

Effects of Paraquat on the Growth and Behaviour of *Oreochromis niloticus*

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Abstract: Sub-lethal bioassays were conducted on the fingerlings of *Oreochromis niloticus* under a static system in the laboratory (22.7±0.77°C) for a period of 8 weeks using paraquat. The toxicology effects of paraquat (1, 1-dimethyl-4,4-bipyridinium dichloride) on the respiratory process, feeding behavior and growth of the fingerling of *O. niloticus* were observed. Respiratory roles of fish exposed to 1.02 and 2.00 mg L⁻¹ were significantly decreased compared to the control. The feeding of the fish in the high toxicant concentrations was low. The weight showed increase in the growth rate of the control fish and a significant difference in the cumulative growth rate of the exposed fish. The fish exposed to toxicant concentration of 2.00 mg L⁻¹ showed an anomaly of a significant decrease in weight the 1st week of exposure, an increase in the 6th week and a decrease towards the end of the experimental period. Ecological reasons for reduction in growth in exposed fish include reduced ability to obtain food and to compete for food, delayed maturation and reproduction. Damage done to the gills resulted in respiratory impairment of the fish.

Key words: *Oreochromis niloticus*, fish, toxicant, growth, food

INTRODUCTION

Parallel serious efforts are being made to increase fish production as well as crop production through intensive and mechanized agricultural practices. The latter has resulted in a large scale use of pesticides. Although, there are definite advantages in the use of pesticides, the extensive use of these materials has resulted in a large reduction in fish production, not only in capture fisheries sector but also in aquaculture (Oloruntuyi *et al.*, 1992).

Pesticides usually get into the aquatic environment through accidents or run offs from surrounding farm lands. Information is available as to the effects of the pesticides on the fishes. There is thus a need to evaluate the significance of such pesticides in order to understand the potential harm if they are persistently used. Herbicides are of particular importance because of their use in aquatic system to control water weeds like water hyacinth (*Eichornia crassipes*) in Nigerian waters. Paraquat salts have been known since 1882 (Weldel and Russo, 1979) they rapidly desiccate all green plants tissues with which they come in contact. They are effective as herbicides at low concentrations of about 0.14-2.20 kg ha⁻¹. These combination of properties lead to their world wide use in a variety of weeds control situations (Summers, 1980). Paraquat is commonly used on land.

Many researchers reported that the growth of fish were reduced by aldrin (0.40 and 0.044 ppm), malathion

(0.400 and 0.156 ppm, 14-17%) and metasytox (2.00, 1.85 and 0.93 ppm, 18-37%) (Pal and Konar, 1987). It was advocated very easily that "growth" should be routinely measured in all chronic experiments (Sprague, 1971). The decline in growth rate of the common carp, *Cyprinus carpio* exposed to sub-lethal concentration of dipterex have been documented by Chinabut *et al.* (1978). Other effects included change in behavioral pattern and respiratory impairment (Omoriegie and Ufodike, 1991).

Oreochromis niloticus Trewavas is a common food fish in Nigeria and thus it is involved in a trophic relationship that involves man. It is therefore necessary to investigate the effects of paraquat in these species.

MATERIALS AND METHODS

The static methods of acute and chronic toxicity tests of pollutants to fish described by Sprague (1971), Mayer and Hamelink (1977) and APHA (1985) were employed.

Oreochromis niloticus of weight rang 6.97-7.72 g and mean weight of 7.35±0.53 g were obtained from the Ahmadu Bello University dam Zaria, Nigeria. The fish were transported to the laboratory in an ice-box containing sufficient water from the dam. The fish were then acclimated to laboratory conditions for 2 weeks at temperature range of 21.9-24°C prior to the commencement of the assays by holding them in aquarium tanks

(30.5×30.5×92.5 cm) with dechlorinated tap water. The aquarium tanks were aerated and water was changed once in 2 days to remove accumulated faecal materials. The fish were fed daily during acclimation on a feed formulated based on the recommendation of the Kainji Lake Research Institute (Sado, 1986). Feeding stopped 24 h prior to the commencement of the acute toxicity assay. During the assay, they were fed twice daily. The statistic method of Bioassay was used to determine the acute and sub-lethal toxicity of paraquat on *O. niloticus*. Physico-chemical parameters of the water during the bioassay were measured by the methods described by APHA (1980, 1985). The LC₅₀ was determined graphically using probit analysis (Dick and Dixon, 1985).

Growth study was carried out during sub-lethal bioassay for 8 weeks. Fishes were introduced in to the toxicant concentrations (0.00, 1.02, 1.40, 2.50 mg L⁻¹) randomly after drying and weighing on the 1st day of the experiment. Sub-sequent weighing was done once in 2 weeks interval for a period of 8 weeks. Growth was estimated from the sum of the individual wet weight of the fish at 2, 4, 6 and 8 weeks of exposure to the toxicant concentrations. Weight was expressed as percentage cumulative wet weight gain.

RESULTS AND DISCUSSION

Water physico-chemical parameters did not differ significantly (p≥0.05) with the various treatment and exposed periods. They range as follows temperature 22.7±0.77, dissolved oxygen 5.7±0.14, conductivity 4.5±0.14, hardness 2.80±0.83, pH = 5.02±0.07 and alkalinity 15.0±0.07 (Table 1). The 96 h LC₅₀ was observed to be 12.25 mgL⁻¹ with a 95% confidence level of ±1.96. The initial mean wet weight of the test fish were 7.64±1.3, for the control and 6.33±0.90, 6.88±0.90 and 3.23±0.70 for the fish exposed to 1.02, 1.40 and 2.00 mg L⁻¹ of paraquat in water, respectively (Table 2). The result showed that the cumulative percent wet weight gain in the control group increased from 3, 0.44 and 1.55% at week 1 to 30.81, 9.59 and 19.81% at week 8, respectively (Table 3). Statistically significant difference in growth rate of the treated and control was observed (p<0.05).

Behavioural changes were observed between the 6th and 8th weeks of exposure which included heamorrhage of the gills, blood shot eyes, agitated swimming, etc.

Histopathological results showed brain damage which include increase in glial cells, Oedema of brain cells and presence of some polymorphs. The greatest effects was observed at 2.0 mg L⁻¹.

Acute toxicity test result revealed increase in mortality with increase in paraquat concentration. The calculated safe concentration for paraquat was

Table 1: Physico-chemical parameters of test water

Parameters	Range	Mean
Temperature (°C)	21.9-24.0	22.7±0.77
Dissolved oxygen (mg L ⁻¹)	5.2-6.1	5.7±0.72
Conductivity (µmhos)	3.5-5.5×10 ²	4.5±0.14
Hardness (mg L ⁻¹)	20-35	28.0±0.83
Alkalinity (mg L ⁻¹)	14-15	15.0±0.07
pH	6.8-7.8	7.3±0.50

Table 2: Mean weight (g) of *O. niloticus* exposed to various paraquat concentrations in sub-lethal toxicity test for a period of 8 weeks. Mean±SE 10 fish are presented

Exposure levels (mg L ⁻¹)	Exposure periods (weeks)				
	0	2	4	6	8
0	7.64±1.3	8.43±2.9	9.48±1.0	10.01±1.0	10.40±3.2
1.02	6.33±0.9	6.52±0.9	7.34±0.9	8.10±1.0	8.28±0.9
1.40	6.88±0.9	6.85±0.9	7.15±0.9	7.33±1.0	7.54±1.0
2.00	3.23±0.7	3.28±0.7	4.24±0.8	3.70±0.7	3.87±0.7

Table 3: Weight gain and cumulative % weight gain in *O. niloticus* during sub-lethal exposure to paraquat concentrations for a period of 8 weeks

Exposure levels (mg L ⁻¹)	Exposure periods (weeks)			
	2	4	6	8
1.00	0.79 (10.34%)	1.84 (24.04%)	2.37 (31.02%)	2.76 (36.13%)
1.02	0.19 (3.0%)	0.01 (15.96%)	1.77 (27.96%)	1.95 (30.81%)
1.40	0.03 (0.44%)	0.27 (3.92%)	0.045 (6.54%)	0.66 (9.59%)
2.00	0.05 (1.54%)	1.01 (31.27%)	0.47 (14.55%)	0.64 (19.81%)

12.25±1.9 mg L⁻¹. This was derived by multiplying the 96 h LC₅₀ with an applicator factor of between 0.1-0.01 (Koesoemadinata, 1980) depending on the persistent of the pollutant. However, 12.25 mg L⁻¹ was discovered to be toxic to *O. niloticus* at 22.7±0.77°C in the long term test. This could be interpreted that paraquat is highly toxic to *O. niloticus* fingerlings in the tropic and thus the application factor to get the safe level should be lower. Morgan (1976) suggested from his data on a safe level of Diazinon in fresh water streams that there are for some species, at least less than one fiftieth (1/50) of the LC₅₀ determined on the basis of a 7 days exposure. The cumulative wet gain showed that growth was reduced significantly (p<0.05) probably due to the reduction of feeding rate at high concentration of paraquat. This was very evident from the food always left in the aquarium with the highest toxicant concentration of 2.00 mg L⁻¹. Pal and Konar (1987) reported that the growth of fish was reduced by aldrin (0.400 and 0.44 ppm), malathion routinely measured in all chronic experiment since it is “easy” (Sprague, 1971). However, Sprague went out to say that growth is not always a sensitive indicator of toxicity. Rosenthal and Alderdice (1976) on the other hand submitted that it is apparent that growth is a reflection of food availability, consumption and utilization efficiency.

It is also a reflection of organism's stage of development and maturation as well as its size. Thus, it is a critical aspect of an organism's existence and more significantly, of a population persistence. Woltering (1984) explained that several inherent difficulties are observed in growth response and these include temporal delay of growth easily in the exposure period but nonetheless equal size attainment by the end of the test. A similar observation was made at the highest concentration of exposure (2.00 mg L^{-1}) in the study by week 8. Other difficulties come from chemical induced growth stimulation (Pickering *et al.*, 1962) and the influence of density on those fish surviving the exposure (Woltering, 1984). Density-dependent, competition for food and space often result in aggressive behaviour and can lead to variation in the growth of individuals (growth dispensation or size hierarchy effects).

Ecological reasons for reduction in growth include increase in susceptibility to predation and disease, reduced ability to obtain food and to compete for food and for suitable habitats, delayed maturation and reproduction (Woltering, 1984).

Behaviour and reaction of fish exposed to acute concentration include lack of balance, agitated swimming, air gulping and period of death. Annune *et al.* (1991) reported a similar reaction to acute toxicity of zinc to fingerling of *C. lazera* and *O. niloticus*. Sub-lethal concentration did not show much visible difference in behaviour from those for the control of the 1st 6 weeks of exposure but hyperventilation, agitated swimming and redness of the eyes were observed at the last week of the experiment. Malsumura (1975) explained that hyperactivity is a primary sign of nervous system failure due to pesticides poison which affects through physiological and biochemical activities. Such, behavioural changes were observed in *O. niloticus* in this report and this corroborated the histopathological report indicating damages to the brain cells.

Behavioural reports of fish to most toxicants and differences in reaction times have been observed as due to the effects of chemicals, their concentration, species size and specific environmental conditions (Adakole, 2006; Bobmanuel *et al.*, 2006; Babatunde *et al.*, 2001).

The findings in this research agree with the research of Adakole and Lawan (2011). Research on behavioral changes of *C. gariepinus* fingerlings on expose to urea fertilizers. Such behaviours as erratic swimming, increased opercular beats, tailfin beats, jumping out of water to gulp air, etc. were also observed by Ofojekwu *et al.* (2008)'s research on effects of urea fertilizer on fingerlings of *Tilapia zilli*.

However, Babatunde (2008) discovered from toxicity of metalachlor and paraquat on *O. gariepinus*

that haemorrhaging of the operculum, copious production of mucus all over the fish and sudden death were observed. Further investigation into histopathology of the test fish brain showed histological changes in the brain of the fish indicating neurotoxic effects. Such changes include Oedema of the fish brain indicated by glial cells, there was increase number of lymphocytes and some polymorphs in the fish brain indicating encephalitis and microvacuolar change. Malsumura (1975) corroborated this by explaining that hyperactivity is a primary principal sign of nervous system failure due to pesticides poisoning.

CONCLUSION

The study has demonstrated that paraquat has effects on the growth and behaviour of *O. niloticus*. Thus, the usage of these pesticides must be controlled and monitored.

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