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Comparative study of white blood cells and variation of its differentials in an apparently healthy and Haemoparasitic infected Clarias gariepinus (Burchell,1822) in Ibadan Southwest Nigeria

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Abstract

The study investigated the immune response by white blood cells (WBCs) and its differentials in the African Catfish (Clarias gariepinus) in Ibadan to haemoparasitic infections using microscopy examination for haemoparasites and automated counts for WBCs. Out of the 405 randomly selected matured fish, 60(14.8%) were infected while 345(85.2%) represented the uninfected. The total white blood cell (WBCx103µl) counts were higher in infected pooled fish (16.99±237.60), similarly in other differentials of WBC(%) such as eosinophil (3.33±0.21) and basophil (0.60±0.13) showing no significant difference (p>0.05), contrary to heterophils (29.42±1.08) (p<0.05). Differentials such as lymphocytes (66.71±0.35%) and monocytes (3.04±0.07%) were both higher in uninfected pooled fish than infected ones suggesting a possible immune suppression or modulation due to infection. Exploring the influence of sex and morphometric parameters on haematological indices, the male WBC (x103µl) counts were higher (17.45±310.94) in uninfected fish than infected ones (16.49±751.30) and ditto both lymphocytes and eosinophil, though the difference were not statistically significant (p> 0.05). In females, higher (WBC x103µl) counts were recorded in uninfected fish (16.54 ± 756.61) than in infected fish (15.91±958.52), also monocytes and lymphocytes were both higher in uninfected than haemoparasitic infected female C. gariepinus with no significant difference (p>0.05). Most morphometric values were higher in infected male except mean weight. This is contrary to female where most were higher in uninfected. The varying immune response recorded indicate the need for further investigation on environmental fluctuations in relation to parasitism in Clarias sp.

Keywords- Defensive role, Differentials, Haemoparasites, Morphometric, White blood cells

INTRODUCTION

Haematological examination serves as a fundamental diagnostic tool in aquaculture to evaluate the health status of fish (Sakyi *et al.*,2019). Fish blood serves as a key indicator of overall physiological function (Witeska *et al.*,2023). Its analysis is essential for assessing the functional status and health of fish (Fazio, 2019). It gives understanding of pathological changes, offering critical insights to general health of fish across various environmental conditions (Hoque and Das, 2025).

In fishes, white blood cells (WBCs) parameters and its differentials (lymphocytes, monocytes, eosinophils, heterophils and basophils) help to assess the immunity and response to infections, stress and environmental fluctuations (Docan *et al.,* 2018).

These haematological indices are often influenced by fish species, sex, maturity and habitat conditions (Witeska *et al.*, 2022). Notably, (WBCs) plays a pivotal role in defending organisms from foreign invaders and variations in their counts often indicate physiological stress or disease presence (Iyiola *et al.*,2024). Factors such as feeding habits, stocking density, water quality, diseases and toxins affect fish blood profile (Ajani *et al.*,2016).

Differential leucocyte counts are a highly source to obtaining knowledge about fish health and evaluation of its immune system (Sharma *et al.*, 2018). Studies have shown shifts in differentials counts occurring under infection or stress, such is characterized by increase in neutrophils and monocytes with a reduction in lymphocytes (Grezlak *et al.,* 2017).

Lymphocytes are regarded as the predominant in a healthy teleost constituting about 50-99% (Witeska *et al.*, 2016), followed by neutrophils which are phagocytic in nature while it also curb inflammatory reactions (Havixbeck and Barreda, 2015). The eosinophils in teleost are effective against parasitic infections (Prakash *et al.*, 2025) where significant rise of eosinophils had occurred in *Trypanosoma* infected *Cirrhinus mrigala*.

Basophils accounted for the least abundant leucocyte according to Park and Kang (2024) and Poto *et al.* (2022), while it is extremely rare in most teleosts (Witeska, 2022). Its function includes providing binding surface for immunoglobulin D (IgD), that triggers the production of antimicrobial factors (Edholm *et al.*, 2011), paradventure parasite inflicts injuries on tissue of fish

The monocytes are responsible for the depletion of resident macrophage populations during inflammatory conditions (Varol *et al.,* 2015).

Environmental disturbances caused by varying biotic and abiotic factors have brought about differential immune response in fishes either to parasites, pathogens amongst others, and based on this, the investigation is aimed at comparing the immune roles of white blood cells in both haemoparasitic infected and uninfected *Clarias gariepinus* in Ibadan.

MATERIALS AND METHODS

Study area:

This study was conducted in Ibadan, the capital of Oyo State, located in South-western Nigeria. Ibadan is found on GPS coordinates of latitude 73°76'73.6" °N and longitude 39°39'78.6" °E (Google, 2025). It comprises diverse population, with fish farming been categorized as private business and existing mostly as individual or at grouped operations. There are numerous fish markets within Ibadan metropolis from where bulk and retail quantity of fish can be purchased.

Collection of Fish Sample

Collection of fish samples were done by the use of combination of careful hand pick protected by rubber hand gloves and fish net, this acted as precautionary measure to prevent rough handling of the fish due to its slippery nature caused by the skin mucus contents, and its display off aggressiveness during catch which may sometimes cause fall off of the fish to cause further contamination from the soil.

Collected fish samples were carefully transferred into a black 50 litre plastic container with the fish habitat water (Kawe *et al.*,2016) All fish samples were collected during the afternoon sales during which time catfish are both less active and aggressive due to temperature rise (Ibrahim et al.,2023) leading to less stress and easier to transport. Varying number of matured and well identified *C. gariepinus* according to Olaosebikan and Raji (1998) were randomly selected per point of collection, totalling 405 fish samples collected in the study area. These collections points were Mashopa fish farms sales point at Alakia on 7.391°N and 3.9741°E, Albarka fish farm along Lagos - Ibadan express way on 7.3483°N and 3.8490°E and Aquatec College of agricultural technology sales point, Ring Road on 7.3767°N, 3.939°E, Others are fish farms estate sales outlet at Logudu Bembo, Apata Area on 7.447°N, 3.905°E and Lantinwy fish farms, Omi Adio on 7.39°N, 3.7537°E (All GPS are according to Google map, 2025).

Transportation of fish Specimens:

The fish were transferred with less agitation along with the water that accompany it from the various points of collection. The samples were allowed to rest for few hours in a 1,000L plastic holden tank with continuous supply of de-chlorinated water at the rate of 3-5 litres per minutes (Delince *et al.*,1987) before the commencement of the haematological studies.

Morphometric measurement and sex determination

The fish specimens were weighed individually using the electronic scale model Gallenkomp England Type DT-.3.000g of d= 0.1g; e=10d. The standard length was measured from the snout tip to the start of the peduncle, the total length was taken from the snout tip to the tip end of the tail (Tarantino *et al.,* 2024). The head length and breadth were measured using standard metre rule, the intestinal length was measured after a careful removal and stretching of the intestine sample on a dissecting board with a tape rule. The weights of the individual fish gill, liver and intestine were taken with the scale. Each fish was given an identification number, while the process was carefully monitored to prevent a mix-up of measurements.

Sex of the fish specimen was determined by the observation of prominence projected genital papillae in male fish, which is reduced to roundish structure in female (Ahmad *et al.*, 2021).

Collection of fish blood:

This was done by carefully placing a wet napkin on the fish head, while the dorsal side was turned up and the gill chamber carefully opened to reveal the heart chamber that is still pumping. Blood collection was done by heart puncture technique according to Konas *et al.* (2010) into a well labelled Ethylene diamine tetra acetic acid (EDTA) bottle. After the blood sample collection, the cap of the EDTA was replaced and the blood contents was shaken gradually and thoroughly thereafter kept in a cooler containing ice pack, and transferred to the laboratory of Veterinary pathology, University of Ibadan, for the thin smear analysis through which haemoparasites were obtained, while white blood cells and its derivatives ware obtained using automated Hema® Vet 950 machine (Drew scientific limited, UK)

RESULTS

Out of the 405 samples, 60 (14.81%) and 345 (85.19%) respectively were infected and uninfected, the mean white blood cell concentration (WBCx10^{3}µl) of the infected was 16.99±237.60 and 15.89±601.20 among the uninfected, this case shows no significant difference (p>0.05).

The lymphocytes (%) was significantly lower in infected fish (63.55±1.07) compared to uninfected (66.71±0.35) (p<0.05). Heterophils (%) mean values was significantly higher in infected fish (29.42±1.08) than in uninfected (26.72±0.37) (p<0.05).

The mean monocytes (%) was (2.87±0.18) in infected and uninfected fish (3.04±0.07), eosinophils (%) in the infected fish was (3.33±0.21) and (3.08±0.01) in uninfected. Mean basophil concentration (%) among the infected *Clarias gariepinus* was 0.60±0.13 and uninfected (0.39±0.04), in these trio of the measurement, no significant differences existed between infected and uninfected (p>0.05).(Table.1).

Table 1: Comparison between haemoparasitic infected and uninfected fish in relation to haematological indices

Variable ± Standard error (S.E)	Infected 60 (14.81%)	Uninfected 345 (85.19%)	P value
WBC ± S. E (x10^3 µl)	16.99±237.60	15.89±601.20	0.08[a]
Lymphocytes ± S. E (%)	63.55 ± 1.07	66.71 ± 0.35	0.01[b]
Heterophils ± S. E (%)	29.42 ± 1.08	26.72 ± 0.37	0.02[b]
Monocytes ± S. E (%)	2.87 ± 0.18	3.04 ± 0.07	0.35[a]
Eosinophils ± S. E (%)	3.33 ± 0.21	3.08 ± 0.01	0.32[a]
Basophil ± S. E (%)	0.60 ± 0.13	0.39 ± 0.04	0.11[a]

a-There is no significant difference (p>0.05), b- There is significant difference (p<0.05).

Key-: WBC = White Blood Cell.

Comparison of White blood cells and its differentials between male *Clarias gariepinus*

The WBC (x10^3µl) of the infected males was 16.49±751.30 with the uninfected been 17.45±310.94, this shows no significant difference (p>0.05). Lymphocytes concentration (%) was higher in uninfected male fish (66.41± 0.52), while infected fish recorded 63.12 ± 1.54). Heterophils concentration (%) was higher in infected males (29.19±1.54) than in uninfected (26.87±0.54 but not statistically significant (p>0.05). The monocytes concentration (%) in both infected and uninfected male fish was similar (3.03± 0.26% and 3.03 ± 0.94%) respectively, also with no significant difference (p>0.05). Eosinophils (%) was slightly higher in uninfected males (3.63±0.29) than infected (3.24±0.14) but not significantly different (p>0.05), the basophils value was higher in infected males (0.59±0.17) compared to uninfected (0.40±0.05) with no significant difference (p>0.05). (Table 2).

Table 2 Comparison of male *Clarias gariepinus* in relation to haematological indices (N=204)

Variable	Status	Mean + Standard Deviation	P value
WBC (x10^3 µl)	Infected	16.49 + 751.30	0.23[a]
	Uninfected	17.45 + 310.94	
Lymphocytes (%)	Infected	63.12 + 1.54	0.05[a]
	Uninfected	66.41 + 0.52	
Heterophils (%)	Infected	29.19 + 1.54	0.16[a]
	Uninfected	26.87 + 0.54	
Monocytes (%)	Infected	3.03 + 0.26	0.99[a]
	Uninfected	3.03 + 0.94	
Eosinophils (%)	Infected	3.24 + 0.14	0.28[a]
	Uninfected	3.63 + 0.29	
Basophil (%)	Infected	0.59 + 0.17	0.27[a]
	Uninfected	0.40 + 0.05	

a- There is no significance difference (p>0.05)

Among the female, the WBC (x10^3µl) in the infected was 15.19±958.52 as against the uninfected which was 16.54.38±356.61, the lymphocytes concentration (%) was significantly lower in the infected (63.96±1.49) compared to uninfected female (67.01±0.48) (p<0.05). Heterophils quantification (%) was significantly higher in infected female (29.68±1.51) than uninfected (26.57±0.51) (p<0.05). The monocytes concentration (%) was 2.68±0.24 and 3.04±0.10 among the infected and uninfected female fish respectively, while the eosinophils concentration was 3.00±0.30 among the infected female fish and uninfected (2.92±0.13). The basophils quantification in the infected female fish was 0.61±0.19 and 0.38±0.06 among the uninfected, however excluding the lymphocytes and heterophils counts that showed significant relationship, all compared values between the female infected and uninfected show no significance difference (p>0.05). (Table 3)

Table 3: Comparison of female *Clarias gariepinus* in relation to haematological indices (N=201)

Variable	Status	Mean + Standard Deviation	P value
WBC (x10^{3}ul)	Infected Uninfected	15.19 $\pm$ 958.52 16.54 $\pm$ 356.61	0.18[a]
Heterophils (%)	Infected Uninfected	29.68 $\pm$ 1.51 26.57 $\pm$ 0.51	0.03[b]
Monocytes (%)	Infected Uninfected	2.68 $\pm$ 0.24 3.04 $\pm$ 0.10	0.18[a]
Eosinophils (%)	Infected Uninfected	3.00 $\pm$ 0.39 2.92 $\pm$ 0.13	0.14[a]
Basophil (%)	Infected Uninfected	0.61 $\pm$ 0.19 0.38 $\pm$ 0.06	0.26[a]
Lymphocytes (%)	Infected Uninfected	63.96 $\pm$ 1.49 67.01 $\pm$ 0.48	0.03[b]

a- There is no significance difference (p>0.05), b. -There is significance difference (p< 0.05).

The morphometric values between haemoparasitic infected and uninfected *Clarias gariepinus* in the males indicated that higher mean weight (442.09 ± 32.70g) was recorded in the infected, than uninfected (422.96 ± 14.31g). Similarly, infected males had a longer standard length (33.88 ± 0.66cm) compared to uninfected (32.86 ± 0.35cm). Among the infected male, the mean total length of male fish measured 38.82 ± 0.77cm slightly longer than uninfected (38.13±0.35 cm). Infected males had a longer intestinal length (78.47±41.05 cm) compared to uninfected (36.33 ± 0.80cm). None of these were statistically significant (p<0.05)

The mean intestinal weight of the infected male fish was 55.28 ± 38.57g, and significantly higher than the uninfected (14.51±0.65g), furthermore infected male had significantly heavier gill (85.66±65.64g) than uninfected (26.91 ± 8.28g). Other morphometric values such as the head length in infected males was 10.20 ± 0.21cm versus uninfected (10.11±0.98). The head breadth of the infected fish was 7.75 ± 0.19 cm against the uninfected (11.20±3.44 cm). Infected males had a slightly higher liver weight (6.81±6.87g) than uninfected (6.18±0.28g). No statistically significant difference (p>0.05) was found between the infected and uninfected male *C. gariepinus* in any of these parameters.

Among the females fish, the infected had a lower mean weight (365.10±28.66g) than uninfected (409.38±13.51g), the mean standard length of infected females was slightly shorter (31.48±0.63 cm) compared to uninfected (32.71±0.29 cm), also the mean total length among the infected female fish was 36.38 ± 0.82, while it was higher in uninfected female (37.55 ± 0.33). The infected female fish recorded mean intestinal length of 33.03±1.57cm as the uninfected had a longer mean total length (56.21±21.32cm), the mean intestinal weight of the infected females was 11.91±1.41g compared to uninfected (13.34±0.60g).

Other morphometrics include mean gill weight which was 86.26±70.14g and 26.92±8.87g in the infected and uninfected female fish respectively, the head length was 10.04± 0.18 cm in the infected and 10.20±0.94 cm in the uninfected, similarly the head breadth in the infected was 7.70±0.31cm while in the uninfected it was 7.60±0.14cm. The mean liver weight recorded for the infected female fish was 4.47±0.44g as the uninfected was 6.0±0.24g, no morphometric parameters showed a statistically significant difference ($p>0.05$) between infected and uninfected females.

Table 4 Comparison between infected and uninfected male and female *Clarias gariepinus* in relations to morphometrics values (N = 405).

Variables	Infected (Male, N=32)	Uninfected (Male, N=172)	P Value	Infected (Female, N = 28)	Uninfected (Female, N= 173)	P-value
M.W (g)	442.09 ± 32.70	422.96 ±14.31	0.60[a]	365.10 ± 28.66	409.38 ± 13.51	21.0[a]
M.SL (cm)	33.88 ± 0.66	32.86 ± 0.35	0.23[a]	31.48 ±0.63	32.71 ± 0.29	11.0[a]
M.TL (cm)	38.82 ± 0.77	38.13 ± 0.35	0.44[a]	36.38 ± 0.82	37.55 ± 0.33	20.0[a]
M.IL (cm)	78.47 ± 41.05	36.33 ± 0.80	0.31[a]	33.03 ± 1.57	56.22 ± 21.32	66.0[a]
M.IW(g)	55.28 ± 38.57	14.51 ± 0.65	0.30[a]	11.91 ± 1.41	13.34 ± 0.60	38.0[a]
M.GW (g)	85.66 ± 65.64	26.91 ± 8.28	0.38[a]	86.26 ± 70.14	26.92 ± 8.87	41.0[a]
M.HL (cm)	10.20 ± 0.21	10.11 ± 0.98	0.74[a]	10.04 ± 0.18	10.20 ± 0.94	42.0[a]
M.HB (cm)	7.75± 0.19	11.20 ± 3.44	0.17[a]	7.70 ± 0.31	7.60 ± 0.14	79.0[a]
M.LW(g)	6.81±6.87	6.18 ± 0.28	0.40[a]	4.47 ± 0.44	6.00 ± 0.24	5.0[a]

Key M.W - Mean Weight, M.SL - Mean Standard length, M.TL – Mean Total length, M.IL – Mean Intestinal Length, M.IW – Mean Intestinal Weight, M.GW – Mean Gills Weight, M.HL – Mean Head length, M.HB–Mean Head Breadth, M.LW –Mean Liver-Weight

DISCUSSION

The study investigated the white blood cell (WBC) response of *Clarias gariepinus* to haemoparasitic infection. Infected fish exhibited higher white blood cell counts than uninfected fish, though not statistically significant, suggesting an immune response to parasitic infection (Panjvini *et al.*, 2016). However, this supports the investigations of Ashok, (2023) and Radwan *et al.* (2021).

The white blood cells values in the infected fish of this study is higher than 7.71±0.20 -8.05±0.26) x10^3/mm^3 recorded by Sulem-Yong *et al.* (2022) and 10500.0 ± 550.0 by Oladunjoye *et al.* (2021)

in *Clarias gariepinus,* while it was lower than 28.33± 1.64 x 10^3 µl and 41.1± 11.048 x10^3 as the mean recorded in the report of Akinrotimi *et al.* (2011) and Erhunmwunse and Ainerua (2013) respectively. The values remained within reference ranges indicating no immune is compromised. However, variations in the white blood cells composition in fish has been reported as normal physiological response (Adesina,2017).

Lymphocytes count were slightly lower in infected fish though very rare in infected animals, however it is in line with outcome of Mahasri *et al.* (2019) investigation in trypanosome infected freshwater fish. Also the reduction is possibly due to migration to infected sites leaving fewer circulating in the blood stream (Moro-Garcia *et al.,* 2018), though both infected and uninfected values were within normal range of 56.67% – 75.0% according to Adesina (2017).

Furthermore, the fish immune system could have curtailed the parasitic infections as a means of defensive mechanism (Wang *et al.,*2019). The findings suggest also that the fish immune system could have controlled infections locally with response not affecting the overall blood profile as observed in Diler *et al.* (2021) investigation. However, the influence of environmental conditions, host variability, parasite species and severity may come to display according to Jimoh *et al.* (2025).

Higher value of heterophils concentration was recorded in the infected fish, although within normal range of 38.0-59.0.0% according to Olanrewaju *et al.* (2018). This may likely reflect inflammatory and physiological stress response according to Vegard *et al.* (2025).

The monocytes values were similar in both infected and uninfected fish contrary to Okeke *et al.* (2024) where lower values were reported for both wild and cultured *Clarias* fish. Such condition may be linked to non -infectious stressors like environmental changes, chemicals presence and poor water quality (Adi *et al.,* 2017).

Eosinophils counts were slightly higher in infected fish than the uninfected, though not significant ($p<0.05$) which differed from the investigation of Akinrotimi *et al.* (2011) where no eosinophil was obtained. The slight rise in infected fish may indicate response to pathogens, allergies and parasites (Salvatore *et al.*,2018).

Immune response based on sex in *Clarias gariepinus*

The uninfected male and female *C. gariepinus* exhibited higher total white blood cell (WBC) counts than infected fish, though differences were not statistically significant. The elevation may reflect immune response to environmental stressors such as pollution, industrial effluents which may likely occur in locations 1 (Mashopa fish farm) and chemical exposure as observed in location 3 (Aquatech College of Agricultural Technology Fish Farm oultlet) as highlighted by Witeska *et al.* (2023).

This is backed up by similar report of increased leucocytes caused by the exposure of a *Clarias* sp to effluents of industrial waste according to Oluah, (2004). The location 1 of collection may be less than the specified 15m distance radius to source of water profile contaminants as stated by The open University (2024). The *Clarias* sp could have been exposed to effluents from a brewing plant that shared boundary with the location 1. While Petrochemical wastes, microplastics, paint materials, carbide and refrigerant chemicals are toxic impurities deposit to location 3 water source which have also been implicated to cause increase in lecucocytes in fish according to Thiele et al. (2021).

The uninfected male and female fish showed higher lymphocytes levels than infected ones, suggesting possible effects of underlying viral infections according to Guo *et al.* (2021) and bacterial infections (Adeyemi *et al.*, 2013). Furthermore, nutritional deficiencies linked to parasitism could also cause weakening of fish and compromised immune system (Kumar,2023; Iwanowicz, 2011).

Although, the mean lymphocytes concentration in infected male and female fish is lower than the uninfected, they remained within the reference of 49.33 ± 5.42 - 70.33 ±5.24% according to Tiamiyu *et al.* (2019). The lymphocytes in this study were the highest among the other white blood differential cells which is typical of most fishes (Owolabi 2011).

Monocytes counts in male fish showed no significant variation between infected and uninfected. This could be that the parasitic infection is not causing strong inflammatory response. However, uninfected female fish had higher values than infected which could be due to stress, or environment toxicity (Ivon *et al.*, 2020).

While the infected female fish showed lower monocytes counts, it is higher than 2.54±0.01 and 2.48±0.01 from the wild and cultured *C. gariepinus* according to Okeke *et al.* (2024) but it is still within the reference range of 2.83±2.18 to 3.6±2.63 obtained from different habitats recorded by Ipinmoroti (2015).

This recorded concentration of monocytes may be due to some physiological conditions that lowers white blood cells according to James (2024) or treatment of the fish with antibiotics by the farmer, which are known to cause direct toxicity and leucocytes suppression (Bojarski *et al.*2020).

Elevated heterophils concentration in both infected sexes compared to monocytes is a pattern of typical teleosts (Owolabi (2011). The concentrations of the white blood cells obtained are also associated with inflammatory response, engulfment and destruction of microbes (Tigner *et al.*,2022).

Relationship between morphometric values, haemoparasitic infection and sexes of fish

The study revealed sex-specific pattern in the relationship between morphometric traits and haemoparasitic infection and showed that the mean weight was similar in both infected and uninfected male fish. The infected female fish had lower weight than uninfected, this suggests that infection in the female fish could have reduced foraging competence (Tillman and Adelman, 2022), which may have caused reduction in weight (Olubiyo *et al.*,2023).

However, all other measurements were higher in haemoparasitic infected male fish than uninfected.

By implication, the well fed - male fish could have become infected due to voyage of food searching thereby exposing male fish to contaminated feed materials leading to infection. This is contrary to Uneke and Oruma (2019) where haemoparasitic infection were found among fish having both higher weight and standard length. Furthermore, this also suggests the agility in male to feed more than the female causing a better feed conversion ratio and higher growth rate as opined by Kareem (2011).

All morphometric parameters were lower in haemoparasitic infected female fish except the gill weight. This is an indication that female fish that were not infected often display restricted movement during the array of processes such as sexual behavior, egg development which brings about changes in foraging ability, feeding competition, and swimming performance and may not likely predispose it to infection (Iain,2000). Meanwhile, Bertucci *et al.* (2019) also implicated hormonal interactions affecting infection in female fish.

The mean gill weight (MGW) that was higher in infected female *Clarias gariepinus* than uninfected could be due to that the bigger gills had provided larger surface area for ventilation and accommodating more parasites, while the blood components of the gills could also provide nutrients for the gill parasites (Riera-Ferrer *et al.*, 2024).

In addition, the lesser morphometric values in the uninfected female compared to uninfected male may not due to parasitic infection but could have been attributed to reproductive development and processes in female which have impacted its feeding habits and contributing to decrease in weight and other morphometric as a result of diversion of energy necessary for growth and reproductive maturation (Arefayne et al., 2025).

The higher mean intestinal length (MIL) and mean intestinal weight (MIW) in the case of infected male of *C. gariepinus* than the uninfected, could be based on larger organ's capability to accommodate more food as well as providing larger surface area and indirectly becoming more parasitized in its bid to satisfy its appetite.

Contrary, the uninfected female *Clarias gariepinus* had similar higher values than infected. The situation here signifies that uninfected fish do not experience parasitism and nutrients' diversion contrary to parasitic infected fish that experiences anaemia according to Witeska, (2015). The disruption in normal physiological processes leads to reduction in both appetite and nutrient absorption ultimately leading to weight loss (Iboh and Ajang, 2016)).

The higher intestinal length to accommodate higher food leading to higher intestinal weight in the infected male may due to larger organ space and feeding agility. The non-parasitism and higher morphometric in uninfected female fish are conjoined to higher mean fish weight supporting the investigation of Duque-Correa *et al.* (2024)

CONCLUSION

Immune response as a reflector of health status of aquatic animal emerges from contact of immunostimulant to the animal and is thus revealed through haematological analysis. This study observed varying response from *C. gariepinus* to haemoparasites which is dependent on sex, environmental factors, age, unknown diseases and other underlying factors. Although values of haematological indices obtained revealed minor physiological changes, the fish species may display self- limiting condition to overcome it. Also, the morphometric variations were minimal to indicate no major loss in productivity. This situation can be referred to as subclinical infection while continuous investigation is eminent to monitor fish health due to environmental stress and co- infection.

Conflict of Interest

The authors declare no conflicts of interest

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