

**STUDIES ON DIEL FEEDING AND DIGESTIBILITY OF  
CYANOBACTERIA**

by

***Oreochromis niloticus* and *Oreochromis mossambicus*  
IN BEIRA LAKE, Sri Lanka.**

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**Abstract**

Beira Lake is eutrophic and covered with a bloom of Cyanobacteria. Hybrids of *Oreochromis niloticus* and *Oreochromis mossambicus* dominate the lake. Present study deals with feeding cycle and digestibility of the bloom by *Oreochromis* species. Volume method and the point method were used to determine feeding intensity of the hybrids. Stomach pH and Chlorophyll-a content in stomach and hindgut were determined at different hours of the day. Four to five diurnals were conducted in the field and in the laboratory.

Results indicated that, *oreochromis* hybrids commenced their feeding at the 6th hour and stomachs were filled up to 25%. At the 12th hour, majority of fish were fed from 50% to 75% and on the 18th hour up to full stomach level. Feeding decreased from 75% to 50% at the onset of resting phase at the 24th hour. Results were similar under laboratory conditions.

At the onset of feeding pH was 7-8 in the stomach, Ch-a concentration in the hindgut was high, and food passed undigested.

At the 12th hour, pH decreased from 3-4 and reached 1-2 at the 18th hour indicating onset of digestion. From 18th to 24th hour, active digestion occurred.

**Key words: Peak feeding, Digestibility, Cyanobacteria *Oreochromis*, Cichlidae**

**1. Introduction**

Beira Lake is one of the most polluted waters in the city of Colombo. It is located in the heart of the city, in a highly urbanised catchment of 422 ha.

It is an eutrophic Lake (Costa & De Silva, 1978) and its water quality began to deteriorate in the nineteenth century. This resulted an obvious reduction in the richness of the aquatic communities. The composition of natural fish fauna in Beira

Lake has drastically altered by the introduction of several new species in the early 1950s (Anon, 1993). However according to the recent data fish species present in the Lake, include *Oreochromis niloticus*, *Oreochromis mossambicus*, *Heteropneustes fossilis*, *Channa marulius*, *Channa striata*, *Cyprinus carpio*, *Rasbora daniconius* (Anon, 1993). Of these, *Oreochromis niloticus* and *O. mossambicus* predominate the ichthyofauna of the Beira Lake. *O. mossambicus* was introduced in 1952 and *O. niloticus* was introduced in 1975 (anon 1985) subsequently. These fish types have remarkable ability to tolerate harsh conditions of the habitats. Their feeding habits are adjustable according to the food type in the environment (Bowen, 1982) They can change their dietary habits from herbivores to omnivores or even to planktivorous depending on the available food types in the environment. For the digestion of the food, the required pH value in the stomach of both species was found as low as two (Bowen, 1982). However at present no pure *O. niloticus* or *O. mossambicus* are present in the Lake. The two types present are hybrids.

Due to the great accumulation of industrial effluents, untreated sewage and domestic garbage has caused nutrient enrichment in the Lake leading to eutrophication followed by greening of the water due to Cyanobacteria blooms throughout the year. This algal bloom mostly consist of Cyanobacteria like *Spirulina*, *Microcystis* and *Merismopodea* (Nahallage, 1995).

The Objectives of the study are to find out the intense feeding hours of the two *Oreochromis* species and to determine the digestibility of algal bloom by *O. niloticus* and *O. mossambicus*. This would help to evaluate capability of the *Oreochromis* species in removing the bloom during heavy blooming situations in eutrophicated water bodies. As *Oreochromis* species in Beira Lake are hybrids, the present surdy reports the digestibility of algal bloom by natural hybrids of *O. niloticus* & *O. mossambicus* but not by pure forms of the two species.

## 2. Materials and Methods

### Study area

The fish samples were collected from the East Lake of the Beira lake, which is the deepest, and the largest out of the four basins.

### Sampling

Since *Oreochromis* species of Beira Lake are natural hybrids of *O. niloticus* and *O. mossambicus*, in the present study depending on the external features of fish, they were identified as either *O. niloticus* or *O. mossambicus*.

Ten diurnal investigations were carried out from September 1995 to February 1996. In each diuranl, the fish samples were obtained from the small scale cast-net fishery in the East Lake. These samples were taken at every six hourly intervals for a twenty- four hour cycle, once a month. Simultaneously diurnal observations

were done under laboratory conditions. At each diurnal investigation (in the field), about 250 individuals of *O niloticus* and *O mossambicus* were used. The standard length (SL), Total length (TL), of each fish were measured and these information were used to determine the size class distribution of the fish in the Lake for the experiments. Fish of the same size class which belong to the highest percentage frequency category, were used for the experiments for comparative purposes.

### **Feeding intensity**

To determine the feeding intensity of both fish species, stomach filling was determined within 24-hour cycle using two methods.

- (1) Volume method: The volume of the stomach of the fish was measured by water replacement method (Hynes, 1972).
- (2) Point method: The amount of filling, was determined by eye observation (Hynes, 1972). According to the point method, when there was no food in the stomach, zero point was given and if the stomach was filled to the full volume by stretching the walls of the stomach, ten points were given. Other filling stages were ranked between these two extremes.

### **Digestibility:**

Fish collected were dissected and pH paper was inserted into the stomach for determination of pH values. Whatman pH papers ranging from one to five and one to fourteen were used to determine the pH values of the stomach contents of fish at different hours of the day. The pH value of the stomach indicates the onset of digestion (Bowen, 1982). In addition, the change of colour in the gut contents from stomach to rectum was determined through observation, which indicated the digestion. During diurnal investigations (4 diurnal) carried out in the laboratory, Chlorophyll-a concentration in the stomach contents also were measured at different hours of the day which indicated the progress of digestion at different hours of the day.

## **3. Results**

### **Size class of fish:**

Fig. 2 illustrates the percentage frequency of size classes of the fish sampled during the field study. The highest percentage of fish belongs to the size class of 10-13 cm. For the studies on intense feeding hours and digestibility of fish, the fish belonging to the size class of 10-13 cm were used for comparison.

**Peak feeding hours:** Fig. 2 illustrates the stomach fullness of the percentage of fish during every hour of the day during five diurnals conducted in the field and in the laboratory. According to fig. 2, most of the fish found during 6th hour of the day was

fed only up to 25% of its stomach volume. This observation was similar in the field as well as in the laboratory. (Fig. 2 a & Fig. 2b). During the 12th hour, 40% of the *O mossambicus* samples were fed up to about 50-75% of stomach levels. However about 40% of the *O niloticus* population was fed up to 75-100% level of their stomach volumes under the field situation and about 50% of them fed up to 25-50% under laboratory condition (Fig 2b). During the 18th hour, about 40% of the *O mossambicus* population sampled under field conditions fed up to 50-75% stomach volume and about 40% of the *O niloticus* population fed up to 75-100% stomach level. Under laboratory conditions, 65% of the *O mossambicus* population fed up to 75- 100 and about 75% of *O niloticus* fed up to 75-100% of the stomach volume. At the 24th hour of the day again the full stomach level was decreasing up to about 75% in 30-40% of the *O niloticus* and *O mossambicus* population under field conditions and 15-35% under laboratory conditions. Based on the results obtained in the field and in the laboratory, the intense feeding hours of both fish species could be generalised as given in Fig 3. which seems to be associated with stomach pH. According to the results of the five diurnal studies generally fish tends to start feeding during the early hours of the day but it reaches 50-75 of the stomach level at noon. Most of the fish sampled at the 18th hour have fed up to full stomach volume. However at the 24th hour of the day the highest proportion of the fish sampled had 50% - 75% full stomachs. This level decreased further to 25% in the early morning hours.

#### **Digestibility:**

Fig 4 illustrates stomach pH values for *O niloticus* and *O mossambicus* during field investigations. More than 75% of the population of *O niloticus* and *O mossambicus* had pH value between 6-8 pH in their stomach contents at 6th hour as they start feeding. At the 24th hour of the day, 50% of the population of both fish species' had 50-75% stomach fullness and their stomach contents reached to a low pH value between 3-4 pH indicating onset of digestion. Majority of fish sampled at 18th hour had full stomachs with pH values, below two. At the 24th hour of the day, high proportion of *O niloticus* population had pH below two in the fluid of stomach, but in *O mossambicus*, about 25% of their population had a low pH value between 1-2 pH, a considerable proportion of the population had higher stomach pH values between 6-8 pH (Fig 4).

Fig 5 illustrates chlorophyll-a (Ch-a) concentrations in the contents of stomach and in the hind gut of both *O niloticus* and *O mossambicus* during laboratory investigations. Both species have comparatively low Ch-a concentrations (about 40- $\mu\text{g/l}$ ) in the stomach contents at the 6th hour sample. *O niloticus* had the highest Ch-a concentration in the 12th hour sample. *O mossambicus* had the highest Ch-a concentration occurred at the 18th hour sample. Ch-a concentrations in the stomachs of fish also indicated that their intense feeding hours is in-between 12th to 18th hour of the day. Ch-a concentrations in hind gut contents of both *O*

*niloticus* and *O. mossambicus* were maximum during 6th hour and gradually decreased from 18th to 24th hour of the day. From 18th to 24th hours of the day, hindgut of the two species contained digested food, which did not have Ch-a but mostly phaeophytin.

#### 4. Discussion

*Oreochromis* species are omnivores (Bowen, (1982) Caulton, (1982) Dokulil, (1983) Hofer & Schiemer, (1983) Maitipe & De Silva, (1984); and according to Bowen (1982) their feeding habits depend on the most available food in environment. In the Beira Lake, the most abundant food item was Cyanobacteria. (Anon 1993 Nahallage 1995). In the present study; gut contents of the two *Oreochromis* species were dominated by *Spirulina* and *Microcystis* belonging to Cyanobacteria. Similar results have been repeated for *O. mossambicus* in Parakrama Samudra by Dokulil, (1983). Dependence of the feeding habits of the cichhids on the availability of the food types in the environment is well documented by Bowen (1982), Hofer & Schiemer in (1983), & Maitipe & De Silva (1985) with regard to diel feeding of *Oreochromis* species Bowen (1982) has recorded that *O. mossambicus* and *O. niloticus* have a twenty four hour feeding cycle, Both species of *Oreochromis* in the Beira Lake feed on the algal bloom, which consists of the *Spirulina* and *Microcystis*, as it is the mostly available food type in their immediate environment. According to the results of this study, both fish types commenced their feeding in the early morning hours around six o'clock very slowly indicating sort of a resting stage. Then their feeding accelerates from 12th to 18th hour and declined from 24th to 6th hour. However their stomachs were not completely empty during the 24-hour cycle. According to Bowen (1982), digestion of *Oreochromis* species is a two stepped process with distinct gastric and intestinal components. (However the importance of gastric enzymes in distinct was not clearly understood and may vary with the species or with the diet for a single species.)

The observations made in the present study indicate that both hybrids pass the food ingested during early hours of the day undigested. This is clear in the chlorophyll-a concentration values in the fore and hindgut during early hours of the day (See fig. 5). These results are in agreement with the findings of Bowen (1982) who stated that in *Oreochromis* species the stomach fluids return to pH 5 to 7 during the resting stage and in those species whose diet is rich in chlorophyll, the food ingested at the onset of feeding, remains green and undigested as it moves along the length of the intestine. The chlorophyll-a values in the fore and hind gut samples indicate status of digestion during different hours of the day.

With increased feeding activity of the fish, the pH value of the gastric fluids gradually decreased to a pH as low as 1. Similar conditions have been observed by Bowen, (1982). Exposing to acid at low pH (below 2) decomposes the algal chlorophyll to phaeophytin and the colour of the food changes from green to brown.

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