostakim G M, Zahangir M M, Mishu M M, Rahman M K and Islam M S. 2015. Alteration of Blood Parameters and Histoarchitecture of Liver and Kidney of Silver Barb after Chronic Exposure to Quinalphos. *Journal of Toxicology*. Article ID 415984, 8 page shttp://dx.doi.org/10.1155/2015/415984.

[41] Muralidharan L. 2014. Haematological alterations in fresh water fish *Cyprinus carpio* (L) exposed to organophosphorous pesticide fenthion. *International Science Journal,* **1(1)**: 107-116.

[42] Pandey R K, Singh R N, Singh S, Singh N N and Das V K. 2009. Acute toxicity bioassay of dimethoate on freshwater air breathing catfish, *Heteropneustes fossilis* (Bloch). *J. Environ. Biol*., **30**: 437- 440.

[43] Pourgholam R, Soltani M, Hassan D M, Esmaeili F, Farhoomand H and Usefi P. 2001. Evaluation of blood characteristics of grass carp *(Ctenopharyngodon idella*) after exposure to organophosphate, diazinon. *Iranian Journal of Fisheries Sciences,* **3**: 1-18.

[44] Pourgholam R, Soltani M, Hassan D M, Ghoroghi A, Nahavandi R. and Pourgholam H. 2006. Determination of diazinon LC_{50} in grass carp (*Ctenopharyngodon idella*) and the effect of sub-lethal concentration of toxin on some haematological and biochemical indices. *Iranian Journal of Fisheries Sciences,* **5**: 67-82.

[45] Ranzani-Paiva M J T, Santos A A, Dias D C, Seriani R and Eganni M. 2008. Hematological and phagocytic response of fat snook, *Centropomus parallelus*, reared in net cages, before and after inoculation with *Sacharomyces ceresivisiae*. *Bioikos,* **22**: 29-35.

[46] Rostami K H, Soltani M and Yelghi S. 2005: Effects of diazinon on the haematological profiles of *Acipenser stelletus* and determination of LC_{50}. *Journal of Agricultural Science and Natural Resources,* **12**: 15-18.

[47] Rao D S. 2010. Carbaryl induced changes in the haematological, serum biochemical and immunological responses of common carp, *Cyprinus carpio* with special emphasis on herbal extracts as immune-modulators. Ph. D. Thesis, Andhra University, India.

[48] Roy B and Nath S. 2011. Some haematological investigations on *Oreochromis niloticus* following exposure to Thiamethoxam. *Acta Zoologica Lituanica,* **21**: 301-305.

[49] Saravan M, Prabhu K and Ramesh M. 2011. Haematological and biochemical responses of freshwater teleost fish *Cyprinus carpio* during acute and chronic sub-lethal to lindane. *Pestic. Biochem. Physiol.,* **100(3)**: 206-211.

[50] Saxena K K and Seth N. 2002. Toxic effects of cypermethrin on certain haematological aspects of fresh water fish, *Channa punctatus*. *Bulletin of Environmental Contamination and Toxicology*, **69**: 364-369.

[51] Shah S L and Altindag A. 2005. Alterations in the immunological parameters of tench (*Tinca tinca*) after acute and chronic exposure to lethal and sub-lethal treatments with mercury, cadmium and lead. *Turkish Journal of Veterinary and Animal Sciences,* **29**: 1163-1168.

[52] Singh N N and Srivastava A K. 1994. Formothion induced haematological changes in the freshwater Indian catfish, *Heteropneustes fossilis*. *J. Ecotoxicol. Environ. Monit.,* **4**: 137-140.

[53] Singh S K, Tripathi P K, Yadav R P, Singh D and Singh A., 2004. Toxicity of malathion and carbaryl pesticides: Effects on some biochemical profiles of the freshwater fish *Colisa fasciatus*. *Bull. Environ*. *Contam. Toxicol.,* **72(3)**: 592-599.

[54] Stoskopf M K. 1993. Clinical Pathology. In Stoskopf MK (Ed.). Philadelphia, Pa: WB Saunder. Fish Medication, pp. 113- 131.

[55] Svoboda M, Luskova V, Drastichova J and Ilabek V. 2001. The effect of diazinon on haematological indices of common carp (*Cyprinus carpio*). *Acta Veterinaria (Brno*), **70**: 457-465.

[56] Taofeek A, Yekeen T A, Fawole O O and Bakare A A. 2013. Evaluation of toxic effects of lambda-cyhalothrin on the haematology and selected biochemical parameters of African catfish *Clarias gariepinus. Zoology and Ecology*, **23 (1)**: 45-52.

[57] Tavares D M, Martines M L and Nascimento K S. 1999. Evaluation of the haematological parameters in *Piaractus mesopotamicus* Holmberg (Osteichthyes, Characidae) with *Argulus sp.* (Crustacea, Branchiura) infestation and treatment with organophosphate. *Revista Brasileira de Zoologia,* **16**: 5553-5555.

[58] Van V J H J. 1986. The effects of toxicants on the haematology of *Labeo umbratus* (Teleostei; cyprinidae). *Comparative Biochemistry and Physiology*, **83**: 155-159.

[59] Wedemeyer G A, Mcleay D J and Goodyear C P. 1976. Assessing the tolerance of fish and fish populations to environmental stress: The problems and methods of monitoring. John Wiley and Sons, New York, pp. 163-195.

[60] Weis J S and Candelmo A. 2012. Pollutants and fish predator/prey behavior: A review of laboratory and field approaches. *Cur. Zool.*, **58(1)**: 9-20.