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Gill Monogenean parasites infestation level and impact on the condition factor of catfish *Heterobranchus longifilis* (Clariidae) in the Ayame 2 man-made lake, Côte d'Ivoire

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Abstract
Heterobranchus longifilis is a key tropical catfish species of high aquacultural relevance in West Africa, owing to its rapid growth, wide ecological tolerance, and resilience to environmental stressors. In the Ayame 2 reservoir, which is subject to significant anthropogenic pressures, no parasitological study has yet been conducted on the gill Monogeneans infesting this fish species. This study, conducted from August 2022 to July 2023, aimed to assess the diversity, prevalence, and infection dynamics of gill Monogeneans in *H. longifilis* populations under local ecological conditions. A total of 302 *H. longifilis* specimens were sampled using gillnets and baited traps. Gill arches were excised and examined for Monogenean parasites, identified morphologically. Four species of the genus *Quadriacanthus* were recorded : *Q. longifilisi* (P : 95.20% ; MI : 32.70), *Q. thysi* (80.80% ; 31.42), *Q. tricorniculatus* (42.73% ; 19.20), and *Q. triunguisi* (45.45% ; 15.85). *Quadriacanthus longifilisi* and *Q. thysi* were dominant taxa, particularly abundant during the main rainy season, while *Q. tricorniculatus* and *Q. triunguisi* displayed peak values during the dry season. Host size had a significant influence on parasitism : fish ≥ 37.5 cm exhibited the highest infection metrics, with *Q. longifilisi* reaching 97.72% prevalence and 28.12 mean intensity. Only *Q. triunguisi* showed no size-dependency. Fulton's condition factor (K) was significantly lower in parasitized individuals, especially in smaller fish (K = 0.33 ± 0.07), indicating compromised somatic condition likely due to parasitic stress. These findings underscore the role of Monogeneans as bioindicators of ecosystem health and support their integration into hydrobiological monitoring and aquaculture sustainability strategies in West African freshwater systems.

Keywords: Fish, parasite, infection, lake ayame 2, Côte d'Ivoire

Introduction

Heterobranchus longifilis is widely recognized as one of the most important tropical catfish species for aquaculture in West Africa (Clay, 1979 ; Akinsanya and Otubanjo, 2006) [7] [3]. This species inhabits a range of freshwater ecosystems, including lakes, rivers, swamps, floodplains, and streams. Its broad geographic distribution, rapid growth rate, and high tolerance to handling and environmental stress make it highly valued for both subsistence and commercial aquaculture across several African countries (Gertjan *et al.*, 1996) [11].

As with most free-living organisms, fish host a wide variety of parasites. Parasitism is considered the most prevalent lifestyle on Earth (Price, 1980 ; Windsor, 1995) [18, 22], and parasites particularly those with complex life cycles are important ecological indicators. Their presence can provide critical insights into host ecology, trophic interactions, biodiversity, and environmental stressors (Overstreet, 1997 ; Marcogliese, 2004) [15, 16].

Among fish parasites, Monogeneans are a group of ectoparasites with direct life cycles (holoxenous), requiring no intermediate host. They are commonly found on external surfaces such as gills, skin, and fins, but can also infest internal sites such as the rectum, nostrils, and stomach (Eyo *et al.*, 2015) [10]. Beyond their biological significance, Monogeneans serve as effective bioindicators of environmental change and aquatic ecosystem health (Luque and Poulin, 2007 ; Ramadan *et al.*, 2014) [13, 19].

In lake Ayame 2, a man-made reservoir in southeastern Côte d'Ivoire, *Heterobranchus longifilis* is frequently exposed to gill Monogenean infestations. Despite increasing anthropogenic pressures on this aquatic environment, no parasitological studies have yet been conducted to assess the composition and infection dynamics of Monogeneans in this host. Such data are crucial for understanding potential health risks, managing parasite outbreaks, and ensuring the sustainability of aquaculture in the region.

Given that parasitic communities vary according to the ecological characteristics of each habitat, this study aims to characterize the Monogenean parasite fauna on the gills of *H. longifilis* in Lake Ayame 2 and to analyze how infestation patterns relate to host size under local environmental conditions.

Material and Methods

Study area

Lake Ayame 2 is a man-made reservoir located in southeastern Côte d'Ivoire, between latitudes 5°34′ and 5°37′ N and longitudes 3°09′ and 3°10′ W (Figure 1). It spans an approximate surface area of 7 km² and was formed following the construction of two hydroelectric dams on the Bia River. The lake lies between the dike of the upstream Ayame 1 dam and the downstream Ayame 2 dam, with its hydrological regime regulated by the release and retention operations of the first dam. This aquatic system is subject to significant ecological fluctuations, including the periodic emergence of floating plant biomass, influenced by both seasonal patterns and dam management. The region experiences a transitional equatorial climate, characterized by four distinct seasons (Eldin, 1971 ; Ahoussi *et al*., 2013) [2, 9] : a long rainy season (April-July), a short dry season (August-September), a short rainy season (October-November), and a long dry season (December-March). The average annual rainfall ranges between 1400 and 1600 mm (Brou *et al*., 2005) [6]. Hydrologically, flood events typically occur twice a year from June to July and from October to November while low water periods are observed during the long dry season (December to March) and the short dry season (August to September). The surrounding vegetation is dominated by dense humid tropical rainforest, contributing to the ecological complexity of the lake and its watershed (Brou *et al*., 2005) [6].

Host sampling and parasite collection

Sampling was conducted monthly over a full annual cycle, from August 2022 to July 2023, using gillnets and baited traps. Upon capture, the *H. longifilis* gill arches were immediately excised by dorsal and ventral incision, then individually referenced according to each fish specimen. The gill samples were wrapped in aluminum foil, stored on ice in the field, and subsequently preserved at 20°C in the laboratory until parasitological examination. A total of 302 individuals of *Heterobranchus longifilis* were analyzed. For each specimen, morphometric measurements were recorded, including standard length (SL : horizontal distance from the anterior tip of the snout to the base of the caudal fin) and total length (TL : horizontal distance from the anterior tip of the snout to the posterior end of the caudal fin), both measured in millimeters. The body weight was recorded in grams using a digital electronic balance. Monogenean parasites collected from the gill tissues were identified morphologically based on the diagnostic criteria described by Malmberg (1957) [14] and later refined by Pariselle and Euzet (2009) [17].

Epidemiological parameters and Condition Factor (K)

Common epidemiological parameters such as prevalence (P) and mean intensity (MI) were calculated according to Valtonen *et al*. (1997) [21] to explain the extent of the parasite population in the host. Thus, parasites are considered dominant, satellite, and rare, respectively when $P > 50\%$, $10 < P < 50\%$, and $P < 10\%$. To determine the species balance within a community, the level of succession, the influence of extreme factors, and the influence of the environment, certain indices were evaluated. These are the prevalence (P) and mean intensity (MI) of parasites, the formulas of which, according to Bush *et al*. (1997) [5], are as follows :

P = Number of infested hosts x 100/total number of fish examined

MI = Total number of individuals of a parasite species (n) in a sample of hosts / Total number of fish infected with the parasite in a sample (N)

The Fulton's Condition Factor (K) suggests that the weight of the fish is proportional to the cube of the length and was used to assess the general health of the fishes, on individual and population level. In all individuals' total length, standard length and body mass were measured. The allometric equation where the b exponent is a constant was used to compare the health index of the different category of fishes.

Thus, Fulton's condition factor (K) was calculated using the formula :

$K = W*100/ Lb^3$ (Le Cren, 1951) [12]

Where W = weight of fish (g), L = standard length of the fish (cm), b = coefficient of allometry considered equal to 3).

The Fulton's condition factor was multiplied with 100 to get it close to 1, and the number 1 indicated a normal condition of the fish, greater 1 indicated fat fish and less than 1 indicated skinny fish. This morphometric index assumes that the heavier fish for a given length the better condition.

Data analysis

All collected data were compiled and organized using Microsoft Excel for subsequent statistical analysis. The chi-square (χ^2) test was applied to evaluate differences in infection prevalence across seasons and host size classes. Variations in parasite abundance were assessed using non-parametric statistical methods, specifically the Kruskal-Wallis test for comparisons among multiple groups, and the Mann–Whitney U test for pairwise comparisons. All statistical analyses were conducted using Statistica software, version 7.1. Results were considered statistically significant at a 95% confidence level ($p < 0.05$).

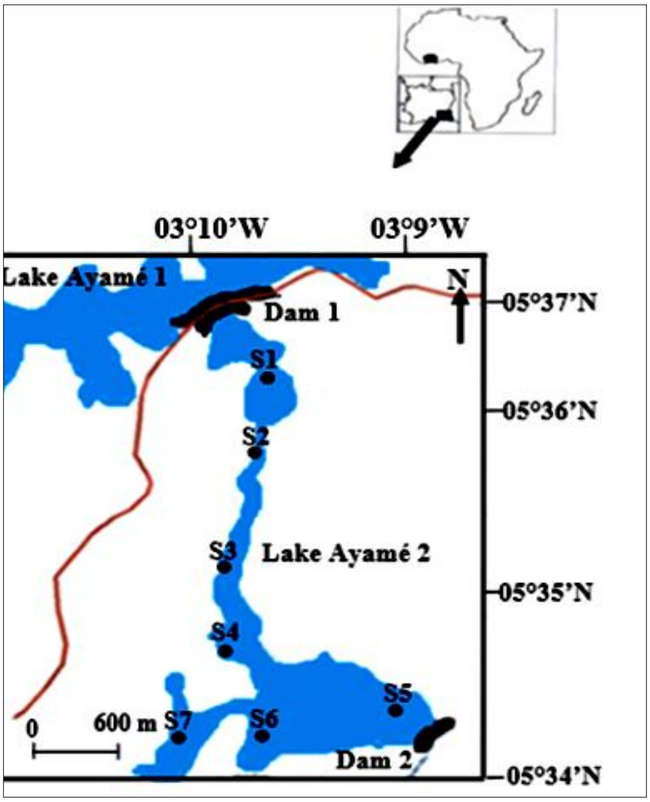

Fig 1 : Map of man-made lake Ayame 2 and the sampling sites

Results

Monogenean species diversity and epidemiological parameters

A total of four Monogenean species were identified on the gills of *Heterobranchus longifilis* : *Quadriacanthus* *longifilisi*, *Q. thysi*, *Q. tricorniculatus*, and *Q. triunguisi*. Among the 302 catfish specimens examined, 95.20% were infested with *Q. longifilisi*, 80.80% with *Q. thysi*, 42.73% with *Q. tricorniculatus*, and 45.45% with *Q. triunguisi*. Based on prevalence, *Q. longifilisi* and *Q. thysi* were identified as dominant species, while *Q. tricorniculatus* and *Q. triunguisi* were considered satellite species. The mean intensity of infection varied among species, with *Q. longifilisi* showing the highest value (32.70), followed by *Q. thysi* (31.42), *Q. tricorniculatus* (19.20) and *Q. triunguisi* (15.85), indicating differing infestation pressures within the Monogenean community structure.

Temporal variation in prevalence and mean intensity of Monogenean parasites in *Heterobranchus longifilis*

The monthly variation in parasitic indices of *Heterobranchus longifilis* in lake Ayame 2 is illustrated in Figures 2 and 3. The highest prevalence rates were recorded during the main rainy season, particularly in June and July, with *Quadriacanthus longifilisi* and *Q. thysi* reaching 95.20% and 80.80%, respectively. Conversely, lower prevalence values for these species were observed during the dry months of August and March. A chi-square (χ^2) analysis revealed a statistically significant difference in prevalence between seasons ($p = 0.02 < 0.05$). Similarly, the mean intensities of infection were notably higher during the rainy season, with *Q. longifilisi* and *Q. thysi* exhibiting peak intensities of 32.70 and 31.42, respectively, in June. The Kruskal–Wallis test confirmed significant seasonal differences in parasite intensity ($p = 0.01 < 0.05$), further supported by pairwise comparisons using the Mann–Whitney U test ($p = 0.01 < 0.05$). These results suggest that *H. longifilis* is more heavily infested with *Q. longifilisi* and *Q. thysi* during the rainy periods. In contrast, higher prevalence and intensity values for *Q. tricorniculatus* and *Q. triunguisi* were recorded during the dry season, specifically in March and September. Prevalence and mean intensity values were 42.73% (19.20) for *Q. tricorniculatus* and 45.45% (15.85) for *Q. triunguisi*. Statistical analyses (Chi-square, Kruskal-Wallis and Mann–Whitney tests) indicated that these seasonal differences were significant ($p < 0.05$), highlighting a differential seasonal pattern of infestation among Monogenean species.

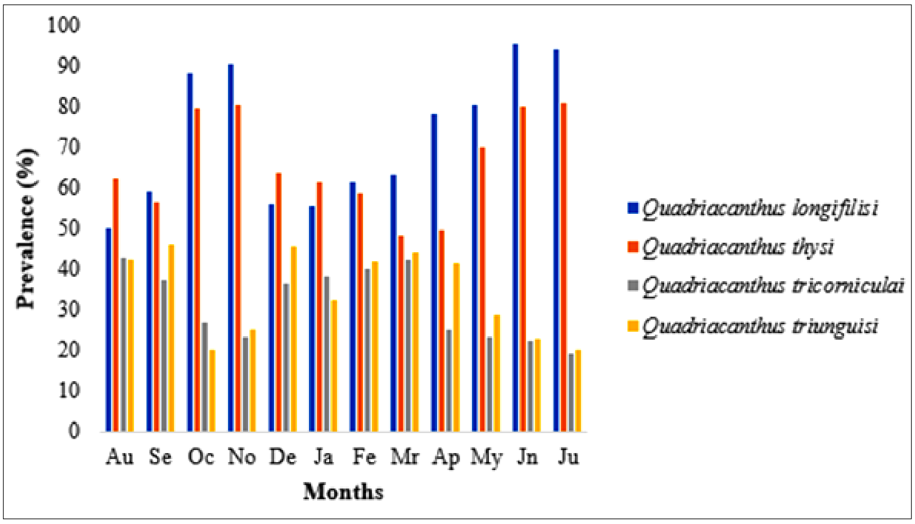

Fig 2 : Prevalence of *Heterobranchus longfilis* parasites sampled in Ayame 2 lake

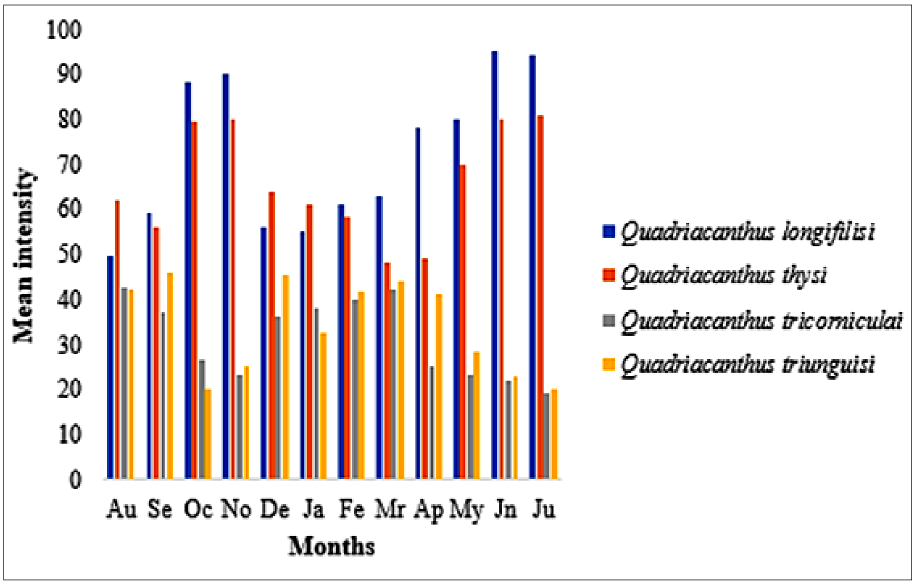

Fig 3 : Mean intensity of *Heterobranchus longfilis* parasites sampled in Ayame 2 lake

Variation of epidemiological indices according to host size (*Heterobranchus longifilis*)

Table1 presents the variations in epidemiological indices across different size classes of *Heterobranchus longifilis*. The results showed that, with the exception of *Quadriacanthus triunguisi*, the prevalence and mean intensity of all Monogenean species increased with host size. The highest prevalence and mean intensity values were recorded in fish with a standard length ≥ 37.5 cm, reaching 97.72% and 28.12 fors *Q. longifilisi*, 90.28% and 22.53 fors *Q. thysi*, 93.11% and 20.83 fors *Q. tricorniculatus*, and 56.23% and 9.67 fors Q. triunguisi. Chi-square tests indicated that prevalence varied significantly with host size for all Monogenean species ($p < 0.05$). Kruskal-Wallis tests, followed by Mann–Whitney U tests, revealed significant size-related differences in parasite intensity for *Q. longifilisi*, *Q. thysi*, and *Q. tricorniculatus* ($p < 0.05$). However, no significant difference was observed in the intensity of *Q. triunguisi* infestations across size classes (Kruskal-Wallis, $p > 0.05$), suggesting that its parasitism is not size-dependent.

Table 1 : Prevalence and Mean Intensity of Monogenean parasites of *Heterobranchus longifilis* in relation to host size in Ayame 2 lake

	Host class sizes (cm)			
Parasite species	**LS < 22.5**	**[22.5 - 27.5[**	**[27.5 -32.5 [**	**LS ≥ 37.5**
Quadriacanthus longifilisi	63.22 (7.02)	76.13 (10.27)	88.25 (14.18)	97.72 (28.12)
Quadriacanthus thysi	59.18 (5.22)	74.53 (12.41)	83.31 (18.2)	90.28 (22.53)
Quadriacanthus tricorniculai	46.32 (4.89)	56.30 (10.41)	80 (16.24)	93.11 (20.83)
Quadriacanthus triunguisi	33.14 (8.46)	33.25 (8.64)	52.6 (9.11)	56.23 (9.67)

LS : Standard Length

Parasitism a function to host size and Condition factor of *Heterobranchus longifilis*

Table 2 summarizes the condition factor (K) of both infested and uninfested *H. longifilis* across size classes. In all classes, uninfested individuals exhibited condition factors below 1. Among infested fish, the condition factor remained consistently low, with the lowest value (0.33 ± 0.07 g/cm³) observed in the smallest size class (< 22.5 cm) and the highest (0.50 ± 0.01 g/cm³) in fish ≥ 37.5 cm. The Mann–Whitney U test revealed statistically significant differences in condition factors between infested and uninfested fish within each size class ($p < 0.05$). Additionally, among infested fish, smaller individuals exhibited significantly lower condition factors than larger ones (Kruskal–Wallis, $p = 0.01 < 0.05$).

Table 2 : Condition factor (K) of infested and uninfested specimens *Heterobranchus longifilis* collected from Ayame 2 lake according to host size

		Host class sizes (cm)			
Examined Fish	**Parameters**	**LS < 22.5**	**[22.5 - 27.5[**	**[27.5 - 32.5 [**	**LS ≥ 37.5**
Uninfested	Total Length (cm)	19.12±0.7	24.72±0.4	28.62±0,2	39.2±0.3
	Weight (g)	62.9±1.1	138.97±0.9	190.75±0,9	518.03±0.2
	Condition Factor (K) (g/cm³)	0.9±0.2	0.92±0.1	0.83±0.2	0.86±1.4
Infested	Total Length (cm)	17.32±1.3	22.8±0.01	28.1±1.3	37.9±0.1
	Weight (g)	17.14±0.5	46.22±0.4	104.28±0.3	272.19±0.9
	Condition Factor (K) (g/cm³)	0.33±0.07	0.39 ±0.03	0.47±0.3	0.5±0.01

LS : Standard Length

Discussion

The gills of *Heterobranchus longifilis* collected from Lake Ayame 2 were found to be infested with four Monogenean species : *Quadriacanthus longifilisi*, *Q. thysi*, *Q. tricorniculatus*, and *Q. triunguisi*. It is well established that Monogenean species richness varies by host species, and such variability can be attributed to a combination of host-parasite coevolution, ecological factors, and water quality parameters. The observed polyparasitism may reflect a balanced parasitic community, as noted in wild environments where ecological equilibrium permits niche partitioning among parasites on the gill surfaces (Simková *et al*., 2006). This co-occurrence may facilitate the simultaneous colonization of a single host by multiple Monogenean species. The highest prevalence and intensity of *Q. longifilisi* and *Q. thysi* were recorded during the rainy season, corroborating findings by Adou *et al*. (2017) [1] and Blahoua *et al*. (2016) [4], who reported similar patterns in *Tilapia guineensis* and *Oreochromis niloticus*. The increase in parasite burden during this period may be linked to elevated turbidity levels caused by runoff and domestic wastewater entering the lake. These suspended particles can serve as vectors for infective larval stages, enhancing transmission. Moreover, increased oxygenation typical of rainy seasons could create favorable physiological conditions for parasite development. In contrast, *Q. tricorniculatus* and *Q. triunguisi* exhibited higher infection indices during the dry season. This could be due to the eutrophication of the lake during dry months, leading to the proliferation of aquatic macrophytes. Dense plant cover may facilitate contact between infective larvae and fish hosts by acting as a reservoir for larval stages. Additionally, reduced water levels during this period likely increase host-parasite encounter rates. Regarding host size, Monogeneans were recovered from all length classes of *H. longifilis*, but prevalence and mean intensity generally increased with fish size, particularly in individuals with standard lengths ≥ 37.5 cm. This trend aligns with previous studies suggesting a positive correlation between parasite burden and host size. Larger and older fish are more likely to accumulate parasites due to prolonged exposure. Furthermore, the increased gill surface area and filtration capacity in larger hosts enhance the likelihood of larval contact and attachment. Parasites may also adapt to their hosts over time, evading immune responses and optimizing colonization on available surface area (Combes, 1995) [8]. Interestingly, Q. triunguisi did not show a significant correlation with host size, indicating species-specific differences in host-parasite interactions. These patterns may also reflect niche differentiation and potential interspecific competition among Monogenean species.

Uninfested fish exhibited a condition factor below 1 across all size classes, suggesting suboptimal growth. This could be attributed to environmental or nutritional stress unrelated to parasitism. However, infested individuals particularly smaller fish displayed markedly lower condition factors, indicating that parasitic burden adversely affected their health. High parasite loads can impair feeding efficiency and cause significant energy loss, making hosts more susceptible to environmental stress (Combes, 1995) [8]. Smaller fish, with less developed immune systems, are especially vulnerable to such effects.

Conclusion

This study provides the first comprehensive assessment of gill Monogenean infestation in *Heterobranchus longifilis* from lake Ayame 2, southeastern Côte d'Ivoire. Four species of *Quadriacanthus* were identified *Q. longifilisi*, *Q. thysi*, *Q. tricorniculatus*, and *Q. triunguisi* with *Q. longifilisi* and *Q. thysi* being the dominant species. The prevalence and mean intensity of infestation were influenced by seasonal variations, with rainy periods favoring the proliferation of *Q. longifilisi* and *Q. thysi*, and dry seasons favoring *Q. tricorniculatus* and *Q. triunguisi*. Host size also played a critical role, with larger fish exhibiting higher infestation rates, except for *Q. triunguisi*, which appeared size-independent. Additionally, the study demonstrated that parasitic infections had a measurable negative impact on host condition, particularly in smaller individuals. These findings emphasize the need to consider parasitic pressures in the ecological monitoring and aquaculture management of *H. longifilis*, especially in anthropogenically influenced freshwater environments such as lake Ayame 2. Future investigations should explore histopathological impacts, host immune responses, and environmental drivers of Monogenean dynamics to better understand the implications for fish health and ecosystem stability.

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