

COMPARATIVE STUDY OF PARASITIC INFECTIONS, WATER QUALITY, AND PATHOLOGICAL EFFECTS IN CULTURED AND WILD FISH POPULATIONS IN JOS METROPOLIS, NIGERIA**Josephine Ene Olofu^{1,2*}, Mohammed Ahmed Ashigar¹ and Victoria Adamu Pam¹**¹Department of Zoology, Federal University of Lafia, Nasarawa State, Nigeria²Department of Parasitology, Federal College of Veterinary and Medical Laboratory Technology, Vom, Plateau State, Nigeria*Corresponding email: olofujossy2017@gmail.com**ABSTRACT**

Fish serve as a vital, affordable source of animal protein in Nigeria, but parasitic infections and environmental degradation threaten the sustainability of aquaculture. This study evaluated parasitic infections, water quality, and organ histopathology in wild (n = 174; catfish and tilapia) and cultured (n = 150; catfish) fish across Jos Metropolis, Plateau State, during the 2025 rainy season (May–October). Physicochemical water parameters generally met standard aquaculture guidelines across all sites. However, cultured environments showed higher nutrient enrichment, featuring elevated turbidity (10.5–12.6 NTU), conductivity (181–190 µS/cm), nitrate (6.2–7.5 mg/L), and phosphate (0.54–0.61 mg/L). Overall prevalence rates for haemoparasites and intestinal parasites were 24.1 % (78/324) and 15.7 % (51/324), respectively. Haemoparasite (*Haemogregarina* spp.) prevalence was significantly higher in wild fish, peaking at 87.5 % in *Oreochromis niloticus* from Kara Dam, compared to 0.0–30.0 % in cultured catfish. In contrast, intestinal parasite rates were similar between wild (15.5 %) and cultured fish (16.0 %), with *Entamoeba* spp. identified as the predominant taxon. Histopathological evaluation demonstrated more severe hepatic and renal lesions—primarily congestion and focal necrosis—in wild fish, aligning with their elevated haemoparasite burden. Cultured fish displayed milder pathological alterations despite facing higher nutrient loads, while gastric tissues showed no significant damage across groups. Overall, these findings demonstrate that wild fish face greater parasite-induced pathology, whereas cultured systems show elevated nutrient levels. Implementing routine parasitological monitoring, proactive aquaculture management, and improved environmental sanitation is essential to safeguard fish health, ensure food security, and protect public safety in the region.

Keywords: Parasitic infections, Histopathology, Aquaculture, Wild fish, *Haemogregarina* spp., Intestinal parasites**INTRODUCTION**

Fish constitute a vital source of high-quality protein, essential fatty acids, vitamins, and minerals, playing a critical role in global food security and nutrition. According to the Food and Agriculture Organization, aquatic foods provide nearly 20 % of animal protein intake for billions of people worldwide and remain essential for livelihoods and economic development, particularly in developing countries (Food and Agriculture Organization [FAO], 2024). However, the sustainability and productivity of fisheries and aquaculture systems are increasingly threatened by parasitic infections, environmental degradation, and declining water quality. Fish parasites, including protozoans, helminths, and haemoparasites, are among the most significant biological constraints affecting aquaculture production and fish health. These parasites can reduce growth performance, impair reproduction, increase mortality, and cause substantial economic losses in fish farming operations (Buchmann, 2022; Alsulami *et al.*, 2025). Haemoparasites such as *Haemogregarina* spp. infect blood cells and may compromise physiological functions, while intestinal parasites interfere with nutrient absorption and increase

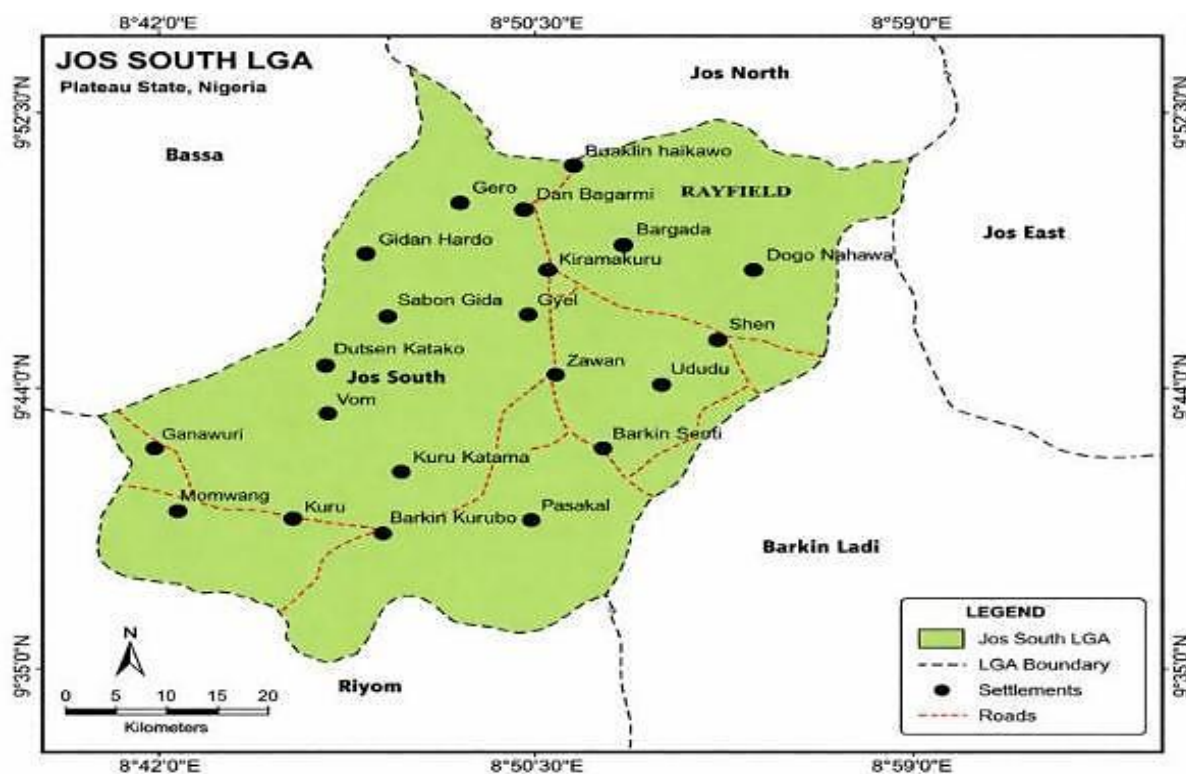
susceptibility to secondary infections. The occurrence and severity of parasitic infections are strongly influenced by environmental conditions and host–parasite interactions. Water quality parameters such as temperature, dissolved oxygen, pH, and nutrient concentrations play critical roles in fish health and disease dynamics. Poor water quality can weaken fish immunity and enhance parasite transmission, particularly in intensive aquaculture systems characterized by high stocking densities and organic waste accumulation (Buchmann, 2022). Histopathological assessment further provides valuable information on the impact of parasitic infections by revealing tissue alterations associated with physiological stress and organ dysfunction. Despite the growing importance of aquaculture in Nigeria, integrated studies examining parasitic infections, water quality, and pathological effects in cultured and wild fish populations remain limited. Therefore, this study comparatively evaluated these parameters in fish populations from Jos Metropolis, Plateau State, Nigeria, to provide baseline information for sustainable aquaculture management and fish health protection.

MATERIALS AND METHODS

Study Area

The study was conducted in Jos Metropolis, Plateau State, North-Central Nigeria, located between latitudes 9°52'–10°00'N and longitudes 8°50'–9°00'E, at an average elevation of 1,200–1,400 m above sea level (Fig. 1). The area experiences a tropical highland climate with distinct wet (April–October) and dry (November–

March) seasons, and mean annual rainfall of approximately 1,200–1,500 mm (Nigerian Meteorological Agency [NIMET], 2021). Sampling sites comprised five natural water bodies (Kara, Lamingo, Dorowa, NIPSS, and Dadin-Kowa dams) and five aquaculture facilities (NVRI, Bukuru, Old Bukuru Park, Terminus, and Doctor Fish farms).



Source: Google Earth/OpenStreetMap/QGIS (2026)

Figure 1: Map of Jos South LGA, Plateau State, Nigeria

Study Design and Sample Size

A cross-sectional comparative study design was employed. Sample size was determined using the standard epidemiological formula: $n = Z^2P(1 - P)/d^2$, where $Z = 1.96$ at 95 % confidence level, P = estimated prevalence, and $d = 0.05$ precision (Thrusfield, 2018). A total of 324 fish were examined, comprising 174 wild fish (93 *Clarias gariepinus* and 81 *Oreochromis niloticus*) and 150 cultured *C. gariepinus*.

Water Sampling and Physicochemical Analysis

Water samples were collected from each site at a depth of approximately 20 cm using pre-cleaned polyethylene containers. Temperature, pH, and dissolved oxygen were measured in situ using calibrated portable meters, while other parameters including biological oxygen demand (BOD), electrical conductivity, total dissolved solids (TDS), turbidity, nitrate, phosphate, and alkalinity were analyzed in the Chemistry laboratory of Federal College of Animal Health and Production Technology, Vom following standard procedures (American Public Health Association [APHA], 2017; World Health Organization [WHO], 2022).

Fish Collection and Handling

Fish samples were collected between May and October 2025 (the early and peak rainy seasons). Wild fish were captured using gill nets, cast nets, and hook-and-line methods, while cultured fish were collected using seine and scoop nets. Samples were transported in aerated containers to the Parasitology Laboratory of the Federal College of Veterinary and Medical Laboratory Technology, Vom, and processed promptly following standard procedures (Roberts, 2012).

Parasitological Examination

Fish blood samples were obtained from the gills and used to prepare thin and thick smears, which were fixed, stained with Giemsa, and examined microscopically for haemoparasites following standard protocols (WHO, 2020). Intestinal contents were collected post-mortem following humane euthanasia of fish by overdose of MS-222. The intestine was aseptically removed and its contents processed using the formalin–ether concentration technique for parasitological examination (Cheesbrough, 2021). Parasites were identified based on morphological characteristics using established taxonomic keys (Garcia, 2016).

Histopathological Analysis

Liver, kidney, and stomach tissues were harvested and fixed in 10% neutral buffered formalin. Samples were processed through graded alcohols, embedded in paraffin, sectioned at 4–5 μm , and stained with hematoxylin and eosin (H&E). Histological sections were examined under a light microscope for pathological alterations, including congestion, necrosis, and cellular degeneration (Bancroft & Gamble, 2019).

Statistical Analysis

Descriptive statistics were used to summarize physicochemical parameters and parasite prevalence. Prevalence was calculated as:

$$\text{Prevalence (\%)} = \frac{\text{number of infected fish}}{\text{total number of fish examined}} \times 100\%$$

Data obtained were analyzed using R Console Software (version 4.5.1 (2025-06-13 ucrt)). Comparison of prevalence between wild and cultured fish was performed using Chi-square (χ^2) test. Statistical significance was set at $P < 0.05$.

RESULTS AND DISCUSSION

Physicochemical Properties of Water

The physicochemical characteristics of water from the sampled wild and cultured systems revealed that all measured parameters were generally within recommended limits for freshwater aquaculture (Table 1). Water temperature ranged from 20.3 to 23.0 $^{\circ}\text{C}$, pH (6.4–7.2), dissolved oxygen (5.7–7.3 mg/L), and biological oxygen demand (2.7–5.3 mg/L) collectively confirmed that the conditions in the studied environments were conducive, favourable and capable of sustaining fish physiological function and growth. However, cultured systems exhibited relatively higher turbidity (10.5–12.6 NTU), conductivity (181–190 $\mu\text{S}/\text{cm}$), nitrate (6.2–7.5 mg/L), and phosphate (0.54–0.61 mg/L) concentrations, particularly at Terminus and Doctor Fish farms, compared with most wild water bodies. The elevated nutrient concentrations observed in cultured environments are likely attributable to feed residues, fish excreta, and the accumulation of organic matter associated with intensive aquaculture practices. Similar observations were reported by Buchmann (2022), who noted that intensive fish production systems often experience increased nutrient loading resulting from feeding activities and waste accumulation.

Likewise, recent studies by Abdel-Tawwab and colleagues reported that nutrient enrichment remains a major challenge in freshwater aquaculture systems, particularly where water exchange is limited.

The relatively low dissolved oxygen values observed in some cultured facilities, although still within acceptable limits, may be linked to increased microbial decomposition of accumulated organic matter. Similar relationships between nutrient enrichment, microbial activity, and oxygen consumption have been documented in freshwater aquaculture systems across Africa and Asia (FAO, 2024). Furthermore, elevated turbidity values above the recommended WHO guideline (<5 NTU) in several cultured sites may reduce light penetration, affect primary productivity, and increase physiological stress in fish. In contrast, most wild water bodies exhibited lower conductivity, nitrate, and phosphate concentrations, likely due to greater water circulation, dilution effects, and natural ecological regulation. Nevertheless, Dorowa and Dadin-Kowa dams recorded comparatively higher turbidity and nutrient levels than other wild sites, suggesting localized anthropogenic influences such as agricultural runoff, livestock activities, or sediment resuspension during the rainy season.

The sampling period (May–October, 2025), which coincided with the early and peak rainy seasons, may also have contributed to the observed nutrient patterns. Increased rainfall and surface runoff during this period can transport sediments, fertilizers, and organic matter into aquatic ecosystems, resulting in elevated nutrient concentrations and turbidity. Similar seasonal increases in nutrient loading have been reported in tropical freshwater ecosystems where rainfall significantly influences water chemistry and biological productivity (WorldFish, 2023; FAO, 2024). The significance of these findings lies in their implications for fish health and disease dynamics. Water quality directly influences fish immune competence and susceptibility to pathogens. Although the measured parameters were generally suitable for fish production, continued nutrient accumulation in cultured systems may increase the risk of eutrophication, oxygen depletion, disease outbreaks, and reduced productivity if not properly managed. Therefore, regular monitoring of water quality, optimization of feeding regimes, and improved waste management practices are essential to ensure sustainable aquaculture production and maintain fish health in the study area.

Table 1: Physicochemical properties of water from wild and cultured sampling locations

Parameter	Locations										WHO Standard
	Kara	Lamingo	Dorowa	NIPSS	Dadin-Kowa	NVRI	Bukuru	Old Bukuru	Terminus	Doctor Fish	
Temp ($^{\circ}\text{C}$)	21.4	22.1	21.0	20.6	22.8	20.3	21.6	22.2	23.0	22.5	25–30
Ph	6.7	6.9	6.4	7.1	6.8	7.2	6.8	6.6	6.9	6.7	6.5–8.5
DO (mg/L)	6.4	6.1	5.7	7.3	6.0	7.1	6.4	6.0	5.8	6.2	≥ 5
BOD (mg/L)	3.6	4.2	5.1	2.9	4.8	2.7	4.3	4.9	5.3	4.6	<6
Conductivity ($\mu\text{S}/\text{cm}$)	120	138	167	102	185	96	145	172	181	190	<500
Turbidity (NTU)	4.7	5.9	9.3	3.4	10.6	3.1	6.8	9.1	10.5	12.6	<5
TDS (mg/L)	71	85	92	60	110	55	88	95	108	120	<1000
Nitrate (mg/L)	3.8	4.7	6.1	2.2	5.4	1.8	3.9	5.8	6.2	7.5	<10
Phosphate (mg/L)	0.26	0.35	0.51	0.18	0.49	0.21	0.33	0.48	0.54	0.61	<1
Alkalinity (mg/L)	32	36	41	29	44	28	34	39	41	46	<120

Prevalence of Haemoparasites

The prevalence of haemoparasites (*Haemogregarina* spp.) across sampling locations is shown in Table 2. Overall parasite prevalence in the sampled fish populations was 24.1 % (78/324). Prevalence varied significantly between the two fish production systems ($\chi^2 = 21.06$, $df = 1$, $P < 0.001$), with higher infectivity in wild fish (34.5 %, $n = 60$) compared to cultured fish (12.0 %, $n = 18$). The highest occurrence was observed in tilapia from Kara Dam. The haemoparasites (*Haemogregarina* spp.) recovered from fish blood are shown in Plate 1a-c. Within the study, wild tilapia showed the highest infection rates, while some cultured sites recorded no infection, reflecting differences in host-parasite interactions between open and controlled systems. This finding agrees with Ayanda (2009) and Ekanem *et al.* (2011) who reported higher parasite prevalence and diversity in wild fish due to the presence of intermediate hosts and complex food webs. Internationally, studies such as those by Sasal *et al.* (1999) and Marcogliese (2004) have similarly demonstrated that parasite richness is typically greater in natural ecosystems than in managed aquaculture systems. However, contrasting reports exist; for instance, Pavanelli *et al.* (2006) observed high parasite loads in cultured fish under poor management conditions, suggesting that aquaculture systems can also become hotspots for infection when biosecurity is inadequate. The relevance of this finding lies in its epidemiological significance. Wild fish may act as reservoirs of haemoparasites, which may be introduced into aquaculture systems through water sources or stocking practices. The implication is that strict biosecurity measures, including water filtration and quarantine of stocked fish, are essential to prevent parasite transmission.

Table 2: Prevalence of haemoparasites in wild and cultured fish

System	Location	Species	No. Examined	No. Positive	Prevalence (%)
Wild	Kara Dam	Catfish	20	10	50.0
		Tilapia	16	14	87.5
	Lamingo Dam	Catfish	20	7	35.0
		Tilapia	18	12	66.7
	Dorowa Dam	Catfish	16	2	12.5
		Tilapia	17	0	0.0
	NIPSS Dam	Catfish	19	0	0.0
		Tilapia	14	0	0.0
	Dadin-Kowa	Catfish	18	6	33.3
		Tilapia	16	9	56.3
Subtotal			174	60	34.5
Cultured	NVRI	Catfish	30	0	0.0
	Bukuru	Catfish	30	3	10.0
	Old Bukuru	Catfish	30	2	6.7
	Park				
	Terminus	Catfish	30	4	13.3
	Doctor Fish	Catfish	30	9	30.0
Subtotal			150	18	12
Total			324	78	24.1

Comparison of prevalence between systems: $\chi^2 = 21.06$, $df = 1$, $p = 0.001$

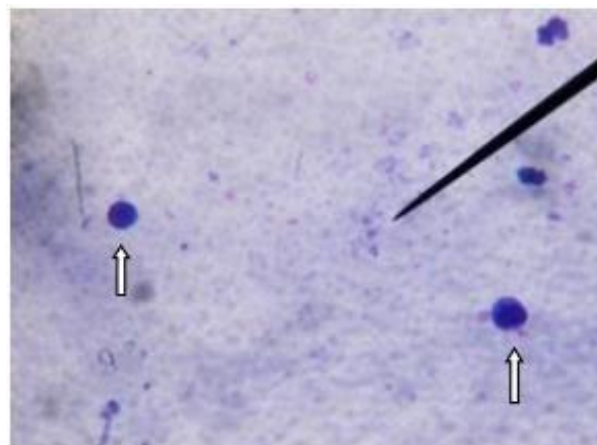


Plate 1a: *Haemogregarina* spp. in blood film of cultured *Clarias gariepinus*. White arrows indicate Haemoparasites. Giemsa stain, magnification 1000x (oil immersion)

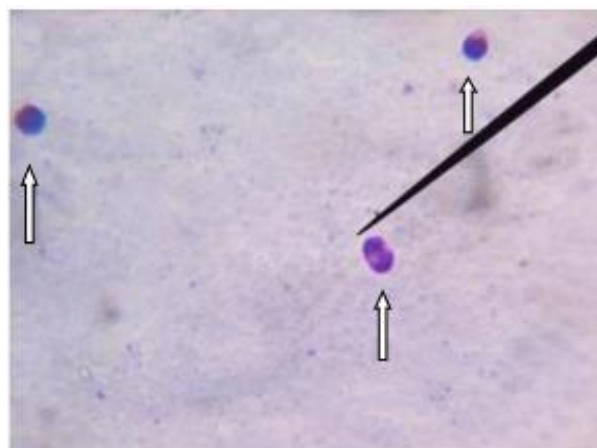


Plate 1b: *Haemogregarina* spp. in blood film of Wild *Clarias gariepinus*. White arrows indicate Haemoparasites. Giemsa stain, magnification 1000x (oil immersion)

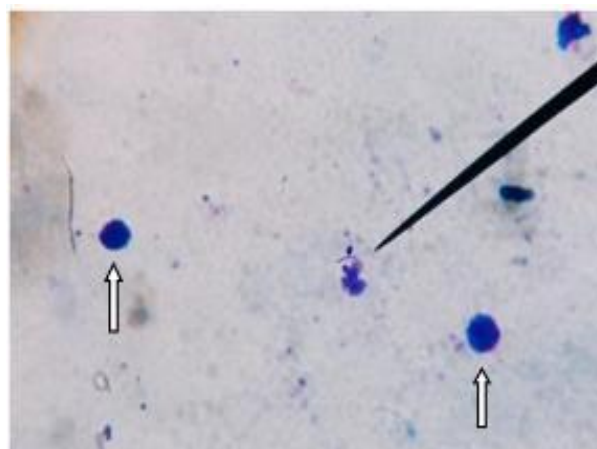


Plate 1c: *Haemogregarina* spp. in blood film of Wild *Oreochromis niloticus*. White Arrows indicate haemoparasites. Giemsa stain, magnification 1000x (oil immersion)

Prevalence of Intestinal Parasites

The distribution and frequency of intestinal parasites are summarized in Table 3. Plate 2 shows the intestinal parasites recovered from the fish examined. Overall prevalence was 15.7 %, with no statistically significant difference ($\chi^2 = 0.008$, $df = 1$, $P = 0.929$) observed between wild (15.5 %) and cultured (16.0 %) fish populations. *Entamoeba histolytica* was the most frequently detected parasite, followed by hookworm, while other parasite taxa occurred at relatively low frequencies. The comparable prevalence of intestinal parasites in wild and cultured fish suggests that both aquatic systems may be exposed to similar environmental contaminants. This finding indicates that aquaculture management practices alone may not completely eliminate the risk of intestinal parasite transmission when water sources are shared with surrounding environments or influenced by anthropogenic activities. Recent studies have shown that environmental contamination, water quality deterioration, and inadequate sanitation remain major drivers of parasitic infections in freshwater ecosystems, irrespective of production system (Buchmann, 2022; Alsulami *et al.*, 2025).

The predominance of *E. histolytica* and hookworm in this study may reflect contamination from human and animal wastes entering aquatic environments through runoff, sewage discharge, or poor sanitation practices. Similar observations have been reported in tropical aquatic ecosystems where enteric parasites were detected in fish inhabiting waters exposed to domestic and agricultural activities (Aunamika *et al.*, 2022; Banyigyi *et al.*, 2023). The occurrence of these organisms in both wild and cultured fish supports the hypothesis that contamination sources are widespread within the study area rather than being restricted to a particular production system. Unlike several recent studies that reported higher intestinal parasite burdens in wild fish due to greater

exposure to natural intermediate hosts and broader feeding niches, the present study did not demonstrate substantial differences between wild and cultured populations. For instance, Buchmann (2022) noted that wild fish generally experience greater parasite exposure because of complex ecological interactions and unrestricted contact with parasite reservoirs. Similarly, recent reviews by Alsulami *et al.* (2025) highlighted that wild fish populations frequently exhibit greater parasite diversity and infection intensity than cultured fish, largely because aquaculture systems benefit from controlled feeding and management practices.

The comparable prevalence observed in this research may therefore reflect shared environmental contamination sources affecting both production systems. This observation may be attributed to the increasing interaction between aquaculture facilities and surrounding environments, particularly where ponds are supplied by natural water sources or are located near human settlements. Recent investigations have similarly reported that environmental contamination can result in comparable parasite burdens in both cultured and wild fish populations when adequate biosecurity and water treatment measures are lacking (Buchmann, 2022; FAO, 2024). From a public health perspective, the detection of enteric parasites is noteworthy because it may indicate fecal contamination of aquatic environments. Such contamination has implications for fish quality, food safety, and consumer health, especially where fish are improperly handled or inadequately cooked before consumption. Consequently, improved sanitation infrastructure, effective wastewater management, routine monitoring of water quality, and adherence to hygienic fish handling practices are essential for reducing contamination risks and safeguarding public health.

Table 3: Distribution of intestinal parasites in wild and cultured fish

Parasite	Wild (n=174)	Cultured (n=150)	Total (n=324)	Prevalence (%)
<i>E. histolytica</i>	16	9	25	7.7
<i>E. coli</i>	0	5	5	1.5
<i>T. trichiura</i>	4	0	4	1.2
<i>Taenia</i> spp.	1	0	1	0.3
<i>I. bütschlii</i>	2	0	2	0.6
<i>Strongyloides</i> spp.	2	0	2	0.6
Hookworm	3	9	12	3.7
Total No. Infected (%)	27(15.5)	24(16.0)	51	15.7

Comparison of prevalence between systems: $\chi^2 = 0.008$, $df = 1$, $P = 0.929$

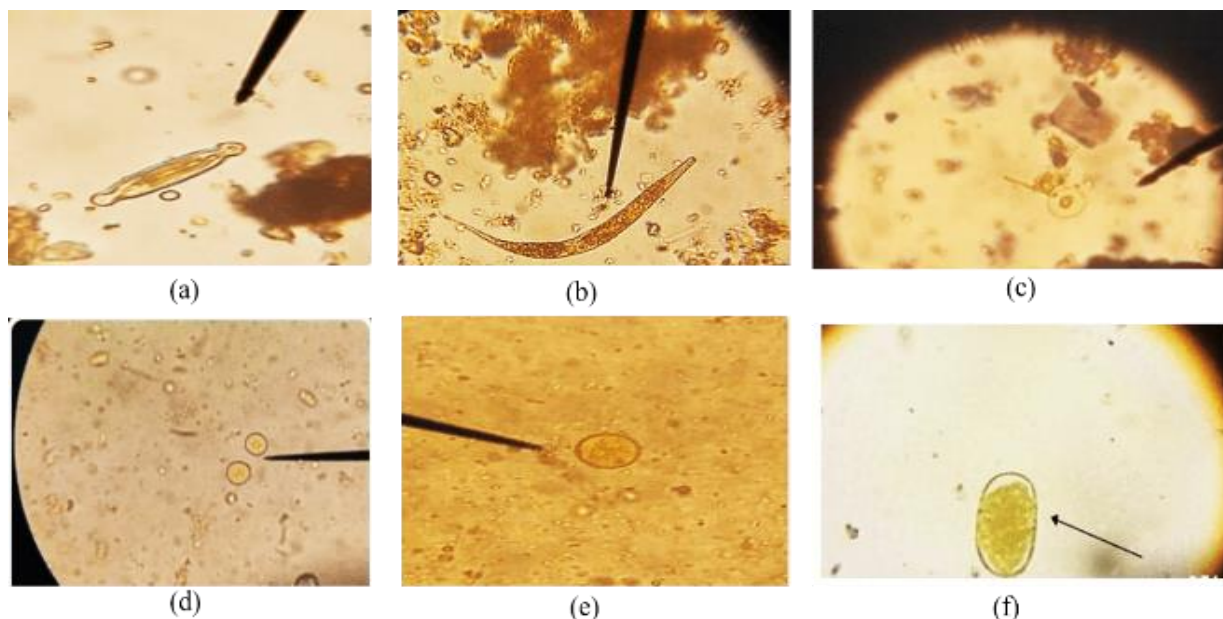
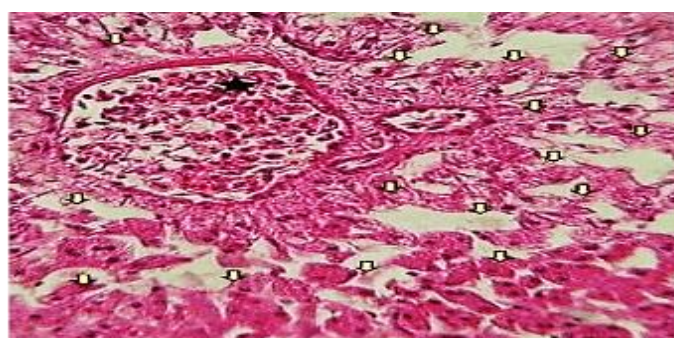
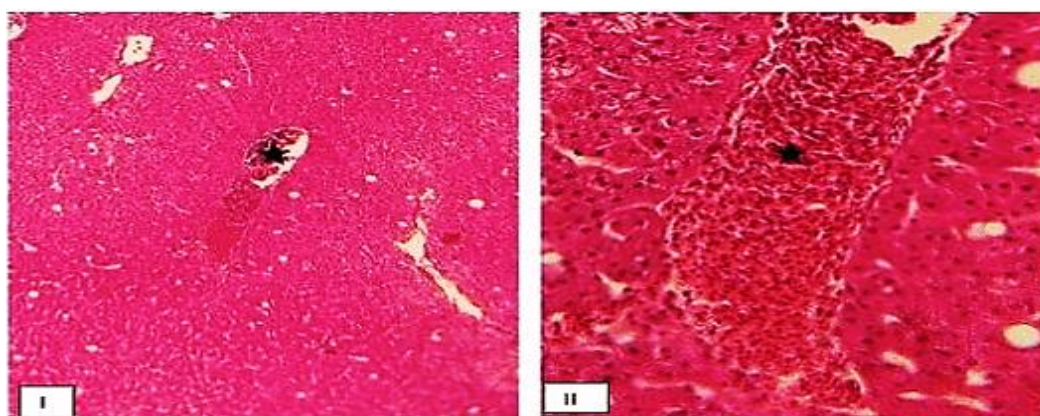


Plate 2: Photomicrographs of intestinal parasites recovered from fish samples collected from wild and cultured aquatic systems in Jos Metropolis

(a) Ova of *Trichuris trichiura* recovered from the intestine of wild *Clarias gariepinus*; (b) Larva of *Strongyloides stercoralis* recovered from intestinal contents of wild *Clarias gariepinus*; (c) Cyst of *Iodamoeba bütschlii*; of wild *Clarias gariepinus*; (d) Cyst of *Entamoeba coli* of wild both wild *Clarias gariepinus* and *Oreochromis niloticus*; (e) Cyst of *Entamoeba histolytica* both wild *Clarias gariepinus* and *Oreochromis niloticus*; and (f) Hookworm egg recovered from intestinal contents both wild *Clarias gariepinus* and cultured *Oreochromis niloticus*. (Photomicrographs were obtained under 10x and 40x objective lenses)



(a)



(b)

Plate 3: Histopathological alterations in the liver of sampled fish

(a) Liver section of wild *Clarias gariepinus* showing severe congestion of the hepatic/central vein (black star) and hepatocellular necrosis (yellow arrows); (b) liver section of cultured *Clarias gariepinus* (I) and wild *Oreochromis niloticus* (II) showing severe congestion of the hepatic/central vein (black star). Sections were stained with hematoxylin and eosin (H&E) and examined at 400x magnification

Histopathological examination of infected organs from fish samples

Histopathological examination was carried out on multiple organs including the liver, kidney and stomach of wild and cultured fish samples. Lesions were variable among tissues and individuals, with the liver, and kidney showing the most pronounced alterations, while the gastrointestinal tract exhibited predominantly normal architecture.

a. Liver Histopathology: Liver sections from wild *Clarias gariepinus* showed severe congestion of the hepatic and central veins accompanied by hepatocellular necrosis (Plate 3a), whereas liver sections from cultured *Oreochromis niloticus* exhibited marked vascular congestion without obvious hepatocellular degeneration (Plate 3b). The occurrence of severe venous congestion suggests circulatory disturbances and impaired blood flow within hepatic tissues. The hepatocellular necrosis observed in wild *C. gariepinus* indicates irreversible cellular injury, likely resulting from prolonged physiological stress associated with parasitic infection and tissue hypoxia. The more severe hepatic lesions observed in wild fish may be related to their higher exposure to environmental stressors and parasite vectors within natural aquatic ecosystems. Similar findings have been reported in parasitized freshwater fish, where hepatic congestion, degeneration, and necrosis were associated with inflammatory responses, toxic metabolites, and impaired tissue perfusion (Buchmann, 2022). According to the Food and Agriculture Organization (FAO, 2024), chronic parasitic infections can induce systemic stress responses that compromise liver function, resulting in reduced metabolic efficiency and increased susceptibility to secondary infections. The

presence of hepatocellular necrosis in wild *C. gariepinus* therefore suggests a greater pathological burden compared with cultured fish.

b. Kidney Histopathology: Kidney tissues exhibited the most extensive pathological alterations among the organs examined. Cultured *Oreochromis niloticus* displayed necrosis of hematopoietic tissues (Plate 4a), while both wild *Clarias gariepinus* and *Oreochromis niloticus* showed similar necrotic changes within hematopoietic regions (Plate 4b). Furthermore, kidney sections from cultured *Clarias gariepinus* and wild *Oreochromis niloticus* exhibited combined lesions of hematopoietic tissue necrosis and vascular congestion (Plate 4c). These findings indicate that pathological effects were not restricted to a particular fish species or production system. The kidney of teleost fish serves as a major hematopoietic and immune organ in addition to its excretory functions. Consequently, necrosis of hematopoietic tissues may impair blood cell production, immune responses, and osmoregulatory functions. Vascular congestion further suggests circulatory impairment associated with systemic infection and inflammatory processes. The widespread occurrence of renal lesions across both wild and cultured fish supports the view that parasitic infections can induce systemic pathological effects regardless of production system. Similar renal alterations, including hematopoietic tissue degeneration, vascular congestion, and nephrotic changes, have been documented in fish subjected to chronic parasitic infections and environmental stress (Buchmann, 2022; FAO, 2024). Such lesions are often associated with reduced disease resistance and compromised physiological performance.

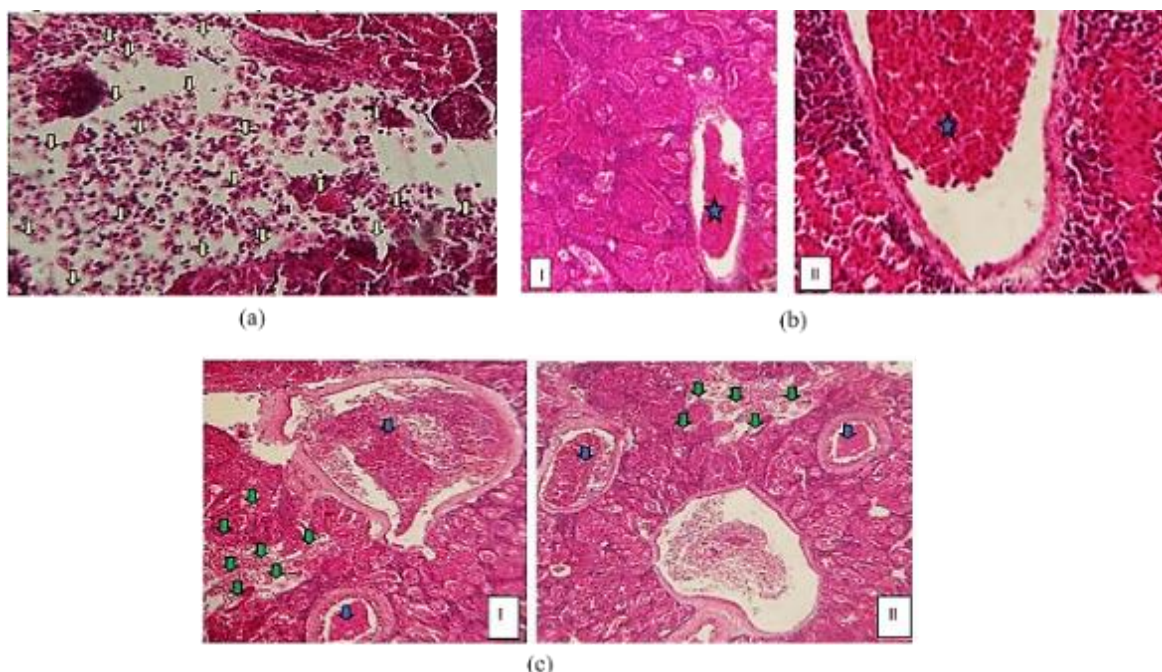


Plate 4: Histopathological alterations in the kidney of sampled fish

(a) Kidney section of cultured *Oreochromis niloticus* showing necrosis of hematopoietic tissues (yellow arrows); (b) kidney section of wild *Clarias gariepinus* (I) and *Oreochromis niloticus* (II) showing necrosis of hematopoietic tissues (blue star); (c) kidney section of cultured *Clarias gariepinus* (I) and wild *Oreochromis niloticus* (II) showing necrosis of hematopoietic tissues (green arrows) and vascular congestion (blue arrows). Sections were stained with hematoxylin and eosin (H&E) and examined at 400x magnification

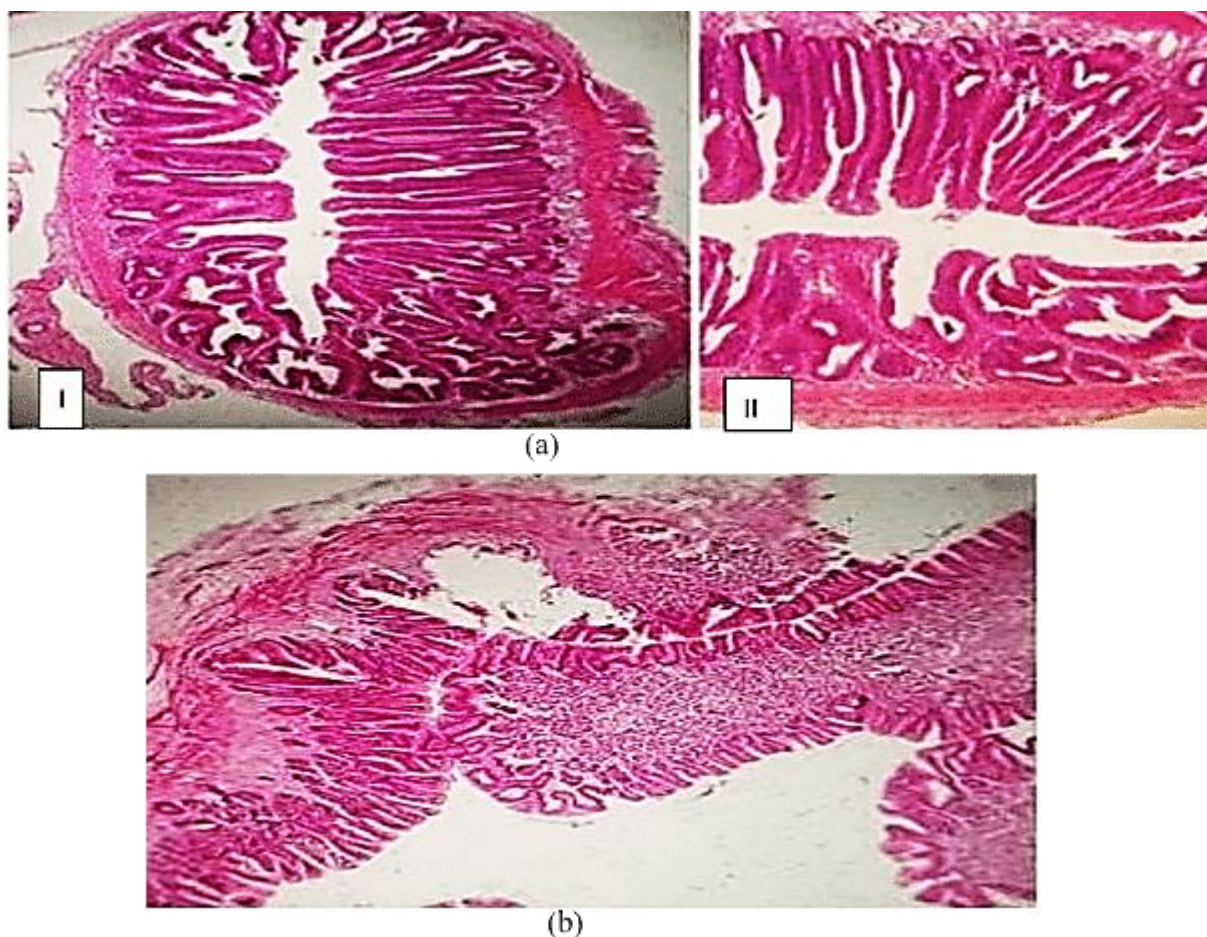


Plate 5: Histological features of the stomach of sampled fish

(a) Stomach section of wild *Clarias gariepinus* (I) and *Oreochromis niloticus* (II) showing intact mucosal layers and normal gastric architecture without observable pathological alterations; (b) stomach section of cultured *Oreochromis niloticus* showing normal mucosal architecture and absence of histopathological lesions. Sections were stained with hematoxylin and eosin (H&E) and examined at 400x magnification

c. Stomach Histopathology: In contrast to the liver and kidney, stomach tissues from both wild and cultured fish exhibited normal histological architecture. Sections obtained from wild *Clarias gariepinus* and *Oreochromis niloticus* showed intact mucosal layers and normal gastric epithelial organization without observable lesions (Plate 5a). Similarly, stomach sections from cultured *Oreochromis niloticus* maintained normal mucosal architecture with no evidence of degeneration, inflammation, or tissue disruption (Plate 5b). The absence of pathological changes in stomach tissues suggests that the parasites detected in the present study did not directly affect gastric structures. Rather, the pathological effects appeared to be concentrated in highly vascularized and physiologically active organs such as the liver and kidney. Similar observations have been reported in fish pathology studies where parasitic infections produced systemic lesions in visceral organs while leaving gastric tissues largely unaffected (Buchmann, 2022). The preservation of gastric architecture further indicates that digestive functions were unlikely to have been significantly compromised by the infections observed in this study.

Collectively, the histopathological findings in this work demonstrated that parasitic infections were associated with systemic tissue damage, particularly in the liver and kidney. Wild fish, especially *Clarias gariepinus*, exhibited more severe hepatic lesions characterized by vascular congestion and hepatocellular necrosis, whereas renal lesions occurred in both wild and cultured fish. The absence of significant stomach pathology suggests organ-specific effects of infection, with the liver and kidney being the primary targets of pathological injury. These findings provide histological evidence that parasitic infections can adversely affect fish health by compromising circulatory, metabolic, hematopoietic, and immune functions.

CONCLUSION

This study demonstrated that parasitic infections, water quality, and histopathological alterations are important factors influencing the health of cultured and wild fish populations in Jos Metropolis, Plateau State, Nigeria. Wild fish exhibited significantly higher haemoparasite prevalence, particularly *Haemogregarina* spp., indicating greater exposure to natural transmission pathways and intermediate hosts within aquatic

ecosystems. In contrast, cultured fish recorded lower haemoparasite prevalence but showed relatively elevated turbidity, conductivity, nitrate, and phosphate concentrations, reflecting nutrient enrichment associated with aquaculture activities.

The similar prevalence of intestinal parasites in wild and cultured fish suggests that both systems may be exposed to common environmental contamination sources. The detection of enteric parasites, including *Entamoeba histolytica* and hookworm, further indicates possible fecal contamination of aquatic environments and highlights potential public health concerns. Histopathological examination revealed pathological alterations in the liver and kidney, including vascular congestion and tissue necrosis, demonstrating that parasitic infections can adversely affect vital physiological functions even in the absence of obvious external clinical signs. Stomach tissues, however, maintained normal histological architecture, suggesting limited pathological involvement of the gastric region. The findings provide evidence that fish health in the study area is influenced by the combined effects of parasite occurrence and environmental conditions. The study also establishes baseline information on parasite prevalence, water quality characteristics, and associated tissue alterations in cultured and wild fish populations. These data contribute to the understanding of host–parasite–environment interactions and provide a scientific basis for improving fish health management, aquaculture sustainability, and fisheries conservation in Nigeria.

Conflict of interest: The authors declare no conflict of interest.

REFERENCES

- Alsulami, M., Baowidan, S., Aljarari, R., Albohri, H., Manasar, M. M., Elkhawass, E. A., Abdel-Latif, H. M. R. and Farag, M. R. (2025). An overview on common parasitic infections affecting the health and sustainability of fish farming with special reference to tilapia culture. *Annals of Animal Science*. Advance Online Publication. <https://doi.org/10.2478/aoas-2025-0104>
- American Public Health Association (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). APHA.
- Aunamika, S. J., Roy, B. C., Islam, Z., Ahmed, N., Rahman, M. K., Biswas, H., Hasan, M. M. and Taluker, M. H. (2022). Prevalence of fish-borne zoonotic parasites and their molecular identification in Bhola district of Bangladesh. *Bangladesh Journal of Fisheries*, 33(2), 283–294. <https://doi.org/10.52168/bjf.2021.33.31>
- Ayanda, O. I. (2009). Comparative parasitic helminth infections of fish in Ilorin, Nigeria. *Journal of Fisheries and Aquatic Science*, 4(5), 250–256. <https://doi.org/10.3923/jfas.2009.250.256>
- Bancroft, J. D. and Gamble, M. (2019). *Theory and Practice of Histological Techniques* (8th ed.). Elsevier.
- Banyigyi, A. H., Ameh, S. M. and Isah, M. H. (2023). Incidence of gastrointestinal parasites of catfish (*Clarias gariepinus*) from River Nasarawa, Nigeria. *FUDMA Journal of Sciences*, 7(4), 90–94. <https://doi.org/10.33003/fjs-2023-0704-1893>
- Bhatnagar, A. and Devi, P. (2013). Water quality guidelines for the management of pond fish culture. *International Journal of Environmental Sciences*, 3(6), 1980–2009.
- Boyd, C. E. (2015). *Water Quality: An Introduction*. Springer.
- Buchmann, K. (2022). Control of parasitic diseases in aquaculture. *Pathogens*, 11(4), 431. <https://doi.org/10.3390/pathogens11040431>
- Cheesbrough, M. (2021). *District Laboratory Practice in Tropical Countries* (Part 1, 3rd ed.). Cambridge University Press.
- Ekanem, A. P., Eyo, V. O. and Sampson, A. F. (2011). Parasites of fish in Cross River, Nigeria. *International Journal of Fisheries and Aquaculture*, 3(1), 25–31.
- Food and Agriculture Organization (2024). *The State of World Fisheries and Aquaculture 2024: Blue Transformation in Action*. FAO. <https://doi.org/10.4060/cd0683en>
- Garcia, L. S. (2016). *Diagnostic Medical Parasitology* (6th ed.). ASM Press.
- Marcogliese, D. J. (2004). Parasites: Small players with crucial roles in the ecological theatre. *EcoHealth*, 1(2), 151–164. <https://doi.org/10.1007/s10393-004-0028-0>
- Nigerian Meteorological Agency. (2021). *Climate data for Plateau State, Nigeria*. NIMET.
- Pavanelli, G. C., Eiras, J. C. and Takemoto, R. M. (2006). *Diseases of fish in Aquaculture*. EDUEM Publishing.
- Roberts, R. J. (2012). *Fish Pathology* (4th ed.). Wiley-Blackwell.
- Sasal, P., Trouvé, S., Müller-Graf, C. D. M. and Morand, S. (1999). Specificity and parasite diversity in fish. *Parasitology*, 119(3), 335–342.
- Thrusfield, M. (2018). *Veterinary Epidemiology* (4th ed.). Wiley-Blackwell.
- WorldFish (2023). *WorldFish Annual Report 2023: Aquatic Food Systems for Sustainable Development*. WorldFish Center.
- World Health Organization (2020). *Basic Malaria Microscopy*. World Health Organization.
- World Health Organization (2022). *Guidelines for Drinking-water Quality* (4th ed.). World Health Organization.