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Epidemiological Assessments of Gastrointestinal parasites in Clarias gariepinus (Burchell, 1822) : Implication for aquaculture sustainability and Public health concerns

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Abstract
Gastrointestinal parasites had significantly affected the health and productivity of *C. gariepinus.* Equally, posing food safety risks, making parasitological assessment essential for sustainable aquaculture and public health concerns. In this study, 405 specimens of *C. gariepinus*, comprising 201 females and 204 males were examined. Infection prevalence was 14.4% in females and 18.6% in males, with no significant sex-related difference (p > 0.05). Among parasite groups, Platyhelminthes had the highest prevalence (6.2%), followed by Nematoda (5.2%) and Protozoa (4.7%), whereas Acanthocephala was least prevalent (0.5%). At the genus level, *Oodinium* sp was the most prevalence protozoan (1.73%), and *Henneguya* sp as the least (0.25%) . *Wenyonia* sp (1.23%) and *Camallanus* sp (1.23%) dominanted the platyhelminthes and nematode respectively, with no significant differences observed across the groups (p > 0.05). Parasite prevalence was also investigated across biometric and gravimetric parameters. Fish of < 30.0cm standard lenght had 20.0% prevalence, and those exceeding 50.0cm recorded 25.5%. Also those with intestinal length of >40.0cm had the highest prevalence (20,8%). In terms of weight, fish of >400.0 g had 22.1%, while those with intestinal weight <10.0g recorded 17.9% while those with gill weights of >20.0g had 19.8% with no significant variations across the parameters. Overall, gastrointestinal parasite prevalence was low, indicating good health status of the fish, effective management practices and favourable environmental conditions that reduce risks to aquaculture productivity and zoonotic transmission, supporting sustainable development goals. Nevertheless, continuous monitoring is recommended to minimize potential future outbreaks influenced by changes in environment conditions and management practices.
Keywords Gastrointestinal; Morphometric; Parasites; Public health; Sustainability; Zoonosis

INTRODUCTION

The African catfish(*Clarias gariepinus*) is a highly valued freshwater fish species native to most of Africa and part of Asia (Nobrega *et al.*, 2024). It is a major contributor to global food security (Ouma and and Echessa, 2022). It is an ideal species for aquaculture (FAO, 2020) and (Sanda *et al.*,2024). This is due to its high tolerance for low oxygen (FAO,2015), high growth rate, good taste, excellent flesh quality and strong consumer acceptance (FAO,2022).
Clarias gariepinus possess high protein contents and omega-3 fatty acids (Atmadja *et al*.,,2020). It has potential for high yield, tolerance to withstand high stocking density and good disease resistance (Adeyemi *et al.*, 2023) and ability to withstand long drought and shortage of food (Chor *et al.*, 2013).
Despite these attributes *C. gariepinus* faces health challenges caused by infection and environmental stressors (Oladele *et al.*, 2021), (Kuchta *et al.*, 2018; Paladini *et al.*, 2017), water pollutants (Pravdova *et al.*, 2021) and nutritional deficiencies (Kumar *et al.*, 2025) which limits sustainable aquaculture.
The fitness adaptation has not eluded *Clarias* species from vulnerability and susceptibility to spectrum of gastrointestinal helminths and protozoan parasites (Odoh *et al.*, 2019). The Parasites have caused slow growth and poor feed conversion ratio (Giri and Das, 2025). In addition, parasites had significantly caused physical defect in fish species (Scarfe and Palic,2020), leading to diminished consumer confidence (Manaf and Zamri, 2025), reduction in production efficiency (Carella *et al.*, 2023) and considerable public-health concerns to human (Giri and Das, 2025) through the consumption of raw or improperly cooked fish (Cong and Elsheikha,2021), (Kawe *et al.*, 2016).
Parasitic prevalence on *C.gariepinus* by previous investigators varied across locations ranging from 50% by Idris *et al.*(2025), 21.62% by Tukur *et al.*(2025), 22.0% from Obi *et al.* (2017) investigation and 38.0% by Biu (2013) with differential prevalence of helminths accounted for 29.0%.
African Catfish (*Clarias gariepinus*) inhabiting freshwater ecosystems have been diseased by wide range of parasitic worms and protozoan (Odoh *et al.*, 2019; Abdel- Gaber *et al.*, 2015). Gastrointestinal parasites reported in *C. gariepinus* include nematodes such as *Camallanus* spp, (Abdel- Gaber *et al.*, 2021) *Capillaria* spp, and *Contracaecum* spp (Eyiseh *et al.*, 2022). While several parasites of *C. gariepinus* possess

zoonotic potential (Okoye *et al.*, 2014), it has induced intestinal inflammation, growth retardation (Hassan *et al.*, 2010), loss of appetite and digestive disorder (Francis- Floyd, 2024).
Trematodes infections in catfishes include *Clinostomum* spp (Phiri *et al.*, 2025) and *Diplostomum* spp (Adesina *et al.*, 2016) with birds and snails documented as intermediate hosts. Cestodes reported in Clarridae species include *Polyonchobothrium clarias, Ligula intestinalis* and *Bothriocephalus* spp (Aliyu and Abubarkar, 2024). The cestode infections are associated with severe emaciation and nutrient malabsorption. Additionally, acanthocephalans such as *Neochynorrhyncus* sp have been recorded in *C. gariepinus* population (Wali *et al.*, 2016).

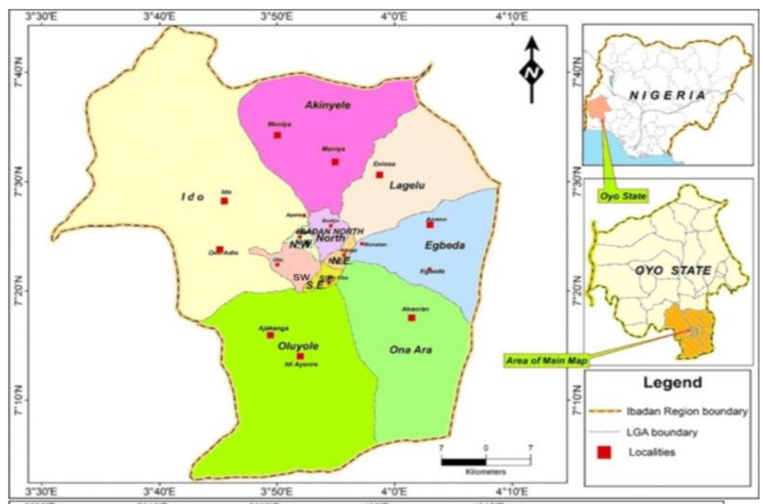
Protozoan endoparasites represent one of the most prevalent disease causative organisms in African catfish (Omeji *et al.*, 2011), this is possible due to their rapid reproduction, direct life cycles and susceptibility of the fish host to infection under intensive culture conditions (Matthew *et al.*,2021).

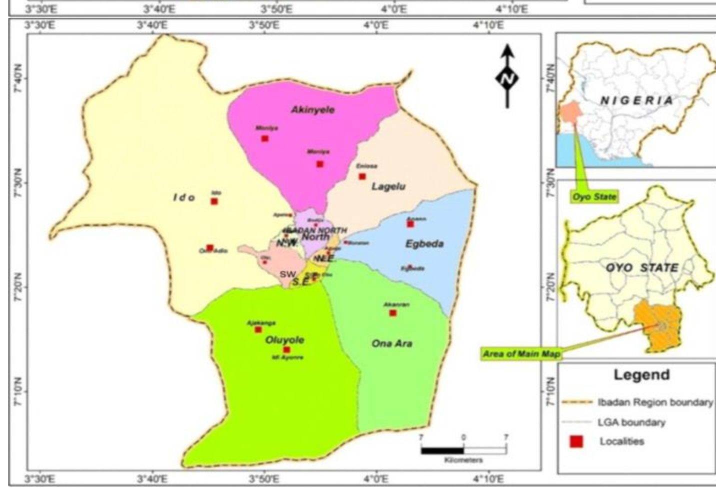
Common protozoan include Ciliates such as *Ichthyophthirius multifiliis* ("Ich"), *Trichodina* sp, *Chilodonella* sp, other Protozoan parasites reported include *Cryptobia* sp, *Epistylis* sp, *Ambiphyra* sp *Eimeria* sp, *Henneguya* sp and *Microsporidiae* sp, many of which are often spread through contaminated water and poor hygienic practices (Petty, 2024, Imran *et al.*, 2021).
Gastrointestinal parasites in *C.gariepinus* have caused significant economic losses due to reduced productivity (Abubarkar *et al.*, 2024), poor feed conversion rate and slow growth rates (Manaf and Zamri, 2025). While protozoans infections disrupt gut epithelia integrity of fish according to Bosi *et al.*(2022), helminths attachment and its larvae migration had also cause physical damages to the intestinal tissues(Yanong, 2025).
Parasitic prevalence is influenced by availability of intermediate hosts, ingestion of infective stages of parasites (Fatima *et al.*, 2025), host species susceptibility (Bubu Davies *et al.*, 2023). Furthermore, multiple stressors from the environmental, high organic pollution (Latief *et al.*, 2023), fish size and age have all been implicated to transmission of gastrointestinal parasites (Olagbemide and Owolabi, 2024)., Ayawei *et al.*, 2024).
In addition, seasonal variation according to El-Fahla *et al.* (2024) and poor sanitation practices such as human unhealthy attitude have made Clariidae be predisposed to gastrointestinal diseases (Ekine and Nathaniel, 2025).
The two groups of parasites namely gastrointestinal helminth and protozoans have been found to cause great mortality in catfishes which is estimated at 1.9% to 19.7% per cycle leading to economic losses (Mukaila *et al.*, 2023) and impairment of physiological processes (Manbe *et al.*, 2020).
Variations in parasite prevalence in *C. gariepinus* across different ecological locations are dynamic and largely influenced by differences in biotic and abiotic factors.
Consequently, epidemiological studies are essential to understand parasite prevalence and distribution within the host populations, also to evaluate the management strategies and assessing their influence on disease occurrence in aquaculture systems.
These underscore the aim of this study focusing on the epidemiological assessments of gastrointestinal helminths and protozoan parasites in *Clarias gariepinus* with implications for aquaculture sustainability and public health concerns.

MATERIALS AND METHODS

Study area

The study was conducted in Ibadan, the capital city of Oyo State located in the Southwestern part of Nigeria. Approximately, it is located on GPS coordinates of latitude 7.3775°N and longitude 3.9470°E. (Google map, 2025). The town is characterized by a tropical climate with distinct wet and dry seasons (Alli- Balogun *et al.*, 2018). The town experiences moderate and approximate mean annual rainfall of 1252 mm, relative high humidity of 76% and temperature range of 23°C-32°C (Daramola *et al.*, 2018). The climate is influenced by both natural and anthropologenic factors (Odjugo, 2005), supports both biological and ecological processes (Alli- Balogun *et al.*, 2018), making the area suitable for parasitological studies on *Clarias gariepinus*.





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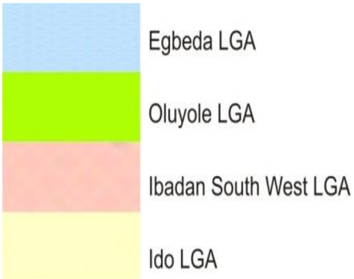

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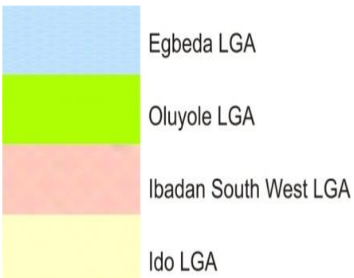

Figure1. Map of Ibadan town showing four local governments area of collection

Sample collection

Four hundred and five (405) *Clarias gariepinus* were collected from different sampling points into a plastic black container along with ambient water. The fish were transported to the laboratory and transferred into 1000 litre holden tank, where they were allowed to acclimatize for few hours while receiving de-chlorinated water prior to parasitological examination**.**

Morphometric analysis

This involved measuring of fish body weights, gills and intestinal weights using electronic scale of 0.01g precision. Linear measurements were taken with graduated tape rule and parameters taken included standard lenght, total length, intestinal lenght without its stretching however uncoiled and the head lengths.

Parasitological examination

Parasitological assessments were done starting with ventral side dissection with a slit from anal pore longitudinally through the trunk to the head region (Claar *et al*., 2021). Physical gross signs examination was carried out by naked eye and magnifying hand lens to detect macro-parasite and pathological signs on the gastrointestinal tract of the fish specimens. The gastro intestinal tracts were carefully cut off from the mouth to the anus using blunt dissection tool to avoid damage (Petkar and Shaikh, 2025), and slitted longitudinally and gently scrapped into the petri dish using a clean glass slides. Physiological saline was added to aid the emergence of the parasites according to Amaechi, (2004), Olurin *et al.* (2012) and Uneke *et al.* (2015). A few drops of 0.1% Sodium tricarbonate (IV) (Na_2CO_3) were added to the slitted gastro-intestine to enhance parasites search according to Paperna (1996). The contents were centrifuged at 3,000 rpm for 5 minutes, after which the sediments were examined microscopically at x100 and x400 repeatedly until its exhaustion.

Recovered parasite identification procedures

This was done based on observed morphological characteristics following established taxonomic keys according to Barson and Avenant-Oldewage (2006), Paperna (1996), Pouder *et al.* (2005, 2011, 2014, 2020a,b,c), Klinger and Francis- Floyd (2013), and Francis- Floyd *et al.,* (2016).

RESULTS

The outcome of this study revealed that 67 out of 405 *C. gariepinus* were infected with parasites, giving an overall prevalence of 16.5%. Infection prevalence was slightly higher in males (18.6%) than in female (14.4%), however, the difference was not statistically significant (p>0.05). (Table 1).

Table1. Prevalence of gastrointestinal parasites infection in *C. gariepinus* in relation to sex

Sex	No of fish	Infection (%)	X^2	P-value
Female	201	29 (14.4)	1.29	0.255
Male	204	38 (18.6)		
Total	405	67 (16.5)		

Among the major parasite group recovered, platyhelminthes recorded the highest prevalence (6.2%), followed by nematode (5.2%), protozoans (4.7%) while acanthocephalan was the least prevalent with 0.5%. Infections across all parasites group were more frequent in males fish than female (Table 2).

Table 2. Prevalence of Parasites in the Intestine of *C. gariepinus* in relation to sex

Parasites Phyla	Sex		
	Female (%)	Male (%)	Total (%)
Protozoans	9(4.5)	10(4.9)	19(4.7)
Platyhelminthes	11(5.5)	14(6.9)	25(6.2)
Nematodes	9(4.5)	12(5.9)	21(5.2)
Acanthocephalan	0(0)	2(1.0)	2(0.5)
Total	29(7.2)	38(18.6)	

Protozoan infection were dominated by *Oodinium* sp in 1.73% of fish species and *Ichthyophithrius* sp (1.48%), others are *Eimeria* sp (0.74%), *Trichodina* sp (0.49%), while *Henneguya* sp had the least prevalence of 0.25%.

Among the platyhelminthes, *Wenyonia* sp were the most prevalent (1.23%), followed by the duo of *Bucephalus* sp and *Diplostomum* with 0.99% each, others include *Ancyrocephala* sp, digenetic fluke and *Diphyllobothrium* sp with 0.74% each, while the least of parasitic plathhelminthes was *Terranova* sp with 0.25% prevalence.

Nematode infections were most commonly caused by *Camallanus* sp (1.23%), followed by trio of *Contracaecum* sp, encysted metacercariae and ascarid egg with each amounting to 0.74% prevalence. Also, recovered were *Capillaria* sp, *Eustrongyloides* sp and *ascarid* worm with each having 0.49% prevalence, the least of the nematode found was *micropapilatum* sp (0.25%). Acanthocephalan was represented by a single parasite with a prevalence of 0.50%. In overall, differences in prevalence among parasites genera were not statistically significant (p>0.05) (Table 3).

Table 3. Differential prevalence of gastrointestinal parasites in *C. gariepinus*

Parasites group	Parasite Genera	No Infected	% infected	X^2	P-value
Protozoa	*Oodinium* sp	7	1.73	1.097	0.778
	Ichthyopthrius sp	6	1.48		
	Eimeria sp	3	0.74		
	Trichodina sp	2	0.49		
	Henneguya sp	1	0.25		
Sub-total		**19**	**4.69**		
Platyhelminthes	*Wenyonia sp*	5	1.23	2.919	0.404
	Bucephalus sp	4	0.99		
	Diplostomum sp	4	0.99		
	Ancyrocephalidae sp	3	0.74		
	Digentic fluke	2	0.49		
	Diphyllobothrium sp	3	0.74		
	Terranova sp	3	0.74		
	Diclobothridae sp	1	0.25		
Sub-total		**25**	**6.17**		
Nematode	*Camallanus sp*	5	1.23	2.919	0.404
	Ascarid egg	3	0.74		
	Contracaecum sp	3	0.74		
	Encysted metacercariae	3	0.74		
	Capillaria sp	2	0.49		
	Eustrongyloides sp	2	0.49		
	Micropappilatum sp	2	0.49		
	Ascarid worm	1	0.49		
Sub-total		**21**	**5.19**		
Acanthocephalan sp	*Acanthocephala* sp	2	0.49	0.5	0.479
Sub- total		**2**	**0.49**		
Total		**67**	**16.5**		

Parasite prevalence in the gastro-intestine of *C. gariepinus* was highest (20.0%) among fish with standard length of <30.0cm followed by those within 35.0-39.9cm (17.5%). The lowest prevalence of 11.4% was recorded in fish with standard length of >40.0cm. Nevertheless, there is no significant association between parasite prevalence and standard length (p>0.05).

The highest prevalence of 25.0% was found in fish of total length of >50.0 cm, followed by those with of 400-44.9cm (21.7%), while the lowest prevalence of 6.7% was found in fish with total length of 45.0-49.9 cm.

The fish species with intestinal length of >40.0cm recorded the highest prevalence of 20.8% while those of 30.0-34.9cm followed with 17.2%, whereas the lowest prevalence of 13.1% was recorded in those with < 30.0cm. Fish species with head length of 10.0-14.9cm had higher prevalence of 17.5% compared to those with <10.0cm (14.7%). These findings indicate that the different linear parameters did not statistically influence parasites infections across the fish population (p>0.05) (Table 4).

Table 4. Prevalence of gastrointestinal parasites in *C. gariepinus* in relations to linear morphometric

Linear variables	Class interval	No of fish	No Infected	% infected	X^2	P-value
Standard length (cm)	<30.0	45	9	20.0		
	30.0-34.9	268	44	16.4	1.097	0.778
	35.0-39.9	57	10	17.5		
	>40.0	35	4	11.4		
Total		**405**	**67**	**16.5**		
Total length (cm)	<40.0	307	50	16.3		
	40.0-44.9	60	13	21.7	2.919	0.404
	45.0-49.9	30	2	6.7		
	>50.0	8	2	25.0		
Total		**405**	**67**	**16.5**		
Intestinal length (cm)	<30.0	107	14	13.1		
	30.0-34.9	93	16	17.2	2.919	0.404
	35.0-39.9	85	12	14.1		
	>40.0	120	25	20.8		
Total		**405**	**67**	**16.5**		
Head length (cm)	<10.0	136	20	14.7		
	10.0-14.9	269	47	17.5	0.5	0.479
Total		**405**	**67**	**16.5**		

Gravimetric analysis revealed that heavier fish (>400.0g) had the highest prevalence (22.1%), followed by those weighing 350.0-399.9g (16.5%), while the lowest prevalence (11.5%) was recorded in class weight of <300.0g. In terms of intestinal weight, prevalence was highest (17.9%) in fish with intestinal weight of <10.0g, followed by 17.4% occurrence among those with of 15.0-19.9g, whereas the least prevalence of 13.6% gastrointestinal parasites was found in fish with intestinal weight of >20.0g.

Gill weight also showed variation in parasite prevalence in relation to gastrointestinal parasites. The highest infection rate (19.8%) was observed in fish intestine whose fish had gill weight of >20.0g, followed by prevalence rate of 15.8% among fish with <10.0g gill weight. The lowest gastrointestinal parasites with 15.3% were each recorded in intestine of fish with 10.0-14.9g and 15.0-19.9g gill weight. In overall, these findings show that although parasite prevalence fluctuated across different weight classes of *C. gariepinus*, the gravimetric variables did not significantly influence gastrointestinal parasite infection in the studied population (p>0.05) (Table 5).

Table 5. Prevalence of gastrointestinal parasites in *C. gariepinus* in relations to Gravimetric morphometric

Gravimetry variables	Class interval	No of fish	No Infected	% infected	X^2	P-value
Weight of fish (g)	<34.9	89	10	11.5	5.621	0.132
	34.9-349.9	99	13	13.1		
	350.0-399.9	79	13	16.5		
	>400.0	140	31	22.1		
Total		**405**	**67**	**16.5**		
Intestinal weight (g)	<10.0	145	26	17.9	0.741	0.863
	10.0-14.9	133	22	16.5		
	15.0-19.9	46	8	17.4		
	>20.0	81	11	13.6		
Total		**405**	**67**	**16.5**		
Gill weight (g)	<10.0	19	3	15.8	1.193	0.755
	10.0-14.9	131	20	15.3		
	15.0-19.9	144	22	15.3		
	>20.0	111	22	19.8		
Total		**405**	**67**	**16.5**		

DISCUSSION

Gastrointestinal parasites of *C. gariepinus* showed an overall prevalence of 16.5%, which is higher than 9.82% reported by Banyigyi *et al.* (2022), however lower than 30% documented by Aliyu and Abubarkar (2024), 21.62% recorded by Dabo *et al.* (2024) and 80.0% by Onoja- Abutu *et al.* (2021). This finding aligns with the reports of Ekanem *et al.* (2011) with a similar prevalence of 16.67%.

The low prevalence observed may be due to good environmental condition (Kawe *et al.*,2016), minimal organic pollution in the culture water (Madsen and Stauffer, 2024) and controlled culture environment with little or no exposure to faecal waste as infective stages of some parasites are shed off with faecal matter of birds or mammals (Omeji *et al.*, 2022). This demonstrates that environmental conditions influence transmission of parasitic infections (Jeronimo *et al.*, 2022).

Variation in the prevalence across the ecological zones are likely due to differences in biotic and abiotic factors (Abdulkari, 2025), in addition to strategic location of fish farms off untreated waste routes and reduction of other anthropogenic factors on water environment which may reduce impacts of pollution to proliferate parasites of which its diversion to water environment caused fish diseases and mortality (Mustafa *et al.*, 2024).

Male fish in this study were more infected than female, although there is no significant association between parasite prevalence and sex of fish (p>0.05). This agrees with Dauda *et al.* (2023) and Nnatuanya *et al.* (2023) who attributed higher male infection to opportunity of increase feeding while females are busy with reproductive strategies attributed to hormonal differences that enhances immunity in female fish (Klein, 2000). However this is contrary to the report of Aliyu and Abubarkar (2024) and Banyigyi *et al.* (2023) where females were more infected than male.

Protozoan infection prevalence ranked third in this study, this may likely to causing short-term infections that could be overpowered by effective fish immune system (Turvey and Broide, 2010) contributing to its low prevalence. The outcome of this study does not align with the outcome of Okoli *et al.* (2019) who recorded *Toxoplasma gondi*, a protozoan as the most prevalent in infected *C. gariepinus.*

In addition, the acidic environment of fish stomach typically of pH range 2-3 (Luckstast, 2015) provides defense mechanism against parasites, judging from the lack of protective coat by the trophozoite stages of protozoans made such vulnerable to acidic environment of the stomach and get wipped off (Mukhopadhyay and Ganguly, 2014), which support the preference of protozoans to infect skin, gills and blood rather than gastrointestinal tracts (Kumar *et al.*, 2021).

Among protozoans, *Oodinium* sp was the most prevalent, though it is a typical ectoparasites. In contrast, the low prevalence of *Henneguya* sp in the gastrointestinal tracts may be due to complex life cycle involving two hosts namely fish and aquatic oligochaete, with its strong preference for gills infestation (Stilwell and Yanong, 2024), while its poor tolerance to withstand high acidic nature of the stomach according to Solovyev *et al.* (2018) may reduce colonization of the protizoans.

Platyhelminthes recorded the highest prevalence among gastrointestinal parasites recovered supporting the reports of Maikai and Ambrose, (2018) and Abdisa *et al.* (2023) where helminths composition were the dominant gastrointestinal parasites. The occurrence of *Wenyonia* sp as the highest prevalent support the outcome of Ibrahim *et al.*, (2020) in similar catfish family.

The dominance of platyhelminthes may be attributed to several biological and host-related factors which include possession of attachment organs to fasten itself to intestinal lining of fish host (Scholz *et al.*, 2021), dorsoventrally flattened body to maximize surface area for efficient nutrient and oxygen absorption (Collins, 2017).

The presence of *Wenyonia* sp in the gut of *Clarias gariepinus* is likely through ingestion of intermediate hosts, and its scolex which allows firm attachment to the intestinal wall and resistance to both peristalsis and digestive enzymes. However, its relatively direct transmission and host specificity may be responsible for higher prevalence than *Bucephalus* sp that has a multi host life cycle(Molloy *et al.*, 1997).

The presence of digenetic fluke and *Diphyllobothrium* sp in the gastrointestine of *C. gariepinus* is possible due to the ability to depend on digested food and ingestion of the intermediate hosts at comparable frequencies (Souza *et al.*, 2019). The higher prevalence of *Camallanus* sp may be due to the ingestion of copepods intermediate hosts and ability to survive effects of digestive enzymes.

Nematode presence in the gut of *C. gariepinus* ranking second prevalent is in line with the outcome of Ibrahim *et al.* (2020), this is contrary to the outcome of Kwaghvihi and Ramalan (2024) where member of the family Camallanidae were the most prevalent and attributed to variation in environmental conditions and location of the investigation as nematodes were often most prevalent in catfishes according to Kawe *et al.*(2016) investigation.

The recovery of variants of nematodes may likely be due to consumption of intermediate host such as mollusc and crustaceans which may likely be fewer supporting a decrease contact betweem the fish host and infective stage of parasites (Oniye *et al.*, 2004), as well as their low-host specificity. However, their weaker attachment organs may result in it dislodgement from the gut leading to their low prevalence compared to platyhelminthes that possese scolex as organ of attachment, despite nematodes prevalence been lower than platyhelminthes, its occurrences is higher than protozoan and acanthocephalans.

The trio of ascarid worm, C*ontracaecum* sp and encysted metacaecariae showed similar prevalence which may be due to comparable level of exposure rate, hosts susceptibility, similar ages, immunity and environmental conditions. Also, their low prevalence may be due to the complex life cycle, high host specificity and immunity, good fish pond management practice and feeding habit that solely depend on processed pelleted feed rather than animal waste, absence of fish eating birds, and absence of larval stages of parasites. Whereas contracaecum is also regarded as parasite of the wild fish rather than cultured fish (Abiyu *et al.*, 2020).

Micropapaillatum sp and *Capillaria* sp recorded the lowest of the nematodial infection possibly due to limited exposure to intermediate hosts, indirect life cycles which reduces transmission efficiency, thereby constraining the optimal conditions necessary for nematodial transmission (Abdisa *et al.*, 2023), and effect of acidic environment and digestive enzymes on worms could contribute to low prevalence (Ajala and Fawole, 2014)

Acanthocephalan recording the lowest prevalence is in line with both Nwadike *et al.* (2023) and Mgbemena *et al.* (2020) reports where acanthocephalan found amongst parasites of Claridae fish were overshadowed by other major parasites groups encountered in the fish species. This may be attributed to paucity of intermediate host for easy transmission (Mgbmena *et al.*, 2020. While their dioceous nature (Perrot-Minnot *et al.*, 2023) may require both sexes to be present in the same host for successful reproduction which may be absent and cause lower prevalence.

Deep penetration into the intestinal wall (Paperna, 1996), may also reduce the recovery of acanthocephala during sampling in addition to complex life cycle involving at least two hosts which may equally reduce transmission.

The relationship between the prevalence and linear morphometric indicated higher prevalence in fish of standard lenght <30.0cm likely due to immature immunity Mahmoud *et al.* (2018), whereas parasite prevalence got reduced among the sub adult of standard lenght>40.0 cm displaying immunity of fish increases with size of fish, this corroborate the findings of Biu and Nkechi (2013). However, the prevalence got increased again among fish species of the longest length (>50.0cm) supporting Saha *et al.* (2015) and Omeji *et al.* (2011) which interprets that longer fish consume more food in its bit to satisfy its appetite thus forage over a long period of time which exposes such to higher parasitism with adequate time to accumulate more parasites through repeated exposure to parasites over period .

The sub -adult fish of total length (45.0-49.9cm) showed less prevalence which is attributed to less time spent in culturing medium compare to adult fish thus reducing both its cumulative exposures to parasites and minimal consumption of intermediate host, in addition to diets dominated by plankton and small prey (Tekle-Giorgis *et al.*, 2016) rather than infective stage of intermediate hosts such as mollusc making it less susceptible to gastrointestinal parasites. This is contrary to the feeding behaviour of adult fish as a bottom dwelling species (Gunder, 2004) with the likelihood of consuming more intermediate host such as mollusc and fish (Lutz, 2024), thus makes it more predispose to higher parasitism.

Fish species with intestinal length of >40.0 cm were the most infected which means by simplicity, expansible and longer intestine can accommodate larger amount of food (Pektar and Shaikh, 2025), providing larger surface area for attachment and colonization of parasites without over crowding, supporting Clements and Raubenheimer, (2005) who documented that feeding habits is influenced by varying intestinal lenghts, with longer intestine also providing longer time for the digested food to transverse causing ingested parasites to remain for a longer period in the gut due to the presence of digested food.

Also, fish that has longer intestine seems older and longer causing more cumulative exposure to infective stages via feeding, furthermore older fish posses the competence for ontogenic diets (Dadebo *et al.* 2014), thereby exposing fish to high risks of parasitism, though the higher parasitic loads can be harbored and be less susceptible to immediate mortality compared to younger fish supporting Wunderlich *et al.* (2022) who affirmed age influences host susceptibility to parasites.

The least prevalence of parasites is found in fish with lesser intestinal length which interprets that distance travelled by

digested food influences the availability of parasites in the gastrointestine of the fish species supporting Awosolu *et al.*(2018) who opined increase in intestine length leads to increase in parasite prevalence in a freshwater fish sample.
This may be due to the provision of little surface area which is associated with reduced susceptibility to colonization of parasites as shorter intestinal length of fish allow faster food transmission in the such intestinal length, ultimately leading to expulsion of parasites with reduced window of time for parasites penetrations to the intestinal wall to establish itself and complete transmission cycle in the host, this allign with the opinion of Sayyaf Dezfulin *et al.* (2021a) who opined alimentary canal of fish is a favourite place for growth, establishment and reproduction of enteric parasites.
The immune system of such fish may not be overwhelmed by repeated exposure to parasites thus allowing both the innate and adaptive immunity not to combat parasites establishment ( ).
In relations to gravimetric, higher parasitic prevalence was associated with fish of highest body weight of >400.0g likely due to cumulative exposure over time through feeding allowing parasites to accumulate in the gastrointestinal tracts, it could also be due to wider range of prey consumption probably leading to interactions with the intermediate hosts( ) .Also larger host body size can lead to larger parasites due to availability of energy for parasite growth (Wunderlich *et al.*, 2025)
Larger fish also posses larger cavities and intestines to accommodate more parasites, to establishing a colony and reproduce without detailed competition with other parasites, they are also physiologically tolerance to higher parasitic burden without showing clinical signs as response to parasitic infection thus allowing parasites to persist, whereas the heavy parasites in smaller fish may lead to mortality.
The least prevalence was among fish of < 300.0g may be attributed to little time exposure of fish to culturing water, limited feeding, smaller gut size and faster transit of digested food over short distance of organs as the length of organ may be in association with weight of the fish. Both innate and adaptive immunity could also prevented heavy burden of parasites on fish of smaller size
Higher parasite burden was found in fish with lowest intestinal weight, this may be due to effect of gastrointestinal parasites causing damages to the intestine (Fairweather, 1997) which may cause reduction in intestinal contents. Also that homeostatic mechanism involving immunological competence of the fish had been reported in Dezfuli *et al.*, (2022) in hosts which may lead to immunological incompetence causing colonization of parasites and hence brings such burden in fish with such morphometry value.
Also, the fish host could have poor nutrient absorption due to damaged intestinal tissue caused by parasites and morphology damage of lesions (Dezfuli *et al.,* 2011b) which may also disturb the physiological of the intestine to function appropriately to accommodate higher quantity of food. Heavy parasites loads could also caused intestinal destruction (Kohn *et al.*, 2007), favoring high parasitic burden (Petty, 2024.
Higher parasitic burden was found in fish with higher gill weight whereas gills in other group had closely related parasitic burden, this is attributed to gills been under stress due to poor environmental condition causing proliferation of parasites and suppressing the immune system making fish more vulnerable to parasitic infection (Zawisza *et al.,* 2023). Also larger gills size connote larger fish, wider surface area and larger food consumption with many gill rakers filtering off prey into the gastrointestinal tract.

Implication for Aquaculture and Public health Concerns

The significance of low prevalence of gastrointestinal parasites recorded in *C. gariepinus* in this study has indicated improved fish health that is hinged on stocking of healthier breed, uncompromising immune system of fish (Sitja-Bobadilla *et al.*, 2016), effective pond management strategies (Mdegela *et al.*,2011) and favourable environmental condition (Ojwala *et al.*, 2018). These factors may enhance better feed conversion ratio as fewest parasites minimizes competition for nutrients leading to higher productivity. Consequently, bringing into place lower cost of treatment which will imminently cause higher profitability in aquaculture operations.
The low parasitic prevalence has placed populace at low level of public health risk of both zoonotic transmission and contamination of food-borne parasitic infections through handling and consumption of infected fish (Caffara *et al.*, 2020). Furthermore, that properly cooked fish minimizes infection risk making it safer for human consumption (Oso *et al.*, 2017).
In addition, a healthy and non-diseased fish looks visually good, which enhances public trust and consumer acceptability of farmed fish (Claret *et al.*, 2014) as a safe protein and cardio-protective oil source. Also precautionary measures to fish-borne parasites minimizes the incidence of illnesses (Ziarati *et al.*, 2022), thereby decreasing healthcare costs and public health interventions that is related to parasitic diseases contrary to highcost due to zoonotic impacts on human (Buchmann, 2022)
Low parasite prevalence show a good environmental sanitation and minimal faecal contamination of water bodies, which also lowers the risk of waterborne parasitic infections that may affect human populations especially the vulnerable group which are the children, pregnant women, and immunocompromised individuals.
The outcome of this investigation is in line with several sustainable development goals (SGDs), such include SDG 1 which is hinged on wiping off poverty as viable aquaculture practice with low parasitic incidence provide a substantial means of livelihood. Also SDG 2 (Zero Hunger) could be ensured in the availability of safe, nutritious, and sufficient food year-round.
Furthermore, its support to SDG 3 is in line with prevention of diseases maintaining good health and well-being, particularly target 3.3 which aims to end neglected tropical diseases by 2030. This study further supports SDG 6 hinged on access to clean water, adequate sanitation emphasizing improved water quality leading to low parasite prevalence, hygienic food production and food contamination critical to hygienic food production and effective farm bio-security measures.
In addition, this study support the attainment of both SDG 12 which aligns with responsible production, promotion and consumption of safe food which enhances market value of fish products, bringing about reduction in food losses as well as

SDG 13 on climate action by encouraging resilient and sustainable aquaculture practices.
Maintaining low parasite levels aligns with public health goals of disease prevention, safe food systems, and promotion of hygienic aquaculture practices bringing reduction to the need for chemotherapeutic treatments which further reduce risks of drug residues, resistance development, and environmental contamination.
SDG 14 and 15 is also captured in the area of environmental sustainability of due to low parasite prevalence by promoting stable ecosystems and reducing disease outbreaks that can affect surrounding water bodies.
Additionally, the results contribute to SDG 12 (Responsible consumption and production) through the promotion of safe food systems, enhanced market value of fish products, and reduced food losses, as well as SDG 13 on climate action by encouraging resilient and sustainable aquaculture practices.
The attainment of low parasite levels reduces dependence on chemotherapeutic treatments, thereby minimizing the risks of drug residues and environmental contamination. Finally, SDG 14 (Life Below Water) and 15 (Life on Land) are supported through the promotion of environmental sustainability, while low parasite prevalence contributes to stable ecosystems and reduces the likelihood of disease outbreaks that could impact surrounding aquatic and terrestrial environments.

CONCLUSION

The low gastrointestinal parasite prevalence in this study reflects effective aquaculture management practices that supports the production of safe, sustainable and economically viable fish. Consolidating these gains requires stable aquaculture policies, continuous environmental education and routine monitoring of pollution in fish culture medium considering its influence on parasitism. Regular parasitological survelliance of Clariidae fish together with effective quarantine measures to ensure stocking of disease-free seedlings is essential to prevent diseases outbreak and reduce zoonotic risks. Furthermore, continuous epidemiological studies on cultured *C. gariepinus* are neccesary to improve the underastanding of parasites dynamics in non-wild systems to strenghtens fish health management strategies

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