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Growth Response and Feed Utilization in the Cichlid, *Tilapia zilli* Exposed to Sublethal Concentrations of Linear Alkylbenzene Sulphonate (LAS) Detergent

F.O. ARIMORO[1*] and A.O. AGBON[2]

[1]Department of Zoology, Delta State University
P M B 1, Abraka-Nigeria

[2]Department of Aquaculture and Fisheries Management
University of Agriculture, Abeokuta-Nigeria

Abstract

Fingerlings of the cichlid *Tilapia zilli*, were exposed to various sublethal concentrations of linear alkylbenzene sulphonate (LAS) detergent, a toxicant, and the effects on growth response indices and feed utilization were recorded using biostatic assays. Water quality was also monitored. The fish were exposed in aerated tanks for 12 weeks, at concentrations of 1.56, 0.39, 0.196, 0.098 and 0.00 (control) mgL^{-1}. No mortality occurred in the exposed fish or in the control group. The toxicant led to significant depression in weight gain in direct proportion to concentrations of the toxicant. Feed utilization was significantly reduced. The environmental impacts on fish of detergents in an ecosystem are discussed.

Introduction

Among ecological toxicants, synthetic detergents released into the aquatic ecosystem may result to a variety of effects on the fish and other

[*] Corresponding author.
E-mail address: fransarimoro@yahoo.com

aquatic organisms. Some detergents are persistent or 'hard' and cause rivers to foam. Such foamy water is harmful to aquatic and human health (Okwuosa and Omoregie 1995). 'These detergents Swans' have been reported to reduce the up take of oxygen considerably for as little as 1.0 pp.m of these substances dissolved in water (Mellanby 1980).

Synthetic detergents were first introduced in the 1930s, but it was not until the 1950s that they became popular, with large quantities entering the aquatic ecosystem as effluent from factories and as 'after wash' from homes (Imonite 1994). Before the advent of detergents, soap was used for household chores and they pose no problem as they are readily decomposed by bacterial action during sewage treatment (Mellanby 1980). With the introduction of synthetic detergents household chores became easier and marketing was more successful as these detergents superseded soap as water softeners and perverted scum in hard water.

Detergents contain traces of iron, manganese and zinc. These surface-active detergents resist decomposition by bacterial action during sewage treatment (Adamson 1973; Abel 1974; Skidmore l977). Monitoring of dispersed anionic and non-ionic surfactants have indicated that surfactants may occur in concentrations that are known to cause acute or chronic effects on sensitive species of fish (Mittal and Garg 2000). The potential environmental impact depends on the exposure, biodegradability and toxicity of the surfactants (Tovell *et al.* 1974).

Detrimental effects and acute toxicity of detergents on vsarious freshwater species have been well documented (Cairns and Scheler 1964; Abel and Skidmore 1977; Ghatak and Konar 1991; Okwuosa and Omoregie 1995; Mittal and Garg 2000).

Although sublethal effects of detergents on fish species is low in literature, Lal *et al*. (1983) reported damage of the gills, impaired respiration and salt balance in fish exposed to sublethal concentrations of detergents.

The Nigerian freshwater system is subjected to a build up of detergent levels as a result of effluent from factories and communal washing along several segments of the rivers, the rational for this investigation.

The cichlid, *Tilapia zilli is* an important freshwater fish in the tropics (Anthony 1982), hence its choice for this investigation. Owing to the continuous contamination of the tropical freshwater system with detergents and the dearth of information on the growth response and feed utilization on fish, this study was carried out with the aim of evaluating the effects of the sublethal concentration on the growth and feed utilization of the Tilapia.

Materials and Methods

Linear Akylbenzene Sulphonate (LAS) detergent with the trade name 'Klin'® was used for this investigation. The experimental fish, *Tilapia zilli* with mean weight of (7.34 ± 0.01) g of the same brood stock were used. The fish were acclimatized for 14 days during which time they were fed with laboratory prepared fish diet (Table 1). The diet was analysed for moisture, ash, crude protein, lipid, fibre and total carbohydrate using standard laboratory methods as described in AOAC (1984). Feeding of fish was done on 5% of their body weight twice daily (0800 and 1500h). The static bioassay technique was employed for this investigation during which time the set up were continuously aerated. For each batch of the experiment consisting of two replicates (20 fish each), six different sublethal concentrations of the toxicant were used. The different concentrations of the detergents in each test tank were prepared as described by Okwuosa and Omoregie (1995). Twelve glass aquaria (50L capacity) were used. The various concentrations used were in the following order: 1.560, 0.780, 0.390, 0.196, 0.098 and 0.00mgL^{-1}. The 0.00mgL^{-1} served as the control experiment. These concentrations were obtained after several preliminary experimental tests, to arrive at a concentration not causing mortality to the exposed fish.

Exposure period lasted for 12 weeks. While anaesthetized by benzocaine, two fish from each aquarium were individually weighed at the start of the experiment and every two weeks thereafter. Mean weights were computed by treatment for each weighing period. The amount of feed given was adjusted to the new weight.

Water physicochemical parameters in each of the aquarium were monitored weekly using the methods described by APHA (1980). Parameters measured included temperature, dissolved oxygen, free carbon IV oxide and total alkalinity.

The mean weight of the fish in each of the aquarium was used in the computation of the specific growth rate (SGR), food conversion ratio (FCR), food conversion efficiency (FCE) and protein efficiency ratio

(PER) according to appropriate formulae given in Anadu and Nwokoye (1993).

Table 1. Formulation and mean proximate composition of experimental diet

	Content
FORMULATION (%)	
Fish meal	35
Groundnut cake	20
Cassava	10
Maize	15
Vegetable oil	10
α- Cellulose	10
Vitamin and Mineral premix*	5
COMPOSITION (%DM)	
Moisture	6.34
Ash	8.12
Lipid	12.36
Crude protein	34.50
Total Carbohydrates	33.26
Mean Gross Energy Value (MJ/Kg diet)	28.43

*Vitamin & mineral premix per gram of diet. Vitamin A 9823 I.U, D_3 1965 I.U, B_{12} 10g/ton, Riboflavin 41mg, Niacin 246 mg, Pantothenic acid 98mg, Folic acid 10mg, Manganese 341mg, Copper 244mg, Zinc 100mg, Iodine 20mg, and Oxytetracycline hydrochloride, 20mg/ton.

The results obtained from this investigation were subjected to statistical analysis by using the analysis of variance (ANOVA) method to test for the level of significance within the various treatments. Differences between the water physicochemical parameters of the various treatments were computed using the student's t-test. Means were computed using the Duncan multiple Range F-test to determine their significant differences ($P>0.05$). The Microsoft Excel (Microsoft Corporation, USA) software was used for all statistical calculations.

Results

No mortality occurred in exposed fish or in the control group throughout the experimental period.

The results of the water physico-chemical parameters during the exposure period for the toxicant are presented in table 2. These values

Table 2. Mean value of water Physicochemical parameters during exposure of the cichlid, *Tilapia zilli* to sublethal concentration of Linear Alkyl benzene Sulphonate (LAS) detergent

	Parameters				
Concentrations (mgL^{-1})	Temperature (^{O}C)	pH	Dissolved oxygen (mgL^{-1})	Alkalinity (mgL^{-1})	Free Carbon IV oxide (mgL^{-1})
Control (0.00)	22.42 ±0.04	6.92 ± 0.02	7.24 ± 0.05	32.32 ± 0.03	4.92 ± 0.05
0.098	22.80 ± 0.06	6.87 ± 0.01	7.05 ± 0.07	30.64 ± 0.05	4.81 ± 0.05
0.196	22.01 ± 0.06	6.74 ± 0.02	6.95 ± 0.04	28.58 ± 0.07	4.70 ± 0.04
0.390	22.51 ± 0.03	6.28 ± 0.03	5.90 ± 0.03	31.02 ± 0.09	4.79 ± 0.08
0.780	22.40 ± 0.04	6.15 ± 0.01	5.28 ± 0.03	27.52 ± 0.04	4.53 ± 0.03
1.560	22.43 ± 0.03	6.04 ± 0.01	5.01 ± 0.02	27.15 ± 0.03	4.26 ± 0.04

were not significantly different (P>0.05) throughout the exposure period, however the values of dissolved oxygen and pH decreased considerably with an increase in the level of the detergents.

During the period of exposure to the toxicant, all the groups of fish with the exception of those exposed to 1.560 mgL^{-1} and 0.780mg L^{-1} fed very well. When food was given, these groups of fish fed vigorously at the water surface and consumed all the food supplied. Exposure to higher concentrations of 0.780 and 1.560 mgL^{-1} affected feeding behaviour resulting to less food consumption. Less than 70% of the total food offered was consumed. Statistical analysis showed that the fish exposed to various concentrations had significantly lower weight gain than the control fish (P<0.05); reduction being proportional to increase in the toxicant concentration (Fig. 1).

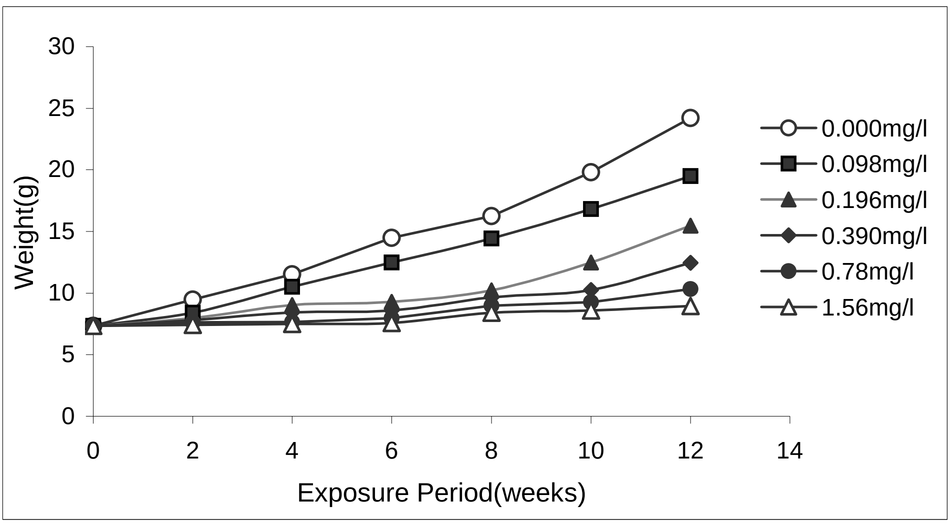

Fig. 1. Cumulative mean weight gain of the cichlid, *Tilapia zilli* exposed to various sublethal concentrations of Linear Alkyl benzene Sulphonate (LAS) detergents for 12 weeks

Growth indices and food utilization values of the fish exposed to various sublethal concentrations of detergents are presented in table 3. The specific growth rate (SGR) of the groups of fish exposed to 0.098mg/L and the control were higher than 1.0 and the differences between these values were not significant. The SGR of group of fish exposed to 0.196, 0.390, 0.780 and 1.560 mgL^{-1} were all less than 1.0. Food conversion ratio (FCR)

Table 3. Mean growth and feed utilization values of *Tilapia zilli* exposed to various concentration of Linear Alkyl Sulphonate (LAS) detergents for 12 weeks (n=20)

Detergent concentrations (mgL^{-1})	Parameters						
	Initial body weight (g)	Final body weight (g)	Mean weight gain (g)	Specific growth rate (% day^{-1})	Food conversion ratio	Food conversion efficiency (%)	Protein efficiency ratio
Control	7.34 ± 0.01	24.20 ± 0.02	16.86 ± 0.01	1.42 ± 0.01	3.28 ± 0.04	30.53 ± 0.03	0.88 ± 0.02
0.098	7.35 ± 0.02	19.48 ± 0.02	12.13 ± 0.02	1.16 ± 0.01	4.04 ± 0.02	24.75 ± 0.02	0.72 ± 0.01
0.196	7.35 ± 0.02	15.46 ± 0.03	8.11 ± 0.01	0.89 ± 0.02	4.86 ± 0.03	20.57 ± 0.03	0.58 ± 0.01
0.390	7.32 ± 0.01	12.46 ± 0.01	5.14 ± 0.02	0.63 ± 0.01	7.09 ± 0.01	14.83 ± 0.01	0.41 ± 0.01
0.780	7.36 ± 0.01	10.32 ± 0.04	2.96 ± 0.01	0.40 ±0.02	11.55 ± 0.03	8.65 ± 0.02	0.25 ± 0.03
1.560	7.34 ± 0.03	8.95 ± 0.05	1.61 ± 0.02	0.24 ± 0.02	20.36 ± 0.02	4.91 ± 0.03	0.14 ± 0.02

showed a significant increase ($p<0.05$) with an increase in the level of the toxicant. This is because the weight gains by the fish subject to various levels of toxicant were low compared to the weight of food consumed by the fish. The controlled fish had a FCR value of 3.28 while the higher value was recorded by the fish exposed to 1.560 mgL^{-1} of the toxicant (20.36). The food conversion efficiency (FCE) in percentage showed significant decrease with increase in the level of toxicant. The FCE (%) was highest in the control 30.53 and lowest in the 1.560 mgL^{-1} (4.91%) toxicant concentration. The protein efficiency ratio (PER) also followed similar pattern as the FCE. The highest toxicant concentration recorded the lowest PER of 0.14 ± 0.02, while the control (0.00 mgL^{-1}) recorded an appreciable higher PER value of 0.88 ± 0.02. The FCE and PER values showed a significant decrease ($P<0.05$) with an increase in the level of toxicant.

Discussion

The results of this investigation indicated that the fish exposed to sublethal concentrations of LAS detergents grew significantly lower and had higher SGR, PER and FCE compared to their counterparts which were not exposed to the toxicants. Observations also indicated that the physico-chemical parameters in the various test tanks did not vary significantly from the control tanks, with all values within the tolerance range suggested by Boyd (1979). Also sublethal concentrations of detergent products, as documented by UNEP (1990), are likely not to have significant effects on water quality in the environment. In most cases, sublethal exposure as reported by Omoregie and Ufodike (1999; 2000) can lead to disruption in the physiological or behavioural activities of aquatic organism but do not cause immediate mortality although death may follow because of interference with feeding behaviour or greater susceptibility to predation.

The crude protein value of 34.5% DM and mean gross energy value of 28.42MJ/Kg diet also suggest that food quality and water could not have been the limiting factors to poor growth and food conversion reported in this study. It would appear from the results of these experiments that the low FCE and PER levels recorded indicated that the toxicant greatly affected the feed utilization of the fish.

The inhibition of growth reported in this investigation can be related to the disturbance of normal metabolism by the detergent. Abel

(1974) reported that the synthetic properties of detergents have growth disruptive properties to fish and other aquatic invertebrates.

The proper management of freshwater demands that water of suitable quality should be provided for use of man, animal and aquatic organisms. Results from this investigation showed that the detergent (LAS) at sublethal concentrations have deleterious effects on the growth rate and food utilization of the fish, *Tilapia zilli* after a 12 week exposure period. The result also indicated that at such a low concentration mortality of the fish is not likely to occur, however growth and feed utilization is affected as earlier indicated by Ghatak and Konar (1991) and Imonite (l994).

Conclusion

The use of detergents in industries and homes cannot be discontinued however, the need for the primary treatment of the 'after wash' needs to be worked out. According to Wade *et al* (2002) adequate treatment of wastewater will allow early elimination of toxicants and fast recovery of receiving water bodies. This will also ensure continuous survival abundance and distribution of aquatic organisms. The campaign against indiscriminate disposal of industrial effluent into the water body should be intensified especially in several developing countries of the world so that the continuous existence of aquatic organisms and fish will not be in jeopardy.

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