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Ectoparasite infestation of *Oreochromis niloticus* and *Clarias gariepinus* in Bontanga and Golinga reservoirs, Ghana

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Abstract

Inland fisheries are the main source of protein and vital nutrients for many communities. However, these fisheries have several challenges, such as ectoparasites, and their detrimental effect on the food security and financial stability of those who depend on them. Ectoparasite infestations significantly negatively affect the profitability and standard of living of fish farmers since they can lower fish yields and quality overall. In the Bontanaga and Golinga reservoirs in northern Ghana, ectoparasite infestations of *O. niloticus* (Nile tilapia) and *C. gariepinus* (African catfish) were investigated for prevalence and variation. The study emphasizes how ectoparasites affect fish health, influencing regional economy and food security. The study discovered that the infestation rates of the different species and reservoirs varied. In general, the infestation rates of *C. gariepinus* were greater in Bontanga and Golinga, at 76% and 48.9%, respectively, than in *O. niloticus,* at 61.5% and 38.4%. The temperature and dissolved oxygen levels in Bontanga reservoir (28.50C and 6.8 mg/l) and Golinga reservoir (26.30C and 5.4 mg/l) were found to be statistically different at $p < 0.05$. In both reservoirs, there was a significant association ($p < 0.05$) between the ectoparasite prevalence and the water quality indicators. Seasons and water quality characteristics differed in the incidence of ectoparasites, highlighting the necessity for efficient management techniques to lessen these parasitic risks.

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Introduction

Inland fisheries are essential for maintaining livelihoods and food security, especially in developing nations. Through direct and indirect employment, these fisheries contribute significantly to local economies and are frequently a community's primary supply of protein and critical nutrients (Simmance, 2021; Smith and Bennett, 2019). Inland fisheries' productivity and sustainability are essential to preserving these advantages.

Fish parasites and their pathogenic effects can have a significant influence on production and economic losses by decreasing growth, predation, reproduction, and resilience while increasing disease sensitivity (Paredes *et al.*, 2021; Brown, 2012). Parasites can infest the host fish's outer surface or penetrate the parenchyma of most tissues. According to Paredes-Trujillo *et al.* (2021), Parasitism is much more common and diverse in the wild than on fish farms, ponds, and hatcheries. The prevalence of ectoparasites in tilapia is impacted by several criteria related to environmental stress (Ahmad *et al.*, 2016; Ojwala *et al.*, 2018; Sheifler *et al.*, 2019; Jiménez-García *et al.*, 2020; Irawan *et al.*, 2021). Studies have shown that ectoparasite infestations can cause a 12–15% drop in fish productivity in the afflicted areas, which can result in a significant reduction in fish yields (Paredes-Trujillo *et al.*, 2021) and slow their growth rates (Enyidi and Uwanna, 2019). Haematological parameters may also provide additional information about the host's health and immune status, which are important indicators of changes in the host (Tesfay *et al.*, 2024). *O. niloticus* and *C. gariepinus* are many fishes that are found in the Bontanga and Gonlinga reservoirs. These species are highly prized species due for leisure and commercial fishing. According to Masturoh and Anggita (2018), the prevalence of parasites is crucial since these species are significant sources of less expensive protein; however, there is little information on infestation dynamics (Akoll *et al.*, 2016). Both Bontanga and Golinga reservoirs are multipurpose fisheries that contribute massively to the surrounding communities through provision of food, employment, nutrition, and poverty reduction. These two freshwater systems have recorded a dwindling in catch resulting in a decrease in revenue (Abobi, 2019). Moreover, there is no report on the occurrence of ectoparasites (Tombi *et al.*, 2014). Enyidi and Uwanna (2019) reported that the incidence of ectoparasites can vary from 30% to 70%, contingent upon the water quality and season. It is therefore necessary to comprehend the frequency and variety of these infestations to develop effective control methods. The current study aimed to identify ectoparasite pathogens that infest one of the most essential global and economic species in Bontanga and Golinga reservoirs and the overall effects on fish health.

Materials and methods

Study area

The Golinga reservoir is in the Tolon district of Ghana's northern region and its surface size is a mere 0.62 km2. (9° 21' 36" N; 0° 57' 14.4" W) are its coordinates. It is in the Guinea Savanna belt, where June through October is the most notable rainy season (Fig. 1).

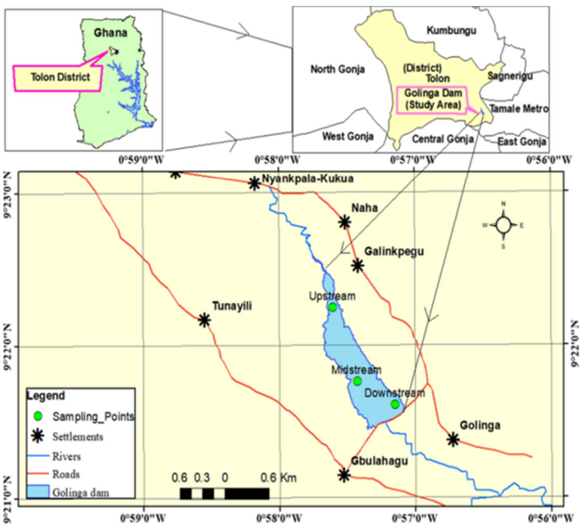


Fig. 1. A map showing the Golinga reservoir (Bekoe *et al.*, 2021)

Originally built in 1974 to facilitate irrigation for agriculture, the Golinga reservoir has evolved into a significant inland fishing area (Abobi, 2019). At full capacity, the reservoir holds 15623 m3 of water with a surface area of approximately 18 hectares and a mean depth of 2.473 m (Atindana *et al.*, 2006).

Bontanga reservoir

Located between latitudes 9° 30´ and 9° 35´ N and longitudes 1° 01´ and 1° 03´ W, the Bontanga reservoir was built in 1986. Its surface area is 770 acres, and its deepest point is 12 m (Fig. 2). Its average depth is 8 m. The region experiences an average of 1100 mm yearly rainfall, with a 75% relative humidity. With an annual mean temperature of 28.3 °C, the temperature ranges from 15 °C to 42 °C.

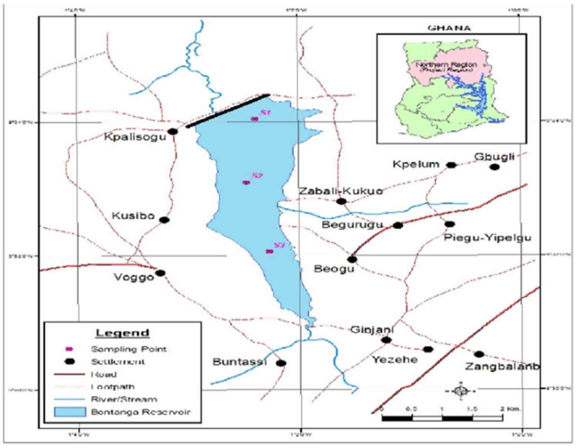


Fig. 2. A map showing the Bontanga reservoir (Cobbina *et al.*, 2013)

The peak season is in July/August during the rainy season, which runs from April/May to September/October. The dry season runs from November to March. According to Alhassan *et al.* (2014), it is the biggest reservoir in Ghana's northern area. The reservoir provides water for inland catch fisheries for fishermen as well as irrigation for crop development.

It is situated in the middle of the Zongbalund, Kumbungu, and Gbulung traditional zones. According to Alhassan *et al.* (2014), the primary vocations of the locals are subsistence farming and fishing.

Methodology

Sample collection

Using scoop nets, 249 live mixed-sex samples of *O. niloticus* (Nile tilapia) and *C. gariepinus* (African catfish) were taken from different cages at the farms. Early in the morning, these samples were taken. Table 1 displays the species composition of the sample of fish that was gathered.

Table 1. The two targeted fish species collected from the study

Species	Bontanga reservoir	Golinga reservoir
Oreochromis niloticus	26	99
Clarias gariepinus	25	99

The fish species were transported to the Spanish Laboratory of the University for Development Studies in Nyankpala, Ghana's Northern Region, for lab-based research after being stored on ice in a plastic container. Using scoop nets, the fish were removed from their various cages at the farms and placed right away in plastic containers filled with reservoir water.

Preparation and processing of samples

A plastic ruler was used to measure the overall length of each specimen, and the specimens were then categorized into three stages according to their sizes. The Initial Phase (0.1 cm - 7.0 cm), the Intermediate Phase (7.1 cm - 12.0 cm), and the Final Phase (12.1 cm - 18.0 cm) were the three stages that were included. The length was measured in cm from the tip of the snout to the farthest point of the caudal fin using a ruler dissecting board. Each fish was weighed individually, and set on a scale, and the results were recorded to the closest 0.1 grams. Based on weight, the fish samples were separated into the following categories: 0.1 g to 30.0 g, 30.1 g to 60.0 g, 60.1 g to 90.0 g, and 90.1 g to 120.0 g are the ranges in question.

Laboratory analysis

Fish samples were transported to the Spanish Laboratory of the University for Development Studies in Nyankpala and were examined for ectoparasites infestations using standard procedures. The exterior portions (skin and skin mucus, fins, gills, eyes, and scales) of the *O. niloticus* (Nile tilapia) and *C. gariepinus* (African catfish) samples were inspected for ectoparasites using a prepared wet slide that was observed using a light microscope and magnified hand lens.

Barker and Cone (2000) provided the methodologies that were used to analyze the fish samples. Data from the study were analyzed for the following variables: prevalence, mean intensity (MI), index of infestation (II), and density of infection (DI), per the recommendations of Bush *et al.* (2012):

Prevalence={(Number of infested with particular ecto-parasite species)/(Total number of fishes examined)}×100%

Mean Intensity (MI) = (Total number of parasite species in host species)/(Total number of infested fish species)

Analysis of physical properties of the reservoir water

Transparency was measured using a Secchi disc, while temperature and dissolved oxygen (DO) in the reservoir systems were measured using a multifunctional probe. The pH in-situ was observed using a HANNA probe meter. To prevent ambient oxygen from evaporating into the reservoir water, samples were gathered in sealed bottles before analysis. The samples were maintained in a -4°C ice cube to prevent the water from warming up and dissolving the nutrients. These parameters were recorded at each sample collection location in the two dams to assess their potential influence on ectoparasite infestations.

Data analysis

The data on fish species, ectoparasite prevalence, and water quality were inputted in a Microsoft excel and exported to SPSS for descriptive statistics analysis. The mean, standard deviation, and frequency distribution were conducted on ecto-parasite prevalence, intensity, species composition and water quality variable using SPSS/R Stadio. Inferential statistical tests, such as chi-square analysis, were used to evaluate the difference in ecto-parasite infestations between reservoirs and fish species at $p < 0.05$. The results were presented in tables.

Results and discussion

Abiotic factors of Bontanga reservoir and Golinga reservoir

During the study period, the physico-chemical parameters were examined (Table 2). The temperature of both Bontanga and Golinga was low in the months of April, May and June compared to high temperatures recorded in March. DO was optimal in all the months in Bontanga however, low in Golinga in Much when temperature was high. pH was optimal in the months of March, April and May with low pH recorded in the month of June.

Table 2. Average physico-chemical properties of Bontanga and Golinga reservoir

Reservoir	Bontanga				Golinga			
Month	March	April	May	June	March	April	May	June
Temperature (°C)	27.6	26.1	26.5	26.4	28.1	27.5	26.1	26.5
pH	5.71	5.91	5.69	4.61	2.69	5.64	5.71	5.91
DO (mg/L)	5.35	7.12	7.14	7.16	7.15	7.16	7.23	7.23

The steadiness of biological properties and physico-chemical factors of ponds, lakes and reservoirs is a critical component for determining successful production of fish and other aquatic resources according to Olanrewaju *et al.* (2017). Variations in the physical and chemical parameters have been reported by many authors (Ibrahim *et al.*, 2009; Olanrewaju *et al.*, 2017; Ajala and Fawole, 2024). According to Yerima *et al.* (2017) variations in the values of different physico-chemical factors reported have been attributed to changes in weather conditions and anthropogenic activities within and around the reservoir. Lawal and Ahmed (2014) stated that average water temperature of a reservoir fluctuates between 27.1-29.8°C. The low water temperature recorded in this study in April, May and June in Both water bodies might be due to the characteristics of the cool weather as a result of the rains while the relatively high-water temperature in March in Golinga may be as a result of low water level and higher atmospheric pressure (Ikongbeh *et al.*, 2017). According to Ibrahim *et al.*, 2009, the average pH values that support most biological activities of lake system range from 6.5-8.5. The exposure of water body, biological activities, temperature changes and decaying vegetation could account for the monthly variation of the water pH (Yerima *et al.*, 2017). Higher DO recorded could be as a result of low temperature and increased mixing of water whereas high temperature coupled with high rate of decomposition may be suggestive of lower DO values (Mustapha, 2008).

Prevalence of ectoparasite infestation

From the Bontanga and Gonliga reservoirs, 249 individuals of *O. niloticus* and *C. gariepinus* were sampled. 51 and 198 *O. niloticus* and *C. garepinus* individuals, respectively, were sampled from the Bontanga and Golinga reservoirs out of the 249 individuals examined to assess the infestation of ectoparasites (Table 3).

Table 3. Prevalence of ecto-parasite infestation of *O. niloticus* and *C. gariepinus* of the two reservoirs

Species	Bontanga			Golinga		
	No. of fish examined	No. of fish infested	% of fish infested	No. of fish examined	No. of fish infested	%of fish infested
Oreochromis niloticus	26	16	61.5	99	38	38.4
Clarias gariepinus	25	19	76	99	49	48.9
Total	51	35	68.62	198	87	43.93

Table 4. Size and prevalence of ectoparasite infestation of the two target fish species from Botanga and Golinga reservoirs

Fish size (cm)	Bontanga			Golinga		
	Sampled fish	Infested fish	% of fish infested	Sampled fish	Infested fish	% of fish infested
O. niloticus						
0.1 - 7.0	10	6	60.00%	40	14	35.00%
7.1 - 12.0	9	6	66.70%	35	14	40.00%
12.1 - 18.0	7	4	57.10%	24	10	41.70%
C. gariepinus						
0.1 - 7.0	8	6	75.00%	35	15	42.90%
7.1 - 12.0	10	8	80.00%	35	18	51.40%
12.1 - 18.0	7	5	71.40%	29	16	55.20%

Of the 51 individuals that were studied in the Bontanga reservoir, 26 of them belonged to *O. niloticu* and 25 to *C. gariepinus*, respectively. On *O. niloticus* and *C. gariepinus*, the prevalence of parasite infestation was 61.50% and 76%, respectively.

A total of 99 *O. niloticus* and 99 *C. gariepinus* individuals were investigated in Golinga for ectoparasite infection. 38 of the 99 *O. niloticus* specimens that were analyzed had ectoparasite infestations, which represent a 38.40% rate of infestation. 49 out of the 99 *C. gariepinus* specimens that were analyzed had infestations, or 48.90% prevalence.

Size variation and the prevalence of ectoparasite infestation

Oreochromis niloticus and *Clarias gariepinus* ectoparasite infestation size variation and prevalence from Bontanga and Golinga reservoir (Table 4).

Smaller *O. niloticus* fish (0.1–7.0 cm) in Bontanga Reservoir showed a 60.00% infection rate; the largest infestation was seen in the middle size group (7.1–2.0 cm), which represented 66.70% of the total. On the other hand, *O. niloticus* from the Golinga Reservoir had lower overall infestation rates; the smallest fish had an infestation rate of 35.00%, and the infestation rate increased somewhat as the fish size grew, culminating at 41.70% for the largest fish (12.1-18.0 cm).

The Bontanga reservoir's *C. gariepinus* was more common in smaller fish and the intermediate-size group, accounting for 80.00% and 75.00% of the infection, respectively. The largest *C. gariepinus* fish in the Golinga reservoir had a high infection rate of 55.20%. In contrast, the findings show that the degree of ectoparasite infestation varies considerably depending on the species, size, and location of the reservoir. In general, *C. gariepinus* exhibits higher rates of infestation than *O. niloticus*, especially in the Bontanga reservoir.

Parasites dominate during a given growth phase and infest specific parts of their hosts. Laboratory analyses revealed that the predominant documented parasite, Ancho worm, flatworms were more prevalent in younger and adult groups. However, the middle fish group was dominated by these parasite infestations. Bazari *et al.* (2009) and Takemoto *et al.* (2009) recorded a high parasitic infection rate in smaller fish. However, some researchers (Bichi and Ibrahim, 2009; Imam and Dewu, 2010) reported that, infection rate rises with increasing weight and length. This could be attributed to the fact that, larger and older fish have a well-developed parasitic immunity, smaller fish and fishes in the middle groups lack parasitic immunity. This conclusion is in agreement with the findings of Shehata *et al.* (2018), who found that younger and smaller fish groups have a longer history than larger fish.

Table 5. Parasite prevalence on the various parts of the two species

Parasite	Location	Bontanga		Golinga	
		C. gariepinus	*O. niloticus*	*C. gariepinus*	*O. niloticus*
		% infested	% infested	% infested	% infested
Anchor worm	Tail	0	0	4	0
	Mouth	7.7	4	4	0
	Skin/Scale	0	2	0	0
	Eye	0	0	4	0
Apiosoma	Skin/Scale	0	0	0	1
Argulus spp	Tail	0	0	4	0
	Eye	0	0	4	0
	Skin/Scale	3.8	0	8	0
Capillaria	Tail	0	2	0	1
	Eye	0	2.2	0	1
Chilodonella	Tail	0	0	0	1
Copepods	Tail	0	0	0	3
	Mouth	0	0	0	3
	Skin/Scale	0	2	0	0
Flat worm	Tail	0	3	0	8.1
	Mouth	0	0	0	2
	Skin/Scale	3.8	4	0	9.1
	Eye	0	3	0	8
Ichthyophthirius multifiliis	Skin/Scale	0	2	0	1
Lernaea	Tail	3.8	0	0	0
	Eye	3.9	0	0	0
Trichodina	Tail	0	4	0	1
	Eye	0	4	0	1

Prevalence of ectoparasites infestation on Oreochromis niloticus and Clarias gariepinus

Table 5 shows the number of parasites and their distribution. *Argulus*, Flatworm, and *Ichthyophthirius multifiliis* were most commonly seen on the skins of *O. niloticus* and *C. gariepinus* in the Bontanga and Golinga reservoirs. The mouths were found to be contaminated by anchor worms of both species from the Bontanga reservoir and solely *C. gariepinus* from Golinga. Only the eye of *C. gariepinus* from Bontanga was infected with *Lernaea* parasites.

Krasnov *et al.* (2005) claim that ectoparasites can be found in specific areas of the host. Nonetheless, three ectoparasites species including Flatworms, Achor worm, and *Trichodina* were most ectoparasites recorded from different organs of the two fish specimens of the reservoirs.

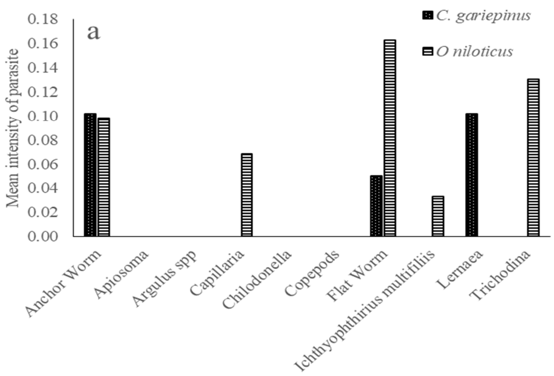
Flatworm was recorded from the general body surface while Anchor worm and *Trichodina* were recorded from mouth and eye respectively. These parasites were obtained from the fish specimen with a different rate of infestation which could be an indication of changes in water quality resulting from anthropogenic pollution yet have not resulted in an increase in ectoparasites load.

The physical conditions of the water body particularly in dissolved oxygen influence embryonic development through reduction in eggs of parasites according to Rafique *et al.* (2002) and Amoako (2006). Moderate changes in abiotic factors and anthropogenic activities can contribute to examination of parasites infestation making the environment unsuitable for ectoparasites.

Though these species are harmful however the present infestation level does not pose any severe threats as confirmed by Alhassan *et al.* (2023) who conducted a study on endoparasites of *O. niloticus* in reservoirs.

Mean intensity of parasites prevalence

In Bontanga, the mean intensity of Flatworm during the study period was 0.16, followed by *Trichodina* (0.13), anchor worm had a mean of 0.10 and *Capillaria* recorded a mean intensity of 0.07 (Fig. 3a). In Golinga, Flat worm recorded a mean intensity of 0.71, and Copepods recorded a mean intensity of 0.16. The remaining parasites recorded a mean intensity of less than 0.10 (Fig. 3b)



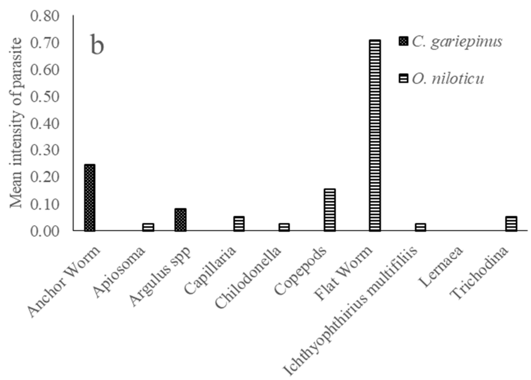


Fig. 3. The mean intensity of endoparasites association with *C. gariepinus* and *O. niloticus* in Bontanga (a) and Golinga (b) reservoir

Monthly and mean prevalence of ectoparasite infestation

The prevalence of ectoparasites on both *O. niloticus* and *C. gariepinus* was relatively high in the month of April and May in Bontanga and Golinga when the level of the water had just begun to increase, followed by Aril where the rains has just begun (Table 6).

The most prevalent parasites found in the two reservoirs from March (dry period) to June (raining season) were Flat worm, *Capillaria*, and *Trichodina* in Gonlinga and *Argulus* sp. and *Lernaea* in Bontanga. This study showed that inland fishes are vulnerable to various types of ectoparasites, especially the Trichodinids, and monogenea groups. This infestation might be resulting from consistent anthropogenic activities and eutrophication which plays an important role in maturation, rise and abundance of fish parasites in reservoirs systems. The finding from this study is similar to Ajala and Fawole (2024) and Ahmed (2016) who confirmed that deterioration of water quality with changing seasons might have resulted to high stress response in fishes making them vulnerable to parasitic infections.

Table 6. Monthly variation in parasite prevalence in Bontanga and Golinga reservoirs

Month	Reservoir	Mean±S.E. prevalence (%)	S.D.	p-value
March	Bontanga	27.0 ± 6.2	20	0.20
	Golinga	24.0 ± 5.5	18	
April	Bontanga	30.0 ± 7.0	23	0.18
	Golinga	26.0 ± 6.0	20	
May	Bontanga	32.0 ± 7.5	25	0.22
	Golinga	28.0 ± 6.5	22	
June	Bontanga	28.0 ± 6.8	24	0.21
	Golinga	25.0 ± 6.0	21	

Table 7 shows that there is a statistically significant difference in parasite prevalence in Bontanga (F-statistic = 4.73, p-value less than 0.01) and Golinga (F-statistic = 3.92, p-value of 0.02, likewise demonstrating substantial variance).

Table 7. ANOVA results for monthly variation in parasite prevalence

Reservoir	F-Statistic	p-value
Bontanga	4.73	<0.01
Golinga	3.92	0.02

The mean temperature, Dissolved Oxygen, and pH were within their optimal range statistically suggesting no significance difference in physicochemical parameters of Bontanga and Golinga reservoirs (Table 8).

Table 8. Physical parameters and parasite prevalence in Bontanga and Golinga reservoirs

Physical parameter	Reservoir	Mean prevalence	p-value
Temperature (°C)	Bontanga	27.5	0.027
	Golinga	26.3	
Dissolved oxygen (mg/L)	Bontanga	6.8	0.015
	Golinga	5.4	
pH	Bontanga	7.2	0.048
	Goling	7.3	0.045

Impacts of environmental factors on ectoparasites prevalence have been discussed by many authors (Qayoomand Shah, 2017) who reported on various physico-chemical parameters including water dissolved oxygen, temperature, total ammonia-nitrogen and pH and eutrophication and confirmed they might have influence on the occurrence of parasite populations. Anova showed no significant difference in physico-chemical parameters and the prevalence of parasites in the two reservoirs. This result disagrees with the findings of Modu *et al.* (2016) who reported a strong positive and highly significant relationship of temperature with the prevalence of parasites.

Conclusion

Ten different ectoparasite species namely, *Capillaria*, Copepods, Flat worms, Anchor worms, *Trichodina*, *Chilodonella*, *Apiosoma*, *Ichthyophthirius multifiliis*, and *Lernaea* spp. were identified from the Bontanga and Golinga reservoirs. Anchor worm was found in the mouth of *C. gariepinus* from Bontanga and in the mouth, tail, and eye of the species from Golinga, while Flatworm was found on the scale of both species from both reservoirs.

In these areas, parasite prevalence and mean intensity were comparatively low. Both Bontanga and Golinga's physicochemical characteristics fell within the ranges that were best for the species under investigation in terms of growth. The fish in the reservoir may not be seriously threatened by the mean endoparasite intensities identified in this study.

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