International Journal of Fisheries and Aquatic Studies 2025; 13(3): 53-60

E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2025; 13(3): 53-60

www.fisheriesjournal.com
Received: 06-03-2025
Accepted: 09-04-2025

Yedehi Euphrasie Adou
Research Unit on Ecology and Biodiversity, Laboratory of Ecology and Sustainable Development, Nangui Abrogoua University, Abidjan, 02 PO Box 801 Abidjan 02, Côte d'Ivoire

Kassi Georges Blahoua
Research Unit on Hydrobiology, Laboratory of Natural Environments and Biodiversity Conservation, Félix Houphouët-Boigny University, Abidjan, 22 PO Box 582 Abidjan 22, Côte d'Ivoire

Assoi Olivier Etchian
Natural Sciences Training and Research Unit, Laboratory of Animal Biology and Cytology, Nangui Abrogoua University Abidjan, Côte d'Ivoire

Souleymane Konate
Research Unit on Ecology and Biodiversity, Laboratory of Ecology and Sustainable Development, Nangui Abrogoua University, Abidjan, 02 PO Box 801 Abidjan 02, Côte d'Ivoire

Seydou Tiho
Research Unit on Ecology and Biodiversity, Laboratory of Ecology and Sustainable Development, Nangui Abrogoua University, Abidjan, 02 PO Box 801 Abidjan 02, Côte d'Ivoire

Corresponding Author:
Yedehi Euphrasie Adou
Research Unit on Ecology and Biodiversity, Laboratory of Ecology and Sustainable Development, Nangui Abrogoua University, Abidjan, 02 PO Box 801 Abidjan 02, Côte d'Ivoire

Parasitism relationships among *Coptodon zillii* (Gervais, 1848), *Coptodon guineensis* (Günther, 1862) and their hybrids by gill *Monogenea*ns in Ayamé 2 man-made lake (Côte d'Ivoire)

Yedehi Euphrasie Adou, Kassi Georges Blahoua, Assoi Olivier Etchian, Souleymane Konate and Seydou Tiho

DOI: https://www.doi.org/10.22271/fish.2025.v13.i3a.3077

Abstract
Coptodon zillii and *C. guineensis* are among the main fish exploited by the artisanal fishery in the Ayamé 2 dam lake. In this lake, it was observed a case of hybridization between these two species of fish to give hybrids. All these fish represent a high halieutic value and are the subject of particular attention in aquaculture because they present a good zootechnical performance in Africa. Despite their importance, they may be affected by parasitism that can hinder their proper development. This study aims to study the parasitic relationships that exist between *C. zillii*, *C. guineensis* and their Hybrids in Lake Ayamé 2 by gill *Monogenea*ns. The gill of 388 *C. zillii*, 361 *C. guineensis* and 409 Hybrids were collected monthly with a monofilament gill nets. Standard methods of parasitological examination were used for identification of *Monogenea*n species. Seven (7), 11 and 9 *Monogenea*n species were inventoried in the gills of *C. zillii*, *C. guineensis* and their Hybrid, respectively. The study indicated that in addition to parasites such as *C. cubitus*, *C. ergensis*, *C. anthemocolpos*, *C. vexus* and *C. digitatus* which are found in the gills of the three fish, those of hybrid Tilapia harbored C. sp1 and C. sp2 which are specific. Generally, the parastic load of the *Monogenea*n species increased with the size of all fish hosts. Moreover, the impact of the host sex was observed for parasitic load of these *Monogenea*ns. The male fish of *Coptodon guineensis* and the hybrid (*C. zillii* and *C. guinensis*) harbored more parasites. However, the females fish of *C. zillii* were the most infested. This study which made it possible to identify hosts vulnerable to infestation could contribute to implementing control and monitoring strategies to control parasitic disease and increase fish productivity.

Keywords: Fishes, parasites, infestation, Lake Aymamé 2, côte d'ivoire.

Introduction

Fishes are important to man as they serve as a good source of animal protein for both man and livestock. It also serves as a source of income in countries in sub-Saharan Africa where some 35 million people depend wholly or partly on the fisheries sector for their livelihood (Ayanda, 2009) [1]. Indeed, 134 million tons of fish was used for human consumption out of a global production estimated at 154 million tons in year 2011 (Ayanda, 2009) [1]. Fish is more or less a complete food because it contains fat, minerals, oils, and vitamins (Ayanda, 2009) [1]. In the world, fish makes up almost 20% of animal proteins for about 3 billion people and approximately 15% of these same proteins for 4.3 billion people (Ayanda, 2009) [1]. The question of the availability on the market of animal proteins origin being posed, continental fish farming aims to diversify and even complete the supply meat supplies for human consumption, but to meet the growing needs expressed in the inland areas. In Africa, the farmed species of the genus *Coptodon* include *C. zillii* and *C. guineensis* and their hybrids (Nobah, 2007 ; Toko *et al*., 2010) [2, 3]. These fish are encountered in most of the Ivorian rivers and also represent a high halieutic value, being among the main fish exploited by the artisanal fishery (Eyi *et al*., 2016 ; Adou *et al*., 2017 ; Kouassi *et al*., 2020) [4, 5, 6]. Such as all fish, those in this study don't escape the parasitic *Monogenea*n infestation.

These parasites are Platyhelminthe infesting mostly the fish gills. However, they may be found in other organs of fish (Eyo *et al*., 2015) [7]. In addition to their fundamental interest for science, these are also potential biological markers, phylogenetic and ecological markers of fish hosts and good indicators of water quality (Ramadan *et al*., 2014) [8]. With their direct developmental cycle, *Monogenea*n parasites are very problematic pathogens to their host health. Thus, these parasites are generally recognized as important pathogens of confined fishes (Buchmann and Lindenstrom, 2002) [9]. *Monogenea*ns are often in equilibrium with their hosts, and can provoke serious morbidity and mortality during fish breeding (Buchmann and Lindenstrom, 2002 ; Kayis *et al*., 2009) [9, 10]. These parasites can affect marketability of fish and raise huge economic losses in iquaculture industy (Velloso and Joaber, 2010 ; Blahoua *et al*., 2016)) [11, 12]. Scarcity of information on pathogenic agents hampers the development of ecologically sustainable strategies for disease control (Bondad-Reantaso *et al*., 2005) [13]. Thus, it is important to identify, in advance, parasitic infections to prevent the devastating infestations (Adeyemo and Daunemughan 2012) [14]. The host fish in this present study could face such problems. In Côte d'Ivoire, few studies (Blahoua *et al*., 2015, 2018) [15, 16] have been conducted on gill *Monogenea*n parasites of *Tilapia* (*Coptodon*) *zillii* from Ayamé1 man-made lake and Lobo river, respectively. No previous study has focused simultaneously on the branchial parasitic *Monogenea*n of *Coptodon zillii*, *C. guineensis* and their Hybrids. The present study aimed to evaluate some ecological data of the *Monogenea*n gill infections of *Coptodon zillii*, *C. guineensis* and their hybrids in the Ayame 2 dam lake where they are abundant in fishermen's catches in order to help minimize catastrophic often observed in natural environments and potential fish ponds.

Material and Methods

1. Study area

The study was conducted from july 2015 to june 2016 in Ayamé 2 lake man-made lake. Located in the South East of Côte d'Ivoire between longitudes 3°09'and 3°10' West and latitudes 5°34'and 5°37' North, this man-made lake is one of the hydroelectric dams in the country (Figure 1). It was built in 1963 on the river Bia and has an average surface of 7 Km^2 (Da Costa *et al*., 2000) [17]. It rises in Sui at Ghana and enters Aby lagoon in Côte d'Ivoire.

2. Sampling fish

Fishes were collected monthly with a monofilament gill nets. In this study, 388 specimens of *Coptodon zillii*, 361 individuals of *C. guineensis* and 409 specimens of Hybrid (*Coptodon zillii* x *C. guineensis*) were examined. The standard length values of these fish varied from 140 to 199mm for the first two fish and between 140 and 239mm for the third fish. It was measured with a meter rule. Sexing fish was done by physical observation of the urogenital papillae. It is long or distended in male fish while in the female it is round and reddish in the matured ones. Also visual observation of the testicles in males and ovaries in the females is necessary.

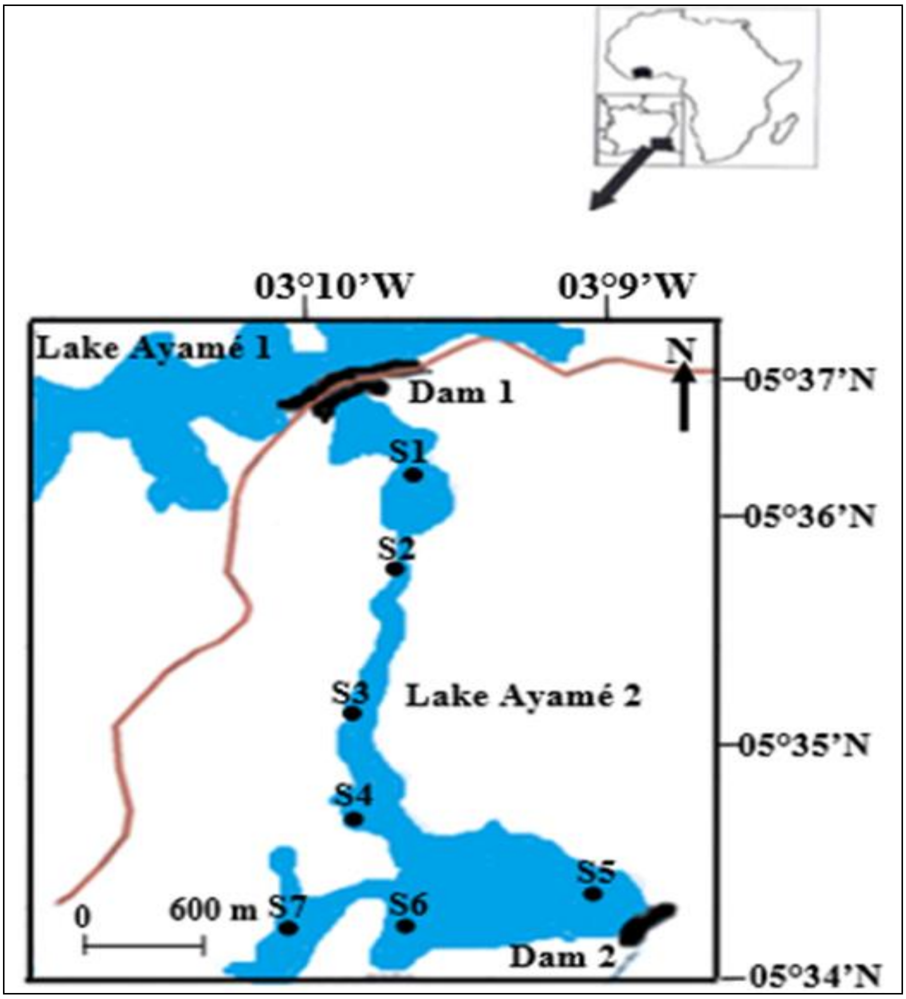

Fig 1: Map of man-made Lake Ayamé 2 and the sampling site

3. Parasitological examination and data analysis

In the laboratory, the gills from each side were dissected and were placed in various Petri dishes. *Monogenea*ns were collected and mounted on a slide into a drop of ammonium picrate-glycerine mixture. The identification of the parasite species was carried out under the light microscope, based on the shape and/or size of the sclerotised parts of their haptoral and copulatory complexes as described by Pariselle and Euzet (2009) [18].

Ecological data such as the prevalence and mean intensity of infestation, were calculated following Bush *et al*. (1997) [19]. The classification of the species based on prevalence (P) was made according to Koskivaara and Valtonen (1992) [20].

Parasitic species are frequent if the prevalence is greater than 50%, they are less frequent if the prevalence is ranged between 10 and 50% and rare if the prevalence is less than 10%.These categories may correspond to what Koskivaara and Valtonen (1992) [20] termed respectively as core, secondary or satellite species. The Mean intensity (MI) was high if its value is greater than 100, average if its value varied from 50 to 100, low if its value ranged between 10 and 50 and very low if its value was less than 10 as described by Bilong Bilong and Njiné (1998) [21].

Diversity indices such as the Shannon-Weaver index, Pielou's measure of evenness and the Simpson index have been used to characterize fish stock diversity. These diversity indices are depicted on annual mean basis and are calculated by the software Paleontological Statistic (PAST) version 2.15 (Hammer *et al*. 2001) [22].

Shannon-Weaver diversity index

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Where, pi is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

When

H' is minimal (H'=0) all the individuals in the stand belong to one and the same species. The index is maximum (of the order of 5) when all the individuals have started from one evenly between species (Frontier, 1983) [23].

Pielou's evenness index

E=H'/ ln (S)

Where : S is the number of observed species, H' is the Shannon-Weaver diversity index and ln is the natural logarithm of S.

This index varies from 0 to 1. It is maximum when the species have identical abundances in the stand. It is minimal when a single species dominates the entire stand.

Simpson index, which is a measure of species diversity in the community

D=Σni (ni-1) / N (N-1)

Where, ni is the total number of individuals of one particular species found, N is the total number individuals parasites found in the sample and Σ is still the sum of the calculations. Simpson's diversity index ranges from 0 to 1. The maximum diversity is represented by the value 1 and the minimum of diversity by the value zero.

4. Statistical analysis

The Chi square test (X^2) was allowed to compare two or more proportions. The Mann Whitney (U) and Kruskall Wallis (K) tests were respectively used to compare two and several averages. All tests were considered significant at the 5% level ($p<0.05$). The various statistical analyses were performed using the Microsoft Excel, PAST and STATISTICA software version 7.1.

Results

1. Specific composition of gill *Monogenea*n parasites

Seven (7), eleven (11) and nine (9) *Monogenea*n species were found to have infested the gills of *Coptodon zillii*, *C. guineensis* and their Hybrids, respectively (Table 1). In the host *Coptodon zillii*, the *Monogenea*n species *Cichlidogyrus ergensis*, *C. cubitus* and *C. anthemocolpos* were the frequent species of the parasitic community of this fish (Figure 2). On the other hand, the *Monogenea*ns *Cichlidogyrus arthracanthus*, *C. digitatus* and *C. aegypticus* were less frequent and the *Monogenea*n *C. vexus* was the rare species. For host *Coptodon guineensis,* the frequent parasites were *Cichlidogyrus vexus*, *C. ergensis*, *C. cubitus* and *C. anthemocolpos* of the parasitic community of this fish. The less frequent parasites were *C. arthracanthus*, *C. dossoui*, *C. digitatus* and *C. louipaysani*. On the other hand, the rare parasites were *C. yanni*, *C. lagoonaris* and *C. kouassii*. The frequent parasites found in the host hybrid are C. *cubitus*, *C. ergensis* and *C. dossoui* of the parasitic community of this fish. The less frequent one are *C. anthemocolpos*, *C. vexus*, C. sp1 and C. sp2. The rare species are *C. digitatus* and *C. aegypticus*. In general, the mean intensity found in the majority of the parasite species is low. The three hosts had several species of parasites in common (Figure 3).

The hybrid, in addition to parasites such as *C. cubitus*, *C. ergensis*, *C. anthemocolpos*, *C. vexus*, *C. digitatus* that it shares with the parents (*Coptodon zillii* and *C. guineensis*), harbors parasites *Cichlidogyrus sp.* 1 and *Cichlidogyrus sp.* 2 which are specific to it. These four species of parasites inventoried on hosts of the same genus have therefore a stenoxene specificity.

2. Prevalence and intensity of parasite infection based on host size

All sizes of fish *Coptodon zillii*, *C. guineensis* and their hybrids specimens appeared infested by the parasite species (Table 2). Highest prevalences (99.22% and 100%) were obtained in *C. zillii* and *C. guineensis*, respectively. The standard lenghts values of these fish varied from 180 to 199 mm. For the Hybrid, the maximum prevalence (98.75%) was noted in the specimens whose length is ranged from 220 to 239 mm. Furthermore, low prevalence values were reported on small fish. Statistical tests showed that there was no significant difference in the prevalence according to the size class (X^2=8.62, 7.18 and 11.023 ; DF=2 and 4, P=0.058 > 0.05) for each host.

Generally, the study showed that the parasitic intensity increased with the host size The highest mean parasite intensity values in *C. zillii* specimens (109.77±2.4) and *C. guineensis* one (87.60±1.5) were noted in individuals with a standard length range from 180 to 199 mm. There was a significant difference in the number of these parasites between fish size (Kruskal Wallis K=9.12 and 8.54, P=0.01 and 0.02 < 0.05). In the host Hybrid, the maximum mean parasite intensity (125.10±2.2) found was obtained in fish with standard length ranged from 220 to 239 mm. Statistically, significant difference was recorded in the parasitic intensity between the host size (Kruskal Wallis K=9.72, P=0.01 < 0.05). In contrast, the lowest mean intensity values were noted in small fish for all hosts examined.

3-Prevalence and intensity of parasite infection based on host sex

Tables 3 and 4 shows the infestation of *Coptodon zillii*, *C. guineensis* and their hybrids by *Monogenea*n parasites according to the host sex. For the host *C. zillii*, the parasites prevalence was 84.95% for male and 96.04% for female. For the host *C. guineensis*, there was 99.42% of male fish which were infested by parasites against 89.36% of female fish. The *Monogenea*ns were present in 98.02% of male Hybrid and 76.55% of female. Statistical tests indicated no significant difference in infestation rates between sex for all three hosts (X^2=5.24, 3.89 and 6.41, DF=1, P=0.1, 0.3, 0.2 > 0.05). Male fish were more infested in *Coptodon guineensis* specimens (62.93±1.4) and Hybrid specimens (92.67±3.8) (Table 4). Host sex affected significantly infestation (Mann-Whitney U=0.7, P=0.01 < 0.05). In contrast, a significantly higher intensity of infestation was observed in female (81.07±1.5) than male (43.98±SE) *Coptodon zillii* specimens (Mann-Whitney U=0.6, P=0.01 > 0.05.

4. Index of diversity of parasitic populations

The diversity indices of the *Monogenea*ns population of *Coptodon zillii*, *C. guineensis* and their hybrid are recorded in the Table 5.

The Shannon index value of *C. zillii* parasites was 3.641 bits/ind. Both Shannon index and Simpson's index values were 0.843 and 0.961, respectively. For the species *C. guineensis* the Shannon index was 3.987 bits/ind. The respective and Simpson's index values for this host were 0.843 and 0.975. In Lake Ayamé 2, the calculated Shannon index of the *Monogenea*ns of the Hybrid was 4.004 bits/ind. The corresponding Equitability was 0.866 and Simpson's value was 0.976.

Discussion

This study has revealed, 7,11 and 9 *Monogenea*n species belonging to genus *Cichlidogyrus* on the gills of *Coptodon zillii*, *C. guineensis* and their Hybrid respectively from man-made Lake Ayame 2. The polyparasitism observed in this study has also been reported by various authors (Pariselle and Euzet, 2009; Ibrahim, 2012 ; Blahoua *et al*., 2018) [18, 24, 16]. This multi-specific parasitism of these three hosts could be explained by the permanent presence of vacant niches on their gill biotope. This is explained by the fact that in the natural environment, the parasitic load is generally weak so there are niches always available on the gill biotope as suggested by authors Buchmann and LindenstrØm (2002) [9] and Simkova *et al*. (2006) [25].

In literacy, the variability of parasite richness has been associated to various factors among them experimentation factors (effort of individuals examined hosts) (Walther *et al*., 1995) [26], factors related to the host and with its social behavior (trait of life, size, habitat and behavior) (Zharikova, 2000) [27] and factors related to the phylogeny of hosts and parasites (Sasal *et al*., 1997) [28]. In addition, factors linked to habitat environmental and biological aspects can also affect structure and species composition (Tavares and Luque, 2008 ; Violante-Gonzalez *et al*., 2010) [29, 30]. Comparing the numbers of parasite species 7, 11 and 9 obtained respectively in fish *Coptodon zillii*, *C. guinensis* and *C. hybrid* with those from previous work by Blahoua *et al*. (2015, 2018) [15, 16], The parasite richness of this study could be due to habitat type. The Ayamé 2 lake would therefore be favorable to the development of certain parasite species. This assertion supports the fact that the specific parasitic composition of a host changes from one study area to another.

The study indicated the frequent parasites (*Cichlidogyrus vexus*, *C. ergensis*, *C. cubitus* and *C. anthemocolpos*), the less frequent parasites (*C. arthracanthus*, *C. dossoui*, *C. digitatus* and *C. louipaysani*) and rare parasites (*C. yanni*, *C. lagoonaris* and *C. kouassii*) with low intensities of the majority parasite species. These results corroborate the assertion that in the natural environment, the parasitic load is generally limited due to the low density of hosts as had been mentioned Obiekezie and Taege (1991) [31]. This low parasitic intensity could also due to the low inflow of infective larvae. Indeed, under such conditions, the infra-population can not easily reach a high level due to its own natural mortality as suggested Combes (1995) [32].

This work underlined that the hybrid, in addition to parasites such as *C. cubitus*, *C. ergensis*, *C. anthemocolpos*, *C. vexus* and *C. digitatus* that it shares with the parents (*Coptodon zillii* and *C. guineensis*), shelters *Monogenea*n parasites *Cichlidogyrus* sp. 1 and C. sp. 2 that are specific to it. A similar finding was made by Lim *et al*. (2016) [33]. On the red Tilapia hybrid. According to these authors, this fish harbored more parasite species and is susceptible to infection than *Oreochromis niloticus* from which it is derived. Simkova *et al*. (2013) [25] obtained the similar results in hybrids of Cyprinidae. They pointed out that these hybrids (*Cyprinus carpio* Linnaeus, 1785 x *Carassius gibelio* Bloch, 1782) harbored more parasite species than their parental hosts. The greater susceptibility of fish hybrids to carry more parasites than parental hosts is due to the fact that they inherited additive traits from each parent such as mucus components involved in the parasite attraction process (Simkova *et al*., 2013) [25].

Generally, the study showed that the parasitic intensity increased with the host size

The findings of this study are supported by those of Koyum (2012) [34]. who noted that the highest values of prevalence and mean intensity of *Dactylogyrus lenkorani* were observed in large individuals (LS > 200 mm). Blahoua *et al*. (2009, 2015, 2016) [35, 15, 12] indicated that large specimens of *S. melanotheron*, *T. zillii* (*Coptodon zillii*) and *Oreochromis niloticus* harbored more parasites than those of smaller sizes. Similarly, in the eastern coastline of Algeria, had showed a positive correlation between the *Lithognathus mormyrus*'s size and parasitic indices. In Medhia, El Mahdi & Belghyti (2006) [36] observed that larger individuals of *Trachinotus ovatus* were more frequently and abundantly parasitized. Possibly, larger hosts may offer more spaces for parasite species and they are supposed to have a greater life expectancy for colonisation by sustainable parasite infrapopulation. According to El Mahdi & Belghyti (2006) [36], other mechanisms that can explain the parasitism increase according to the fish size. The first is attributed to the large gill surface of fish that offer a larger surface to host many parasites. The second is due to the increased water volume passing through the gills of large hosts which would increase the chances of invasion by the parasite larvae. Furthermore, the large hosts secrete a lot of mucus whose components are attractive to the oncomiracidia of these gill parasitic *Monogenea*n

Table 1: List of parasite species collected from *Coptodon zillii*, *C. guineensis* and their hybrids in Lake Ayamé 2

	Hosts Species		
Parasite species	***Coptodon zillii***	***Coptodon guineensis***	**Hybrid (C. zillii × *C. guineensis*)**
C. vexus	+	+	+
C. ergensi	+	+	+
C. cubitus	+	+	+
C. anthemocoplos	-	+	+
C. ariirocanthus	-	+	+
C. dossoui	-	+	+
C. digilatus	+	-	-
C. louipaysani	-	+	-
C. yawri	-	+	+
C. lagoonaris	-	+	-
C. kouassi	-	+	+
C. aegypticus	+	-	+
C. sp1	-	-	+
C. sp2	-	-	+

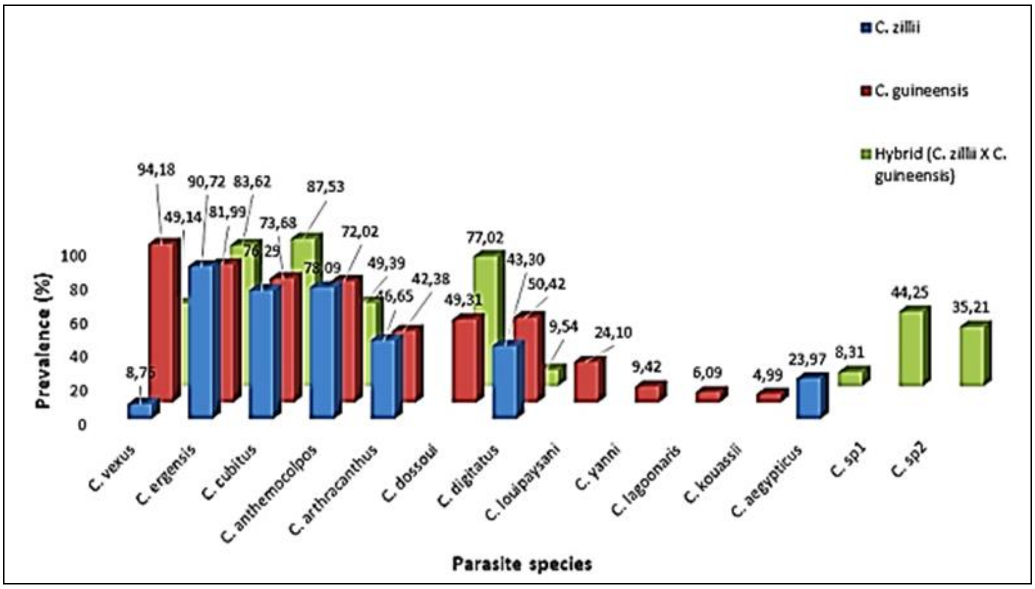

Fig 2: *Prevalence (%) of parasite species collected from Coptodon zillii, C. guineensis, and their Hybrid in the Ayamé 2 dam lake*

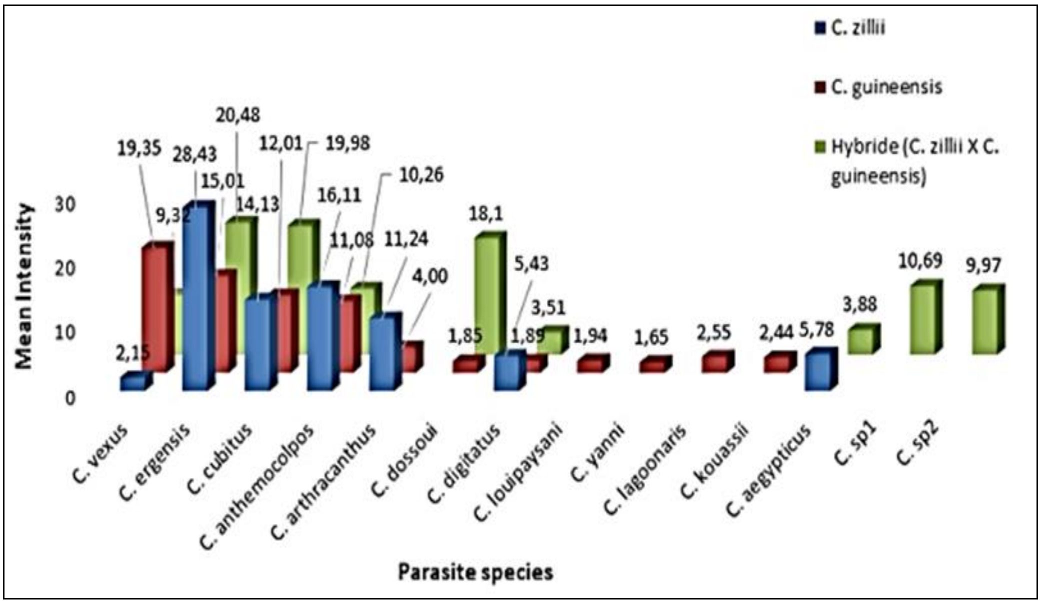

Fig 3: *Mean intensity of parasite species collected from Coptodon zillii, C. guineensis, and their Hybrid in the Ayamé 2 dam lake*

Table 2: Parasite infection statistics by standard length and host species in Lake Ayamé 2

Standard length (mm)	No examined (%)	No infected	Prevalence (%)	Mean intensity±SE
Coptodon zillii				
140-159	132 (34.02)	101	76.52	19.86±0.9
160-179	127 (32.73)	123	96.85	53.83±0.2
180-199	129 (33.24)	128	99.22	109.77±2.4
Total	388 (100)	352	90.72	64.42±0.6
Coptodon guineensis				
Standard Length (mm)	**No. Examined (%)**	**No. Infected**	**Prevalence (%)**	**Mean Intensity±SE**
140-159	121 (33.52)	109	90.08	25.35±1.3
160-179	122 (33.24)	113	92.62	49.65±0.7
180-199	118 (32.68)	118	100.00	87.60±1.5
Total	361 (100)	340	94.18	55.03±1.2
Hybrid (C. zillii × *C. guineensis*)				
Standard Length (mm)	**No. Examined (%)**	**No. Infected**	**Prevalence (%)**	**Mean Intensity±SE**
140-159	83 (20.29)	52	62.65	25.08±0.3
160-179	80 (15.56)	68	85.00	35.76±1.1
180-199	82 (20.05)	77	93.90	64.69±1.6
200-219	84 (20.53)	82	97.62	107.88±2.5
220-239	80 (15.56)	79	98.75	125.10±2.2
Total	409 (100)	358	87.53	76.66±1.03

SE: Standard Devistation

Table 3: Prevalence of Monogenean infection in *Coptodon zillii*, *C. guineensis* and their Hybrid caught in man-made Lake Ayamé 2 in relation to sex

Hosts	Total Examined	Males Examined	Prevalence (% Infected)	Females Examined	Prevalence (% Infected)	Total Infection Rate (%)
Coptodon zillii	388	186	158 (84.95%)	202	194 (96.04%)	90.72
Coptodon guineensis	361	173	172 (99.42%)	188	168 (89.36%)	94.18
Hybrid (C. zillii × *C. guineensis*)	409	202	188 (93.02%)	209	160 (76.55%)	87.53

Table 4: Intensity of Monogenean infection in *Coptodon zillii*, *C. guineensis* and their Hybrid caught in man-made Lake Ayamé 2 in relation to sex

Hosts	Male			Female		
	Total Infected	Parasite Recovered	Mean Intensity±SE	Total Infected	Parasite Recovered	Mean Intensity±SE
Coptodon zillii	158	6,949	43.98±2.6	194	15,728	81.07±1.5
Coptodon guineensis	172	10,824	62.93±1.4	168	7,887	46.95±2.1
Hybrid (*C. zillii* × *C. guineensis*)	198	18,352	92.67±3.8	160	9,094	56.84±2.04

Table 5: Parasite diversity index values calculated for each of the hosts in Lake Ayamé 2

Hosts species	Shannon-Weaver diversity index	Equitability of Pielou	Simpson index
Copton zilli	3.641	0.843	0.961
Coptodon guineensis	3.987	0.843	0.975
Hybrid (C. zilli x *C. guineensis*)	4.004	0.866	0.976

This study revealed that male fish in *Coptodon guineensis* and the hybrid (*Coptodon zillii* x *C. guineensis*) harbor many parasites. However, in *Coptodon zillii*, it is the female fish that are more infested. Özer (2002) [37] reported that the largest number of *Dactylogyrus extensus* and *D. anchoratus* was collected from the gills of Cyprinus carpio of the male sex. Aloo *et al*. (2004) [38] concluded that males of several freshwater fish tendent to carry more parasites than females. Ibrahim (2012) [24], on the other hand, has found that the prevalence and average intensity of *C. arthracanthus*, *C. aegypticus*, *C. tiberianus* and *C. tiliapiae* were higher in female hosts. Lizama *et al*. (2005) [39] noted that the *Monogenean*s *Dactylogyrus extensus* and *Tereancistrum curimba* were more concentrated in females of *Cyprinus carpio* and *Prochilodus lineatus* respectively. The results of this work could be attributed to a combination of several factors including the host's diet. Indeed, in their active search for a partner at the breeding time and for food, male fish are more exposed to parasite infestation as highlighted by Siddiqui *et al*. (2014) [40]. The high parasitic intensity observed in female hosts would be linked to their reproduction period. Indeed, during this period, the females increase in size, thus providing a larger surface area for parasite attachment as found by authors (Ibrahim, 2012) [24]. In addition, at the time of the laying, some females huddle in the cavities of the rocks and become more sedentary. This change in behavior is conducive to an increase in parasitic intensities. Akther (2014) [41] explained that host sex is a factor that ensures the stability of the host-parasite system. According to this author, differences in the degree of parasite infestation between male and female hosts would be related to the physiological change of the latté by the secretion quality and quantity of steroid hormones (androgen for males and estrogen for females).

For the study of the parasitic diversity of fish in Lake three measures of biodiversity were chosen for their frequent use in parasitology : the species richness, the Shannon-Weaver index and the Simpson diversity index. According Ternengo (2004) [42], it seems necessary to take into account the abundances of species in diversity estimation. This is why indices such as those of Shannon-Weaver and Simpson have been developed. In this parasitic study, the Shannon-Weaver indices and

Simpson records for each of the host species are above average. The diversity parasite is therefore considered high. The equitability values obtained among all the hosts are very high and close to 1. This testifies to the existence of a certain homogeneity in the parasites distribution in each host species as indicated by Zander (2005) [43]. According to this author, equitability values greater than 0.6 means that there is homogeneity in the distribution of parasites within hosts. When its values exceed 0.7, stand homogeneity is considered high.

Conclusion

The study provided that *Coptodon zillii*, *C. guinenensis* and their hybrids fish harbored different *Monogenea*n parasite species over their gills in Ayame 2 lake. The hybrid fish hosts both parasite species found in both parents (*Coptodon zillii* and *C. guinenensis*) and two parasite species specific to it. Morover, this study indicated that the number of most *Monogenea*n parasites increased with the size of the host fish. It also revealed that the effect of fish sex do not have an imapct on the infestation. This information revealed hosts that are vulnerable to parasite infestation. Such information may provide strategies in aquaculture management to reduce potential economic losses of these fish caused by parasitic infection.

Acknowledgements

The authors are grateful to the local fishermen for the data collecting on the study area.

References

1. Ayanda OI. Comparative parasitic helminth infection between cultured and wild species of *Clarias gariepinus* in Ilorin, North-Central Nigeria. Sci Res Ess. 2009;4(1):18-21.
2. Nobah CSK. Critères d'identification et performances zootechniques des tilapias hybrides (*Tilapia zillii* (Gervais, 1848) x T. guinensis (Bleeker, 1862)) dans trois structures d'élevage: cages flottantes (lac d'Ayamé), étangs en terre et bassins en béton (Aboisso). Thèse de Doctorat. Université de Cocody d'Abidjan (Côte d'Ivoire), 2007, p. 219.
3. Toko II, Attapka E, Yand E, Legbe H. Performances biologiques, zootechniques et nutritionnelles de Tilapia guineensis en milieux naturel et d'élevage. Int J Biol Chem Sci. 2010;4(5):1629-1640.
4. Eyi AJ, Konan KJ, Tano K, N'Da K, Atsé BC. Étude préliminaire des communautés ichtyofauniques de la lagune Ono (Côte d'Ivoire). J Appl Biosci. 2016;104:9894-9903.
5. Adou YE, Blahoua KG, Bamba M, Yao SS, Kouamelan EP, N'Douba V. Premières données sur l'inventaire du peuplement ichtyologique d'un lac ouest Africain situé entre deux barrages hydroélectriques: Lac d'Ayamé 2 (Côte d'Ivoire). J Appl Biosci. 2017;110:10808-10808.
6. Kouassi DK, Diaby M, Soro Y, N'Da K. Faune ichtyologique du lac de barrage Solomougou (Korhogo, Côte d'Ivoire). Int J Biol Chem Sci. 2020;14(7):2528-2537.
7. Eyo VO, Edet TA, Ekanem AP. *Monogenea*n parasites of the African catfish *Clarias gariepinus* from two fish farms in Calabar, Cross River State, Nigeria. J Coast L Med. 2015;3(6):433-437.
8. Ramadan MR, Ghobashy MA, Taeleb AA. Establishing cause-effect of multistressor environments on *Oreochromis niloticus* and its parasite communities. Afr J Microbiol Res. 2014;8(32):3038-3043.
9. Buchmann K, Lindenstrøm T. Interactions between *Monogenea*n parasites and their fish hosts. Int J Parasitol. 2002;32:309-319.
10. Kayis S, Ozcelep T, Capkin E, Altinok I. Protozoan and metazoan parasites of cultured fish in Turkey and their applied treatments, 2009.
11. Velloso AL, Joaber PJ. Influence of ectoparasitism on the welfare of Micropogonias furnieri. Aquaculture. 2010;310:43-46.
12. Blahoua KG, Yao SS, Etilé RN, N'Douba V. Distribution of gill *Monogenea*n parasites from *Oreochromis niloticus* (Linné, 1758) in man-made Lake Ayamé I, Côte d'Ivoire. Afr J Agric Res. 2016;11(2):117-129.
13. Reantaso BMG, Subasinghe RP, Arthur JR, Ogawa K, Chinabut S, Adlard R, *et al.* Disease and health management in Asian aquaculture. Vet Parasitol. 2005;132:249-272.
14. Adeyemo AO, Daunemughan T. Parasitic investigation in wild Parachanna obscura. Int J Curr Biol Med Sci. 2012;2(1):195-198.
15. Blahoua KG, Yao SS, Etilé RN, N'Douba V. Infection dynamics of four gill *Monogenean* species from Tilapia zillii (Gervais, 1848) in man-made Lake Ayame I, Côte d'Ivoire. Int J Biol Chem Sci. 2015;9(1):12-23.
16. Blahoua KG, Adou YE, Etile RN, Yao SS, N'Douba V. Occurrence of gill *Monogenea*n parasites in Redbelly tilapia, Tilapia zillii (Teleostei: Cichlidae) from Lobo River, Côte d'Ivoire. J Anim Plant Sci. 2018;35(3):5674-5688.
17. Costa DKS, Gourène G, Morais TDL, Audenaerde VDDFET. Caractérisation des peuplements ichtyologiques de deux fleuves côtiers ouestafricains soumis à des aménagements hydro-agricoles et hydroélectriques. Vie Milieu. 2000;50(2):65-77.
18. Pariselle A, Euzet L. Systematic revision of dactylogyridean parasites (*Monogenea*) from cichlid fishes in Africa, the Levant and Madagascar. Zoosystema. 2009;31(4):849-898.
19. Bush AO, Lafferty KD, Lotz JM, Shostak AW. Parasitology meets ecology on its own terms. J Parasitol. 1997;83:575-583.
20. Kooskivaara M. Environmental factors affecting *Monogenea*n parasites on freshwater fishes. Parasitol Today. 1992;8:339-342.
21. Bilong Bilong CF, Njiné T. Dynamique de populations de trois Monogènes parasites d' *Hemichromis fasciatus* (Peters) dans le lac Municipal de Yaoundé et intérêt possible en pisciculture intensive. Sci Nat Vie. 1998;34(2):295-303.
22. Hammer O, Harper DAT, Ryan PD. Paleontological statistics software package for education and data analysis. Palaeontol Electron. 2001;4(1):1-9.
23. Frontier S. L'échantillonnage de la diversité spécifique. In: Stratégie d'échantillonnage en écologie, 1983, p. 494.
24. Ibrahim MM. Variation in parasite infracommunities of Tilapia zillii in relation to some biotic and abiotic factors. Int J Zool Res. 2012;8(2):59-70.
25. Simkova A, Davidova M, Papousek I, Vetesnik L. Does interspecies hybridization affect the host specificity of parasites in cyprinid fish? Parasit Vect. 2013;95(6):1-10.
26. Walther BA, Clayton DH, Cotgreave PC, Gregory RD,

Price RD. Sampling effort and parasite species richness. Parasitol Today. 1995;11:306-310.
27. Zharikova TI. The adaptive reactions of the gill ectoparasites of the bream (*Abramis brama*) and the white bream (*Blicca bjoerkna*) onto the anthropogenic factor influence in the Ivan'kovo reservoir. Parasitol. 2000;34(1):50-55.
28. Sasal P, Morand S, Guegan JF. Determinants of parasite species richness in Mediterranean marine fishes. Mar Ecol Prog Ser. 1997;149:61-71.
29. Tavares LER, Luque JL. Similarity between metazoan parasite communities of two sympatric brackish fish species from Brazil. J Parasitol. 2008;94(4):985-989.
30. Gonzalez VJEF, Franco MA, Herrera RSG, Gil G. Factors determining parasite community richness and species composition in black snook Centropomus nigrescens (Centropomidae) from coastal lagoons in Guerrero, Mexico. Parasitol Res. 2010;107:59-66.
31. Obiekezie AI. The principal pathogens and diseases of cultured fishes in Nigeria. In: Aquaculture in Africa. Sci Publ. 1991;197-207.
32. Combes C. Interactions durables. Ecologie et évolution du parasitisme. Collection d'Ecologie, 1995, p. 524.
33. Lim SY, Ooi LA, Wong LW. Gill *Monogenea*ns of Nile tilapia (*Oreochromis niloticus*) and red hybrid tilapia (Oreochromis spp.) from the wild and fish farms in Perak, Malaysia: infection dynamics and spatial distribution. Syst Plus. 2016;5:1-10.
34. Koyun M. The occurrence of parasitic helminths of Capoeta umbla in relation to seasons, host size, age and gender of the host in Murat River, Turkey. J Anim Vet Adv. 2012;11(5):609-614.
35. Blahoua KG, N'Douba V, Koné T, Kouassi NJ. Variations saisonnières des indices épidémiologiques de trois Monogènes parasites de Sarotherodon melanotheron (Pisces: Cichlidae) dans le lac d'Ayamé I (Côte d'Ivoire). Sci Nat. 2009;6(1):39-47.
36. El Madhi Y, Belghyti D. Distribution de deux Monogènes dans les individus hôtes de *Trachinotus ovatus* (L., 1758) de la côte de Mehdia. Biol S. 2006;6(2):65-76.
37. Özer A. Co-existence of Dactylogyrus anchorathus Dujardin, 1845 and D. extensus Muller & Van Cleave, 1932 (*Monogenea*), parasites of common carp (Cyprinus carpio). Helminthol. 2002;39:45-50.
38. Aloo PA, Anam RO, Mwangi JN. Metazoan parasites of some commercially important fish along the Kenyan coast. Western Indian Ocean J Mar Sci. 2004;3(1):71-78.
39. Lizama M, Los DAP, Takemoto RM, Pavanelli GC. Influence of host sex and age on infracommunities of metazoan parasites of *Prochilodus lineatus* (Valenciennes, 1836) (Prochilodontidae) of the upper Paraná River floodplain. Parasit. 2005;12:299-304.
40. Siddiqui S, Matera C, Radakovic ZS, Hasan MS, Gutbrod P, Rozanska E, *et al*. Parasitic worms stimulate host NADPH oxidases to produce reactive oxygen species that limit plant cell death and promote infection. Sci Sign. 2014;7(3):20-33.
41. Akhter AS. Effects of seasons, host age, size and sex on monogenetic trematode, *Hamatopeduncularia indicus*, of host fish, Arius jella. J Chem Biol Phys Sci. 2014;2(4):1146-1151.
42. Ternengo S. Caractérisation des communautés de parasites de poisons de la réserve naturelle des Bouches de Bonifacio. Thèse Doctorat. Université Corse de Bonifacio (France); 2004. 210 p.
43. Zander CD. Ecology of host-parasite relationships in the Baltic Sea. Naturwissenschaften. 1998;85:426-436.
44. Valtonen ET, Prost M, Rahkonen R. Seasonality of two gill *Monogenea*ns from two freshwater fish from an oligotrophic Lake in Northeast Finland. Int J Parasitol. 1997;20(1):101-107.