Fish Parasite Diversity, Prevalence, and Morphometry in Commercially Important Finfish Species: Impacts on Health and Food Safety

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Abstract
Globally, both obligate and opportunistic parasites exert a significant impact on the economic viability, productivity, and sustainability of finfish. Parasitic infestations compromise fish health, reduce growth efficiency, and affect consumer safety, thereby posing major challenges to aquaculture and fisheries-dependent communities. This study aimed to investigate and establish the economic and ecological importance of parasitic infestations in different species of finfish marketed in Kano, Nigeria. A total of 60 samples (30 samples each) of *Clarias gariepinus* (*C. gariepinus*) and *Oreochromis niloticus* (*O. niloticus*) were indiscriminately purchased from local fish traders at Galadima Fish Market, Kano State. Standard parasitological survey techniques were employed to identify and quantify parasite prevalence across host species. The study revealed a high prevalence (86.7%) of ectoparasites among the examined specimens. The dominant parasites identified included *Trichodina spp.*, *Epistylis spp.*, *Eimeria spp.* and *Chilodonella spp.* Parasite diversity and infection rates were influenced by host species, ecological niches, and prevailing environmental conditions. The findings highlight the ecological and economic significance of parasitic infestations in inland finfish species, emphasizing the need for effective fish health management. Strengthening biosecurity measures and improving post-harvest handling practices are crucial for safeguarding food safety, enhancing aquaculture sustainability, and contributing to responsible consumption and production to align with the Sustainable Development Goal (SDG) 12.

Keywords: *Clarias Gariepinus*, Kano State, *Oreochromis Niloticus*, Parasites, Public Health, Sustainability.

1. Introduction

Report revealed that 30% of human race is facing the challenge of malnutrition while 70% of the planet is covered with water, this qualifies aquatic foods such as finfish to represent a large source of global food basket in tackling the problem of malnutrition [1]. Finfish belongs to the most diverse class of vertebrates uniquely characterized by fins, bones and gills. So many aspects of microbial interaction have commonly been discussed and published but less attention is given to parasitism in aquatic ecosystem [2]. This directly or indirectly affects both the survival and health of the fish itself as well as its consumers by reason of the statistic that they are a well-recognized host to several parasites such as helminths, arthropods and protozoans reported to possess complex life cycles [3]. It is thereby very important to take the issue of food safety in Aquatic products seriously. Excellent food safety routines are obligatory in aquatic commodities for the benefit of environmental protection, improved water quality, food security, public health as well as economic stability [4]. All these are aimed at preventing food waste, food loss, food-borne disease outbreaks and ensure sustainability of aquatic food supply because production and consumption of aquatic animals have both direct and indirect influence on food cycle [2, 5].

There are about 3,000 taxa of aquatic foods constituting microorganisms, cell- and plant-based foods, animal and plants with collective benefit to nourish the consumers contributing to healthy diets and life sustenance [6]. Few examples of the aquatic products include Cephalopods (octopus and squids), aquatic plants (water spinach: Ipomoea aquatica), algae (seaweed), aquatic animals (mammals, insects and sea cucumbers), crustaceans (such as crabs and shrimps) and Finfish [6].

Several pathogens ranging from viral (such as nodaviruses), bacterial and others have been recounted to be found in finfish [7]. Nematodes (e.g. *Pseudoterranova*, *Anisakis*) and Cestodes such as *Diphyllobothrium* are commonly regarded to as tapeworms, are described as a group of parasitic flatworms that commonly inhabit the intestinal tracts of several aquatic animals, including finfish [8]. Their parasitic presence in finfish is of significant concern due to implications for fish health, reported zoonotic infection transmission to human beings consuming the fish and also its negative impact on aquaculture productivity. Another common parasite found in finfish is Trematodes such as Clonorchis and Opisthorchis [9]. They are flukes, are generally parasitic flatworms that infect finfish and other wide range of aquatic organisms. These parasites can significantly affect the health, growth, behavior, and survival of finfish, leading to serious health challenges to both wild fish populations and aquaculture operations as well as fish consumers [10].

Protozoans are another group of parasites whose presence in finfish poses a serious concern in both wild and cultured fish populations. Though Protozoans are microscopic, single-celled organisms, their capability to infect various tissues of fish, including the skin, blood, intestines, and gills are chief cause for fear [11]. Despite the fact that few protozoans are reported to be harmless commensals, there is possibility that many of them are either pathogenic or opportunistic pathogens and they can be held liable for severe maladies, particularly under stress or poor water conditions.

Due to environmental factor, there is possibility of pathogenic infestation of additional pathogens that have not been previously identified in finfish [12]. Emerging parasitic threats of such pathogens should be put into consideration such as *Neobenedenia* spp. which have been regularly reported in marine and brackish aquaculture for severe fin and skin damage, along with causing secondary infections in snappers, cobia, groupers, barramundi leading to high mortality in juvenile fish [13].

Several means of transmission pathways of the parasitic pathogens to humans have been identified, especially in regions where fish is a dietary staple or aquaculture practices are intensive [14]. Few of such identified route involve consumption of raw or undercooked Fish, contaminated water or environmental contact, occupational exposure, use of untreated fish waste in agriculture, cross-contamination during food handling [15].

Some of the common health implications of fish parasites infestation in human beings include gastrointestinal disorders, allergic reactions, infections and long-term effects [16]. To properly control this, it is advisable to observe some preventive and control measures such as proper cooking and freezing, public health education of the masses and inspection by food health officials [17].

Few sustainable practices required to overcome the negative impact of these pathogens involve proper stocking densities to avoid stress and parasite proliferation in finfish, regular parasite screening and health monitoring of finfish, use of parasite-free broodstock and hatchery controls cohesive pest management (e.g., biological control), in addition to adoption of biosensors to detect foodborne pathogens [18].

The intend of this research is to investigate prevalence, diversity, and morphometric characteristics of parasites affecting commercially important finfish species in Kano State. The study seeks to establish how parasite infestations influence fish health, productivity, and overall market value. Ultimately, the outcomes of this research will postulate baseline records to improve fisheries management, food safety and promote sustainable aquaculture practices.

2. Methodology

2.1. Sampling Site

The sampled species were stockpiled from Galadima fish market in Kano State, Nigeria. It is located at Fagge Local Government Area of Kano state (Latitude 12.0127º 'N and longitude 8·5344ºE) and occupies approximately 21km^2 stretch [19].

Source: [19]

Fig 1: The geographical location of Galadima Fish Market, Kano

2.2. Collection of Fish Samples
An aggregate of 60 specimens (30 *Clarias gariepinus* and 30 *Oreochromis niloticus*) were randomly sampled and obtained for three (3) months from local sellers at the Galadima Fish market, Kano metropolis. The specimens were collected live and transported in ice to ward off loss of vital internal details before the laboratory examination will take place [20].

2.3. Morphometric measurement
The total length (from the tip of the snout to the extreme end of the caudal fin) were measured using a calibrated meter rule mounted on a dissecting board while the total weight of each fish was evaluated on a top loading meter balance (to the nearest 0.1g). The Fulton's condition factor was computed using the formula: $k = (W/L^3)100$, where k is the Fulton's condition factor, W is the weight of fish (grams), and L is the total length of fish (centimeters).

2.4. Assessment for Parasites
For examination of the parasites in the sampled fish, they were allowed to thaw before dissected to bring out the gills and intestines that were examined for the presence or absence of parasites. The expunged gastrointestinal tracts were cut open in small portions, washed and rinsed in 0.1% sodium chloride and 0.1% sodium bicarbonate solutions respectively to enhance parasite search [21]. Each drop of the residue or smear was placed on the slide, stained with Giemsa stain and then viewed under x10 and x40 objective light microscope to check for the number and distribution of parasites. The observed parasites were compared with the key's compendium by [22] for identification.

2.5. Data Analysis
Statistical Package for the Social Science (SPSS) was used for the data analysis. The overall prevalence of the parasitic infection was expressed in percentage. Data (prevalence, mean intensities (MI) and the measures of parasite community structure - the Shannon-Wiener, Margalef richness, Berger-Parker and dominance indices) determined as described by [23] and were presented in tabulated form.

3. Results
3.1. Morphometric measurement
Table 1 shows an overview of the fish sample distribution, mean total lengths, mean weight, and condition factors. *Clarias gariepinus* had the highest condition factor of 1.8 (± 0.2) while *Oreochromis niloticus* had the lowest at 1.4 (± 3.2). The Mean total length (cm) for *O. niloticus* is 15.6 cm (range: 6.7 - 28.4 cm) while for *C. gariepinus* is 34.7 cm (range: 19.0 - 32.0 cm). The Mean Total weight (g) ranged between 5 - 21.3 g for *O. niloticus* and 7.1 - 93.8 g for *C. gariepinus*.

Table 1: Morphometry measure of the sampled fish species from Galadima market, Kano

S/N	Fish Species	Sample Size (n)	Total length (cm) Mean (Min – Max)	Total weight (g) Mean (min - max)	Condition factor (k) Mean (±SD)
1	*Oreochromis niloticus*	30	15.6 (6.7 - 28.4)	69.0 (5 - 21.3)	1.4 (±3.2)
2	*Clarias gariepinus*	30	34.7(19.0 - 32.0)	72.1(7.1 – 93.8)	1.8 (±0.2)

3.2. Occurrence and host organs of parasites
3.2.1. Infection Prevalence in Sampled Fish
Out of a total of sixty (60) specimens of *Clarias gariepinus* (*C. gariepinus*) and *Oreochromis niloticus* (*O. niloticus*) examined in this study, 52 (86.7%) were found to be infected (Figure 2).

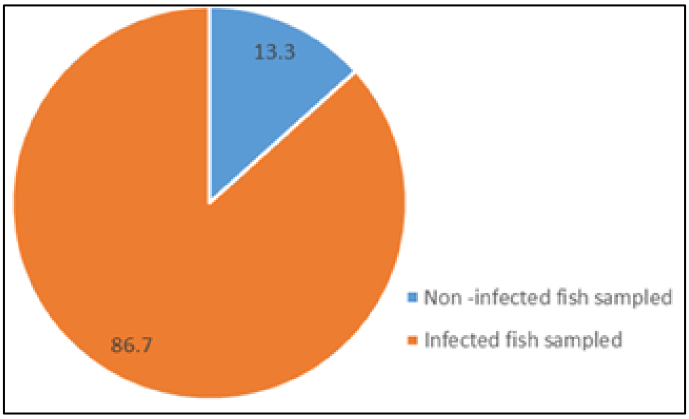

Fig 2: Infection Prevalence in *Clarias gariepinus* and *Oreochromis niloticus*

In Table 2, The parasitological survey revealed the presence of ten (10) different parasite taxa infecting the sampled Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) populations. *Trichodina spp., Epistyles spp., Eimeria spp.* and *Chilodonella spp.* are common ectoparasites recorded for both species of fishes – *Oreochromis niloticus* and *Clarias gariepinus* while the monogenean flatworms of the genus *Heterophyes* spp., *Eimeria* and *Clinostomum* were detected in the gills of *Oreochromis niloticus* only.

Trichodinids and *Chilodonella* spp. showed relatively high prevalence, affecting over 35% of the sampled tilapia. The intestines harbored parasites like Cestoda (tapeworm) larvae, *Eimeria* and nematodes for *Clarias gariepinus* and protozoan cysts for *Oreochromis niloticus*, suggesting transmission through the diet or paratenic hosts in the food chain. Notably, 62.7% of *O. niloticus* was infected with cestode larvae at a mean intensity of 3.4 parasites per infected host.

Table 2: Occurrences and host organs of parasites found in sampled *Oreochromis niloticus* and *Clarias gariepinus*

S/N	Parasites	*Oreochromis niloticus*			*Clarias gariepinus*		
		Host Organs	***p***	**MI**	**Host Organ**	***p***	**MI**
1	*Trichodina spp.*	gills	3.2	negligible	Gills	11.9	negligible
2	*Cestoda* larvae	ND			intestine	62.7	3.4
3	*Heterophyes*	gills	22.5	2.2	ND		
4	*Epistyles.*	gills	1.8	negligible	Gills	3	negligible
5	*Eimeria*	gills	24.1	2.7	intestines	3.2	negligible
6	*Chilodonella*	gills	35.9	2.9	Gills		
7	Protozoa cyst	intestines	3.2	negligible	ND		
8	*Clinostomum*	gills	64.5	13.4	ND		
9	*Nematoda*	ND			intestine	4.5	negligible
10	*Trypanosoma*	ND			gills	10	negligible

Note: *p* – Prevalence; MI – mean intensity; ND – Not Detected

The trematode *Clinostomum*, which uses fish as secondary hosts, exhibited the highest prevalence of 64.5% and mean intensity of 13.4 parasites per infected tilapia. While low-level Eimeria was detected in the catfish intestines as well as the gills of the Nile tilapia, the higher 24.1% prevalence and intensity in tilapia may reflect species-specific susceptibilities and transmission patterns of this parasite. Interestingly, the hematozoic protozoan, *Trypanosoma* was only recovered in 10% of sampled catfish gills. The gills and intestines were the organs examined and the gills of both species were detected to be more infected by parasites than the intestines. The dominant parasite for *O. niloticus* is the *Clinostomum spp. while the dominant parasite for C. gariepinus* is the Cestoda larvae.

Table 3 shows the implications of parasites in commercially important finfishes collected from the Galadima Fish Market in Human and fish species. Zoonotic risks are mainly associated with *Cestoda larvae*, *Heterophyes spp.*, *Clinostomum spp.*, and some nematodes. Parasites like *Trichodina spp.*, *Epistylis spp.*, and *Chilodonella. Chilodonella spp.* are primarily fish health threats, reducing productivity and market value.

Table 3: Implications of Parasites in Finfishes from Kano State

S/N	Parasite	Fish Health Impact	Human Health Implications
1	*Trichodina spp.*	Gill irritation, impaired respiration, reduced growth	Not zoonotic; affects fish quality and market value
2	Cestoda larvae	Intestinal blockage, poor nutrient absorption	Some cestodes (*Diphyllobothrium*) infect humans, causing abdominal discomfort, diarrhea, and anemia
3	*Heterophyes spp.*	Gill damage, impaired oxygen uptake	Zoonotic trematode; ingestion can cause intestinal inflammation (heterophyiasis)
4	*Epistylis spp.*	Gill blockage, stress, secondary infections	Not zoonotic; reduces fish marketability
5	*Eimeria spp.*	Intestinal damage, impaired digestion	Generally, fish-specific; low zoonotic risk
6	*Chilodonella spp.*	Severe gill necrosis, high mortality in stressed fish	Not zoonotic; main risk is reduced fish availability for humans
7	Protozoan cysts	Intestinal lesions, mild digestion impairment	Some protozoa may be opportunistic in humans, but risk is low if fish is properly cooked
8	*Clinostomum spp.* ("yellow grub")	Tissue damage, reduces fish market value	Zoonotic; can cause pharyngitis ("yellow grub disease") if raw/undercooked fish is consumed
9	Nematodes	Intestinal irritation, reduced feed conversion	Some (*Anisakis*, *Contracaecum*) infect humans, causing anisakiasis (abdominal pain, nausea)
10	*Trypanosoma spp.*	Anemia, weakness, reduced growth in fish	Not zoonotic; affects fish health but not human consumers

3.3. Diversity Indices of the Parasites communities

Table 4 below shows the various diversity indices for the observed parasites detected in the gills and intestines of *Oreochromis niloticus* and *Clarias gariepinus*. For Shannon-Wiener Index, it was higher in *O. niloticus* (1.62) than *C. gariepinus* (1.51) while for Margalef Richness, it was higher in *O. niloticus* (0.63) than *C. gariepinus* (0.57). The Berger-Parker Index was higher in *C. gariepinus* (0.53) compared to values recorded for *O. niloticus* (0.48).

Table 4: Comparison of the diversity characteristics of the parasite's communities in *Oreochromis niloticus* and *Clarias gariepinus*

S/N	Component Communities	*Oreochromis niloticus*	*Clarias gariepinus*
1	Total number of fish sampled	30	30
2	Shannon-Wiener Index	1.62	1.51
3	Margalef Richness	0.63	0.57
4	Berger-Parker Index	0.48	0.53
5	Dominant taxon	*Chinostonum spp.*	*Cestoda* larvae

4. Discussion

The present study investigated the morphometric measurements, parasite prevalence, and diversity indices in *Oreochromis niloticus* and *Clarias gariepinus* obtained from Galadima Fish Market, Kano.

Understanding the parasitic burden in these commercially important fish is crucial for both fisheries management and public health, as fish-borne parasites can significantly impact aquaculture productivity and pose zoonotic risks to consumers [24].

The condition factor (K) is an essential indicator of fish health and reflects physiological state and environmental conditions of fish species [25]. In this study, *C. gariepinus* exhibited a higher mean condition factor (1.8 ± 0.2) compared to *O. niloticus* (1.4 ± 3.2), indicating that *C. gariepinus* was in a relatively better physiological state, potentially due to species-specific growth patterns or differential environmental adaptability. Related inclinations have been conveyed in previous studies [26 - 28], where variations in condition factor were attributed to differences in feeding habits, environmental conditions, and parasite loads. The lower condition factor observed in *O. niloticus* could be linked to the higher diversity of parasites affecting this species, as parasitic infections have been established to reduce fish health and growth performance [29].

The parasite compositions were not identical between tilapia and catfish, with several taxa like Heterophyes, Clinostomum, protozoan cysts, and nematodes unique to one host species based on this sampling. This likely reflects differences in diet, habitat preferences, immune responses, and evolutionary adaptation.

The high parasite prevalence (86.7%) observed in this report support conclusions from related studies in African freshwater systems, where high infection rates of the gills have been attributed to environmental factors, direct exposure of gill tissues to waterborne parasites and pollutants, host susceptibility, and the presence of intermediate hosts [30 - 33], The high infestation rate in *O. niloticus* compared to *C. gariepinus* suggests species-specific differences in susceptibility to parasites, possibly influenced by variations in immune response, feeding habits, and habitat preferences but contradicts the reports of [33], who reported a 45% prevalence of gastrointestinal parasites in *C. gariepinus* from the Gwagwalada River, Abuja, with protozoa like *Toxoplasma gondii* being predominant.

Gills were categorized as the most frequently infected organ, which corroborates previous studies highlighting the gills as primary sites for parasite attachment due to their rich blood supply and direct exposure to the external aquatic environment [29]. Parasites such as monogeneans, protozoans, and trematodes preferentially target the gills, leading to significant tissue damage and respiratory distress in infected fish [30].

The observed variation in parasite species across the two fish species suggests differences in immune responses, feeding habits, and habitat preferences. The presence of *Clinostomum spp.*, *Heterophyes spp.*, and protozoan cysts exclusively in *O. niloticus* may denote that this species is more susceptible to trematode infections, as reported by [34]. Conversely, the detection of *Cestoda larvae*, *Nematoda*, and *Trypanosoma spp.* only in *C. gariepinus* agreed with conclusions from akin researches implying that catfish species are more prone to cestode and nematode infections due to their benthic feeding habits [35]. These present results are in harmony with research by [36], who documented various helminth parasites, including cestodes and nematodes, in fish from River Anambra, Nigeria. The presence of species-specific parasites underscores the importance of understanding host-parasite dynamics for effective management and control strategies.

Diversity indices are essential in understanding the ecological stability of parasite communities within host populations. The parasite diversity indices indicate notable differences in parasite richness and dominance between the two fish species. The higher Shannon-Wiener Index (H' = 1.62) in *O. niloticus* suggests a more diverse parasite community compared to *C. gariepinus* (H' = 1.51), which coherent with previous discoveries that omnivorous fish tend to host a wider range of parasites due to their feeding habits and increased exposure to infection sources [32]. Conversely, the Berger-Parker Index, which reflects dominance, was higher in *C. gariepinus* (0.53) than in *O. niloticus* (0.48), suggesting that a single parasite species, likely *Cestoda larvae* was more dominant in *C. gariepinus*, possibly due to the benthic feeding habits of the species, which increase exposure to infected intermediate hosts [37; 38]. The Margalef Richness Index values (0.63 in *O. niloticus* and 0.57 in *C. gariepinus*) further support the observation that *O. niloticus* harbors a broader range of parasite species and confirming a greater parasite species richness. These patterns may be influenced by factors such as host species susceptibility, environmental conditions, and the occurrence of intermediate hosts. Bubu-Davies [39] highlighted the role of environmental factors in shaping parasite communities in cultured *C. gariepinus* in Port Harcourt.

The high parasite burden observed in this study could be linked to environmental pollution and deteriorating water quality in fish habitats. Report from [40] also showed that poor water quality, by means of organic pollution and eutrophication, can increase parasite prevalence by weakening fish immune defenses and promoting the proliferation of parasite intermediate hosts. Industrial effluents, agricultural runoff, and improper waste disposal in aquatic ecosystems have been implicated in increasing parasite loads in wild fish populations [14; 40].

5. Conclusion

This survey ascertained ten parasite taxa (including protozoans, monogeneans, digenean trematodes, cestodes, nematodes, and apicomplexans) infecting *Oreochromis niloticus* (Nile tilapia) and *Clarias gariepinus* (African catfish) sold in Galadima Market, Kano. Notably, *Clinostomum* trematodes and *Trichodina* protozoans exhibited particularly high prevalence and infection intensities, posing significant risks to fish health, productivity, and food safety. The high diversity and burden of parasites observed highlight the urgent need for routine monitoring, improved handling practices, and effective parasite management strategies to safeguard aquaculture productivity and consumer well-being.

Prospective researches should concentrate on grasping the ecological and environmental drivers of parasite transmission, as well as the impending zoonotic threats linked with consuming infected fish. Evaluating the efficacy of integrated parasite control strategies within aquaculture systems is also critical. Furthermore, public health education and awareness campaigns targeting fish-borne parasites can play a fundamental role in reducing zoonotic threats, improving food safety, and promoting sustainable fisheries in

Kano and beyond.

6. Conflicts of interest

The authors declared no conflicts of interest.

7. Author's Contribution

Both authors (VFA and OOA) conceived, designed and collected the samples. VFA worked on the morphometry aspect while OOA worked on the prevalence and diversity of parasites. Both authors led the writing of the manuscript while the final draft was prepared by VFA. Both authors contributed significantly to the success of the experiment, analysis and manuscript writing.

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