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Gastrointestinal helminths in tilapia (*Oreochromis niloticus*) sold for human consumption in Maiduguri, Nigeria: A potential public health risk

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Abstract

Fish is an important and cheap protein source for human consumption in developing countries. It is the second most popular source of protein diet in both rural and urban communities in Nigeria. Fisheries resources contribute about 5.40% to the nation's gross domestic product (GDP) through income generation, employment, food security, and foreign exchange earnings. Despite the significant contributions of fisheries to the Nigerian economy, the aquatic ecosystem is prone to pollution from human activities which increases the chances of transmission of parasitic infections, which are detrimental to aquatic and human life. The present study assessed the prevalence of gastrointestinal helminths of tilapia fish from different market sources in the Maiduguri metropolitan council of Borno State, Northeastern Nigeria. Samples of fresh Nile tilapia (*Oreochromis niloticus*) fish (n= 125), comprising 50 juveniles and 75 adults, were screened for gastrointestinal helminths using standard parasitological methods. Twenty-nine (23.2%) harboured at least one helminth parasite. Of the 29 positive individual fish samples, 16% (n=20), 4% (n=5), 2.4% (n=3), and 0.8% (n=1) were infected by Acanthocephala, Cestode, Nematode, and Trematodes, respectively. The infection rate was higher in adults (26%) than juveniles (18%) and in females (23.5%) than males (22.8%). Fish samples from Baga markets showed higher infection rates than the other two market sources. Sex, age, and location were not significantly associated with parasite recovery rate (p>0.05). The study concluded that Nile tilapia fish sold in Maiduguri metropolis were infected with different groups of helminths, underscoring public health risks to farmers, sellers, and consumers. Therefore, fish farmers should regularly consult veterinarians for advice on good fish management practices and observe proper hygienic handling of harvested fish at the farm level, during transportation to fish markets, and processing. The public should thoroughly clean and properly cook fish for human consumption.

Keywords: Gastrointestinal helminths, Markets; Maiduguri; Nigeria, Nile tilapia fish

Introduction

Fish is an important protein source, especially in developing countries (Obiero *et al.*, 2019; Tran *et al.*, 2019). On a global scale, fish provides more than 60% of the world's supply of protein. Fish is an essential protein source in the diets of both rural and urban communities in developing countries (Balami *et al.*, 2019; Sarojnalini & Hei, 2019). It is second to livestock (cattle, sheep, goats, and poultry) as a leading source of protein diet to the Nigerian populace (Inyeinyang & Ukpog, 2019). Therefore, fish represent an alternative and cheaper source of animal protein (Allam *et al.*, 2020; Maulu *et al.*, 2020; Maulu *et al.*, 2021) to supplement the high demand from the Nigerian populace. Fish protein comprises a complete array of amino acids and provides a good source of vitamins and minerals (Pal *et al.*, 2018).

Besides its high nutritional value reported earlier (Balami *et al.*, 2019; Sarojnalini and Hei, 2019), fisheries represent an important subsector of the Nigerian economy, contributing about 5.40% of the nation's gross domestic product (GDP). In this regard, it is noted that the fishery subsector provides employment, food security, and foreign exchange earnings and plays a crucial role in improving the livelihoods of many rural people (Béné *et al.*, 2016; Oladimeji, 2018). Despite the huge opportunities in the Nigerian fisheries industry, domestic supply still falls below national demand because Nigeria is the world's fourth-largest importer of fish products in terms of quantity, expending \$876 million and \$106 thousand on frozen fish in 2020 (Odioko & Becer, 2022). Moreover, despite the significant contribution of the fish industry to the Nigerian economy, the aquatic ecosystem may be polluted by human activities such as industrial procedures, increased urbanization, and domestic waste discharge (Aladaileh *et al.*, 2020). Tilapia fish are prone to many infectious disease-causing agents, including zoonotic parasites (Bao *et al.*, 2019). This could be attributed to environmental degradation and stress predisposing tilapia fish to pathogen infection risks. Zoonotic transmission of parasitic infections from fish is usually accidental (Chibwana *et al.*, 2020); due to ingestion of undercooked fish containing viable parasites or during fish processing and evisceration (Wang *et al.*, 2018). Symptoms of fish zoonotic disease in humans range from subclinical fever, abdominal pain, vomiting, and weight loss (Koinari *et al.*, 2013).

In the literature, some workers in Northeastern Nigeria have previously documented preliminary reports on the occurrence of gastrointestinal helminths in tilapia fish from Borno and neighbouring Gombe States (Biu & Nkechi, 2013; Dauda *et al.*,

2016). Therefore, this study was conducted to determine the current prevalence and risk factors (sex, age, and location) associated with gastrointestinal helminth infection in the Nile Tilapia (*Oreochromis niloticus*) fish sold for human consumption in Maiduguri metropolis council, Borno State, Northeastern Nigeria.

Materials and Methods

Study area

This study was conducted in Maiduguri Metropolis, Borno state's capital and largest city, Northeastern Nigeria. Borno State with a total land mass area of 70,898 km² is located between latitude 11°30'N and longitude 13°00'E, and shares international boundaries with the Republic of Niger to the north, the Cameroon Republic to the east, and the Chad Republic to the northeast. It is a Semi-arid zone characterized by rather austere climate conditions with dry seasons from November through early June, during which daily temperature could vary between 30°C and 41°C, especially from March to June (Eresanya, 2018). The rainy season is usually from late June through October, with low relative humidity and short wet seasons. The population of Borno state was estimated to be 5,860,200 in 2016, with a population density of 83.0 inhabitants per km². The population of the Maiduguri metropolis was 1,052,500 people in 2016 and consists mainly of farmers, herders, fishermen, traders, and civil servants. Water bodies (rivers, streams, and dams) and marketplaces for livestock, fish, and goods are found across the metropolis.

Sources of fish, preservation, and transportation

Tilapia fish used in this work were sourced from Monday, Baga, and the Custom markets in Maiduguri metropolis. These represent the largest markets in the Maiduguri metropolis, where about 95% of fish consumers buy their fish. Fresh tilapia fish samples were bought from the retailers in these markets. The purchased fish was preserved in an ice-packed cooler and transported to the Veterinary Parasitology Laboratory, Faculty of Veterinary Medicine, University of Maiduguri, for further processing.

Identification of sexes, external measurements, isolation and identification of recovered helminths

After dissecting the fish, the presence of testis or ovaries determine the sex (Holden & Reed, 1972). A measuring tape was used to measure the length of each fish sample. Based on the length, the fish samples were grouped as juveniles (3-5 cm) or adults (6 -9 cm) (Goselle, 2008). A ventral incision from the anus to the throat opened the body cavity to expose

the gut, and a second longitudinal incision exposed the intestinal mucosal surface. We obtained the sample by scrapping the mucosa with a scalpel onto a petri dish containing normal saline. The contents were observed macroscopically for the presence of adult worms, transferred to a test tube, allowed to sediment, and the supernatant decanted. The residue was observed for helminth eggs using a light microscope, as described by Goselle *et al.* (2008). Briefly, a drop of the residue was placed on a clean glass slide, covered with a coverslip, and examined using x10 and x40 objective lenses to identify parasite eggs morphologically based on size, shape and colour (Panda & Dash, 2016). Parasites recovered from the intestine were washed, placed on a glass slide, flattened with another slide, examined microscopically, noted, and then preserved in a sample bottle in 5% formalin. For the identification of the helminth classes or groups, key morphological features previously described were followed (Kabata, 1985; Schmidt, 1986; Dezfuli *et al.*, 2016). Briefly, adult cestodes or tapeworms consisted of a chain of segments (or proglottids), each with a set of reproductive organs and identified using the sizes and shapes of the scolex. Acanthocephala possesses thorny heads and proboscis (hooks). Furthermore,

adult nematodes or roundworms are circular in cross-section, taking the form of an elongated cylinder tapered at each extremity. Lastly, adult trematodes or flukes possess suckers on their anterior and ventral surfaces, which they use to attach to their hosts.

Statistical analysis

The data generated from this study were analyzed using the IBM® SPSS Statistics version 20 (IBM, Armonk, NY: IBM Corp.). The results obtained were presented using tables and percentages. The strength of evidence of the association between risk factors and the occurrence of helminths was assessed using the Chi-square test—reporting Odds ratio (OR) and their respective 95% confidence intervals. Values of $p \leq 0.05$ were considered statistically significant in univariate analysis.

Results

Of the fish (n=125) sampled, 54% were female, 60% were adult, and about 43% were sourced from Monday market (Table 1). Out of the 125 fish sampled, 29 were positive, given an overall prevalence of 23.2%. The highest location-specific prevalence of 25.9% was recorded in the Baga market, followed by the Monday market (24.7%) and the Custom market (20.4%), as shown in Table 2.

Table 1: Baseline characteristics of sampled Nile Tilapia fish (n=125) from Maiduguri metropolis council, Nigeria

Variables	Categories	Frequency	Percentage (%)
Sex	Male	57	45.6
	Female	68	54.4
Age	Juvenile (3 - 5 cm)	50	40.0
	Adults (6 - 9 cm)	75	60.0
Location	Baga market	27	21.6
	Custom market	44	35.2
	Monday market	54	43.2
Overall		125	100

Table 2: Univariate analysis assessing the strength of association between helminthosis and some independent variables of Nile Tilapia fish (n=125) from Maiduguri metropolis council, Northeastern Nigeria

Variables	No. Sampled	No. Positive (%)	OR (95% CI)	<i>p</i> -value
Sex				
Male	57	13 (22.8)	Ref.	
Female	68	16 (23.5)	0.96 (0.42, 2.21)	0.924
Age				
Juvenile (3 - 5 cm)	50	9 (18.0)	Ref.	
Adults (6 - 9 cm)	75	20 (26.7)	1.30 (0.56, 3.0)	0.545
Location				
Baga market	27	7 (25.9)	Ref.	
Custom market	44	9 (20.5)	1.75 (0.57, 5.38)	0.329
Monday market	54	13 (24.7)	1.39 (0.52, 3.73)	0.517
Overall	125	29 (23.2)		

OR = Odds ratio; CI = Confidence interval; Ref = Reference category

Table 3: Distribution of helminths classes among the positive samples of Nile Tilapia fish from Maiduguri metropolis council, Northeastern Nigeria

Class of helminths	No. Positive (%)
Trematodes	1 (0.8)
Cestodes	5 (4.0)
Nematodes	3 (2.4)
Acanthocephalans	20 (16.0)
Total	29 (23.2)

Out of the total fish examined, juveniles had a lower prevalence of 18.0% compared to adults with 26.0%, which was not statistically significant ($p = 0.545$) (Table 2). Also, male fish had a 22.8% prevalence compared to female fish (23.5%), which was not statistically significant ($p = 0.924$) (Table 2). Out of the 29 (23.2%) infected tilapia, 1 (0.8%) was trematode, 5 (4%) were cestodes, 3 (2.4%) were nematodes, and 20 (16%) were acanthocephalans as was shown in Table 3.

Discussion

The overall prevalence obtained in this study is significant to the aquaculture industry due to the detrimental effects of parasitic diseases on fish health and production (Bao *et al.*, 2019). Additionally, zoonotic transmission of fish parasites to man can also occur through accidental ingestion (Chibwana *et al.*, 2020) or consumption of raw or improperly cooked infected fish, as observed by Wang *et al.* (2018). Also, the frequent mortality and severity of the lesions, especially skin haemorrhages and ulcers associated with parasitic infestations in fish, could affect the market value of the fish. Therefore the current prevalence of helminthosis in tilapia fish is economically significant. This finding agrees with Paladini *et al.* (2017) findings, which revealed that parasitic diseases incur economic losses to the farmer due to stock mortality, reduced productivity, and marketability. The obtained prevalence was relatively higher than the 18.7% reported by Biu & Nkechi (2013) in the same study area. It is, however, lower than the 42.7% reported by Dauda *et al.* (2016). The differences in the prevalence of helminths in the present study and the results of previous studies may be due to differences in the aquatic origin of fishes and changes in the epidemiology of parasitic infections due to the influence of environmental variables and time passage. For instance, flooding may cause freshwater pollution and increase helminth prevalence. At the same time, excessive draught may reduce the population of amphibious intermediate hosts of fish helminths and cause a

decrease in transmission and prevalence of helminths in fish populations.

This study has shown that the location-specific prevalence of gastrointestinal helminths is higher in fishes sampled from the Baga market (25.9%), followed by the Monday market (24.7%) and Custom Market (20.4%), which may reflect the aquatic origin of the fish in the two different markets. It is not clear at this time if the two markets have a separate source of fish to justify the effects of location on the prevalence of helminths. The presence of helminthosis in tilapia fish sourced from various fish markets is a potential risk of infection from fish to the handlers and possible environmental contamination during evisceration. Mardu *et al.* (2019) suggested that up to 81 million African people are at risk of parasitosis. The higher prevalence of Acanthocephalans (16.0%) compared to cestodes (4.0%), nematodes (2.4%), and trematodes (0.8%) in the infected tilapia signifies a high risk of zoonotic infection with *Acanthocephala* species in the study area. In humans, this parasite was reported to induce severe abdominal pain, ileus, ulceration, and bleeding (Fujita *et al.*, 2016). The result agrees with Uhwo *et al.* (2014), who reported Acanthocephalans as the dominant helminths in tilapia. However, unlike this finding, Dauda *et al.* (2016) reported nematodes as the dominant helminth. The prevalence and intensity of helminthiasis in tilapia depend on parasite species and their biology, the feeding habits of the host, physical factors, hygiene of the aquatic environment, and the presence of intermediate host species (Olurin *et al.*, 2012; Nimbalkar & Deolalikar, 2015).

Although not statistically significant, the high prevalence of gastrointestinal helminths in adults compared to juveniles could be attributed to differences in their diets, ranging from weed, seed, phytoplankton, and zooplankton in juveniles, to insect larvae, crustacean, and worms in adult fish. Moreover, increased weight enhances fish susceptibility to parasitic infections (Amare *et al.*, 2014). This finding aligned with that of Dauda *et al.* (2016), who also reported a higher prevalence of

gastrointestinal helminths in adult fish. However, in contrast to the present study's findings, Biu & Nkechi (2013) reported a higher prevalence of gastrointestinal helminths in juveniles among tilapia in the study area. The present study recorded a higher prevalence in female than male tilapia. Although not statistically significant, the higher prevalence could be due to the feeding pattern. In instances for optimal productivity, female fishes are likely to consume more than males. They could feed indiscriminately on organic matter and potential sources of infection to meet their dietary requirements, which might likely increase their exposure to helminthiasis than males. Moreover, gravid females become more susceptible to parasitic infections due to changes in their physiological state caused by hormonal activity and the stress of production, as seen in other domestic animals (Shah et al., 2019). This finding agrees with Dauda *et al.* (2016), who reported a higher prevalence of gastrointestinal helminths in females. However, in contrast to this finding, Biu & Nkechi (2013) and Amechi (2014) reported a higher prevalence of gastrointestinal helminths in male tilapia fish. In conclusion, the results revealed that acanthocephalans, cestodes, nematodes, and trematodes are abundant in the gut of tilapia fish sold for human consumption in the study area. The high prevalence of infection observed among Nile tilapia from the two different markets suggests the likelihood of transmitting potentially zoonotic species of gastrointestinal helminths from fish during harvesting, evisceration, and handling, exposing farmers and traders in the area at a high risk. Therefore, we recommended that fish farmers regularly consult veterinarians on good fish management practices such as routine deworming of their stock, water replacement, and clearing bushes around the ponds to decrease snail intermediate host and fly vector populations. Similarly, fish farmers should institute hygienic handling of harvested fish at the farm level and during transportation to fish markets. The application of food safety measures, including the hazard analysis and critical control points (HACCP) at the farm level and during transportation, distribution, processing, and consumption of tilapia fish and its products. Lastly, proper cooking of fish products will kill the larvae or adult stages of potentially zoonotic helminth parasites in the fish product.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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