FOOD AND FEEDING HABITS OF MOZAMBIQUE TILAPIA *Oreochromis mossambicus* (Peter, 1852) FROM HARDAP DAM, NAMIBIA

BY

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DEDICATION

This work is dedicated to God who gives me life;

My mother, who has taught me that I can achieve anything in my life if I set mind to it;

My father who has taught me a love of nature;

My children Christopher and Elizabeth for missing me during this study.

TABLE OF CONTENTS **Page**

ABSTRACT

This paper provides information on the food and feeding habits of *Oreochromis mossambicus* (Peter,1852) species in Hardap Dam. A total number of 72 specimens were examined. The natural food of *O. mossambicus* in Hardap Dam, Namibia were studied from the gut contents of fish measuring 7.3 - 45 cm total length. Gut contents were analyzed using two methods, the frequency of occurrence and stomach fullness index. A study of the quantitative dynamics of the food components in the course of a year has proved that the species in question feeds more intensely in spring, this being the time when zooplankton forms are more abundant in the water of the Dam. The main food items were diatoms, blue green algae and green algae constituted main food of plant origin. Diatoms were found to be the most preferable food of plant origin where it occurred in more than 72.2% of the examined fish. Crustacean, copepods, while the detritus occurred in about 41.67% of the examined guts respectively. It was concluded that O. mossambicus in Hardap Dam is apply both herbivorous and omnivorous.

Key words: Hardap Dam. *Oreochromis mossambicus*. Natural food. Gut contents. Frequency of Occurrence. Stomach fullness index method.

1.0.INTRODUCTION

"Tilapia" is the generic name of a group of cichlids endemic to Africa. The group consists of three aquaculturally important genera–including *Oreochromis* and *Sarotherodon*. Several characteristics distinguish these three genera, but possibly the most critical relates to reproductive behavior (Popma and Masser, 1999).

The Mozambique tilapia (*Oreochromis mossambicus*) are native to Africa and occurs in the coastal regions of eastern Africa (Skelton,1993). It has been introduced into at least 90 countries some the countries are Swaziland, Malawi, Tanzania, Namibia, South Africa, Egypt and Australia (western Australia and Queensland) and is important for food fish in many of those countries (Maughan *et al*., 2007). Mozambique tilapia it was introduced in Namibia from the western Cape in 1947, mainly for recreational angling purpose (Schrader, 1985).

1.1.Habitat and Ecological tolerances

Mozambique tilapia prefers to the environmental were the rivers flowing slow and streams and still water habitats such as lakes and lagoons and in both fresh and brackish waters. A 'type' habitat of the species is the lower Zambezi River, (eastern Africa, 18° 46'S) central Mozambique (Maughan *et al*., 2007).

Mozambique tilapia is a remarkably hardy species and its success in exploiting new and diverse habitats has been attributed, in part, to its tolerance of a wide range of environmental conditions with enhance growth characteristics and environmental tolerances including to low temperature, overcrowding stress and pathogens (Behrends *et al*. 1990; Cnaani et al. 2000 and Cai et al. 2004).

Tilapia is a warm water, stenothermal species though potential habitat it can occupy is restricted only by a limited tolerance of low temperature (Hickling 1963). Lower lethal temperatures between 8 and 15°C have been reported (Smit et al. 1981; Philippart & Ruwet 1982). The species has a thermal 'zone of tolerance' between 15° and 37°C, and a limited tolerance of temperatures between 39 and 40°C, with lethal temperatures at 41-42°C (Philippart & Ruwet

1982; Stauffer 1986). The species can also tolerate extremes of acidity and alkalinity, with low oxygen and high and low pH values ranging between 3.7 and 10.3 (Krishna Murthy et al. 1981; van Ginneken et al. 1997 and Leghari et al. 2004).

Lahser (1967) further reported that, *O. mossambicus* killed aquatic macrophytes while feeding on periphyton such as diatoms, filamentous algae and cynobacteria. Leaves, stems and roots were scraped or rasped to shreds; the plants were killed and consumed secondarily. Field observations by Lahser showed that *O. mossambicus* eliminated several species of submerged and emergent macrophytes, either by grazing or by uprooting plants.

Several studies have found that free bacteria and cynobacteria (*Microcystic* spp) to be a dominant or frequent component in the herbivory to detritivory or between phytoplankitivory to zooplanktivory) it is related to incidental feeding. When deposit feeding, fish may ingest a mixture of sediment phytoplankton, detritus and small invertebrates, eg., copepods, virtually indistinguishable to the diets of suspension feeders. *O. mossambicus* also undergoes ontogenetic change in feeding with a shift from macrophage in fry and fingerlings (e.g., bacteria, diatoms, microcrustacea, rotifers) to predominantly macrophage in adults (Vaas and Hofstede, 1952; Le Roux, 1956; Bowen, 1976; Bowen & Allanson, 1982).

Mozambique tilapia has been reported from its native and introduced range as feeding on live aquatic and submerged terrestrial plants, benthic algae, phytoplankton, periphyton (algae attached to plants), zooplankton, and organic detritus (Hofstede & Botke, 1950; Pannikar & Tampi, 1954; Man & Hodgkiss, 1977; Bowen, 1978, 79, 80a, 81; Aravindan, 1980; Dudgeon 1983; De Silva *et al.* 1984; De Silva, 1985; Dickman & Nanne, 1987; Blühdorn *et al.* 1990; Milward and Webb, 1990; Webb, 1994; Kim *et al.* 2002).

1.2.Social-Economic Importance

According to Abdel-Aziz, and Gharib, (2007) recent studies on natural feeding of fish permit to identify the trophic relationships present in aquatic ecosystems, identifying feeding composition, structure and stability of food webs . In the same time, Oronsaye, & Nakpodia, (2005); and Oso, Ayodele and Fagbuaro, (2006.) reported that the study of the food and feeding habits of freshwater fish species is a subject of continuous research because it constituted the basis for the development of a successful fisheries management programme on fish capture and culture. Studies on diet composition are important in community ecology because the use of resources by organisms has a major influence on population interactions within a community (Mequilla, and Campos, 2007). Studies of species resources requirements have been used in attempts to understand factors controlling the distribution and abundance of organisms (Ross, 1986). Data on different food items consumed by fish may eventually result in identification of stable food preference and in creation of trophic models as a tool to understand complex ecosystems as reported by Lopez-Peralta, & Arcila, (2002) and Bachok, Mansor and Noordin, (2004).

Begum *et al* (2008), explained their food and feed habits and stated that food is the main source of energy and plays an important role in determining the population levels, rate of growth and condition of fishes. Food and feeding habits of fishes have a great significance in aquaculture practice. It helps to select such species of fishes for culture which will utilize all the available potential food of the water bodies without any competition with one another but will live in association with other fishes (Begum *et al*, 2008).

1.3.Habitat and Ecological impacts

There are few reports that document the extent of impacts of predation by *O. mossambicus* on other fish populations. Fuselier (2001) reported *O. mossambicus* feeding directly on fish eggs and small endemic pupfish fish in a natural lake, contributing to population declines. Aravindan (1980) also reported that *O. mossambicus*, in open riverine waters, supplemented its diet with fish eggs and small fry.

The highly invasive *Oreochromis mossambicus* has been implicated in the decline or disappearance of resident species from freshwater, estuarine and marine habitats in several countries following its introduction (Maughan *et al*.,2007). It can have negative impacts on aquatic communities through grazing or predation, interference competition (overcrowding) for food and space, as a vector of disease-causing pathogens, or by activities which lead to changes in the abiotic environment. For example, loss of water quality which may affect survivorship of resident species. Lahser (1967), also observed increased turbidity in shallower margins due to the activity of male fish clearing areas for courtship display pits that subsequently resulted in further loss of photosynthetic production.

Cahoon, (1953); Noble et al. (1975); Forester and Lawrence, (1978) and Taylor et al,. (1984) all have demonstrated that overcrowding by exotic fishes, including tilapias, such as *Oreochromis mossambicus*, can have devastating effects on native species. Significant decreases in the size of native fishes caught and overall contribution to fish production in several lakes and reservoirs in India and Sri Lanka were reported, following the introduction of *O. mossambicus* (Natarajan, 1971; de Silva, 1988; Bhagat and Dwivedi, 1988).

Arthington and Blühdorn (1994) referred to an observations by Arthington and Milton that analysis of fish diets from sub-tropical impoundments provided evidence that *O. mossambicus* consumes small forage fish (rainbow fish and gudgeons) and that consumption of such fish and aquatic invertebrates may be higher in water bodies with low primary productivity.

1.4.STUDY AREA *(Hardap Dam)*

The Hardap Dam was constructed in 1962 for irrigation purposes north of Mariental in the south central part of Namibia. The Hardap Dam is primarily fed by the Great Fish River and has capacity of 2500 ha (Hay *et al.*, 1999). The Hardap Dam is the largest of its kind in Namibia with a water surface area of about 25 sqkms (*see plate* 2). The Hardap is fed by the set in the Great Fish River , the only river in the country's interior that flows just about all year around, although carrying very low quantities of water during dry season (Hay *et al.*, 1999).

Fig. 1. The map of Hardap Dam, Namibia.

There is no published data available on feeding habits of *O. mossambicus* which represent the major content of fish food available in large size of Hardap Dam. Therefore, this study aimed to provide information about the main components of the diet of *O. mossambicus* in the Hardap Dam Namibia for facilitating the sustainable aquaculture. To achieve this objective, the following aims were formulated:

To identify feed component available in the Hardap Dam.

Establish possible existence for Preferences for certain feed types at different life stage.

To identify if feed components are restricted to water column, benthic only or entire water spectrum.

1.5.RESEARCH HYPOTHES

H$_{01}$: The are no significant feed components and feeding habits consumed by *Oreochromis mossambicus* are restricted to water column on benthic only or entire water spectrum.

2.0.MATERIALS AND METHODS

2.1.Sample collection

The sample of *Oreochromis mossambicus* have been collected by using small boat fixing with outboard engines and seine net. A total number of 72 fishes of different size, maturity and sex groups were collected randomly from different places at Hardap Dam, during the period of September to October, 2010, by using seine net 10mm mesh size and gill net 73mm, 93mm, 118mm, 150mm mesh size as indicated in **figure 2, 3** and **figure 4** indicate different areas where samples was collected. Immediately after collection the fishes were preserved in a container with water and were then are transferred to the laboratory, where the fishes were washed, cleaned and their total length was measured in millimeters and weight in grams. All sample specimens were dissected and their gut removed by the following method.

The abdominal cavity was opened by a longitudinal mid-ventral incision. The small intestine was severed posterior to the pyloric valve, and the stomach freed by cutting through the muscular esophagus (*see figure 5*).

2.2.Sample Preparation and Preservation

Immediately after gutting, the stomachs were removed from the fish and kept to the sampling bottles were preserved in a 10% formalin solution to avoid post mortem digestion. A label bearing the date, the locality, the method, and time of capture, the species name, name of observer, and gears used was placed to the each sampling bottles.

Stomachs were weighed nearest 0.45 g were recorded. The samples were transferred from laboratory of Ministry of Fisheries and Marine Resources (Hardap) to the University of Namibia fisheries laboratory room for further analysis, (*figure 5*).

Fig.2. Indicate pulling seine net out of the water. **Fig.3**. Preparation for setting gillnet

Fig.4. Indicate sample are preserved into formalin. **Fig.5**.Researcher analyzing stomach contents.

Fig. 6: The map of Hardap Dam indicate the sites where sample are collected.

Fig.7. Indicate the method used to gut the fish.

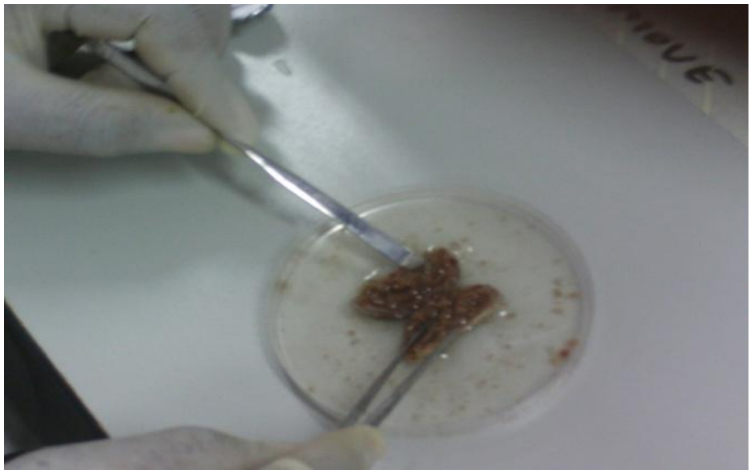

Fig. 8. Indicate stomachs were dissected and the contents were emptied into a Petri-dish.

2.3.Laboratory analyses

In the laboratory, the stomachs were leached in fresh water for a period of 12 to 24 hours to remove excess formalin. The stomachs were dissected and the contents were emptied into a Petri-dish (*figure 8*).

All of the stomach contents were carefully removed on to Petri-dish by using forceps. The contents were diluted into 40ml distilled water. The stomach contents of individuals fishes were analyzed by using a light microscope and the bimonthly data were grouped by season. A drop of the sample was taken from the bottle and put on a Haematocytometer with a volume of 0.00025mm^3 where it was observed using a light microscope at different magnifications. The numbers of individuals identified in the Haematocytometer were multiplied by 160 to correct 40ml dilution. The number of empty stomachs was also recorded. Field Guide to Zambian Fishes, Planktons and Aquaculture (Utsugi and Mazingaliwa, 2002) were used to identify the phytoplankton and zooplankton up to phylum level. The number of species or group of organisms was recorded to the data sheet (*Appendix 7).* Microphotography of the species identified was taken for reference (*figure 9,10,11 and 12*).

2.4.Data Analysis

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The qualitative and quantitative analyses of stomach contents of each specimen were done by point and percentage of frequency of occurrence methods as followed by Dewan and Shaha (1979). The percentage occurrences of each food item, expressed in terms of the number of stomachs containing a particular food item based on the total number of stomachs examined throughout the period of study, were obtained for each site.

The percentage of occurrence of a particular food item was calculated on the basis of the following formula as described by Hyslop, (1980) and Smyly, (1952).

$$\text{percentage of occurrence} = \frac{\text{Number of gut where the food occurred}}{\text{Total number of gut analyzed}} \times 100$$

To apply occurrence method all the food items eaten by the species were identified as far as possible, in most cases to the species name and phylum level. The degree of stomach fullness was determined by Lipinski and Linkowski, (1988) and classification as follows: 0 = empty stomach, 1 = traces of food, 2 = less than half filled, 3 = more than half filled and 4 = full.

The gut contents analyses of *Oreochromis mossambicus* were performed by two methods namely frequency of occurrence method and index of fullness method. It is well known that no single method is adequate for analysis of stomach contents of food.

2.5.Food composition

Determination of food composition included species identification, if possible, and counting of stomachs. The percentage composition of food items was calculated as the number of an item in all stomachs, divided by the number of all food items for the particular length-group of fish (e.g. Hynes 1950, Alkholy & Abdel-Malek 1972).

The stomach fullness index.

Stomach fullness index was calculated as follows:

$$\text{Stomach Index (SI)} = \frac{\text{Weight of stomach (g)}}{\text{Weight of fish (g)}} \times 100$$

Since it is difficult to obtain weight or volume of minute food items separately, this index is used on the basis of weight, for comparing feeding activities and diet overlap according to variation in size class of fish or month.

2.6.Statistical analysis

The collected data are computed into Excel and import in STATISTICAL 9 software statistical package for analysis. Data on stomach weight and total amount of food item found in stomach were subjected to t-test for comparison of independent mean, following Snedecor and Cochran (1982). Significance was assigned at $P < 0.05$ confidence level.

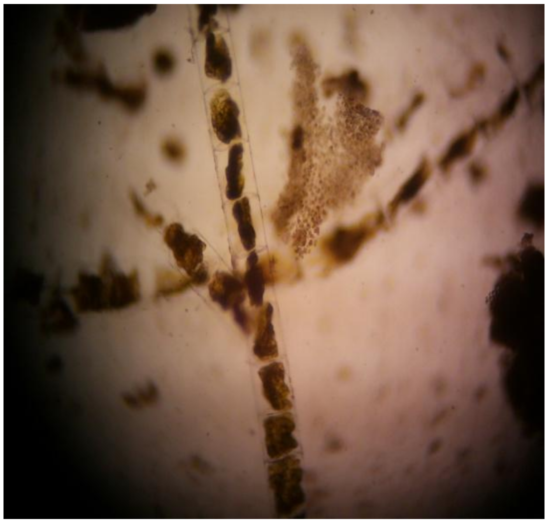

Fig. 9. *Anabaena smithii* and *Microcystic.*

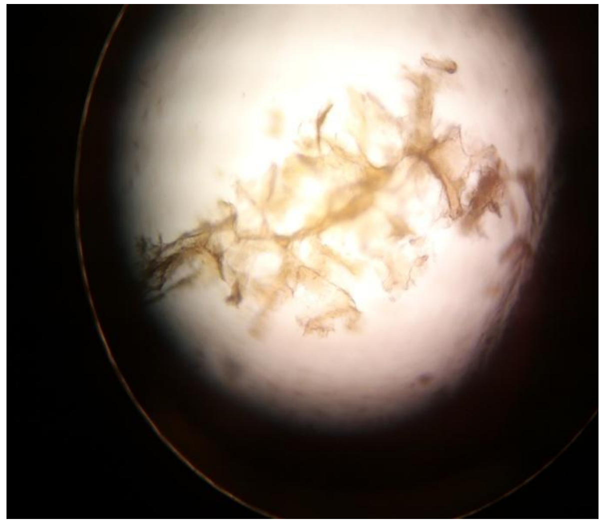

Fig.10.*Pediastrum duplex*

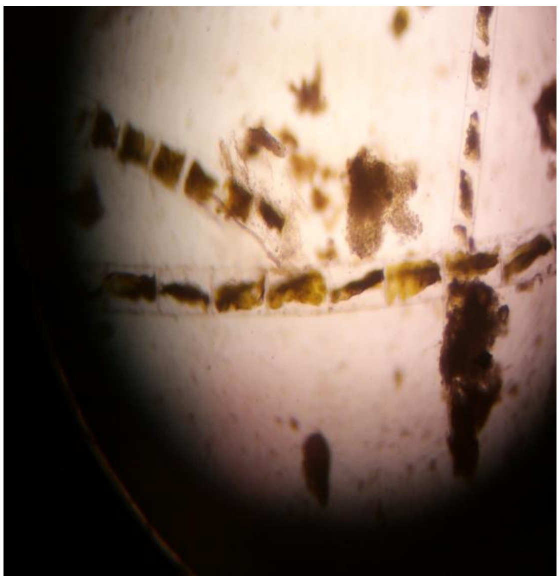

Fig.11.*Synedra* and *Quadricoccus species.*

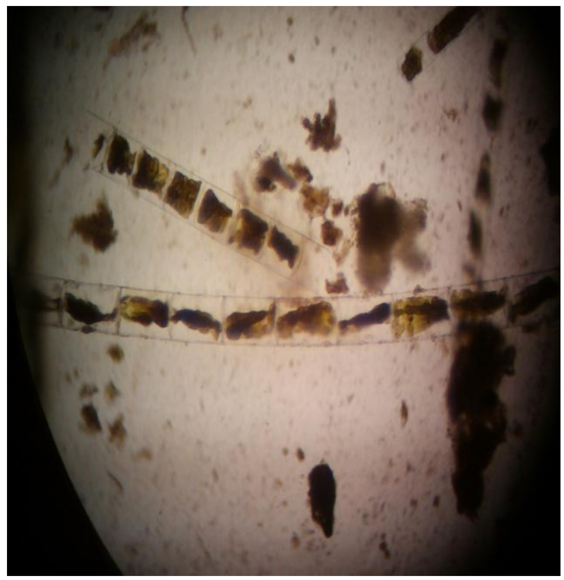

Fig.12.*Synedra* and *Euglena species*

3.0.RESULTS

Average size of all O.mossambicus ranged between 7.3 to 45 cm. The gut contents analysis of fishes from each size showed that the fish feed on a variety food items. Main dietary organisms identified from stomach analyzed included Crustacea (*Cydrorus, Ceriodaphnia, Simocephalus, and Moina*); Copepods (*Cyclops*), Cynobacteria (*Anabaena, Novacekii, Aeruginosa, Euglena, Phacus, Trachelomonas, Distigma),* diatoms (*Synedra and cyclotella*), Green algae (*Carteria, Closterium, Quadricoccus, Sphaerocystis, Dictyosphaerium, Chorella, Makinoella, Micractinium, Coelastrum, Golenkinia, Sphaeroplea, Pediastrum duplex, Simplex and Cosmarium)*; and others which include unidentified items.

All these food organisms were categorized into seven main food groups e.g. Crustacea, Copepods, Cynobacteria, Diatoms, Green algae, Detritus and others (semi digested unidentifiable parts of plants and detritus). Amongst these food groups, green algae was the most dominant food item both by percentage of total points (0.5494) and percentage of occurrence (86.11%).The next preferred food items were diatoms and cynobacteria (blue-green algae). But the percentage occurrence of cynobacteria (73.61%) was found to be the most dominant, food group which was closely followed by diatoms (72.22%), copepods (11.11%) and Crustacea which was account about (8.3%). Examination of the diet of *O. mossambicus* showed that, there was low percentage of detritus and sand particles occurred in its stomach, which compressed about (0.0650) total points and percentage occurrence (41.67%) respectively.

Regarding percentage occurrence of different food items in the guts of *O. mossambicus*, (Fig.1) shows that a high percentage of occurrence of green algae were recorded during both sampling period (0.5494 and 86.11%, respectively). Diatoms were represented mainly by *Synedra spp* were recorded percentage of occurrence 72.22% respectively. Green algae were represented in fish attainted its highest occurrence during research period and formed about (0.5494) total points and 86.11%, respectively.

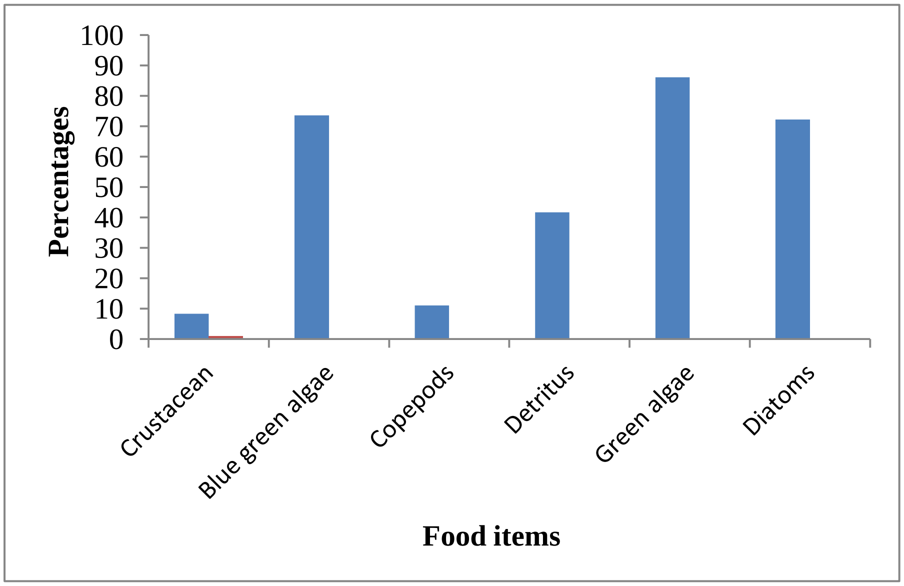

Figure.13.Monthly occurrence of food items of *Oreochromis mossambicus* in Hardap Dam by percentage occurrence method.

According to the percentage occurrence methods, green algae, blue green algae and diatoms formed the most important diet (86.11, 73.61 and 72.22%, respectively). Monthly variation of different food items showed that, green algae formed the most important food items of plant origin during the monthly as shown in **Fig. 1**.

Table 1 : Summary of overall mean of food items found in stomachs content.

Classes	September	October	Minimum	Maximum	Mean
Green algae	21915	19954	1600	73120	20650
Blue-green algae	16480	4819.39	160	123840	9220
Diatoms	7923.81	2255.48	160	8960	3282
Copepods	480	240	160	960	420
Crustacean	533.33	160	160	800	346.7
Detritus	1828.57	18730	160	96000	10843

3.1.Copepods

The abundance of copepod analyzed to the stomachs content in *O. mossambicus* were ranged between 160 to 960 from September with mean of (480 ± 303.6) to October period (240 ± 113.1). **Appendex No. 1** . The statical analysis shows that there are no significant decreases in copeponds fed upon by *O. mosaambicus* (n = 8, P = 0.3354). The mean Copepods concetration recorded was 420 during the sampling . This result indicate that there are positve correlation between amount of copepods in the stomach and fish weight (r^2 = 0.905), this due to copepods become active,it made hard for smaller fish to feed them and only adult fish can manage to feed copepods for higher amount.

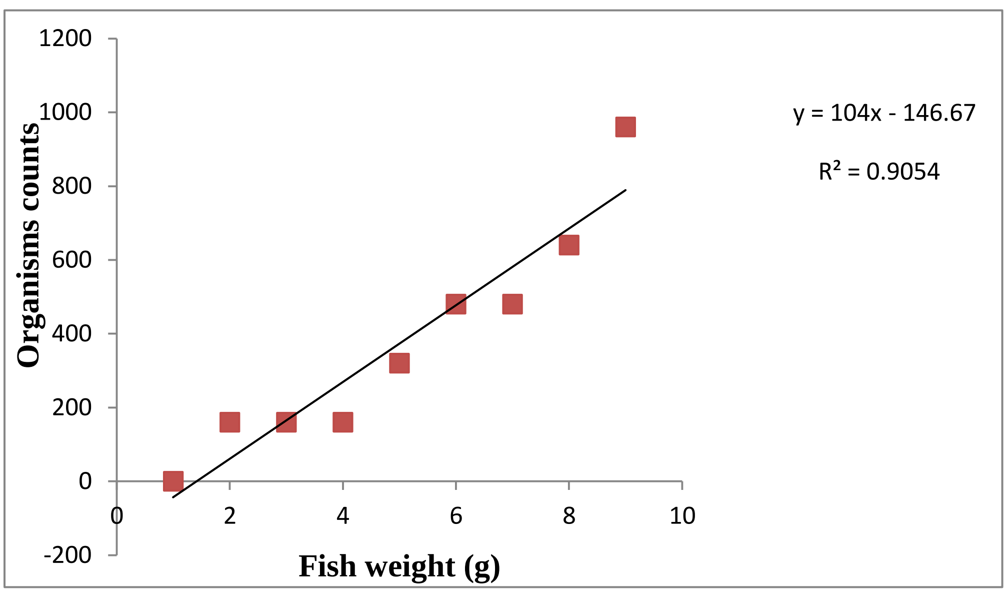

Figure 14: Monthly variation of copepod examine to the stomach content *Oreochromis mossambicus* in Hardap Dam.

3.2.Crustacea

The abundance of crustacea analyzed to the stomachs content in *O. mossambicus* were ranged between 160 to 800 from September with mean of (533.3 ± 333.0666) to October period (160 ± 0.00). **Appendex No. 2** . The statical analysis shows that there are no significant decreases in copeponds fed upon by *O. mosaambicus* ($n = 6$, $P = 0.124$). The highest mean crustacea concetration was recorded in September was 346.7 during the sampling. This result indicate that there are negative correlation between amount of crustacea in the stomach and fish weight($r^2 = 0.151$) , this is due to small fish is prefering crustacea food and eating high amount than adult fish, although it was found into adult fish.

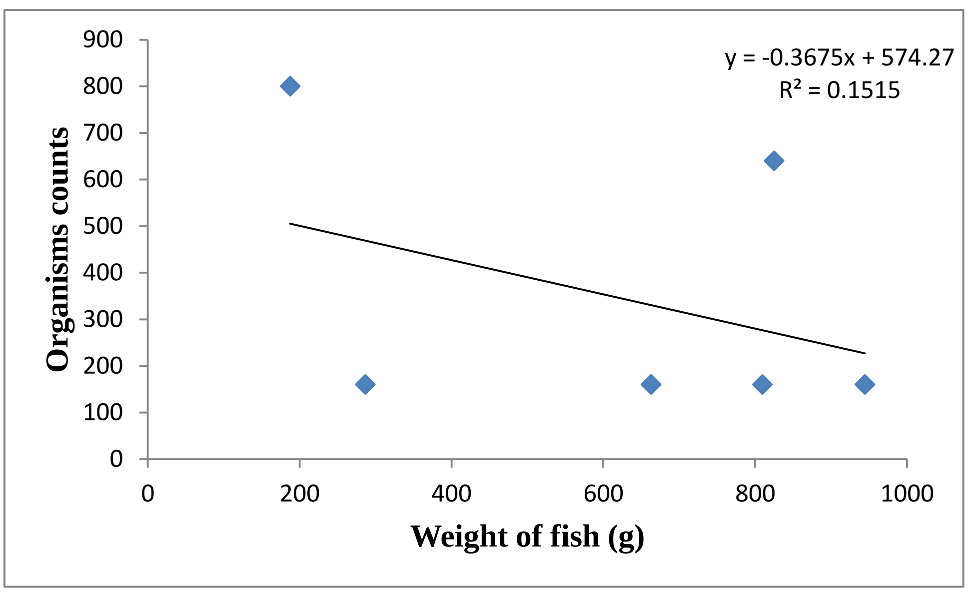

Figure 15: Monthly variation of crustacea examine to the stomach content *Oreochromis mossambicus* in Hardap Dam.

3.3.Blue green algae

The abundance of blue green algae analyzed to the stomachs content in *O. mossambicus* were ranged between 160 to 12640 from September with mean of (16480 ± 30250.18) to October period (4819.394 ± 4481.385). **Appendex No. 3** . The statical analysis shows that there was significant decreases in blue green algae fed upon by *O. mosaambicus* (n = 44, P = 0.0332). The mean blue green algae concetration recorded was 9220 during the sampling. This result indicate that there are negative correlation between amount of detritus in the stomach and fish weight (r^2 = 0.019), this is due to small fish is prefering detritus food and eating high amount than adult fish, although it was found into adult fish.

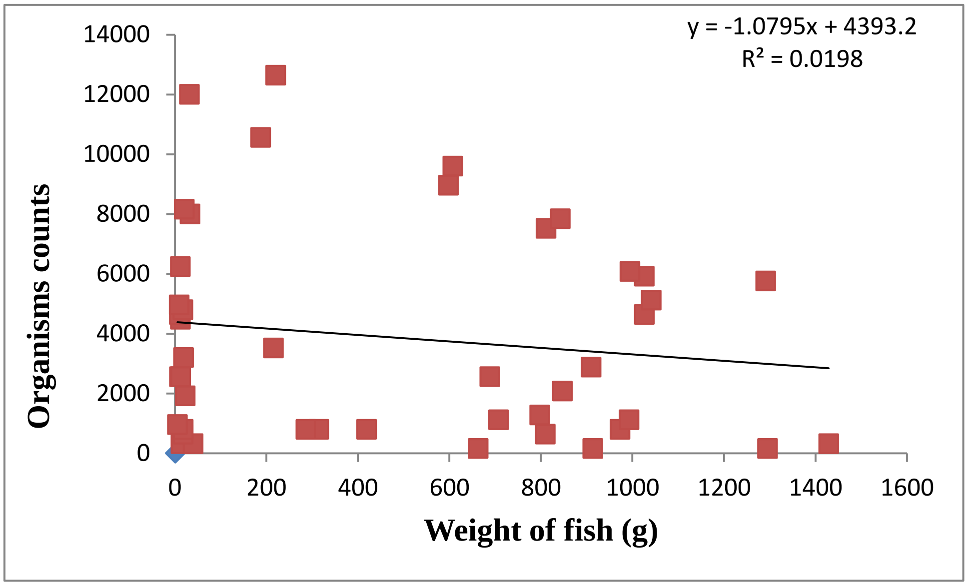

Figure 16: Monthly variation of Blue-green algae examine to the stomach content *Oreochromis mossambicus* in Hardap Dam.

3.4.Green algae

The abundance of Green algae analyzed to the stomachs content in *O. mossambicus* were ranged between 1600 to 34720 from September with mean of (21915 ± 18996.05) to October priod (19954 ± 10163.47) **Appendex No. 4** . T The statical analysis shows that there are no significant decreases in green algae fed upon by *O. mosaambicus* (n = 56, P = 0.597). The mean green algae concetration recorded was 20650 during the sampling. This result indicate that there are slight negative correlation between amount of green algae in the stomach and fish weight (r^2 =

0.005), this is due to small fish is prefering green algae food and eating high amount than adult fish where the consuption of green algae were decreased, although it was found into adult fish.

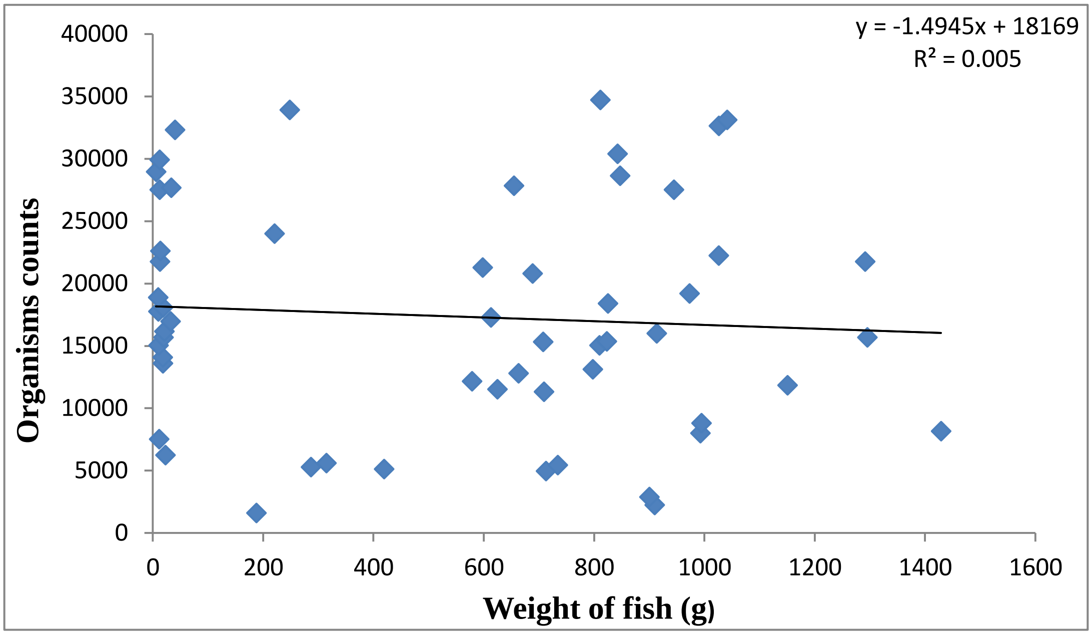

Figure 17: Monthly variation of Green algae examine to the stomach content *Oreochromis mossambicus* in Hardap Dam.

3.5.Diatoms

The abundance of diatom analyzed to the stomachs content in *O. mossambicus* were ranged between 160 to 8960 from September with mean of (7923.81± 9995.02) to October period (2255.48 ± 2861.08). **Appendex No. 5** . The statical analysis shows that there are was significant decreases in diatom fed upon by *O. mosaambicus* (n = 46, P = 0.0043). The highest mean diatom concetration was recorded in September was 7923.81 during the sampling . This result indicate that there are positve correlation between amount of diatom in the stomach and fish weight (r^2 = 0.846), this is due to adult fish can fed higher amount diatom than the smaller fish.

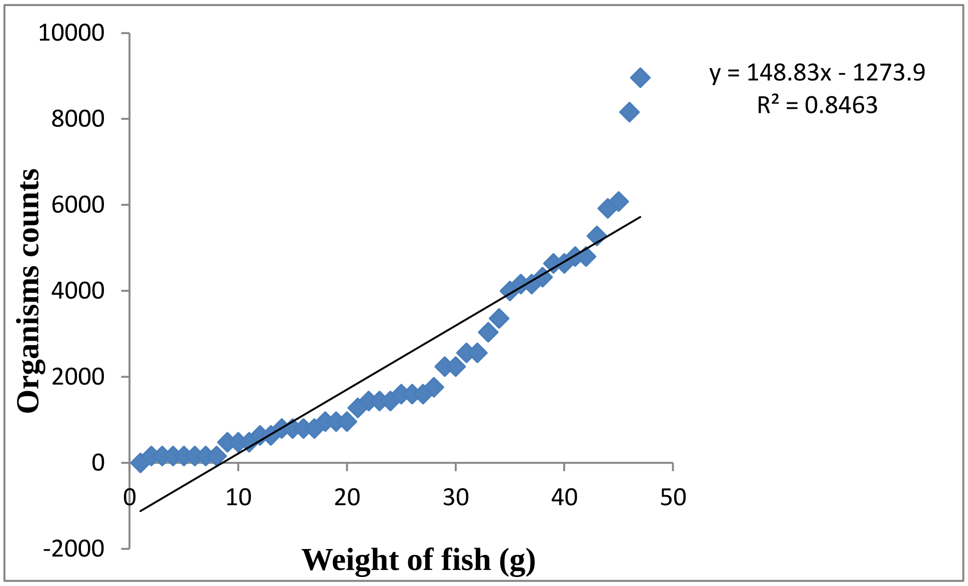

Figure 18: Monthly variation of Diatoms examine to the stomach content *Oreochromis mossambicus* in Hardap Dam.

3.6.Detritus

The abundance of detritus analyzed to the stomachs content in *O. mossambicus* were ranged between 160 to 1760 from September with mean of (1828.57 ± 2387.84) to October period (18730 ± 28971.08). **Appendex No. 6** . The statical analysis shows that there was significant decreases in detritus fed upon by *O. mosaambicus* (n = 18, P = 0.0385). The mean detritus concetration recorded was 10843 during the sampling. This result indicate that there are negative correlation between amount of detritus in the stomach and fish weight (r^2 = 0.013), this is due to small fish is prefering detritus food and eating high amount than adult fish, although it was found into adult fish.

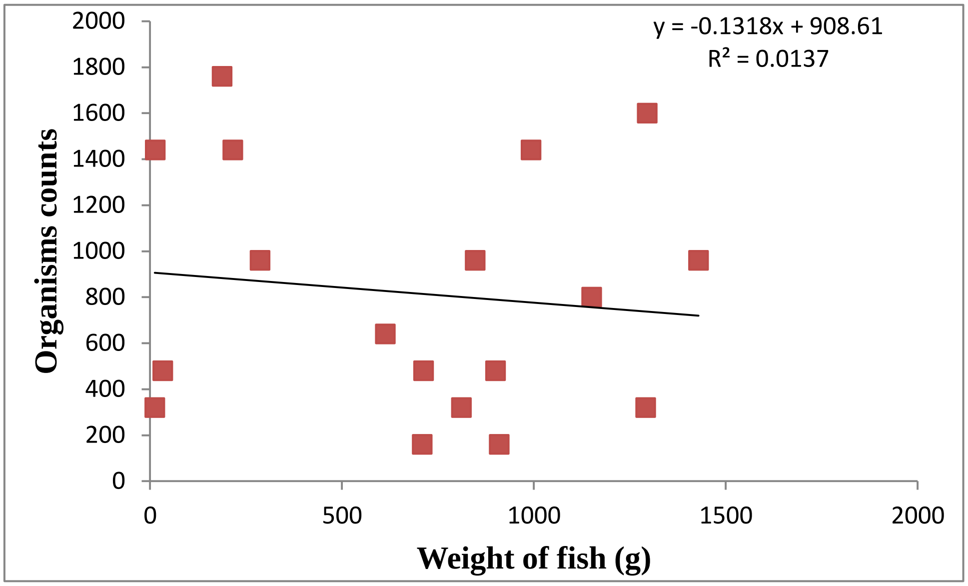

Figure 19: Monthly variation of Detritus examine to the stomach content *Oreochromis mossambicus* in Hardap Dam.

Animal derivatives were the preferable food of animal origin during September and October. Generally, results of the two methods of analysis emphasized the importance of plant as a major food resource in the stomach of *Oreochromis mossambicus* and foods of animal origin were observed on some occasions and these were mainly copepods and animal derivatives.

Table 2: Mean variation in gut fullness of *Oreochromis mossambicus* in Hardap Dam.

State of gut	September	October
Full	1.68	6.86
More than half filled	2.67	22.83
Less than half filled	19.08	15.43
Trace of food	1.99	2.83
Empty	9.61	12.17

Regarding the monthly variation in the feeding intensity as an index of the stomach fullness, it could be stated that the maximum number of empty stomachs was recorded during the period of September and October (mean 9.61 and 12.17, respectively) as shown in Table 1.

Table 3: Monthly variations in the amount of food taken by *Oreochromis mossambicus* in Hardap Dam based on average index of fullness.

		Items		
Months	**No. of fish examine**	**No. of stomach with food**	**Empty stomach**	**Av. Index of fullness**
September	26	21	5	4.67
October	46	42	4	1.67

The monthly variations in the amount of food taken by *O. mossambicus* based on average index of fullness in **Table 3** showed that during the period of September the fish start minimize the feeding rate, due to pre-spawning period. The result of the study of the monthly variation of food and feeding patterns of fishes observed that during September period it is attained the highest average of fullness (4.67) whereas the lowest was recorded during October was (1.67).

Table 4: Diet composition of *Oreochromis mossambicus* based on percentage of occurrence and percentage of total points.

	Food Groups					
Items	**Crustacean**	**Copepods**	**Blue green algae**	**Diatoms**	**Green algae**	**Detritus**
No. of fish in which occurred	6	8	53	52	62	30
Percentage of occurred	8.3%	11.11%	73.61%	72.22%	86.11%	41.67%
Percentage of total point	2.83%	3.79%	25.12%	24.65%	29.39%	14.22%

All the food groups showed considerable monthly variations in the diet composition of the fish (Table: 4). Among all the food groups green algae was found to be the most dominant food item by percentage of total points per fish in most of the months. Next to green algae, blue-green algae, diatoms, detritus, Copepods, arthropods and Aschelminthes occupied the successive position by percentage of total point per fish. Comparatively greater amount of green algae was found to occur during September and October months whereas diatoms and blue-green algae was found to be most dominant during September months in the gut contents of the fish. The food groups such as copepods, arthropods and detritus were recorded mostly in the gut contents of mature and some immature fishes.

4.0.DISCUSION

The monthly variation in the type and quantity of food consumed suggest that the diet of *Oreochromis mossambicus* is related to food availability. Within this food availability, there are indications of food selection. Since green algae and blue-green algae are abundant in the stomach content during September and October sampling period.

The food items in the stomach of *O. mossambicus* suggest that they are euryphagous (i.e. feeding on a wide range of organisms). It was also observed that *O.mossambicus* can be categorized either as an omnivorous or herbivorous feeder as the diet covers a wide spectrum of food ranging from various types of plankton to invertebrates and plants (Maughan *et al*.,2007). The fish also exhibits an overlapping in food and feeding habits in order to avoid inter and intra specific competition for available food.

The study of the tropic ecology is useful and fundamental to understand the functional role of the fish within their ecosystems Gharib and Abdel-Aziz, (2007). Analysis of stomach contents of *O. mossambicus* during the study showed the presence of three algal groups and diatoms was the most preferable food of plant origin where it occurred in more than 73.61% of the examined fish.

Investigation of Mohamed (2005), found that the phytoplankton assemblage of the freshwater lakes consists of 138 species belonging to seven classes. Chlorophyceae, Bacillariophyceae and Cyanophyceae represented the three main classes in lakes, diatoms was the second important predominant phytoplankton group and it attained its maximum occurrence during winter season, while the result from experiment was done in Hardap dam during September and October period to determine food and feeding habit in *O.mossambicus* where the result indicate that green algae was dominant with percentage occurrence 86.11% followed with blue-green algae percentage occurrence 73.61% respectively.

Getabu, (1994), pointed out that the diatoms is the most important food item than any food items in the gut of *O.niloticus* in Nyanza Gulf Lake Victoria. Copepods and crustacean were observed as the prefer food of animal origin whereas, it contributed percentage of occurrence about

11.11% and 8.3% of the examined fish. According to Getachew and Fernando, (2004) pointed out that animal foods were observed on the guts of *O. niloticus* on rare occasions and these were mainly rotifers. So, analysis of stomach contents of *O. mossambicus* in this study showed good relation with the ambient plankton, where all species found in the stomach of this fish were previously recorded in the water of Hardap dam. Results of the two methods of analysis emphasized the importance of live aquatic and submerged terrestrial plants, benthic algae, phytoplankton, periphyton (algae attached to plants), zooplankton, and organic detritus as a major food resource in the stomach of Mozambique tilapia, which agrees with (Hofstede & Botke, 1950; Pannikar & Tampi, 1954; Man & Hodgkiss, 1977; Bowen., 1978, 79, 80a, 81; Aravindan, 1980; Dudgeon, 1983; De Silva *et al.*, 1984; De Silva, 1985; Dickman & Nanne, 1987; Blühdorn *et al.,* 1990; Milward and Webb, 1990; Webb, 1994; Kim *et al.* 2002).

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Examination of the diet composition of *O. mossambicus* species showed that there was high total point percentage of green algae and blue-green algae occurred in its stomach during, both September and October comprising percentage total point about 29.39 and 25.12%, respectively. In live aquatic species showed that there were recorded total percentage of copepods and crustacean occurred in stomach content during September and October comprising percentage total point about (3.79 and 2.83% respectively) followed by diatoms and detritus where accounted about 24.65 and 14.22% respectively.

It is important to emphasize that the effect of seasonality should always be considered in the studies on natural feeding of fish, because the temporal changes of biotic and abiotic factors alters the structure of the food web along the year and as a consequence, the fish often shows seasonal diet shifts (Wotton, 1992). During this study the maximum number of empty stomach was recorded during September and October (mean 9.61 and 12.17 respectively), this period of poor feeding activity coincided with the spawning season of *O. mossambicus* in Hardap dam. So these results may be interpreted in light of the abdominal cavity is fully occupied by the ripe gonads and so stomachs were always empty during these season.

Furthermore Joadder, (2007) mentioned that the period of poor feeding activity is coincided with the peak of spawning season because the abdominal cavity is fully occupied by the voluminous ripe gonads and so the stomachs were always empty and small in size. The recorded monthly variations in the mean weight of content in collected fish samples revealed that October attained the highest mean weight of content(11.33 g) while the lowest value was observed during September and it was recorded (5.56 g). These results coincide with that of variation in gut fullness in this study. Changes in mean weight of stomach contents through the month or year indicate differences in feeding intensity (Man and Hodgkiss, 1977). *Oreochromis* species was found to be an omnivorous opportunistic-generalist benthophagic browser or surface grazer (Vaas and Hofstede, 1952; Le Roux, 1956; Bowen, 1976; Bowen & Allanson, 1982; Lahser, 967 and FAO, 2004). The feeding habits in this study were similar to those reported by (Oso, Ayodele and Fagbuaro, 2006) in a Tropical Reservoir, Nigeria on *O. niloticus, O.mossambicus* and *S. galilaeus* (L.).

4.1.CONCLUSION

This study provides information on food and feeding habits of Mozambique tilapia (*Oreochromis mossambicus*) in Hardap dam. In conclusion, the results of this study indicated that the major food or diet of *O. mossambicus* in Hardap dam were dominated by blue-green algae, detritus, diatoms, copepods, green algae and crustacean and a changing feeding strategy in response to prey availability in the environment. So the ability to exploit different varieties of food items makes *O. mossambicus* to be classified as herbivorous or omnivorous. From the above findings it can be concluded that the different food groups varied monthly in their abundance in the gut contents of the fish where it showed some seasonal preference to certain food groups. The adult fish preferred to feed copepods, diatoms, detritus, green algae and crustaceans where the immature fish preferred to feed on crustacean, detritus, green algae and blue green algae.

The average index of fullness were found to be higher in September (4.67) than those the found in October (1.67). Future work must investigate the presence of food and feeding habits in water column fish species including time (day and night) and seasonally such as winter, spring and summer period where it can give good result and indicate which group of food are most preference.

4.2.REFERENCES

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4.3.APPENDENCES

Appendex. 1.

Variable	**T-test:** Grouping; Month (Spreadsheet 12) Group 1 : October Group 2: September									
	Mean October	Mean September	t-value	d.f	p-value	Valid N October	Valid N September	Std. Dev. October	Std. Dev. September	F-ratio Variance	P Variance
Copepods	240.000	480.000	-1.04623	6	0.33576	2	6	113.1371	303.5787	7.20000	0.550672

Appendix. 2.

Variable	**T-test:** Grouping; Month (Spreadsheet 8) Group 1 : October Group 2: September										
	Mean October	Mean September	t-value	d.f	p-value	Valid N October	Valid N September	Std. Dev. October	Std. Dev. September	F-ratio Variance	P Variance
Crustacean	160.000	533.333	-1.941	4	0.12417	3	3	0.000	333.0666	0.00	1.000

Appendix. 3.

Variable	**T-test:** Grouping; Month (Spreadsheet 10) Group 1 : October Group 2: September									
	Mean October	Mean September	t-value	d.f	p-value	Valid N October	Valid N September	Std. Dev. October	Std. Dev. September	F-ratio Variance	P Variance
Blue-green algae	4819.394	16480.00	-2.188	51	0.0332	33	20	4481.385	30250.18	45.56500	0.000

Appendix. 4.

Variable	**T-test:** Grouping; Month (Spreadsheet 19) Group 1 : October Group 2: September										
	Mean October	Mean September	t-value	d.f	p-value	Valid N October	Valid N September	Std. Dev. October	Std. Dev. September	F-ratio Variance	P Variance
Green algae	19954.00	21915.00	-0.531	60	0.597248	40	22	10163.47	18996.05	3.493350	0.000720

Appendix. 5.

Variable	**T-test:** Grouping; Month (Spreadsheet 12) Group 1 : October Group 2: September										
	Mean October	Mean September	t-value	d.f	p-value	Valid N October	Valid N September	Std. Dev. October	Std. Dev. September	F-ratio Variance	P Variance
Diatoms	2255.484	7923.810	-2.994	50	0.004272	31	21	2861.080	9995.022	12.20415	0.0000

Appendix. 6.

Variable	**T-test:** Grouping; Month (Spreadsheet 12) Group 1 : October Group 2: September										
	Mean October	Mean September	t-value	d.f	p-value	Valid N October	Valid N September	Std. Dev. October	Std. Dev. September	F-ratio Variance	P Variance
Detritus	18730.00	1828.571	2.171605	28	0.038512	16	14	28971.08	2387.837	147.2041	0.0000

Appendix. 7.

Sample No.	Months	TotalWeight	Total Length	Blue green algae	Green algae	Diatoms	Detritus	Crustacean	Copepods
1	september	187.59	22	10560	1600	800	1760	800	640
2	september	314.5	25	800	5600	3360	8160	0	160
3	september	228	22	0	0	0	0	0	0
4	september	248	23.5	18240	33920	8960	0	0	0
5	september	286.5	24.5	800	5280	960	960	160	160
6	september	1295.3	41.5	160	15680	0	1600	0	960
7	september	909.7	38	2880	2240	640	160	0	0
8	september	712.6	33	19040	4960	13920	480	0	0
9	september	220.5	25	12640	24000	4000	0	0	0
10	september	215.5	23.5	3520	54720	14080	1440	0	0
11	september	218.5	25.5	74720	73120	23360	6400	0	0
12	september	772	34	14720	52320	24640	0	0	0
13	september	825	35	123840	18400	5920	0	640	480
14	september	1291.3	37	5760	21760	39040	320	0	480
15	september	847	42	2080	28640	1600	960	0	0
16	september	1429	45	320	8160	1760	960	0	0
17	september	33.2	13	8000	27680	2240	0	0	0
18	september	33	13	23680	37120	4800	480	0	0
19	september	28.1	12.5	0	0	0	0	0	0
20	september	10.1	9	2560	15040	4160	0	0	0
21	september	13.1	9	0	0	0	0	0	0
22	september	9.5	8.5	4960	18880	5280	0	0	0
23	september	9.1	8	0	0	0	0	0	0

24	september	11.2	8.7	0	7520	960	0	0	0
25	september	13.4	9.5	320	22610	4640	1440	0	0
26	september	8.9	8	0	0	0	0	0	0
27	september	900.1	36	0	2880	1280	480	0	0
28	October	1025.9	39	5920	22240	4800	4800	0	0
29	October	1026.1	39	4640	32640	13280	0	0	0
30	October	972.9	37.8	800	19200	4320	0	0	0
31	October	624.6	32.5	0	11520	2560	0	0	0
32	October	688.4	33	2560	20800	1600	9600	0	0
33	October	607.6	37.5	9600	37760	8160	0	0	320
34	October	597.9	31	8960	21280	3040	0	0	0
35	October	1150.6	39.5	0	11840	4640	800	0	0
36	October	944.6	36.3	13440	27520	2240	0	160	0
37	October	662.9	33	160	12800	480	0	160	0
38	October	994.6	37	6080	8800	1440	0	0	0
39	October	734	34.5	0	5440	1440	0	0	0
40	October	709	34.5	0	11320	1440	160	0	0
41	October	669.9	33	0	0	0	0	0	0
42	October	1041.1	39	5120	33120	800	0	0	0
43	October	809.6	36	640	15040	1600	0	160	0
44	October	992.6	38.5	1120	8000	640	1440	0	0
45	October	842.4	37.5	7840	30400	800	0	0	0
46	October	654.6	33	16320	27840	2560	0	0	0
47	October	822.9	35.5	0	15360	800	0	0	0
48	October	419.1	31	800	5120	160	0	0	0
49	October	707.5	33.5	1120	15320	160	0	0	0
50	October	578.6	32.2	0	12160	160	48000	0	0
51	October	913.4	35.5	160	16000	160	6400	0	0
52	October	819.9	36	0	0	0	0	0	0

53	October	811.2	36	7520	34720	6080	320	0	0
54	October	880.5	37.2	0	0	0	0	0	0
55	October	797.5	35.5	1280	13120	160	64000	0	0
56	October	274.1	24.2	14240	52480	4160	48000	0	160
57	October	612.9	23	0	17280	160	640	0	0
58	October	40	13.5	320	32320	0	0	0	0
59	October	22.7	11.2	1920	6240	0	0	0	0
60	October	31.9	12.4	12000	16960	0	6880	0	0
61	October	20.7	11	8160	16160	0	0	0	0
62	October	16	10	0	0	0	0	0	0
63	October	18.1	10.6	640	13600	480	0	0	0
64	October	17.7	10.2	4800	14080	0	96000	0	0
65	October	18.3	10.5	800	18080	0	0	0	0
66	October	19.1	10.6	3200	15680	0	0	0	0
67	October	12.1	10.2	6240	29920	0	5920	0	0
68	October	9.8	8.5	4640	17760	160	0	0	0
69	October	6.4	7.5	0	0	0	0	0	0
70	October	5.7	7.3	960	28960	960	0	0	0
71	October	12.2	9	4480	27520	480	320	0	0
72	October	12.7	9.5	2560	21760	0	6400	0	0

Appendex. 8.

FishNumber	month	Total Weight	Total Length	StomacWeight	
1	september	187.59	22	5.5	full
2	september	314.5	25	1.5	empty
3	september	228	22	1.5	empty
4	september	248	23.5	6.5	full
5	september	286.5	24.5	5.7	trace
6	september	1295.3	41.5	11.5	full
7	september	909.7	38	4	full
8	september	712.6	33	3.5	full
9	september	220.5	25	5	full
10	september	215.5	23.5	2.5	more_half
11	september	218.5	25.5	5	full
12	september	772	34	3	full
13	september	825	35	6	full
14	september	1291.3	37	6.5	more_half
15	september	847	42	1.5	empty
16	september	1429	45	1.5	empty
17	september	33.2	13	2.5	empty
18	september	33	13	1.5	more_half
19	september	28.1	12.5	2.5	empty
20	september	10.1	9	3.5	empty
21	september	13.1	9	2.5	less_half
22	september	9.5	8.5	1.5	empty
23	september	9.1	8	1	empty
24	september	11.2	8.7	0.5	more_half
25	september	13.4	9.5	0.5	full
26	september	8.9	8	1.5	empty
27	october	900.1	36	8.3	full
28	october	1025.9	39	9.6	full
29	october	1026.1	39	9.8	full
30	october	972.9	37.8	10.2	trace
31	october	624.6	32.5	5	trace
32	october	688.4	33	5.9	more_half
33	october	607.6	37.5	7	more_half
34	october	597.9	31	10.3	full
35	october	1150.6	39.5	7.9	trace
36	october	944.6	36.3	13	full
37	october	662.9	33	11.5	trace
38	october	994.6	37	9.4	full
39	october	734	34.5	9.4	trace
40	october	709	34.5	7.3	trace

41	october	669.9	33	7.5	more_half
42	october	1041.1	39	9	more_half
43	october	809.6	36	10	trace
44	october	992.6	38.5	9.2	trace
45	october	842.4	37.5	8.2	full
46	october	654.6	33	7.9	less_half
47	october	822.9	35.5	6	trace
48	october	419.1	31	7.5	trace
49	october	707.5	33.5	8.4	more_half
50	october	578.6	32.2	7.6	full
51	October	913.4	35.5	10	empty
52	october	819.9	36	7	less_half
53	october	811.2	36	9.6	empty
54	october	880.5	37.2	7	trace
55	october	797.5	35.5	7.1	full
56	october	274.1	24.2	8	trace
57	october	612.9	23	7	full
58	october	40	13.5	4.8	less_half
59	october	22.7	11.2	4	full
60	october	31.9	12.4	6.6	full
61	october	20.7	11	5.6	empty
62	october	16	10	4	less_half
63	0ctober	18.1	10.6	5.1	more_half
64	october	17.7	10.2	5.1	more_half
65	october	18.3	10.5	4	trace
66	october	19.1	10.6	4.9	less_half
67	october	12.1	10.2	4.8	full
68	october	9.8	8.5	4.4	empty
69	october	6.4	7.5	3.7	more_half
70	October	5.7	7.3	4.2	more_half
71	october	12.2	9	3.4	less_half
72	october	12.7	9.5	4.4	more_half