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Comparative Management Practices and Parasitic Infestations of Farmed Tilapia in Kiambu and Kirinyaga Counties, Kenya

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Original Research Article

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Abstract: A cross sectional study was undertaken in Kiambu and Kirinyaga counties of Kenya between October 2016 and March 2017. Semi structured questionnaires assessing pond types, farmed fish species, culture practices, pond water sources, source of fingerlings and predation were administered to 137 and 148 fish farmers in Kirinyaga and Kiambu counties, respectively. Parasitological examination was conducted on 463 tilapia (*Oreochromis niloticus*). Earthen ponds were most common (56.2% Kirinyaga; 53.9% Kiambu). Siltation and overgrown vegetation were observed in many ponds. Mixed sex tilapia (66.5% Kirinyaga; 49% Kiambu) was the main species farmed in monoculture system. Others were: catfish, ornamental fish and rainbow trout. Rivers were the main sources of water (65.7% Kirinyaga; 33.1% Kiambu). Most farmers sourced their initial stock of fingerlings from government hatcheries (66.4% Kirinyaga; 33.1% Kiambu) but restocked from private hatcheries. Some left the fish to continue inbreeding without restocking. Piscivorous birds, otters, monitor lizards, and snakes were the common predators reported. Of the sampled fish, 31.7% had one or more species of parasites with Kirinyaga having a higher prevalence of infested fish (39%) than Kiambu (26.2%). Fish from earthen ponds were significantly (p=0.04) more infested (46% Kirinyaga; 31% Kiambu) compared to those from liner ponds (10% Kirinyaga; 3.3% Kiambu). The parasite genera recovered in both counties were: *Acanthocephalus*, *Diplostomum*, *Clinostomum*, *Dactylogyrus* and *Gyrodactylus*. *Diplostomum* spp. (21.7% Kirinyaga: 8.5% Kiambu) and *Acanthocephalus* spp. (11.3% Kirinyaga; 10.4% Kiambu) were most common. Management factors influenced fish production, hence farmers should be trained on proper husbandry and further research conducted to establish the impact of these factors on aquaculture growth in Kenya.
Keywords: *Acanthocephalus* spp., aquaculture, *Diplostomum* spp., parasite, pond, production.

INTRODUCTION

The Kenyan government launched the Fish Enterprise Productivity Programme (FFEPP) with an aim of promoting production and improve fish farming as one of the solutions to food security challenge in the country [1]. As a result, aquaculture is one of the fast growing food production sectors in the country and many farmers have adopted it as a source of income. The demand for aquaculture products is high due to a rapidly growing human population, declining natural fish stocks and active fish farming promotion by the government [2]. Profitable fish farming is run with an objective of raising the largest amount of fish by the most economical means. Good management practices ensure successful culture and high fish yields [3]. Therefore, adoption of better management practices ensure improved effectiveness and efficiency of farming practices and overall contributes to sustainability of farming and economic viability of farmers [4].

Diseases represent an important constraint in aquaculture production unless proper management practices are in place [5]. Parasitic infestations cause clinical or subclinical disease and pathology in fish that may result in economic losses due to mortalities, reduced production and increased cost of treatment [6]. The damage caused in fish is relative to the rate of infestation with lightly infested fish showing no or few clinical signs of the parasite, while heavily infested fish may become physiologically impaired and even die [7]. The market value of infested fish is greatly reduced as they are rejected by consumers for aesthetic reasons [8].

There are also public health concerns as some fish parasites are zoonotic [6].

In Kenya, fish farming management practices have not been adequately characterized and there is inadequate information on factors that influence fish production. Farmers stock the ponds but the economic returns are still not realized due to low harvesting weights and other production challenges [9]. This study therefore aimed at investigating factors that influence production and parasitism of farmed tilapia in Central Kenya.

MATERIALS AND METHODS

Study area

The study was done in Kiambu and Kirinyaga counties, Kenya between October 2016 and March 2017. Kiambu County is located at 1° 10' S, 36° 50' E and has four topographical zones. These include Upper Highland, Lower Highland, Upper Midland and Lower Midland Zones whose altitudes are 1,800-2,550, 1,500-1,800 1,300-1,500 1,200-1,360 metres above sea level, respectively. Temperatures range from 7^0C in upper highlands and 34^0c in lower midland zone. The county experience long rains from mid-March to May and short rains between mid-October and November. The annual rainfall varies with altitude, with higher areas receiving as high as 2,000 mm and lower areas as low as 600 mm. Kirinyaga County is located between latitudes $0^0$1' and 0^0 40' South and longitudes 37^0 and 38^0 East. It lies between 1,158 and 5,380 metres above sea level in the south and at the peak of Mt. Kenya, respectively. The temperature ranges from a mean of 8.1^0C in the upper zones to 30.3^0C in the lower zones during the hot season. The county experience long rains between March to May and the short rains between October to November which average 2,146 mm and 1,212 mm, respectively [10].

Study design

A cross sectional study was carried out in both counties. Semi structured questionnaires were administered to 137 and 148 randomly selected fish farmers in Kirinyaga and Kiambu counties, respectively. They were used to assess pond types, fish species kept, culture practices, pond water sources, source of fingerlings and predation. Direct observations were also done to supplement the information obtained from questionnaires. Eight sub-counties (3 in Kirinyaga and 5 in Kiambu) with the highest number of active fish ponds were purposively selected for fish sampling after the questionnaire survey. A total of 463 tilapia (203 Kirinyaga; 260 Kiambu) were collected in plastic containers with pond water and transported to the laboratory for parasitological examination.

Parasitological examination

Post mortem of the fish was done as described by Noga [11]. The skin was grossly examined for ectoparasites. Wet mounts of skin scrapings, gill filaments, gut and eye contents were collected on slides with saline and examined under the microscope at x10 and x40 for parasites. Parasites recovered were characterized and identified using morphological features as described by Woo [12] and Robert [8].

Data analysis

Data was entered, cleaned and stored in a Microsoft excel spreadsheet. Analysis was done using SPSS version 16.0 and Epi info statistical software version 7.0. Parasite distributions were described using prevalence as described by Margolis *et al*., [13]. Chi square was used to compare the proportions with $p<0.05$ considered significant.

RESULTS

Pond types and management

Most farmers in both counties had earthen ponds with a slightly higher percentage in Kirinyaga (56.2%) relative to Kiambu (53.9%). Other farms had liner (42.8% Kiambu; 40.9% Kirinyaga) and concrete (3.3% Kiambu; 2.9% Kirinyaga) ponds. The proportion differences in pond types were not statistically significant ($p>0.05$). In both counties, many ponds especially the earthen ones were silted with lots of organic material and overgrown vegetation in and around them.

Farmed fish species

Tilapia (*Oreochromis niloticus*), catfish (*Clarias gariepinus*) and ornamental (Goldfish and Koi carp) fish were common in both counties while rainbow trout (*Oncorhynchus mykiss*) was only farmed in Kiambu County in the cold upper highland zone. Mixed sex tilapia was the major fish farmed in both counties as monoculture with a significantly higher proportion ($p=0.01$) in Kiambu (66.5%) than Kirinyaga County (49%). Catfish farming was more in Kiambu (31%) than Kirinyaga (21%) while ornamental fish were more farmed in Kirinyaga than Kiambu (3%; 2%) but the differences were not statistically significant ($p>0.05$). Only 0.5% of farmers farmed trout in Kiambu County. Harvested mixed sex tilapia were noted to be small in size (less than 200 grams).

Pond water sources

Pond water was mainly sourced from rivers in both counties with a significantly ($p<0.05$) higher proportion in Kirinyaga County (65.7%) relative to Kiambu County (33.1%). Other water sources included wetlands/underground springs (27% in Kiambu; 7.3% in Kirinyaga), boreholes (25.7% Kiambu; 6.6% Kirinyaga), and piped water (20.4% Kirinyaga and 8.1% Kiambu). Dams (4.1%) and harvested rain water (2%) were used in Kiambu County only.

Source of fingerlings

As shown in Table-1, most farmers in both counties sourced their initial stock of fingerlings from government hatcheries with more farmers being from

Kiambu relative to Kirinyaga though the difference was not statistically significant (p=0.06). During restocking, almost equal proportion of farmers sourced fingerlings from private hatcheries in both counties with more farmers from Kirinyaga County getting fingerlings from private than from government hatcheries. However, more farmers in Kiambu left fish to inbreed in the ponds without restocking compared to Kirinyaga but the difference was not statistically significant (P=0.46).

Table-1: Sources of fingerlings in Kiambu and Kirinyaga counties

Source of fingerlings	Initial stock		Restocking	
	Kiambu (%)	Kirinyaga (%)	Kiambu (%)	Kirinyaga (%)
Government hatchery	78.8	66.4	25.6	16.9
Private hatchery	17.8	21.2	25.6	26.9
Wild fish capture	1.4	5.8	0.8	6.9
Other farmers	2.1	6.6	1.6	8.5
Own breeding (in breeding)	0	0	46.4	40.0
Import fish or eggs	0	0	0	0.8

Fish predation

Piscivorous birds, otters, monitor lizards, and snakes were the common predators in both counties. Among these, birds were of major concern due to their numbers and frequency in the ponds especially in Kirinyaga County. Herons (43.8%) and kingfishers (37.2%) were the major predatory birds in Kirinyaga while kingfisher (22.3%) and Ibis (18.5%) were most common in Kiambu County. Other predatory birds reported in both counties were hamerkop, cormorants, egrets, pelicans and fish eagles. Marabou stork, wild ducks and crows were only reported in Kiambu County.

Fish parasitism

Out of 463 tilapia sampled 147 (31.7%) had one or more species of parasites with Kirinyaga having a higher proportion (39%) of infested fish compared to Kiambu (26.2%). The differences were not statistically significant (p=0.07). Fish from earthen ponds were more infested (46% Kirinyaga and 31% Kiambu) compared to those from liner ponds (10% Kirinyaga and 3.3% Kiambu).The difference in infestation in earthen ponds was significant (p=0.04) while that of liner ponds was not (p=0.08).

Parasite genera recovered were: *Acanthocephalus*, *Diplostomum*, *Clinostomum*, *Dactylogyrus* and *Gyrodactylus* (Table-2). *Diplostomum* spp. and *Acanthocephalus* spp. were the most common parasites in both counties with Kirinyaga County recording higher infestation than Kiambu County. The difference in *Diplostomum* spp infestation was significant (p=0.02) while that of *Acanthocephalus* was not (p=1.0).

Table-2: Parasite genera isolated from fish in Kiambu and Kirinyaga counties

Genera	Infested organ	Prevalence of infested fish (%)	
		Kirinyaga	Kiambu
Dactylogyrus	Gills	3.0	3.5
Diplostomum	Eyes	21.7	8.5
Clinostomum	Skin and muscles	4.9	3.5
Gyrodactylus	Skin	0.0	0.4
Acanthocephalus	Intestines	11.3	10.4

DISCUSSION

Similar to reports by Ngwili *et al.*, [14] and Mavuti *et al.*, [15] earthen ponds were the most common ponds in Kiambu and Nyeri counties, respectively. Shitote *et al.*, [16] reported poor pond management and siltation as one of the challenges facing farmers in Siaya County, Kenya. Aquatic vegetation in a pond cause problems including interference with fishing, restriction of fish movement, utilization of nutrients needed for phytoplankton growth, fish deaths due to depletion of dissolved oxygen and gill entanglement, fouling due to decomposition of dead weeds, provision of shelter and breeding places for disease vectors and predators as well as water loss by evapotranspiration [17]. Prolonged exposure of fish to marginal dissolved oxygen conditions affects fish growth, increases risk to stress related diseases (such as fin rot and white spot) and death [18]. Siltation and organic material leads to low water levels making it easy for birds to wade through the water resulting to increased predation. These contribute to low production

As reported by Ngwili *et al.*, [14] and Mavuti *et al.*, [15] in Kiambu and Nyeri counties, respectively, mixed sex tilapia was the major fish farmed in both counties as monoculture. This is because many farmers had either not restocked since the Economic Stimulus Program or restocked with mixed sex tilapia. Little *et al*. [19] demonstrated that monosex fishes reach a larger final individual size than mixed sex due to breeding and the effects of competition for food from progeny with

older mixed-sex fishes. The monosex fish also have a homogenous size which is advantageous to commercial producers. Chakraborty *et al.,* [20] demonstrated that monosex tilapia have significantly higher weight, length, daily weight gain, specific weight gain and protein content than mixed-sex fish. Mbiru *et al.,* [21] while comparing growth performance, survival rate, condition factor and final fish biomass (yield) showed that hybrids (*O. niloticus* × *O. urolepis hornorum*) have superior growth performance and condition factor than sex-reversed and mixed-sex *O. niloticus* but have similar yields to hormonal-sex-reversed *O. niloticus*. Therefore, *O. niloticus* farmers can improve growth rate and yield by rearing hybrids without affecting survival rate. Since the harvested fish were small, county extension officers were encouraging farmers to rear monosex tilapia or catfish as they perform better and the fingerlings were readily available.

In agreement with studies by [22, 14 and 15], pond water was mainly sourced from rivers in both counties. Kirinyaga County has six major rivers namely; Sagana, Nyamindi, Rupingazi, Thiba, Rwamuthambi and Ragati, all of which drain into Tana River [10]. The rivers are harnessed through canals to support irrigation and are the principal source of water in the county. Kiambu County has fewer rivers and thus has more ponds along the wetlands and a number of farmers use water from boreholes. Non-infectious diseases usually occur due to poor water quality. Amount of dissolved oxygen is affected by temperature, biological demand and source of water [23]. Water from rivers may be contaminated with heavy metals and agrochemical pollutants which adversely affect fish health and production [15]. Infections from upstream can also be transmitted to the ponds downstream. Good management of water quality reduces stress avoiding the risk of poor production and disease occurrence. Since aquaculture is highly dependent on water availability and quality, higher production will be realized where good quality water is available all year round than where seasonal fluctuations are experienced.

Initial stocks of fingerlings were mainly sourced from government hatcheries. This is because the fingerlings were distributed through the government funded Economic Stimulus Programme (ESP). During this programme many private hatcheries were started to fill the gap for the high demand of fingerlings [24] with Kirinyaga having big breeding farms such as Emmerick Fish, Mwea Aquafish and Green Algae Highland Fish farms. Some farmers in Kiambu sourced restocking fingerlings from breeding farms in Kirinyaga. For maximum production farmers should only source fingerlings from authenticated hatcheries which are mandated by the government to produce quality fish seed. Some farmers left fish to continue inbreeding in the ponds without restocking as they practiced partial harvesting but the fish became smaller in size with subsequent generations resulting in poor production.

Piscivorous birds were the predators of major concern. They are attracted to fish farms with open ponds which form ideal feeding sites as observed during this study. They are highly mobile and rapidly exploit food abundance situations. They affect aquaculture directly by repeatedly consuming or injuring fish and also act as hosts to parasites thus spreading infestations between or in fish farms [25].This results in loss of crop, income and significant expenditure of time and funds in establishing bird management programmes and training personnel. Severity of the problem varies with the species and number of birds present and whether the birds are seasonal or present throughout the year [25]. Birds were reported to be present throughout the year in the two counties.

The parasite genera recovered in both counties were: *Acanthocephalus*, *Diplostomum*, *Clinostomum*, *Dactylogyrus* and *Gyrodactylus*. These parasites have been observed elsewhere in Kenya and other countries in both farmed and capture fish [26-29, 6]. In agreement with Mdegela *et al*., [22] fish parasitic infestations were more in earthen compared to liner ponds. Mavuti *et al.,* [29] found no significant difference in parasite infestation between earthen and liner ponds in Nyeri County. The presence of the parasites can be attributed to poor management of ponds and presence of predatory birds. Pond siltation and vegetation cover provide a good environment for the intermediate (snails) and definitive (piscivorous birds) hosts [30,28] which were observed in the two counties during this study. Kirinyaga County recorded higher parasite infestation than Kiambu. This can be attributed to the long history of fish farming and abundance of piscivorous birds in Sagana and Mwea Aquafish breeding farms in Kirinyaga County where most fish were acquired from allowing propagation of the parasites. Parasitic infestations cause economic losses through direct mortality, retarded growth, decreased reproduction, increase in susceptibility of fish to diseases and predation and high cost of treatment [31].

The eye fluke, *Diplostomum* spp. cause severe ocular disease and lens opacity leading to blindness [32]. This affects fish ability to feed and compete well with others. In addition *D. spathaceum* cause changes in fish behavior increasing their vulnerability to predation by piscivorous birds [33, 34]. This contributes to low production with consequent economic loss to the farmers. *Clinostomum* spp. are highly visible to the unaided eye as yellow cysts or grubs in the muscle or under the skin of infested fish. They are harmful to humans if fish is not well cooked and consumers do not readily accept infested fish due to their unsightly appearance [35]. Monogenean worms, *Gyrodactylus* spp. and *Dactylogyrus* spp. disturb the respiratory function of the skin and gills causing the fish to become dull, feeble, frequently swimming to water surface with erratic movements and may die of exhaustion [36].

Acanthocephalus spp. adult parasite attach while larval stages encapsulate in the digestive tract tissues where the extent of damage is proportional to the depth of penetration of the proboscis [37]. Damages become extreme with extensive granuloma and subsequent fibrosis when the worms' proboscis is anchored in the muscle layer or entirely perforates the intestinal wall.

CONCLUSIONS

- Present study showed that aquaculture productivity in Kiambu and Kirinyaga counties was influenced by management practices
- Fish parasitism and predation are important factors which may affect fish productivity in the study area

RECOMMENDATIONS

- For optimal production, farmers should be educated on proper aquaculture management practices, importance of fish parasites and predators
- Long term measures in terms of policy planning should be undertaken to enable large scale aquaculture production in Kenya

Conflict of interests

The authors declare that there is no conflict of interest

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