growth and its somewhat acceptable market price (FAO, 2003) as reported by Samuel *et al.* (2021a).

Pesticides are among the major contributor to aquatic pollution and these inadvertently end up in aquatic media with debilitating effects on the biota found there. There are more than 200 types of organic pesticides that have been used in thousands of different products; and pesticides contain a number of heavy metals such as iron, chromium, cadmium, nickel, copper, lead, zinc and manganese that ultimately end up in water bodies, and adversely affect the growth, reproduction, physiology and even survival of the non-target aquatic organism including fish (Ullah *et al.*, 2015). Environmental threats to freshwater ecosystems are increasing at faster rates as industrialization, urbanization and agricultural activities intensify. Billions of kilograms of industrial chemicals find their way into freshwater bodies around the world annually including 140 billion kilograms of pesticides (Naidu *et al.*, 2021). The effects may be sometimes irreversible, and harmful to humans and the environment. Given that their properties differ, toxicity to fishes can vary with each pesticide group, with insecticides typically the most toxic (Sabra *et al.*, 2015). Previous studies have suggested that pyrethroid exposure can disrupt the normal physiological functions of aquatic organisms by affecting their nervous systems and inducing oxidative stress. However, there is limited knowledge regarding the specific effects of pyrethroids on *Clarias gariepinus* and their hematological responses. Understanding these effects is pivotal for evaluating the ecological risks associated with pyrethroid use and implementing effective mitigation strategies to safeguard aquatic ecosystems and fish populations (Palmquist *et al.*, 2012).

The exposure of aquatic biota to myriads of pesticides inadvertently has had tremendous effect in different forms. For instance, Elias *et al.* (2018) reported that fish species boost their metabolic activities towards toxicant excretion, thereby allowing enough energy for homeostatic maintenance than preserving it for growth. Uchenna *et al.* (2022) also reported that the growth of *Clarias gariepinus* exposed to sub-lethal concentrations of dimethoate, gave decrease in weight gain and growth; and exposure to glyphosate induced a variety of abnormalities in the behaviour of the fish which included gasping for air, agitated and erratic swimming, loss of activity, loss of balance and reflexes, mucous secretion, discolouration, hanging on water surface and inactivity; and that the intensity of the behaviour was dose dependent. In like manner, Lawee and Imgbian (2017) also reported that there was decrease in weight and growth in *Clarias gariepinus* fingerlings exposed to sub-lethal concentrations of Bentazon pesticide. In a related development, during the 48, 72, and 96h of exposure to Chlorpyrifos, the fish displayed physiological malfunctions such as hyperventilation, motionless state, increased opercular ventilation, general body weakness, skin discolouration, loss of reflex, erratic swimming which were noticeable particularly among some fish in the highest concentration (Adewunmi *et al.*, 2018).

Haematological parameters have been used as sensitive indicators of stress in fish exposed to different aquatic contaminants and toxins of various types and these can result in numerous physiological dysfunctions in fish which induce alterations in haematological parameters as a result of blood-water interaction (Akinkuolie *et al.,* 2021). Significant reduction in PCV, Hb, and RBCs with increasing concentration and exposure time of *Clarias gariepinus* to Chlorpyrifos and Deltamethrin diphosphate (DD) force which apparently reflected erythrocyte haemolysis and, or irreversible impairment of kidney functions have also been reported (Adewunmi *et al.,* 2018).

The use of pyrethroid pesticides in agriculture and pest control has become widespread, leading to their inadvertent entry into aquatic ecosystems; and their presence in water bodies poses a significant threat to the aquatic organisms. *Clarias gariepinus*, as a vital component of aquatic ecosystems and potential food sources, may be exposed to pyrethroids. However, the specific effects of pyrethroids on the growth and haematological indices of *C. gariepinus* remain poorly understood, raising concerns about potential ecological and human health implications. *Clarias gariepinus* is a commercially important fish species consumed by humans. Investigating the effects of pyrethroids on this species is crucial for ensuring food safety and preventing potential health risks associated with pyrethroid-contaminated fish consumption. It is anticipated that the findings from this research will inform regulatory decisions and conservation efforts aimed at preserving freshwater ecosystems and their associated aquatic life.

MATERIALS AND METHODS

Sources of experimental fish/acclimatisation

Two hundred (200) samples of *Clarias gariepicnus fingerlings* (6 weeks old) were purchased from private fish farm in Abuja. These fishes were carefully transported to the Animal Biology Laboratory, Gidan Kwano Campus in a 25 litres container with water. Fifty (50) juveniles were carefully distributed into the rearing plastic Aquaria tank (19cm x 13.5cm x 9.6) containing twenty (20) litres of borehole water. This was done to make them get used to the new environment, to check if there was any form of infection and also to relieve them from stress and overcrowding in the tank in order to prevent cannibalism which will lead to mortality. During the period the fishes were fed with vital feeds to satiation twice a day (Morning_0800hr and Evening_1700hr). The acclimatisation lasted for 14 days (Ayanwale *et al.*, 2017).

Experimental Setup

Cypermethrin (100g) of Cyperview was purchased from commercial chemical store. The chronic sub-lethal phase had three treatments including control with two replicates each. They were set-up with varying concentration of 0.00mg/L (Control), 0.006mg/L (T_1), 0.06mg/L (T_2), and 0.012mg/L (T_3), respectively and lasted for a period of 14days. Water exchange was every 48hours and the same concentrations were administered after renewal of the water (Davies *et al.,* 2022).

Weight Measurement (g)

Five (5) *Clarias gariepinus* were selected at random from each aquarium using a sieve. The analytical weighing scale was used to weigh individual fish and the weighing scale was adjusted to zero before taking readings.

Weight Gain (%)

The weight gain was calculated using this formula:

Weigh gain (WG), $WG = W_1 - W_0$

Where, W_0 = initial body weight

W_1 = final body weight

Percentage weight gain

$$\text{Weight Gained Percentage} = \frac{\text{Weight Gained (g)}}{\text{Initial Weight}} \times 100$$

Specific growth rate (SGR)

$$SGR = \frac{\ln(\text{Final Weight}) - \ln(\text{Initial Weight})}{\text{Number of days}} \times 100$$

Determination of Haematological parameters

At the end of the 14th day after exposure to cypermethrin, 3 fish were randomly selected from each treatment tank and blood samples of fish were collected by inserting the hypodermal syringe between the operculum and the pectoral fin on the ventral surface of the fish such that the syringe was held perpendicularly to draw-out the blood by suction pressure (Samuel *et al.,*2021b). Each blood sample was collected in duplicate, into heparinized (50 IU per mL of blood) bottles which were used for haematological analyses. The haematological analyses of blood samples were carried out in the Laboratory Services of General Hospital, Minna, Nigeria. Evaluation of haemograms involves the determination of the total erythrocyte count (RBC), total white blood cell count (WBC), haematocrit (PCV) and haemoglobin (Hb) concentration. Determinations were carried out in duplicate using complete blood count haemogram.

Behavioural Responses

During the acute exposure, the fingerlings were observed at different time intervals of 30 minutes, 2 hours, 24 hours and their behavioural changes were noted (Abozaid *et al.,* 2020).

Data Analyses

Data generated from the haematological parameters of *Clarias gariepinus* and physic-chemical parameters were subjected to a one-way Analysis of Variance (ANOVA) using SPSS version 20. Mann Whitney range test was used to separate the means where significant at $P \leq 0.05$ level of significant.

RESULTS

Sub-lethal concentrations of cypermethrin on weight of *Clarias gariepinus fingerlings*

The results of sub-lethal concentrations of cypermethrin on some growth parameters of *Clarias gariepinus* fingerlings indicated that, the body weight showed significant decrease ($P<0.05$) with increasing concentration of cypermethrin. The results also revealed that the weight of the fish were significantly higher ($P<0.05$) in the control samples. Other parameters calculated such as percentage weight gain (%WG) and Specific Growth Rate (SGR) from the weight also pointed toward the same direction. There was also significant decrease ($P<0.05$) in the weight gain, percentage weight gain and specific growth rate as the concentration of cypermethrin increases in other treatments. (Table 3.1).

Table 3.1: Mean weight of *Clarias gariepinus* fingerlings exposed to sub lethal concentration of cypermethrin for a period of 14 days

Parameters	C	T_1	T_2	T_3
Initial Weight (g)	1.60±0.03	1.50±0.06	1.73±0.07	1.87±0.05
Weight after 14 days (g)	0.68±0.01	6.52±0.01	6.11±0.02	6.23±0.04
Weight gained (g)	1.08±0.02	1.94±0.05	1.62±0.05	1.11±0.04
Weight gained (%)	100.1±0.19	12.16±0.16	11.32±0.12	19.25±0.16
Specific growth rate	1.97±0.03	2.51±0.01	2.14±0.02	1.05±0.01

Values with different Alphabets vary significantly ($P < 0.05$) across the rows. C stands for the control (0.00mg/L), T_1 (0.006mg/L), T_2 (0.009mg/L) and T_3 (0.012mg/L), respectively

Effects of sub-lethal concentrations of cypermethrin on haematological parameters of *Clarias gariepinus* juveniles

The results of sub lethal concentrations of cypermethrin on some haematological parameters of *Clarias gariepinus* fingerlings displayed there were no significant differences ($P>0.05$) in the red blood cells (RBC) and white blood cells (WBC) of fish exposed to control and T_1. However, as the concentration of toxicant increased there were significant differences ($P<0.05$) in the RBC of fish exposed T_2 and T_3. Also, as the concentration of toxicant increased there were significant decrease ($P<0.05$) in the Packed cell volume (PCV) and Haemoglobin (Hb) of the fish in all the treatments. Moreover, as the concentration of toxicant increased there were significant increase ($P<0.05$) in the WBC of fish expose to T_2 and T_3. The study also showed that, as the concentration of toxicant increased there were significant difference ($P<0.05$) in the platelets (PLT) of fish with the highest concentration having the peak value of 133.0 ± 13.2mm³. (Table 3.2).

Table 3.2: Effects of sub lethal concentration of cypermethrin on some Haematological parameters of *Clarias gariepinus* after the duration of two weeks

Parameters	Dose (mg/L)			
	C	T_1	T_2	T_3
RBC (mm³)	3.09 ± 0.15^a	3.68 ± 0.18^a	3.45 ± 0.16^b	3.26 ± 0.02^c
PCV (%)	39.0 ± 1.75^a	34.0 ± 3.90^b	30.5 ± 1.12^c	28.5 ± 0.56^d
Hb (g/dl)	20.0 ± 30.4^a	6.95 ± 0.33^b	6.92 ± 0.44^b	6.58 ± 0.16^c
WBC (µL)	10.5 ± 0.52^a	11.2 ± 0.42^a	13.56 ± 0.70^b	13.60 ± 0.79^b
PLT (mm³)	110 ± 9.05^d	125.5 ± 7.30^c	120.0 ± 11.2^b	133.0 ± 13.2^a
MCV (fl/cell)	95.7 ± 0.06^a	93.5 ± 6.47^a	89.5 ± 2.56^b	85.8 ± 2.75^b
MCH (pg/cell)	18.6 ± 0.11^c	19.4 ± 0.39^b	20.7 ± 0.09^a	21.0 ± 0.79^a
MCHC (g/dl)	19.3 ± .056^c	20.7 ± 1.55^b	23.0 ± 0.77^a	23.5 ± 0.18^a

Values with different alphabet varies significantly at $P < 0.05$ across the rows. RBC - Red Blood Cell, PCV - Packed Cell Volume, Hb - Haemoglobin, WBC - White Blood Cell, PLT - Platelet, MCV - Mean Corpuscular Volume, MCH - Mean

Corpuscular Haemoglobin, MCHC - Mean Corpuscular Haemoglobin Concentration. C depicts the control (0.00mg/L), T_1 (0.006mg/L), T_2 (0.06mg/L) and T_3 (0.012mg/L), respectively.

Behavioural changes of *Clarias gariepinus fingerlings* exposed to sub-lethal concentrations of Cypermethrin

The results of behavioural changes of *Clarias gariepinus* fingerlings exposed to sub-lethal concentrations of cypermethrin indicated that there were weak (+) and strong (++) erratic swimming in fish exposed to T_2 and T_3, respectively. Weak (+) loss of balance was observed in T_1 and T_2 samples; strong (++) loss of balance was observed in T_3. Restlessness occurred in T_1 and T_2, with greater vigour in T_3. There were weak (+) and strong (++) mucus secretion in the samples exposed to T_2 and T_3, respectively. Discolouration was observed in T_1 and T_2 with strong (++) discolouration in T_3. Hanging on surface of water coupled with inactivity (-) featured strongly (++) in T_3 samples. (Table 3.3).

Table 3.3: Behavioural responses of *Clarias gariepinus* fingerlings after 14 days of exposure to sub-lethal concentrations of Cypermethrin

Behavioural Responses	Dose (mg/L)			
	C	T_1	T_2	T_3
Erratic swimming	-	-	+	+
Loss of balance	-	+	+	++
Restlessness	-	+	+	++
Mucus secretion	-	-	+	++
Discolouration	-	+	+	++
Hanging on water surface	-	+	+	++
Inactivity	-	+	+	++

Keys: (-) No activities were observed, (+) Weak activities were observed, (++) Strong activities were observed. C indicates the control (0.00mg/L), T_1 (0.006mg/L), T_2 (0.06mg/L) and T_3 (0.012mg/L), respectively.

DISCUSSION

Contaminants in general from different sources in aquatic media and pesticides in particular usually have tremendous effects on the resident biota especially the non-target species. In this present study, it was observed that the weight of the fish reduced as the concentration of cypermethrin and period of exposure (14days) increased. The percentage weight gain and specific growth rate also towed the same line. This is probably because of difference in feed intake and the physiological perturbation elicited by the presence of the toxicant such that the body's metabolism was mobilized towards excretion of harmful substance from the body rather than engaging in any kind of growth. In like manner, similar reasons were advanced by Uchenna *et al.* (2022) for reduction in growth of the African catfish when they were subjected to varying concentrations of glyphosphate. Elias *et al.* (2018) also reported decrease in growth across the treatments when

Clarias gariepinus was treated with sub-lethal concentrations of the herbicide, thiobencarb; which they attributed to increase in activity associated with an attempt to avoid the toxicant, and that more energy was used up on chemical detoxification and tissue repair.

Haematological studies usually indicate physiological imbalances due to the presence of xenobiotics in the environment of the organism. The results obtained from this research have shown that the major blood parameters analysed such as red blood cells (RBCs), packed cell volume (PCV), haemoglobin (Hb) decreased with increase in concentration of the toxicant; while white blood cells (WBCs), blood platelets (PLT) increased with increase in the concentration of the toxicant. This is probably because of the effects elicited on the fish from the toxicant since the body must respond to counteract such physiological perturbation, These parameters were probably used up to combat the onslaught of the xenobiotic; and higher values of WBC and PLT must be generated to ensure the survival of the organism. Davies *et al.* (2022) reported steady significant decline in the RBC, PCV and haemoglobin due to the increasing doses of Xylene as evidence of the effects of the toxicant on *Clarias garienpinus.* Ojutiku *et al.* (2013) also reported higher significant values of WBC and lower values of RBC when *C. gariepinus* was subjected to acute concentration of Cypermethrin. Omoniyi (2018) attributed the reduced values of PCV, Hb and RBC of *C. gariepinus* to toxin factor, haemagglutinin which had adverse effect on blood formation or could be as a result of stress imposed by the presence of atrazine.

Some behavioural responses such as erratic swimming, mucus secretion erratic swimming, loss of balance, discolouration, hanging on water surface and inactivity at the highest concentration of cypermethrin were observed, which were concentration dependent. Similar behavioural responses were reported by Uchenna *et al.* (2022) when *Clarias gariepinus* was exposed to glyphosate.

CONCLUSION AND RECOMMENDATION

The outcome of this research has shown that as the concentration of cypermethrin increased the weight and some of the haematological parameters such as red blood cells (RBC), packed cell volume (PCV) and haemoglobin (Hb) of *Clarias gariepinus* fingerlings decreased when compared to the values of control. The white blood cells and blood platelets increased with increase in the concentration of the toxicant. Varying behavioural responses such as; erratic swimming, mucus secretion, erratic swimming, loss of balance, discolouration, hanging on water surface and inactivity were also observed with greater intensity as the concentration of the toxicant increased.

From the findings of this research, it is evident that cypermethrin is toxic when it gets in contact with aquatic biota especially at higher concentration. Therefore, indiscriminate application near water bodies should be avoided.

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