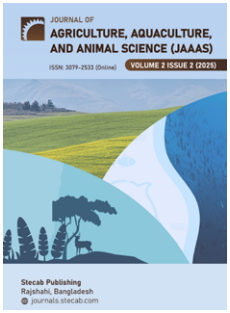

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Review Article

Trematode Infections and Histopathological Effects in *Chrysichthys nigrodigitatus* from the Polluted Andoni River, Niger Delta, Nigeria

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About Article

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ABSTRACT

This study evaluated the prevalence, histopathological effects, and environmental drivers of trematode metacercariae in *Chrysichthys nigrodigitatus* from the Andoni River in the Nigerian Niger Delta. One hundred specimens were examined for parasitic cysts and associated tissue pathology, while physicochemical parameters of water samples from fish landing sites were analyzed following American Public Health Association protocols. The results revealed a 74% prevalence of infection, with metacercariae predominantly located in the gills, intestines, and muscle tissues. Infected fish exhibited significant histopathological alterations, including lamellar fusion, mucosal necrosis, goblet cell hyperplasia, myofibre degeneration, and fibrotic encapsulation. The condition factor was significantly lower in infected individuals, indicating impaired physiological status. Water quality analysis showed elevated concentrations of nitrates, phosphates, BOD_5, and turbidity, all of which were positively correlated with parasite prevalence. To our knowledge, this is the first documented assessment in the Niger Delta that integrates prevalence, histopathological alterations, and quantified environmental drivers of trematode infection in *C. nigrodigitatus*, offering an ecological and public health perspective rarely addressed in African inland fisheries research. These findings highlight the role of environmental stressors in promoting parasitic infections, and underscore the value of fish health indicators for monitoring aquatic ecosystem integrity and zoonotic risk in fish-consuming communities. Consequently, consumption of *C. nigrodigitatus* from the Andoni River may pose public health concerns.

Citation Style:

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1. INTRODUCTION

Aquatic ecosystems in sub-Saharan Africa are under constant pressure from human activities such as industrial discharge, agricultural runoff, deforestation, and unregulated urban development (Mazigo *et al*., 2012; Agrawal & Rao, 2011). In the Niger Delta region of Nigeria, these stressors have led to significant environmental degradation, negatively impacting aquatic biodiversity, fisheries productivity, and public health (Okoye *et al*., 2022). Among the affected species, *Chrysichthys nigrodigitatus*, a commercially important freshwater catfish, is vulnerable to parasitic infections due to the region's polluted waters (Singh *et al*., 2009).

Globally, aquaculture of finfish in freshwater and marine systems is expanding (FAO, 2020), with freshwater aquaculture dominating in Asia, especially China and Indonesia (Lun *et al*., 2005; Hong & Fang, 2012). Expansion is also possible in Europe and the Americas through advanced recirculation technologies. Aquaculture now supplies fish for human consumption at levels comparable to capture fisheries, and new species are continually being domesticated (FAO, 2020). However, all aquacultured species face challenges from pathogens that may originate from wild fish populations or contaminated water sources. Parasites can infect cultured fish (spill-over) and proliferate under confined conditions, leading to disease outbreaks that threaten fish health and the economic viability of aquaculture operations (Singh *et al*., 2009; Parija, 2013).

Trematodes, or flukes, are digenetic parasites that attach to hosts using characteristic suckers (Parija, 2013; Singh *et al*., 2009). They are of global significance due to their clinical impact on humans and other animals. Schistosomiasis alone affects over 200 million people worldwide, while infections by *Clonorchis sinensis*, *Paragonimus* species, *Fasciola* species, and *Opisthorchis* species place hundreds of millions at risk (Mazigo *et al*., 2012; Chai *et al*., 1998). The prevalence and transmission of trematodes are closely linked to freshwater habitats, where aquatic snails serve as intermediate hosts (Horák *et al*., 2015; Badr *et al*., 2011). Human infections occur through skin penetration by cercariae or through consumption of contaminated aquatic animals and plants, with populations living near freshwater bodies at the highest risk (Sangweme *et al*., 2010; Agrawal & Rao, 2011).

Foodborne trematodiasis, caused by liver, lung, and intestinal flukes, is an emerging public health concern in several regions and has been associated with aquaculture practices (Lun *et al*., 2005; Procop, 2009). While trematode infections have been widely documented in Asia, Europe, and the Americas, limited data exist for West African freshwater systems, particularly in the Niger Delta, despite high levels of pollution and human interaction with rivers (MacLean *et al*., 1996; Sakru *et al*., 2011). Given the ecological degradation of the Andoni River and the commercial importance of *C. nigrodigitatus*, there is a need to investigate the prevalence of trematode infections and their histopathological effects in this species.

2. LITERATURE REVIEW

2.1. Anthropogenic pressures on aquatic ecosystems in sub-saharan africa

Freshwater ecosystems in sub-Saharan Africa, particularly in the Niger Delta region of Nigeria, are increasingly affected by human activities, including industrial discharges, agricultural runoff, deforestation, and uncontrolled urban expansion. These pressures have contributed to widespread environmental degradation, resulting in reduced water quality, declining biodiversity, and compromised fisheries productivity (Okoye *et al*., 2022). The degradation of aquatic habitats also poses risks to public health due to increased exposure to pollutants and waterborne pathogens.

The Niger Delta is characterized by a complex network of rivers, creeks, and estuaries that support high levels of biodiversity and provide critical ecosystem services. These include freshwater supply for domestic and industrial use, irrigation, fisheries, flood control, and the regulation of local climate (Okpoji *et al*., 2025). In addition, the rivers and creeks of the region serve as cultural and recreational spaces, supporting activities such as fishing, boating, and subsistence livelihoods for local (Tavares-Dias & Martins, 2017).

2.2. Aquaculture and pathogen spill-over in the niger delta

Human pressures on these freshwater systems are compounded by the increasing expansion of aquaculture in the region. Aquaculture in the Niger Delta has the potential to supplement capture fisheries, yet farmed fish are vulnerable to pathogens originating from polluted waters and wild fish populations N. Spill-over of parasites from wild fish and contaminated water into aquaculture settings can lead to infections that threaten both fish health and the economic viability of local fisheries (Lun *et al*., 2005). The environmental degradation of rivers like the Andoni River has created conditions favorable for the proliferation of parasites, including trematodes, which are digenetic flukes with global medical and veterinary importance.

2.3. Trematode infections and public health significance

Human populations living along the rivers are at higher risk of infection through direct contact with contaminated water or consumption of infected aquatic organisms (Sangweme *et al*., 2010). Trematode infections, such as those caused by Clonorchis, *Paragonimus*, *Fasciola*, and *Opisthorchis* species, are of public health concern due to their association with liver, lung, and intestinal diseases (MacLean *et al*., 1996). Despite the known global significance of trematodes, data on their prevalence and histopathological impacts on commercially important freshwater fish species in West African rivers remain limited. *Chrysichthys nigrodigitatus*, a key food fish in the Niger Delta, is particularly vulnerable to these infections due to the combined effects of environmental pollution and high human interaction with riverine systems.

3. METHODOLOGY

3.1. Study area

The study is focused on the Andoni River system, located in the Andoni Local Government Area of Rivers State, Nigeria. Specifically, the river system is an estuarine water body, part of the Niger Delta ecosystem, and is affected by tidal influences from the Atlantic Ocean and freshwater inflows from inland areas. The region has a tropical humid climate characterized by high rainfall (over 2,500 mm annually) and temperatures

ranging from 25°C to 32°C. The river's coordinates are Latitude: 4.455°N and Longitude: 7.512°E. Local activities such as artisanal fishing, sand mining, boat building, and petroleum-related operations contribute significantly to ecological stress and water quality deterioration.

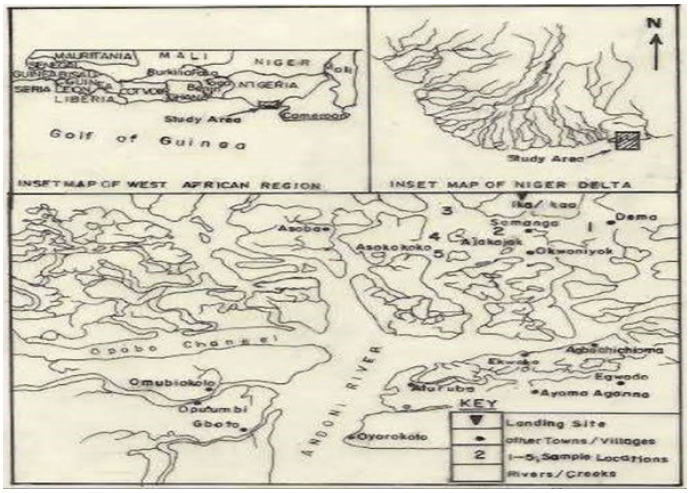

Figure 1. Map of the study area showing the andoni river.

3.2. Fish sampling and identification

A total of 100 live specimens of *Chrysichthys nigrodigitatus* were collected during the early rainy season (April–May 2025) from three artisanal fish landing sites along the river. Fishers used gill nets, cast nets, and longlines—gear types commonly deployed in the region. Immediately after capture, fish were transported in ice-packed containers to the parasitology laboratory. Species identification was conducted using standard taxonomic guides, including FAO field manuals and West African freshwater fish references.

3.3. Morphometric analysis and condition factor determination

Each fish was measured for total length (cm) using a graduated measuring board and weighed (g) using a digital electronic balance. The condition factor (K), a measure of health and nutritional status, was calculated using the formula:

$K = (W / L^3) \times 100$

Where,

W is body weight in grams and L is total length in centimetres. Condition factor values were statistically compared between infected and uninfected groups to assess the impact of parasitism on physiological condition.

3.4. Parasitological examination

All specimens were dissected under sterile conditions to examine the gills, liver, intestines, and muscle tissues for the presence of metacercarial cysts. Parasites were extracted using fine-tipped forceps and preserved in 70% ethanol. Microscopic examination was performed at ×40 and ×100 magnifications using a compound light microscope. Identification of metacercariae was based on morphological features such as body shape, sucker arrangement, and tegumental characteristics, following standard diagnostic keys and atlases (Yamaguti, 1958; Niewiadomska, 2002). Specieslevel identification was limited by the absence of molecular confirmation.

3.5. Histopathological examination

Tissue samples from infected and uninfected fish were fixed in 10% neutral-buffered formalin for 24–48 hours. After dehydration and paraffin embedding, sections of 5–7 µm thickness were cut using a rotary microtome. Slides were stained with haematoxylin and eosin (H&E) and examined under a light microscope for pathological lesions including epithelial necrosis, lamellar distortion, inflammatory cell infiltration, fibrotic encapsulation, and myofibre degeneration. Representative photomicrographs were captured using a digital photomicroscopy system.

3.6. Water quality assessment

Surface water samples were collected from each of the three sampling sites at a depth of 30 cm using pre-cleaned polyethylene bottles. Triplicate samples were collected at each site and stored in ice-filled containers during transport. Analysis was conducted within 24 hours. The following parameters were measured:

Temperature and pH – recorded in situ using a multiparameter probe (Hanna Instruments HI9829)

Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD_5) – determined by the Winkler titration method

Nitrate (NO_3^-) and Phosphate (PO_4^{3-}) – analysed using UV-visible spectrophotometry according to

APHA Methods 4500-NO_3 and 4500-PO_4

Turbidity – measured with a Hach 2100Q Turbidimeter

Electrical Conductivity (EC) – determined using a handheld EC meter (Hanna HI99300)

All analytical procedures followed the protocols outlined in the American Public Health Association (APHA, 2017).

3.7. Statistical analysis

Parasitological indices such as prevalence, mean intensity, and mean abundance were calculated using standard epidemiological formulas. Descriptive statistics (mean ± standard deviation) were computed for morphometric and environmental data. Independent-samples t-tests were applied to compare the condition factor (K) between infected and uninfected fish. Pearson's correlation analysis was used to explore relationships between parasite prevalence and water quality parameters. All statistical analyses were performed using IBM SPSS Statistics version 25, with significance set at $p < 0.05$.

4. RESULTS AND DISCUSSION

4.1. Prevalence and intensity of infection

A total of 100 specimens of *Chrysichthys nigrodigitatus* were examined for trematode infections, of which 74 were found to harbour encysted metacercariae. This represents an overall infection prevalence of 74.0%. The mean intensity of infection was calculated as 6.2 parasites per infected fish, with observed parasite loads ranging from 2 to 15 cysts per host. The intestinal tract and gill tissues were the most frequently infected sites, while the liver and muscle tissues showed lower parasite burdens. Statistical analysis revealed no significant difference

in infection prevalence between male and female fish ($\chi^2 = 1.27$, $p > 0.05$), indicating that sex was not a determining factor in susceptibility to trematode infection.

4.2. Morphological characterisation of trematodes

Microscopic evaluation of the extracted metacercariae revealed morphological characteristics consistent with digenetic trematodes belonging to the families Heterophyidae and Diplostomidae. The cysts contained parasites with pyriform bodies, prominent ventral suckers, tegumental spines, and centrally located excretory vesicles. These features were indicative of genera such as Clinostomum and Haplorchis, both of which are commonly associated with freshwater teleost hosts in tropical regions. However, due to the lack of molecular analysis, definitive species identification was not achieved.

4.3 Condition Factor in Infected and Uninfected Fish

The mean condition factor (K) of infected individuals was significantly lower than that of their uninfected counterparts. Infected fish recorded a mean K value of 0.79 ± 0.04, while uninfected fish had a higher mean value of 0.92 ± 0.03. This difference was statistically significant ($t = 5.21$, $df = 98$, $p < 0.001$). Additionally, a strong negative correlation was observed between parasite intensity and condition factor ($r = -0.62$, $p < 0.01$), suggesting that heavier parasitic burdens were associated with diminished physiological condition and reduced overall health of the host fish.

4.4. Histopathological changes in infected tissues

Tissue analysis revealed distinct histopathological lesions in organs from infected fish. In the gills, notable alterations included epithelial hyperplasia, lamellar fusion, and inflammatory infiltration, which may impair respiratory efficiency. The intestinal tissues displayed goblet cell proliferation, mucosal epithelial sloughing, and focal necrosis around encysted parasites, indicating localised inflammation and disrupted digestive function. Liver sections exhibited mild vacuolar degeneration and lymphocytic infiltration in perivascular areas, reflecting systemic stress responses. In the musculature, metacercariae were observed within fibrous cysts, accompanied by degeneration of adjacent myofibres and infiltration of chronic inflammatory cells. Uninfected tissues maintained normal histological architecture with no evident lesions, confirming the pathological influence of the parasitic infections.

4.5. Physicochemical parameters of the aquatic environment

Analysis of water samples from the three sampling sites along the Andoni River revealed conditions indicative of moderate to severe pollution. The mean water temperature was 28.6 °C (±1.2), and the pH ranged from 6.8 to 7.4, with a mean of 7.1 (±0.3), falling within the acceptable range for freshwater ecosystems. However, dissolved oxygen concentrations averaged 4.1 mg/L (±0.8), which is below the World Health Organization's recommended threshold of 5.0 mg/L for aquatic life. Biochemical oxygen demand (BOD_5) values ranged from 4.3 to 6.7 mg/L, with a mean of 5.4 mg/L (±1.1), exceeding permissible limits and indicating organic pollution. Nutrient levels were also elevated, with nitrate and phosphate concentrations recorded at 3.6 increasing infection risk in the studied fish population.

mg/L (±0.5) and 1.2 mg/L (±0.3), respectively. Turbidity levels averaged 42.7 NTU (±6.1), far above recommended limits, while electrical conductivity ranged from 266 to 391 µS/cm, averaging 341 µS/cm (±45.2).

Correlation analysis demonstrated significant positive associations between parasite prevalence and key environmental parameters, including turbidity ($r = 0.51$), BOD_5 ($r = 0.57$), nitrate ($r = 0.54$), and phosphate ($r = 0.56$), all statistically significant at $p < 0.05$. These findings suggest that declining water quality may play a critical role in promoting parasite transmission.

Table 1. Prevalence and mean intensity of trematode infection in *chrysichthys nigrodigitatus* from the andoni river (n = 100)

Parameter	Value
Number of fish examined	100
Number of fish infected	74
Prevalence (%)	74.0
Mean intensity of infection 6.2 parasites/fish	
Range of parasite burden	2 – 15

Note: Prevalence = (Number of infected fish / Total number examined) × 100.

Table 2. Comparison of mean condition factor (k) between infected and uninfected fish

Infection Status Mean	K ± SD	Sample Size (n)	t-value	p-value
Infected	0.79 ± 0.04	**74**	**5.21**	**< 0.001**
Uninfected	0.92 ± 0.03	**26**		

Note: Condition factor (K) = (Weight / Length³) × 100. Statistical analysis performed using independent-samples t-test.

Table 3. Histopathological changes observed in infected tissues of *C. nigrodigitatus*

Tissue Examined	Histopathological Lesions
Gills	Epithelial hyperplasia, lamellar fusion, inflammatory cell infiltration
Intestine	Goblet cell proliferation, epithelial sloughing, focal necrosis
Liver	Mild vacuolar degeneration, perivascular lymphocytic infiltration
Muscle	Fibrotic cysts, myofibre degeneration, chronic inflammatory infiltration

Note: No lesions were observed in the tissues of uninfected specimens.

Table 4. Mean physicochemical parameters of the andoni river at fish sampling sites

Parameter	Mean ± SD WHO Recommended Limit
Temperature (°C)	28.6 ± 1.2 —
pH	7.1 ± 0.3 6.5 – 8.5
Dissolved Oxygen (mg/L) 4.1 ± 0.8 ≥ 5.0	Biochemical Oxygen Demand (mg/L) 5.4 ± 1.1 < 4.0
Nitrate (mg/L)	3.6 ± 0.5 < 2.0
Phosphate (mg/L)	1.2 ± 0.3 < 0.5
Turbidity (NTU)	42.7 ± 6.1 < 5.0
Electrical Conductivity (µS/cm)	341 ± 45.2 < 250

Note: Values represent average measurements across three sampling locations. WHO limits based on aquatic ecosystem protection guidelines.

4.6. Discussion

The results of this study demonstrate that *Chrysichthys nigrodigitatus* inhabiting the Andoni River system are heavily burdened by trematode infections, with a prevalence rate of 74%. This high infection rate is consistent with observations from other freshwater systems in sub-Saharan Africa, particularly those experiencing ecological degradation. The presence of encysted metacercariae predominantly in the intestines, gills, and muscle tissues aligns with the established tropism of digenetic trematodes for metabolically active and immunologically susceptible organs. These findings reflect the vulnerability of benthopelagic fish like *C. nigrodigitatus*, whose bottomfeeding behaviour and sediment association increase exposure to infective stages of parasites released by gastropod intermediate hosts.

The histopathological alterations observed in infected tissues substantiate the pathogenicity of the trematodes encountered. In the gills, lesions such as epithelial hyperplasia, lamellar fusion, and inflammatory infiltration likely compromise gas exchange, predisposing fish to hypoxic stress. Intestinal sections displayed mucosal necrosis and goblet cell hyperplasia, impairing nutrient absorption and digestion, while liver tissue showed signs of systemic inflammation. Muscle fibres surrounding encysted parasites were structurally degraded, suggesting chronic tissue injury and reduced motility. These observations are consistent with previous studies documenting the cellular and physiological impacts of helminth infections in freshwater fish (Ahmed *et al.*, 2019; Tavares-Dias & Martins, 2017).

In the present study, the mean condition factor (K) of infected *Chrysichthys nigrodigitatus* was significantly lower than that of uninfected individuals, with values of 0.79 ± 0.04 and 0.92 ± 0.03, respectively ($t = 5.21$, $df = 98$, $p < 0.001$). This finding indicates that parasitic infections adversely affect the physiological condition of the fish. Furthermore, a strong negative correlation was observed between parasite intensity and condition factor ($r = -0.62$, $p < 0.01$), suggesting that heavier parasite burdens lead to reduced overall health and compromised growth performance.

These results are consistent with observations reported by Abba *et al.* (2020), who found that although there was generally a strong positive correlation between fish length and weight ($r > 0.8$), the condition factor in infected fish was often lower than in uninfected fish, reflecting the physiological stress imposed by parasitic infections. However, similar to their study, slight exceptions can occur in specific populations; for example, in Oreochromis niloticus from Jibia Reservoir, infected individuals exhibited a slightly higher K factor than uninfected fish. Such deviations may reflect species-specific responses, environmental conditions, or compensatory mechanisms in growth and energy allocation.

The results indicate that trematode infections significantly compromise the physiological condition of *Chrysichthys nigrodigitatus*, as evidenced by the lower condition factor in infected individuals compared to uninfected fish. This reduction in condition reflects diminished growth, energy reserves, and overall health, which can negatively affect the population's reproductive success and survival. Beyond the individual level, these findings highlight broader ecological consequences, signaling environmental stress and degraded water quality in the Andoni River, while also pointing to potential public health risks for communities that rely on these fish as a food source.

These methods may be insufficient to eliminate viable metacercariae, thereby creating a route for human infection through oral ingestion. Such zoonotic risks, although under-reported in West Africa, have been well documented in Asia and other regions where freshwater fish are consumed semi-cooked (Pozio & Morales, 2005; Audicana *et al.*, 2022).

Beyond their clinical effects on fish hosts, trematode parasites serve as useful bioindicators of ecosystem integrity. Unlike chemical tests, which provide snapshot measurements, parasitological data reflect cumulative exposure to environmental stressors over time. The heavy parasite burdens and associated lesions observed in this study, together with concurrent evidence of water quality decline, reinforce the role of fish-parasite interactions as sentinel tools in aquatic environmental monitoring (Anarado *et al.* 2023). This integrative approach is particularly relevant in complex systems like the Niger Delta, where conventional surveillance may overlook chronic but biologically significant impacts of pollution and habitat disturbance.

Although this study contributes novel insights into parasite–host–environment relationships in the Andoni River, some limitations should be acknowledged. The absence of molecular confirmation restricted parasite identification to the genus level, while the temporal scope did not account for seasonal variations in infection dynamics. Future research should incorporate molecular diagnostics, broader temporal sampling, and assessments of intermediate host populations to provide a more comprehensive understanding of trematode transmission ecology in this region.

5. CONCLUSION

The study demonstrated a high prevalence (74%) of trematode metacercariae in *Chrysichthys nigrodigitatus* from the Andoni

River, with infections primarily affecting the gills, intestines, and muscle tissues. Histopathological examinations revealed significant tissue damage, including lamellar fusion, mucosal necrosis, goblet cell hyperplasia, myofibre degeneration, and fibrotic encapsulation, while the condition factor of infected fish indicated reduced physiological health. Environmental assessments highlighted elevated levels of nitrates, phosphates, BOD_5, and turbidity, all of which were positively correlated with parasite prevalence, underscoring the influence of water quality and environmental stressors on parasitic infections. The consumption of *C. nigrodigitatus* from this river is therefore unsafe.

To address these risks, routine fish health surveillance programs should be established as part of environmental monitoring in the Niger Delta, with specific attention to parasite screening and water quality testing. Public health authorities should issue advisories and promote safe fish-handling practices, while environmental agencies enforce regulations to reduce nutrient pollution and turbidity. These measures will not only safeguard public health but also help maintain ecosystem integrity in the Andoni River.

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