A STUDY ON NEMATODE INFESTATION IN FISH FOUND IN THE HARDAP DAM, NAMIBIA

By

LUSIA MWADHINA NDAMWENA NEGONGA

(200823761)

A research report in the Department of Fisheries and Aquatic Sciences submitted to the Faculty of Agriculture and Natural Resources, University of Namibia, in partial fulfillment of the requirements for the award of the Honours degree of Bachelor of Science in Fisheries and Aquatic Sciences of the University of Namibia.

SUPERVISORS:

Mr. ESTERHUIZEN J. ALBERT

Dr. Hay J. CLINTON

Fisheries and Aquatic Sciences

University of Namibia

Windhoek, Namibia

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DECLARATION

“I hereby declare that this work is the product of my own efforts, undertaken under the supervision of Mr. Esterhuizen J. Albert and Dr. Hay J. Clinton and has not been presented elsewhere for the award of a degree or certificate. All sources have been duly and appropriately acknowledged.”

Candidate signature ……………………………..

LUSIA MWADHINA NDAMWENA NEGONGA

Student number: 200823761

Date…..

CERTIFICATION

"This is to certify that this report has been examined and approved for the award of the honors degree of Bachelor of Science in Natural Resources (Fisheries and Aquatic Sciences) of the University of Namibia".

External Examiner ……………………………………………

Internal Examiner …………………………………………….

Supervisor…………………………………………………..

Co-Supervisor…………………………………………………

Head of the Department………………………………………

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Lusia M.N. Negonga

December 2012

DEDICATION

This work is dedicated to my daughter Sheila Abia Tegelela Iyaloo Njambali for the time spent away during my studies.

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ABSTRACT

This study was conducted to investigate the abundance of nematode infestation in several fish species found in the Hardap Dam. The under taken study aimed at identifying the fish parasite (nematode) found in the fishes of the Hardap Dam and illustrate its correlation between the fish species, sizes, within and between the species as well between the sexes in each species.A total of 2951 fishes belonging to six different species were collectedin August and October 2012. These species included; *Cyprinus carpio* (Common carp), *Barbus paludinosus (*Straight-fin barb*)*, *Labeobarbus aenus x Labeobarbus kimberleyensis (*Yellow-fish hybrid), *Labeo umbratus* x *L. capensis* (Labeo mudfish-hybrid), *Clarias gariepinus* (African Sharp-tooth catfish) and *0reochromismossambicus (*Tilapia).Of the 2952 specimens collected, 2.6% were infected with the nematode parasite. The nematode parasite was identified as the Contracaecum species. *Clarias gariepinus*, *Oreochromis mossambicus* andYellow-fish hybridwere found to be more prone and Labeo mudfish-hybridthe least infested with the nematode. The intensity of the infection was 1-73 worms per fish in yellow-fish hybrid, 0-19 worms per fish in the Tilapia fish, 22 -832 worms per fish in *Clarias gariepinus*and 0-2 worms in the Labeo mudfish-hybrid. Species variation in the prevalence of parasite was observed with no significant difference in the prevalence of infection between males and females. Body length was positively correlated with the number of parasites in the yellow fish hybrid (r^2=0.3713; P<0.0001).

Keywords: Hardap scheme, parasites, Nematode, *Cyprinus carpio, Clarias gariepinus*,*Oreochromis mossambicus*, Mudfish hybrid, Yellow fish Hybrid

1. INTRODUCTION

Hardap dam is situated near Mariental in the southern part of Namibia (24° 52'S, 17° 52'E) and is the country's largest man-made reservoir which was constructed in 1962 for irrigation purposes, today known as the Hardap Irrigation Scheme. Also, this reservoir supplies water to the Mariental town (Desert research foundation of Namibia, 2009). The dam drains the Fish River, a non-perennial tributary to the Orange River with a catchment area of 13 699 km^2 (Økland *et al*. 2001).The reservoirhas high surface temperatures during rainy season, reaching up to 27 to 28 ºC and during winter temperatures drop to 12 ºC due to high altitude and low air temperatures (Økland *et al*. 2001).Hardap dam provides refuge to about 10 different fresh water fish species namely *Cyprinus carpio* (Linnaeus, 1758), *Barbus cf. kimberleyensis (B. aenus* x *B. kimberleyensis* hybrid), *Barbus aeneus* (Steindachner, 1894), *Barbus paludisnosus* (Peters, 1852), *Labeo capensis* (Smith, 1841), *Labeo umbratus* (Smith, 1841), *L. capensis* x *L. umbratus* hybrid, *Clarias gariepinus* (Burchell, 1822)and *0reochromis mossambicus* (Peters, 1852). Bird species commonly found in Hardap area associated with the aquatic environment includes; *Pelecanus onocrotalus* and *Pelecanus rufescens* (pelicans), cormorants (Family: Phalacrocoracidae), spoonbills (Family: Threskiornithidae) as well as fish eagles belonging to the Family: *Haliaeetus* (Namibia wildlife resort, 2012).

Serious human diseases can be the result of consuming fish infected with certain parasites; therefore it has become very important to study fish parasites (Deardorff, 1986). A parasite is an organism which inhabitsanother organism, known as the host in order to carry out its biological functions.Usually the parasite is smaller than its host. Although not all parasites have the ability to cause diseases, diseases associated with parasitic infections are a common phenomenon (Moravec, 1994). Parasitic diseases are able to affect all living organisms (Akhtar, 2008). In fish, parasites invade various tissues and organs including the skin, gills, eyes, kidneys, liver, intestines, spleen, heart and brain (Akhtar, 2008). Infections caused by parasites tend to decrease the growth rate resulting in stunted growth of fish.Parasites can affect the fish population by causing mechanical, physiological as well as reproductive damagewhich may lead to the decline in the stock (Iwanowicz, 2011).

According to Iwanowicz (2011),the presence of parasites in a water body usually becomes a concern when they affect a fish species of interest, or cause damaging effects to the economy, a recreational activity or a commercial fishery.

Parasitic fish infections was ignored and first received worthy studies in the early 1900’s when fish aquaculture started to become commercialized (Hoffman, 1999). According to Iwanowicz (2011) the roles, functions and life-styles of parasites help characterize an ecosystem also allowing the recognition of the role of the fish (host) in an ecosystem.

Other studies done on fresh water fish parasites in North America have shown the economical importance of acquiring knowledge from studying the occurrence of parasites are not only for fishing as an amenity but also for culturing of fish (Hoffman,1999).

The most common types of parasites are; Trematodes, Cestodes, Naematodes, monogenea and copepods.

Trematodes are one of the most common types of fish parasites known found to live on the outside and inside of fish. Cestodes are parasitic tape worms which inhabit the intestine of its host.**Nematodes** are known as round worms and are the most common types of fish parasites which can also be free-living (non-parasitic).Monogenea are flatworms which are commonly found in the gills, skin or fins of fishes and other lower aquatic invertebrates. Copepods are crustaceans which can be found embedded in the flesh, gills or mouth of a fish and others move freely over the body of the surface.

The occurrences of some parasites in a water body are triggered by a number of factors. The factors that are most commonly associated with parasitic occurrences in an aquatic environment are the drastic change in water quality. Factors known to alter water quality include a change intemperature, oxygen, CO_2, pH, Alkalinity and increased levels of total ammonia. According to a study undertaken by Khan *et al* (2003), findings have indicated that high water temperatures generally created suitable conditions for most fish parasites to reproduce.The study then concluded that a direct relation in temperature and parasitic infection existed and that parasitic infections were promoted by the increase in temperature. The nematode species *Contracaecum* is one that is influenced by temperature, requiring temperatures between 21- 24^{0}C to hatch their eggs (Paperna, 1996).

1.1 Impacts of parasites on fish

According to Iwanowicz (2011) the effects of parasites on fish health, can be categorized into mechanical, physiological and reproductive damages.

Mechanical damages involves the *fusion of the gill lamella* where by parasites are described to invade the gills of the fish causing mild discoloration of the gill filaments and increased mucus secretion. *Tissue Replacement* is also described by Iwanowicz (2011) as a mechanical damage where by high numbers of parasites occupy a large total area of a specific organ such that the parasites replace the organ with themselves causing deterioration of the host condition due to the loss of functional activities of the organs infected.

Iwanowicz (2011) described physiological damages to include *cell proliferation* caused by the presence of parasites, this proliferation is one which hassimilar effects to the one that is found in human that causes cancer, *Immunomodulation* (parasites evading the host's immune system), *Altered growth* (delayed growth and stunting) as well as *detrimental behavioral responses*(altering host behavior) are types of physiological damages caused by parasites.

Lastly, she describes reproductive damages as being the influence of parasite inthe diversion of resources in their hosts which consequently results to a tradeoff between the allocations of limited resources that are used in reproduction, parasitic infestations and parasite resistance.

Nematodes are parasitic fish worms which belong to a parasitic group of internal round worms known as Helminths (Moravec, 1994). These parasites' adult stage usually occurs in a vertebrate host and the larvae stage in an invertebrate host (Akhtar, 2008). The Nematode parasite is known to be a part of a large and successful group of helminths known to be extremely diverse consisting of up to 256 families (Williams & Jones, 1994). According to Paperna, (1996), forty species of adult nematodes, found in 9 families of fish have been identified in Africa.

Parasitic nematodes comprise of the earliest known groups of helminths infishes. They infect freshwater, marine and brackish-water fish species and sometimes cause substantial damage to the host. Although parasitic nematodes can infect almost all organs in a fish, the majority of currently known species have been described to occur in the alimentary system (Abowei and Ezekiel, 2011). Studies have shown that the fish species that are usually heavily infected are the predatory ones (Paperna, 1996). Catfish being a predatory fish is one fish species which can be heavily infected by thenematode *Contracaecum* sp. larvae and yet not be affected physiologically (Barson, 2003).Although the parasitic infection does not render the fish unfit for human consumption, the parasite itself remain unsightly and unsuitable for human consumption especially if the larvae encysts are in the muscle tissue (Barson, 2003).

According to Woo & Leatherland (2006) most nematodes infect fish as adults, but large proportions of them occur at larval stages. These are usually parasites of fish-eating birds,mammals and reptile as well as predatory fishes.

Different types of parasites have different life cycles which involve different stages and hosts in order for them to be complete. Williams & Jones (1994) described the life cycles of most fish Nematodes to require an intermediate host in order for it to be complete but there is evidence that an intermediary host is not always required for some species, for instance, the *Cucullanide* species. According to Moravec (1994), some parasitic species need an intermediate host in which the parasite undergoes a significant part of its ontogenetic development which ensures a selective transmission of these parasites.

Parasitic nematodes have complicated life cycles, moving between hosts and locations in the host's body. If the Nematode has a direct life cycle, then it does not need an intermediate host and infection can spread directly from one fish to another by means of a fish ingesting its eggs or larvae.

As sexes are separate in nematodes, the females are oviparous meaning they produced eggs which usually hatch in water or they release free-swimming larvae which are then ingested by an intermediate host, often a crustacean and then by a fish in which it either matures to an adult or encysts (Noga, 2010), this cycle is referred to as an indirect life cycle. The larvae encysted in fish are ingested by a bird, mammal or another fish as final host.

A direct life cycle is one in which the nematode infects the fish directly without the need of an intermediate host. Although not experimentally validated, it was observed by Molnár et al. (2006) in the species *Capillaria pterophylli* which was found to infect freshwater angelfish and other cichlids at temperatures of 20 -23 C^o (Molnár, 2006).

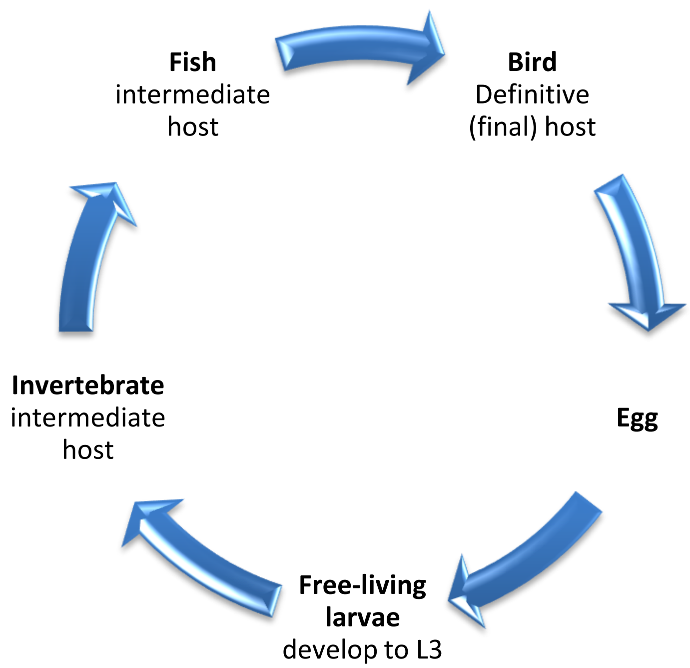


Figure 1:A general life cycle of the Nematode larvae: *Contracaecum* species.

According to Paperna (1996), larval stages of *Contracaecum* species are found in freshwater fish and adults of the *Contracaecum* sp. in fish eating birds such as pelican, cormorants and herons (definitive hosts). Larval stages are observed in cyprinids (carp and related species) and cichlids

(Yanong, 2002; Moravec, 1994). Eggs are released from the bird via de-feacation (the release of faces) into the water body but can also be released into the water when whole nematodes are vomited from the bird's stomach (Paperna, 1996). According to Paperna (1996) eggs are released from such discharged nematode by ovipostion or after death, following their decomposition. The eggs hatch within only 2-3 days if released in warmer water of temperature of 24^0C and taking longer to hatch in less warmer waters (21^0C) (Paperna,1996).

After the eggs hatch, free living infective (second) stage of the larvae according to Paperna (1996), can survive in water for several months attaching to substrates in the aquatic habitat by their posterior end. Small crustaceans are the first intermediate host for nematode of the Anisakidae family (Paperna, 1996) before being passed on to fish as the final intermediate host.

In fish, *Contracaecum*larval infection passes from prey to predator before finally accumulating in the predatory fish such as *Clarias gariepinus* or *Oreochromis mossambicus* (Paperna, 1996).

The *Contracaecum* sp. larvae infections although do not severely affect the fish, tissue reaction, inflammation, epitheloid formation and fibrous encapsulation around encysted larvae is contained and renders the fish unsightly and unsuitable for human consumption especially if the larvae encysts are in the muscle tissue (Barson, 2003).Human health might be compromised when larval nematodes are ingestedeither directly or through the consumption of raw or undercooked fish,this causing a condition known as anisakiasis also known as helminthiasis (Al-Zubaidy, 2009). Symptoms of aniskiasis include violent abdominal pains, nausea, vomiting and diarrhea (Sakanari & McKerow, 1989).

In studies done by Rohde (1993) indicated that plankton feeders had relatively few kinds and numbers of parasites and the frequency of infestation was low, whereas carnivores had many kinds and numbers of parasites occurring at higher frequencies as they tend to be accumulated with parasites from fish they consume.

The fishes under investigation included; the 3 cyprinidae species; Mudfish hybrid (*Labeobarbus umbratus* x *Labeobarbus capensis*), *Cyprinus carpio*, *and* Yellowfish Hybrid (*Labeobarbus aenus* and *Labeobarbus kimberleyenis*). Yellow fish hybrid forms part of the Yellowfish species group which are important species although well known for their potential in the angling business and for being good ecological indicators, this species has numerous and varied threats (Impson *et al*, 2008). *Cyprinus carpio* (Common carp) which is particular popular for its endurance and tolerance to a wide variety of conditions (Næsj *et al.*, 2007) is favored for these reasons as an aquaculture species.The other two species,*Clarias gariepinus* and *Oreochromis mossambicus* belonged to the Clariidae and Cichlidae families respectively are both well known important aquaculture species.

To conclude, fish parasites have the ability to result in diseases possibly resulting to server health deterioration in both the fish and consumer (i.e. humans). Human dependency may also be compromised if the fish infected are relied on as a source of income generation, food security and employment opportunities.

In the light of the experience described above, the main objectives of this study include:

- Identifying the fish parasites (Nematode) that are found in the different fish species found in the Hardap dam at different stations of the dam and confirm that this Nematode (Larvae of *Contracaecum* sp.) is indeed prevalent.
- To illustrate the correlation of Nematode infestation between fish species,size, and host gender.

Therefore, the following hypotheses can be derived:

H_{01}: There is no significant difference in nematode infestation between the different fish species found in Hardap Reservoir.

H_{02}: There is no significant difference in nematode infestation between the different sizes (Length) within the species found in the Hardap dam.

H_{03}: There is no significant difference in nematode infestation between male and femalewithin and between the fish species found in Hardap dam.

2. MATERIALS AND METHODS

2.1. Study Area and sampling Methods

The study sampled a variety of sites in the dam with the aim of having a fair representative of all the species as well as variety of habitat to represent the different habitat preference for the different species.The four stations in the Hardap Reservoirat which the study was completed in were, namely; A) Sluice gates, B) Pelican Point, C) Punt in die Wind and D) Bird Paradise.

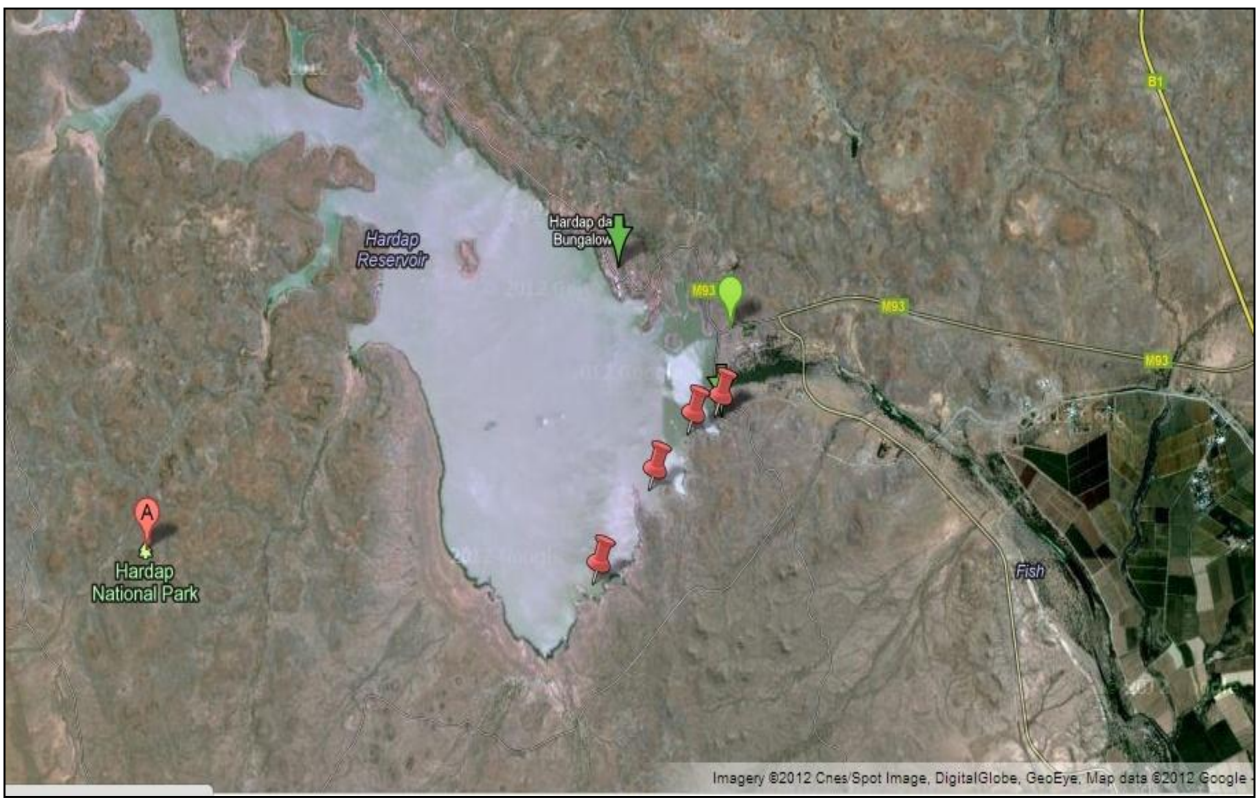


Figure 2: The map of Hardap dam indicating the sites where samples were collected

Table 1: Name and position of the sites sampled in Hardap dam during August – October 2012.

Site	Position	Station	Station name
1	S24°30'08.1", E017°51'33.8"	A	Sluice gates
2	S24°30'12.3", E017°51'21.9"	B	Pelican Point
3	S24°30'08.1", E017°51'33.8"	A	Sluice gates
4	S24°30'12.3", E017°51'21.9"	B	Pelican Point
5	S24°30'33.5", E017°51'03.6"	C	Punt in die Wind
6	S24°31'00.2", E017°50'38.2"	D	Bird Paradise
7	S24°30'33.5", E017°51'03.6"	C	Punt in die Wind
8	S24°31'00.2", E017°50'38.2"	D	Bird Paradise

Six different fish species were collected for this study from thefour stations of the dam. Two different sampling stations were sampled per sampling visit and repeated twice. Sampling was conducted twice, firstly in winter (August) and then in summer (October) of 2012 in order to observe seasonal variation.For winter, the observed water temperatures inclusive of all sampled sites (mean = 14.2 °C), pH (mean = 8.06), dissolved oxygen was observed to be low (mean = 0.075 mg/l). During summer, water temperatures (mean = 20.5°C), pH (mean, 7.26), dissolved oxygen was observed to be much higher in comparison to winter (mean=5.47).

Multifilament gill nets of mesh sizes 12, 16, 22, 28, 35, 45, 57, 93, 118 and 150 mmof a length of 10 meters each were used for collecting the fish samples from the dam.This was done by setting the nets in the dam between the late hours of 16h30 and 18h00 and they were hauled out the following morning between the hours of 07h00 and 10h00 to retrieve the fish caught. The fish samples which were collected were separately kept in temporary holding plastic bags which were marked according to their respective mesh sizes they were hauled from.

2.2 Laboratory procedures

After collection, the fish samples were taken to the laboratory wherethe fish were weighed to the nearest0.1 grams using an electronic measuring balance. The forklength for some fishes (those with a forked caudal fin) and total length for others (those with rounded caudal fin) was measured to the nearest mm using a meter ruler and details were recorded on data collection forms (**appendix 4, appendix 6)** along with other necessary information relevant to the study such as gender, maturity stage and indication of the presence or absence of the nematode.

2.3.Examining fish for nematode parasites

The nematodes were obtained by carrying out a helminthological dissection of the fish and examining mainly the digestive tract as well as the abdominal cavity, throat and gills. The parasites were gently removedfrom the fish with the use of sharp twisters from and placedin a petidish of water to relax them while warming up 70% ethanol in which they were fixed in for about 5 minutes to straighten them up. The straightening of the nematodes is very important as it makes it easier for further laboratory observations. The nematodes were all preserved in valves filled with prepared 10% buffered formalin and labeled accordingly, based on which fish sample they were obtained from.

2.3.Examination& identification of the nematodes

For the examinationof the fixed nematode specimens, the external morphology was studied using a 5 megapixel CMOS camera ZessiAxioCamERc 5s microscope (figure 3). This microscope was used to obtain images of the nematodes for identification purposes.

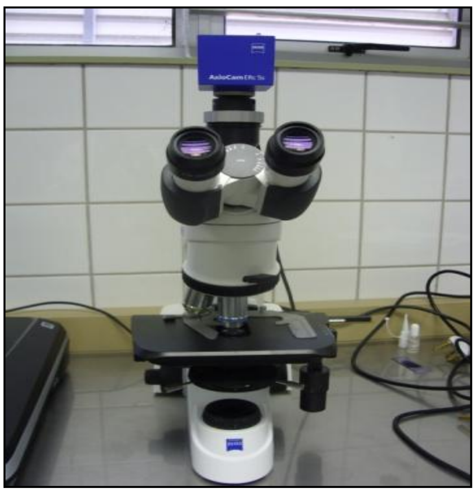


Figure 3: The 5 megapixel CMOS camera (AxioCameraERc. 5s) microscope – Photo: Lusia M. N. Negonga

2.4.Statistical Analysis

All collected data imported into Microsoft Excel© and then imported to PASGEAR 2© (version 2.5) which was used to perform the calculations and statistical analysis. PASGEAR is a customized data base software intended for experimental fishery data from passive gears.

2.5.Data analysis

Prevalence and Mean intensity

The data was also analyzed according to prevalence and mean intensity as suggested by Margolis et al (1982).

a) Prevalence which is the percentage of host individual infected with a particular species or the number of host species infected divided by the number as suggested by Margolis et al (1982) based on the formula:

$$\text{Prevalence (\%)} = \frac{\text{Number of fish infested with parasites}}{\text{Total number of fish examined}} \times 100$$

b) Mean intensity is referred to as the number of individuals of a particular parasite species in each host of each species and it will be calculated using the formula:

$$\text{Intensity} = \frac{\text{Total number of individual parasite in a sample of a host species}}{\text{Number of infected host species in the sample}}$$

Table 2: Infestation level of nematode in fish

The infestation level of the nematode parasite in fish is based on its prevalence in a single fish.

Level of infestation	**Prevalence in fish (%)**
Severe	>80
Moderate	60-79
Low	1-59
None	0

3. **RESULTS**

3.1.Species diversity of Hardap dam

A total of 2951 fish samples were collected from the Hardap dam using multifilament gill nets. Six different fish species were sampled using these gill nets. The species were ranked based on the index of relative importance (IRI), which takes into account the numbers, biomass and frequency of species caught (**Figure 4, appendix 3).** According to the IRI, the Mudfish hybrid (46%) and *Barbus paludinosus* (45.6%) were by far the most important species and constituted together 91.6% of the total IRI. They were followed by the Yellow-fish hybrid (7.9%) and the remaining species each had an IRI of less than 1% while *Cyprinus carpio* contributed nothing (**appendix 3)**.

The total weight of the 2951of fish which was caught during the survey period weighed in total, 253 kg. Mudfish hybrid (192 Kg, 76%) and Yellow-fish hybrid (27.9 kg, 11%) had the highest biomass and together comprised 87% of the total biomass.

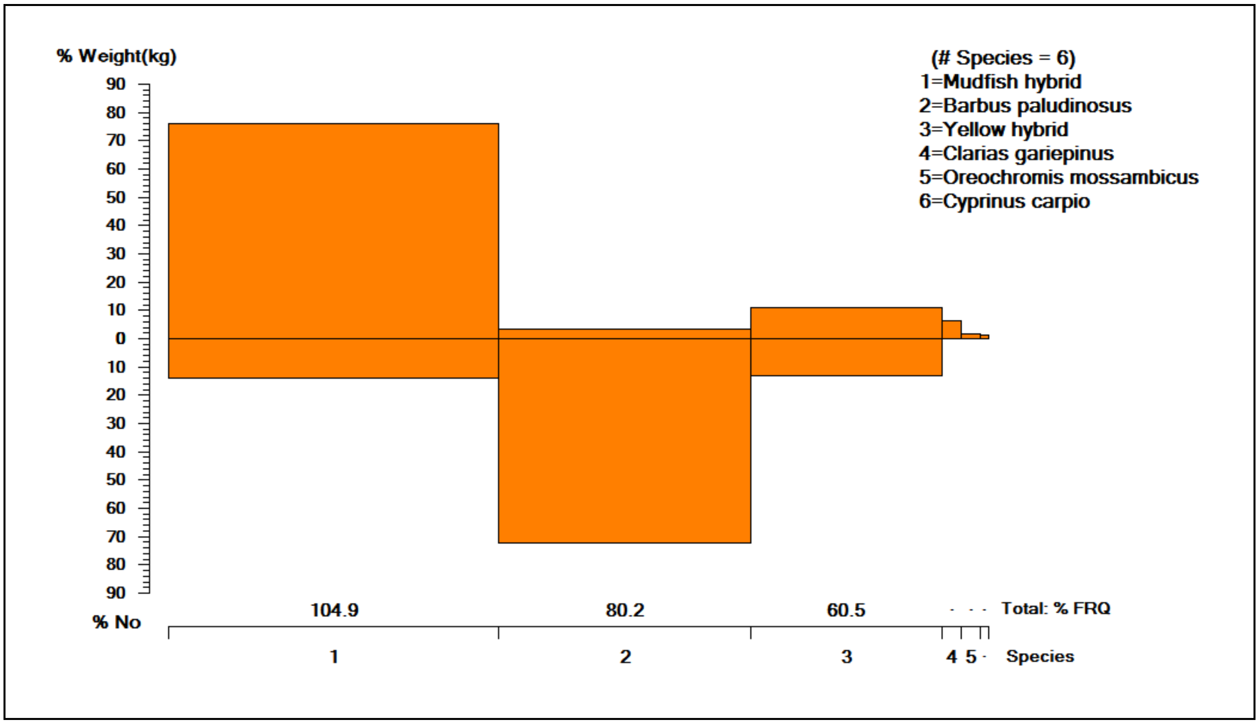
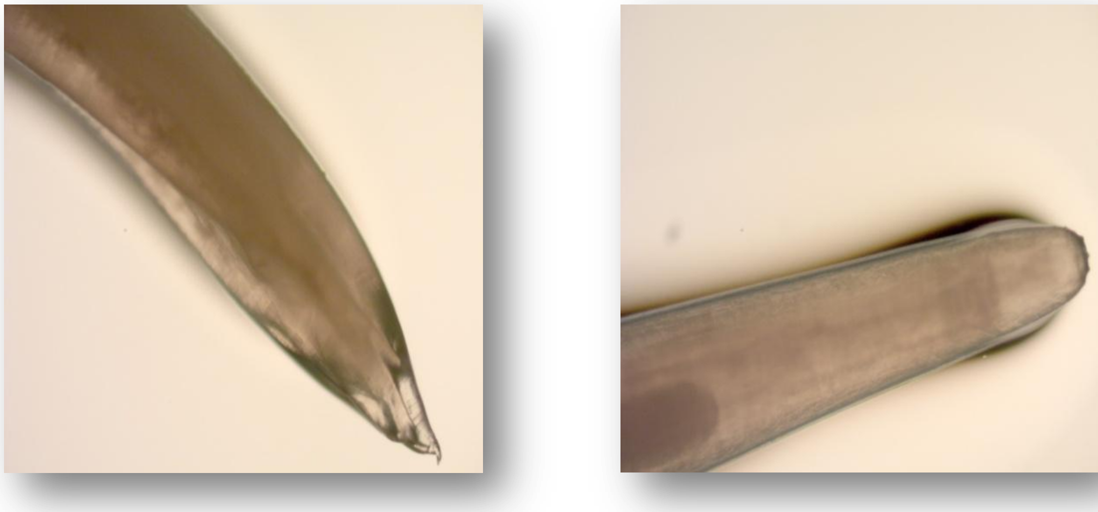


Figure 4: Species composition of gillnet catches (multifilament, 12-150mm mesh sizes) from Hardap dam August – October 2012

3.2.Identified parasite (Nematode)

The nematode was identified as *Contracaecum* sp. larvae (Nematoda: Anisakidae) and could not be identified to species level as it is difficult to do so since the larvae lack genital systems and several other features of adult stages which are utilized as taxonomic criteria(Paperna, 1996).



a) b)

Figure 5: Larvae of *Contracecum* sp. Under the microscope a) Posterior end b) Head region

Photos: Lusia M. N. Negonga.

Table 3: Prevalence of parasites (Nematode) **withineach species** sampled with gill nets in Hardap dam.The nematode parasite was observed in only four out of the six species collected.

Species	No. of fish examined	No. infected	Prevalence %
Yellowfish hybrid	392	66	16.8
Clarias gariepinus	5	5	100
Oreochromis mossambicus	5	4	80
Mudfish hybrid	414	3	0.7
Cyprinus carpio	2	0	0

Statistically, parasite prevalence was severe in *Clarias gariepinus* (100%)and*Oreochromis mossambicus* (80%). Both the Yellow hybrid and the Mudfish hybrid had low prevalence scoring only 16.8% and 0.7% respectively.

Table 4:Prevalence of parasites (Nematode) **between species** in both sexes sampled with gill nets in Hardap.

	Females infected		**Males infected**		**Unknown infected**		**Total infected**	
Species	No.	%	No.	%	No.	%	No	%
Yellow hybrid	32	88.9	26	78.8	8	80	66	84.6
Clarias gariepinus	2	5.6	2	6.1	1	10	5	6.4
Oreochromis mossambicus	2	5.6	2	6.1	-	-	4	5.1
Mudfish hybrid	-	-	3	9.1	-	-	3	3.8
Total	36	100	33	100	9	90	78	100

Results in **table 4**indicate that in the species Yellow fish hybrid, slightly more females (32%) were found to have been infested with the parasite as compared to the males (26%). The sex ratio of the *Clarias gariepinus* and *Oreochromis mossambicus* was found to be a 1:1 for both species.

Table 5: Prevalence between the nematode parasite in the females and males

Species	% Females infected	% Males infected	% Unknown infected
Yellow-fish hybrid	41	40	3.2
Clarias gariepinus	100	100	100
Oreochromis mossambicus	100	67	-
Mudfish hybrid	0	100	-

Table 6: Intensityof the parasites (Nematode) per species sampled with gill nets in Hardap dam

Species	Intensity (worms/fish)	Mean intensity
Yellow-fish hybrid	0-73	5.4
Clarias gariepinus	22-832	356
Oreochromis mossambicus	0-4	7.5
Mudfish hybrid	0-2	1.3

3.3.Yellowfish Hybrid

Seeing that the infectednumber of fish samples collected for the four species (*Cyprinus carpio*, Labeo mudfish-hybrid, *Clarias gariepinus*and *0reochromis Mossambicus*) were relatively few (n<10), correlations for parasite infestation between length and gender were done only for Yellow-fish hybridwhich had much higher numbers (n=66). This was done with the aim of preventing biasinterpretation of rezults.

3.3.1. The correlation between body lengths and parasite infestation (Yellow-fish hybrid)

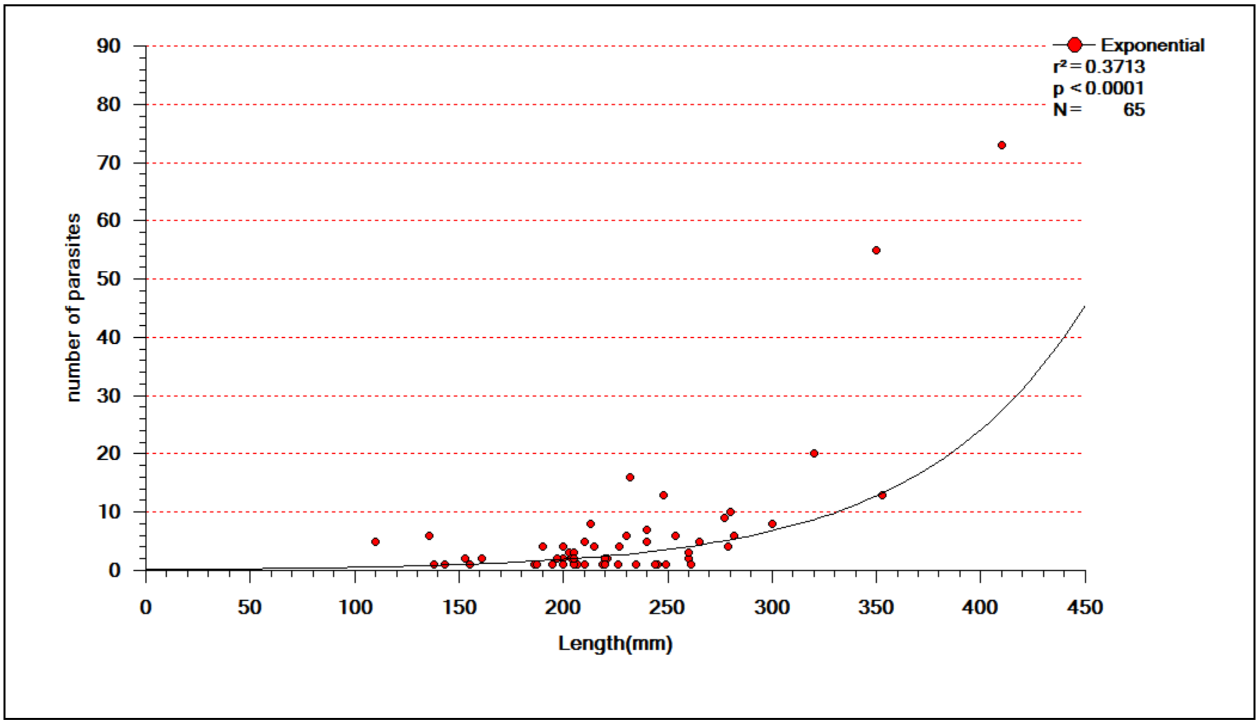


Figure 6: The correlation between length and number of parasites in the yellow fish hybrid (for both sexes).

The correlation between fish length and infestation rate is highly significant for the Yellow-fish taking into account both sexes ($r^2 = 0.3713$, $p<0.0001$). This was also found to be the case when analysis was done separately for both sexes.

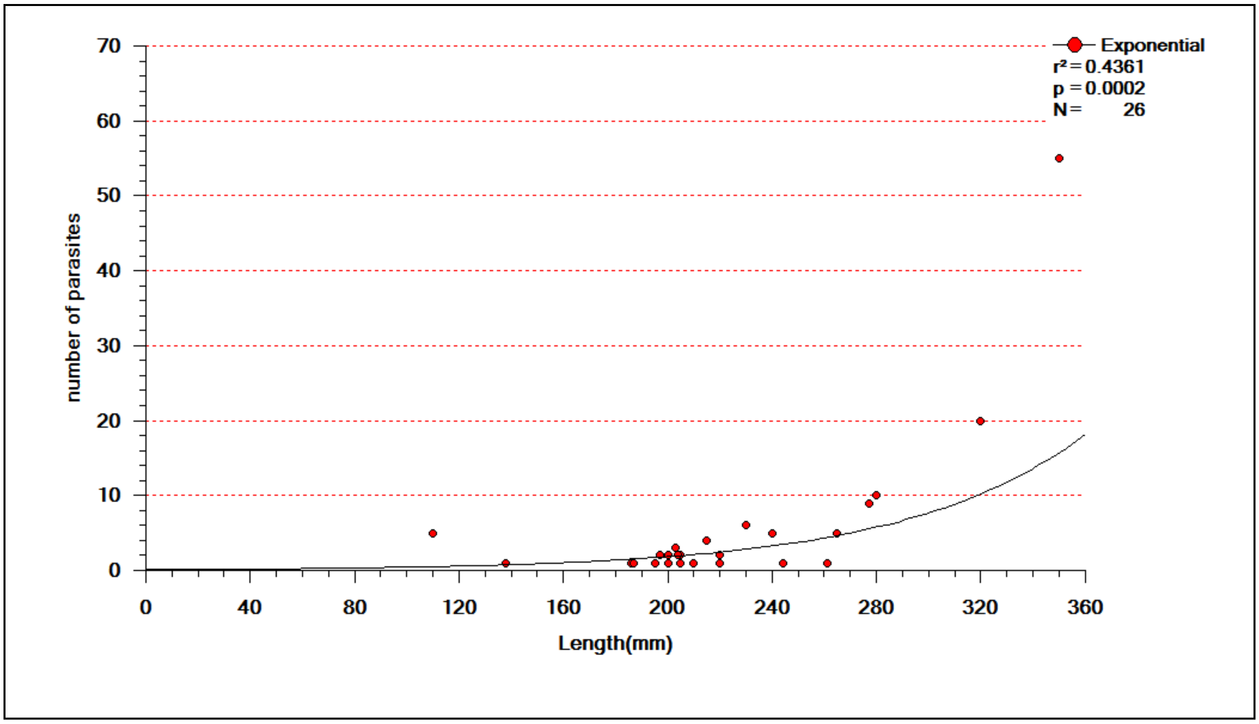


Figure 7: The correlation between length and the number of parasite in yellow fish hybrid (males).

The number of parasites in yellow fish hybrid males increased with an increase in length, thus showing a positive correlation (r^2 = 0.4361,P<0.05).

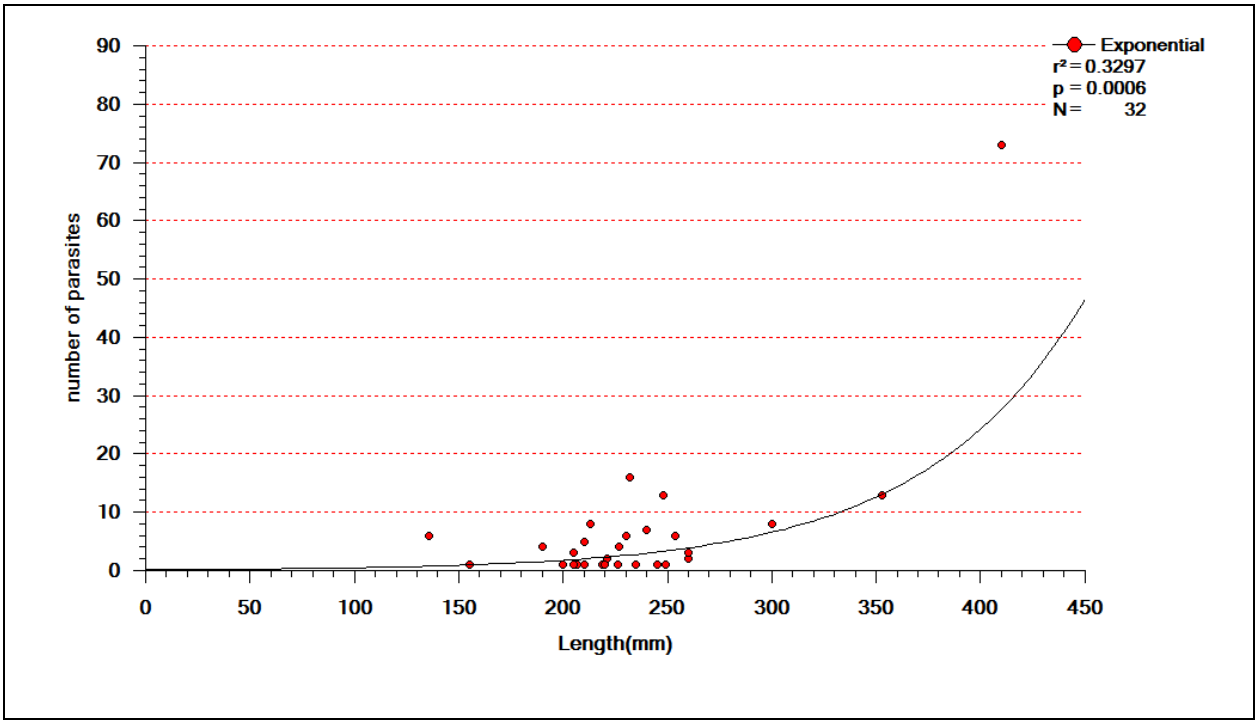


Figure 8: The correlation between length and the number of parasite in yellow fish hybrid (females).

The number of parasites in yellow fish hybrid females increased with an increase in length, thus showing a positive correlation ($r^2 = 0.3297$, $P<0.05$).

3.3.2. Body length distribution and parasite infestation (Yellow-fish hybrid)

Of the total 392 host individuals of the yellow-fish hybrid, 66 were infested by the nematode parasite of which 26 were male and 32 were females.

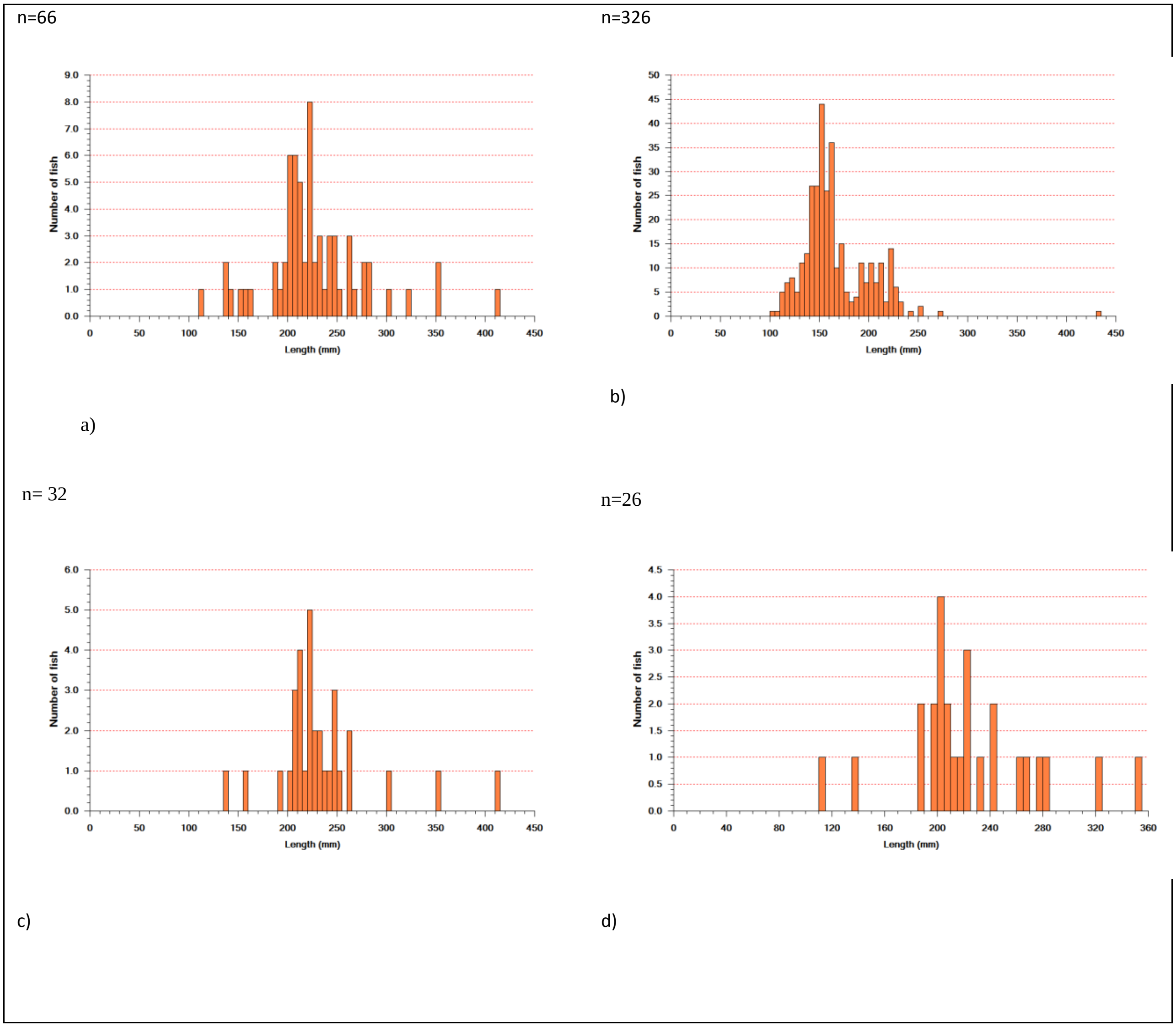


Figure 9: Length frequencies of the yellow fish hybrid a) All yellow fish hybrid with parasites b) All yellow fish hybrid without parasites c) Female yellow fish hybrid with parasites d) male yellow fish hybrid with parasites

Figure9 indicates that larger fish groups (length between 200 -250mm) show high counts of parasite infestation in the yellow fish hybrid. The smallest size of fish infested with the parasite was 101mm while the largest being 410mm.

3.4.Feeding behavior

Feeding is an important part in the biology of fishes as it governs their growth, maturity, migratory movement and most important with relevant to this study, the transmissions of parasites (Akhan, 2008).

Table 7: Feeding behavior of fish species occurring in the Hardap Dam (Winker, 2010; Kotze, 2002)

Scientific Name	Common Name	Feeding niche
Barbus paludinosus	Straight-fin barb	Variety of small organisms (insects, small snails, crustaceans, algae, diatoms & detritus)
Cyprinus carpio	Common carp	Omnivorous
Labeobarbus aenus* x *Labeobarbus kimberleyensis	Yellowfish hybrid	Grazes from rock surfaces & plants (specialized feeder on algae & detritus)
Labebarbus umbratus* x *L. capensis	Labeo mudfish-hybrid	Grazes on firm surface of rocks and plants
Oreochromis mossambicus	Tilapia	Herbivorous
Clarias gariepinus	Sharptooth catfish	Omnivorous (fish, birds, frogs, small mammals, reptiles, snails & plant materials)

4. DISCUSSION

Species diversity

Based on appendix 2, from 2 951 fish samples that were collected from the Hardap dam 2 133 were *Barbus paludinosus* which made up 72% of the total. *Barbus paludinosus* (weight = 3.2%) are relatively small species with low biomasses compared with the number caught (**appendix 3)**.The remaining 28 % included the rest of the other five fish species (*Mudfish hybrid, Yellow-fish hybrid, Clarias gariepinus, Oreochromis mossambicus and Cyprinus carpio).* Although the *Barbus paludinosus* species was highly significant based on the numbers caught, the *mudfish hybrid* was more significant based on weight measurement.

4.1.Parasite infestation in the species

The identified larvae nematode, *Contracaecum* sp. is said to infect fresh water fish species and its adult stage is usually found in fish-eating birds such as cormorants and pelicans (Paperna, 1996). The larval stages of the *Contracaecum* sp. that is found to infect fresh water species has been observed mainly in cyprinids and cichlids (Yanong, 2002; Moravec, 1994).

4.1.1. Yellowfish hybrid

The results of the present study indicated that there was a significant difference in size and number of parasites infested in the yellow-fish hybrid. The larger yellow-fish hybrid reflected heavier infestations compared to the smallerindividuals; the smallest infected fish was 110 mm.According Moravec (1994), the degree of infestation in a fish can strongly be influenced by its body size. Moravec described this phenomenon to be closely associated with the mode of acquiring helminths infection by the definitive host. A change in their diets between juvenile stage and the adult stage can also be a source of variation in size and the numbers of parasites acquired (Næsje *et al, 2007*).

4.1.2. Mudfish hybrid

Out of a total of 414 individuals of the mudfish hybrid only three individuals were found to be infected with the nematode parasite. According to Moravec (1994), the reason for this very low prevalence (0.7%) could be related to the fish's feeding habits as well as its life cycle.Mudfish hybrid being a benthopelagic- bottom feeder(de Moor & Bruton, 1988), this fish mainly grazes on algae and organic detritus.And it is becauseof this fish's dietwhere it excludesinvertebrate intermediate hosts of the nematode parasite that makes it hard to transmit the parasite within its population.It can be concluded that very few mudfish hybrids get infected with the *Contracaecum sp*because of the interruption in this parasite's life cycle and the results of this study has coincided with this observation.

This fish being a fast grower has its young reaching up to 80-90 mm standard length after only a year and a maturity for both males and females being attained at lengths of about ±220mm (Næsje *et al.,* 2007).The results of this study have indicated that all three mudfish hybrid individuals found with the nematode parasite were matured and this can be an indication that size (length) had also played a part in this and as Næsje *et al* (2007) have mentioned, the possibility that feeding patterns differs in the diets of juvenile stage and the adult stage is there and itmay be the source of how the fish had acquired the parasite.

4.1.3. *Clarias gariepinus*

Based on the results, the*Contracaecum* sp. in *C. gariepinus* was recorded from 5 host (n= 569, 292, 22, 45 and 832) (appendix 5). The intensity of the infection of the *Contracaecum* spp. larvae was found to be 22 -832 worms per fish, with a high prevalence of 100% (n=5). Although the sample number was too small to make conclusive deductions on the prevalence and intensities of this parasite in catfish, it is well documented that parasitic infection levels is a very common phenomenon (Barson, 2003).Intensities as high as 700-2000 worms per fish have been recorded with prevalence of 10–100% for the nematode parasite in *C. gariepinus.*

Although theresults obtained fromthis study indicate that there were no differences in prevalence between males and females (Table 5),studies done in Lake Naivasha, Kenya by Aloo (1999) indicated differently, where the differences between males and females were observed with females having higher prevalence rates compared to the males. The possible explanation to why results of this study indicated no differences in prevalence between the sexes was because of the sample size which was inadequate (n=5) to observe any differences.

4.1.4. Cyprinus carpio

Although the results obtained from this study indicated that there were no parasites observed in the in carp, conclusions are hard to make on the prevalence of this parasite in carp as the sample size (n=1) was too small. But in studies done by Davydov *et al* (2011),*C. carpio* is one fish species which has a high diversity of parasites due to the fact that this fish is able to adapt to a wide range of environmental conditions such as temperature, altitude, different water quality parameters as well as feeding on a wide range of prey items. According to Davydov *et al* (2011), most parasitic species (61.9%) actively infect carp, (38.1 %) of them are transferred with food. Based on the studies done by Davydov *et al* (2011), in Ukraine, Uzbekistan and Russia on parasites of carp, it showed that the *Contracaecum* sp. was found to infect carp.

4.1.5. Oreochromis mossambicus

This study has indicated that prevalence of the*Contracaecum* sp. larvae in *O. mossambicus* was 80% with intensity numbersof 1-4 worms per fish (n=4), compared to other studies done in Zimbabwe,*O. mossambicus*was recordedwith a prevalence of 3% and a mean intensity of 12 (Paperna, 1996).

According to Paperna (1996), large tilapia with weight between 200-350g could accommodate up to 12 worms, which may reach a length of 6cm.Paperna continues on to say that prevalence of *Contracaecum*in *Oreochromis* mossambicus have been recorded to 100% in contaminated ponds usually with intensities of 1-4 worms per fish. Also in Lake Naivasha, Kenya, prevalence of about 85% has been reported, infected with a mean of 9 worms per fish.

Although the sample size (n=4) which was taken for this study was very small, a high prevalence of the *Contracaecum* sp. larvae in the *O. mossambicus* was still observed and the reason for this could be because of the fact that Hardap dam is an impoundment and according to Paperna (1996), high prevalence as high as 85 -100% are observable in water bodies held in containments.

Contribution to knowledge

This study contributes to the reduction of information deficit on fish parasites in the Hardap scheme. It documents the different levels of parasite (Nematode) infestation between the different fish species groups, giving an indication of the fish species which are more affected and least affected by the nematode parasite.

4.2.Conclusions

Findings of this study conclude that there were differences observed in parasite infections between the species of Hardap dam scheme with high prevalence and intensity levels observed in *Clarias gariepinus*and *Oreochromismossambicus*and very low prevalence in Labeo mudfish hybrid. From the above findings it can be concluded that the Labeo mudfish is by far one of the least affected fish species in the Hardap dam by the Nematodeparasite which makes it a favorable aquaculture species. Based on the findings of this study, the preferred fish species of the Nematode parasite are mainly *Clarias gariepinus* and *Oreochromis mossambicus.*

Nematode infections showed an increase in infection intensity with an increase in the size of the fish. Further research must be done to investigate the presence of the Nematode parasite in the fish species such as the common carp in order to give a better representative of results prior to this research.

4.3.Recommendations

Due to observed high prevalence of the *Contracaecum* sp.this nematode species is referred to as one of the most prevalent fish parasite and because of the fact that its life cycle involves migratory bird species (e.g. cormorants), possible effective means of reducing *Contracaecum* infection according to Paperna (1996) is to control aquatic birds. This might not be a feasible option for natural water bodies, but can be achieved on private aquaculture ventures.

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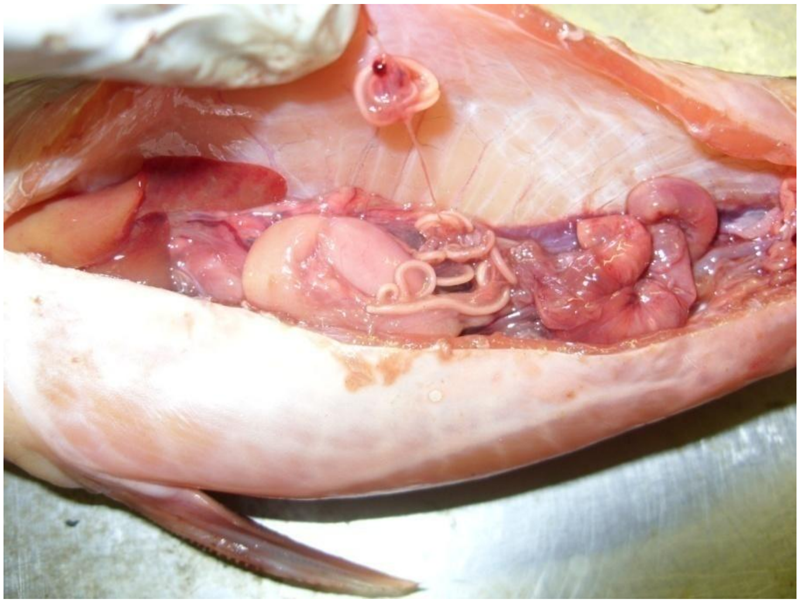
Yanong, R. P. E. Associate Professor, Tropical Aquaculture Laboratory, Department of Fisheries and Aquatic Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Ruskin, FL 33570-3434.

6. APPENDICES

Appendix 1: Larvae of *Contracaecum* sp. found in different sites in the fishes

(Photos: Lusia M. N. Negonga)



Larvae of *Contracaecum* sp. in the stomach of *Clarias gariepinus*

Larvae of *Contracaecum* sp. in the throat of *Oreochromis mossambicus*

Appendix2: Species composition based on males, females and the unknown of gillnet catches (multifilament, 12-150m) from Hardap dam August – October 2012.

	Females			Males			Unknown			Total		
Species	No	% No	Weight(kg)	No	% No	Weight (kg)	No	% No	Weight (kg)	No	% No	Weight(kg)
Mudfish hybrid	153	65	94.8	165	69.9	90.842	96	3.9	7.553	414	14	192.235
Barbus paludinosus							2133	86	8.194	2133	72.3	8.194
Yellowfish hybrid	78	33	10.7	65	27.5	7.1	249	10	10.137	392	13.3	27.938
Clarias gariepinus	2	0.9	2.67	2	0.8	13.632	1	0	0.243	5	0.2	16.541
Oreochromis mossambicus	2	0.9	1.245	3	1.3	3.458				5	0.2	4.703
Cyprinus carpio				1	0.4	3.468	1	0	0.008	2	0.1	3.477
Total	235	100	108.453	236	100	118.5	2480	100	26.134	2951	100	253.087

Appendix 3: Species composition of gillnet catches (multifilament, 12-150m) from Hardap dam August – October 2012.

Species	No	% No	Weight(kg)	% Weight	FRQ	% FRQ	IRI	% IRI	H`
Mudfish hybrid	414	14	192.235	76	55	67.9	6110	46	0.276
Barbus paludinosus	2133	72.3	8.194	3.2	65	80.2	6060	45.6	0.235
Yellow hybrid	392	13.3	27.938	11	35	43.2	1051	7.9	0.268
Clarias gariepinus	5	0.2	16.541	6.5	5	6.2	41	0.3	0.011
Oreochromis mossambicus	5	0.2	4.703	1.9	4	4.9	10	0.1	0.011
Cyprinus carpio	2	0.1	3.477	1.4	2	2.5	4	0	0.005
Total	2951	100	253.087	100	-	-	13276	100	0.805

Appendix 4: Data collection forms

Data Collection sheet

Date: ______________________

Station: ____________________

Site Id: _____________________

GPS: _______________________ Gear: ____________________________

Gear	Species	Length (mm)	Weight (g)	Sex (M/F)	Gonad stage	Evisc. Weight (g)	Sample no.

Appendix 5: Raw data of the fish sampled from Hardap dam using gill netsduring August – October 2012.

Date	Station	Mesh	Species	Length (mm)	Weight (g)	Sex	Gonad stage	Gonad weight (g)	No. of Parasites
04/08/12	ZONE A	45	YELLOW	205	94.1	M	1	-	2
04/08/12	ZONE A	45	YELLOW	195	80.8	M	5	-	1
04/08/12	ZONE A	45	YELLOW	200	87.2	M	1	-	2
04/08/12	ZONE A	45	YELLOW	197	74.9	M	1	-	2
04/08/12	ZONE A	45	YELLOW	210	107.1	F	1	1	5
04/08/12	ZONE A	45	YELLOW	110	89.4	M	1	-	5
04/08/12	ZONE A	45	YELLOW	186	73	M	1	-	1
04/08/12	ZONE A	45	YELLOW	205	100	M	1	-	1
04/08/12	ZONE A	45	YELLOW	187	81.2	M	1	-	1
04/08/12	ZONE A	45	YELLOW	203	91	M	1	-	3
04/08/12	ZONE A	57	YELLOW	248	156.2	F	1	1	13
04/08/12	ZONE A	57	YELLOW	138	160.2	M	1	-	1
04/08/12	ZONE A	57	YELLOW	232	142	F	1	1	16
04/08/12	ZONE A	57	YELLOW	230	124.2	F	1	1	6
04/08/12	ZONE A	57	YELLOW	260	167.6	F	1	1	2
04/08/12	ZONE A	57	YELLOW	240	158.5	F	1	1	7
04/08/12	ZONE A	57	YELLOW	220	111.1	F	1	1	1
04/08/12	ZONE A	150	CATFISH	986	7010	M	5	-	569
04/08/12	ZONE B	57	YELLOW	265	203.2	M	1	-	5
04/08/12	ZONE B	57	YELLOW	260	193.7	F	1	-	3
04/08/12	ZONE B	57	YELLOW	220	108.5	M	1	-	1
04/08/12	ZONE B	57	YELLOW	136	148.8	F	1	-	6
04/08/12	ZONE B	57	YELLOW	254	156.7	F	1	-	6
04/08/12	ZONE B	57	YELLOW	220	106.1	F	1	-	1
04/08/12	ZONE B	57	YELLOW	249	153.5	F	1	-	1
04/08/12	ZONE B	57	YELLOW	245	139.7	F	1	-	1
04/08/12	ZONE B	57	YELLOW	210	93.6	F	1	-	1
04/08/12	ZONE B	45	YELLOW	235	126.5	F	1	-	1
04/08/12	ZONE B	45	YELLOW	200	74.1	F	1	-	1
04/08/12	ZONE B	45	YELLOW	227	109.1	F	1	-	4
04/08/12	ZONE B	45	YELLOW	207	86.7	F	1	-	1
04/08/12	ZONE B	45	YELLOW	210	107.5	M	1	-	1
04/08/12	ZONE B	45	YELLOW	226	104.5	F	1	-	1
04/08/12	ZONE B	73	YELLOW	353	566	F	5	-	13
04/08/12	ZONE B	73	YELLOW	300	337.6	F	5	-	8
04/08/12	ZONE B	93	CATFISH	620	1566.3	F	5	-	45
04/08/12	ZONE B	118	CATFISH	910	6621.5	M	5	-	832

05/08/12	ZONE A	28	YELLOW	140	23			-	1
05/08/12	ZONE A	35	YELLOW	153	36.5			-	2
05/08/12	ZONE A	35	YELLOW	161	45			-	2
05/08/12	ZONE A	45	YELLOW	221	101	F	1	1	2
05/08/12	ZONE A	45	YELLOW	219	101.7	F	1	1	1
05/08/12	ZONE A	45	YELLOW	205	93.5	F	1	1	3
05/08/12	ZONE A	45	YELLOW	213	90.2	F	1	1.2	8
05/08/12	ZONE A	45	YELLOW	220	86.1	F	1	1	1
05/08/12	ZONE A	45	YELLOW	205	77.6	F	1	0.9	1
05/08/12	ZONE A	45	YELLOW	204	83.3	M	1	-	2
05/08/12	ZONE A	57	YELLOW	220	136.9	M	1	-	2
05/08/12	ZONE B	35	YELLOW	155	38.1	F	1	0.9	1
05/08/12	ZONE B	35	YELLOW	143	28			-	1
05/08/12	ZONE B	45	YELLOW	220	78.2	F	1	1	1
05/08/12	ZONE B	45	YELLOW	215	91	M	1	-	4
05/08/12	ZONE B	45	YELLOW	210	96.2	F	1	1.1	1
05/08/12	ZONE B	45	YELLOW	190	74	F	1	1	4
05/08/12	ZONE B	45	YELLOW	200	63	M	1	-	1
05/08/12	ZONE B	57	YELLOW	240	158	M	1	-	5
05/08/12	ZONE B	57	YELLOW	230	142	M	1	-	6
05/08/12	ZONE B	57	YELLOW	220	97	M	1	-	1
05/08/12	ZONE B	57	YELLOW	244	162.1	M	1	-	1
05/08/12	ZONE B	57	LABEO	220	115	M	1	-	2
24/10/12	ZONE C	45	LABEO	230	128.9	M	1	-	1
24/10/12	ZONE C	57	YELLOW	261	177.5	M	5	-	1
24/10/12	ZONE C	93	YELLOW	350	325	M	2	-	55
24/10/12	ZONE C	150	TILAPIA	410	1250.9	M	3	-	19
24/10/12	ZONE C	118	TILAPIA	329	650.5	F	3	5.9	6
24/10/12	ZONE C	118	CATFISH	600	1100.4	F		-	292
24/10/12	ZONE D	45	LABEO	200	88.3			-	1
24/10/12	ZONE D	57	YELLOW	277	217.6	M	1	-	9
24/10/12	ZONE D	57	CATFISH	351	242.6			-	22
24/10/12	ZONE D	57	YELLOW	282	262.7			-	6
24/10/12	ZONE D	57	YELLOW	279	262.8			-	4
24/10/12	ZONE D	118	TILAPIA	315	594.2	F	3	6.9	4
24/10/12	ZONE D	118	TILAPIA	414	1167.1	M	5	-	1
25/10/12	ZONE C	45	YELLOW	205	70.7			-	2
25/10/12	ZONE D	57	YELLOW	280	256.3	M	2	-	10
25/10/12	ZONE D	35	YELLOW	200	64.9			-	4
25/10/12	ZONE D	73	YELLOW	320	341.3	M	2	-	20
25/10/12	ZONE D	93	YELLOW	410	988.4	F	3	24.2	73

Appendix 6: Illustration of the sampling and study area as well as the procedures undertaken for the study. (Photos by Lusia M.N. Negonga.)

Hardap dam walls

Left: Hardap dam gate **Right:** Bird paradise

Left: Instuments used to take water parameters on board **Right:** gill nets set

Above: Students retriving catches from the gill nets from the dam.

Left: Length measurements **Right**: Weight measurements

Left: Inspecting fish for parasites **Right:** recording data

Left: Examining fish for parasites **Right:** quantifying the nematodes