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A comparative study on the behavioral responses of *Clarias gariepinus* on exposure to soap and detergent effluents

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Abstract

Populations of Clarias gariepinus fingerlings and adults were exposed to lethal and sublethal concentrations of soap and detergent effluents to allow behavioral changes to be observed. The fingerlings were observed to exhibit prompt and erratic behavioral responses at extremely low concentrations of effluents compared to the adults. The abnormal behavior observed in both fingerlings and adults of C. gariepinus were characterized by hyperactivities, erratic swimming, frequent surfacing followed by sinking, loss of equilibrium, colouration and gradual onset of inactivity. The behavioral responses were dependent on concentrations, as the concentration increases the behavioral responses increased. The fishes exposed to lethal concentrations of the effluents exhibited high degree of behavioral responses when compared with those in sublethal concentrations. No significant change was observed in the control treatments of the bioassay tests.

Key words: Behavioral, Sub lethal Responses Erratic Bioassay.

INTRODUCTION

Fishes are grown for commercial purposes to meet the dire need of animal protein of man and to earn foreign exchange (Fagade *et al.*, 1993). Nigeria with about thirteen million hectares of freshwater bodies has the potentials of developing fish production as high as 511, 702mt per year but the natural population of fish is being threatened as a result of over exploitation a

Most of the industrial wastewaters discharged into the environment contain organic and inorganic pollutants in dissolved, suspended and insoluble forms. The ability of the pollutant to disrupt the biological balance or cause deleterious effects on the aquatic ecosystem is dependent on the concentration and the physicochemical characteristics of the wastewaters. Even in situations where the pollutants are discharged in low concentrations with increase in discharge rate to ecosystems, there is an accumulated effect which in turn may be hazardous (Odiete, 1999). A great deal of research has been conducted toelucidate the effect of pollutants on the physiology and survival of many aquatic organisms. Scott and Sloman (2004) reported that because behaviour links physiological function with ecological processes, behavioral indicators of toxicity appear ideal for assessing the effects of aquatic pollutants on fish populations.

When pollutants enter water bodies they produce harmful effects directly or indirectly to fish and other animals. The presence of these pollutants cause different degrees of effect, depending on the species of affected fish (Rao and Murty, 1982); its sex, age, size, general physical condition, exposure time and the concentration of the pollutants (Stross and Haines, 1979); type of toxicant used and environmental factors (Fafioye, 2001). Such effects may be influenced by water characteristics such as hardness, alkalinity and hydrogen ion concentration (Rand and Petrocelli, 1985). Behavioral abnormalities in various fish species on exposure to pollutants have been reported by several researchers. Sprague, (l97l) reported that fish fed pollutant contaminated phytoplankton and zooplankton comes up with damaged peripheral organs and reduction in swimming activities. Ghatak and Konar, [1990] observed frequent surfacing with irregular opercular movement and loss of equilibrium in *Tilapia mossambica* when exposed to different concentrations of cadmium. Fafioye [1990], reported erratic swimming in *Oreochromis niloticus* and *Sarotherodon galilaeus* fingerlings exposed to Gammalin 20, Gramazone, Primextra and Sandox. Adeogun [1994], also noted that the extracts of .*Raphia hookeri* caused erratic behaviour, darting up and down the water column and swimming alternatively on lateral and ventral sides in *0. niloticus* and *C. gariepinus.* Schooling behaviour of Fathead minnows; *Pimphales promelas* and Rainbow trout, *Orchoryn mykiss*, was disrupted when they were exposed to Keltane, Bisulton, Pydrin, Dursban and Permethrin (Holcombe *et al.*, 1982). *C. gariepinus* and *0. niloticus* exposed to aqueous and ethanoic extracts of *Parkia biglobosa* and *Raphia vinfera* experienced overturning times, which decline with increase in the concentration (Fafioye, 2001). Holcombe *et al.* [1976] observed hyperactivity, erratic swimming and loss of equilibrium in Brook trout, *Salvalinus frontalis* in response to lead treatment. The loss of equilibrium, frequent surfacing and sinking, burst of erratic swimming and gradual onset of inactivity in Rainbow trout, *Salmo gairdneri* on exposure to mecury have also been reported. (Macloed and Pessah, 1973).

Lewis and Lewis [1971] reported surfacing, restlessness, failure to school, sluggishness and lost of equilibrium in Golden shiner; *Notemigonus crysoleveus* when exposed to 5ppm of copper. Lethargic response and frequent surfacing along with gulping of air in exposure to 0.25ppm copper were also observed in *Heteropneustes fossilis, Entroplus maculatus* on exposure to copper, mercury and selenium showed irregular erratic swimming, frequent surfacing, gulping of air, revolving, convulsions and accelerated ventilation with rapid opercular and mouth movements (Veena *et al.,* 1997). Ikpi *et al,* [2003] observed the lost of skin coloration in *0. niloticus* fingerlings exposed to different concentrations of textile mill effluents. Data on the behavioral response of *C. gariepinus* to detergent effluent remain obscure as there have been no reports from any of the lakes where the fish occurs or laboratory exposures. A review of literature showed that only a few accounts have described the effects of detergent effluent on the behaviour of fish. The chemical receptor of *Letalurus natalis* (Leseus) was reportedly damaged by detergents (Bardach *et* al 1965). Foster *et al* [1966] documented that sublethal concentration of detergents prevented feeding activities in flag fishes, *Jodanella floridea* burst of erratic swimming and gradual onset of inactivity in Rainbow trout.

The aim of this work therefore, is to ascertain the effects of lethal and sub lethal concentrations of soap and detergent effluents on the behavioral responses of the laboratory populations of *Clarias gariepinus* fingerings and adults.

MATERIALS AND METHODS

Clarias gariepinus fingerlings and adults were purchased from the fish farm of the Ministry of Agriculture, Fisheries Division, Ogbomoso, Oyo State. They were allowed to acclimatized to the Laboratory conditions for a period of two weeks (14 days) in rectangular glass tanks (300m x 30cm x 30cm) with well aerated and dechlorinated borehole water. The test organisms were fed once daily during acclimatization with pelleted formulated feed to avoid the inherent problems that could results from starvation, the feeding discontinued twenty four horns prior to the commencement of the experiments (Sprague, 1971). The fish length varied from *3.5* to 6.0cm for fingerlings and 19 to 25cm for adults respectively.

Renewal static bioassay was employed, during the exposure period, ten fishes were introduced into each aquarium (measuring 39 x 29 x 18cm) containing known volume of well aerated chlorinated borehole water. Seven concentrations each were used in both lethal and sub lethal experiments. Each treatment and control had two replicates according to Sprague, (1971) and Manson, (1991) methods. The fishes were introduced into the test solutions and the experimental set ups were monitored for 96hrs and two weeks respectively. The behaviour and general conditions of the fish were observed before, during and after the experiments.

RESULTS

The lethal and sub lethal tests for both fingerlings and adults of *Clarias gariepinus* showed variations in their responses and tolerance to different concentrations of soap and detergent effluents(Table1).

The abnormal behaviour observed in both fingerlings and adults were characterized by, hyperactivity, erratic swimming, frequent surfacing followed by sinking, loss of equilibrium and colourations and gradual onset of inactivity. The behavioral responses were dependent on concentration; as the concentration increases the behavioral responses increased. Observations from the bioassay revealed that fingerlings exhibited increase in stress as evidenced by slow and uncoordinated movement. It was however observed in the course of range finding tests the preliminary test that the least lethal concentration for the adults killed all the fingerlings within ten minutes of exposure. Hence the sub lethal concentrations of the adults turn to be lethal concentrations for the fingerlings within 96 hours of the experiments.

The mean lethal concentration (LC_{50}) recorded for fingerlings was 0.1 mg/l at 96hr while that of the adults was 0.03 mg/l at 2- weeks. However both the adults and fingerlings on exposure to lethal concentration of detergent effluents showed high level of behavioral responses than the adults at sub lethal concentrations. However, the fishes in the control experiment did not show any behavioral abnormalities compared to those exposed to different concentrations of the effluents.

The fingerlings exhibited loss of equilibrium, frequent surfacing, discolouration, erratic swimming and gill movement at all concentrations. While these responses were only noticed in adults, at concentrations higher than 0.2 mg/l (lethal) and 0.05 mg/l (sub lethal). Lethargies were observed in fingerlings and adults at lethal concentrations but only prominent in adults at 0.07 mg/l.

Table 1: Behavioral Responses of C. *gariepinus* Fingerlings Adults to Soap and Detergent Effluents

ADULTS																	FINGERLINGS							
Parameter	Lethal Concentration(mgl^{-1})								Sublethal Concentration(mgl^{-1})								Lethal Concentration(mgl^{-1})							
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
Erratic Swimming	-	-	-	+	+	+	+	+	-	-	-	-	-	+	+	+	-	+	+	+	+	+	+	+
Loss of Reflexes	-	-	-	+	+	+	+	+	-	-	-	-	-	+	+	+	-	+	+	+	+	+	+	+
Discolouration	-	-	-	+	+	+	+	+	-	-	-	-	-	+	+	+	-	+	+	+	+	+	+	+
Changes in Behaviour	-	-	-	+	+	+	+	+	-	-	-	-	-	+	+	+	-	+	+	+	+	+	+	+
Gill Movement	-	-	-	+	+	+	+	+	-	-	-	-	-	+	+	+	-	+	+	+	+	+	+	+
Frequent Surfacing	-	-	+	+	+	+	+	+	-	-	-	-	-	+	+	+	-	+	+	+	+	+	+	+
Lethargy	-	+	+	+	+	+	+	+	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+

+ *indicates an increase;* **-** *indicates no response*

DISCUSSION

The toxicity of soap and detergent effluents on the fingerlings and adults of *C. gariepinus* increased with increasing concentration and exposure time (Adewoye *et al.*, 2005). During the first two hours of exposure of the test organisms to various concentrations of the effluents, abnormal behavioral changes such as erratic swimming, frequent surfacing discolorations, loss of reflex, gill movement and lethargy were exhibited. These responses are in consonance with the observations of Omoriege *et al.*, (1990), Okwuosa and Omoregie, (1995) and Avoaja and Oti, (1997) that exposed fishes to various concentrations of pollutants. Oti, [2005], submitted that these behavioral responses are indication of death due to depletion of oxygen and nervous disorder.

The comparative study of the effects of detergent effluents on *C. gariepinus* fingerlings and adults at different concentrations revealed that the fingerlings are more sensitive and responded promptly to the toxic effects of the effluents. This was confirmed considering the erratic responses and death of fingerlings even at extremely low concentrations of the effluents compared with the adults. These observations were also reflected in the median lethal concentration (LC_{50}) recorded for both the fingerlings and adults. The trends observed in the behavioral pattern of the fish could be traced to the variations in size and the developmental levels. The vulnerability of the fingerlings to the toxic actions of the effluents could be attributed to the impairment and or seizure of the metabolic activities as a result of incomplete physiological system as compared to the adults. The relative tolerance of the adults could be linked with the presence of the accessory breathing organ which serves as compensatory means of accommodating and adapting to the stressor. The studies of Canli and Kargin (1995), and

Nriagu, (1979) corroborated this present study. They however stated that the variations in the responses of the fingerlings and adults could be as a result of the degree of the development and the blockage of nervous systems, depression and/or paralysis of respiratory muscles and depletion of energy.

The erratic swimming, loss of reflexes, gill movement and lethargic conditions expressed by the fingerlings and adults was not unconnected to the variation of the responses to increase in organic loads as a results of the presence of effluents which brought about increase in biological oxygen demand (BOD) hence, a depletion of oxygen concentration of the test solutions, a factor that brought about a compensatory increase in the metabolic activities and higher respiratory rate. These situations eventually made the organisms to expend their energy, hence a lethargic condition. These observations however conformed to the submissions of Donaldson, (1975), SarojGupta, (1987), Shah, (2002) and Oti, (2005), that increase in swimming activities with increased breathing rate, lethargic conditions and loss of equilibrium were as a result of disturbances in metabolic reaction resulting in the depletion of energy and higher respiration.

The discolouration of the skin was more pronounced in the fingerlings than the adults. It was observed to be more pronounced at the lethal concentrations of the adults compared to the sub lethal. The observations could be traced to the weakening or inhibition of melanin production due to the extent of the depletion of the oxygen content; in major constituent of melanin. Novales, (1959) and Mishra and Shukla, (1994) however opined that the discoloration experienced in the fish exposed to toxicants could be due to the dispersion of melanin pigment in the chromatophores.

Due to the paucity of information on the behavioral responses of fish to aquatic pollutants, the implications are only beginning to be appreciated. It should therefore be noted that pollutants does not only involves mortality but also causes destruction of complex behaviors that provides the foundation for fish population structure. This study has proved convincingly that soap and detergent effluents are deleterious to natural population of fish. The confirmed indiscriminate discharge of these effluents can not only be traced to lack of proper awareness on wastes disposal but also to inadequate functioning of environmental monitoring groups and law enforcement agent in Nigeria. It is however imperative that all tears of Governments should enforce the more, on the industries, the proper treatment and disposal of effluents, lest our waters become wastes banks and eventually lose their aesthetic values while the natural fish population becomes impaired.

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