



MAKERERE

UNIVERSITY

**COLLEGE OF NATURAL SCIENCES**

**PREVALENCE OF PARASITES ON NILE TILAPIA (*Oreochromis niloticus*) FRY  
DURING SEX REVERSAL STAGE AT MIG FISH FARM, MAYUGE DISTRICT-  
EASTERN UGANDA**

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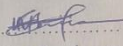
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**A DISSERTATION SUBMITTED TO THE DEPARTMENT OF ZOOLOGY,  
ENTOMOLOGY AND FISHERIES SCIENCES IN PARTIAL FULFILLMENT FOR THE  
AWARD OF BACHELOR OF SCIENCE IN FISHERIES AND AQUACULTURE OF  
MAKERERE UNIVERSITY.**

**AUGUST, 2024**

**DECLARATION**

I NAMA KULA HALIMAH, hereby declare that this work is originally prepared by my own effort and has never been submitted to any other institution of learning for any academic reward.

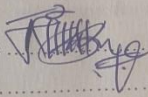
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**APPROVAL**

This is to officially certify that I have approved this dissertation for submission.

Signature  .....

Date ..... 12<sup>th</sup> Aug. 2024

DR JOHN JOSEPH KISAKYE

## **DEDICATION**

I dedicate this dissertation to my family and friends for the unconditional support and encouragement. I am forever grateful for the overwhelming guidance and financial support from my father, mother, brothers and sisters. I also dedicate the dissertation to my supervisors who were devoted to enhancing the quality of my research.

## **ACKNOWLEDGEMENT**

Special appreciation to my supervisor for always creating time for me to come up with this research, I shall always be indebted to you. Appreciation to the staff at the Department of Zoology for handling me as a child of your own, the continued advice and guidance I have acquired can never be taken for granted.

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Special appreciation to my friends for the standing with me throughout this academic journey.

Special thanks to me for coming this far it has not been an easy journey but am grateful to come through it.

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## ABSTRACT

This study investigated the occurrence, infestation levels and diversity of ecto-parasites during sex reversal in Nile tilapia fry. Two subpopulations were used to study the prevalence of parasites in fry that is one fed on sex reversal hormone and another that was not treated with the hormone.

Fish fry were collected from the brood stock ponds using a seine net (Weinstein and Davis, 1980) counted and their weight measured using a digital weighing scale. A total of 150 fish fry were examined for ectoparasites using standard parasitological procedures.

Five species of parasites were identified, consisting of 3 protozoans (*Trichodina heterodentata*, *Trichodina magna*, and *Trichodina constrostrigata*) and 2 monogeneans (*Gyrodactylus salaris*, and *Dactylogyrus vastator*).

The study findings showed that *Trichodina heterodentata* was the most abundant followed by *Gyrodactylus salaris*, *Trichodina magna*, *Dactylogyrus vastator* and *Trichodina constrostrigata* being the least abundant. Furthermore, the prevalence of the parasites in examined fish fry was significantly higher in the sample treated with sex reversal hormone (91.33%) than in the fish fry sample not treated with the hormone (62.67%).

Nevertheless, the diversity of parasites was low illustrated by the low value of Shannon Weiner diversity indices recorded in sex reversed sample ( $H=1.07$ ) and control group ( $H=0.74$ ).

In the view of the study findings and the pathological effects of the different parasites identified on the examined fry samples, MIG fish farm is liable to facing high mortalities, increased cost of production, reduced profit margin, losses and at the extreme failure of the business enterprise. Therefore, appropriate and strategic management measures should be designed and followed for proper management and business flow.

**Key words:** Prevalence, Mean intensity, and Diversity.

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background

Globally, tilapia have become the second most farmed fish species after the carps. Nile tilapia are farmed commercially in over 100 countries making it second in sales and volume in international trade after the salmonids. Tilapia, especially, the Nile tilapia (*Oreochromis niloticus*), frequently referred to as ‘aquatic chicken’, has become the basis of aquaculture in a number of countries just as chicken makes the basis of poultry (Menaga, 2017). FAO (2020) reports that the global production of tilapia has exceeded 5 million tons per year since 2014. This is because Nile tilapia possesses many attributes making it an excellent candidate for warm water aquaculture, including fast growth rates, high tolerance to a wide range of environmental conditions, resistance to stress and diseases, ability to reproduce in captivity, a short generation time, ability to feed at a low trophic level and acceptance of artificial feeds immediately after yolk-sac absorption (Adeleke *et al.*, 2020).

This extensive popularization of Nile tilapia has depended on a number of technologies geared towards rationalization of input resources such as water and electricity, improved quality and number of fertilized eggs, improved production of tilapia fry, enhanced growth rates and feed conversion, and generating of monosex populations. Generation of monosex populations of *Oreochromis niloticus* tends to promote higher growth rates, prevent stunted growth and improve marketability of the fish, thereby making the strategies for generating of monosex populations a critical objective for the tilapia culture industry.

However, the benefits of the various technologies, including development of monosex populations have been compromised by a diversity of elements including environmental factors such as temperature, pH (Orban and Liew, 2014) and parasite infestations. Parasitic infestations and other infectious diseases have emerged as a limiting factor to hatchery production (Paladini *et al.*, 2017). Especially during the early course of fish development particularly at fry and fingerling levels

when the immune capacity of the fish is still limited to fight the etiological agents (Wang *et al.*, 2017). In fish, parasites range from ectoparasites to endoparasites with the ectoparasites attaching on different surfaces of the skin such as gills, anal opening and the endoparasites infecting different body organs (Marzouk *et al.*, 2013). Parasites in a hatchery may be as a result of increased stocking densities and water pollution. Monogenean worms and ciliated protozoans are the most common parasites in Nile tilapia culturing and their presence indicates the health and environmental pollution of the ecosystem (Garcia, 2020).

Nile tilapia fry are more susceptible to parasitic infestations due to their under developed immune system and the lack of protective mucus and scales on their skin. However, husbandry practices such as overcrowding and undesirable environmental changes in water quality can also compromise the immune system of the fry making them more susceptible to parasitic diseases. Thereby leading to massive death hence low production of an aquaculture system.

Occasionally, these objectionable husbandry practices and obnoxious environmental parameters in water quality coupled with subjection of the fry to stress while administering sex reversal protocol may happen in the hatchery facility thereby exposing the fish stage to parasites leading to subsequent reduction in survival of the fingerlings, which is common at MIG fish farm.

MIG fish farm is one of the fastest growing private commercial aquaculture farms in the Eastern region of Uganda with a total production of 1,300 tons per year. The farm usually faces low fingerling production hence having to import fingerlings from other neighboring farms with high production.

## **1.2 Statement of the problem**

Parasite infestations in tilapia fry are among the major causes of low fry production in the hatchery thereby leading to massive mortalities and reduced survival of fingerlings when transferred to the nursery. This has led to the continued purchasing of fingerlings from other farms. During sex reversal stage, fish tend to be stressed hence compromising immunity of the fish, thereby exposing fish to a diversity of parasites. Parasites, whether ecto or endo, have varying impacts on fish including mechanical damage such as fusion of gill lamellae, tissue replacement and physical damage such as cell proliferation, immunomodulation, detrimental behavioral responses, altered growth, reproductive damage and in severe cases mortalities. However, in Uganda, limited information has been accumulated on the parasitic infestations during sex reversal. Therefore, the

study aims at identifying the different parasites infesting Nile tilapia fry during the reversal stage, otherwise low survival of fingerlings from the hatchery will continue unabated at MIG fish farm hence purchasing of fingerlings elsewhere will persist thus leading to low development of the farm.

### **1.3 Major objective**

Assess the prevalence of parasitic infestations in Nile tilapia fry during sex reversal at MIG fish farm.

### **1.4 Specific objectives**

1. To document the different parasite communities in Nile tilapia fry populations under treatment of sex reversal hormone.
2. To determine the diversity of parasites in Nile tilapia fry at MIG fish farm.
3. To determine the water quality of the culture system

### **1.5 Research questions**

What are the types of parasites infesting Nile tilapia fry during sex reversal?

Is the abundance of the different parasite communities found in Nile tilapia fry treated with sex reversal hormone different from those not treated with the hormone?

Is the water quality within the recommended levels?

### **1.6 Significance**

The study will help to understand the prevalence of parasitic infestations on *Oreochromis niloticus* and will provide a better understanding of whether the parasite infestations are related to sex reversal hormone at MIG fish farm. The information will be used by the MIG fish farm and other such relevant parties to implement farm-based management procedures during hormone administration to control parasite infestations in fry. The information will also motivate the hormone manufacturers to consider addition of immune boosters to the sex reversal hormone so as to strengthen the immune system.

## CHAPTER TWO

### LITERATURE REVIEW

#### **2.1 Overview of Aquaculture production**

In 2020, fish production from aquaculture contributed 49.2% globally (FAO, 2022), with inland aquaculture producing 54.4 million tons of aquatic animals accounting for 44.4% of the world's farmed fish production (FAO, 2022). Aquaculture is a vital economic activity and therefore provides livelihood to majority people in Africa through providing good alternative sources of income especially in the rural communities. In 2020, an estimated 58.5 million people were engaged in primary sector of fisheries and aquaculture with 23% of whom were women (FAO, 2022). Globally, the proportion of women in the total work force in aquaculture is 19% larger than that in fisheries at 12%. In total, about 20.53 million people are employed in aquaculture and 38.98 million in fisheries (FAO, 2022).

#### **2.2 Sex reversal in tilapia**

Sex reversal techniques are largely used for the control of sex in fish farming and in fundamental studies on sex determinism mechanisms. All-male culture of tilapia is preferred because of their faster growth than females and to prevent uncontrolled reproduction (Beardmore *et al.*, 2001). Production of all male tilapia can be accomplished by such techniques as separating the males and females manually, hybridization, chromosomal manipulation and hormonal sex reversal. The most efficient and least expensive method is sex reversal with the use of  $17\alpha$ -methyl testosterone (Megbowon, 2013). Sex reversal in tilapia involves the treatment administration of male steroid to recently hatched fry so that the undifferentiated gonadal tissue of generic female develops testicular tissue, thus functioning reproductively as male (Megbowon, 2013).  $17\alpha$ -methyltestosterone hormone was reported to up-regulate *dmrt1*, a gene involved in testicular differentiation, from 19 dpf in XX tilapia (Kobayashi *et al.*, 2008). However precocious initiation of the differentiation pathway that could occur in the brain or in the primordial germ cells before the development of the gonad (Tsai *et al.*, 2000). Therefore sex reversal treatments target early developmental stages in order to study the upstream mechanisms and trace the sex determinism cascade up to the major determinants (Oluseun *et al.*, 2015). During ontogenesis, the brain starts to morphologically differentiate from 31 hour post-fertilization (hpf) and the primordial germ cells can be identified from 46 hpf in Nile tilapia (Morrison *et al.*, 2001). Primordial germ cells then migrate to the genital ridge to form a gonadal primordium by the 7th hpf (Kobayashi *et al.*, 2008).

Basing on the assumption that the first steps of molecular sex differentiation would occur during these precocious developmental events, it could be possible to modify the sex determinism by treatments applied during the embryonic period.

### **2.3 Fish parasites**

Major parasitic infections in fish are associated with protozoans and monogeneans (Sayyaf *et al.*, 2021)

#### **2.3.1 Protozoa**

Protozoans are unicellular organisms which are mainly free living in aquatic environments (Klinger and Floyd, 2002). Protozoan parasites usually develop under favorable conditions such as poor water quality, high stocking densities, insufficient feed and poor handling methods (Lom and Dykova, 1992). Parasitic protozoa that infest fish can either be endo or ecto (Lom and Dykova, 1992). Reproduction is by binary fission hence easily accumulating when the fish are crowded (XU *et al.*, 2012). The parasite can cause weight loss that is the fry do not add on weight and can also cause mortality in the fry (Florio *et al.*, 2009). Protozoan parasites infest the gills, skin and body surface of the fish. Notable protozoans common in infesting fish include *Trichodina*, *Ichthyoboda*, *Ichthyophthirius*, and *Chilodonella* species. The most abundant protozoan groups parasitizing fish are; coccidian species such as *Eimeria* and *Gaussia* spp, ciliates like *Ichthyophthirius multifiliis*, *Chilodonella* spp and *Trichodina* (Basson, 2006).

#### **2.3.2 Monogeneans**

Monogeneans are a class of parasitic flatworms found on the gills and skin of fish and lower aquatic vertebrates (Cribb *et al.*, 2002). Monogeneans move freely on the fish's body surface while feeding on mucus and epithelial cells of the gills and skin although adult forms remain permanently attached on a single site of the host fish (Bakke *et al.*, 2002). Monogeneans have a haptor which is a specialized "holdfast organ" at their posterior end that has hooks or clamps for attachment to their host. (Ellis and Watanabe, 1993). Common monogeneans infesting fish fry include members of genera *Gyrodactylus* and *Dactylogyrus*. *Gyrodactylus salaris*, *G. ulinganisus*, *G. hildae* and *G. cichlidarum* attach on the skin surface and the gills (Garcia *et al.*, 2010).

# CHAPTER THREE

## MATERIALS AND METHODS

### 3.1 Study area

The study was conducted at MIG Fish Farm located in Busuyi village Wairasa Sub County, Mayuge district in the Eastern Region of Uganda. The farm is in the neighborhood of Busuyi landing site on Lake Victoria. MIG fish farm is located 0.442781 North and 33.331721 East, about 40 km from the Jinja on Mbale highway. MIG fish farm is seated on four hectares of land onto which a total of six earthen ponds are used for a number of purposes such as brood stock and fry rearing.

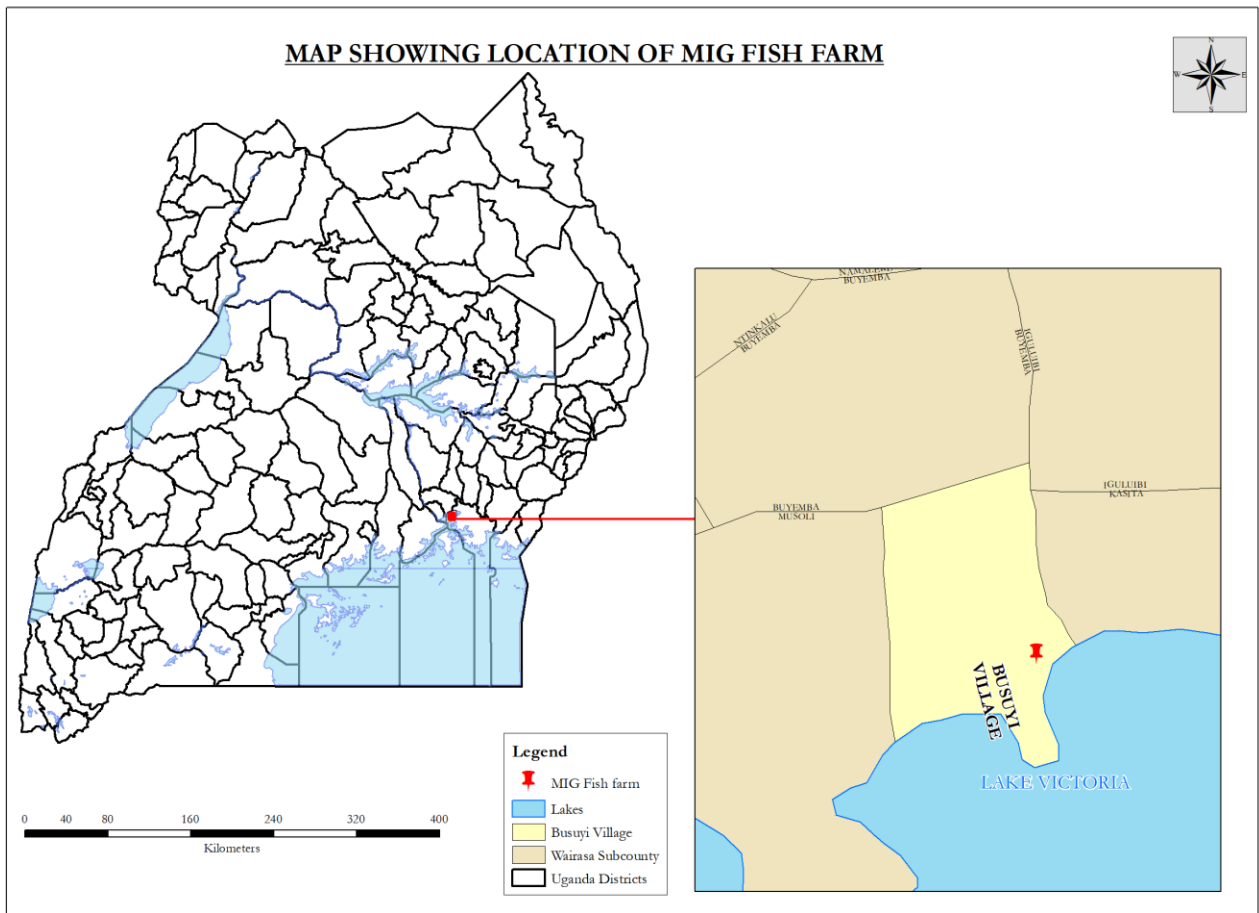


Figure 1: Location of MIG fish farm in Busuyi village, Uganda.

### **3.2 Fish fry sampling and processing**

1000 Fries were collected from the brood stock ponds using a seine net (Weinstein and Davis, 1980) counted and their weight measured using a digital weighing scale. A sample of 10 fry was taken to the laboratory for observation under a microscope to record parasites. The remaining 990 fries were introduced into a happa in the rearing pond. After introducing the fry in the happa, powdered feed mixed with the hormone (17 $\alpha$ -methyltestosterone) was used to feed the fry (Okoko, 1996). The water quality parameters including temperature, pH and ammonia were measured while feeding the fry. Samples of fry were picked at an interval of 3 days a week for one month from the happa and observed under a microscope to identify any possible parasites that maybe attached on the fish. The observed parasites and their intensity of occurrence on the different fry were recorded. The observation and collection of samples was done for a period of 21 days while the fry are still fed on the hormone.

### **3.3 Examination and identification of parasite species**

The ecto-parasite examination procedure began with scrapping on the surface of the fish. Gill examination was done by cutting the operculum so that the gill sheets are exposed, scarping on the gill lamella was done then smeared on a slide with little physiological solution, before observing under a microscope as described by Noga (2011).

Furthermore, fin examination was done following a method outlined by Lucky (1977). by cutting pieces followed by placing them in petri dishes containing physiological solutions. The preparation was the observed under a microscope.

### **3.4 Water quality sampling**

Water samples were obtained daily from the investigated fish farm. The water's physical and chemical parameters, including dissolved oxygen, pH and temperature, were measured using a multipara meter probe. Total ammonia nitrogen concentration (mg/l) was measured using an ammonia probe (Arie, 2011).

### **3.5 Data presentation and analysis**

Raw data collected were presented as number of sampled fish, number of infested fish and number of the different species of parasites on infested fish body parts (Rosner and Glynn, 1997).

In order to determine whether the number of parasites on infested fish differ, Shannon wiener diversity index was used to establish the species richness of the identified parasites in the examined fish fry samples. R-statistical software was then used to analyze the data for any significant differences in the diversity of parasites infesting tilapia fry between sex reversed and the non sex reversed sample.

Descriptive statistics including percentages and 95 % confidence intervals were used to summarize the proportion of infested fish. Statistical significance was set at 5% level of significance.

The prevalence was calculated as the number of infested fish (number of infested fish/total number of fish examined  $\times 100$ ) (Reiczgel, 2003). The mean intensity, which is the number of particular parasites found on an infested fish, was also calculated to show the rate of infestation by the parasites.

## CHAPTER FOUR

### RESULTS

#### 4.1 Infestation and prevalence of parasites in the examined fry

Two subpopulations were used to study the prevalence of parasites in fry that is one fed on sex reversal hormone and another that was not treated with the hormone.

A total of 1152 parasites were identified on 300 fries for a period of one month during the 14 days of sampling. Table 4.11 summarizes the numbers of the different parasites along with their mean intensities.

**Table 4.1 1: Different parasites found on examined fry and their prevalence.**

Parasite	Treated Group				Control Group			
	No. of parasites	No. of fish infested	Mean intensity	Prevalence (%)	No. of parasites	No. of fish infested	Mean intensity	Prevalence (%)
<i>Gyrodactylus salaris</i>	133	35	3.80	23.33	74	28	2.64	18.67
<i>Trichodina constrostrigata</i>	0	0	0	0	1	1	1.00	0.67
<i>Dactylogyrus vastator</i>	2	1	2.00	0.67	0	0	0	0
<i>Trichodina magna</i>	48	33	1.45	22	28	23	1.22	15.33
<i>Trichodina heterodentata</i>	582	68	8.56	45.33	284	42	6.76	28

From Table 4.11 it can be noted that that 5 species of parasites were recorded, consisting of 2 protozoa and 3 monogeneans

*Dactylogyrus vastator* was only detected in the sample treated with sex reversal hormone while *Trichodina constrostrigata* was only detected in the sample that was not sex reversed.

Furthermore, the mean intensities of the s species of protozoans (*Trichodina magna*, *Trichodina heterodentata* and *Gyrodactylus salaris*) were higher in the sample treated with sex reversal

hormone than in the sample which was not treated with the hormone as illustrated in Table 4.11 above. Generally, the prevalence of parasites in examined fries was higher in the sample treated with sex reversal hormone (91.33%) than in the sample where fries were not fed on the sex reversal feed (62.67%) as illustrated in table 4.11.

#### **4.2 Diversity of parasites found on examined fry samples**

The diversity of parasites in the sex reversed sample according to Shannon wiener diversity index was  $H=1.07$  while that of the control group was  $H= 0.74$ .

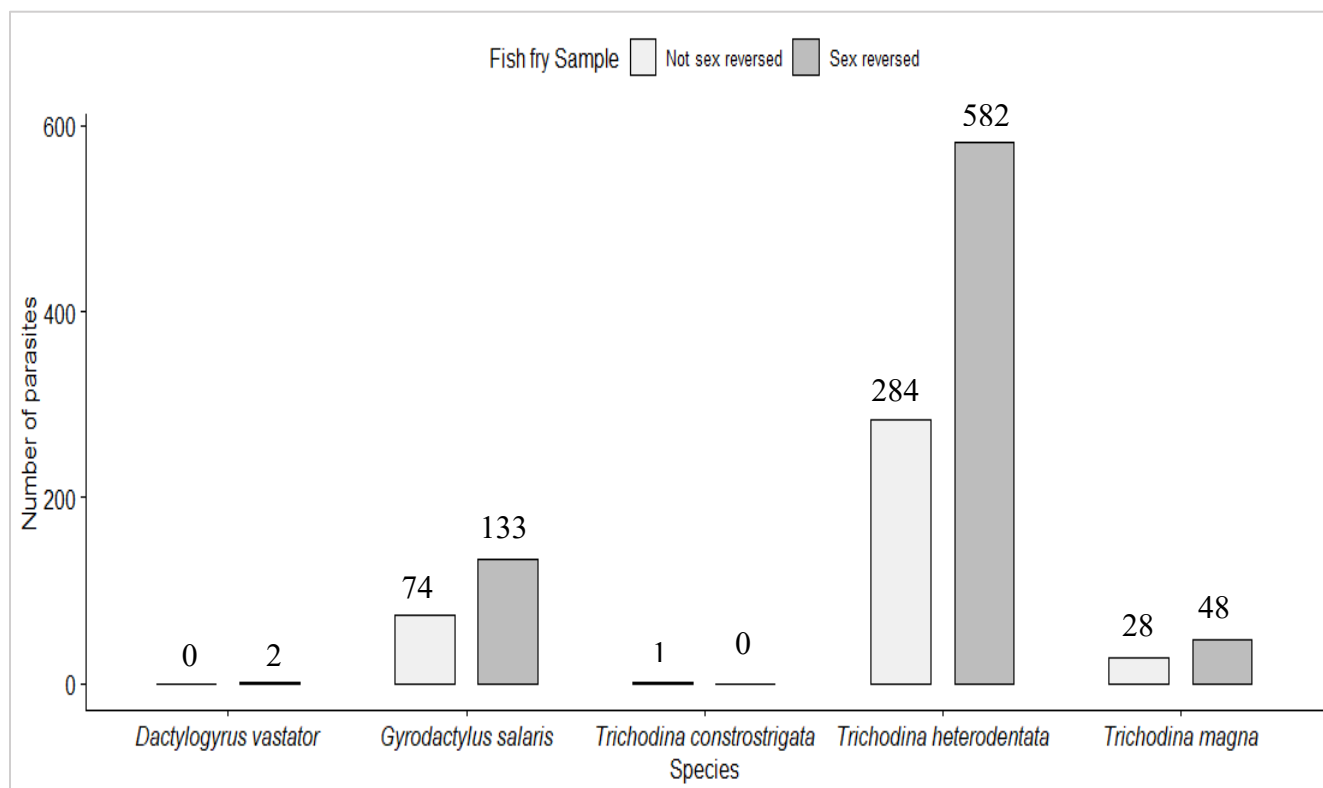
Then t test for unmatched pairs at 5% significant level clearly indicated that the prevalence of parasites was significantly higher in the sample of fries treated with sex reversal hormone than in the control group which were not treated with the sex reversal hormone

Table 4.12 summarizes the results of the statistical tests. The species richness and abundance for each habitat are illustrated in Figure 2.

**Table 4.1 2: Statistical analytic results of tests of significance**

Statistical test	Test statistic	p-value
Shapiro Wilk Normality test	W = 0.57412	0.322
t test for unmatched pairs	t = 5.1102	0.03112

The abundance of the detected parasites in the examined fish fries for each sample is illustrated in Figure 2. It can be noted from Figure 2 that the number of parasites identified in the two samples of Nile tilapia fry (sex reversed and non-sex reversed) is higher in the sex reversed Nile tilapia fry than in the sample which was not sex reversed.



**Figure 2: Number of the different parasites found in examined fish fry samples**

### 4.3 Water quality results

The water quality in the happas was found good for fish life as consistent with (Arie, 2011), who reported that tilapia (*Oreochromis niloticus*) was able to tolerate temperatures between 14- 38°C, optimal oxygen content for the growth of tilapia 4 mg/l, and a good pH range for Tilapia ranges between 6.5 and 8.5 The water quality results are summarized in Table 4.13.

**Table 4.1 3: Mean water quality parameters**

<b>Parameter</b>	<b>Mean Value</b>	<b>Quality standards</b>
Temperature	$29.5 \pm 3^{\circ}\text{C}$	28-32°C
Dissolved oxygen	$5.2 \pm 0.9\text{mg/l}$	$\geq 4\text{mg/l}$
pH	$7.82 \pm 0.38$	6-9
Ammonia	$0.01 \pm 0.6 \text{ mg/l}$	$\leq 0.02\text{mg/l}$

## CHAPTER FIVE

### DISCUSSION

The ectoparasites found in this study have been commonly observed in *Oreochromis niloticus* and described in several previous reports under various culture systems (Braccini *et al.*, 2008; Bucur *et al.*, 2011; Jerônimo *et al.*, 2011). The diversity was low due to the less number of the different parasites identified infesting Nile tilapia fry compared to those identified in Mexico (Francisco *et al.*, 2018) who reported 13 species in a similar study on the examined fish samples. This is because the study in Mexico was run for a longer period of 11 years as compared to this study that was undertaken for a shorter period of time (1 month) thus fewer parasites species were identified. The Shannon Weiner diversity index is a function of number of species and evenness of individual distribution in the species therefore a low number of species and individuals with in the same species will decrease the diversity (Ghirardelli *et al.*, 2006).

Furthermore, the five species of parasites (*Trichodina magna*, *Trichodina heterodontata*, *Gyrodactylus salaris*, *Trichodina constrostrigata* and *Dactylogyrus vastator*) identified in examined fry samples in this study correspond with those that were found in Brazil (Aline *et al.*, 2014).

The findings of prevalence and intensity of ectoparasites indicated in Figure 2 are often contradictory, as reported by Baidoo *et al.* (2015) who found prevalence and the mean intensity of parasites relatively low in cage farmed tilapia in Ghana but also recorded a low rate of prevalence and intensity of parasites on *Oreochromis niloticus* from fish ponds, attributed to good pond water and proper management practices.

From this study the prevalence of ectoparasites was investigated to determine the effect of sex reversal feed on the immunity of Nile tilapia fry. In the light of this, the study findings indicated that the prevalence of the parasites in examined fish fry was significantly higher in the sample treated with sex reversal hormone (91.33%) than in the fish fry sample not treated with the hormone (62.67%). This is due to the fact that, there is a clear relationship between ectoparasites and nutritional quality as affirmed by Suliman and Al-Harbi (2015)

The presence of ectoparasites is related to water quality and pond management (Moraes and Martins 2004). Other authors also found a relationship between host, parasite, and the environment (Buchmann and Lindstrom 2002; Suliman and Al-Harbi 2015), who reported higher prevalence of parasites in culture systems with deteriorated water quality

In the view of this, water quality sampling results indicated in Table 4.13 that the water quality parameters were within the recommended levels for fish growth. Therefore, the differences reported in the prevalence of parasites between the two fry samples groups are solely as a result of the sex reversal hormone treatment and handling practices. Additionally Pavanelli *et al.*, (2008), suggested that the susceptibility of fish to parasites and diseases depends on several factors related to stress caused by nutritional status, handling and, particularly, water quality. Thus the existence of the identified parasites found in the examined fries is a function of the environment and management practices. Therefore, from the present study feed treated with the hormone stressed the fries lowering their immunity and defense mechanism rendering them more susceptible to parasite infestation than those that were not sex reversed.

Furthermore, the study findings showed that *Trichodina heterodentata* was the most abundant followed by *Gyrodactylus salaris*, *Trichodina magna*, *Dactylogyrus vastator* and *Trichodina constrostrigata* being the least abundant. Similar patterns have been reported in previous studies carried out in various culture systems in Cost Rica (Donald *et al.*, 2017), Ethiopia (Solomon *et al.*, 2024) and Egypt (Aly *et al.*, 2020). The similarity that exists in the study findings suggests existence of the same parasites in Nile tilapia fries.

Trichodinid parasites have great significance in the commercial production of tilapia and occur in a wide quantity of fish farming systems (Ghirardelli *et al.*, 2006). In the present study, *Trichodina* spp presented the highest abundance and mean intensity in the examined fry samples. Additionally, Akoll (2005) reported that *Trichodina* spp is the most prevalent protozoan parasite taxa recorded in Uganda.

*Trichodina* spp occur in the gills and on the body surface of fish and may cause mucus hypersecretion and lesions in the integument and gills (Pavanelli *et al.*, 2008) and their transmission is through the water as well as direct contact with infected fishes (Indahsari *et al.*, 2019). Furthermore, in young fish, the *Trichodina* spp infestation has a serious effect, particularly when the parasite intensity exceeds 25 parasites /microscope fields as reported by Eissa (2004).

On the other hand, monogeneans (*Gyrodactylus* and *Dactylogyrus* species) are considered to be responsible for the most important parasitic diseases in fish farming and cause high mortality rates. (Aline *et al.*, 2014). The presence of these parasites in fish gills causes hypersecretion of mucus, cell hyperplasia, and even fusion of the filaments of gill lamellae, reducing the host's gaseous exchange and hence respiratory capacity (Pavanelli *et al.*, 2008).

*Dactylogyrus vastator* infest the gills and induce severe hyperplasia on the gill filament epithelium that interferes with respiratory function at extreme proliferation and can result into mortalities (Barker and Cone, 2000).

The parasites identified in the present study have been reported in previous studies carried out in various culture systems; tanks and ponds in Cost Rica (Donald *et al.*, 2017), ponds in Ethiopia (Solomon *et al.*, 2024) and cages in Egypt (Aly *et al.*, 2020). In the light of this, the different culture systems used don't inflict the abundance of the parasites infesting the fish but rather the nutritional status and water quality as illustrated above.

In the view of the study findings and the pathological effects of the different parasites identified on the examined fry samples as stated above, MIG fish farm is liable to facing high mortalities, increased cost of production, reduced profit margin, losses and at the extreme failure of the business enterprise. Therefore, appropriate and strategic management measures should be designed and followed for proper management and business flow.

## CHAPTER SIX

### CONCLUSIONS AND RECOMMENDATIONS.

#### 6.1 Conclusions

1. Four species (*Trichodina magna*, *Trichodina heterodentata*, *Gyrodactylus salaris*, and *Dactylogyrus vastator*) of parasites were documented in the examined fish fry samples during treatment with sex reversal hormone. This implies that the parasites may compromise the health and development of the fry potentially leading to increased mortality rates and reduced growth of the fry. The parasitic infestations could also affect the overall sex reversal treatment as stressed fish may not respond well to hormonal interventions.
2. The high mean intensities of *Trichodina* spp which causes irritations and damage to the fish's gills and skin leading to respiratory distress, increased mucus production and reduced feeding behavior. This implies that effective control measures such as improving water quality and implementing appropriate treatment and proper handling of fry to minimize the effects of the parasite.
3. The water quality at MIG fish farm was good and within the optimum ranges that support fish growth which indicates that the culture environment is suitable for smooth operation of the aquaculture enterprise. This implies is likely to maintain good fish health and productivity hence potentially leading to increased yields and profitability.

#### 6.2 Recommendations

1. The study recommends treatment of water through filtration, heating and ultraviolet radiations to kill any possible parasites that come along with the water as well as cut off the reproduction chain through killing of eggs and removal of cysts of the parasites.
2. Furthermore, when the sex reversal hormone is administered, critical handling and improvement in management practices at MIG fish farm should be put into practice. This is because handling tends to subject fish to stress which reduces the immunity of the fish making them susceptible to parasitic infestations.
3. Further studies should be done putting temporal and spatial variables such as more time and other areas of the country. This is because this study was carried out in a period of 1 month therefore more time should be used so as to be able to make comparisons with other

farms in different areas of the country. This will enable to establish a reliable baseline for designing strategic and appropriate management measures.

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## APPENDICES

### APPENDIX 1: COLLECTION AND SAMPLING OF FRY



Figure 3: collection of fry



Figure 4: collected fry to be taken to the laboratory

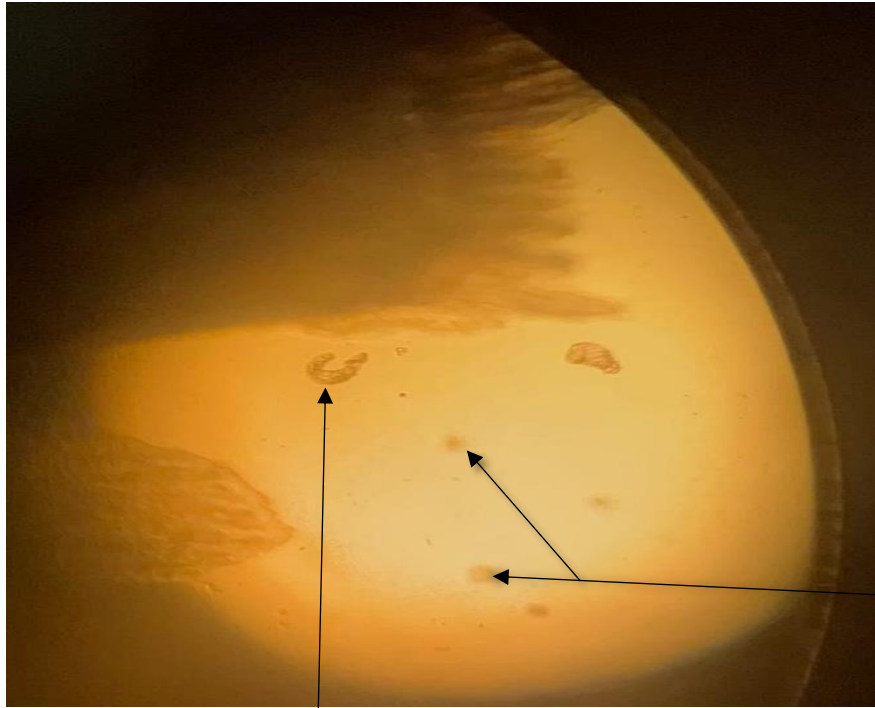


Figure 5: placement of fry onto the microscope stage

## **APPENDIX 2: EXAMINATION AND IDENTIFICATION OF PARASITES**



Figure 6: observation of the different parasites on fry



*Trichodina* spp

*Gyrodactylus salaris*

