Tanzania Journal of Science 46(1): 42-52, 2020 ISSN 0856-1761, e-ISSN 2507-7961

A Survey of Fish Parasites from Pangani Catchment and Lake Kitangiri in Singida, Tanzania

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Received 22 Sep 2019, Revised 27 Dec 2019, Accepted 1 Jan 2020, Published 31 Mar 2020

Abstract

Inland water fisheries are a significant source of dietary protein to human populations, and consequently they are essential economic activities worldwide. However, both natural waters and aquaculture systems, which form the freshwater fisheries are faced with a problem of fish parasitic diseases which may result in reduced productivity and market value. The present study, therefore, carried out a survey on fish parasites from the Pangani catchment (Nyumba ya Mungu dam and Lake Jipe) and Lake Kitangiri in Singida Region in Tanzania to seal the gap of occurrence, diversity and abundance of helminths. Three species of fish *viz.* 111 African sharptooth catfish (*Clarias gariepinus*), 36 African butter catfish (*Schilbe mystus)* and 9 cichlid tilapia (*Oreochromis amphimelas*) were examined for parasites. Most fishes were co-infected with two helminth genera, *Contracaecum* in the abdominal cavities and *Tylodelphys* in the cranial cavities with prevalences higher than 70%, while a few fish were infected with *Diplostomum* in the eyes' vitreous humour and unidentified trematodes in the intestines. Pangani catchment and Lake Kitangiri were recorded as new localities for *Tylodelphys* species, and *O. amphimelas* as a new host species.

Keywords: Fish, Helminths, Nyumba ya Mungu Dam, Lakes Kitangiri and Jipe

Introduction

Freshwater fisheries industry has a significant contribution to development as a vital source of proteins. Besides providing food to millions of people, the freshwater fisheries contribute significantly to the overall economic incomes through export commodity trade, tourism and recreation (Worldfish Center 2002). As a consequence, the freshwater fisheries industry has become an essential economic activity for both rural and urban populations in Africa and the globe. The increasing gap between supply and demand for fish products has further made fisheries capture the most substantial extractive use of wildlife worldwide. An increase in the human population, improved livelihood incomes and the rise in urbanisation coupled with stagnation or decline of extra proteins further exacerbate the need for fish products. As a result, most communities globally have responded by venturing into aquaculture to enhance wild fisheries capture. Accordingly, as African aquaculture advances, societies need to address cross-cutting challenges including lack of national policies to guide aquaculture development, unfavourable investment policies, the absence of linkage between farmers and conservation organs, limited research/technology and extension, inadequate quality seed and feed, and above all infectious and parasitic diseases (Hecht and Endemann 1998, Brummett and Williams 2000). The occurrence of parasites and parasitic diseases in natural and aquaculture systems impairs fish productivity.

Helminthiasis is a common parasitic disease resulting from an infection with monogeneans, trematodes, cestodes, nematodes and acanthocephalans. Some of these helminths have a three host life cycle involving snails/crustaceans as primary hosts, fish as secondary hosts and piscivorous birds/mammals as definitive hosts. These helminths have attracted much attention because of their pathogenicity in fishes in aquaculture or natural systems. For instance, metacercarial stages of some trematodes like *Diplostomum* may lodge in the eyes and brain cavities of fishes (Chappell et al. 1994, Chibwana 2018). When at high densities, they can cause haemorrhage, eye cataracts or cranial distortion that could ultimately result in reduced host survival and massive fish deaths in farms (Sandland and Goater 2001). On the other hand, intestinal helminths in fishes may lead to stunted growth. Consequently, parasites can severely reduce fish yields from the natural and/or aquacultural systems and, therefore, become among the limiting factors for the 2030 Agenda of the United Nations in achieving its second Sustainable Development Goal (SDG) of zero hunger.

In Tanzania, so far fishes that have been examined for helminths are the clariids (*Clarias gariepinus*) from various freshwater systems (Mwita and Nkwengulila 2008, Chibwana and Nkwengulila 2010, Mwita 2014), the cichlids (*Oreochromis urolepis*) of Mindu dam (Chibwana 2018) and cyprinids of Lakes Victoria and Malawi (Wanink 1992, Msafiri et al. 2014). Besides, fishes of some lakes such as Lake Jipe, Nyumba ya Mungu Dam and other small water bodies have been reported to experience stunted growth. Overfishing is, however, the only factor which is mostly incriminated in reduced fish production. As such, a parasitological survey becomes obligatory to provide all stakeholders in the fisheries industry with a better understanding of the potential parasites affecting small lakes fisheries in Tanzania. Therefore, the present study was initiated to determine the occurrence, diversity and abundance of helminths harboured by selected fish types from Nyumba ya Mungu dam and Lakes Jipe and Kitangiri in Tanzania.

Materials and Methods

The study area

The present study was carried out in three water bodies, namely Nyumba ya Mungu Dam and Lakes Jipe and Kitangiri. Nyumba ya Mungu is a human-made water reservoir that was constructed in 1965 for hydro-electric power generation and irrigation and fisheries activities. The dam is located in Pangani River Valley in the Masai Steppe, approximately 10 km south of Mwanga town in Kilimanjaro, Tanzania (Figure 1). The dam is maintained by two significant inflows: the rivers Kikuletwa and Ruvu. The dam is connected to Lake Jipe through the River Ruvu, about natural 35 km to the east, but geographically separated by the North Pare mountain range.

Lake Jipe is located along the border between Tanzania and Kenya (Figure 1). The lake is shared between two countries: 12 km^2 on the Tanzanian side and 14 km^2 to Kenya as part of Tsavo West National Park, which covers the southern portion of the lake. It is a small and shallow lake with an area of about 28 km^2 and an average depth of less than 3 m. It is found in Mwanga district, in Kilimanjaro Region. The lake has a length of approximately 12 km, and a width of 2.5 km wide (Maltby 2009). Lake Jipe has the main inflow from Mount Kilimanjaro in Tanzania through River Lumi with a meander in Kenya. River Muvulani forms another main inflow together with other several temporary streams from the Pare Mountains. Ruvu River is the only outflow which connects the lake to Nyumba ya Mungu.

Lake Kitangiri is located in Singida region in Tanzania at latitude 4°4′ South and 34°17′ East (Figure 1). Lake Kitangiri, is next to Tulia River, has an area of length of 105 square kilometres (Reuben et al. 2017). Various activities are conducted around the area such as aquaculture activities, fishing and irrigation.

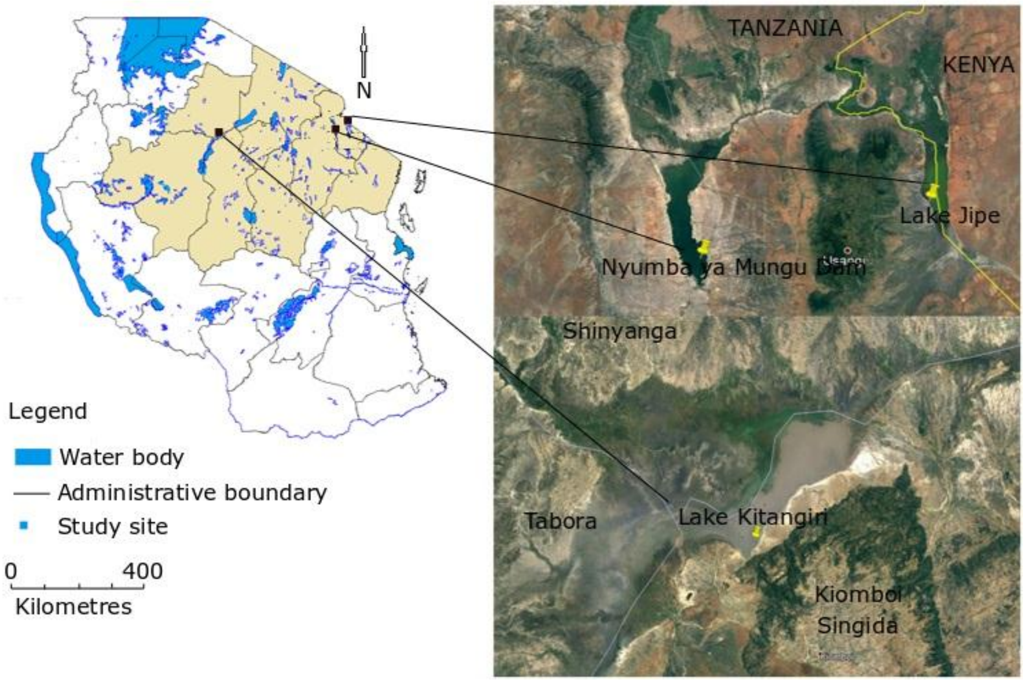

Figure 1: Map showing the study sites, i.e., Nyumba ya Mungu Dam, Lakes.

Fish collection and parasites recovery

The African sharptooth catfish (*Clarias gariepinus*), the African butter catfish (*Schilbe mystus*) and the cichlid tilapia (*Oreochromis amphimelas*) were bought from artisanal fishers at Lakes Kitangiri and Jipe, and Nyumba ya Mungu Dam between January and February 2019. Fish identification, examination for parasites and their subsequent identification as well as parasites counting followed standard guides and procedures (Moravec et al. 1991, Anderson 1992, Eccles 1992, Khalil et al. 1994, Gibson et al. 2002). The parasitological terms: prevalence and mean intensity of infection were attributed according to Bush et al. (1997). The trematode metacercariae were recovered from the cranial cavity of *Clarias gariepinus* and eye's vitreous humour of *Oreochromis amphimelas*, while nematodes were removed from abdominal cavity and intestines (Plate 1).

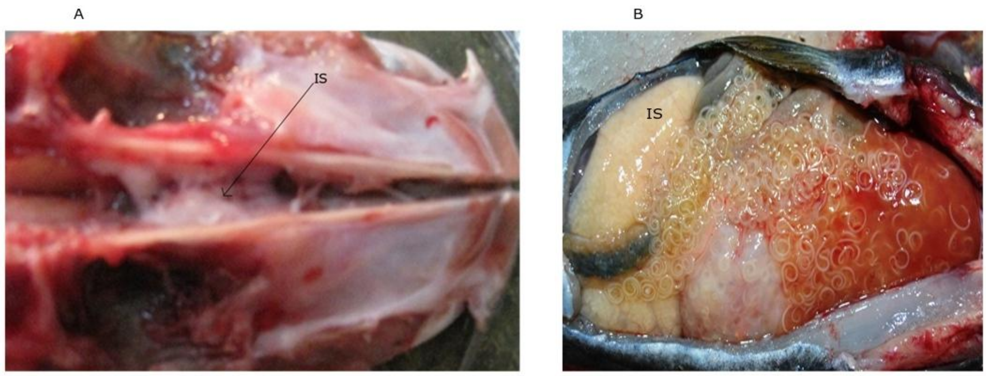

Plate 1: Infection sites (IS) of some parasites: diplostomids in the cranial cavity and anisakids in the abdominal cavity.

Data analysis

Both descriptive and inferential statistics were used. Data did not fit the Gaussian assumptions, so Spearman correlation coefficient was used to test if the lengths and weights of *C. gariepinus* correlated with *Contracaecum* sp and *Tylodelphys* sp infections. Data for prevalence and mean intensity with respect to sex and size of fish were analysed by Chi-square. Tables and charts for descriptive statistics were plotted in Excel.

Results

Parasites in fish samples from Nyumba ya Mungu

Among the examined specimens of fish, 12 out of 15 (80%) were infected. The most abundant parasites were *Tylodelphys* sp and *Contracaecum* sp (Figure 2A) at a prevalence of 33% and 67%, respectively. They were correspondingly recovered from the cranial and abdominal cavities. The fishes measuring between 21 cm and 30.9 cm long were infected with *Contracaecum* at 47.3% prevalence, while bigger fish of between 31 cm and 40.9 cm lengths had a prevalence of 34.2%. The fishes measuring between 41 cm and 50.9 cm long had the lowest prevalence of 18.5%. Similarly, 74.3% of *Tylodelphys* metacercariae were isolated from fish measuring 21 to 30.9 cm long, while 25.7% of the parasites were recovered from 31 to 50 cm long fishes.

The overall prevalences of infection were not significantly different in male and female fishes (Figure 2B) (x^2 = 0.8637, P = 0.352708). Although the mean intensity of *Tylodelphys* sp was higher than that of *Contracaecum* sp (Table 1), the variations were not significantly different (t = 1.508, P = 0.142). The correlations between fish condition parameters (body weight and host length) and the two parasite families were not significant (Figure 2 C & D). However, *Contracaecum* sp had a positive significant correlation with host length (r = 0.622, P = 0.0132). The prevalences of parasites between sexes of fish were not significantly different (x^2 = 0.864, P = 0.3527).

Table 1: Prevalence, mean intensity and intensity range of *Contracaecum* sp and *Tylodelphys* sp for both sexes in Nyumba ya Mungu Dam

Parasite	Host sex	Prevalence (%)	Mean intensity ± std	Intensity range	Site of Infection
Contracaecum sp	Female	33.3	41 ± 32.81	9-88	Abdominal cavity
	Male	46.7	35 ± 54.30	2-154	Abdominal cavity
Tylodelphys sp	Female	13.3	764 ± 282.84	564-964	Cranial cavity
	Male	26.7	143.25 ± 139.61	20-304	Cranial cavity

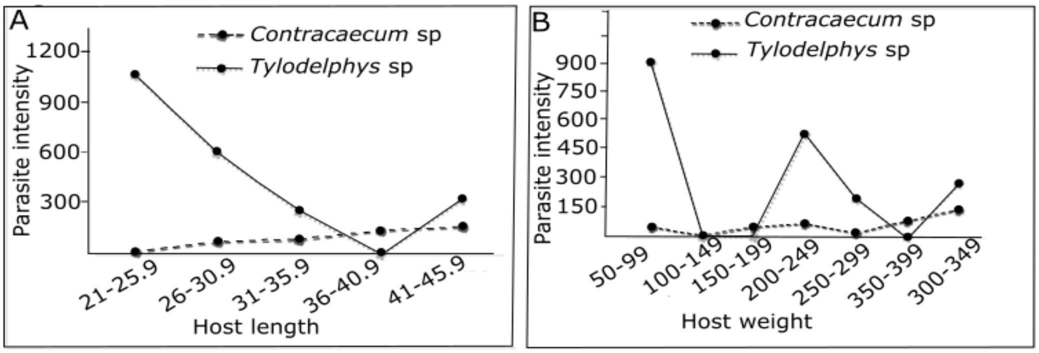

Figure 2: The relationship between parasite intensity (number of parasites per host) and body conditions (length and weight) of fish from Nyumba ya Mungu Dam.

Parasites in fish samples from Lake Kitangiri

In Lake Kitangiri, 80 fish, 35 catfish *C. gariepinus*, 36 African butter catfish *S. mystus*, and 9 tilapia *O. amphimelas*, were examined for parasites. A total of 1479 parasites were isolated from the three host species. In *C. gariepinus*, 27 individuals were infected with helminths at an overall prevalence of 77.14%. Two groups of parasites were found, i.e., nematodes (*Contracaecum* spp and unknown nematodes) and trematoda (*Tylodelphys* spp) and their respective prevalences and intensities are shown in Table 2. African butter catfish *S. mystus*, were also infected with undescribed nematodes and *Contracaecum*, with an overall prevalence of 61.11%. On the other hand, *O. amphimelas* were infected with *Diplostomum* species in the vitreous humour of the eyes, and *Contracaecum* species in the abdominal cavity. The overall prevalence of parasites in *O. amphimelas* was 66.67%. Prevalence and intensities for parasites recovered from *S. mystus* and *O. amphimelas* are also shown in Table 2. In *Clarias gariepinus*, the most vulnerable fish were those with large body sizes, particularly those ranging from 27 to 48 cm, which confirmed the variation between infection and host sizes (x^2 = 8.624, P < 0.025). Similarly, in *S. mystus*, 18–26 cm long fish were more infected than 9–17 cm long fish (x^2 = 2.5, P < 0.25).

The prevalence and mean intensity concerning sex were not analysed to avoid bias as in all species unequal numbers of males and female fish were examined due to availability.

Table 2: Prevalence, mean intensity (number of parasites per host) and intensity range of helminths recovered from fish species in Lake Kitangiri

Host species	Parasite species	No. fish examined	No. fish infected	Prevalence (%)	Mean intensity	Intensity range	Site of infection
Clarias gariepinus							
	Undescribed nematodes	35	7	20	2	1-8	Intestines
	Tylodelphys	35	21	60	125	1-5000	C. cavity
	Contracaecum	35	9	25.71	2.8	1 - 50	A. cavity
Schilbe mystus							
	Undescribed Nematodes	36	22	61.11	4.64	1-10	Intestines
	Contracaecum	36	29	80.56	6.662	1-23	A. cavity
Oreochromis amphimelas							
	Diplostomum	9	2	22.22	2	1-3	Eye
	Contracaecum	9	5	55.56	7	6-12	A. cavity

Note: A = Abdominal; C = Cranial

Parasites in fish samples from Lake Jipe

The catfish *C. gariepinus* from Lake Jipe were also infected with two major groups of endo-helminths; nematodes (roundworms) and the platyhelminths (flatworms). Roundworms *Contracaecum* (Family: Anisakidae) were abundant in the abdominal cavity and *Tylodelphys* species (Family: Diplostomidae) were occupying the cranial cavity. The overall prevalence of *Contracaecum* and *Tylodelphys* infection were 86.89% and 85.14%, respectively (Table 3). The prevalences of infection between the parasite families were not significantly different ($x^2 = 0.017$, $P > 0.9$). There was no significant infection variation between male and female fish with either diplostomids or anisakids ($x^2 = 0.019$, $P = 0.8902$). Also, the chi-square statistic of 0.04 at a p-value of 0.841 showed no significant variation in infection between young and adult catfish. There was, on the other hand, a significant difference in the intensities of infection between sexes of hosts; male fish had a heavier infection than females ($x^2 = 49.1853$, $P < 0.05$).

Figures 3A and 3B show a relationship pattern of coinfection of anisakids and diplostomid species in an individual catfish of Lake Jipe. Although the sites of infection of *Contracaecum* and *Tylodelphys* species are far apart in the fish body, the intensities of diplostomid species in the cranial cavity were negatively correlated with those of *Contracaecum* in the abdominal cavity. For instance, fishes that were infected with more than 5000 individuals of diplostomid species, they had no *Contracaecum* species. Similarly, fishes that were infected with 181 individuals of *Contacaecum* species (the highest intensity value) harboured zero diplostomid species (Figures 3A and B). Numerically, diplostomid species were more than *Contracaecum* ($t = 6.157$, $P = 1.06 \times 10^{-8}$) as depicted by Figures 3A and B.

Table 3: Prevalence, mean intensity (number of parasites per host) and intensity range of helminths recovered from *Clarias gariepinus* species in Lake Jipe

Host	Parasite species	No. fish examined	Prevalence (%)	Intensity of infection (No. parasite per fish host)		
				Mean	Range	Std Error
Total	*Tylodelphys* spp	61	86.89	679.98	3-5880	166.78
	Contracaecum sp	61	85.25	32.35	1-181	4.55
Male	*Tylodelphys* spp	40	87.5	475.44	3-5500	155.73
	Contracaecum sp	40	87.5	56.33	1-181	22.73
Female	*Tylodelphys* spp	21	85.71	874.85	4-5880	328.87
	Contracaecum sp	21	80.95	18.45	2-54	3.73

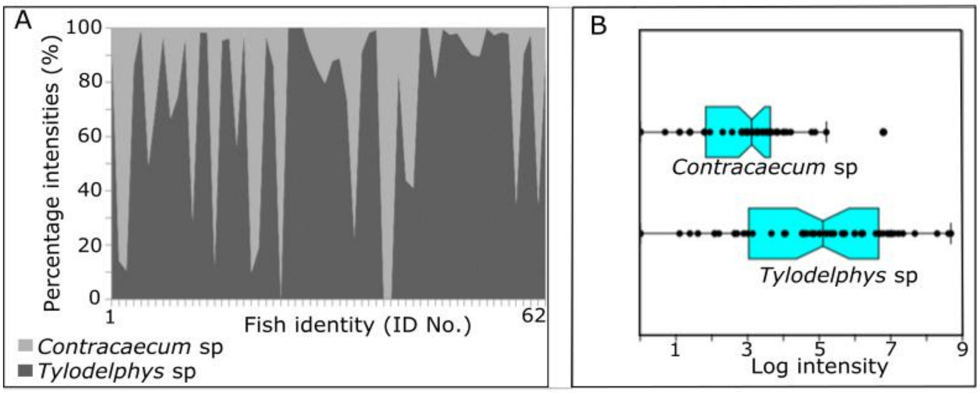

Figure 3: The relationship between intensities of anisakid and diplostomid species (number of parasites per host) in coinfected *Clarias gariepinus* from Lake Jipe.

Discussion

This study provides baseline information on fish parasites in small lake systems, i.e., Lakes Jipe and Kitangiri and Nyumba ya Mungu Dam. Similar studies in Tanzania have been mostly conducted in Lake Victoria and Mindu Dam Tanzanian (Musiba and Nkwengulila 2006, Mwita and Nkwengulila 2008, Chibwana and Nkwengulila 2010, Mwita 2014). However, this study differs from the previously mentioned reports by its inclusion of more fish species from different families. For instance, Musiba and Nkwengulila (2006) and Chibwana and Nkwengulila (2010) explored the parasites of only one fish species, *Clarias gariepinus*, while Mwita and Nkwengulila (2008) and Mwita (2014) examined parasites of only one family, the Clariidae. This study, on the other hand, has dealt with three families of fish: Clariidae, Schilbeidae and Cichlidae. However, its scope was similar to Mwita (2014), i.e., to examine all helminths in a particular host, unlike Chibwana and Nkwengulila (2010) that intended to study diplostomids occurring in the cranial cavities of *C. gariepinus*.

The findings of the current study have revealed the presence of roundworms and flatworms infecting a wide range of fishes irrespective of waterbody under study. Among these parasites, the trematodes, *Tylodelpys* (Family: Diplostomidae) and nematode *Contracaecum*, of the (Family: Anisakidae) were the most common. Sites of infection (i.e., eyes and the cranial cavities) for *Tylodelphys* and their closely related genus *Diplostomum*, have been frequently reported (Musiba and Nkwengulila 2006, Mwita and Nkwengulila 2008, Chibwana and Nkwengulila 2010, Madanire-Moyo and Barson 2010, Chibwana et al. 2013, Mwita 2014, Tavakol et al. 2015, Chibwana 2018). Similarly, the occurrence of *Contracaecum* species in the abdominal cavities of fish is common (Mwita and Nkwengulila 2008, Mwita 2014). Moreover, both diplostomids and anisakids are common parasites of catfish in natural and human-made freshwater systems in Tanzania (Musiba and Nkwengulila 2006, Mwita and Nkwengulila 2008, Chibwana and Nkwengulila 2010, Mwita 2014) and elsewhere in Africa (Madanire-Moyo and Barson 2010, Tavakol et al. 2015).

The prevalence of parasites in the present study was higher than previously reported. Out of 156 fish examined, 102 were infected with parasites. Three known and one unknown species of helminths were isolated from 102 infected fish collected from the three freshwater bodies Nyumba ya Mungu Dam, and Lakes Jipe and Kitangiri. The endoparasites comprised of *Contracaecum* larvae from all the fish species studied; two digenean metacercariae (*Tylodelphys* species complex in *C. gariepinus* and *Diplostomum* sp from *O. amphimelas*); and unidentified nematodes from *C. gariepinus* and *S. mystus*. This number of species was supprisingly much smaller than reported for catfish alone in other freshwater bodies. Mwita and Nkwengulila (2008) and Mwita (2014) recorded 13 species from *C. gariepinus* from Lake Victoria. Nkwengulila and Mwita (2008) argued that the intensity and diversity of the parasites could be influenced by diet and vagility of the host intensities (see Balbuena and Raga 1993, Holmes and Bartoli 1993), and highly vagile fish such as catfish can transverse a wide range of habitats and thus increasing chances of being infected by diverse parasites at varying intensities. Furthermore, *C. gariepinus* is omnivorous (Awachie and Ezenwaji 1981), which makes it prone to infection by many parasites. The fewer parasite species found in the present study corroborate Woolnough et al. (2009) view that water body size and shape influence both species interactions (i.e., host-parasite interactions), genetic changes, resource use and mate choices.

Generally, the parasitological status for majority of fishes in Tanzania is incomplete, and *S. mystus* and *O. amphimelas* are not exceptional. *S. mystus* have been studied, though not extensively in Sudan (Khalil 1969) and Egypt (El-Naggar 1985). Both studies reported the occurrence of a monogenean, *Schilbetrema aegyptica* in gills. The present study, on the other hand, has recorded two nematode species in *S. mystus* in the small intestine and abdominal cavity with a prevalence of more than 80%. Parasitic infections in *S. mystus* were also significantly correlated with sex and body size in which case, large-sized fish and males were more preferred by parasites than small-sized and females. It could be attributed to more internal spaces for parasite occupancy in larger-sized than smaller-sized fish. The elevated levels of oestrogen are suggested to protect female hosts from parasitic infections (Mwita 2014).

Furthermore, *O. amphimelas*, which is endemic to Lakes Kitangiri, Singida, Manyara and Eyasi in Tanzania, is one of the endangered fish species in the world. As such, a parasitological study in this species had not been carried out. The findings of the present survey have shown *O. amphimelas* being infected with *Diplostomum* metacercariae in the vitreous humour of the eye and *Contracaecum* larvae in the abdominal cavity. The presence of *Diplostomum* metacercariae trematodes in the eyes of *O. amphimelas* might further reduce their populations because fish heavily infected with the metacercariae may lose vision, experience reduced growth and subsequently cause death of the fish (Chappell et al. 1994, Chappell 1995, Niewiadomska 1996).

The present study also reported the superabundance of nematode larvae of the genus *Contracaecum* under the family Anisakiidae from all the fish species and water bodies studied. Nematode species belonging to this family include parasites of significant economic and medical importance because of their capability to infect humans (Oshima 1987). This ability is facilitated by their three host life cycles, which involve invertebrates and fish as first and second intermediate hosts, respectively; and piscivorous fish, sea mammals, mammals and fish-eating birds as definitive hosts (Levsen et al. 2008). Humans succumb to anisakids infection upon consumption of uncooked or undercooked fish, resulting in hypersensitivity and allergic reactions induced by proteins produced by dead parasites or epigastric pain related to the presence of living parasites (Buchmann and Mehrdana 2016). Nematodes of the family Anisakidae are ubiquitous and occur in Asia, Europe, Africa, and America (Dadar et al. 2016). Accordingly, the occurrence of anisakids (*Contracaecum* larvae) in the three water bodies studied and all fish species studied is a warning sign to potential risks of consuming raw or underprepared fish.

Conclusion

The present study has explicitly shown that fishes from Pangani catchment (Lake Jipe and Nyumba ya Mungu Reservoir) and Lake Kitangiri in Singida, are susceptible to parasites and parasitic diseases. The fishes harbour parasites of medical, veterinary and economic importance, i.e., Diplostomids (*Diplostomum* and *Tylodelphys*) in the cranial cavities of *Clarias gariepinus* and eyes of *Oreochromis* species, respectively. Anisakids (*Contracaecum*), on the other hand, inhabit in the abdominal cavities of almost every fish species in the studied areas. It implies that although fishes from inland water bodies are a good source of protein (an alternative to red meat), if not well prepared they can be detrimental to our health. Thorough preparation or cooking of fish is highly recommended to avoid consumption of metacercariae of harmful parasites. Since aquaculture settings rely upon the natural systems (rivers and lakes) for seedling/fingerlings, we recommend the use of fingerlings of the second or third generation to avoid keeping infected fish from the wild.

Acknowledgements

We thank the University of Dar es Salaam for funding this research through a provision of a research grant (UDSM Research Grants, CoNAS-ZLW18059), without which the study would not have been possible. Besides, we appreciate the continual support offered to us by the University of Dar es Salaam particularly the Department of Zoology and Wildlife Conservation, for frequently allowing us to be away from the station of our duty for fieldwork. We also recognise the services of Mr Richard Massinde of the Department of Zoology and Wildlife Conservation for his technical assistance in the field and laboratory.

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