INTRODUCTION

Bihar is the agriculturally based state, which is typically based on the cultivation of various types of Kharif and Rabi crops. For a better yield of crops, pesticides are widely used by the farmers. In recent times, fish farming in the state has attracted a lot of farmers. These fishes are cultivated near the agricultural land in the aquatic bodies. The aquatic bodies such as rivers, ponds also receive lots of agricultural runoff water which contains pesticides. These pesticides in higher concentrations are causing toxicity in the water fauna of the ponds, especially the fishes. Humans have been consuming these fishes due to its high nutritious value. The fishes through biomagnification of the pesticides are causing health hazards to humans. The organochlorine pesticides are more toxic than organophosphates. Synthetic pyrethroids have been known as safe and environmentally friendly due to their mild toxicity to insects, mammals and birds, and they are reported highly toxic to a number of other non-target organisms especially aquatic organisms including fishes. Fenvalerate pesticide is capable of existing together in harmony with several other pesticide group and chemicals used to modify plant growth and plant micronutrients (Tomlin, 1995; Elbert et al., 2005; Bretschneider et al., 2007, Caglayan et al.,2016). It causes very least impact on the mammalians but possesses very high insecticidal activity. Fenvalerate is a known neurotoxic pesticide which disrupts the sodium channels of neurons of insects followed by damaging the gamma-aminobutyric acid receptors and ATPase pathways (Narahasi, 1983; Cole et al., 1984; Clark and Matsumura, 1982; Matsu-
mura, 1983; Eells et al., 1993). Indiscriminate use of fenvalerate pesticides in agricultural practices has resulted in accumulation in vital tissues of fishes (Coats et al., 1989; Mishra, 1996). The toxicological evaluation of fenvalerate has been carried out by various researchers (Lee et al., 1985; Tripathi, 1992; Tripathi and Verma, 2004; Jigyasu and Paul, 2016).

A new approach for the treatment of toxicity induced by medicinal plants has been very much popular in the recent times as they have proven a promising role to control the problem (Dutta-Mitra and Ahmed, 2015; Jha and Paul, 2020; Kumari and Paul, 2020). To enhance the fish immunity and to control the toxic effects of pesticides various medicinal plants have been widely used by the fish farmers (Vallejos et al., 2016; Awad and Awad, 2017; Nhu et al., 2020). All the parts of neem (Azadirachta indica), a member of the Meliaceae family is known as an excellent medicinal plant showing important role as health-promising effect due to its antioxidant source. Leaves mainly contain quercetin (flavonoid) and nimbosterol (β-sitosterol) as well as a number of limonoids (nimbin and its derivatives). Quercetin (a polyphenolic flavonoid) is known to have antibacterial and antifungal properties. The principal constituents of neem leaves include protein (7.1%), carbohydrates (22.9%), minerals, calcium, phosphorus, vitamin C, carotene etc. But they also contain glutamic acid, tyrosine, aspartic acid, alanine, praline, glutamine and cystine like amino acids, and several saturated and unsaturated fatty acids (Sujarwo et al., 2016; Gupta et al., 2017).

Neem is widely used for the treatment of skin manifestations, skin lesions, ulcers, urinary tract problems, gastrointestinal problems, diabetes etc. (Pandey et al., 1994; Subapriya and Nagini, 2005; Manikanand et al., 2008; Neem, 2012; Sharma et al., 2014). The objective of the present investigation was to evaluate the toxic impact of fenvalerate, a commonly used insecticide, on haematological and biochemical parameters of a freshwater air-breathing fish Clarias batrachus and to find the restorative effect of medicinal plant, Azadirachta indica L. (neem) against fenvalerate induced toxicity.

MATERIALS AND METHODS

Live specimens of C. batrachus were procured from the local market of Patna, Bihar (India) and were acclimatized in the laboratory before experimentation. The proper condition was maintained for 15 days to acclimatize the fishes in aquaria. The fishes were fed with a mixture of egg and chopped wheat (flour) /suji with a very little amount of starch. The fishes were also fed with sliced goat liver every alternate day during midday. Utmost care was taken to keep the animals healthy and disease-free animals for the experiment. The experiments were done in the Post Graduate Department of Zoology, Patna University, Patna, Bihar, India. To conduct experiments, the ethical approval was given by Post Graduate Departmental Council of Zoology, Patna University, Patna, Bihar.

Fenvalerate 20% (Isagro-Asia, Gujarat, India) was procured from Patna market, and fishes were treated with it in the water contained in an aquarium at the dose of 1/3 of LC₅₀, i.e. 0.92 ppm and observed for 96 hrs.

To prepare an extract of leaves of neem were collected from the tree present in Patna Science College, Patna University and aqueous extract of neem leaves obtained using the method adopted by Neogi et al. (2007). LD₅₀ of leaf extract was estimated as 600 mg/Kg body weight. The aqueous extract of neem at the dose of 100 mg/Kg body weight of the fish per day was given orally to the fenvalerate treated fishes daily.

A set of 10 fishes were considered as control group. The control group of fishes received no treatment. The second group of 10 fishes were treated with fenvalerate (0.92 ppm) for 96 hours. The third aquarium fishes treated with fenvalerate insecticide were administered neem extract in the prerequisite dose, i.e. 100 mg/Kg body weight of fishes per day orally for 15 days.

For the study of biochemical parameters, serum from the fish blood was extracted, and tests were carried out for the analysis of the total glucose levels, total protein levels and total cholesterol levels as per the methods suggested by Darmady and Davenport (1954).

For the study of biochemical parameters, serum from the fish blood was extracted, and tests were carried out for the analysis of the total glucose levels, total protein levels and total cholesterol levels as per the methods suggested by Godkar and Godkar (2006).

Statistical evaluation of the results was done by adopting one-way ANOVA and Dunnett's test. Results are shown as mean and standard deviation.

RESULTS AND DISCUSSION

In the fenvalerate treated fishes the decreased value of haematological indices such as RBC counts (x 10⁵/mm³), TLC counts (x 10³/mm³), differential counts (x10³/mm³), packed cell volume (%), haemoglobin (g/100 ml), eosinophils (%) and monocyte levels(%) whereas increase level was observed in lymphocytes (%) after the fenvalerate exposuer to the fishes. The restorative effect in haematological parameters was seen when the fishes were fed with the neem leaf extract for two weeks (Table 1).

During the biochemical study of fishes Increased level of serum glucose and serum cholesterol of fishes was observed whereas serum protein level showed increased manner due to fenvalerate treatment in comparison to control fishes. Again, there was an ameliorating effect in the altered values of biochemical indices after the treatment of neem extract for 15 days (Table 2).

The pesticides have caused serious health hazards to aquatic life. The biomagnification of the pesticides
In the present study, neem leaf extract played a vital role in the hematological parameters of *Clarias batrachus*. The aqueous extract of neem leaves as an antidote against fenvalerate has led to the change in biochemical parameters of fishes due to exposure with fenvalerate. The fats are stored in the form of cholesterol and glucose in the form of glycogen in the liver. The hepatotoxicity caused due to fenvalerate has led to the change in biochemical parameters. Hence, change in the levels denotes the impact of toxicity. The decrease in the levels of protein and cholesterol indicates the change in the immune response of the fish. The increase in the levels of glucose indicates the increased glucose consumption due to increased activity. The increased levels of hemoglobin indicate the increased oxygen carrying capacity of the fish. The differential counts and PCV percentage after fenvalerate exposure while after neem extract treatment was a significant decrease in their levels. There was a significant increase in the Lymphocyte percentage after Fenvalerate exposure, but in neem leaf extract-treated group, there was a significant decrease in their levels. Fenvalerate has caused significant damage on *C. batrachus* on the haematological parameters. The significant decrease (from 2.76 ± 0.032 x 10^6 mm^-3 to 2.14 ± 0.023 x 10^6 mm^-3 ) in RBC indicated that erythropoietic stem cell damage due to fenvalerate, while decrease in the total leucocyte counts (from 18.10 ± 0.015 x 10^3 mm^-3 to 16.30 ± 0.074 x 10^3 mm^-3) was due to myelosuppression. Ultimately it caused low immunity and anaemia in the pesticide-treated fish (Narra, 2016; Narra et al., 2017; Abd El-Rahman et al., 2019). Furthermore, the increased value of lymphocytes denoted the obvious defence breach in the fish body (Gul et al., 2012).

During experimentation, there was increased value in serum glucose levels from 50.33 mg/dl to 103.73 mg/dl and serum cholesterol value from 168.52 g/dl to 248.99 g/dl while decrease value in the serum protein from 3.16g/dl to 2.52 g/dl in biochemical parameters of fishes due to expoer with fenvalerate. The fats are stored in the form of cholesterol and glucose in the form of glycogen in the liver. The hepatotoxicity caused due to fenvalerate has led to the change in biochemical parameters. Hence, change in the levels denotes the impact of toxicity. (Binukumari et al., 2016; Nejatkhh Manavi et al., 2018; Vieira and Dos Reis Martinez, 2018; Pico et al., 2019).

In the present study, the aqueous extract of neem leaves was used as an antidote against the fenvalerate induced toxicity in *Clarias batrachus*. There was a significant increase in the haematological parameters such as RBC counts, Total leucocyte counts, Differential counts, Packed cell volume percentage, haemoglobin percentage, Eosinophil percentage and Monocyte percentage while a decrease in the Lymphocyte percentage against fenvalerate induced toxicity. This denotes that the haematopoietic stem cells are significantly revived due to quercetin (flavonoid) and nimbosterol (ß-sitosterol), limbin and its derivatives which are active constituents of neem. The active ingredients quercetin, a flavonoid and nimbosterol (ß-sitosterol) play the vital role as antioxidant and immuno-booster. This enhances the defence mechanism of the fishes such as *Channa punctatus Lates calcarifer*, *Pangasianodon hypophthalmus*. Moreover, they are also helpful to eliminate the pesticide bioaccumulation from the fish body (Farah et al., 2006; Talpur and Ikwanuddin, 2013; Nhu et al., 2019).
*b*atrachus. The normalisation of haematological and biochemical parameters of the fishes at much extent denotes the active function of the quercetin and nimbosteryl particularly against pathogen *Aeromonas hydrophila* in goldfish, zebrafish (*Danio rerio*). (Hankrishnan and Balasundram, 2008; Batista et al., 2018; Kapinga et al., 2018; Nhu et al., 2019). Hence, Neem extracts can be used as an antidote against fenvalerate induced toxicity in *C. batrachus*.

**Conclusion**

Fenvalerate caused a deleterious effect on the fishes at the haematological and biochemical level such as RBCs, total leucocytes, haemoglobin, serum glucose, serum cholesterol, serum protein in the indigenous fish *C. batrachus*, common food item of the people. *A. indica* (neem) played a vital role to control the fenvalerate induced toxicity. Hence, it possessed the restorative activity in fenvalerate induced toxicity. The aquatic extract of the different parts of neem trees, easily available in India, may be used for therapeutic uses of several diseases of the fishes caused due to common pollutant pesticides in the aquatic bodies.

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**Conflict of interest**

The authors declare that they have no conflict of interest.

**REFERENCES**


