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Risk factors associated with parasites of farmed fish in Kiambu County, Kenya

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Abstract
A cross sectional study was undertaken between October 2016 and March 2017 to determine the risk factors associated with parasitism of farmed tilapia (*Oreochromis niloticus*) in Kiambu County, Kenya. Semi-structured questionnaires supplemented with direct observations were administered to 148 fish farmers and 260 tilapia examined for ecto- and endo-parasites. Tilapia was the main species (66.5%) farmed under semi intensive system in earthen ponds. Most (53.5%) ponds were silted, with overgrown vegetation in and around them. Many farmers (46.4%) left fish to continue inbreeding in the ponds without restocking. Most farmers (33.1%) sourced water from rivers but majority (55.7%) did not change or refill the water within a production cycle. Only few farmers drained (30.3%) and limed (32%) ponds after fish harvesting. Majority (74.6%) shared a fishing net and only a few (4.1%) of them cleaned and disinfected it after use. Piscivorous birds (58.8%) and otters (22.6%) were the main predators reported. Fish parasites recovered were the helminth, *Acanthocephalus* spp. (10.4%) in the intestines, *Diplostomum* spp. (8.5%) in the eyes and *Clinostomum* spp. (3.5%) in the muscles. Others were the monogeneans *Dactylogyrus* spp. (3.5%) and *Gyrodactylus* spp. (0.4%) on the gills and skin, respectively. Infestation of fish from earthen ponds (31%) was significantly higher ($p < 0.05$) compared to liner ponds (3.3%). Various management practices were identified as risk factors for parasitism. There is therefore need to build capacity on proper fish farm management and increase health experts in Kenyan aquaculture.

Keywords: aquaculture, earthen ponds, management practices, parasites, tilapia

1. Introduction
There is a rapid increase in human population in Kenya, which requires more protein and micronutrients that can be provided by the fishes. Capture fisheries is declining from lakes and oceans hence a need to develop the aquaculture sector (FAO, 2016) [1]. Therefore, fish farming has recently received increasing attention among governments and development agencies. However, it has a number of challenges in form of predators, lack of feeds, high fish mortality, lack of management information capacity and poor fish seeds (Orina *et al*., 2014) [2], environmental pollution, biosecurity and spread of fish diseases (Munguti, 2014) [3]. Infectious and non- infectious diseases are considered the key limiting factors to aquaculture production, both from an economic and sanitary point of view (Blanco *et al*., 2000) [4]. Some parasites could be zoonotic especially helminths including the anisakid nematodes, *Anisakis simplex* and *Pseudoterranova decipiens*, cestodes of the genus *Diphyllobothrium* spp. and digenetic trematodes of the families Heterophyidae, Opisthorchiidae and Nanophyetidae (Noga, 2010 [10]; Robert, 2012 [22]) or occur as epizootics causing mass mortality (Otachi, 2009) [5].
Parasites are ubiquitous surviving in a dynamic equilibrium with their host(s) (Iwanowicz, 2011) [6] but alteration of this equilibrium by factors like environmental changes cause disease or mortality in fish. Various factors including: host age and size, parasites size, host specificity, host diet and sex, environmental factors, such as season of the year, size and type of water body, altitude, temperature, salinity, oxygen content and pH have been shown to influence parasitism in fish (State and State, 2009 [7]; Lagrue *et al*., 2011[8]; Ali *et al*., 2014 [9]). Influence of these and other management factors on parasitism have not been adequately documented in Kiambu County, Kenya.
Aquaculture has the advantage that it is possible to control the production system and many potential hazards at the production level can be controlled by using good fish farm management practices (Blanco *et al*., 2000) [4].

This study, therefore investigated management practices that can contribute to occurrence of ecto- and endo-parasites of farmed fish in Kiambu County, Kenya.

Materials and methods

Study area

The study was carried out in Kiambu County, Kenya between October 2016 and March 2017. The county is located at 1° 10' 0" South, 36° 50' 0" East with an average rainfall of 1,200 mm and mean temperature of 26 ºC.

Study design and data collection

A cross sectional study involving farm visits in the area was undertaken. A semi-structured questionnaire was prepared, reviewed, pretested and a final version incorporating the pre-test results was produced. The questionnaires were administered through face-to-face interviews to 148 fish farmers randomly selected from the 12 sub-counties of Kiambu County. Direct observations were also done to supplement the information given during the interviews.

Questionnaires assessed fish farm and owner data, farm management practices (pond water sources and frequency of changing pond water, pond drainage and treatment after harvesting, sharing of fishing nets, cleaning of fishing nets, animals found in and around the pond and management of vegetation around the ponds). Fish abnormalities seen in the farm, any disease control measures and farmers' knowledge on fish parasites were also assessed.

Fish samples

Two hundred and sixty (260) tilapia (*Oreochromis niloticus*) were obtained using a seine net 1cm by 1cm and transferred to a container with water from the pond where the fish came from. Of these, 200 were from earthen ponds and 60 from liner ponds. They were immediately transported to the laboratory at the Department of Veterinary Pathology, Microbiology and Parasitology, University of Nairobi for parasitological examination.

Parasitological examination

Live fish were stunned with a single blow to the back of the head and pithed to separate the central nervous system from the spinal cord. Gross examination of the skin was done for ectoparasites. Wet mounts of the skin scrapings and gill filaments were collected on slides with saline and examined under the microscope for ectoparasites. The eyes were removed and contents expressed on a slide and examined for eye flukes. Post mortem of the fish was performed as described by Noga (2010) [10]. Stomach and intestinal contents were collected in a Petri dish with saline and examined for parasites using a dissecting microscope.

Parasite identification

All the parasites recovered were manually counted and recorded. Identification and characterization of parasites was done using morphological features as described by (WOO, 2006) [11].

Data analysis

All the data collected was entered and cleaned in the computer using Microsoft Excel. Analysis was done using the Statistical Package for Social sciences (SPSS version 16.0) and Epi info statistical software version 7.0 where descriptive statistics by use of frequencies were obtained.

Results

Farmer's experiences in fish farming

Most farmers (52%) had been in fish farming for more than five years. Tilapia was the main (66.5%) fish farmed under mixed sex monoculture system (74.8%). Other farmed fish were catfish (31%), ornamental fish (2%) and rainbow trout (0.5%). Other culture systems practiced were monoculture one sex (17.7%) of either catfish or tilapia and catfish/tilapia polyculture (7.5%).

Farming system and pond types

Over sixty percent (60.8%) of the farmers had semi intensive farming system in earthen ponds (53.9%). There were also extensive (23%) and intensive (16.2%) farming systems. Other pond types used in the study area were liner (42.8%) and concrete (3.3%) ponds.

Source of fingerlings

Majority (78.8%) of farmers sourced their first stock of fingerlings from the government hatchery at Sagana in Kirinyaga County while, only few (17.8%) sourced from private hatcheries. The number of farmers who restocked from private and government hatcheries was equal (25.6%) while, a considerable number (46.4%) left the fish to inbreed in the ponds without external sourcing of fingerlings for restocking (Table 1). Five private hatcheries (i.e., Samaki tu, Jasa fish farm, Athi fish farm, Jambo fish and Mwea Aqua fish farm) served the farmers in the county.

Table 1: Source of fingerlings for fish farms in Kiambu County

Source of fingerlings	Number of respondents			
	Initial fish stock sources		Fish restocking sources	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Government hatchery	115	78.8	32	25.6
Private hatchery	26	17.8	32	25.6
Wild fish capture	2	1.4	1	0.8
Import fish or eggs	0	0	0	0
Own pond (in breeding)	0	0	58	46.4
Other farmers	3	2.0	2	1.6
Total	146	100	125	100

3.4 Pond water source and frequency of changing/refilling pond water

Rivers (33.1%) were the major sources of water for the ponds followed by wetlands (27%) and boreholes (25.7%). Other sources were piped water (8.1%), dams (4.1%) and harvested rain water (2%). Majority of farmers (55.7%) did not change or refill water in the fish ponds during a production cycle. Others changed or refilled at various intervals including once per month (20.5%), twice per month (17%) and once every two months (6.8%).

3.5 Pond draining and treatment
Only 30.3% of the farmers drained their ponds while, 44.4% treated the ponds after fish harvesting. Sun drying was the major pond treatment method used by majority (64%) of the farmers followed by liming (32%).

3.6 Fishing nets usage and cleaning methods
Majority of the farmers (74.6%) shared fishing nets with other farmers while 90.1% of those with multiple ponds used the same net between ponds. After using the nets, most farmers (75.4%) washed them with water only while, 10.7% dried the nets on the sun without cleaning them and 4.1% cleaned the net using water with a disinfectant. About 9.8% of the farmers did not clean the fishing nets at all.

3.7 Animals seen in and around fish ponds
Predatory birds were the major animals seen in ponds followed by otters, dogs, snakes, snails and monitor lizards in a decreasing order (Figure 1). Kingfishers were the major (22.3%) predatory birds reported followed by Ibis (18.5%), herons (13.6%) and egrets (10.3%). Others included: marabou stork (8.2%), cormorants (7.6%), hammerkop (7.1%), fish eagles (6%), wild ducks (2.7%), pelicans (2.2%) and crows (1.6%).

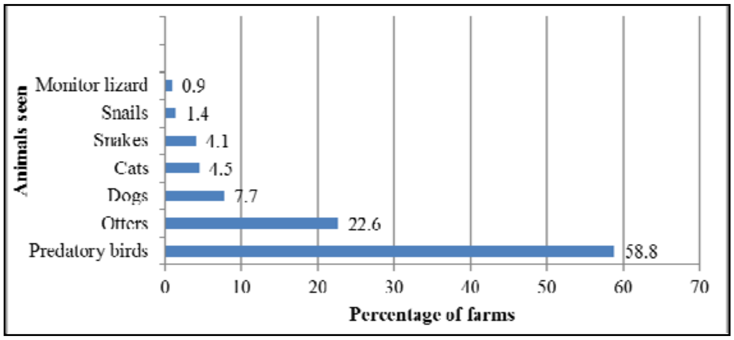

Fig 1: Animals found in and around fish ponds in Kiambu County

3.8 Vegetation management around ponds
Among the 148 fish farms visited, 53.5% had overgrown vegetation around the ponds (Figure 2). Majority were also observed to be highly silted.

Fig 2: An earthen pond with overgrown vegetation (blue arrows) around it in Githunguri sub-county, Kiambu County

3.9 Presence of fish abnormalities and deaths
Only 41.2% of farmers had seen fish abnormalities in the farm. Among the abnormalities seen included: skin lesions (spots, nodules, discolouration and dry skin), bent tail, sluggish swimming, rubbing on pond sides, flashing while swimming, retarded growth, floating and death. Fish death was the major (68.4%) loss reported by farmers. Majority of farms (51%) experienced fish deaths occasionally (16.7%) after harvesting, or monthly (13.7%), weekly (12.7%) and daily (5.9%).

3.10 Fish parasitism
Only 7.4% of farmers reported that their fish had been infested by parasites. Of the farmers interviewed, 21.6% did not know any sign of fish parasitism while, others mentioned various signs including: skin discolouration, poor or lack of feeding and reduced pond activity (27.1%) and fish deaths (21.1%) as the main signs (Table 2). Other signs mentioned included: flashing while swimming, difficult breathing/gasping for air, skin or gill lesions like white spots, loss of weight, rubbing against pond sides, overproduction of gill and /or skin mucus, bloating and clamped or droopy wings, respectively.

Table 2: Knowledge of farmers on signs of fish parasites

Clinical signs	Number of responses	Percentage (%)
Don't know	43	21.6
Death	42	21.1
Flashing while swimming	15	7.5
Difficult breathing/gasping for air	14	7.0
Skin or gill lesions like white spots	13	6.5
Loss of weight	8	4.0
Rubbing against pond sides and other objects	7	3.5
Overproduction of gill and/or skin mucus	1	0.5
Fish appear bloated	1	0.5
Clamped or droopy fins	1	0.5
Others (discoloration, poor or no feeding, reduced activity in pond)	54	27.1
Total	199	100

3.11 Disease control in fish farms
As shown in Table 3, clearing of vegetation was the major disease control activity practiced as reported by 54.3% of the farmers followed by control of predatory birds (39.8%).

Table 3: Disease control activities practiced by fish farmers in Kiambu County

Activity	Number of farms	Percentage of farms (%)
Clearing of vegetation	101	54.3
Control of birds	74	39.8
Liming	3	1.6
Water treatment	2	1.1
Control of snails	1	0.5
Others (fencing, water changing)	5	2.7
Total	186	100

3.12 Fish parasites observed
Of 260 fish sampled 68 (26.15%) were found to be infested by one or more species of parasites. Fish from earthen ponds (31%) were more parasitized compared to those from liner ponds (3.3%) while, more fish from ponds with overgrown vegetation (30.3%) were parasitized as opposed to those ponds whose vegetation around the pond was well trimmed (9.7%). Differences between the types of ponds and status of vegetation in and around the ponds were statistically significant ($P < 0.05$).

Fish parasites recovered were digenean trematodes, *Diplostomum* spp. (Fig. 3) and *Clinostomum* spp. (Fig. 4), monogenean trematodes, *Dactylogyrus* spp. (Fig. 5) and *Gyrodactylus* spp. (Fig. 6) and the helminth, *Acanthocephalus* spp. (Fig. 7)

Fig 3: *Diplostomum* spp. (red arrow) from the eyes of tilapia from Gatundu sub-county, Kiambu County

Fig 4: Yellowish cysts on the skin (red arrows) and *Clinostomum* spp. (right) metacercariae recovered from the muscles of a tilapia in Kikuyu sub-county, Kiambu County

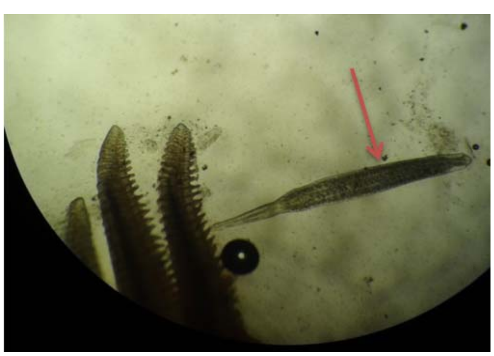

Fig 5: *Dactylogyrus* spp. (red arrow) attached to the gills of a tilapia from Thika sub-county, Kiambu County

Fig 6: *Gyrodactylus* spp. with anchor hooks (red arrow) at the posterior end recovered from the skin of a tilapia from Thika sub-county, Kiambu County

Fig 7: *Acanthocephalus* spp with protruding proboscis (red arrow) recovered from the intestines of a tilapia in Kikuyu sub-county, Kiambu County

The parasites recovered had various prevalences as shown in Figure 8.

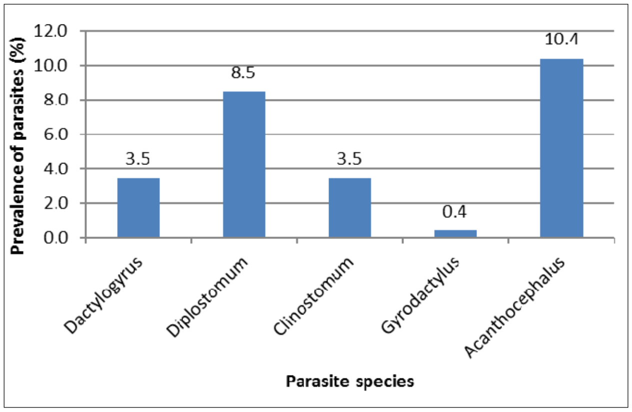

Fig 8: Prevalence of parasites recovered from tilapia in Kiambu County

All fish infested with *Diplostomum* and *Clinostomum* spp. were from earthen ponds with overgrown vegetation. Snails (*Lymnae* spp.) were observed in earthen ponds where *Diplostomum* spp. were recovered. More fish from earthen ponds (13%) with overgrown vegetation were infested with *Acanthocephalus* spp. compared to liner ponds (1.7%). Fish (4%) infested with *Dactylogyrus* spp. were from earthen ponds without vegetation whereas, only one fish from an earthen pond without vegetation was infested with *Gyrodactylus* spp.

Discussion

Most farmers had been in fish farming for more than five years and reared mixed sex tilapia under semi intensive system in earthen ponds. This is as reported by Ngwili *et al.* (2015) [12] and Mavuti *et al.* (2017) [13] that tilapia monoculture farming in earthen pond is mostly practiced in Kiambu and Nyeri counties, Kenya, respectively. This is contrary to reports from Nigeria where most farmers reared tilapia species in concrete ponds (Garcia-Rodríguez and De La Cruz-Aguero, 2011) [14].

Most earthen ponds were silted and had overgrown vegetation, though majority of farmers reported trimming of vegetation around the ponds as one of the disease control strategies practiced on the farms. Fish from earthen ponds (31%) were generally more parasitized compared to those from liner ponds (3.3%) and the differences were statistically significant. Mdegela *et al*. (2011) [15] reported excessive siltation and recorded significantly higher parasite infestation rates in fish reared in earthen ponds (20.9%) relative to fish reared in concrete ponds (4.7%) in Morogoro, Tanzania. However, Mavuti *et al.* (2017) [16] reported no significant difference in overall fish parasite infestation rates between earthen and liner ponds in Nyeri County, Kenya. The mud can be a reservoir for cysts of dinoflagellates and invertebrates intermediate hosts for digenean trematodes such as snails (Komar and Wendover, 2007) [17] and also provides a good environment for protozoan parasites.

More fish from ponds with overgrown vegetation (30.3%) were parasitized as opposed to those ponds whose vegetation around the pond was well trimmed (9.7%) and the differences were statistically significant. All fish infested by digenean trematodes *Diplostomum* and *Clinostomum* species were from earthen ponds with overgrown vegetation and snails were collected from ponds with *Diplostomum* spp. infested fish. A study by Mathenge (2010) [23] in Kenya, reported the presence of weeds in the ponds at Sagana Fish Breeding Farm, Kirinyaga County and suggested that this contributed to the high prevalence of digenean helminths found in the fish from that farm. Overgrown vegetation provides a good environment for parasites such as crustacean copepods or leeches and snails that are vectors for various parasites. *Acanthocephalus* spp. was recovered from fish collected from earthen ponds with overgrown vegetation. This is because the vegetation encourages presence of intermediate host (amphipods, isopods, copepods or ostracods) and the final definitive hosts (piscivorous birds) that helps in continuity of the lifecycle.

Farmers obtained their first fingerling stock mainly from a government hatchery while, few sourced from private hatcheries as most were provided by the government during the economic stimulus programme (ESP) as was reported by Ngwili *et al.* (2015) [12]. During the ESP period, many hatcheries sprung to fill the gap for high demand of fingerlings with no proper systems put in place to enforce standards and ensure Best Aquaculture Management Practices (BAMPs) (Orina *et al*., 2014) [2]. Parasites such as leeches, gastropods, nematodes and trematodes are among the main fish health challenges experienced in hatcheries (Orina *et al*., 2014) [2]. Trade of fish and embryos from hatcheries poses a high risk of transmitting parasites like gonadal myxosporeans (Sitja, 2009) [18]. Many farmers left the fish to breed in the ponds without restocking which could lead to propagation of direct lifecycle parasites like monogeneans and protozoans. Orina *et al*. (2014) [2] attributed the occurrence of diseases, parasites and deformities to inbreeding among other reasons. Other farmers sourced fingerlings from fellow farmers whose quality cannot be certified while, others sourced from the wild, especially rivers. This could lead to transmission of parasites and other pathogens from one farm to the other or from the wild to the farmed fish in ponds.

Most farmers sourced pond water from rivers along which the ponds were constructed. This agrees with the reports of Mdegela *et al.* (2011) [15] in Tanzania, Ngwili *et al.* (2015) [12] and Mavuti *et al* (2017) [13] in Kenya that rivers are the main pond water sources. However, Shitote *et al*. (2012) [19], Garcia-Rodríguez and De La Cruz-Aguero, (2011) [14] reported springs and boreholes as the main water sources in Siaya County, Kenya and Nigeria, respectively. River water source can introduce microorganisms which are potential pathogens for fish (Blanco *et al*., 2000)[4]. Mdegela *et al.* (2011) [15] in Tanzania, reported highest infestation rate with intestinal parasites in earthen ponds which used river water while, in a study by Voutilainen *et al*. (2010) [20], the rearing tanks of fish received *Diplostomum* spp. cercariae via the incoming water indicating the importance of water source in parasite transmission.

In agreement with Ngwili *et al*. (2015) [12] and Mavuti *et al.* (2017) [13], majority of farmers did not change or refill pond water within a production cycle and also did not drain or treat the ponds after harvesting. The resulting accumulation of organic material contributes to occurrence of external fungal, bacterial and parasitic infestations (Blanco *et al*., 2000) [4]. Lack of pond drainage and treatment after harvesting encourages persistence of intermediate hosts of digenean trematodes like snails thus continuous infestation of fish. Ponds can be sanitized by draining, drying and use of chemicals such as hydrated lime.

Many farmers shared fishing nets and only a few of them cleaned or disinfected it after use. These findings have not been recorded in Kenya. This can lead to transmission of pathogens between farms and between ponds. Any equipment used in a fish pond should be thoroughly dried or chemically disinfected before being used in another pond or between groups of fish (Blanco *et al*. 2000) [4]. In a report by Martin *et al.* (2000) [21] in Brazil, the occurrence of monogenean trematodes, ectoprotozoans (*Ichthyophthirius multifiliis, Piscinoodinium pillulare*) and copepodid (*Lernaea cyprinacea)* was attributed to high organic matter content, high stocking densities and farmers' failure to clean the fish nets.

Although some farmers reported that they did not know any sign of parasitism**,** fish abnormalities reported (skin lesions, sluggish swimming, flashing while swimming, retardation, floating and death) are signs of parasitism in fish (Komar and Wendover, 2007) [17]. Fish deaths were reported to occur occasionally as most parasites cause unthriftness and gradual fish deaths (Otachi, 2009) [5]. Piscivorous birds and otters were the main predators reported. The predators feed on the fish leading to economic losses and piscivorous birds act as final hosts of fish parasites like digeneans and helps to maintain the parasite life cycles (Robert, 2012) [22]. Otachi (2009) [5] and Mathenge (2010) [23] attributed the diverse fish helminth community and prevalence in Sagana Breeding Farm in Kenya to the presence of definitive piscivorous birds in the area.

Conclusion and recommendations

Fish farm management practices that can influence the occurrence of fish parasites in Kiambu County include: Non-certified sources of fingerlings, silted ponds, overgrown vegetation around the ponds, water sources, failure to change water within a production cycle, lack of pond draining and treatment after harvesting, sharing of fishing nets, lack of proper cleaning and disinfection of fishing nets, lack of knowledge on signs of fish parasitism and poor predator control especially piscivorous birds.

This study also shows that tilapia in Kiambu County are infested with both ecto- and endo- parasites. In order to reduce the risk of fish parasitism, proper farm management practices, observing biosecurity measures and capacity building for famers and fish health workers is recommended.

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