DETERMINING THE FOOD AND FEEDING HABITS OF *Labeo capensis* (Orange River Mud Fish) IN HARDAP DAM

By GETHINGS CHISULE

(200702084)

A research report in the Department of Fisheries and Aquatic Sciences submitted to the Faculty of Agriculture and Natural resources university of Namibia, partial fulfilment of the requirements for the award of the degree of bachelor of science in fisheries and aquatic science of the university of Namibia.

SUPERVISOR

Mr. Esterhuizen J. Albert

Department of fisheries and aquatic sciences

University of Namibia,

Windhoek, Namibia.

November, 2010.

ACKNOWLEDGEMENT

I would like to sincerely thank my supervisor Mr. Esterhuizen J. Albert. and the course coordinator Mr. Martin Tjpute for the supervision and direction that he gave me in making this project a success –even accompanying me and my colleague Nyandoto .J. Marwa in the field for sample collection under quiet and some difficult conditions . To the laboratory technicians Mr. Akawa and Ms. Ekanjo, not forgetting Ms Namasiku I simply say keep the spirit up. I appreciate the untiring support as we had to work even during weekends –when you were supposed to with your family.

DEDICATION

Special thanks to my wife Mrss. Eunice chisule for taking care of my son Cholwe chisule while I was away from him for four years. Thanks for your patience guys; I know it was not easy life was tough. This work was done with you in mind.

Table of Contents **Page**

ABSTRCT

Aspects of food and of feeding habits of *Labeo capensis* (Orange River Mud Fish) in the Hardap dam which is the biggest dam in Namibia. The fish belongs in the *cyprindae* family of which is a very hard fish although known for habitat destruction In general *Labeo capensis* can ingest a wide range of food including plant and animal material with detritus being the most eaten food which matches with the shape of its mouth and niche in which they exist. Also some organisms are preferred by certain size of fish for example Cephalopodella and chlorella are eaten more by the small sized fish. There was an increase in the amount of most organisms consumed from September to October. The type of feeding habits characterized by L. capensis is that of bottom feeders and with an inferior type mouth.

Key words: *Labeo capensis*, Omnivores, species, debris, *cyprinids*

1.0. INTRODUCTION

Orange River mud fish (*Labeo capensis*) is an endemic species to the Orange – Vaal system and to the sections of the Olifants river section of Western Cape in South Africa. This type of fish is usually found in running waters of large rivers but also does well in large impoundments. The Orange River mud fish is an omnivore and is known to graze on rock surfaces and on plants; the large fish can easily eat small fish, frogs and crabs Skelton (1993). According to Skelton (1993) *Labeo capensis* can attain a maximum standard length of about 50 centimeters and South Africa angling records has recorded 3.83kg.

Information that is available on *Labeo species* suggest that they could be susceptible to overfishing because of their life history which includes mass annual aggregations at river mouths and succeeding migrations up these rivers to spawn, this tends to be dependent on rainfall and other environmental conditions (Bowmaker 1973, Bayley1, Jackson & Coetzee 1982).

Also the eggs, embryos and larvae of *Labeo species* may be in danger due to strong floods which are associated with siltation, this can lead to a significant reduction in recruitment (skelton et al.1991)

1.1.Environmental preferences of *Labeo capensis*

The Orange River mud fish is a fresh water fish and the fish is originally from the western cape waters which have average minimum and maximum water temperatures of about 9^{o}C and 29^{o}C respectively (Harrison,1950). The Orange River basin and Olifants catchment area where this fish is native are part of the Zambezi Lowlander aquatic eco-region, which in nature supports high fish diversity due to the mixing of tropical and southern temperate faunas (Skelton et al., 1995). This region supports 124 fish species, most of which are cichlids, cyprinids, gobies, and mochokid catfishes (Thieme et al., 2005).

Aquaculture is the fastest growing sector of the world food trade, increasing by more than 10% per year and currently accounts for more than 30% of all fish consumed. Most farmed fish are omnivorous species, such as carp and tilapia, although farming of carnivorous species, such as salmon, is a booming industry and the number of other farmed carnivorous species is growing rapidly (Lambert and Dutil, 2001).

Fish, like any other animal, requires nutrients to grow and stay alive, healthy, and active. The study of feeding behavior in several fish species has revealed that the adjustment of feeding times to match natural rhythm improves nutritional efficiency, feeding frequency, food-conversion efficiency and can even influence the utilization of certain nutrients Gozdowska*et al*, (2003).

The culture of *Cyprinids* is an old system; it includes four different species which have varying feeding habits such as Plankton consuming, herbivorous, malacivorous and benthivorous (Salehi, 2004). After the introduction of *cyprinids* to waters of the United States it has been proven to be a nuisance to fishery managers because of its negative effects on indigenous fish, ecosystems, and water quality in wetlands and lakes (Hill, 1999). The deterioration of wetland water quality affects aquatic vegetation on which waterfowl rely on during migration. *Cyprinids* can easily adapt and despite initial theories that chilly waters would put a stop to its spread northward, it has spread throughout most of the water systems in the United States and into Canada. *Cyprinids* thrive in shallow mud-bottom lakes and large streams, avoiding rapid, rocky streams characteristic of trout streams (Eddy *et al*., 1974).

It is important to understand the diet of fish and its influence on growth, as it can be an essential factor for understanding the ecological role and the productive capacity of fish populations (Bowen, 1982). In the case where the micro -crustaceans and insect larvae are limited, cyprinids have shown that they can go back to diets of mainly detritus, including large quantities of dead macrophytes (Chapman & Fernando, 1994).

Although a number of ecological studies suggest that Cyprinids prey on fish eggs and other fish there is no confirmation about this information, according to Wegena (1912), even if cyprinids are not a strict predator, large Carp occasionally eats small fish by swallowing them whole, especially when food sources get scarce, but given their body makeup it would not be a general rule. According to Hyslop (1980) the number of organisms in a carp stomach is difficult to evaluate due to mastication of food items before they reach the area of examination. Ana and Manal (1988) observed eggs of other fish and small fish in the digestive tract of Cyprinids also Çetinkaya et al., (2006) reports that although plant based feeding rate is high in Akşehir Lake they observed 1-5 fish in the digestive tract of 17 Cyprinids and the *Chironomid* larvae were seldom seen.

According to most conservationists, fish in this family (cyprinids) are considered to be a pest because of their destructive feeding habit of grubbing through bottom sediments for food they are notorious for altering their environment by uprooting and disturbing submerged vegetation causing serious damage to native birds and fish populations and fecundity Skelton (1993). Hence it is important to study the feeding behavior of the cyprinids. An understanding of fish diet and its influence on growth can be essential for understanding the ecological role and the productive capacity of fish populations Bowen (1982), In Namibia the *Labeo capensis* is also farmed and was introduced into dams such as Hardap dam.

The *Labeo capensis* used in this study was obtained from Hardap Dam. The dam was constructed in 1962 mainly for the purpose of irrigation farming this led to the fast to the growth of Mariental town. It is the biggest dam in Namibia with a water surface area of 25sq.kms and 862 meter long dam wall. This dam blocks the waters of the Fish River which is the only river in Namibia's interior that flows just about all year round although carrying very low quantities of water during the dry season. The Fish River is connected to the Atlantic Ocean through the Orange River in South Africa. The dam provides water for irrigation, making it possible to cultivate animal fodder, as well as corn, fruits and vegetables, dairy farming is also sustained by water from the dam. The dam provides fish such as *Labeo species* which are caught by local fishermen for sustainable use (rich source of protein) and is also sold for extra income on a micro-scale. Labeo is also a sought after species for recreational angling although the economical importance of sector has not been established yet for the Hardap Dam

The name Hardap is a Nama word meaning "nipple" because of the conical shaped hills surrounding the area. Figure 1 is the aerial view of Hardap Dam while Figure 2 shows the sites where sampling by both gill netting and seine netting were done. Mariental town experience temperatures which are as high as (35°C+) daytime in summer (December to March) and it can go as cold as (0°C) during nighttime in winter (June to July), (http://www.britannica.com).

When aquaculture was discovered to be a profitable of socio economic venture to nation's world over, endeavors were made to farm *Cyprinids* in extensive system in dams such as Hardap dam in Namibia. Experimental results and observations have shown that the introduction of *cyprinids* to places where they never existed naturally has proved their ability to colonize indigenous species, “regions with either simple or relatively fragile fish communities or which are under pressure for other reasons such as over fishing or environmental modification” Welcome (1984).

Labeo capensis is known by the behavior of uprooting the vegetation, consumption of substrate organisms, in the process releasing nitrates and phosphates into the water. Turbidity increases and is further raised by planktonic algae using dissolved nutrients this speeds up the eutrophication process changing the environment to the disadvantage of indigenous clear water species (Hoffmann, 1995).

Evidence has shown that *cyprinids* prey on the eggs of other fish species (Moyle, 1976).

1.2.Why study the feeding habits of Labeo capensis

Cyprinids are among the most popular of the cultured of the fish families’ world over, therefore establishing the food type and feeding habits for this family of fish (Cyprinids) will enable the recommendation of appropriate feed for the Cyprinids and help scientists to develop a feed that uses locally available and cheap materials for the production of this species. This may also help decide which species’ of fish can be poly-cultured with *cyprinids* without problems such as habitat destruction. The fish can also be used as a food for the local people in the Hardap dam and they can sell it to nearby towns for income. The fish will may attract tourist who might come for angling competition in the end the livelihood of the people living around this dam and Namibia at large will improve.

It is essential to understand the feeding habit of any fish and its influence on the environment, as this information can be an essential factor for understanding the ecological role it play to the any water body you might need to introduce it.

1.3. AIM OF THE STUDY AND STUDY OBJECTIVES

1.4. Aim

Bearing in mind the above understanding, the present study aims at unfolding the main components of the diet of *Labeo capensis.*

1.5. Objectives

- To establish the food and feeding habits of a bottom feeding fish species, *Labeo capensis*.
- To characterize the type of food that is consumed by *Labeo capensis,* in Hardap dam.
- To establish the feeding habits characterized by *Labeo capensis* in Hardap dam.
- To establish whether food type fed by *L. capensis* is dependent on the size of fish.
- To establish if there's a shift in the diet from September to October
- To determine which food type enjoys most preference

1.6. Study hypothesis

The type of feed consumed and feeding habits of *Labeo capensis* is characteristic of bottom feeder fish.

Figure 1: bellow shows the aerial view of Hardap dam where the samples for the present experiment were collected.

Figure 1: Aerial view of Hardap Dam

2.0. MATERIALS AND METHODS

2.1. Sample collection

A 90m long gillnet made of four different mesh sized netting materials was set, using the speed boat with an out board engine on the Hardap dam in the evening at 18:30hrs on the 25 of September, 2010 and hauled the following morning at 7:00hrs the average water temperature during setting and hauling of gillnet was 15^{o}c. The total length of the fish caught ranged from 33cm to 49.5cm and 303 grams to 1250 grams of weight. One hundred and two samples of *Labeo capensis* were collected. Also on the second sampling a seine net of 30meters long was used and after seven dragging times on the 8th of October, 2010, 14 samples were collected. Immediately after collections the fish were rushed to the laboratory for identification and dissection so as to remove stomachs, this was done so rapid to avoid self digestion (autolysis) which occurs when an organism dies.

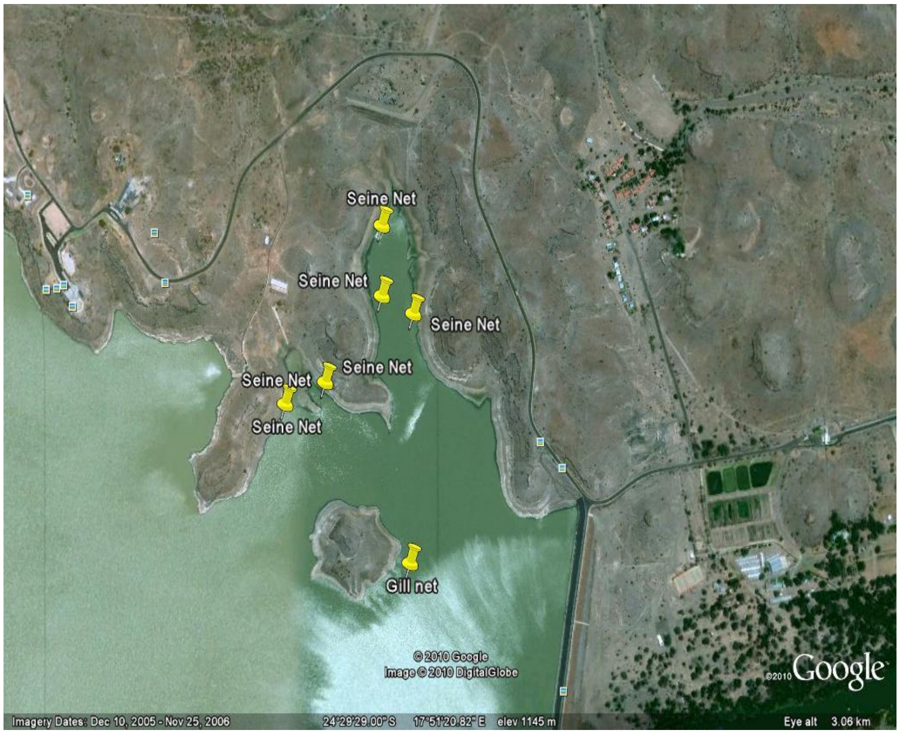

Figure 2: Map indicating sampling points

2.2. Gutting and weighing of samples in laboratory at the Ministry of Fisheries Office in Mariental

At the laboratory, the sampled fish were identified using Skelton (2003) as a taxonomic key, the standard length was in centimeters, total weight was in grams and the stomach weight was in grams was taken after gutting. The abdominal cavities were opened using the longitudinal mid ventral incision the materials used to open and dissect the samples are indicated in **appendix 1**, all the necessary information was recorded on the collection data sheet (**appendix 2**) in the laboratory at Hardap, Ministry of Fisheries and Marine Resources Office in Mariental town. Immediately the samples were rushed for dissection, so as to preserve the stomach in the 10mls of formalin containing sampling bottles. The percentage of the formalin used was ten percent (10%) concentration; this was done to avoid autolysis (Breaking down of food materials). During dissecting the samples were weighed using the Mettler Toledo electronic scale, the total length was taken by using the Measuring board, the stomach weight was taken by using the Mettler Toledo electronic scale and the stomach was put into the sampling bottles containing 10% formalin. The sampling bottles were sealed safely, labeled using tape and pencil and packed, then transported to the Fisheries and Aquatic Science laboratory of the University of Namibia.

Figure 3: Researchers setting a gill net

Figure 4: Researchers operating a seine net.

Figure 5: Researchers gutting the samples

Figure 6: Researchers fixing samples in formalin containing bottles

2.3. Fixation of Samples at the University of Namibia Fisheries laboratory

Upon arrival the samples were taken to the Fisheries laboratory for stomach content analysis. In the laboratory the procedure for stomach content analysis was done as follows: - Firstly before analyzing starts the sampling bottles containing the stomachs are opened and put into the carbon fume to get rid of formalin smell which can be toxic to researcher. There after the stomach is split open using the dissecting knife and the stomach content are washed into the jar and diluted in one hundred milliliters of water. Then two samples are taken from the one hundred milliliter jar after stirring to mix thoroughly and analyzed under a light microscope. The Haematocytometer was used to count the organisms that were identified under the microscope mega x10 using the key by Utsugi and Mazingaliwa (2002); it has three grooves with a total volume of 0.00025mm^{3}, into which the samples are filled and counted, the number of organisms found are multiplied by 400 accordingly and the planktonic organisms were identified to the lowest possible taxon level which was the phylum level in this case, whilst doing this the findings of what was available in the stomach was recorded on the sampling data sheet. The processes were repeated three times for each and every sample until all the samples were done.

Figure 7: Researchers counting the stomach contents**.**

The information collected about the samples is recorded on the data sheet on **appendix 1**.

2.4. DATA ANALYSIS

- The collected data compared into excel and imported in STATISTICAL 9 Software statistical package for analysis. Data on stomach weight and total amount of item found in stomach were subjected weight to t-test for comparison of independent mean, following Snedcor and Coohran (1982). Significance was assigned at $P < 0.05$ confidence3.

Data was also run in excel compare the relationship between length centimetre and stomach weight in grams.

2.5. Frequency occurrence of feed type

The stomach of individual *L. capensis* was cut open and removed on to petri dish with the help of forceps. The percentage of occurrence for a particular food organism was calculated on the basis of the formula bellow:

$$\%\ of\ ocurence\ of\ a\ food\ type = \frac{\text{Number of gut were the food ocured}}{\text{Total number of gut analysed}} \times 100$$

APPENDIX 7: Diet composition of *Labeo capensis* based on percentage of occurrence

3.0. RESULTS

A total number of 112 *Labeo capensis* had their gut content examined to determine their diet the size of the fish ranged from 33cm to 59 cm standard length. To determine if there's a relationship between the stomach weight and the standard length of *L. capensis* data was run in Regression and the outcome is represented on the graph bellow:

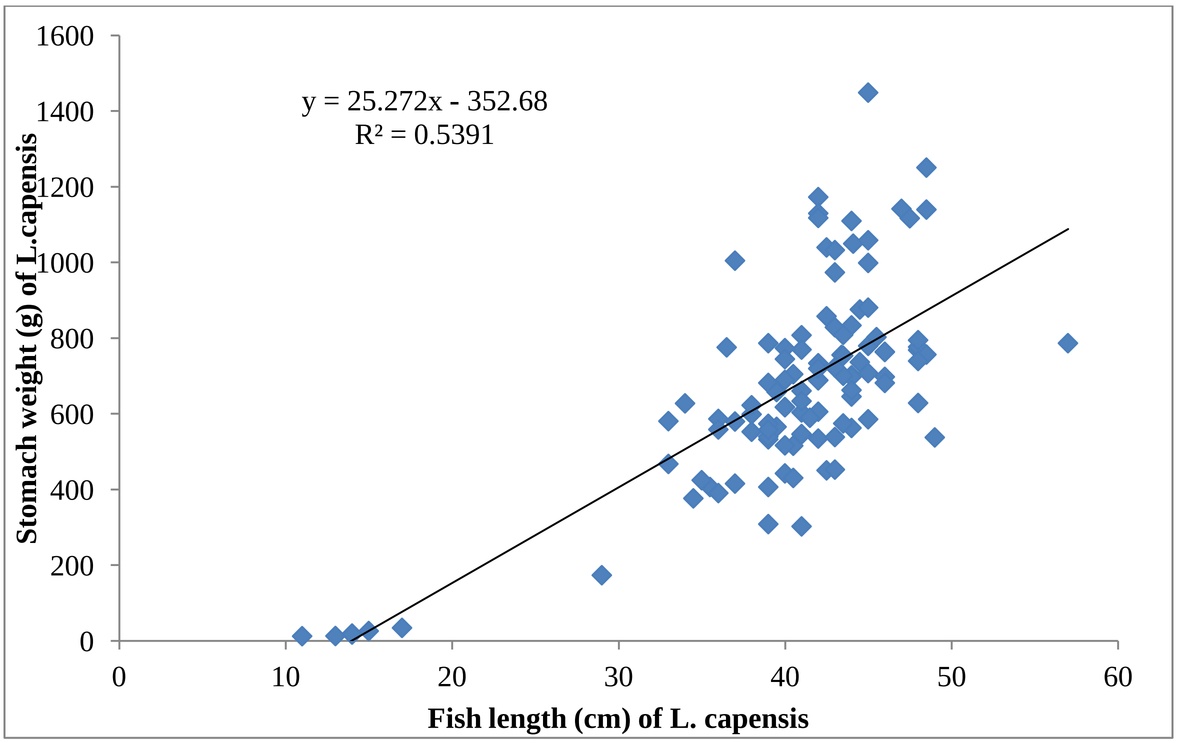

Fig 3: Relationship between fish length (cm) and stomach weight (g) of *L. capensis*.

There is a significant positive linear relationship between fish length and the stomach weight (<0.001).

The model: Stomach weight = -341.1+ 24.92 Fish length

However the fish length alone is not a good predicator of stomach content, since it only explains 53% of the total variation (R^2 coefficient of determination).

Table 1: the table bellow shows the cumulative figures band the percentage of the fish caught using the two different fishing gears and methods to catch the samples (*L. capensis*).

	frequency	percentage	Cumulative	Cumulative%
Seine net	10	8.9	10	8.9
Gill net	102	91.1	112	100.0

The two methods used to catch fish were gillnetting and seine netting. However, only a small proportion 8.9% of the fish were caught using the seine net while 91.1 % were caught using gill net, hence the method of catching the fish was not considered as an important factor in the analysis. A total of twelve dietary organisms were identified in the stomach of *Labeo capensis,*

occurrence frequency of dietary organisms are shown in table 2.The detritus were most abundant in the dietary composition followed by *Synedra species*, *Cosmarium species*, *chlorella species*, *Quadricoccus species*, *Worms*, *Sphaeroplea species*, , *Makinoella species*, *Cephalopodella spps*, *Synchaeta spps*, *Trachelomonas spps*, and *Distigma*. Interesting enough *Labeo capensis* with well developed gonads had no/little food in their stomach. Worms in the guts appeared to be fragmented and was therefore not possible to identify. All organisms which could not be identified were considered as detritus this included macrophytes brownish in color. Three quarters of the stomachs observed were less than half full and one quarter of them were empty.

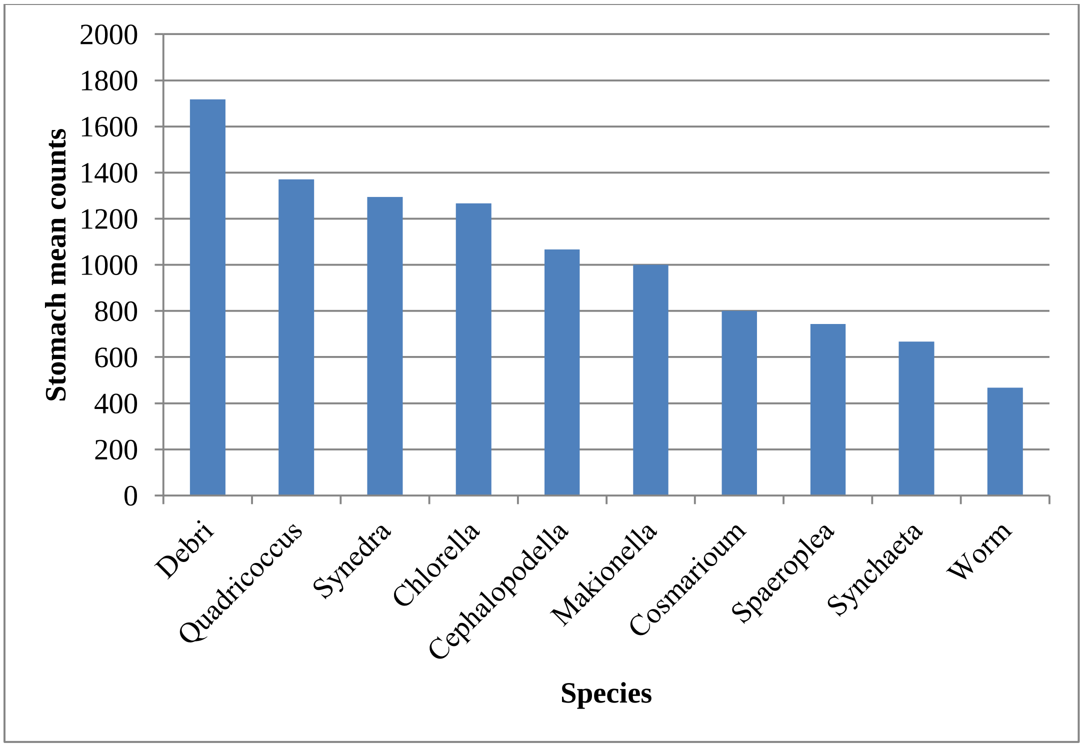

Figure 4: Frequency Distribution of the various organisms fed by *Labeo capensis* (counts Vs organisms fed by *Labeo capensis*)**.**

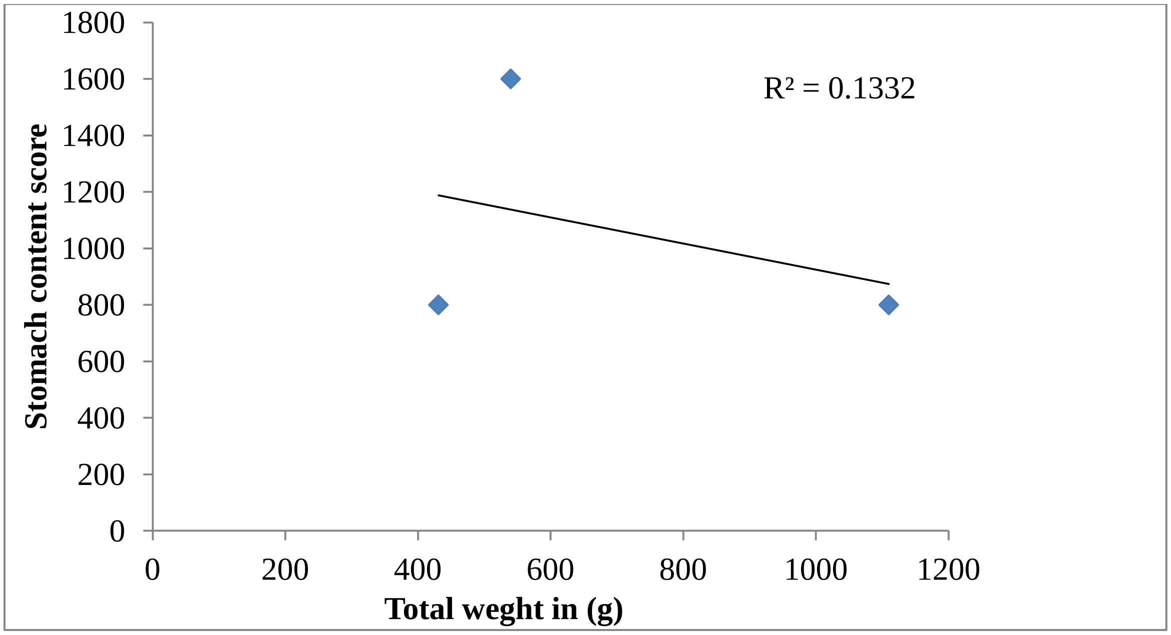

Figure 5: Relationship between fish total weight (g) and Stomach content score of *Cephalopodella species* consumed by *L. capensis***.**

Sample size of this species was very small; this was because most of the outcomes were zero. Therefore this can give us bias results. To come up with reliable information we need a bigger sample size.

There was a significant increase in the amount of debris consumed by *L. capensis* from September with mean counts 1171.429 to October mean counts 3971,429 (p = 0.00000, N for October = 14, N for September = 56) as shown in **appendix 3.**

The amount of *Sphaeroplea species* fed by *L. capensis* showed no significant difference as there was few samples and only one occurrence in October as shown on **appendix 4**. This data can mislead the interpretation (p = 0.720971, N for October = 1, N for September = 6).

There was a significance increase in the amount of *Synedra species* fed by Labeo capensis from September to October (p = 0.000000, N October 12, N September 59) as shown in **appendix 5.**

The sample size for worms (12) that is (P = 0.003094, N October = 3, N September = 9), this was therefore a very small sample size to give information about this food. To come up with proper findings there was need for a bigger sample size; most of the entries were zero function which could lead to a bias out come and therefore, was not considered. This information is shown on **appendix 6.**

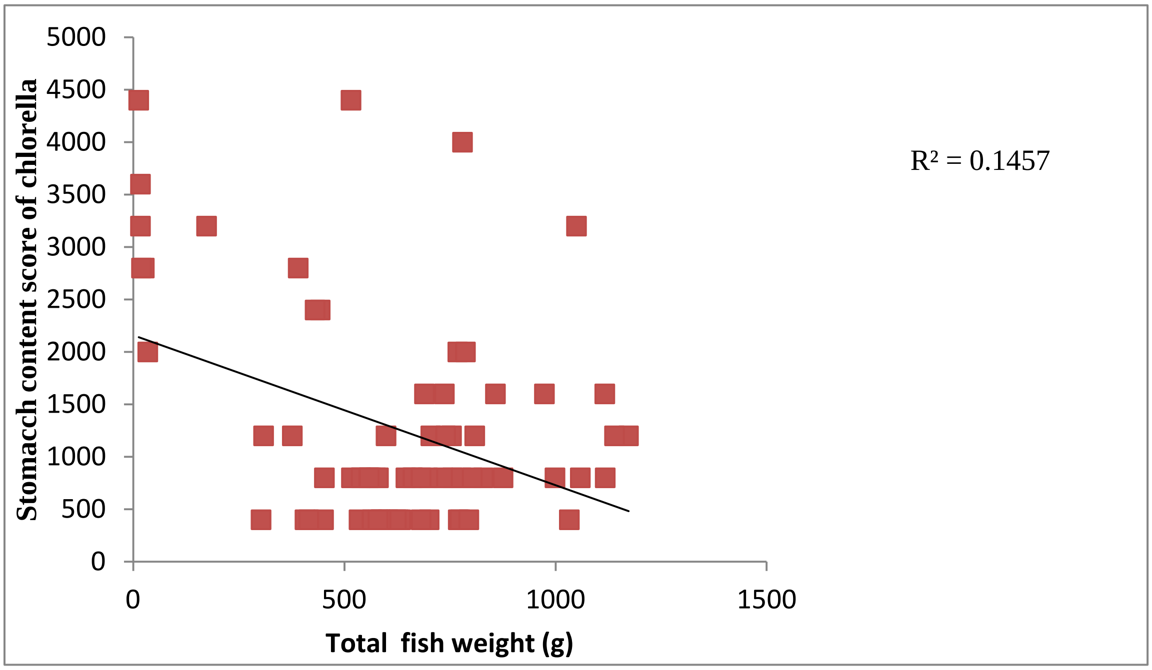

Figure 6: Relationship between fish total weight (g) and Stomach content score of *Chlorella species.*

There was a significant decrease in the amount of *chlorella species* consumed by *L. capensis* with an increase in size of the fish.

The graph bellow shows a relationship between the debris fed by the *L. capensis* and total weight of the fish. The data was fed into excel and the outcome was as shown below:

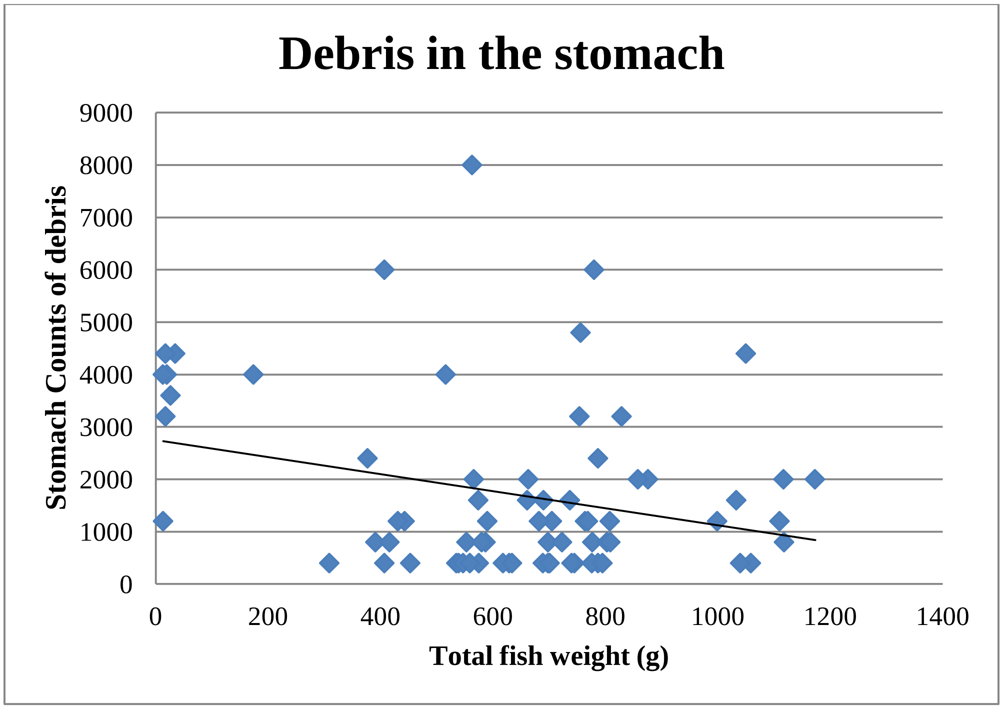

Figure 7: Relationship between fish total weight (g) and debris of *L. capensis.*

4.0. DISCUSSION

The gut contents found in the samples were a combination of invertebrates, algae, plants and unstructured debris particles mixed with mud which were too small to be separated physically for counting.

The approach of determining the frequency of occurrence is one of the most common methods towards quantitative analysis and gives valuable insights to fish diets. This method shows the type of food organisms in percentage and the food type consumed most will have the highest percentage compared to others, in this study of *L. capensis* debris had the highest percentage 27.6% followed by *Chlorella* and *Synedra* both with 27.586% as shown in **appendix 7**

Debris is commonly composed of dead plant remains and undefined organic matter; this is usually together with the associated heterotrophic and autotrophic microorganisms (Bowen, 1982). Detritivory (organisms that feed on decaying organic material of plant and animal origin) feeding habit is a common form of omnivores, since detritus originates differently throughout the trophic spectrum and does not form one consistent food source Polis and Strong (1996).The food composition of *Labeo capensis* in Hardap dam indicates the way this fish has adapted itself to the ecosystem. Therefore the dominance of detritus in the diet indicates that *Labeo capensis* is a bottom feeder, this also matches with the shape of its mouth which is an inferior type of mouth. This study also suggests that the *Labeo capensis* in Hardap dam is an omnivore's fish as both animal and plant origin food types such as worms and phytoplankton respectively were identified. Also the amount debris fed by the fish increased significantly from September to October, this could have been due to the increase in temperature from 15^{o}C to 18^{o}C respectively. The temperature of water is one of the most significant abiotic parameters that influence the metabolic process in the ectothermic aquatic invertebrates Hardewig and van Dijk (2003). Also in October there was no overcast which meant that there was enough light for photosynthesis which is a key factor to primary production. Also temperature is known to affect the functioning of flora and fauna directly by negatively or positively influencing primary production; most findings have proved that primary production increases with increasing temperature (Quinn et al., 1992; kishi et al., 2005.

The significance increase in the amount of *Synedra species* fed by Labeo capensis from September to October could be associated to the increase in temperature, as the increase temperature is known to be an important role in the setting upper limits on physiological rate processes in plankton Eppley (1972). This may mean that Synedra is one of the planktons that become excited by the increase in temperature and as a result chances of failing in the mouth of the cyprinid became very high in the warmer month.

There was a significant decrease in the amount of *chlorella species* consumed by *L. capensis* with an increase in size of the fish, this could be that small fish prefers this type of organisms' more than older fish or the organism can easily be captured by the small fish. The significant decrease in number of chlorella with increasing fish size (p value) can possibly be attributed to the type of substrate preferred by a certain size fish. (See if there is a correlation between debris and fish size as well as chlorella and fish size)

Some food types like Worms, *sphaeroplea spps*, *Cephalopodella spps* had very small sample size therefore were not used to determine results as they could have led to biased results.

Cosmorium species only had a sample size of six of which only one sample was collected in October, this was also not used for analysis.

The above findings concur to the data that was presented by Benzer*et al*., (2007), who stated that the digestive tract content of Tench (*Tincatinca*) another fish in the Carp family was dominated by phytoplanktonic organisms (*Cyanophyta spps, Chlorophyta spps, Bacillariophyta spps, Euglenophyta spps*).

The diet of the *Labeo capensis* in Hardap dam also appear to be fairly unselective which makes these results concur with earlier findings that cyprinids can feed on a wide variety of food types including detritus, plant material, algae, diatoms and crustaceans whenever they are available. Proportions of food types in *L. capensis* gut contents were similar to those of many other cyprinids, which consumed large amount of organic debris Summerfelt *et al*., (1970).

On the other hand the presence of bottom water organisms, debris and mud in its stomach of the samples indicates that the fish feed at the bottom of the lake. The stomach contents of *Labeo capensis*, living in Hardap Dam show certain similarities with some other studies in literature.

Phytoplanktonic organisms such as *Synedra spps* and *Chlorolla spps*, were observed although other studies have shown a more of zooplanktons in the stomach of cyprinids, this could be that these organisms dominate the ecosystem of Hardap dam.

According to Crimmon (1968), Cyprinids consumes Mollusc, Annelida, Crustacea, Insect and Detritus, water plants and phytoplanktonic organisms, this statement also collaborate with the findings of this research.

In this study it was also observed that the stomach of the female fish with developed gonads had empty stomach content this may be due to less feeding when fish is in the reproduction stage and most of the fish were found to have a stomach content of less than half; the reason for this could be due to the low temperatures of about 15^{o}c which were recorded during the time of sampling also it could due to time spent in the gillnet in which they were entangled, as noted by Rosenblum*et al*., (1994) they stated that the water temperature is related to the feeding habits of crucian carp this means less temperature less feeding.

During the study it was also discovered that there is a significant positive linear relationship between the stomach weight and the length of the fish, this may suggest that as the fish grows also the weight of the stomach increases.

Although two fishing methods were used to catch fish (gillnetting and seine netting) the catching methods could not be used as an important factor in the analysis, due to the fact that the percentage of fish caught by gillnetting was too small (only 8.9%) of to total sample collected while those caught by seine netting was about 91.1%. although just by mere observation during dissection, all the fish caught by the seine net had their stomach more than three quarters full. Time of the day may affect the quantity and type of organisms that a fish eats but due to lack of enough time this was not examined in this study.

5.0. Conclusion

The results of this study concur with previous reports that the cyprinids are omnivorous and their diet is that of the fish that have an inferior mouth, also their feeding habit is not selective. In general, it seems that *Labeo capensis* can ingest a wide range of food items including plant and animal material with detritus being the most eaten food which matches with the shape of its mouth and niche in which they exist. Debris (dead plant remains and undefined organic matter) consumption indicates that Labeo is not very selective in its dietary preference.

Also some food type like Chlorella species consumed by this fish are size dependent in the case chlorella and Cephalopodella are preferred by small fish.

Debris, Synedra and *Cephalopodella* species were found to be more in the stomach of small fish than adult fish this could be due to the substrates in which these fish of different age are found.

There was an increase in the amount of most food types consumed from September to October which maybe associated to abundance due to the increase in temperature and nutrients availability which promotes the growth of planktons.

This analysis can positively tell that debris is the most preferred by looking at the percentage consumed compared to other organisms consumed.

6.0. References

Ahlgren, M. O., Bowen, S. H. (1992). *Comparison of Quantitative Light Microscopy Techniques Used in Diet Studies of Detritus-consuming Omnivores*, Hydrobiologia239:79–83.

Benzer, S. Ş., Gül, A., Yılmaz, M. (2007). *The Feeding Biology of Tincatinca.* L., 1758 Living in Hirfanlı Dam Lake. C.Ü. Fen-Edebiyat Fakültesi Fen Bilimleri Dergisi 28:40-50.

Bowen, S. H., (1982). *Feeding, Digestion and Growth: Qualitative Considerations, In: The Biology of Culture of Tilapias.* R. S. V. Pullin and R. H. Lowe-McConnell (Eds.), ICLARM Conference Proceedings, Manila, Philippines. Volume 7, pp. 141-156.

Bowen, S. H., (1982). *Feeding, Digestion and Growth: Qualitative Considerations, In: The Biology of Culture of Tilapia.*R. S. V. Pullin and R. H. Lowe-McConnell (Eds.), ICLARM Conference Proceedings, Manila, Philippines. Volume 7, pp. 141-156.

Bowmaker, A.P. (1973). *Potadromesis in the Mwenda River, Lake Kariba*. pp. 159–164. *In*: W.C. Ackermann, G.F. White, E.B. Worthington & J.L. Ivens (ed.) Man-Made Lakes: *Their Problems and Environmental Effects, Geophysical Monograph*, American Geophysical Union, Washington, D.C.

Çetinkaya, S., Çınar, Ş., Özkök, R. veErol, K.G. (2006).BeyşehirGölü'ndekiSazan Populasyonu (*Cyprinuscarpio*L., 1758)'nun Büyüme Özellikleri, I. UluslararasıBeyşehirveYöresiSempozyumu.Beyşehir/Konya 11-13 May 2006, 697-704.

Chapman, G. and Fernando, C.H. (1994).*The diets and related aspects of feeding of Nile tilapia (Oreochromisniloticus L.) and common carp (Cyprinuscarpio L.) in lowland rice fields in Northeast Thailand.* Aquaculture, 123: 281-307.

Eddy, S. and J.C. Underhill. (1974). *Northern fishes with special reference to the upper*

Eppley, R. W.: Temperature and phytoplankton growth in the sea, Fish. Bull., 70, 1063–1085, 1972. *Mississippi Valley*. Third Edition. University of Minnesota Press.

Geldiay, R., Balık S., (1988). *TürkiyeTatlısuBalıkları, EgeÜniversitesi Fen FakültesiKi-taplar*Serisi No: 97,519 s, Bornova, İzmir.

Gozdowska, M. Sokoowska E. and Kulczykowska, E. (2003).*Plasma* Ca^{2+} *concentration limits melatonin night production in two fish species.*Journal of Fish Biology, 62: 1405–1413.

Hana, H. M., Manal, M.A., (1988). Limnological investigation on the Al-Iatifiyah common carp (*Cyprinuscarpio*) pond (Baghdad-Iraq), ii, food and feeding habits of *Cyprinuscapio*L., 1758, Environ, Scr. Health, A, 23 (6), 513-524.

Hardewig i. & van Dijk P.L.M. (2003): *Is digestive capacity limiting growth at low temperatures in roach? J. FishBiol. 62: 358–374.*

Harison A (1965). *River zonation in Southern Africa*. Arch. Hydrobiol. **61** 380-386.

<http://www.britannica.com/EBchecked/topic/365141/Mariental>, 23/11/10 retrieved online.

Hill, K.R. (1999). *Evaluation of the impact of common carp on an intensively managed largemouth bass, channel catfish, and pan fish fishery*. Federal aid to fish restoration completion report: small reservoir investigations, project no. F-160-R.Iowa Department of Natural Resources.

Hoffmann, R.C (1995). *Environmental change and the culture of common carp* in Medieval Europe.Canada: T.F.H. Publications.

Jackson, P.B.N. & P.W. Coetzee. 1982. *The spawning behavior of Labeo umbratus* (Smith) (Pisces: Cyprinidae). S. Afr. J. Sci. 78: 293–295.

Kishi D, Murakami M, Nakano S and Maekawa K (2005), *Water temperature determines strength of top-down control in a stream food web*. *Freshwater Biol.* **50** 1315-1322.

Lambert, Y. and Dutil, J-D.(2001). *Food intake and growth of adult Atlantic cod* (Gadusmorhua L).reared under different conditions of stocking density, feeding frequency and size-grading.Aquaculture 192: 233-247.

McCrimmon, R.H., (1968). Carp in Canada Fisheries Research Board of Canada, Ottawa, Bulletin 165.

Moyle, P. B. (1976). *Inland fishes of California*. University of California Press, Berkeley, CA.

Panek, F. M. (1987). *Biology and ecology of carp in: Cooper E.L. (ed.) Carp in North America*. Bethesda, Md., American Fisheries Society, p. 1-15.

Polis, G. A., Strong, D. R. (1996), *Food Web Complexity and Community Dynamics*, the American Naturalist, 147:813–846.

Quinn J, Williamson R, Smith R and Vickers M (1992), *Effects of riparian grazing and channelisation on streams in Southland New Zealand*. 2. Benthic invertebrates. *N. Z. J. Mar. Freshwater Res.* **26** 259-273.

Rosenblum, P.M., Brandt, T.M., Mayes, K.B. and Hutson, P. (1994). *Annual cycles of growth and reproduction in hatchery-reared Florida Largemouth bass, Micropterussalmonidefloridanus, rose on forage*or*pelleted diets*. J. Fis Biol., 44: 1045-1059.

Ross, S. T. (2001). *Inland fishes of Mississippi*.University Press of Mississippi, 624 p.

Salehi H. (2003).*Carp culture sector in Iran: An economic analysis of farmed production*.Presented in World Aquaculture 2003, Brazil, unpublished, 17p.

Skelton, P. (1993). *Acomplete guide to the freshwater fishes of Southern Africa*.Southern book publishers (pty) Ltd in 1993.Pp188-189.

Skelton, P. 1993. *A complete guide to the freshwater fishes of southern Africa*. Southern Book Publishers (Pty) Ltd., Halfway House. 388 pp.

Skelton, P.H., D. Tweddle & P.B.N. Jackson. 1991. *Cyprinids of Africa*. pp. 211–239. *In*: I.J. Winfield & J.S. Nelson (ed.) Cyprinid Fishes. Systematics, Biology and Exploitation. Chapman & Hall, London.

Summerfelt, R. C., Mauck, P. E., Mensinger, G. 1970. *Food Habits of the Carp (CyprinuscarpioL.) in FiveOklahoma Reservoirs, Proceedings of the Southeastern Association of Game and Fish Commissioners*, 24: 352-377.

Utsugi,T. and Mazingaliwa, T.(2002), *field guide to Zambian fishes planktonandAquaculture* . Japan International cooperation Agency (JICA), 2002: 97-124 pp.

Wegener.A, (1912), '*The Origins of Continents and Oceans'*

Welcomme ,R. (1984). *International transfers of inland fish species*. Pp.22-40

7.0. APPENDICES:

Appendix 1: Materials

- Sampling bottles
- Formalin
- Gill net of different mesh sizes 90meters long (73mm, 93mm, 118mm and 150mm).
- Dissecting kit
- Measuring board
- Scale (Mettler Toledo electronic scale)
- Boat
- Light Microscope
- Fuming chamber
- Haematocytometer used to hold samples under a microscope
- Measuring cylinder
- Enough manpower to haul gillnets.
- Pencil
- Fume carbon
- Seine Net (30meters long and10mm mesh size)
- Speed boat.
- Very Fine forceps
- Petri dish

APPENDIX 2: Data collection sheet for September and October 2010.

Sample No.	Fish (rep)	Total L(cm)	Total W(g)	Stomah weight(g)	STOMACH CONTENT												
					Debris	Empty	Synchaeta sp	*Quadricoccus spps*	*Cephalopodella spps*	*Trachelomonas valvona*	*Distigma spps*	*Cosmarium spps*	*Chlorella spps*	*Makinoella tosaensis*	*Synedra Spps*	*Sphaeroplea annulina*	worm
80	4	33	581	8.5	700	*	*	*	*	*	*	*	800	*	*	*	*
77	17	33	468	2	*	*	*	*	*	*	*	*	*	*	*	*	*
94	7	34	628	3.5	*	*	*	*	*	*	*	*	*	*	*	*	*
78	18	34.5	377	6	2400	*	*	*	*	*	*	*	1200	*	*	*	*
47	18	35	425	1.5	*	*	*	*	*	*	*	*	*	*	*	*	*
79	3	36	391	8	*	*	*	*	*	*	*	*	*	*	*	*	*
92	6	36	559	6.2	450	*	*	*	*	*	*	*	700	*	800	*	*
85	18	36	587	3.5	800	*	*	*	*	*	*	*	400	*	400	*	*
81	1	36.5	776	2	400	*	400	400	*	*	*	*	*	*	*	*	*
81	1	36.5	776	2	400	*	400	400	*	*	*	*	*	*	*	*	*
91	15	37	416	6.5	800	*	*	*	*	*	*	*	100	*	1600	*	*
86	3	37	580	6.5	*	*	*	*	*	*	*	*	*	*	*	*	*

Sample No.	Fish (rep)	Total L(cm)	**Total W(g)**	**Stomah weight(g)**	**STOMACH CONTENT** Debris	Empty	Synch aeta sp	*Quadrico ccus spps*	*Cephalopo della spps*	*Trachelo monas valvona*	*Distigma spps*	*Cosm arium spps*	*Chlorella spps*	*Makinoell a tosaensis*	*Synedra Spps*	*Sphaerop lea annulina*	worm
74	12	38	623	4	*	*	*	*	*	*	*	*	400	*	1200	*	*
54	10	38	599	5	*	*	*	*	*	*	*	*	1200	*	1200	*	*
90	4	39	407	5.5	400	*	*	*	*	*	*	*	*	*	*	*	*
55	14	39	574	8	1600	*	*	*	*	*	*	*	*	*	800	*	400
61	16	39	682	5.5	1200	*	*	*	*	*	*	*	400	*	1200	*	*
76	7	39	558	5.5	*	*	*	*	*	*	*	*	800	*	800	*	*
73	2	39	540	4	*	*	*	*	*	*	*	*	*	*	*	*	*
32	12	39	787	6	400	*	*	*	*	*	*	*	*	*	1200	400	400
82	19	39	309	4.5	400	*	*	*	*	*	*	*	1200	*	*	*	*
65	11	39	533	2	*	*	*	*	*	*	*	*	*	*	*	*	*
62	10	39.5	658	4.5	*	*	*	*	*	*	*	*	*	*	650	*	*
52	16	39.5	566	6.5	2000	*	*	*	*	*	*	*	400	*	1200	*	*
50	15	40	774	6.5	*	*	*	*	*	*	*	*	400	*	1600	*	*
53	12	40	745	9	400	*	*	*	*	*	*	*	*	*	800	*	400
89	2	43	1033	6.5	*	*	*	*	*	*	*	*	*	*	*	*	*
67	2	40	690	7	*	*	*	*	*	*	*	*	*	*	*	*	*
71	9	40	517	4	*	*	*	*	*	*	*	*	500	*	450	*	*
60	19	40	443	5	1200	*	*	*	*	*	*	*	2400	*	1200	*	*
70	3	40.5	431	6	*	*	*	*	*	*	*	*	*	*	*	*	*
58	15	40.5	704	8.5	1200	*	*	*	*	*	*	*	1200	*	800	*	*
48	10	41	770	5.5	*	*	*	*	*	*	*	*	400	*	800	*	*

Sample No.	Fish (rep)	Total L(cm)	Total W(g)	Stomah weight(g)	STOMACH CONTENT												
					Debris	Empty	Synchaeta sp	*Quadricoccus spps*	*Cephalopodella spps*	*Trachelomonas valvona*	*Distigma spps*	*Cosmarium spps*	*Chlorella spps*	*Makinoella tosaensis*	*Synedra Spps*	*Sphaeroplea annulina*	worm
66	8	41	634	7.5	400	*	*	*	*	*	*	*	400	*	800	*	*
15	2	41	808	8.5	*	*	*	*	*	*	*	*	*	*	*	*	*
88	1	41	303	9.5	400	*	*	*	*	*	*	800	400	*	800	*	*
64	8	41	547	4.5	500	*	*	*	*	*	*	*	450	*	600	*	*
46	9	41	604	4	*	*	*	*	*	*	*	*	400	*	400	*	*
51	13	41	546	3	*	*	*	*	*	*	*	*	*	*	*	*	*
57	4	41.5	590	2	*	*	*	*	*	*	*	*	*	*	*	*	*
101	17	42	1118	4	800	*	*	*	*	*	*	*	800	*	*	*	*
87	4	42	1130	5	*	*	*	*	*	*	*	*	*	*	*	400	400
36	11	42	689	6.5	400	*	*	*	*	*	*	*	*	*	800	*	*
4	6	42	734	7.5	*	*	*	*	*	*	*	*	600	*	500	*	*
56	9	42	606	2	*	*	*	*	*	*	*	*	*	*	*	*	*
43	11	42	535	9	400	*	*	*	*	*	*	*	400	*	*	*	*
45	12	42	720	9	400	*	*	*	*	*	*	*	1200	*	2800	*	*
3	19	42	1173	10	2000	*	*	*	*	*	*	*	1200	*	1600	*	*
42	8	42.5	1040	7	400	*	*	*	*	*	*	*	*	*	1200	*	*
69	7	42.5	451	4	*	*	*	*	*	*	*	*	400	*	800	*	*
40	15	42.5	858	7.5	2000	*	*	*	*	*	*	*	1600	*	800	*	*

Sample No.	Fish (rep)	Total L(cm)	Total W(g)	Stomah weight(g)	STOMACH CONTENT												
					Debris	Empty	Synchaeta sp	*Quadricoccus spps*	*Cephalopodella spps*	*Trachelomonas valvona*	*Distigma spps*	*Cosmarium spps*	*Chlorella spps*	*Makinoella tosaensis*	*Synedra Spps*	*Sphaeroplea annulina*	worm
44	9	43	723	9.5	700	*	*	*	*	*	*	*	*	*	1500	*	*
59	10	43	539	7.5	400	*	*	*	*	*	*	*	670	*	*	*	*
31	13	43	974	8	400	*	*	*	*	*	*	*	1600	*	400	400	*
83	12	43	453	4.5	400	*	*	*	*	*	*	*	800	*	1200	*	*
14	17	43	829	6.5	3200	*	*	*	*	*	*	*	800	*	800	*	*
37	13	43.5	809	10	800	*	*	*	*	*	*	*	1200	*	800	*	400
49	8	43.5	575	8	400	*	*	*	*	*	*	*	800	*	1200	*	*
38	8	43.5	701	8	400	*	*	*	*	*	*	*	400	*	*	*	*
16	16	43.5	754	10	3200	*	*	*	*	*	*	*	1200	*	800	400	*
13	3	44	1110	7.5	*	*	*	*	*	*	*	*	*	*	*	*	*
10	6	44	834	4.5	*	*	*	*	*	*	*	*	*	*	750	*	*
39	16	44	663	6	2000	*	*	*	*	*	*	*	800	*	400	*	*
8	14	44.5	867	10	2000	*	*	*	*	*	*	*	1200	*	400	*	400
19	6	44	646	8	*	*	*	*	*	*	*	*	600	*	400	*	*
20	5	44	698	8	500	*	*	*	*	*	*	*	800	*	*	*	*
18	5	44	702	7	*	*	*	*	*	*	*	*	*	*	*	*	400

Sample No.	Fish (rep)	Total L(cm)	Total W(g)	Stomah weight(g)	STOMACH CONTENT												
					Debris	Empty	Synchaeta sp	*Quadricoccus spps*	*Cephalopodella spps*	*Trachelomonas valvona*	*Distigma spps*	*Cosmarium spps*	*Chlorella spps*	*Makinoella tosaensis*	*Synedra Spps*	*Sphaeroplea annulina*	worm
41	17	44	563	7	8000	*	*	*	*	*	*	*	400	*	400	*	*
7	18	44.5	738	8.5	1600	*	*	*	*	*	*	*	1600	*	1600	*	*
27	14	45	586	4	*	*	*	*	*	*	*	*	400	*	400	*	*
6	11	45	1449	4.5	*	*	*	*	*	*	*	*	*	*	*	*	*
21	6	45	1059	8	500	*	*	*	*	*	*	*	655	*	*	*	*
11	5	45	881	8	*	*	*	*	*	*	*	*	*	*	*	*	*
12	7	45	708	6.5	400	*	*	*	*	*	*	*	*	*	870	*	*
29	18	45	999	5	1200	*	*	*	*	*	*	*	800	*	1200	*	400
35	14	45.5	803	8	800	*	*	*	*	*	*	*	800	*	400	*	*
96	1	46	682	6	*	*	*	*	*	800	400	1600	800	1200	*	*	*
28	5	46	698	7	600	*	*	*	*	*	*	*	*	*	*	*	*
1	11	46	764	3.5	*	*	*	*	*	*	*	*	*	*	*	*	*
33	13	47	1142	3	*	*	*	*	*	*	*	*	*	*	*	*	*
100	19	47.5	1117	6	2000	*	*	*	*	*	*	*	1600	*	800	*	*

APPENDIX 3: **Debris**

variable	t-tests; Grouping: Month (spreadsheet 1) Group 1: Oct. Group 2: Sept.										
	Mean Oct.	Mean Sept.	t-value	df	p	Valid N Oct.	Valid N sept.	Std. Dev. Oct.	Std. Dev. Sept.	F-ratio Variances	p Variances
Stomach content Score	3971.429	1171.4	7.717053	68	0	14	56	1344.75	1181.327	1.295815	0.487371

APPENDIX 4: *Sphaerop*lea

variable	t-tests; Grouping: Month (spreadsheet 1) Group 1: Oct. Group 2: Sept.										
	Mean Oct.	Mean Sept.	t-value	df	p	Valid N Oct.	Valid N sept.	Std. Dev. Oct.	Std. Dev. Sept.	F-ratio Variances	p Variances
Stomach content Score	800	400	0.0377964	5	0.720971	6	1	1	0	0	1

APPENDIX5: *Synedra*

variable	t-tests; Grouping: Month (spreadsheet 1) Group 1: Oct. Group 2: Sept.										
	Mean Oct.	Mean Sept.	t-value	df	p	Valid N Oct.	Valid N Sept.	Std. Dev. Oct.	Std. Dev. Sept.	F-ratio Variances	p Variances
Stomach content Score	3000	955.9322	8.975566	69	0	12	59	1212.061	580.2114	4.363914	0.00019

APPENDIX 6: Worm

variable	t-tests; Grouping: Month (spreadsheet 1) Group 1: Oct. Group 2: Sept.										
	Mean Oct.	Mean Sept.	t-value	df	p	Valid N Oct.	Valid N sept.	Std. Dev. Oct.	Std. Dev. Sept.	F-ratio Variances	p Variances
Stomach content Score	666.6667	400	3.872983	10	0.003094	3	9	230.9401	0	0	1

APPENDIX 7: Diet composition of *L. capensis* based on percentage of counts of organisms consumed.

ORGANISMS	FOOD GROUPS											
	Cephalopodella	*Chlorella*	*Cosmarium*	*debris*	*Distigma*	*Makinoella*	*Quadricoccus*	*Sphaeroplea*	*Synchaeta*	*Synedra*	*Trachelomonas*	*worms*
Number of fish in which occurred	3	72	6	72	1	1	4	7	3	72	1	12
percentage of occurrence (%)	1.149	27.586	2.299	27.6	0.383	0.383	1.532	2.682	0.0115	27.586	0.383	4.598