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Prevalence of Endoparasites and Haematology in Redbelly Tilapia from a Shallow Tropical Reservoir in Ghana

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Abstract

The goal of this study was to assess common endoparasites on *Tilapia zillii* in the Tono Reservoir, as well as to investigate the mean intensity and prevalence of these parasites. A total of 175 fish specimens were examined during the study. Endoparasites of three metazoans and one protozoan were observed from the *Tilapia zillii* gills, intestines, and stomach. The findings showed that the most common endoparasites affecting *Tilapia zillii* are *Ichthyopthirius multifiliis*, *Bothriocephalus* sp., *Contracaecum* sp., and *Dactylogyrus* sp. Also, *Contracaecum* sp had the highest prevalence of 29.71, followed by *Bothriocephalus* sp (18.86), *Ichthyopthirius multifiliis* (12), and *Dactylogyrus* sp (6.86). The average quantity of *Bothriocephalus* sp was 0.84, *Contracaecum* sp was 1.33, *Dactylogyrus* sp was 0.31, and *Ichthyopthirius multifiliis* was 0.54. The reservoir's physicochemical parameters changed every month due to inflows and other runoffs joining. Low levels of these parameters were discovered to influence the prevalence and distribution of these parasites. Haematological parameters showed significant changes between the adult and fingerling groups, where it was observed an improvement in health status in the adult group. It was also observed that fingerlings (0.1–20 g) were more infected, which significantly affected their blood profile.

Keywords: *Tilapia zillii*, endoparasite, blood profile, pathogenic effects, environmental stress.

Introduction

Fish parasites and their pathogenic effects can significantly affect production and also contribute to economic losses by reducing growth, reproduction, and resilience, and increasing vulnerability to disease and predation (Sitja-Bobadilla et al. 2016, Cable et al. 2017, Putra et al. 2021a, 2021b). In intensive fish culture systems where water quality is compromised, the severity of parasitic effects is very high (Addo et al. 2021). Parasites can infest the host fish's outer surface (ectoparasites) or penetrate the parenchyma of most tissues (endoparasites). In the wild, parasitism is much more common and diverse than on farms, ponds, and hatcheries (Mitiku and Adisu 2021). Infections occur not only as a result of overcrowding but also as a result of environmental stress (Scheifler et al. 2019). A study discovered that parasitic infections of tilapia tend to slow their growth rates (Wirawan et al. 2018, Osman et al. 2018). Several factors contribute to the low productivity of tilapia, especially in Sub-Saharan Africa, and one most significant factor which is often ignored is the prevalence of parasitic infections and diseases. This is because fish and other vertebrates serve as either intermediate or final hosts to a number of parasitic agents, resulting in their stunted growth, and hence the low volume of production in fish farms (Adou et al. 2017). As a result, blood profile

studies are vital because they provide relevant information about the physiological capacity of fish and serve as a useful tool for evaluating the immune system. Haematological parameters may also provide additional information about the host's health and immune status, which are important indicators of changes in the host (Ballarin et al. 2004, Wells et al. 2005, Tavares-Dias and Moraes 2007).

Tilapia zillii (Gervais 1848) (Osteichthyes, Perciformes, Cichlidae) the fish species usually known as redbelly tilapia is one of many that can be found in Ghana's Tono Reservoir. It is employed in many nations across the world for recreational fishing, aquaculture, the commercial aquarium trade, and weed management (Adesulu 2008, López-Elías et al. 2015). Aquatic plant species are managed using redbelly tilapia. Additionally, it has been used to manage mosquitoes, chironomid midges, and toxic aquatic insects. The redbelly tilapia is a highly prized species for both commercial and leisure fishing. Studies on the prevalence of parasites are crucial since redbelly tilapia is a significant source of less expensive protein (Pariselle and Euzet 2009); however, there is apparently little information on infection dynamics (Akoll et al. 2012, Tombi et al. 2014, Blahoua et al. 2016). The Tono Reservoir is a multipurpose fishery that provides food, nutrition, poverty reduction, and employment to those who rely on it. However, fish stocks have been declining for over a decade. Tono Reservoir fishers have reported poor catches, the landing of smaller-sized fish, and a decrease in revenue (Akongyuure et al. 2017). Moreover, there is no report on the occurrence of endoparasites on redbelly tilapia in the natural population of freshwater in the reservoir. The current study is necessary because it aimed to identify endoparasitic pathogens that infest one of the world's most important food and economic fish (redbelly fish) in the Tono Reservoir, Ghana as well as to check some water quality parameters that may stimulate endoparasites and the overall effects on fish health.

Materials and Methods

Study area

The Tono Reservoir (Figure 1), located at latitude10°60′N and longitude 1°07′W in the Kassena-Nankana Municipality of the Upper East Region of northern Ghana, is recognised as one of the largest agricultural reservoirs in West Africa. The vegetation in the study area is dry Guinea savannah characterized by short grasses and fire-resistant trees. The climate is sub-Sahelian, with mean minimum and maximum temperatures of 14 and 40 °C, respectively. Taysec, a British engineering firm, built the reservoir in the late 1970s and early 1980s. It is managed by the Upper East Region Irrigation Company. The reservoir is 2 km in length and irrigates 2,490 hectares of land (Asaana and Sadick 2016).

Fish sampling and data collection

One hundred and seventy-five live *Tilapia zillii* fish (redbelly Tilapia) of different sizes were collected from the Tono Reservoir using cast net method and were transferred into a plastic container with water and transported to the research laboratory in the University for Development Studies. Samples were collected between 7:00 am and 10:00 am every day as recommended by Adebisi (1981). Transportation was done in the morning to avoid undue stress due to temperature rise. These species were classified as adults and fingerlings. Adults with total lengths ranging from 12 cm to 19 cm and body weights ranging from 20.1 g to 40 g. Fingerlings had body weight of 0.1–20 g and total length of 8–11 cm. The total length was measured from the tip of the snout to the extreme end of the caudal fin and recorded in centimetres using a fish measuring board. The weights of the fish were measured by placing the individual fish on an electronic weighing scale and the readings were taken to the nearest 0.1 g.

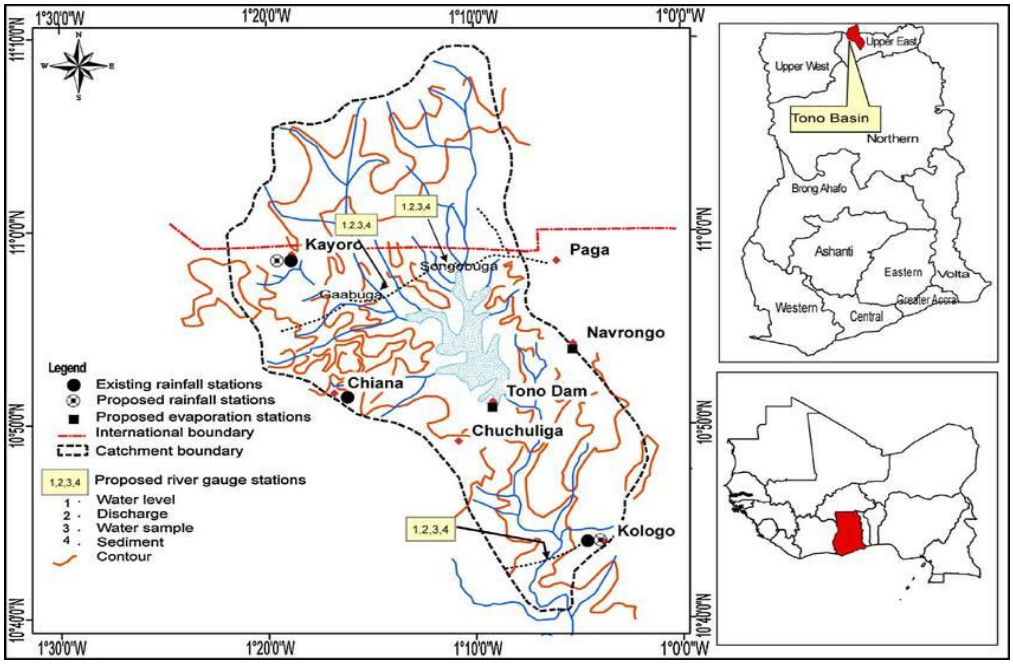

Figure 1: A map of Kassena-Nankana Municipality showing the Tono Reservoir.

Physico-chemical water quality analysis

Using a multipurpose probe, the reservoir water was tested for dissolved oxygen, temperature, turbidity, pH and nutrients (nitrites, nitrates, ammonia and phosphates). Turbidity was measured with a turbidimeter, and pH was measured with a Jenway 3510 pH meter. It was done at each time of sampling.

Laboratory examination and parasite identification

The stomach, intestines, and gills of fish were dissected with a dissecting kit and examined for parasites using a Celestron LCD Digital microscope model 44340 with a magnification of 80. The endoparasites were identified through careful examination under the microscope. Images were captured using a Celestron LCD Digital microscope Model 44340 and transferred to a laptop for identification. The parasitology manual of Stewart and Bernier (1999) was used as a guide for the identification of endoparasites.

Blood sampling

To assess the impacts of endoparasite on their health, blood samples were taken from 9 fish in each group: the adult group (12 cm to 19 cm and body weights ranging from 20.1 g to 40 g) and the fingerlings group (0.1–20 g and total length of 8–11 cm) right after capture. Using a 1 mL disposable syringe, a whole blood sample (0.5–1 mL) was drawn from the caudal section of the nine (9) selected fish from each group (Ye et al. 2019). For analysis, blood was drawn and decanted into a polypropylene specimen tube containing dipotassium EDTA. Blood was drawn before samples were sent to the laboratory.

Data analysis

The number of individual parasites found in an infected fish or host determines the intensity of parasites in a species. It is mathematically expressed as (Bush et al. 1997);

$$\text{Mean intensity} = \frac{\text{TPs}}{\text{TIF}}$$

Where: TPs = Total number of parasites in fish species; TIF = Total number of infected fish species.

The prevalence (%) of endoparasites was determined by expressing the total number of

infested fish individually as a ratio of the total number of fishes examined, expressed in percentages. It is expressed mathematically as (Bush et al. 1997);

$$\text{Prevalence} = \frac{\text{TIF}}{\text{THE}} \times 100$$

Where: TIF = Total number of infested fish species with a particular parasite species; THE = Total number of hosts examined.

Data acquired from the laboratory and field were analysed using Microsoft Excel (2013). By subjecting the measured indices to the IBM Statistical Package for Social Sciences (SPSS version 16.0), one-way ANOVA was used to determine significance in differences ($p < 0.05$) in haematological parameters. When there were differences in treatment means, the Duncan multiple range test was used to separate the differences in means ($p < 0.05$). The findings were presented as means with standard error (± SE).

Results

Prevalence of endoparasites with length

In Table 1, thirty-nine (39) of the total fish were infested with parasites. Twenty-seven (27) fish specimens were within the range of 8–11 cm representing 69.23%, and 12 were within the length range of 12–19 cm representing 30.77%. A total of 136 of the fish specimens were un-infested with parasites, 56 were within 8–11 cm representing 41.18%, and 80 were within 12–19 cm, and 58.82% fish specimens within the length range of 8–11 cm were the most infested with parasites, while specimens within the length range of 12–19 cm had the least infestations of parasites.

Prevalence in relation to body weight

Out of the total number of specimens examined, 21 fishes were infested representing 53.85% of weights between 0.1–20 g, and the remaining 18 fishes infested representing 46.15% were of weights within the range 20.1–40 g as shown in Table 2.

Table 1: Prevalence of endoparasites of *Tilapia zillii* with total length in the Tono Reservoir

Total length	Number of fish examined	Number of infested fish	Number of parasites identified
8–11	83	27	73
12–19	92	12	45
Total	175	39	118

Table 2: Prevalence of endoparasites of *Tilapia zillii* in relation with their body weight in the Tono Reservoir

Fish weight (g)	Number of fish examined	Number of infested fish	Number of parasites identified
0.1–20	97	21	82
20.1–40	78	18	36
Total	175	39	118

Prevalence in relation to site of infection

The gills of the fish were examined to be more infested with endoparasites (64) with a percentage of 54.24%, intestines recorded a total of 28 parasites with a percentage of 23.73%, and the least which was the stomach recorded 26 parasites with a percentage of 22.03% as shown in Figure 2.

Number of parasites against organs investigated

Table 3 presents the number of parasites and their distribution. Three metazoan and one protozoan endoparasites were obtained from the gills, intestines and stomach of infested *Tilapia zillii* species. These endoparasites that were identified include *Ichthyopthirius multifiliis*, *Bothriocephalus* sp, *Contracaecum* sp and *Dactylogyrus* sp.

The gills were observed to be infested with more *Ichthyopthrius multifiliis* followed by nematodes, *Bothriocephalus* sp and *Dactylogyrus* sp. The intestines were also observed to be infested with more *Bothriocephalus* sp and *Contracaecum* sp, and the stomach was also examined to be infested with more *Contracaecum* sp followed by *Bothriocephalus* sp.

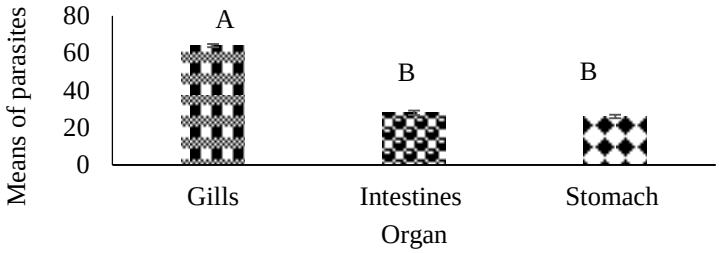

Figure 2: The number of parasites associated with each organ of *Tilapia zillii* in the Tono Reservoir.

Table 3: Parasites encountered and their distribution

Parasites	Taxonomic group (Phylum)	Organ infested	Number of infested fish	Parasite number
Bothriocephalus sp.	Platyhelminthes	Gills Intestines Stomach	11 13 9	33
Ichthyopthirius multifiliis	Ciliophora	Gills Intestines Stomach	21 - -	21
Contracaecum sp	Nematoda	Gills Intestines Stomach	20 15 17	52
Dactylogyrus sp (Flukes)	Platyhelminthes	Gills Intestines Stomach	12 - -	12

Parasite prevalence

Of all the parasites identified during this study, *Contracaecum* sp was observed to have the highest prevalence of 29.71% followed by Cestodes with 18.86%, *Ichthyopthirius multifiliis* with 12%, and *Dactylogyrus sp* with the least prevalence of 6.86% at ($p < 0.05$) (Figure 3).

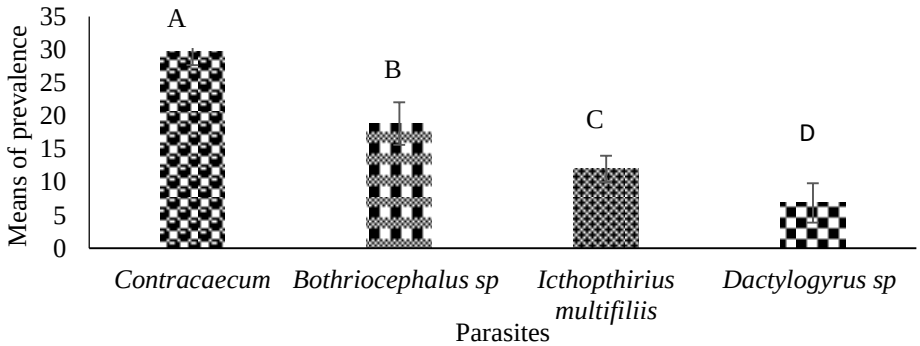

Figure 3: Prevalence of parasites associated with *Tilapia zillii* in the Tono Reservoir.

Prevalence in relation to water quality

The prevalence of endoparasites on *Tilapia zillii* in the reservoir was relatively high in the month of January when the level of the water in the reservoir had reduced, followed by March and February. The months that recorded the least prevalence were April and May when the water levels in the reservoir were relatively high at ($p < 0.05$) (Figure 4).

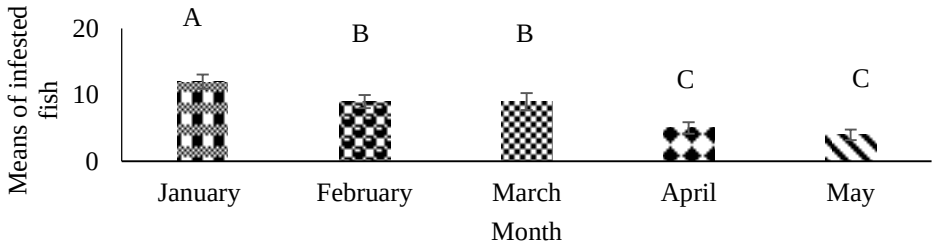

Figure 4: The monthly number of infested fish at the Tono Reservoir.

Mean intensity parasites prevalence

The mean intensity of Cestodes during the period of study was 0.84, *Contracecum* sp had a mean intensity of 1.33, *Dactylogyrus* sp had a mean of 0.31, and *Ichthyopthirius multifiliis* also recorded a mean of 0.54 at ($p < 0.05$) (Figure 5).

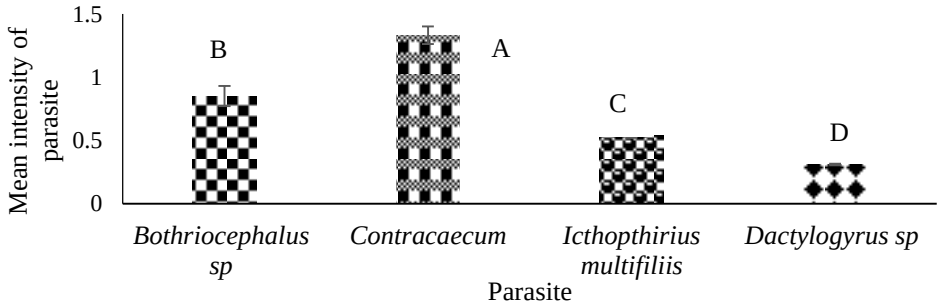

Figure 5: The mean intensity of endoparasites associated with *Tilapia zillii* in the Tono Reservoir.

Water quality

Physico-chemical water quality analysis

During the study period, the physico-chemical parameters of the reservoir were monitored. The temperature of the water was low in the month of January as compared to other months and was high in May during the study period. Dissolved oxygen was also low in the month of January and high in the month of May, pH was high in the month of May and low in the month of January, and Turbidity was also low in the month of January and high in the month of May. Nutrients were also high in the month of May and low in the month of January as shown in Table 4.

Haematological analysis

Results (Figures 6 and 7) revealed white blood cells (WBCs), red blood cells count (RBCs), haemoglobin (HGB) content and hematocrit (HCT) of both adults with total lengths ranging from 12 cm to 19 cm and body weights ranging from 20.1 g to 40 g and fingerlings with body weight of 0.1–20 g and total lengths of 8–11 cm showed significant different changes in the haematological parameters assessed. It was observed that adult fish had higher levels of the aforementioned haematological indices which were superior statistically to the fingerlings ($p < 0.05$). Observed parameters indicated decreasing trend in both adults and fingerlings in the form of WBCs, RBCs, HGB and HCT.

Table 4: Average physico-chemical parameters of the Tono Reservoir (n = 9)

Parameters	Upstream	Midstream	Downstream	Mean
Dissolved oxygen (mg/L)	3.36	3.02	3.11	3.16
Temperature (ºC)	26.7	27.9	26.5	27.03
Turbidity(NTU)	65.2	63.6	66.2	65.0
pH	7.5	7.3	7.1	7.3
Ammonia (mg/L)	0.637	0.603	0.619	0.619
Nitrate (mg/L)	0.873	0.996	0.897	0.922
Nitrite (mg/L)	0.079	0.061	0.073	0.071
Phosphate (mg/L)	0.001	0.001	0.001	0.001

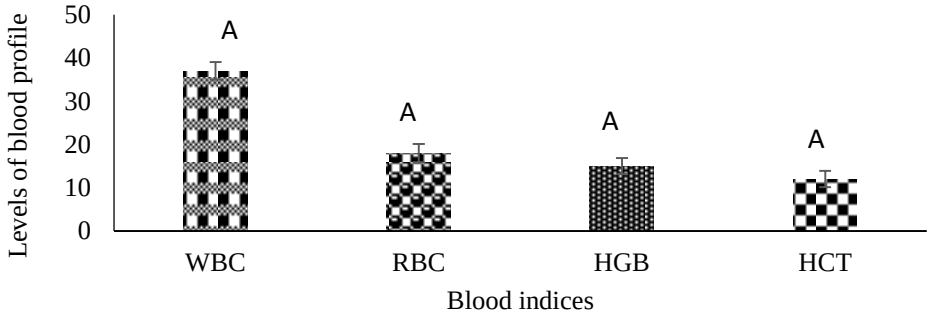

Figure 6: Blood profile of adult of weight (20.1–40 g) redbelly *Tilapia zillii*.

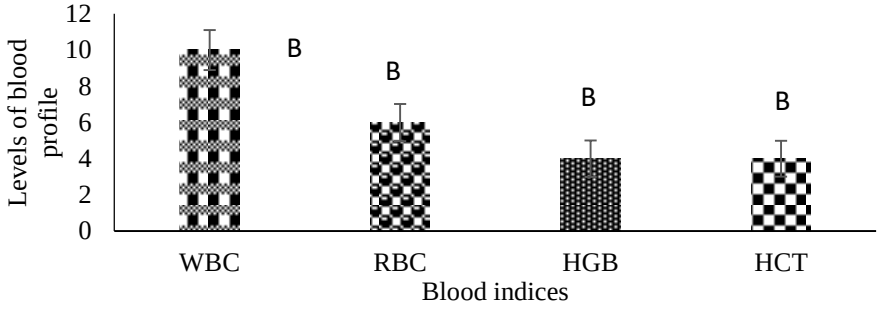

Figure 7: Blood profile of fingerling of weight (0.1–20 g) redbelly *Tilapia zillii*.

Discussion

The results of this study revealed *Contracaecum* sp., *Bothriocephalus* sp., *Dactylogyrus* sp., and *Ichthyopthirius multifiliis* as parasites encountered out of the 175 fish samples investigated. This is similar to the findings of several authors (Saleeza et al. 2014, Bozorgnia et al. 2012, Azhari et al. 2019, Akinsanya et al. 2007) who found *Dactylogyrus sp*., *Contracaecum sp*., and *Bothriocephalus* sp. in *Clarias anguillaris* in Onitsha along the Niger River and *Dactylogyrus* sp and *Ichthyopthirius multifiliis* in tilapia in cage culture system around Mpakadam in Ghana (Alhassan et al. 2018).

The highest intensity and prevalence were recorded in *Contracaecum* sp., followed by *Bothriocephalus* sp., *Ichthyopthirius multifiliis*, and *Dactylogyrus* sp. The physico-chemical parameters in relation to parasitic infestations revealed that the optimal parameters resulted in a low prevalence and intensity of endoparasites (Rückert et al. 2010, Nwadike 2018, Ngesa 2019). The physico-chemical parameters measured on the Tono Reservoir were generally favourable for tilapia growth. The conducive nature of the environment, in addition to the

appropriate physico-chemical parameters, may have contributed to the low levels of endo-parasite prevalence and intensity (Gichohi 2010, Alhassan et al. 2018). The prevalence of the parasites was higher in January during the sampling period, when water levels were low and lower in April and May when water levels were high.

High temperatures affect the solubility of dissolved oxygen, exposing fish to stress and, eventually, parasitic diseases (Wirawan et al. 2018). Temperature and dissolved oxygen levels were in a suitable range for fish growth in this study, which could explain the low intensities and prevalence of parasites. Moreover, the presence of these endoparasites could be due to fish-eating birds, horizontal transmission (occurring as a result of fishing nets used by fishermen at different landing sites with parasites present), or cattle drinking from the water. According to Ellis et al. (2017) and Wirawan et al. (2018), parasite vectors are spread by fish-eating birds, which carry the parasites in their mouth and release them into the water body during feeding or through faeces.

According to Otachi (2009), parasites can be discovered in mixed infestations on some parts of the host. Specific parasites infest specific host parts and dominate during a particular growth phase. Laboratory examinations during the study showed that *Bothriocephalus* sp were more present in the intestines than the gills and stomach, *Contracaecum* sp were more present in the stomach than the gills and intestines, and *Ichthyopthirius multifiliis* and *Dactylogyrus* sp dominated the gills of the fingerlings group compared to the adult group. This means that the smaller/younger fish were infested more than the larger/older fish. This could be attributed to the fact that younger fish have less developed parasitic immunity, whereas larger and older fish have well-developed parasitic immunity. This observation aligns with Sitja-Bobadilla and Palenzuela (2012) and Shehata et al. 2018) who reported that smaller fish are more vulnerable than bigger fish.

Blood is an excellent bio-indicator of any organism's health, and a pathological reflector of the entire body. As a result, haematological indices are useful in determining the functional status of a parasitized fish (host) as well as assessing the fish's physiological state (Radwan et al. 2021). According to the current study, parasitic infestations reduced WBC counts, RBC counts, haemoglobin (Hb) values, and hematocrit in the fingerlings group compared to the adult group. Furthermore, the parasites simply act as stressors, and during the early stages of stress, the haemaglobin and hematocrit change due to catecholamine release, which can mobilize red blood cells from the spleen or induce red blood cells swelling due to fluid shift into the intracellular compartment (Martins et al. 2004, Radwan et al. 2021, Sabry et al. 2021). WBCs play an important role during infestations by stimulating the haemopoietic tissues and immune system to produce antibodies and chemical substances that act as defence agents against infections. Therefore, the current study discovered an increase in WBCs and other haematological parameters studied in the adult group as evidence of improved health in response to pathological conditions as suggested by Saravanan et al. (2011).

Conclusion

A total of four species of endoparasites were identified namely, *Bothriocephalus* sp., *Ichthyopthirius multifilliis*, *Contracaecum* sp., and *Dactylogyrus* sp. *Bothriocephalus* sp and *Contracaecum* sp were found in all the parts examined, that is, the sampled fish gills, intestines and stomachs. The prevalence and the mean intensities of parasites on these selected parts were relatively low. The measured physico-chemical parameters fell within the optimum values for growth of tilapia. The mean levels of intensities of endoparasites observed in this study, may not pose major threats to the fish in the reservoir. Haematological indices also showed significantly more in the adult fish group than in the fingerling group. It was revealed that, health of the fish corresponds to the water quality parameters as well as the parasite infestations.

Competing and Interest
Authors declare no conflict of interest for this research.

Data availability: Data will be available upon request.

Permission ethical approval
All permission and ethical approval were sorted before the preparation of this manuscript.

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