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Microecology of Monogenean Gill Parasites of *Tilapia Rendalli* Boulenger, 1897 From Bamendjing Lake, Cameroon

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Abstract

The present work aimed to study preferences for microhabitat by the monogenean gill parasites of *Tilapia rendalli* Boulenger, 1897. Fifty-four specimens were sampled using gill net in February 2014 at Bamendjing Lake. Each gill arch was removed and examined to both quantify the number of parasites and their distribution on the gills. This examination enabled us to find 6583 specimens of monogeneans belonging to 5 different species, *Cichlidogyrus arthracanthus*, *C. dossoui*, *C. quaestio*, *C. tiberianus* and *C. tilapiae* with 3708, 1708, 858, 210 and 99 individuals respectively. All species were aggregated within the host population.

The spatial distribution of each parasite species was studied on different partitions of the gill arches. This study supports the hypothesis that gill site preference is a result of water flow over gills during respiration and mate finding habitat. There was no evidence of competition among the various species.

Keywords: Monogenea, Ectoparasites, *Tilapia rendalli*, Site preference, Bamendjing Lake

1. Introduction

The role of parasitism seems essential in ecology because parasites are good tools to study the structure and the organization of communities (Mouritsen & Poulin, 2002; Koehler & Poulin, 2010). Monogenean gill parasites are not exceptional to this rule. These organisms constitute the most ubiquitous and abundant group of helminth parasites in the aquatic environment. More than 95% are fish ectoparasites and highly host specific when compared to other groups of parasites (Whittington et al., 2000; Matejusova et al., 2003; Ivona, 2004). Most species are restricted not only to a particular host, but also to a particular part of the host (Poulin, 2002; Turgut et al., 2006; Bi & Janovy, 2011; Soylu et al., 2013). For these reasons, monogenean gill parasites are suitable models to study site selection (Desdevises et al., 2002). Various cases of site preference have been identified in relation to gill arch, hemibranch, sector or filamentous zone. The effect of these gill preferences is not clear and many host and environmental factors could be involved (Pie et al., 2006). Monogenean site specificity have been associated with particular feeding guilds and diet (Marcogliese, 2002), reinforcement of reproductive barriers and en-hancement of the chance to mate (Whittington & Ernest, 2002), avoidance of intra and interspecific competition (Rohde et al., 1995), differences in the area between the gill arches (Buchmann, 1999).

Systematic studies carried out by Paperna (1960), Ergens (1981) and Douëllou (1993) revealed the presence of several monogenean species belonging to *Cichlidogyrus* genus on the gills of *Tilapia rendalli* Boulenger, 1897. In Cameroon, the ecological studies of the monogenean gill parasites of this Cichlid are nonexistent. The aim of this study is to examine some aspects of monogeneans ecology in terms of site preference within an ecological framework (i.e number and distribution of parasites).

2. Materials and Methods

2.1 Host Collection

A total of 54 adult *T. rendalli* were sampled in February 2014 at Bamendjing hydroelectric reservoir also called Lake Bamendjing (5°49' 60" N and 10°30' 00" E). All fish were caught using a 1 cm by 1 cm mesh gillnet by local fishermen. Right away after sampling, the fish individuals were immersed into 10% formalin solution and transported to the laboratory for parasitological analysis (Tombi et al., 2014).

2.2 Spatial Distribution of Parasite Species

Gills from the left and right sides of the fish were dissected. Data regarding the distribution of monogeneans on the gill biotope of *T. rendalli* were carried out in special topographic card (Figure 1). The gill arches were numbered 1 to 4 from anterior to posterior. Each gill arch was divided into two hemibranches and five sectors: dorsal (S1), medio-dorsal (S2), median (S3), medio-ventral (S4) and ventral (S5). In addition, three equidistant zones: distal zone (1), median zone (2) and basal zone (3) were established at the level of each gill filament and following the vertical gradient.

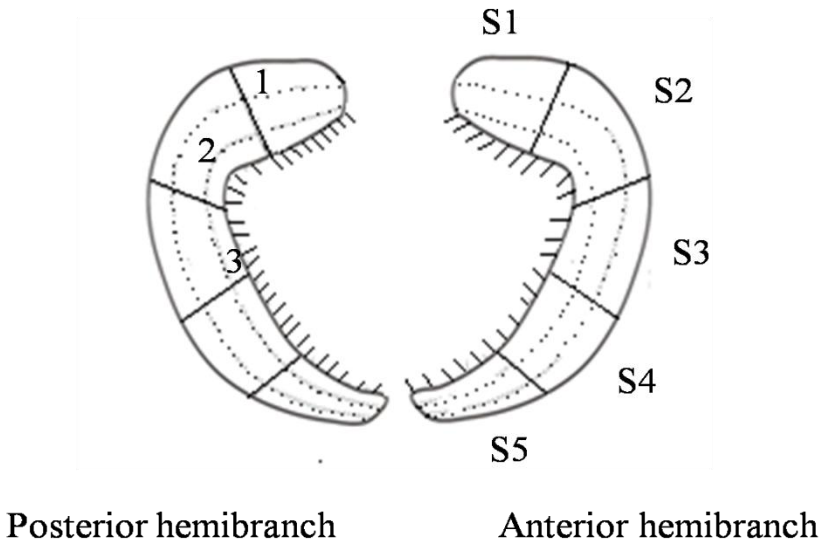

Figure 1. Schematic drawing of hemibranches showing division into sectors and zones

2.3 Parasite Data

Under a stereo-microscope, each hemibranch was examined filament by filament from the dorsal towards the ventral part. The position of each monogenean individual found on each gill filament was recorded in order to determine the microhabitat preference of each species. The specimen was then isolated, mounted on slide in a drop of water and observed with an OLYMPUS M50 light microscope. All species were identified using sclerotized parts of the haptor and reproductive organs according to Paperna (1960), Ergens (1981) and Douëllou (1993).

2.4 Statistical Analysis

Prevalence (%) and mean intensity were use as defined by Bush et al. (1997). The distribution of each monogenean species on particular gill arches, hemibranches, sectors and zones was analyzed by Kruskal Wallis's K test and Mann-Whitney's U test to assess the significance of the difference. Differences of $P < 0.05$ were considered significant. Statistix version 2.0 and Microsoft Excel software were used for the analysis of various data.

3. Results

During this study, 54 *Tilapia rendalli* caught in the Bamendjing Lake were examined and all were infected. A total of 6583 specimens of monogenean were recorded on the gills of this fish host including *Cichlidogyrus arthracanthus*, *C. dossoui*, *C. quaestio*, *C. tilapiae* and *C. tiberianus*. All these species had the typical aggregated pattern of distribution ($S^2 > Im$).

3.1 General Occurrence of the Parasites

The distribution of *C. arthracanthus*, *C. dossoui*, *C quaestio*, *C. tilapiae* and *C. tiberianus* on the gills of *Tilapia rendalli* was analyzed (Table 1). The 54 fish infected with *C. arthracanthus* harbored 3708 individuals of this species. The difference was not significant between the number of parasites found on the right and on the left set of the gills (U, P = 0.78 > 0.05). Gill arch II was preferred compared to the other three (K = 18.02 > 7.81; df = 3). A significant greater number of *C. arthracanthus* occurred on the anterior hemibranch than on the posterior one (U, P = 0.029 < 0.05). This species preferred the median sector (K = 45.40 > 9.48; df = 4) and its parasitic load progressively decreased from the distal zone towards the basal one with a significant difference between two consecutive zones (P < 0.05).

The 54 fish infected with *C. dossoui* harbored 1708 individuals of this species. This parasite did not show a left or right side preference (U, P = 0.935 > 0.05). The parasitic load of *C. dossoui* reduced significantly in the anteroposterior direction thus, parasites mostly occurred on the first gill arch (K = 52.99 > 7.81; df = 3). The anterior hemibranch was more colonized than was the posterior one (U, P = 0.038 < 0.05). The specimens of this monogenean species mostly occurred on the third sector (K = 76.79 > 9.48; df = 4) and on the basal zone (K= 24.15 > 5.99; df = 2).

Of the 54 dissected fish, 51 (94.44%) were infected by *C. quaestio* and 858 specimens of this species were found. *C. quaestio* did not show preference for the left or right side of the gills of *Tilapia rendalli* (U, P = 0.79 > 0.05). Parasitic load decreased insignificantly in the anteroposterior direction (K = 2.10 < 7.81; df = 3). *C. quaestio* showed more affinity for the anterior hemibranch (U, P = 0.0054 < 0.05), the third sector (K = 28.43 > 9.48; df = 4) and the median zone (K = 14.55 > 5.99; df= 2).

Of the 54 dissected fish, 31 (57.40%) were infected by *C. tiberianus* and 210 parasites were collected. No significant difference was found between the number of the right and left gill parasites (U, P = 0.25 > 0.05). Parasitic load decreased significantly in an anteroposterior direction (K = 10.99 > 7.81; df = 3). A greatest number of *C. tiberianus* was recorded on arch I (K = 16.94 > 7.81; df = 3) and on the third sector (K = 12.71 > 9.48; df = 4). No preference for zones (K = 2.82 < 5.99; df = 2) and for hemibranches (U, P = 1.14 > 0.05) was observed.

Table1. General occurrence of monogenean species on the gills of *Tilapia rendalli*

Species	*C. arthracanthus*	*C. dossoui*	*C. quaestio*	*C. tiberianus*	*C. tilapiae*
M(SD)	68.67(47.97)	31.63(18.47)	16.82(20.07)	6.77(7.02)	2.91(1.82)
Left side	1897	878	399	87	60
Right side	1811	830	459	123	39
Gill arch I	1059	636	263	75	25

Gill arch II	1132	470	232	64	40
Gill arch III	964	415	211	47	17
Gill arch IV	553	187	152	24	17
Anterior hemibranch	1954	1098	475	88	46
Posterior hemibranch	1754	610	383	122	53
Sector 1	422	169	39	14	15
Sector 2	930	354	179	65	33
Sector 3	1095	571	326	75	19
Sector 4	948	451	268	42	25
Sector 5	313	163	46	14	7
Distal zone	2131	33	228	56	74
Median zone	1477	112	589	58	12
Basal zone	100	1563	41	96	13

Of the 54 examined fish, 34 (62.96%) were infected with *C. tilapiae*. A total of 99 individuals were recorded and no preference for gill arches (K = 6.96 < 7.81; df = 3), hemibranches (U, P = 1.26 > 0.05), sectors (K = 6.06 < 9.48; df = 4) and zones (K = 3.49 < 5.99; df = 2) was observed.

3.2 Simultaneous Occurrence of all the Parasite Species (Table 2)

Twenty-two *T. rendalli* were simultaneously parasitized with the five monogenean species. In these hosts, 1741 *C. arthracanthus*, 796 *C. dossoui*, 542 *C. quaestio*, 71 *C. tilapiae* and 141 *C. tiberianus* were recorded. The number of the specimens of each species was similar on both sides of the host (U, P > 0.05). *C. arthracanthus* preferred gill arches I, II and III (K= 9.02 > 7. 81; df = 3), median sector (K= 24.46 > 9. 48; df = 4) and distal zone (K= 82.34 > 5.99; df = 2). A significantly greater number of *C. dossoui* occurred on gill arch I (K= 29.43 > 7.81; df = 3), anterior hemibranch (U, P = 0.000 < 0.05), median sector (K = 45.47 > 9.48; df = 4) and basal zone (K= 63.5 > 5.99; df = 2). *C. quaestio* preferred median sector (K = 38.43 > 9.48; df = 4) and median zone (K = 19.66 > 5.99; df = 2). *C. tiberianus* preferred posterior hemibranch (U, P = 0.034 < 0.05) and median sector (K = 30.39 > 9.48; df = 4). *C. tilapiae* preferred gill arch II (K = 11.52 > 7.81; df = 3) and distal zone (K = 12.65 > 5.99; df = 2).

Table 2. Distribution of monogenean species on the gills of *Tilapia rendalli* in simultaneous infection

Species	*C. arthracanthus*	*C. dossoui*	*C. quaestio*	*C. tiberianus*	*C. tilapiae*
M(SD)	79.14(49.74)	36.18(16.88)	24.18(27.58)	6.41(6.35)	3.23(1.82)
Left side	913	426	254	52	44
Right side	838	370	288	89	27
Gill arch I	514	296	167	48	20

Gill arch II	523	219	145	39	26
Gill arch III	462	191	133	36	12
Gill arch IV	242	90	97	18	13
Anterior hemibranch	917	516	336	54	38
Posterior hemibranch	824	280	206	87	33
Sector 1	171	64	16	4	11
Sector 2	422	144	104	47	22
Sector 3	635	293	207	56	15
Sector 4	406	215	184	27	16
Sector 5	107	80	31	7	7
Distal zone	999	700	56	63	15
Median zone	668	66	353	40	16
Basal zone	74	30	133	38	40

3.3 Simultaneous Occurrence of the Abundant Parasites Species (Table 3)

This type of infection concerned *C. arthracanthus*, *C. dossoui* and *C. quaestio*. Each of this trio infected more than 90% of hosts dissected. Of the 54 fish examined, 11 (20.37%) were simultaneously parasitized by this trio and harbored 620 *C. arthracanthus*, 271 *C. dossoui* and 79 *C. quaestio*. *C. arthracanthus* preferred distal zone ($K = 10.98 > 5.99$; df = 2). *C. dossoui* preferred gill arch I ($K = 8.05 > 7.81$; df = 3), anterior hemibranch (U, $P = 0.01 < 0.05$) and basal zone ($K = 13.98 > 5.99$; df = 2). *C. quaestio* showed no preference for gill arches ($K = 0.55 < 7.81$; df = 3), hemibranches (U, $P = 0.84 > 0.05$), sectors ($K= 6.32 < 9.48$; df = 4) and zones ($K = 0.81 < 5.99$; df = 2).

Table 3. Distribution of monogenean in simultaneous occurrence of the abundant species

Species	*C. arthracanthus*	*C. dossoui*	*C. quaestio*
M(SD)	56.36(53.28)	24.67(18.41)	7.5(6.06)
Left side	322	130	38
Right side	298	141	41
Gill arch I	155	107	21
Gill arch II	197	62	22
Gill arch III	167	66	22
Gill arch IV	101	36	14
Anterior hemibranch	287	176	45
Posterior hemibranch	333	95	34
Sector 1	63	33	4
Sector 2	136	58	13
Sector 3	191	93	33
Sector 4	172	57	26

Sector 5	58	30	3
Distal zone	360	9	23
Median zone	225	14	51
Basal zone	35	248	5

4. Discussion

The present study reports occurrences of five monogenean species parasitizing the gills of *Tilapia rendalli* from Bamendjing Lake. In Cameroon, simultaneous colonization of Cichlid gill systems by several monogenean species has already been reported (Dossou & Birgi, 1984; Tombi et al., 2014). Such observations were also made for other African Cichlids (Pariselle et al., 2003; Ibrahim, 2012). The coexistence of congeneric species in the gill system of *T. rendalli* allows the exclusion of interspecific competition among the factors involved in the structuring of this component community. According to Lim (1990), competition does not permit similar species to coexist. For Rohde (1994), positive interactions are more frequent between fish ectoparasites of the same host than negative interactions. Niche heterogeneity, unpredictable recruitment or the aggregated utilization of fragmented resources favour species coexistence (Morand et al., 1999).

All the parasite species presented an aggregate distribution which is in accordance with the typical distribution pattern found in fish parasites and can be explained by the heterogeneity of the host-parasite relationship (Nering & Zuben, 2010). This observation fits the conclusion of Langlais & Silan (1995) indicating that in intensive fish farming where the density of hosts is high, most of the parasite species are overdispersed.

The exploitation of both sides of the gill system of *T. rendalli* by all parasite species did not show a significant difference. Many parasitologists agreed upon this observation in Cichlid species. Tombi et al. (2014) noted an equipartition of *Cichlidogyrus halli, C. thurstonae, C. tilapiae* and *Scutogyrus longicornis* on both sides of *Oreochromis niloticus*. Other previous studies also didn't indicated significant preference between the left and the right sides by monogenean ectoparasites (Soylu et al., 2010; Le Roux et al., 2011; Soylu et al., 2013; Stavrescu-Bedivan, 2013; Sujana, 2015). The bilateral symmetry of *T. rendalli* associated to that of its monogeneans could justify a similar exploitation of both sides of this fish species (Tombi et al., 2014). This symmetry was due to the equal chances for infection of both sides with the monogenean eggs (Stavrescu-Bedivan, 2013).

This work has indicated defined microhabitat of each monogenean species. *C. arthracanthus* preferred gill arch II, anterior hemibranch, median sector and distal zone. *C. dossoui* preferred gill arch I, anterior hemibranch, median sector and basal zone. *C. quaestio* showed more affinity for anterior hemibranch and median sector, as well as the median zone. *C. tiberianus* preferred gill arch I, median sector and median zone. *C. tilapiae* preferred gill arch II and the distal zone. Various works also showed that microhabitat selection is common among fish gill monogeneans and that the choice of attachment site varies with the species (El Hafidi et al., 1998; Tombi et al., 2010; Le Roux et al., 2011; Sujana, 2015). The majority of the representatives of the studied component community are preferentially found on gill arches I and II and on the anterior hemibranch. The high water flow that passes through these parts of the gill system, favours the creation of suitable conditions for these monogenean species (Izumova & Zharikova, 1982). Suydam (1971) demonstrated that the high number of *Diclidophora maccallumi* on the first three arches was linked to the high volume of water passing through them. All monogenean species of *T. rendalli* preferred the median sector. Similar results were obtained by Sujana (2015). Some monogeneans often prefer this sector because it is the most exposed to the respiratory current (Yang et al., 2006).

It is essentially on the vertical gradient of distribution (zonal) that occur the segregation of monogenean gill parasites of *T. rendalli*. The most abundant monogenean species, *C. arthracanthus* and *C. dossoui* preferred respectively the distal and basal zones. The second most abundant species, *C. quaestio* preferred the median zone. These three species were the main contributors to the microhabitat distribution. The least abundant species, *C. tiberianus* and *C. tilapiae* did not show a preference for zone but *C. tilapiae* had the tendency to settle on the distal zone. It is therefore clear that, to coexist the species of this guild have adopted to share their space resource. Such aggregation of individuals of each parasite species on specific zone suggests the absence of an intraspecific competition (Soylu et al., 2013). For Rohde (1977), this restriction of the niche facilitates mating. However, according to Buchmann & Lindenstrom (2002), the exact explanation of site selection by the monogeneans remains enigmatic. Despite sharing the space resource by the five species studied, there is some mutual tolerance between them as their respective niches tend to overlap indicating the absence of interspecific competition.

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