Parasites of Commercially Important Fish Species Caught for Food in Lake Ziway, Ethiopia

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Abstract

Background: In order of importance, the most commercially important fish species often caught for food in Lake Ziway are *Oreochromis niloticus*, *Clarias gariepinus*, *Carassius carassius*, and *Cyprinus carpio*. Some fish parasites have been reported in this lake, and the lake ecosystem appears to be conducive to parasite propagation, which may have an impact on fish marketability and societal health.

Objective: The purpose of this study was to look into the prevalence of major fish parasites in four of the most commercially important fish species in Lake Ziway, as well as their effects on the commercial values of host fishes and the health of fish consumers.

Materials and Methods: From May to July 2019, the study was carried out by purchasing random samples of live fish from local fishermen at Wafiko, Korokonch, and Kafteria landing sites and administering a research questionnaire to various stakeholders. Within three months, 240 specimens from the four species were examined in the Laboratory of Batu Fish and Aquatic Life Research Center. The data were analyzed using SPSS software.

Results: About 87.5% of the fish examined were found to be infested with 64.2% (trematodes), 42.5% (nematodes), 40% (crustaceans), 17.1% (cestodes) and 1.3% (*Acantocephala*). The fish examined were found to be heavily infested with zoonotic *Clinostomum*, *Contraceacum,* and *Capillaria* species. Thus, fishers were losing some catches due to the effect of parasites. The differences in the prevalence of parasites among the studied fish species were statistically significant (P = 0.00), but it was not statistically significant for the fish sexes (P = 0.60).

Conclusion: Lake Ziway's commercially important fish species are heavily infested with various types of external and internal parasites, which have both health and economic consequences for the people living on raw fish as food. Therefore, it is vital that awareness creation is done and sanitary measures are taken to stem the problem of human health caused because of eating raw fish and to enhance the productivity of the lake ecosystem.

Keywords: Fish marketability; Parasitic infestation; Parasitic prevalence; Zoonotic diseases

1. Introduction

Fish resources are vital to support human well-being and economic development. More than 17% of animal protein for the global population is obtained from fish (FAO, 2018). In addition, fish also serve as an important sources of energy and a range of essential nutrients such as fatty acids, iodine, vitamin D, and calcium (Pal *et al.*, 2018; Khalili Tilami and Sampels, 2018). Hence, fish represents the very important sources of protein-rich food and a reasonably important supplementary source of income through fishing, processing, transporting, and retailing, particularly in developing countries where other options are often limited (Lynch *et al.*, 2016).

In natural situations, small proportions of fish larvae reach the adult stages, while the majority are preyed upon by predators or die out due to several restrictive agents (Abowei *et al.*, 2011). Among these restrictive agents, fish parasites are considered as one of the major factors that limit human wellbeing through production losses from high fish mortality, morbidity, growth rate and weight reduction, and rejection of fish as well as causes of human diseases (Marcogliese, 2004; Kayis *et al.*, 2009). In terms of these constraints, the annual global cost of parasites in finfish aquaculture is estimated to be \$1.05 to \$9.58 billion with losses ranging from 1% to 10% of harvest size (Shinn *et al.*, 2015; FAO, 2018). In general, the presence of pathogenic parasites in fish is one of the most significant constraints limiting fish production and productivity. As a result, a better understanding of the various effects of fish parasites on their hosts and fish consumers is critical to the global development and maintenance of fisheries (Barber *et al.*, 2000).

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ISSN 1993-8195 (Online), ISSN 1992-0407(Print)

During their parasitic phase, almost all fish species are hosts to at least a few parasitic species, which are small, short-lived, and are usually found hiding on or within organs of their hosts (Marcogliese, 2004). Parasitic organisms, on the other hand, are frequently overlooked in the management and conservation of biological resources and ecosystems (Marcogliese, 2004; Sitja-Bobadilla and Oidtmann, 2017). As a result, information on the parasite fauna, particularly in/on freshwater fishes of sub-Saharan African regions, is limited due to a lack of experienced personnel in fish parasitology (Aloo, 2002) and poor aquaculture production practices.

The most commercially important fish species in Ethiopian lakes, including Lake Ziway, have been found to carry variety of pathogenic parasites from nematodes, cestodes, trematodes, crustaceans, and protozoan families (Hailekiros Gebreegziabher and Assefa Kebede, 2017). However, existing studies on fish parasites in Ethiopia in general, and Lake Ziway in particular, have primarily focused on simple epidemiology rather than parasitic effects. For instance, the study conducted by Eshetu Yimer (2000), Lemma Abera (2013), and Jossy Bekele and Daniel Hussien (2015) in Lake Ziway documented the presence of some nematodes, trematodes, and larval Cestodes from *Oreochromis niloticus* and *Clarias gariepinus*, but not their impacts. These two fish species were the largest stock in the lake and the largest catch size in fishermen nets during their study period.

Cyprinid fishes such as *Carassius carassius* and *Cyprinus carpio* have recently dominated the Lake Ziway fish production and marketing system. However, there has been little or no reporting on the level of parasitism in these species in the country. Furthermore, Lake Ziway is polluted (Hayal Desta and Brook Lemma, 2017), which may promote the growth of parasites and have a negative impact on people's health because some people enjoy eating raw or undercooked fish meat (Lemma Abera, 2013). Consuming raw or undercooked raw fish meat may result in the transmission of zoonotic parasites to consumers. As a result, the information obtained from this study is intended to provide some supportive knowledge to all interested bodies that have direct or indirect contact with fishery products and the health of fish consumers.

This study hypothesized that, commercially important fish species in Lake Ziway are infested with myriads of internal and external parasites. As a result, the specific objective of the study was to look into the prevalence of the major parasites in four commercially important fish species in Lake Ziway, as well as their effects on the market values of the host fishes and the health of the people consuming fish in the study area.

2. Materials and Methods

2.1. Description of Study the Area

Lake Ziway is found in the Central Ethiopian Rift Valley (CERV), 165 km South of Addis Ababa at an altitude of 1636 m above sea-level, with latitude ranging from 7°51'N to 8°07'N and longitude ranging from 38°43' E to 38°57' E (Figure 1). It is a shallow natural freshwater lake with a surface area of approximately 434 km^2 and maximum and mean depths of 9 m and 2.4 m, respectively (Lemma Abera, 2016). It is 25 km long and 20 km wide, with a margin of macrophyte vegetation and marshy grassland all around it. The lake is fed by the Meki River, which flows from the North-West Gurague Mountains and River Kattar (Qatar), which flows from the North-East Chilalo Mountain. Its water drains into Lake Abijata in the South via the Bulbula River (Abebe Getahun, 2017; Hayal Desta and Brook Lemma, 2017). The lake watershed has a semi-arid to sub-humid climate and two rainy seasons, with the main rainy season lasting from June to the end of September and the short rainy season lasting from March to May. Lake Ziway's average annual rainfall and temperature are 650 mm and 25 °C, respectively (Lemma Abera *et al.*, 2014).

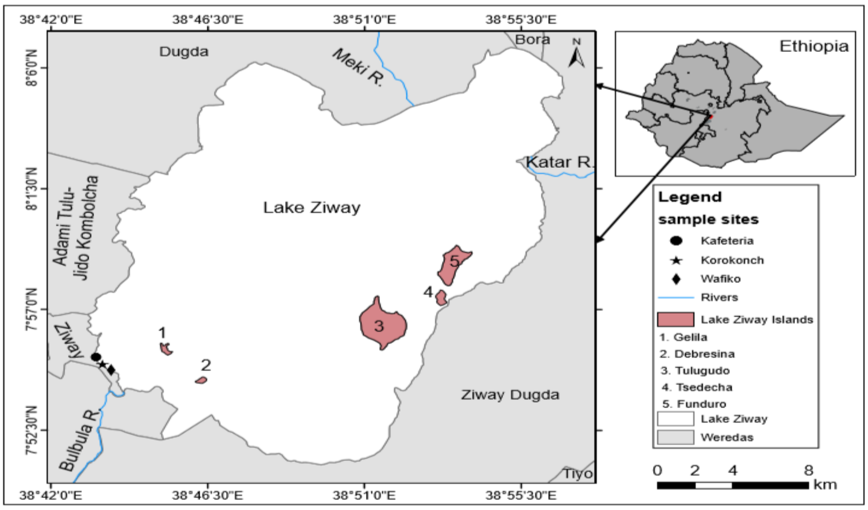

Figure 1. Map of Lake Ziway with the location of sampling sites.

2.2. Study Design and Sample Size Determination

Standing from our experience in the study area and reports of previous studies listed in the above, our study was designed to investigate the prevalence of major fish parasites, their effects on host fish market values, and clinical incidences on residents. To do so, primary data were gathered through parasitological examination and questionnaires, and secondary data were gathered from parasitological diseases result reports of Batu hospital. The study was conducted from May 2019 – July 2019. The study's target species were *O. niloticus*, *C. gariepinus*, *C. carassius*, and *C. carpio*. The sample size was determined using Ossiander and Wedemeyer (1973) sample size determination table for fish disease assessment and study to take approximately equal samples of each species for comparison of parasitic prevalence in the four fish species of the lake. Accordingly, 20 specimens per week were examined from one commercially important fish species, with the sampled fish species changing at weekly intervals. Within three months, 60 specimens from each species and 240 specimens from the four species were examined.

2.3. Field Samples Collection

Three landing sites namely, Wafiko, Korokonch and Kafeteria, were chosen for fish sampling based on accessibility, volume of catch, and classification of fishermen by Batu Fishermen Cooperative based on the government guidelines for natural fish stock harvesting. Live fishes were purchased early in the morning with random sizes between 6:00 to 7:30 a.m. from local fishermen who used wooden boats to access the lake and fish with hook-and-lines and beachsein net. The collected live fishes were kept in a 40-litter bucket filled with oxygenated lake water (Justine *et al.*, 2010) and transported to Batu Fish and Other Aquatic Life Research Center laboratory on L. Ziway shore, which was very close to the fish landing.

2.4. Parasitological Examinations

The lake water in the bucket containing the sampled fish specimens was aerated in the laboratory using BB.34BA aquarium air pump to keep the fishes alive until the closer examinations were done (Justine *et al.*, 2010). The sexes of the specimens were then determined visually by inspecting their genitals and gonads. The external bodies of the specimens, such as fins and skin, were scraped off with scalpels and visually examined for ectoparasites in Petri dishes (Cribb and Bray, 2010). A scalpel, forceps, and scissors were used to remove the eye balls and gill arches (Justine *et al.*, 2010). Following that, a scissor was used to open the abdominal wall along the ventral middle line. Another incision was made from the anus to the lateral line, and then from the lateral line to the gill cover (Justine *et al.*, 2010; Calhoun *et al.*, 2018). The heart, liver, spleen, gall bladder, intestine, kidneys, muscles, and brains of the specimen were all carefully examined. Swimming bladders from two carps and a Nile tilapia were collected separately for endoparasite recovery.

Drops of 0.85% physiological NaCl solution were applied to each examined organ, and the parasites released were collected in wet Petri dishes to avoid drying (Cribb and Bray, 2010; Khalil *et al.*, 2014). Each organ was thoroughly examined with the naked eye for the presence of cysts, larval and adult parasites internally and externally, as well as under a 40x binocular microscope (Mohammed Reshid *et al.*, 2015). The collected parasites were counted and identified morphologically to the genus level using the identification guidelines of Paperna (1996), Florio *et al.* (2009), and Shehata *et al.* (2018). As directed by Oros *et al.* (2010), some representative samples of the collected parasites were preserved in 4% neutral formalin for further identification. After one to two weeks, the preserved parasites were transformed into 70% ethanol according to procedures by Oros *et al.* (2010) and Khalil *et al.* (2014) to prevent the parasites' bodies from becoming hard and fragile as a result of long-time preservation with formalin. Finally, the ethanol-preserved parasites were transported to Sebeta, National Fisheries and Aquatic Life Research Center fishery laboratory for furthermore identification.

2.5. Research Questionnaires

A research questionnaire was developed, validated, and distributed to members of the local communities, including fishermen and fish traders or middlemen, fishery experts in Zonal Agricultural Offices, restaurants serving fish dishes, and public health professionals at Batu Hospital, who have direct or indirect contact with Lake Ziway fish and fish products. This was done to assess stakeholders' perceptions of the types of common fish parasites found in commercially important fish species in Lake Ziway, as well as their effects on the marketability of the fishes. Secondary data were also gathered from Batu Hospital in order to learn about clinical incidences in the surrounding community.

2.6. Statistical Tools

Prevalence describes the presence or absence of parasites in the examined samples. To arrive at the percentage of infected individuals, the number of infected hosts at least by one parasite is divided by the total number of examined hosts and multiplied by 100 (Bush *et al.*, 1997).

$$\text{Prevalence (\%)} = \frac{\text{Total number of infected fish}}{\text{Total number of examined fish species}} \text{X } 100$$

2.7. Statistical Data Analysis

All the data obtained during the study period were recorded in Microsoft Excel sheet and differences in the parasitic prevalence among the four fish species, and between sexes were analyzed using SPSS software, version-21. P-values less than 0.05 were considered as statistically significant at 95% confidence interval.

3. Results

3.1. Prevalence of Parasitic Infestations

About 87.5% of the 240 fish specimens examined were found to be infested with at least one internal or external parasite. *Clarias gariepinus* had the highest level of parasite infestation (100.0%), followed by *O. niloticus* (90.0%), and *C. carassius* (85%). *Cyprinus carpio* had the lowest (75%) proportion of parasite infestation (Table 1). The differences in parasite infestations of the different fish species were statistically significant (P= 0.00, χ = 17.83, df= 3). During the study period, 94 (86.2%) of the 109 male fishes examined were infected with at least one external or internal parasite, while 116 (88.6%) of the 131 female fishes examined were infected by parasites, but the difference in parasitic prevalence between the sexes was not statistically significant (P = 0.592, df = 238, SE = 0.098).

Table 1. Fish species sampled and prevalence of parasites in the four commercially important fish species of Lake Ziway (n = 240).

Sampled fish species	Infected fish number	Parasitic prevalence (%)
O. niloticus (n=60)	54	90
C. gariepinus (n=60)	60	100
C. carassius (n=60)	51	85
C. carpio (n=60)	45	75
Total (n = 240)	210	87.5

3.2. Types of Parasites and their Prevalence

A total of 22,909 parasite specimens grouped under fourteen genera were identified (Table 1). Out of the 240 fishes examined during the study period, 154 (64.2%) fishes were infected by trematodes, 102 (42.5%) were infected by nematodes, 96 (40%) by crustaceans, 41 (17.1%) by cestodes, and five (1.3%) were harboring *Acantocephala* parasites. From 210 fish specimens infected with one or more parasites, a total of 22,909 parasite specimens which belong to fourteen different genera were identified (Table 2). During the study period, 154 (64.2%) of the 240 fish examined were infected with trematodes, 102 (42.5%) with nematodes, 96 (40%) with crustaceans, 41 (17.1%) with cestodes, and five (1.3%) with *Acantocephala* spp.

Table 2. Organ of infestation, prevalence and intensity of parasites collected from the four commercially important fish species of Lake Ziway (n = 240).

Taxonomy of the parasites		Infected fish organs	Number of infected fish				No. of detected parasites	P (%)
			O. niloticus	*C. gariepinus*	*C. carassius*	*C. carpio*		
Crustacean	*Argulus* spp.	Gill, Skin	1	8	5	13	55	11.25
	Copepodite	Gill, Skin	12	2	36	27	358	32.08
Monogenean	*Gyeodactylde* spp.	Skin	0	15	0	0	25	6.25
	Cichligogyrus spp.	Gill	3	0	0	0	5	1.25
Digenean	*Tylodelphys* spp.	C. cavity, Eye	41	59	29	25	20,002	64.17
Trematodes	*Clinostomum* spp.	Gill, Muscle, B. cavity, Eye orbit	19	11	0	0	132	12.5
	Clinostomum cyst	Muscle	0	45	0	0	959	18.75
	Neascus spp.	Muscle	3	0	0	0	4	1.25
	Unidentified trematode	Intestine	0	11	0	0	42	4.58
Nematodes	*Contraceacum* spp.	Mesentery, P. cavity	13	53	5	3	855	30.83
	Capillaria spp.	Intestine	28	8	0	0	152	15
	Procamallanus spp.	Intestine	0	18	0	0	84	7.5
Cestodes	*Botreocephalus* spp.	Intestine	0	31	0	0	173	12.92
	Unidentified cestode	Intestine	10	0	0	0	55	4.17
Acantocephala	*Acantocephala* spp.	Intestine	5	0	0	0	8	2.08

Note: *B. cavity is for branchial cavity, C. cavity for cranial cavity and P. cavity for pericardial cavity*
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3.3. Demography of the respondents

The study was supported by information generated from different group of people involved in the fishing activities of Lake Ziway, fish and fishery experts, and health professionals in Batu Hospital. These were: fishermen (30), fish traders (20), fish house owners (10), fish and fishery experts (6) from the Oromia Agricultural Research Institute, Batu livestock bureau and (4) from Oromia Agricultural Research Institute Batu Fish and Aquatic Life Research Center, Medical doctors (7) and laboratory technologists (4) from Oromia Health Bureau Batu Hospital. Their ages ranged from 20 to 50 years. Of the interviewed participants 73 (90.12%) were males and 8 (9.88%) were females. 81 respondents with different status participated in throughout the study.

3.4. Stakeholders' Perspectives on Various Types of Fish Parasites and their Commercial Implications

Parasites affected the commercially important fish species in Lake Ziway, according to respondents. All respondents (100%) including fishermen, fish traders, fish restaurant owners, and fish and fishery experts agreed that parasites have a significant impact on the commercially important fish species, particularly African catfish. *Contraceacum* spp, also known as "Wesfat" or "Maga," and *Clinostomum* spp., also known as "Koso," are the two well-known fish parasites. *Tylodelphys* spp. are also common in the cranial cavity of African catfish and occasionally in the eyes of Cyprinid fish species in Lake Ziway, according to the four (40%) fish and fishery experts. The presence of too many parasites causes fish losses, according to 22 (73.3%) fishermen, 16 (80%) fish traders, 10 (100%) fish restaurant owners, and 4 (40%) fish and fishery experts. *Clinstomum* spp. were the most common parasite in the muscles of African catfish, causing a significant loss of the fish in the market. According to the interviewees' responses, up to ten fish per box (one box may contain 25-50 fish depending on the fish size) may be lost in some cases, costing 2 to 15 Ethiopian Birr per fish (equivalent to 0.05$ to 0.34$ USD per fish at the current exchange rate).

3.5. Stakeholders' Responses to Clinical Incidences of Fish Parasites

All respondents in the research questionnaires among the health professionals of Oromia Health Bureau Batu Hospital stated that they had not experienced any zoonotic human diseases caused by consuming parasite-infected fish such as those described above. However, because of the local people's tradition of eating raw fish and poorly prepared fish, there have been reports of the presence of zoonotic fish parasitic diseases. Although no active cases were observed during this study, oral narratives of helminth diseases contracted from fish have been heard on several occasions. According to Batu Hospital health professionals, up to 90 people per month are infected with helminth parasitic diseases. When asked which parasites were present, the health workers were unable to identify the type and severity of the infections. According to reports, all patients were treated with broad-spectrum antihelminthic drugs.

4. Discussion

The higher parasitic prevalence observed in the current study could be attributed to a variety of natural and anthropogenic factors that provide favorable conditions for the parasite's increased magnitude. For example, the shore area of Lake Ziway is covered by several macrophytes (Hayal Destaa and Brook Lemma, 2017), that may be suitable for the propagation of the parasites' first intermediate hosts (Crotti, 2013). Furthermore, a variety of water birds visit the lake, which may serve as the final hosts for several helminth larval parasites lodged in or on the fish that birds eat. Furthermore, almost all fish caught by fishermen are eviscerated at the lake's shore, washed, and the offal (guts, heads, scales, and so on) other fish carrion are disposed there at the spot of the operation. The fish carrion is likely to contain parasites at various stages of development. When the carrion is eaten by flesh-eating birds such as storks, hammer-cops, and some dogs, the parasites in some cases continue their life cycles in these secondary or tertiary hosts (Lemma Abera, 2013).

In comparison, the overall parasitic prevalence (87.5%) in this study was higher than the total parasitic prevalence of 63.7% in Armand River, Iran (Raissy and Ansari, 2012), 50% in the Ase River Catchment, Delta State, Nigeria (Ito, 2017), 65.8% in upper Tana Basin, Kenya (Mathenge, 2010), 47.8% in Lake Hayq (Abadi Amare *et al.*, 2014), 66.3% in Koka Reservoir (Yewubdar Gulelat *et al.*, 2013) and 24.6% and 20.8% in Lake Ziway by Eshetu Yimer (2000) and Jossy Bekele and Daniel Hussien (2015), respectively. The higher parasites prevalence in the present study might be attributed to the fact that, the sample size of this study was high as it involved four different fish species with various models of feeding habits, which may have apparently increased the probability of parasite richness (Ito, 2007). Furthermore, the present study was conducted in the rainy season in the study area (May, 2019 to July, 2019) that may have increased the occurrence of parasites, because of the proliferation of high number of first intermediate hosts such as molluscs, oligochaetes, and zooplankton (Bichi and Dawaki, 2010).

This study also revealed the prevalence rate for *O. niloticus*, *C. geriepinus*, *C. carassius* and *C. carpio* were 90%, 100%, 85%, and 75%, respectively. These results are also consistent with previous prevalence rates of 100% reported for *C. griepinus* by Gumpinger (2016) in Lake Baringo. However, the results of this study revealed a higher rate of prevalence of fish parasites than those found previously by other researchers, specifically, 22.6% for *C. gariepinus* (Carp, 2007), 74.5% for *C. gariepinus*, 63.8% for *O. niloticus*, and 51.2% for *C. carpio* (Shehata *et al.*, 2018), 76.1% for *O. niloticus* (Brian *et al.*, 2018), 42.47% for *O. niloticus* (Yewubdar Gulelat *et al.*, 2013). The parasitic prevalence in the current study, on the other hand, was lower than the prevalence of 98.4% reported for *O. niloticus* from Gigel Gibe-I Dam in Ethiopia (Marshet Adugna *et al.*, 2018). This variation of parasitic infection from location to location suggest that the occurrence of fish parasites is influenced by a variety of factors, including differences in physical and chemical parameters of the water, climatic conditions of the areas and season that stress fish hosts and predispose for parasite infection (Edema *et al.*, 2008; Abadi Amare *et al.*, 2014).

Clarias griepinus had the highest prevalence of parasitic infestation, followed by *O. niloticus*, *C. crassius*, and *C. carpio*, and the difference in parasitic prevalence among the studied fish species was significant. The higher prevalence of total parasitic infection in *C. gariepinus* could be attributed to the presence of *Tylodelphys* spp. and *Contraceacum* spp., which have prevalence rates of 98.3 % and 88.3 %, respectively. *C. gariepinus* has the highest infestation rate due to its ability to live and feed near the bottom as well as in midwaters or near the surface of freshwater bodies which termed as benthopelagic behavior (Abebe Getahun, 2017). This aids in the transmission of many internal parasites by feeding on aquatic animals that harbor the infective stages of these parasites. Furthermore, *C. gariepinus* is a "scaleless" fish whose skin may be easily penetrated by the infective stages of parasites. It is also possible that *C. gariepinus* is highly susceptible to infections as a result of its diverse feeding habits, which take it into a variety of micro-habitats and expose it to multiple and severe parasitic infestations (Shehata *et al.*, 2018). *C. carpio* and *C. carassius*, on the other hand, were the fourth and third least infected fishes in the current study, respectively. This could be attributed to carps' hardiness (Copp *et al.*, 2008), which could serve as a non-specific defense mechanism to trap and inhibit the growth of parasitic organisms (Rasouli *et al.*, 2012). This could also be due to the fact that carps are newcomers to the lake, having been introduced by some fishery experts. Furthermore, the detection of lower parasitic prevalence rates in *O. niloticus* and the two carps than in *C. gariepinus* could be due to the fact that *O. niloticus* and carps are fast growers, reaching marketable size in a short period of time, reducing their period of exposure to parasitic infestations (Shehata *et al.*, 2018).

There was no any significant difference in parasitic prevalence between the sexes. However, female fish had a slightly higher parasitic prevalence (88.6 %) than male fish (86.2%). This could be attributed to the fact that females, particularly gravid females, are physiologically more vulnerable to parasitic infestations (Simkova *et al.*, 2005). This observation is consistent with the findings of Shehata *et al.* (2018) in Egyptian freshwater aquaculture, Brian *et al.* (2018) in Lake Baringo, Kenya, and Abadi Amare *et al.* (2014) in Lake Hayk, Ethiopia.

During the study period, 22,909 parasites from 12 identified and 2 unidentified different taxa were collected from 210 (87.5 %) infected fishes. This value was higher than the findings of Gumpinger (2016), who found 2598 parasites from ten different taxa in 101 fishes from four commercially important fish species in Lake Baringo, Kenya. It was also higher than the findings of Brian *et al.* (2018), who discovered 6027 parasites from six taxa in 447 *O. niloticus* fish species at River Molo Inlet in Lake Baringo, Kenya. The differences in the geo-climatic conditions of the study areas, variations in the host-parasite relationships, and differences in the quality of the environments where the Lake Ziway study has become so conducive to the propagation of parasitic agents could all be reasons for this (Ito, 2017). The latter case is exemplified further by the fact that the parasite load per fish (109) in this study is significantly higher than that found in both Kenyan studies (26 and 14 parasites per fish, respectively).

Only three of the fourteen different parasite genera identified in this study, namely *Clinostomum* spp., *Contraceacum* spp., and *Bothriocephalus* spp., were previously reported from Lake Ziway fishes by Eshetu Yimer (2000), Lemma Abera (2013), Jossy Bekele and Daniel Hussien (2015), and Temesgen Bihonegn and Getachew Tilahun (2017), while the remaining (11genera) are new reports of this study. This might be attributed to pollution (eutrophication) of Lake Ziway from time to time that may have created a conducive environment for propagation and proliferation of valuable fish parasites. In addition, it could be due to the research method such that we used live fish samples for the parasitological examination that may have enhanced the chance to find existing parasites compared to the use of long time stored dead host (Justine *et al.*, 2010).

The classes of parasitic prevalence revealed that trematodes made up 64.2%, nematodes 42.5%, crustaceans 40.0%, cestodes 17.1%, and *Acantocephala* spp 1.3%. The findings of this study contradicts those of Kiprono (2017), who found 34.5% nematodes, 26.5% trematodes, 15% cestodes, 11.3% crustaceans, and 3.8% *Acantocephala* spp., most likely belonging to Class *Eoacanthocephala*. These findings are also not comparable to Mathenge's (2010) work, which reported 45.3% nematodes, 41.5% trematodes, 13.9% *Acantocephala*, and 2.5% cestodes. In the current study, the most common parasitic trematode class was *Tylodelphys* spp., which was the most common parasite affecting 201 fish specimens from the four examined fish species that were positive for one or more parasitic species. This could be because Lake Ziway is surrounded by a margin of macrophyte vegetation and marsh (Abebe Getahun, 2017; Hayal Desta and Brook Lemma, 2017), which provides important habitat for the propagation of mollusks, which are the first intermediate hosts of this parasite (Crotti, 2013). The trematodes colonize the mouths and pharynxes of pescivorous birds such as egrets, herons, darters, cormorants, storks, and pelicans (Paperna, 1996). Furthermore, the presence of *Tylodelphys* spp. in all examined fish species suggests that this parasite is adaptable in its host selection, ensuring its survival in a diverse range of hosts (Rasouli *et al.*, 2012).

The questionnaire survey was designed primarily to gather stakeholders' perspectives on Lake Ziway's commercially important fish parasites and their effects on fish market value and health of the residents. As a result, 100 percent of the respondents agreed on the presence of fish parasites, which continue to be a nuisance in the processing and marketing of Lake Ziway fish harvests. This concurrent response in this study was higher than the findings of Haftom Abay (2018), who reported that 41.6 percent of respondents were from people living near Lake Ashenge. According to the respondents' responses, the most common parasites of commercially important fish species in Lake Ziway were *Contraceacum* spp. (locally known as "wesfat" or "Maga"), *Clinostomum* spp. (locally known as "Coso til"), and *Tylodelphys* spp. (has no local name).

Respondents confirmed that *Clinostomum* spp., particularly those that lodge in the muscles of *C. gariepinus*, have a significant economic impact, rendering the fish flesh unappealing or repulsive to consumers (see also the reports of Brian *et al.*, 2018). Furthermore, even though all health professionals responded that there had been no reports of zoonotic disease thus far, the patients' profiles recorded at Batu Hospital revealed a higher occurrence of helminth disease. According to Amer (2014), parasites such as *Contraceacum* spp., *Capillaria* spp., and *Clinostomum* spp. are zoonotic and can be transmitted from fish to humans when raw flesh is consumed. It is therefore unlikely that, with such a high abundance of these parasites in Lake Ziway fish and the raw fish consumption habits of the people in Ziway, some of the zoonotic diseases have gone unnoticed.

5. Conclusion

The results of this study have demonstrated that various types of external and internal parasites seriously affect commercially important fish species in Lake Ziway. It was found that 87.5% of the fish catches examined were found to be infested with 64.2% trematodes, 42.5% nematodes, 40% crustaceans, 17.1% cestodes, and 1.3% Acantocephala as well as infected with zoonotic *Clinostomum*, *Contraceacum*, and *Capillaria* species. Fishers are losing some of their catches due to parasitic effect, especially due to unattractive muscle of *C. gariepinus* infected by numerous *Clinostomum* cyst. These parasites, which have a significant impact on the fish market, have gone unnoticed so far in the study area. What is more, the local inhabitants eat raw fish and have no awareness about the dangers it poses to their health. To avert the dangers of suffering from internal parasites and concomitant zoonotic disease, people living on fish as food should be made aware of the problem and discouraged from eating raw fish and encouraged to take appropriate sanitary measures. Research should be done in the future focused on fish ecology with the participation of biologists, parasitologists, public health experts, and aquatic ecologists. This can help to generate more reliable data in improving the quality of the aquatic environment, decrease fish parasites, and protect the public from fish-borne internal parasites and zoonotic diseases.

6. Acknowledgments

The authors thank Aquatic Ecosystem and Environmental Management (AEEM) joint MSc Project of Addis Ababa University, Bahir Dar University and Sebeta Fish and Aquatic Life Research Center in collaboration with Austrian Development Agency for funding the research through University of Natural Resources and Life Sciences, (BOKU), Vienna, Austria. The authors also thank Addis Ababa University, Research Directorate through thematic research project ["*Improving the health and productivity of market-oriented livestock (MOL) and public health risk*" from CVMA] for co-funding the research and for providing material supports for laboratory work at Batu Fish and Other Aquatic Life Research Center located on the shores of Lake Ziway.

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