Parasitic loads in the genetically improved (F7) Nile tilapia Oreochromis niloticus (L.) cultured in fish farms in Busia and Siaya Counties, Kenya: indicators of increased resistance and efficiencies of synergistic technologies adoptions

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Abstract

In Kenya, breeding programmes whose source of genetic material is local water bodies are at inception with the National Aquaculture Research Center, Sagana being the Nile tilapia and African catfish breeding nucleus. Fish are susceptible to a variety of infections and diseases. These microorganisms are often present on the external surfaces and visceral organs of the fish. In order to minimize fish disease burdens a number of fish health management practices and biosecurity measures have been recommended. In this study, a combination of new genetically improved fish strains, liming, netting and biofloc technologies were used in selected fish farms in Busia and Siaya Counties for validation. A total of 113 Nile tilapia were collected (93 from Bukani Aquaparks and 20 from WOODM fish farm) using a seine net. The fish were killed by cervical dislocation. This was followed with measurements of the total lengths and weights. Standard examination procedures were used. A total of 6 different taxa of parasitic species were recovered during the study. These included: Protozoans such as *Trichodina* sp; Myxozoans such as *Myxobolus* sp.; Flatworms such as the monogenean *Cichlidogyrus* sp.; the Trematodes such as the digeneans *Tylodelphys* sp. and *Euclinostomum* sp. and the Acanthocephalans such as *Acanthogyrus (Acanthosentis) tilapiae*. Overall, the findings of this study showed that there were very few parasites infesting fish with also very low infection rates. This study concluded that with the improved fish strain, employment of adequate biosecurity measures, parasitic infestation levels can be significantly lowered to levels of little concern.

Introduction

The world's population is expected to hit 9.8 Billion people by the year 2050 (UN 2017). In Africa alone, the population is expected to grow to up to 2.5 Billion in 2050. Concomitant with the population increase in the continent will be the increased food demand. The continent has an immense biodiversity of native fish resources and an alley of exotic species. However, due to poor management and genetic erosion, most aquaculture stocks in current use on the continent are genetically inferior to wild, undomesticated stocks (Lind et al. 2012; Brummet et al. 2004). It is widely accepted that successful aquaculture development in Africa requires improvements in feed quality and availability, business and marketing models, and local technical capacity. Another important factor that should be considered is the effective utilization and management of fish genetic resources (Lind et al. 2012; Ponzoni et al. 2011). Specifically, improved strains that are faster growing, resistant to disease, and suited for culture in a variety of fish farming conditions could go a long way to meet the demand for fish protein (Ansah et al. 2014). Indeed, it has been recognized that aquaculture will play a big role in food and nutritional security (Munguti et al. 2021). Besides that, aquaculture provides direct employment to many fish farmers, income generation, plays an important role in the Kenyan economy, contributing to food production, alternative livelihood opportunities, poverty alleviation and social development (Ogello and Munguti 2016; Rothius et al. 2011).

To achieve a rapid transformation of the aquaculture industry, there is need to upscale modern technologies, innovations and management practices (TIMPs) to realize sustainable development envisaged in the SDGs (Munguti et al. 2021). Due to the increasing importance of the tilapias in global fish farming, the intensity and diversity of efforts to improve the genetic baseline of these species have intensified over the last few decades. Ponzoni et al. (2009; 2008; 2006) showed that genetic improvement is one of the most powerful and least expensive means of increasing the efficiency of aquaculture. In Kenya, breeding programmes whose source of genetic material is local water bodies are at inception with the National Aquaculture Research Center, Sagana being the Nile tilapia and African catfish breeding nucleus supported by several multiplication centers across the country. External fertilization gives room for advanced genetic manipulation ranging from chromosome set manipulation, to gene transfer, hybridization, as well as selective crosses. Nile tilapia is at F7 generation under family selection approach. Ultimately, a genetically improved aquatic organism confers certain aquaculture advantages to the producer resulting in high productivity and economic gains at minimal cost (Munguti et al. 2021).

Fish are susceptible to a variety of infections and diseases caused by microbial pathogens and parasites just like other animals. These microorganisms are often present on the external surfaces and visceral organs of the fish (Paperna 1996; 1980). In order to minimize fish disease burdens a number of fish health management practices and biosecurity measures have been recommended (Kyule-Muendo et al. 2022). In this study, a combination of new genetically improved fish strains, liming, netting and biofloc technologies were used in selected fish farms in Busia and Siaya Counties for validation under the Kenya Climate Smart Agriculture Project. Biofloc technology (BFT) is a climate-smart technology that works on the basis of mass production of *in situ* microorganisms (Ogello et al. 2021). The microorganisms are credited for among other things: maintaining good water quality (Emerenciano et al. 2017) and biosecurity (Defoirdt et al. 2011).

Materials And Methods

Study area

The study was conducted in Bukani Aquaparks in Busia County and WOODM fish farm in Siaya County. Odende et al (2022) have provided a detailed description of the Bukani Aquapark, its location and rationale.

Fish sampling

A total of 113 Nile tilapia were collected (93 from Bukani Aquaparks and 20 from WOODM fish farm) using a seine net. The fish from Bukani Aquaparks were transported alive with the pond water to Wakhungu hatcheries for examination, while those from WOODM were transported to the Ugunja Sub-County offices for examination.

Fish examination

The fish were killed by cervical dislocation (Schäperclaus 1990). This was followed with measurements of the total lengths and weights. Standard examination procedures were used (Florio et al. 2009). Ectoparasites were identified through scrapings from the fins, skin and gills of the specimen and examined under light microscopes. The fish were then dissected with a pair of scissors and the internal organs removed for examination. A squash of some organs including the eyes, kidney, spleen, intestines and the muscle were made and examined under a dissecting microscope for the presence of endo-parasites. The parasites were identified morphologically using standard identification keys and pictorial guides (Paperna 1980, 1996; Scholz et al. 2004; Kuchta et al. 2012) and the parasitological parameters (prevalence, mean intensity, and mean abundance) calculated according to Bush et al. (1997). The estimation of the intensity of protozoan parasites infecting the fish was done in three categories defined by Jirsa et al. (2011) as follows: low < 10 parasite individuals per field of view, medium for 11–100 parasite individuals per field of view, and high for more than 100 parasite individuals per field of view at magnification of ×100.The parameters, such as the Shannon-Wiener diversity index, Simpson index of dominance, and Margalef species richness, were calculated using an online biodiversity calculator (https://www.alyoung.com).

Determination of the Fulton’s condition factor

The weights and lengths of the fish were used to calculate the fish’s well-being also known as the Fulton’s condition factor.

k=$\left(\frac{w}{l\square}\right)$ 100 (Froese 2006) Where; k = Fulton’s condition factor, W = the weight of the fish in grams (g), L = the total length of the fish in centimeters (cm).

Results

Characteristics Of The Fish Examined During The Study

The mean total length of the fish from Bukani fish pond 1 was 20.0 ± 1.2 cm, those of Bukani fish pond 2 had 18.5 ± 1.8cm, and those of Bukani fishpond 3 had 16.3 ± 1.8cm while those of WOODM fish farm had 16.8 ± 2.3cm. The sex ratios of the examined fish were as follows: all males, 1:1, 2:1 and 1:2, respectively. The fish which had the highest condition factor were those of Bukani fishpond 3 (Table 1).

Table 1
Showing the characteristics of the fish examined during the study

Study site	n	Mean Total length ± SD	Mean weight(g) ± SD	Mean k ± SD
Bukani fishpond 1	32	20.0 ± 1.2	131.9 ± 30.6	1.6 ± 0.2
Bukani fishpond 2	40	18.5 ± 1.8	124.1 ± 37.9	1.9 ± 0.1
Bukani fishpond 3	21	16.3 ± 1.8	89.6 ± 33.1	2.0 ± 0.5
WOODM fish farm	20	16.8 ± 2.3	-	-

Quantitative Parasitological Data (Dup: Abstract ?)

A total of 6 different taxa of parasitic species were recovered during the study (Table 2). These included: Protozoans such as *Trichodina* sp; Myxozoans such as *Myxobolus* sp.; Flatworms such as the monogenean *Cichlidogyrus* sp.; the Trematodes such as the digeneans *Tylodelphys* sp. and *Euclinostomum* sp. and the Acanthocephalans such as *Acanthogyrus (Acanthosentis) tilapiae*. Generally, the findings of this study showed that there were very few parasites infesting the studied fish with also very low infection rates (Tables 3–6**)**.

Table 2
Showing the parasites present in the various farms in Busia and Siaya Counties, Kenya

Parasite taxa	Bukani Fishpond 1	Bukani Fishpond 2	Bukani Fishpond 3	WOODM
Trichodina sp.	-	-	+	+
Myxobolus sp.	-	-	+	+
Cichlidogyrus sp.	+	+	+	+
Tylodelphys sp.	+	+	-	-
Euclinostomum sp.	-	-	+	-
Acanthogyrus tilapiae	-	+	+	+

Table 3
Showing the parasite infection parameters in Bukani Fishpond 1, Busia County, Kenya

Parasite taxa	Prevalence (%)	Mean Intensity	Abundance
Trichodina sp.	-	-	-
Myxobolus sp.	-	-	-
Cichlidogyrus sp.	3.1	1.5	0.09
Tylodelphys sp.	6.3	1	0.06
Euclinostomum sp.	-	-	-
Acanthosentis tilapiae	-	-	-

Table 4
Showing the parasites infecting fish in Bukani Fishpond 2, Busia County, Kenya

Parasite taxa	Prevalence (%)	Mean Intensity	Abundance
Trichodina sp.	-	-	-
Myxobolus sp.	-	-	-
Cichlidogyrus sp.	27.5	2.3	0.61
Tylodelphys sp.	7.5	1	0.08
Euclinostomum sp.	-	-	-
Acanthogyrus tilapiae	5	4.5	0.23

Table 5
Showing the parasites infecting fish in Bukani Fishpond 3, Busia County, Kenya

Parasite taxa	Prevalence (%)	Mean Intensity	Abundance
Trichodina sp.	4.8	Very low	Very low
Myxobolus sp.	4.8	Very low	Very low
Cichlidogyrus sp.	38.1	2.9	1.1
Tylodelphys sp.	-	-	-
Euclinostomum sp.	4.8	1	0.05
Acanthogyrus tilapiae	9.5	4	0.38

Table 6
Showing the parasites infesting fish in WOODM farm, Siaya County, Kenya

Parasite taxa	Prevalence (%)	Mean Intensity	Abundance
Trichodina sp.	5	Very low	Very low
Myxobolus sp.	5	Very low	Very low
Cichlidogyrus sp.	25	2.4	0.6
Tylodelphys sp.			
Euclinostomum sp.			
Acanthogyrus tilapiae	5	1	0.05

Discussion

Characteristics of the fish examined during the study

All the examined fish had a very high condition factor, with the lowest having a mean of 1.6±0.2. The high condition factors showed that the fish were in a very good health status or well-being. These fish being newly improved strain of Nile tilapia depicted promising results in terms of their good condition of growth.

Parasitic infections

Qualitative parasitological data

This is the first study on parasitic loads in a genetically improved fish in Kenya. Three monoxenous parasites: *Trichodina* sp., *Myxobolus* sp. and *Cichlidogyrus* sp. were recovered at very low prevalences, intensities and abundances. These parasites are known to have simple lifecycles. Under certain favorable conditions they are known to build up quickly. However, with the Biofloc Technology, which maintains water quality and biosecurity (Ogello et al. 2021), it seems to have helped reduce parasitic loads, especially with Trichodinids. Trichodinids are sometimes considered to be ecto-commensals (Woo 1995), and therefore, by providing bioflocs, hence restricting them within the unit. The heteroxenous parasites observed: *Tylodelphys* sp., *Euclinostomum* sp and *Acanthogyrus (Acanthosentis) tilapiae*, they seemed to have been accidental infestations, possibly introduced at stocking from seed source (Otachi et al. 2009).

Quantitative parasitological data

From the findings of this study, very few parasite taxa were recorded compared to other studies in cultured Nile tilapia in Kenya and elsewhere. For example, the study of Ojwala et al. (2018) recovered a high diversity of up to 15 species of parasites infesting Nile tilapia from several farms in Nakuru County, Kenya. Mitiku et al. (2019) also reported a higher number of parasitic taxa of up to 9 in Sebeta fish ponds in Ethiopia infesting Nile tilapia. In Uganda, Akoll et al. (2012) reported 8 helminth species in cultured Nile tilapia. In another study by Mwainge et al. (2021), they also observed low levels of infections in Nile tilapia in cages in Lake Victoria, although they did not specify the strain of the fish. The lower number of parasite taxa infesting the new improved F7 strain of Nile tilapia could be attributed to several probable factors. One of the factors could be increased resistance to parasitic infections. This is because other studies have reported increased immunity and resistance to diseases in selectively bred fish (Ansah et al. 2014; Greer and Harvey 2004), as was the case with the fish studied. Other factors, such as implementation of biosecurity measures, which were in place in the studied fish ponds such as; the use of lime and netting could also have had an impact on the parasites' ecology. Liming is known to among other things, improve and maintain the water quality but is also an effective disinfectant (Bhujel 2014). Disinfection should be an essential part of standard biosecurity practices to prevent disease outbreaks (Machen et al. 2008). Proper disinfection can be expected to be less expensive than the economic cost of antimicrobial treatment of an infected population, or the loss of part or all of that population due to the disease outbreak. The use of nets to prevent the entry of birds is also advantageous to the farms. The net not only prevent potential losses due to predation but also keeps away the piscivorous birds some of which are important definitive hosts of many heteroxenous parasites (Florio et al. 2009).

Conclusions

This study concluded that with the improved fish strain, employment of adequate biosecurity measures, parasitic infestation levels can be significantly lowered to levels of little concern as to the possibility of disease outbreaks and mortalities. If these measures are adopted and implemented by most fish farmers, then the overall fish production will increase significantly.

Declarations

Ethical approval and consent to participate

The research was carried out under Ethics approval by the Egerton University Ethics approval Committee

Human and animal ethics

The research was carried out under Ethics approval by the Egerton University Ethics approval Committee

Consent for publication

All authors have consented to the publication

Availability of supporting data

Data is available on request from the corresponding author

Competing interests

All authors declare that there are no competing interests

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were perofermed by EOO, DK, JA, JI, VM, and NO. EO, KO and JM provided critical review of the first manuscript written by EOO. All authors approved the final manuscript.

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Figures

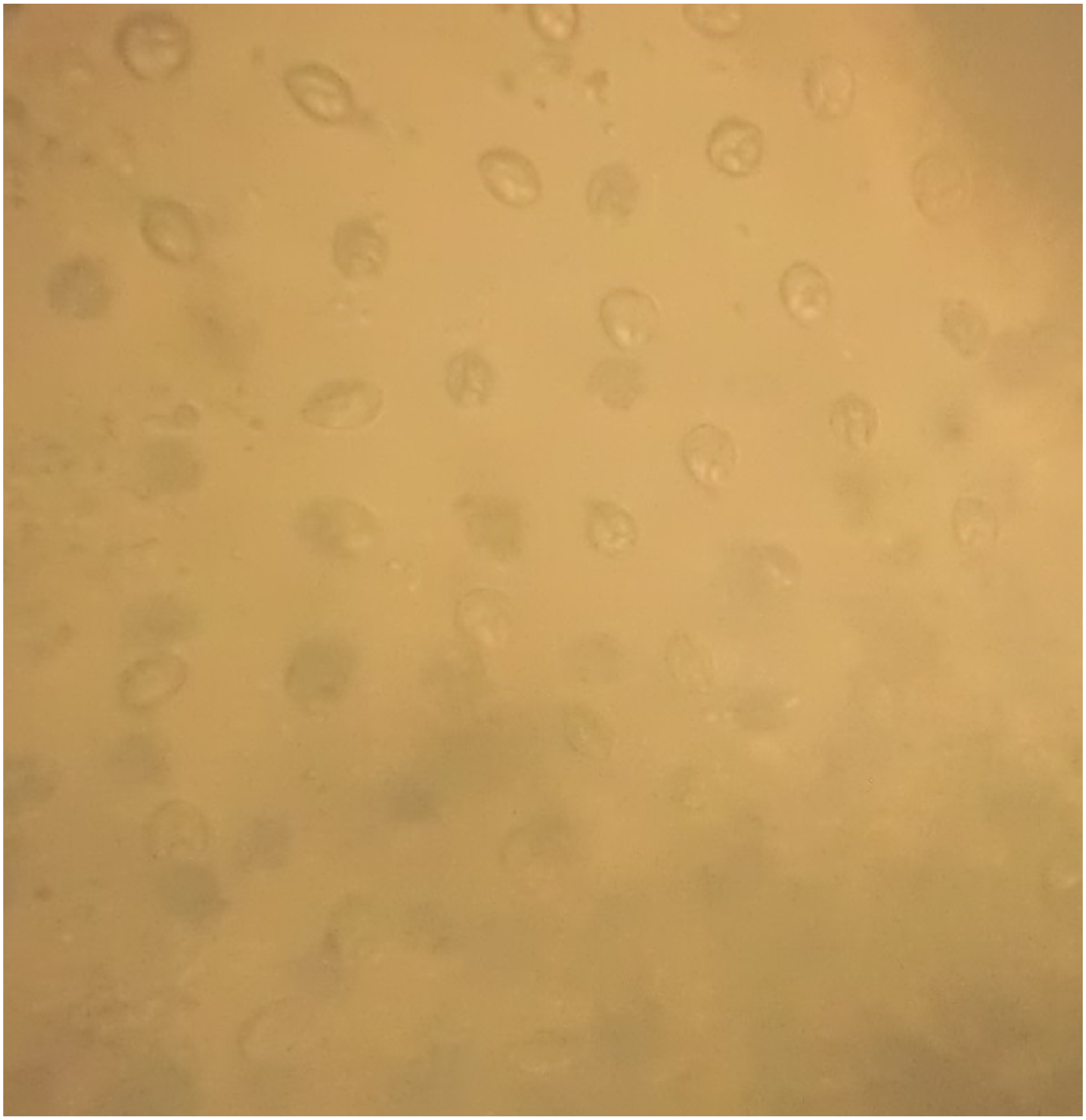

Figure 1

Showing *Myxobolus* sp recovered during the study

Figure 2

Showing *Euclinostomum* sp recovered during the study

Figure 3

Showing *Acanthosentis tilapiae* recovered during the study