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ORIGINAL RESEARCH ARTICLE

# Prevalence and Parasitological Examination of Fish Parasites in *Clarias gariefinus* from Selected Fish Farms in Sokoto Metropolis, Nigeria

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## ABSTRACT
Fish are known to be affected by parasites both internally and externally with detrimental effects on fish growth and development. This study aimed to determine the prevalence of fish parasites in selected fish farms in the Sokoto metropolis. A total of one hundred and twenty fish samples were collected from ten selected fish farms and subjected to microscopic examination. Water samples were collected from ten fish farms and analysed using the standard procedures recommended by the American Public Health Association. The results indicate that 35.0% of the fish were infected with the parasite (P<0.0300). Significant high prevalence of 50.0% and 48.1% was recorded in the gender and age groups of the fishes (P<0.0308) and (P=0.0003), respectively. However, a significantly high prevalence of 47.6%, 49.1% and 31.7% was also observed in the length, weight, and body part of the fishes (P<0.0.0000). This study identified two nematode species (*Camallanus spp.* and *Capellaria spp.*) with *Camallanus spp.* showing a higher prevalence of 60.3% was obtained in *Camellanus spp.* among the parasite species identified. The parameters such as pH, dissolved oxygen (DO) and nitrate (NO3) were assessed, and results were analysed using one-way analysis of variance (ANOVA) with the aid of SPSS version 27.0. The values of the physicochemical parameters were between the range of 6.68+0.11 to 7.83±0.05 for pH, 5.23+0.03 to 8.17±0.88 mg/L for DO, and 13.70+1.37 to 100.33+0.33 for $NO_3$ respectively. All parameters examined were within acceptable limits recommended by the World Health Organization. Maintaining an optimum feeding strategy, regular monitoring of the water quality parameters and vaccinations will help to further decrease the rate of the parasite.

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Prevalence of Parasite, Physicochemical Parameters, Fish farm and Sokoto



## INTRODUCTION
Fish serves as a vital protein source globally, constituting approximately 25% of animal protein intake for people. Fish farming, the cultivation of fish for various purposes, has evolved into an indispensable industry, addressing the rising global demand for seafood (Soliman *et al.*, 2022). Among aquaculture practices, fish farming stands out as a prominent method to ensure a steady and sustainable fish supply for human consumption (Dimelu *et al.*, 2018). The sector is rapidly expanding worldwide and plays a vital role in providing essential protein for human consumption (FAO, 2022). To maintain sustainable aquaculture, it is imperative to uphold good water quality in fish farms.

The family Claridae, which includes *Clarias gariepinus*, is regarded as having significant importance in tropical catfish farming in West Africa. It is highly widespread in swamps, lakes and rivers throughout Africa, and it is the principal fish angler catches (Magami *et al.*, 2016). Because *Clarias gariepinus* fish have a large geographic distribution, a rapid growth rate, the ability to withstand stress and high appreciation, they are thought to hold tremendous promise for fish farming in Africa (Magami *et al.*, 2016). Fish producers and consumers in Nigeria are willing to pay a premium for it, and they like it either fresh or smoked. In both the wild and in culture, a variety of parasites are linked to *Clarias gariepinus*, causing movement, mortality, and financial losses in aquaculture operations worldwide (Magami *et al.*, 2016).

Fish are susceptible to various parasites, both internally and externally. Ectoparasites are found on the skin or body of fish, while intestinal helminths are parasitic worms inhabiting the gastrointestinal tract of the fish (FAO, 2023). Fish breeding and commercial production are severely hampered by parasitic illnesses, particularly those caused by worms (Ayeloja *et al.*, 2021). By weakening their immune systems, increasing their susceptibility to secondary diseases, and lowering the nutritional value of fish, parasites can put hosts at risk for other infections and result in financial losses (Soliman *et al.*, 2022).

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Furthermore, parasites can cause illness, mortality, and additional economic effects by competing for resources depriving fish of essential nutrients and limiting their growth (Anthony and Richard, 2016).

These worms can lead to health issues in fish, such as anaemia, reduced growth, lowered immunity, and, in severe cases, death. Several species of intestinal helminths, including nematodes, cestodes, and trematodes, have been reported to infect fish (Saanu *et al.*, 2017). However, the consumption of fish may pose health risks due to parasitic infections with zoonotic potential, including *Anisakis spp.*, *Gnathostoma spp.* and *Clinostomum spp.* negatively impacting both fish and humans. Ensuring proper water quality is essential to prevent parasitic contamination in aquatic environments where fish are raised for human consumption (Onajobi *et al.*, 2023).

Fisheries and aquaculture contribute significantly to Nigeria's economy, accounting for 3–4 percent of the country's annual Gross Domestic Product (GDP). Beyond its economic impact, this sector is crucial in meeting about 50 percent of the population's animal-source food needs, providing essential dietary nutrients (Ayeloja *et al.*, 2021). According to Iruo *et al.* (2018), fisheries contribute approximately ₦126.417 billion to the Nigerian economy, with a capitalisation of ₦78.530 billion. Additionally, aquaculture accounts for an investment of ₦7 billion and a capital contribution of ₦20 billion. This translates to a substantial one billion US dollars added to the nation's GDP, showcasing a rapid 25-33% annual expansion in the demand for fish and investment in commercial fish farming (Uzonwanne *et al.*, 2023). Therefore, this research aims to assess the prevalence of fish parasites in selected fish farms in Sokoto metropolis, Nigeria.

## MATERIALS AND METHOD

### Study Area

This study was carried out across ten (10) selected fish farms within the Sokoto metropolis, which comprises the metropolitan local government areas of Sokoto North and Sokoto South. Geographically situated between longitude 13˚ 3' 5" North and 5˚ 13' 53" East. Sokoto metropolis spans approximately 20 square kilometres and is home to a population exceeding one million people. It is bordered by Kware, Dange Shuni, Silame and Rabah LGAs to the North, South, West and East respectively (Maikano *et al.*, 2020).

The region's vegetation belongs to the Sudan Savannah biome, characterised by abundant grasses with scattered trees, typically reaching heights of 1.5 – 2m for grasses and not exceeding 15m for trees. The primary rainy season spans from May to September, with an average annual rainfall of around 1000mm (Lema *et al.*, 2023). The inhabitants of Sokoto metropolis are predominantly Hausa-Fulani, engaging primarily in farming, animal husbandry, business, and civil service. Significant communities of Yoruba, Igbo, Kabawa, Zamfarawa, and Zabarmawa also reside in the area. Additionally, various other tribes, such as Dakkarawa, Igala, Ibra, Nufawa, and Gwarawa, are present, drawn to the region due to its diverse economic activities (Lema *et al.*, 2023).

### Study Design

A survey conducted in the study area revealed a total of thirty-seven fish farms, of which less than fifteen are operational due to the nation's economic situation. Ten (10) fish farms from among less than fifteen fish farms were randomly selected for this study. We bought twelve (12) samples of *Clarias gariepinus* from each of the farms and taken to the Biology laboratory of the Department of Biological Sciences, Sokoto State University, Sokoto, for parasitological analysis of external and intestinal parasites of the samples using microscopic examination.

### Ethical Clearance

An introduction letter to undertake the study was obtained from the Head of the Department of Animal and Environmental Biology, Kebbi State University of Science and Technology, Aliero. The letter was submitted together with the research proposal to the management of all the selected fish farms. Permission to undertake the study was sorted from the management of all the selected fish farms.

### Sample Size Determination

The formula adopted by Dauda *et al.* (2023) was used to calculate the sample size. A prevalence of 8.33% was found for intestinal helminth in *Clarias gariepinus* in Sokoto, according to the study by Magami *et al.* (2016). This prevalence was used to calculate the sample size, with 5% absolute precision and a 95% confidence range. Consequently, the following is how the computed sample size was determined.

$$N = \frac{Z^2pq}{d^2}$$

Where:

N = sample size
Z = standard normal distribution
p = prevalence of the previous research
q = complementary proportion of p (1-p)
d = tolerable margin of error
Thus:
N=?
Z= 1.96
p = 0.0833 (Magami *et al.*, 2016)
q = 1- p = 1- 0.0833 = 0.9167
d = 5% (0.05)

Therefore

$$N = \frac{1.96^2 \times 0.0833 \times 0.9167}{0.05^2}$$

$= 3.84 \times 0.0764$
$0.0025$
$= 117 \approx 120$

However, a total of one hundred and twenty (120) samples of *Clarias gariepinus* were purchased from the selected fish farms in the Sokoto metropolis.

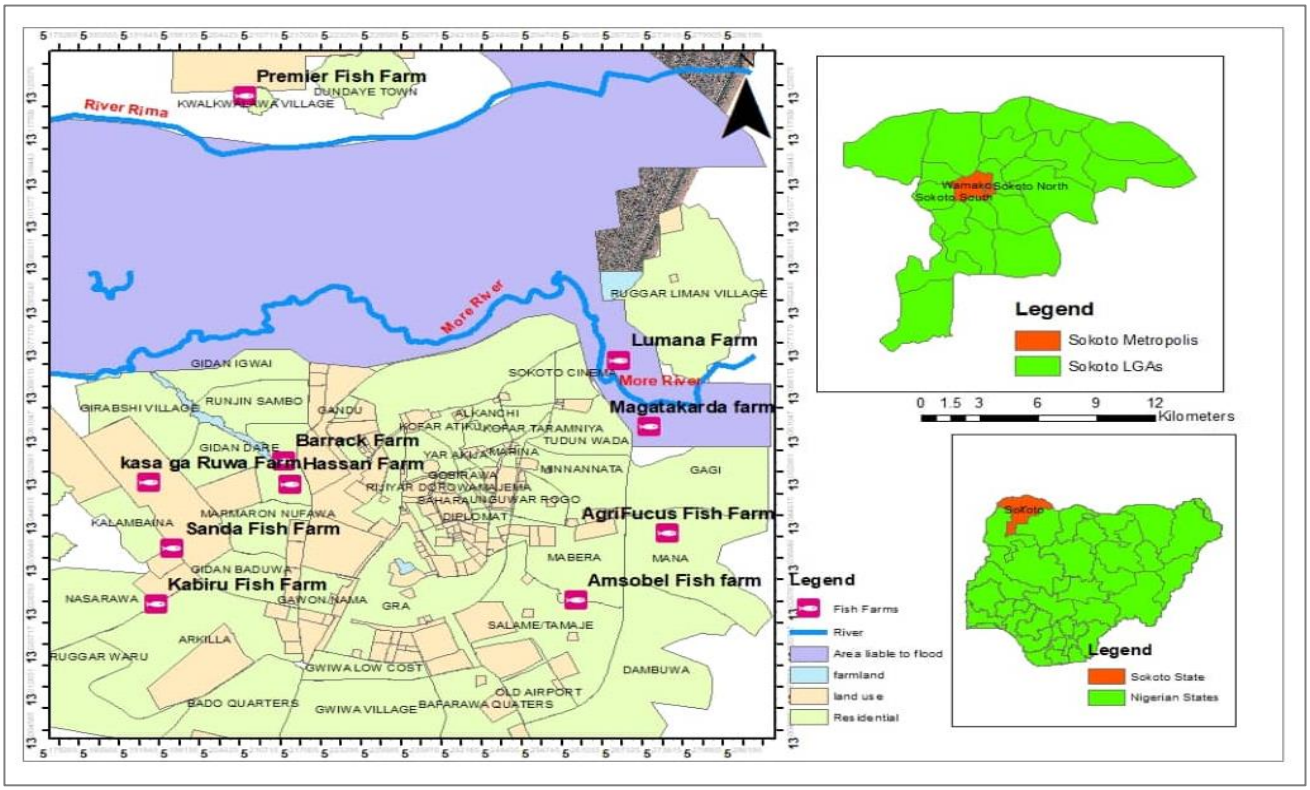


**Figure 1: Map of Sokoto and its Environs showing the Study Area**
**Source: GIS Laboratory, Department of Geography, Sokoto State University, Sokoto**

### Collection of Fish Samples

A total of 120 live fish samples of *Clarias gariepinus* species were purchased from ten (10) selected fish farms in the Sokoto metropolis. They were kept in an ice chess container and then immediately transported to the Biology laboratory of the Department of Biological Sciences, Sokoto State University, Sokoto, for parasitological analysis of external and intestinal fish parasite examination (Ashmawy *et al*., 2018).

### Collection of Water Samples

In order to evaluate the physiochemical parameters present, water samples were taken in clean 75cl plastic bottles from ten (10) carefully chosen fish farms in Sokoto city. The water samples were labelled with the names of the farms and delivered to the Sokoto Rima River Basin Development Authority's National Water Quality Reference Laboratory for examination.

### Measurement of Length and Weight

The length of each fish was determined by measuring from the anterior part of the mouth to the end of the caudal fin, using a measuring board with centimetre markings. Fish length measurements were recorded to the nearest centimetre. To obtain accurate weights, the fish was gently blot-dried with a clean hand towel before being weighed using a weighing balance and recorded to the nearest gram as described by Orobator *et al.* (2020).

### Examination of fish for External parasites

All the fish samples undergo visual inspection aided by a naked eye and hand-held lens with special emphasis on the fins and operculum. Gills, after removal, were immersed in 4% formalin solution and shaken vigorously. The resultant solution was filtered through a sieve into a centrifuge tube, followed by centrifugation at 1000 rpm for five minutes. The supernatant was discarded, a drop of residue was placed on a clean glass slide covered with a cover slip and a drop of iodine was added to the edge of the cover slips. Subsequently, these slides were examined using a binocular microscope at magnifications of ×10 and ×40 objectives for the presence of fish external parasites (Ashmawy *et al*., 2018). The parasites were identified following a standard key provided by Ashmawy *et al.* (2018).

### Examination of fish for intestinal parasites

Using dissecting scissors, a ventral incision was created from the fish's anal hole to its lower jaw, exposing the majority of its internal organs and the body cavity. The contents of the intestines and stomach were properly

mixed and put into different petri plates with 4% formalin. After passing the mixture through a sieve and into a centrifuge tube, it was centrifuged for five minutes at 1000 rpm. After the supernatant was poured out, a drop of residue was added to the spotless slides, coverslips were put on top of them, and a drop of iodine was added to the edge of each coverslip. These slides were then inspected under a microscope for the presence of fish intestinal parasites at magnifications of ×10 and ×40 objectives (Ashmawy *et al*., 2018). The parasites were identified following a standard key provided by Ashmawy *et al.* (2018).

### Determination of Water Quality Parameters

The National Water Quality Reference Laboratory of the Sokoto Rima River Basin Development Authority (SRRBDA) in Sokoto carried out an analysis of water quality parameters in compliance with the standard procedure for water and wastewater analysis that the American Public Health Association (APHA, 2017) recommends. Using a multifunctional water quality tester (model C600), the pH of the water was measured in the lab by diffusing it into the water and letting it settle for roughly two minutes. The reading was then recorded in accordance with the guidelines provided by APHA (2017). Using a portable DO analyser (model JPB 607A), the dissolved oxygen content of the water was measured in the lab. The reading was obtained by dipping the electrode into the water and letting it settle for approximately two minutes, as per the guidelines provided by APHA (2017). A HACH DR 900 colourimeter was used in the laboratory to determine the nitrate levels in the water samples. A 25-millilitre colourimeter container that had previously been rinsed with the sample was filled with 10 millilitres of each sample. After adding the Nitro Ver pillow reagent, the sample was forcefully agitated for a minute. The colorimeter measurement was reset to zero using a blank sample. After that, the prepared sample bottle was put inside the colorimeter cell tube, the colourimeter cap was put on, and the measurement was initiated by pressing enter, and reading was then recorded as described by APHA (2017).

### Data Analysis

The data collected was subjected to chi-square statistical analysis. Water quality analysis was subjected to one-way analysis of variance (ANOVA) using SPSS version 27.0 to determine the differences between mean values. Correlation between the prevalence of the fish parasites and water quality parameters was subjected to Spearman correlation analysis to compare the significance of the association. Differences between the variables were considered to be significant at $p < 0.05$, as described by Ashmawy *et al.* (2018).

## RESULTS

### Prevalence of Fish Parasites in the Study Area

The results of the prevalence of fish parasites in selected fish farms in Sokoto metropolis according to the farms selected have been summarised in Table 1. Out of the 120 fish samples examined for the presence of fish parasites, 42 (35.0) were positive. The highest prevalence of [9/12 (75.0%)] was recorded in Amsobel fish farm, followed by Hassan farm [8/12 (66.7%)], followed by Barrack farm [7/12 (58.3%)], followed by Kabiru farms [5/12 (41.7%)], followed by Kasa ga ruwa farm [4/12 (33.3%)], followed by Magatakarda farm [3/12 (25.0%)], followed by Lumana and Sanda fish farms [2/12 (16/7%)], while the lowest prevalence [1/12 (8.0%)] Agrifocus and Premier fish farms has. The prevalence of fish parasites was significant between the selected fish farms (P=0.0300).

**Table 1: Prevalence of Fish Parasites in the Study Area**

| Farms | No. Examined | No. Positive | Prevalence (%) | P Value |
|---|---|---|---|---|
| Agrifocus Farm | 12 | 1 | 8.3 | 0.0300 |
| Amsobel Farm | 12 | 9 | 75.0 | |
| Barrack Farm | 12 | 7 | 58.3 | |
| Hassan Farm | 12 | 8 | 66.7 | |
| Kabiru Farm | 12 | 5 | 41.7 | |
| Kasa ga Ruwa Farm | 12 | 4 | 33.3 | |
| Lumana Farm | 12 | 2 | 16.7 | |
| Magatakarda Farm | 12 | 3 | 25.0 | |
| Premier Farm | 12 | 1 | 8.3 | |
| Sanda Farm | 12 | 2 | 16.7 | |
| **Total** | **120** | **42** | **35.0** | |

### Prevalence of Fish Parasites According to Demographic Information.

The results of the prevalence of fish parasites according to the demographic information have been summarised in Table 2. A significant (P=0.0308) prevalence of [28/56 (50.0)] was recorded in females and [14/64 (21.9%)] had been observed in males. Significant prevalence (P=0.0308 had been observed between male and female fishes. The prevalence of fish parasites according to the age group of the fish: the fish between the age group 11-20 weeks had the highest prevalence of the parasites [26/54 (48.1%)], followed by 20-30 weeks [10/37 (27.0%)], while those between the aged group of 30-40 recorded the lowest [6/29 (20.7%)]. Similarly, a significant prevalence (P=0.0003) also exists between the fishes of different ages.

**Table 2: Prevalence of Fish Parasites According to Demographic Factors**

| Demographic Factor | No. Examined | No. Positive | Prevalence (%) | P-Value |
|---|---|---|---|---|
| **Sex** | | | | |
| Male | 64 | 14 | 21.9 | 0.0308 |
| Female | 56 | 28 | 50.0 | |
| **Total** | **120** | **42** | **35.0** | |
| **Age (Weeks)** | | | | |
| 11-20 | 54 | 26 | 48.1 | 0.0003 |
| 21-30 | 37 | 10 | 27.0 | |
| 31-40 | 29 | 6 | 20.7 | |
| **Total** | **120** | **42** | **35.0** | |

**Prevalence of Fish Parasite in Relation to Length and Weight of the Fish**

The result of this study in relation to the length and weight of the fish has been summarised in Table 3. The result of the prevalence of fish parasites in relation to the length of the fish shows that the highest prevalence was observed in 11-20cm [28/59 (47.6%)], followed by 21-30cm [9/36 (25.0%) and least prevalence was recorded in 31-40cm [5/25 (20.0%)]. Similarly, the prevalence of fish parasites in relation to the weight of the fish shows that the highest prevalence was recorded in 1-100g [28/57 (49.1%)], followed by 101-200g [8/35 (22.9%)], while the lowest prevalence was observed in 201-300g [6/28 (21.4%)]. Similarly, a higher significant (P=0.0000) was recorded in both the length and weight of the fish, respectively.

**Table 3: Prevalence of Fish Parasite in Relation to Length and Weight of the Fish**

| Length (cm) | No. Examined | No. Positive | Prevalence (%) | P-Value |
|---|---|---|---|---|
| 11-20 | 59 | 28 | 47.6 | 0.0000 |
| 21-30 | 36 | 9 | 25.0 | |
| 31-40 | 25 | 5 | 20.0 | |
| **Total** | **120** | **42** | **35.0** | |
| **Weight (g)** | | | | |
| 01-100 | 57 | 28 | 49.1 | 0.0000 |
| 101-200 | 35 | 8 | 22.9 | |
| 201-300 | 28 | 6 | 21.4 | |
| **Total** | **120** | **42** | **35.0** | |

**Prevalence of Fish Parasite Base on the Fish Body Part**

The result of the prevalence of fish parasites based on the body part where the parasites are found in the fish has been summarised in Table 4. The highest prevalence of [38/120 (31.7%)] was observed in the stomach, followed by the intestine [29/120 (24.2%), while the lowest prevalence of [0/120 (0.00%0] was recorded in the skin and gills. There is also a higher significant association between the fish body part (P=0.0000).

**Table 4: Prevalence of Fish Parasite Based on the Fish Body Part**

| Body part | No. Examined | No. Positive | Prevalence (%) | P-Value |
|---|---|---|---|---|
| Skin | 120 | 0 | 0.00 | 0.0000 |
| Gills | 120 | 0 | 0.00 | |
| intestine | 120 | 29 | 24.2 | |
| Stomach | 120 | 38 | 31.7 | |

**Percentage of Parasite Species Identified in the Study**

The result of this study on the percentage of parasite species identified has been summarised in Table 5. The percentage of parasite species identified in this study shows that *Camallanus spp.* had the highest percentage of 60.3% and *Capellaria spp.* with percentage of 39.7%. There were insignificant differences between the percentage of parasite species identified (P=0.0896).

**Table 5: Percentage of Parasite Species Identified in the Study**

| Species | Observed Microscopic Features | Density | Percentage (+) | P-Value |
|---|---|---|---|---|
| *Camallanus spp.* | Thicker, cylindrical body, chitinous buccal capsule with stylet and longer | 41 | 60.3 | 0.0896 |
| *Capellaria spp.* | Thin, thread-like worms, simple mouthparts and generally shorter | 27 | 39.7 | |
| **Total** | | **68** | **100** | |

Plate 1: *Camallanus spp.*

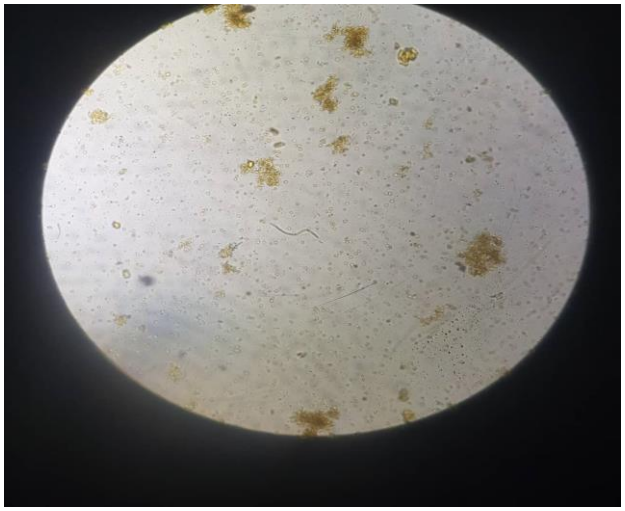

Plate 2: *Capellaria spp.*

**Result of Fish Feeding Practice and Stocking Density in Selected Fish Farms in Sokoto Metropolis**

The result of fish feeding practices across the selected fish farms shows that 40.00% of the farms feed their fish twice daily, 20.00% of the farms feed their fish once and thrice daily, respectively, and 10.00% of farms feed their fish once in two and three days respectively as seen in the table. Similarly, the result of fish stocking density across the selected fish farms shows that 50.00% of the fish farms maintain optimum stocking density, 30.00% of the fish farms overstocked their farms, and 20.00% of the fish farms understocked their farms, as seen in table

**Table 6: Result of Fish Feeding Practice and Stocking Density in Selected Fish Farms in Sokoto Metropolis**

| Frequency of Feeding | Farms Frequency | Percentage | P Value |
|---|---|---|---|
| Once daily | 2 | 20.00 | 0.5578 |
| Twice daily | 4 | 40.00 | |
| Thrice daily | 2 | 20.00 | |
| Once in two days | 1 | 10.00 | |
| Once in three days | 1 | 10.00 | |
| **Total** | **10** | **100.00** | |
| **Stocking Density** | | | |
| Under stocking | 2 | 20.00 | 0.4966 |
| Optimum stocking | 5 | 50.00 | |
| Overstocking | 3 | 30.00 | |
| **Total** | **10** | **100.00** | |

**Mean Value of Water Quality Parameters of Ten (10) Selected Fish Farms in Sokoto Metropolis**.

As presented in Table 7, a Maximum mean pH value of 7.83+0.05 was observed in Kabiru farm, and a minimum value of 6.68+0.11 was recorded in Lumana farm. Dissolve oxygen (DO) was recorded to have a maximum mean value of 8.20+0.06 ppm in the Magatakarda farm and a minimum value of 5.23+0.03 ppm in the Amsobel farm. The highest mean nitrate of 100.33+0.33 ppm was recorded in Amsobel farm, and the lowest value of 13.70+1.37 ppm was observed in Hassan farm. as seen in Table 7.

**Table 7: Mean Value of Water Quality Parameters of Ten (10) Selected Fish Farms in Sokoto Metropolis**

| Parameters | pH | DO (ppm) | $NO_3$ (ppm) |
|---|---|---|---|
| Agrifocus Farm | $7.22+0.04^{abc}$ | $7.53+0.20^{b}$ | $95.23+1.18^{b}$ |
| Amsobel Farm | $7.16+0.22^{bc}$ | $5.23+0.03^{f}$ | $100.33+0.33^{a}$ |
| Barrack Farm | $7.23+0.18^{abc}$ | $5.27+0.67^{f}$ | $100.00+0.00^{a}$ |
| Hassan Farm | $7.41+0.27^{ab}$ | $6.63+0.22^{c}$ | $13.70+1.37^{e}$ |
| Kabiru Farm | $7.83+0.05^{a}$ | $8.17+0.33^{a}$ | $14.93+0.46^{e}$ |
| Kasa ga Ruwa Farm | $6.68+0.19^{c}$ | $8.17+0.88^{a}$ | $94.70+0.40^{b}$ |
| Lumana Farm | $6.68+0.11^{c}$ | $5.47+0.33^{ef}$ | $53.07+0.07^{c}$ |
| Magatakarda Farm | $7.21+0.12^{abc}$ | $8.20+0.06^{a}$ | $95.23+0.15^{b}$ |
| Premier Farm | $7.43+0.23^{ab}$ | $5.67+0.19^{e}$ | $15.73+0.18^{e}$ |
| Sanda Farm | $7.68+0.28^{ab}$ | $6.13+0.03^{d}$ | $18.03+0.94^{d}$ |

**Correlation of the Water Quality Parameters with Prevalence of Fish Parasites**

The results of this study on the correlation between the prevalence of fish parasites and water quality parameters in selected fish farms are summarised in Table 8. pH positively correlated with dissolved oxygen but significantly shows a a negative correlation with nitrate and negatively correlates with the the prevalence of fish parasites (P=0.05). Dissolved oxygen positively correlates with pH but negatively correlates with nitrate and the prevalence of fish parasites. Nitrate also positively correlated with the prevalence of fish parasites but showed a significant negative correlation with pH and negatively correlated with dissolved oxygen (P=0.05). The prevalence of fish parasites in the selected fish farms positively correlated with nitrate and negatively correlated with pH and dissolved oxygen.

**Table 8: Correlation of the Water Quality Parameters with Prevalence of Fish Parasites**

| Parameters | Ph | DO (mg/l) | $NO_3$ (mg/l) | Prevalence (%) |
|---|---|---|---|---|
| **pH** | 1.000 | 0.107 | -0.579* | -0.076 |
| **DO (mg/l)** | 0.107 | 1.000 | -0.317 | -0.214 |
| **$NO_3$ (mg/l)** | -0.579* | -0.317 | 1.000 | 0.162 |
| **Prevalence (%)** | -0.076 | -0.214 | 0.162 | 1.000 |

## DISCUSSION

The result of this study on the prevalence of fish parasites across the selected fish farms shows an overall prevalence (P=0.0300) of 35.0%. This low prevalence may be related to the quality of the water, availability of feed and regular monitoring and changing of the pond water. The results were in agreement with the findings of Dauda *et al.* (2023), 32.5% in their study on Prevalence of parasite infestation in Cultured and Wild African Catfish in Zaria Kaduna State, Nigeria, 31.4% reported by Okpasuo *et al.* (2016) in their study on Parasites of Freshwater and Condition Factor of Bagrid Fishes in Anambra River Basin, Nigeria and 30.0% observed by Banyigyi *et al.* (2023) in their study on Incidence of Gastrointestinal Parasites of Catfish (*Clarias Gariepinus*) From River Nasarawa, Nigeria. Similarly, the result was higher than 8.33% reported by Magami *et al.* (2016) in River Rima Sokoto, 11.25% observed by Okita *et al.* (2020) in Makurdi, Benue state, 20.0% reported by Afolabi *et al.* (2020) from ponds in Akure, Ondo state, 22.3% reported by Uruku and Adikwu (2017) from the lower Benue river, 23.3% observed by Sadauki *et al.* (2022) from Zobo reservoir in Katsina state, 24.4% recorded by Alkali *et al.* (2021) in culture fish in Sokoto and 25.3% recorded by Osimen and Anagha (2020) from rivers in Edo state, Nigeria. However, the result was lower compared to 56.7% reported by Omeji *et al.* (2022) in selected fish farms in Makurdi, Benue state, and 64.5% recorded by Ashmawy *et al.* (2018) in Alexandria.

The results of this study on the prevalence of fish parasites based on fish sex show that female has the highest prevalence (P=0.0308) of the parasite 50.0%. The result was in agreement with the findings of Okpasuo *et al.* (2016), who reported a high prevalence of 54.8% in females in their study in Anambra state, Afolabi *et al.* (2020) who recorded a high prevalence of 57.5% in female in their study in Akure, Ondo state and Banyigyi *et al.* (2023) who also reported high prevalence of 33.7% in female in their study in Keffi, Nasarawa state. However, the results were in contrast with the finding of Dauda and Ibrahim (2017), who reported a high prevalence of 34.2% in males in their study in Katsina state, Osimen and Anagha (2020) who also reported high prevalence of 19.8% in male in their study in Edo state, Omeji *et al.* (2022) who also reported high prevalence of 64.0% in male in their research in Makurdi, Benue state and Sadauki *et al.* (2022) who also observed high prevalence of 46.80% in male in their study in Katsina state

The results of this study, according to the age group of the fish, show that the lower age group, 11-20 weeks, has the highest prevalence (P=0.0003) of 48.1%. This high prevalence in lower age groups may be related to their immune system development, which was unable to challenge and minimise parasitic infestation. However, Jajere *et al.* (2023) reported that bigger fish have a larger surface area and, therefore more susceptible to parasitic infection. The results were in agreement with the results of Magami *et al.* (2016), who also reported a high prevalence of 36.7% in the lower age group in their study in Sokoto.

The result of this study on the prevalence of fish parasites in relation to the length of the fish shows that fish within the lower lengths (11-20cm) have the highest rate (P=0.0000) of 33.3%. This higher prevalence in low-length fishes may also be related to the immune system development of the fish. The result was in contrast with the findings of Magami *et al.* (2016) who recorded high prevalence of 63.6% in fish within the high length category (30-37.9cm) in their study in Sokoto, Omeji *et al.* (2022) who observed high prevalence of 16.7% in high length classes (35.1-40.0cm and 40.1-45.0cm) in their study in Makurdi, Benue state, Sadauki *et al.* (2022) who reported high prevalence of 83.3 in middle length class (20.1-25.0cm) in their study in Katsina state and Banyigyi *et al.* (2023) who also observed high prevalence of 35.2% in high length class (21-30cm) in their research in Nasarawa state.

The results of this research on the prevalence of fish parasite in relation to weight of the fish shows that, low weight fishes (1-100g) have the highest prevalence (P=0.0000) of 49.1%. This higher prevalence in low-weight fishes may also be related to the immune system development of the fish. This agreed with the findings of

Banyigyi *et al.* (2023), who also recorded a high prevalence of 42.8% in low-weight fish (<100g) in their study in Nasarawa state. Similarly, the results slightly differ compared to the results of Afolabi *et al.* (2020), who reported a high prevalence of 83.3% in middle-weight fish (500-599g) in their study in Akure, Ondo state. However, the result completely differs from that of Magami *et al.* (2016), who observed a high prevalence of 90.9% in fish with high weight (121-140g) and Omeji *et al.* (2022), who also recorded a high prevalence of 13.3% in high weight fish (340.1-400g) in their study in Makurdi, Benue state. The higher prevalence in lower class of both length and weight may be related to the underdeveloped immune system of the fish, which cannot properly attack and challenge the parasite, thereby allowing the parasite to infest the fish body.

The prevalence of fish parasites based on the fish body part shows that, the stomach has the highest prevalence (P=0.0000) of the parasites, 13.3%. The result was in agreement and lower than the finding of Magami *et al.* (2016), who reported 63.6% in the stomach and 36.4% in intestine respectively in Sokoto. However, the results were in contrast with the findings of Sadauki *et al.* (2022), who reported 59.3% in the intestine and 40.7% in the stomach respectively in Katsina. This may be due to the regional localisation in the gut attributed to food reserves. Magami *et al.* (2016) also demonstrated that helminths vary in their nutritional and respiratory needs, which may influence their habitat selection.

The results of this study on the fish parasite species identified and their percentage show that only two species of Nematode (*Camallanus spp.* and *Capellaria spp.*) were identified without any Cestodes, Trematodes or Acanthocephalans, with *Camallanus spp.* having an insignificant high percentage (P=0.0896) of 60.3% and *Capellaria spp.* with 39.7%, respectively. The result agreed with the findings of Omeji *et al.* (2022), who also reported the same species along with one Cestode specie (*Diphillibothrium latum*) in their study in Makurdi, Benue state, Sadauki *et al.* (2022), who also recorded the same parasite along with many others in their study in Katsina state, Jajere *et al.* (2023) who observed Nematodes, Cestodes, Trematodes and Acanthocephalans in his study in Maiduguri, Borno state, Okpasuo *et al.* (2016) who reported the same species together with others in their study in Anambra state. However, the result slightly differ from the results of Uruku and Adikwu (2017), who reported only *Capellaria spp.* along with other parasites in this study in Benue state and Afolabi *et al.* (2020), who recorded only *Camallanus spp.* in their research in Akure, Ondo state, Nigeria.

The highest mean pH that was observed in Kabiru Fish Farm was 7.83+0.05 and the lowest that was recorded in Lumana fish farm was 6.68+0.11 could also be related to the location of the farms and soil nature of the area. This result was relatively higher than the findings of Danba *et al.* (2015), who reported a maximum mean pH of 7.1+0.62 in their study on Physicochemical analysis of pond water conservation in Kano State, Nigeria, Soliman *et al.* (2022), who also reported a maximum pH of 7.8 in their study on Fish Growth Performance, Body Composition and Water Quality in Integrated System. Additionally, the result was higher than the results of Orobator *et al.* (2020), who reported a higher pH of 6.39 in their study on Water Quality Evaluation from Selected Aquaculture pond in Benin city, Nigeria. Similarly, this result was lower compared to the findings of Aydin (2018), who reported a maximum mean pH of 8.590+0.146 in his study on Statistical Analysis of Water Quality Parameters for Pollution Source Identification in Bektas Pond, Turkey, Mustapha (2017), who reported maximum mean pH of 8.03+0.2 in his study on Comparative Assessment of the Water quality of Four Type of Aquaculture Pond Under Different Culture System. However, both the minimum and maximum mean pH recorded in this study are within the acceptable permissible limit reported by Orobator *et al.* (2020), Iwar *et al.* (2021), Soliman *et al.* (2022) and Yohanna *et al.* (2020) respectively. The pH value positively correlates with turbidity, electric conductivity, dissolved oxygen and prevalence of the fish parasites but negatively correlates with temperature, alkalinity and significant correlate negatively with nitrate.

The highest mean Dissolved oxygen that was observed in the Magatakarda fish farm was 8.20+0.06 and the lowest that was recorded in Amsobel fish farm was 5.27+0.67 may be related to the water sources and location of the farms. The result is slightly higher than that of Mustapha (2017) who reported maximum mean dissolve oxygen of 6.1+01 in his study on Comparative Assessment of Water Quality of Four Type of Aquaculture Pond Under Different Culture Systems, Bubu-Davies and Kpikpi (2021) who also reported higher dissolve oxygen of 7.09+3.16 in their study on Evaluation of Water Quality Index in Some Artificial Aquatic Environment in Port Harcourt, River State, Nigeria, Akpotayire *et al.* (2020) who reported the maximum dissolve oxygen of 6.45 in their study on Assessment of Physicochemical Characteristics of Artificial Fish pond Water in Ogoni, A case Study of Ka-Gwara Community, Ukwe and Abu (2016) who reported the higher dissolve oxygen of 6.36+1.85 in their study on Physicochemical Parameters of Water Holdin Tanks of *Clarias gariefinus* induced with Ovaprim and Ovulin Hormones and Orobator *et al.* (2020) who reported high dissolve oxygen of 7.34 in their study on Water Quality Evaluation from Selected Aquaculture Pond in Benin City, Nigeria. Additionally, the results were much higher than the result of Danba *et al.* (2015), who reported high dissolved oxygen of 3.08+0.13 in their study on Physicochemical analysis of pond water conservation in Kano State, Nigeria, Khan *et al.* (2018), who reported maximum dissolve oxygen of 5.6, Mramba and Kahindi (2023) who reported high dissolve oxygen of 5.7+1.6 and Onajobi *et al.* (2023) who also reported maximum dissolve oxygen of 4.95 in their different studies on water quality parameters. However, the result is also slightly lower than that of Collins and Sawere. (2019), who reported maximum dissolve oxygen of 9.3, Aydin (2018) who

reported a high dissolved oxygen of 13.583+0.304 and Saanu *et al.* (2017) who reported maximum dissolve oxygen of 9.23+1.41 respectively. The maximum and minimum mean dissolve oxygen obtained in this study are also within the acceptable permissible limit reported by Orobator *et al.* (2020), Iwar *et al.* (2021), Soliman *et al.* (2022) and Yohanna *et al.* (2020) respectively. Dissolve oxygen significantly correlates positively with temperature and positively correlates pH, turbidity, electric conductivity, nitrate and alkalinity but negatively correlates with the prevalence of fish parasites.

The highest mean nitrate that was recorded in Amsobel fish farm was 100.33+0.33 and lowest that was observed in Hassan fish farm was 13.70+1.37 could be as a result of management practice and water changing time. The result was higher than that of Bubu-Davies and Kpikpi (2021) who reported maximum mean nitrate of 0.50+0.71 in their study on Evaluation of Water Quality Index in Some Artificial Aquatic Environment in Port Harcourt, River State, Nigeria, Aydin (2018) who reported a maximum mean nitrate of 3.898+0.428 in his study on Statistical Analysis of Water Quality Parameters for Pollution Source Identification in Bektas Pond, Turkey, Saanu *et al.* (2017) who reported maximum mean nitrate of 7.63+1.65 in their study on Assessment of Effect of Fish Feeding Practices on Water Quality of Some Fish Pond, Ado Ekiti, Nigeria and Orobator *et al.* (2020) who reported high nitrate of 59.40 in their study on Water Quality Evaluation from Selected Aquaculture pond in Benin city, Nigeria. However, this result was lower compared to the findings of Onajobi *et al.* (2023), who reported high nitrate of 600.0 in their study on Microbial and Physicochemical Assessment of Selected Fish Pond Water samples in South-West, Nigeria. The minimum mean nitrate obtained in this study is within the acceptable permissible limit but the maximum exceeds the permissible limit reported by Orobator *et al.* (2020), Iwar *et al.* (2021), Soliman *et al.* (2022) and Yohanna *et al.* (2020) respectively. Nitrate positively correlates with temperature, dissolved oxygen and prevalence of fish parasites but significantly correlates negatively with pH and also negatively correlates with turbidity, electric conductivity and alkalinity.

## CONCLUSION

The results of this study revealed a low prevalence across the selected fish farms. Female fish recorded a higher prevalence than males, and fish aged 11-20 weeks showed a higher prevalence of parasites than other age groups. Similarly, fish measuring 11-20cm in length and weighing 0-100g had the highest prevalence of parasites. The study also found a high prevalence of parasites in the stomach, with no parasites detected in the gills and skin.

Two species of nematodes were identified: *Camallanus spp.* and *Capillaris spp.*, with *Camallanus spp.* showing a higher prevalence. All parameters examined were significantly associated with the prevalence of fish parasites, except for the percentage of species identified, which was statistically insignificant (P=0.05).

The study's findings demonstrate that the water quality criteria are generally within allowable bounds, which qualifies the area for aquaculture and fish farming. Nonetheless, the fish farms like Agrifocus, Amsobel, Barrack, Hassan, Lumana, and Magatakarda have higher than allowed nitrate levels. This could result in eutrophication, disease outbreaks, or fish mortality as a result of elevated oxygen demand.

1. Although the parasites prevalence is very low, there is need for the farmers to used nematicide to ensure total eradication of the parasite in the affected farms.
2. Vaccination against other parasitic species should carried out by farmers to prevent the emergence of those parasites in their farms.
3. In order to enhance the quality of the water, farmers should regularly monitor the indicators related to water quality.
4. It is recommended to implement aeration and filtration systems in order to enhance the water's quality criteria.
5. Fish farmers should adopt regular water quality checks and use anti-parasitic treatments to minimise production losses and improve fish health
6. Further research should be carried out by other researchers in the area on the same topic to evaluate more parasite species that were not identified in this study.

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