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Research Article

Occurrence and Prevalence of Fish Parasites and the Interaction with Water Quality Parameters in Selected Small Water Bodies in Western Kenya

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ABSTRACT

Water quality and the environment greatly influence the existence and proliferation of parasites in the water and consequently, fish. This can have profound implications on aquaculture within the water bodies. Few studies have been conducted on parasite aggregations about the water quality in small water bodies in Kenya. This study assessed the suitability of selected Small Water Bodies (SWBs) for aquaculture as regards fish parasites by assessing the relationship between the occurrence and prevalence of parasites to water quality, water depth, land use, and shoreline habitat type. Standard protocols and procedures were used in the collection, analysis of water quality, and assessment of fish specimens for parasitology. White spot disease, (a parasite with economic significance) was in 4 of the 6 SWBs studied and had varying prevalence rates ranging between 10% to 20%. *Clinostomum*, a zoonotic parasite was also recorded in one of the SWBs sampled in this study. Additionally, the study recorded some significant differences in the water quality from the various selected SWBs ($p<0.05$), which could be a pointer to the noted diversities in the parasite communities. The findings of this study indicated that there was a strong positive correlation ($r2>0.8$) between some parasites (*Ichthyopthirius multifiliis*, *Clinostomum* spp., *Procamallanus*, and *Camallanus*) and some water quality parameters (temperature, turbidity, soluble reactive phosphorous, total phosphorous, and silicates). In light of the increase in focus on fisheries and aquaculture as key drivers of the blue economy and food and nutrition security, and as the country explores new frontiers for investment in aquaculture in SWBs, the water quality and consequent habitat features such as depth and land use, need to be addressed before investment.

Keywords: Small water bodies; Water quality; Nutrients; Parasites; Aquaculture

INTRODUCTION

Aquaculture has grown very rapidly in Kenya in the past decade, playing a vital role in the national fish supply and food security. Additionally, in doing this, it has resulted in the creation of many employment opportunities, directly and indirectly, hence promoting incomes to various households [1]. The rapid growth of this sector in Kenya has seen it ranked 4th major producer of aquaculture in Africa producing about 24,096 MT annually as of 2014, government interventions in the last two decades has seen this sector increase its vibrancy, thus moving from extensive systems to mainly intensive systems to meet the rising demand for fish.

Small Water Bodies (SWBs) can be described as small water reservoirs which can have various aspects of water quality and chemistry which determine the kind of species they support [2]. The potential of SWBs in aquaculture in Kenya has not been fully utilized, with most interventions focusing on large water bodies like lakes, oceans, etc. Few studies have been done on the potential of SWBs in aquaculture in Kenya. There is an increase in focus on fisheries and aquaculture as key drivers of the blue economy and food and nutrition security [3]. Additionally, with the declining capture fisheries and with the need to boost aquaculture production, SWBs offers a new frontier to increase fish production in Kenya. The utilization of water bodies including SWBs for aquaculture depends on a myriad of factors including but not limited to; water quality, bathymetry, and competition with other resource users. Various SWBs have been identified as potential areas for the exploitation of cage aquaculture to increase fish production in the country. Biological components especially the occurrence and prevalence of fish parasites in these water bodies can determine their viability of aquaculture potential [4].

Diseases and parasites are real threats to an aquaculture establishment. Disease occurrence is one of the main challenges that hinder the sustainable production in aquaculture systems which increase with the rise in intensification as seen in most if not all aquaculture enterprises [5]. High parasite loads (ectoparasites

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or endo-parasites) significantly contribute to decreased fish growth, mortalities, and market unacceptability culminating in undesired aquaculture losses [6]. Generally, fish diseases can be attributed to infections due to introduced fish, contamination by transportation containers, avian spread, intermediate host population rise, malnutrition, lack of seed traceability, and disease ambient conditions. This rapid assessment aimed to provide a baseline study of selected SWBs in the western region of Kenya for their suitability in aquaculture. The study assessed the possible influence of the adjacent land use characteristics, water depths, water quality, and respective parasite occurrence, and their potential applicability for aquaculture.

MATERIALS AND METHODS

Area of study

The assessment was conducted in 6 (six) small water bodies each located in 6 counties of Homabay, Migori, Kisumu, Kakamega, Siaya and Busia along the Lake Victoria, Kenya basin. The selected small water bodies were Pap Orage (HP), Olasi (MO), Huma (KiH), X rasa (KaX), Uranga (SU) and Munana (BM) as shown in Figure 1. The sites had been pre-selected to assess their potential applicability for fish production to meet the rising demand for fish in the region and also reduce pressure from capture fisheries in Lake Victoria, with the increased exploitation.

Fish samples were collected using a beach seine 50 meters long with a depth of 3 meters and a stretched mesh size of 1. Fish measurements (morphometric) were taken; length by using the measuring board to the nearest cm and weight; using the weighing scales to the nearest gram. Additionally, fish were identified to species level. For the entire fish specimen, necropsy and parasitological evaluation were performed by following specific diagnostic protocols and standard procedures. Identification of the isolated parasites then followed the taxonomic keys by Paperna [7]. Thereafter, the prevalence of the parasites was calculated by using the protocols outlined by Bush, et al. [8].

Assessment of water characteristics followed published standard methods for aquatic environmental studies (APHA, 2012). Portable water Physico-chemical electronic sensor-based probes were used to take in situ water quality measurements at the dams. The main physical and chemical parameters measured were; column depth (m), temperature (°C), dissolved oxygen (mg^{1}), pH, turbidity (Formazin Turbidity Units-FTU), and Total Dissolved Solids (TDS) (age-1). Water transparency measured as Secchi depth (photic depth) was measured using a standard Secchi disk of 20 cm diameter.

This study also investigated the levels of nitrogen (ammonium-NH4+-N; nitrite-NO_2-N; nitrate-NO_3-N; Total Nitrogen-TN), phosphorus (Soluble Reactive Phosphorus-SRP; Total Phosphorus-TP), and silicate species concentrations on all the study sites. Chlorophyll-a, a measure of levels of primary production which acts as the primary energy source for the heterotrophs was also measured.

Sampling

Sampling sites were identified (two at the littoral areas and one at the center) and triplicates were collected for each station. The samples were then composited to make one sample per station. Water samples were collected using a van Dorn water sampler at the surface. The water samples for soluble nutrient fractions were then filtered and stored in polyethylene bottles under refrigeration at about 4°C for further laboratory analyses. Samples for TN and TP were refrigerated without filtration. Samples for chlorophyll-a was filtered using GF/C filters, securely wrapped in aluminum foil before refrigeration at about 4°C. The samples were later on transported to the laboratory and analyzed according to methods adopted from APHA 2012.

RESULTS

Water quality

Findings from the study indicated varying levels of interactions in the environment that were informed by various reasons as depicted in Figures 2a and 2b. The Secchi depth in all the small water bodies was relatively low, indicating high turbidity in the water column. However, Olasi had the highest turbidity levels. This could be because the dam was under rehabilitation with freshly constructed dykes. The dam was characterized by loosened sediments, bare shores, and banks. The surrounding areas were covered by scanty trees mainly euphorbia. Munana dam had the highest TDS values which could be attributed to the fact that the dam was a multiple-user water body, allowing for watering of the domestic animals. The effect of this was a disturbance of the substrate as a result of the animals' activity. Dissolved oxygen, a vital component in the survival and growth of fish was relatively low (below 3 mg/L) in Pap orage and Uranga dams. Nutrients and Chlorophyll had a relatively different pattern of distribution as depicted in Figures 3a and 3b. Pap Orage and Olasi dams had the highest ammonium and TP levels respectively in all the dams.

Habitat characteristics

The habitat characteristics are shown in Table 1.

Occurrence and prevalence of parasites

Results indicated that the fish in the various SWBs had been infested by parasites. Nematodes, Parasitic copepods, cestodes and trematodes were observed from the fish samples investigated. Olasi dam had the richest diversity of parasites. White spot disease (*Ichthyopthirius multifiliis*) was present in all the dams apart from Uranga and X-Rasa. Worth noting is the high infestation of fish in SU with black spot disease (50% prevalence) (Table 2).

Correlation between water quality and occurrence of the various parasites in the SWBs

The study set out to investigate the possible interactions between the various parasites observed and water quality as shown below. There was a marked strong positive correlation between Turbidity,

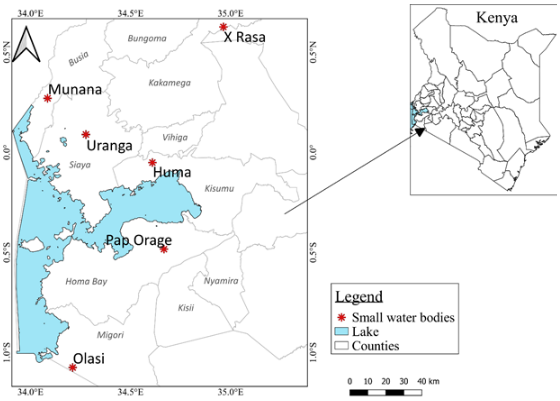

Figure 1: Map of the study area showing Pap orage, Olasi, Huma, X-Rasa, Uranga, and Munana small water bodies in Homabay, Migori, Kisumu, Kakamega, Siaya, and Busia counties respectively. **Note:** (*) Small water bodies; (▭) Lake; (▭) Countries

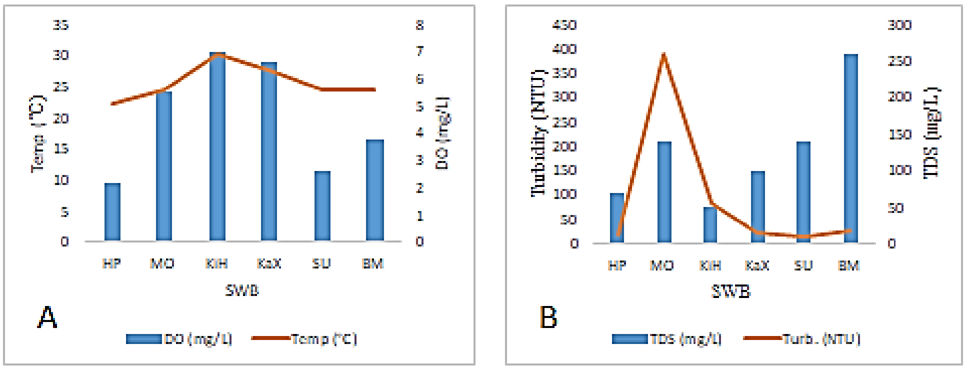

Figure 2: Water quality parameters of the sampled SWBs observed during the sampling. (A) Dissolved oxygen and Temperature variations and (B) Total dissolved solids and Turbidity. Note: (A): (▬) DO (mg/L); (—) Temperature; (B): (▬) TDS (mg/L); (—) Turbidity

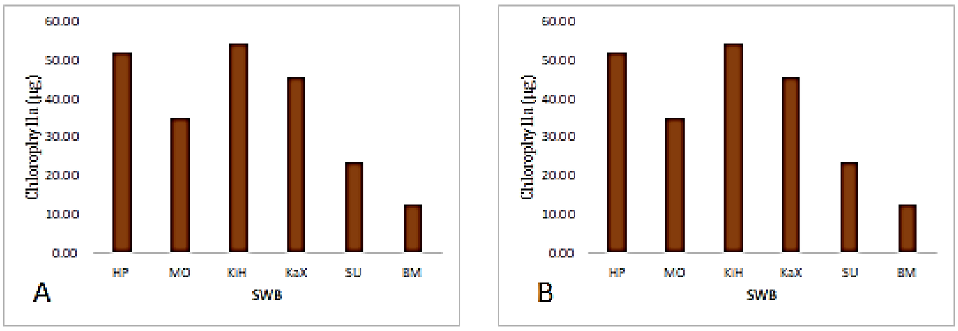

Figure 3: Chlorophyll-a (A) Nutrient (B) Concentration in the SWBs sampled.

Table 1: Representation of the dam, habitat type, and surrounding land uses of the sampled small water bodies during the study.

Dam	Shoreline habitat type	Surrounding land use
Pap Orage	Vast mixed bare ground and grass cover. Sedges on the western shores and rocky outcrops on the northern shores. Planted eucalyptus further out. Muddy: shrubs.	Grazing fields for livestock.
Olasi	A dam under rehabilitation with freshly constructed dykes. Bare shores and banks from construction. Basin characterized by scanty trees of mainly euphorbias. Muddy: grassland.	No activity in the direct surroundings.
Huma	Dam outflows into banks. Marshland. Muddy: grassland.	Minimal activities in the surroundings.

X – Rasa	Shrunk dam due to siltation. Dam fed by natural springs but no visible outlet. Palm trees around the dam. Mostly grassy; few hydrophytes in the waterline. Sandy: grassland	Minimal activities in the surroundings.
Uranga	Irregularly shaped water mass with multiple sheltered bays and a wide-open main body. Inflow through a permanent stream while outflow is through a controlled channel. Dense macrophyte cover (Typha, phragmites, and a few higher shrubs).Water lettuce spreading out into the main body Muddy: shrubs	Water from the dam is mainly used for local irrigation.
Munana	A dam constructed within a permanent swamp and a stream basin. Presence of floating water lilies covering about 90% of the water surface. A water intake and pumping station located at the outflow/downstream side. Dam has cement protected rectangular banks. Vegetation comprising of mixed shrubs and Typha on the shore sides; Sandy: shrubs	Dam water abstracted for domestic use and aquaculture.

Table 2: Parasite status in the various small water bodies sampled. The SWB name, parasite identity, common name or family name, fish species affected and prevalence he various sites sampled during the study period.

SWB name	Parasite identity	Family/common name of parasite	Host fish species	Prevalence
HP	*Philometra* spp	Nematoda	*Oreochromis niloticus*	7.70%
	Ergasilus spp	Parasitic copepod	*Clarias gariepinus*	7.70%
	Diphlobothrium spp	Cestoda	-	7.70%
	Ichthyopthirius multifiliis spp	White spot	-	15.40%
	Glochidia spp	Parasitic bivalve	-	7.70%
	Clinostomum spp	Digenetic trematodes	-	15.40%
MO	*Philometra* spp	Roundworms	*Oreochromis leucostictus*	10%
	Ergasilus spp	*Parasitic copepod*	-	10%
	Procamallanus spp	*Nematoda*	-	10%
	Camallanus spp	*Nematoda*		10%
	Glochidia spp	Parasitic bivalve	-	10%
	Ichthyophthirius multifiliis spp	White spot disease	-	10%
KiH	*Ichthiopthirius multifiliis* spp Uvulifer spp	White spot disease	*Oreochromis niloticus*	16.70% 16.70%
KaX	*Philometra* spp	Roundworms	*Oreochromis niloticus, Clarias gariepinus*	20%
SU	*Neascus* spp	Black spot disease	*Oreochromis leucostictus*	50%
	Ergasilus spp	Parasitic copepod	-	50%
BM	*Ichthyophilirius multifiliis* spp.	White spot disease	*Oreochromis leucostictus*	20%
	Philometra spp.	Roundworms	-	20%
	Acanthocephala spp.	Thorny headed parasitic worms	-	20%
	Eustrongylides spp.	Nematoda	-	20%
	Glochidia spp.	Parasitic bivalve	-	20%

Note: HP: Pap Orage, MO: Olasi, KiH: Huma, KaX: X rasa, SU: Uranga, BM: Munana

SRP, TP, and Silicates on *Clinostomum* spp, *Procamallanus* spp, *Camallanus* spp, and *Ichthyopthirius* multiplies during the study as illustrated below.

DISCUSSION

Currently, the production of fish in Kenya is not able to meet the demand hence the rising interest in aquaculture to address the deficit [9]. Efforts in promoting aquaculture have resulted in the establishment of several projects to encourage investment in this area. However, with varying water uses in Lakes, rivers and the inability to fully explore the EEZ in the oceans, the focus is being shifted to the utilization of the Small Water Bodies (SWBs). Small water bodies in Kenya are a viable option for investment in aquaculture in its quest to boost fish production. This study which was conducted in selected small water bodies within the Western region was to provide a rapid assessment of the SWBs for the potentiality for use in aquaculture by considering various factors; depth, land use, shoreline characteristics, water quality, and lastly; parasite occurrence, abundance, and diversity.

The influence of adjacent land use characteristics and user conflicts can be varied and contribute significantly to the success or failure of any aquaculture intervention for a certain water body [10]. An example in this study is the Uranga dam. The dam had a high potential for application in aquaculture, but due to the agricultural activities in the surroundings, the potential risks for interference as a result of using agricultural inputs could pose a challenge. Agricultural inputs particularly fertilizers can be drained into the water bodies during the rainy seasons and result in elevated levels of some nutrients. Interestingly though are the relatively high concentrations of Total Phosphorus (TP) in Olasi dam which had no agricultural activities taking place around it. A probable reason for this could be the fact that since this SWB did not have an outlet, there was an exaggerated accumulation of nutrients in which the reservoir could be acting as a sink. The contribution could be due to runoff passing through farmlands ending up in the dam. These observations are similar to those seen in the Ngei dam as reported by Kaggwa, et al. which showed exceptionally high levels of both TP and Silicates throughout the study period within this dam that also lacked an outlet [11]. These high levels of nutrients can have negative impacts on fish especially by encouraging algal blooms in the SWBs.

The success of utilization of an SWB for aquaculture and the system to set up is heavily dependent on its depth profile. This study found the depths of the SWBs to range between 1 m to 3 m. These depths were below those recommended for cage aquaculture Orina, et al. hence if this system is to be applied, dredging needs to be incorporated [1]. However, for utilization in general pond aquaculture, all the dams apart from Huma dam are good candidates since their depths ranged between 1 m and 3 m. At these depths, phytoplankton productivity is regulated and not in excess, and additionally, there is a better flow of nutrients and oxygen. Secchi depth; is another important factor that should guide the suitability of water for fish culture. From this study, Huma, Xrasa, Uranga, and Munana had Secchi values within the recommended range of 30 cm to 60 cm. At those Secchi depths, there is good fish production and sufficient shading for the underwater weeds which act as refugia for fish and also as spawning sites. On the contrary, a Secchi of below 30 cm (as is the case in Pap Orage and Olasi SWBs, issues of dissolved oxygen problems are rampant. Above 60 cm, the growth of underwater macrophytes is promoted, and consequently, there is less phytoplankton which is food for fish.

Out of the sampled SWBs in this study, the most suitable candidates are Xrasa (Kakamega country) and Uranga (Siaya country). This is because in addition to the fact that they had lower parasite prevalence, their water quality characteristics, accompanying shoreline features and habitat use can be accommodative for fish culture. However, there is a need to consider dredging for better depth profiles. In as much as the prevalence of black spot disease was high in Uranga, their presence has little to no effect on the host, apart from reducing the aesthetic appeal of the fish to consumers [9]. Pap Orage on the other hand was used for livestock grazing, and this excludes it as a potential candidate. This is because of the potential to harbor more parasites since livestock can be intermediate hosts of some parasites hence this would encourage the proliferation of those parasites [12]. Additionally, user conflicts could arise which would then hamper the optimal performance of aquaculture activities. Pap Orage and Olasi had a wide diversity of parasites which would possibly make them unsuitable for aquaculture. Of concern is the appearance of *Clinostomum* species and *Diphyllobothrium* species (parasites of zoonotic significance) in Pap Orage with a relatively high prevalence. Additionally, this SWB had significantly high levels of microbial contamination (700/100 cfu) which is indicative of fecal contamination.

Before investment in aquaculture of any water body, it is vital to conduct a water quality analysis to assess its suitability for applicability while considering sustainability and value for investment [13]. The study found a positive correlation between Turbidity, SRP, TP, and Silicates with some fish parasites; *Clinostomum*, *Procamallanus*, *Camallanus*, and *Ichthyopthirius multifiliis*. This could point to the fact that due to available nutrients, then the growth of the host is favored and in addition, there is a free flow of nutrients for the parasite and its infective stages [14]. A related study on parasite communities and related water quality parameters in Lorwai swamp and Lake Baringo, Kenya also reported a positive correlation between nutrients and the abundance of *Clinostomum* spp. in fish [15-21].

CONCLUSION

The study found that the various SWBs had been home to fish that hosted various parasites but in different levels. Fish from 2 of the sites (HP and MO) had a wide variety of parasites which would can suggest that the environments could be conducive for their proliferation and hence make them unsuitable for aquaculture. The presence of some parasites of zoonotic concern (*Clinostomum* and *Diphyllobothrium* species) in HP with a relatively high prevalence could point to the need to capacity build the local consumers of the need to thoroughly cook the fish so as to minimize the chances of infection. There was a positive correlation between turbidity, SRP, TP, and silicates with some fish parasites; *Clinostomum*, *Procamallanus*, *Camallanus*, and *Ichthyopthirius multifiliis*. This could point to the fact that with available nutrients, the growth of the fish host is favored hence a free flow of nutrients for the parasite and its infective stages are promoted. Some parasites of economic significance were also observed, pointing to the need for intervention if massive culture for instance through cage aquaculture is to be considered as an option. Generally, it is important to assess the SWB dynamics before investing in fish culture so as to realize the intended benefits.

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