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Epidemiological study of *Acanthogyrus tilapiae*, gut parasitic helminth of *Hemichromis elongatus* in the Mefou hydrographic system (South-Cameroon): Effect of the environment

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Abstract
Hemichromis elongatus is used as a voracious accompaniment to control *Tilapia* in fish farming. The management of parasitic problems is a major limiting factor of aquaculture. This study compares the dynamics of *Acanthogyrus tilapiae* infections in *H. elongatus* in three different ecosystems of the Mefou hydrographic system. Fish were sampled from December 2017 to September 2019. From the 303 host specimens examined, a total of 1034 *A. tilapiae* individuals were collected. The high infection observed in the forest downstream course (prevalence= 89.7% and mean intensity=13.55 ±1.66) is probably due to the abundance of intermediate hosts in the wild. In the Mefou dam, the lowest epidemiological values (prevalence = 0.8% and mean intensity = 1±0) could be linked to the low abundance of invertebrate hosts. These findings reinforce the practice recommending quarantining native fish specimens captured in the wild and used as sires in ponds, in order to avoid epizootic outbreaks.

Keywords: Acanthocephalans, Cichlidae, ecosystem, dynamics, season, Cameroon

1. Introduction

Hemichromis Peters, 1848 is an African Cichlid genus which encompasses the five-spotted species complex of fishes characterized by the presence of an incomplete row of teeth in the mouth and five vertical black spots on the body flanks [1, 2]. This complex was previously made-up of three species, namely: *Hemichromis fasciatus* Peters, 1858, *Hemichromis elongatus* (Guichenot, 1861) and *Hemichromis frempongi* Loiselle, 1979. The latter species has been considered as a junior synonym of *H. fasciatus* (Teugels and Thys van den Audenaerde 1992); therefore *Hemichromis* (the five spotted subgroup) currently includes *H. fasciatus* and *H. elongatus*. The first taxon is believed to be restricted in West Africa while the second is the only one known in Lower Guinea [3]. Both species are used as voracious accompaniments to control *Tilapia* in fish farming with high resilience [4, 5]. Their presence promotes the qualitative yield of Tilapia ponds [6], but without increasing the quantitative yield [4]. In the South Centre Plateau of Cameroon, *H. elongatus* is frequently consumed by rural populations [7]; it is also the main fish species caught in the municipal lake of Yaoundé, sold and very palatable/appreciated by townsmen (Fishermen pers-com). It therefore provides a significant animal protein supplement for humans. *Hemichromis elongatus* is also a serious candidate for fish farming due to its resistance to stress. The management of parasitic problems is a major limiting factor of aquaculture in terms of profitability and environmental health [8]. Cichlids may harbor many groups of parasites: Protista, Myxozoa, Monogenea, Trematoda, Cestoda, Acanthocephala, Nematoda and Crustacea [9]. One species of Acanthocephalans, *Acanthogyrus tilapiae* (Baylis, 1948) parasitizes many Cichlids [10]. Acanthocephalans are a class of endoparasitic helminths from freshwater and marine fishes [11], reptiles, birds and mammals [12]. They are excellent indicators of environmental pollution [13]. In cases of severe infections, they can cause intestinal obstructions [14]. These parasites have sometimes been invoked in the decline of the quality of certain fish of economical interest [15]. According to the [16, 17], they determine pathologies slowing the growth of hosts and increasing their mortality rate.

This study compares the dynamics of *Acanthogyrus tilapiae* infections in *H. elongatus* in three different ecosystems of the Mefou hydrographic system (South-Cameroon).

2. Materials and methods
2.1 Study sites
This study was conducted around Yaoundé (political capital of Cameroon), on the southern plateau characterized by a bimodal humid tropical rainfall regime with four seasons : a long dry season (LDS) from mid-November to mid-march, a short rainy season (SRS) from mid-march to June, a short dry season (SDS) from July to august, and a long rainy season (LRS) from September to mid-November [18] .The annual rainfall is 1650mm with maxima in May (196mm) and October (293mm), minima in January (30mm) and July (37mm); the atmospheric mean temperature is 23.5°C and average wetness of 80% [19]. Three different ecosystems where considered in the Mefou hydrographic system : the Mefou dam (MD) in the Ozom village (11°27'N; 3°40'E) in the upstream course, Obili (3°51'N ; 11°29'E) a private semi-intensive pond (PO) in the middle course, and two tributaries in the forest downstream (FD) course: Essazock (11°32'N ; 3°40'E) and Ekali (11°32'N; 3°38'E) .These localities were visited for fishing at least twice a month; no sampling was done in the SDS 2018 due to infrastructural and logistic shortages. Fishes were sampled from December 2017 to September 2019 using a gill net and transported to the laboratory in isothermal tanks. In the laboratory, they were euthanized; a spike was introduced into the brain of the fish which was then disrupted by rotary movement [20]. The parasitological examination was carried out within 24 hours after fish capture. Standard length [(SL horizontal distance from the front tip of the snout to the base or articulation of the caudal fin [3]] was measured to the nearest millimeter (mm) using a Carbon fiber Calliper.

2.2 Host sampling and parasitological examination
The abdominal cavity was opened by a medio-sagittal section. The fish sex was determined (as male, female or undetermined), then the digestive tract was removed and placed in a Petri dish containing a wet filter paper the digestive tract was fixed in a 10% formalin solution. After thorough cleaning, the gut was opened longitudinally; Acanthocephalans were dislodged from the gut epithelium, placed in a Petri dish containing tap water and counted.

2.3 Data analysis
Abundance, intensity, mean intensity and prevalence were defined according to [21]. Multiple comparisons of mean intensities were tested using variance analysis (ANOVA). The Student's t-test was used to compare mean intensities between male and female. The Tukey's post-hoctest was performed to compare helminth loads between two seasons or ecosystems. The Chi-square ($\chi2$) test made it possible to compare prevalence. The correlation between parasite abundance and hosts standard length was investigated by the Sperman's coefficient "r" expressed in percent. These analyses were performed using the software PAST.16 and Quantitative Parasitology 3.0. All values of P <5% were considered significant.

3. Results
3.1 Epidemiological data of *Acanthogyrus tilapiae* in the three ecosystems of the Mefou Hydrographic system
During the current work, 303 *H. elongatus* were sampled in the three different ecosystems (Pond, Mefou dam and forest downstream course) and examined. A total of 1034 *Acanthogyrus tilapiae* individuals were collected. The parasitological indexes varied significantly between ecosystems (prevalence: X^2=119.7, P=1.5^{E-42}) intensity: K=11.53, P=0.003) and even between two of them; PO and FD (K=9.23, P=0.0024) for the intensity; PO and MD (X^2 =4.25, P=1.19^{E-05}), PO and FD (X^2 = 69.8, P=4.8^{E-22}) and between MD and FD (X^2 =112.7, P=1.23^{E-37}) for prevalence (Table 1). Both parasitological indexes were highest in the forest ecosystem (less anthropized) and lowest in the Mefou dam.

Table 1: Prevalence and mean intensity of *Acanthogyrus tilapiae,* intestinal parasite of *H. elongatus* in three ecosystems of the Mefou hydrographic system

Region studied	Fish examined	Prevalence (%)	Mean intensity ±SE	Aggregation (s^2/MI)
PO	101	16	4.94±1.29	9.10
MD	123	0.8	1±0	1
FD	78	89.7	13.55±1,66	15.73
Statistics		X^2= 119.7 P= 1.5^{E-42}	K= 11.5 ; P=0.003	/

SE=Standard Error, PO=pond; MD=Mefou dam; FD= forest downstream course; MI=mean intensity

3.2 Relationship between intensity of *A. tilapiae* and the host standard length
In the Pond, the intensity of *A. tilapiae* positively correlated (r^2=16%, P=0.00002) with the host standard length; it was also the case in the forest downstream course (r^2 = 18%; P= 0.00008**).** In the Mefou dam comparisons of epidemiological indexes were not realizable because only one fish was parasitized.

3.3 Relationship between *A. tilapiae* intensity, prevalence and host sex

Table 2: Prevalence and mean intensity of *A. tilapiae* as a function of the host sex

Host			Prévalence (%)	MI±SE
Sex	**Examined**	**Infected**		
Males	123	32	26.80	15.80±14.48
Females	154	43	27.27	10.97±12.75
Statistics			X^2=0.004 P=0.93	t= -1.53 P=0.13

SE=Standard Error, MI = mean intensity.

Among the total hosts sampled (303 *H. elongatus*), the sex of 277 individuals was determined. The intensity and the prevalence of *A. tilapiae* were not sex dependent (Table 2).

3.4 Seasonal variation of the parasitism by *A. tilapiae* in the three ecosystems

Due to the small number of fishes examined by ecosystem and by season, we decided to investigate the seasonal variation of the different epidemiological indexes (intensity and prevalence) of *A. tilapiae* in the whole Mefou hydrographic system. The helminth load (intensity) varied among seasons (K=17.98; P=0.003), due to differences revealed by pairwise comparisons between LDS 2018 and SDS 2019 (P=0.02), LDS 2018 and SRS 2019 (P=0.001), SRS 2018 and LDS 2018 (P=0.003) (Figure 1).

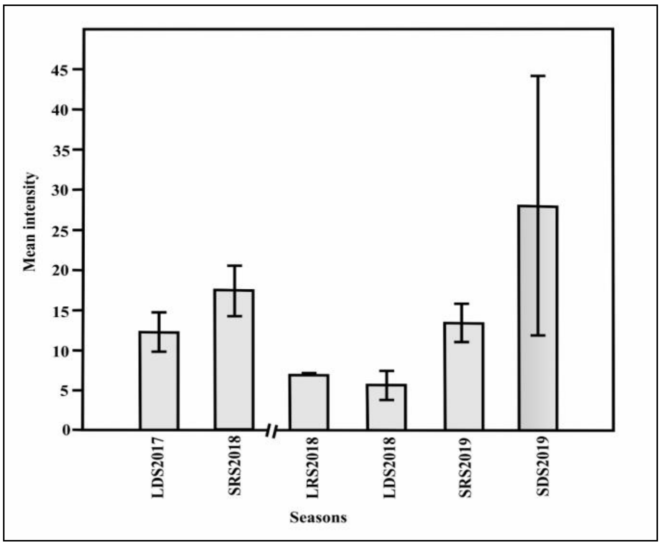

Fig 1: Seasonal variation of intensity of *A. tilapiae*

Therefore, no clear seasonal profile pattern emerged from these data. Moreover the parasitism was not cyclical. The same remarks were done for the prevalence (Figure 2) which differed between seasons (X^2= 16.07; P=0.0001). Pairwise comparisons did not reveal significant variation between SDS 2019 and LRS 2018 (P=0.40), SRS 2019 and LDS 2018 (P=0.37), SRS 2019 and SRS 2018 (P=0.21), SRS 2018 and LDS 2017 (P=0.56), SRS2018 and LDS2018 (P=0.46).

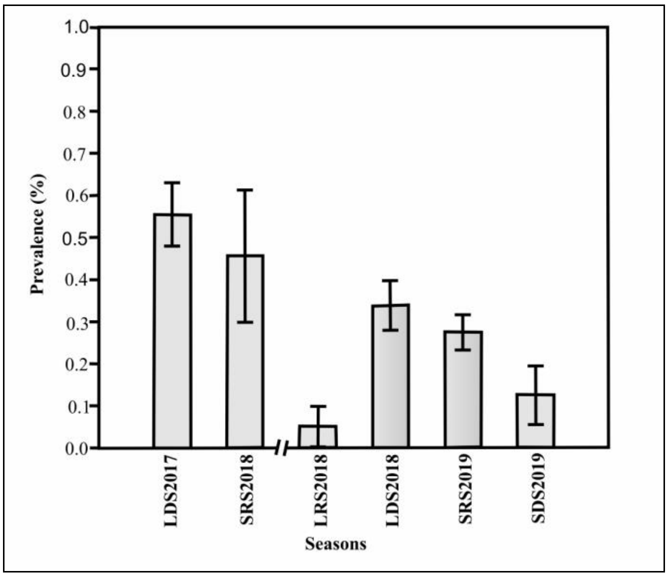

Fig 2: Seasonal variation of prevalence of *A. tilapiae*

4. Discussion

This work dealt with the dynamics of *Acanthogyrus tilapiae* (Acanthocephala, gut parasite of *H. elongatus*) in three ecosystems of the Mefou hydrographic system. Among Pisces, helminths are mostly found in freshwater fishes because parasite species and their biology, hosts and their feeding habitats, physical factors, hygiene of the water body and the presence of intermediate hosts contribute to their prevalence and intensity [22].

We found a significant difference of *A. tilapiae* intensity in *H. elongatus* from the forest downstream course (FD) and the Pond (PO) ; significant variations of prevalence were also found between PO and MD, PO and FD, MD and FD. This could be due to the mode of transmission of acanthocephalans which have complex life cycles, infesting invertebrates as intermediate hosts and mainly the final vertebrate hosts [23]. The high infection level observed in the forest downstream course is probably due to the abundance of the intermediate hosts in the wild. [24] also showed that, infestation levels are headed by local abundance of intermediate hosts. Therefore, the reduced abundance of the latter in the pond, frequently drained, could explain the low intensity and prevalence of *A. tilapiae*. In the upstream of the Mefou watershed, we noticed the presence of many cocoa and palm tree farms. To fight against weeds and pests, farmers use biocides which contain non-degradable elements (e.g. heavy metals) that can remain in the soil or be driven by the runoff into groundwater, surface water and be transferred to plants, animals and humans [25]. These pollutants also have a direct impact on the aquatic system; their elevated concentrations are known to endanger ecosystems and introduce a potential risk to living organisms. In the Mefou dam, the lowest epidemiological values could be linked to the low abundance of intermediate hosts of acanthocephalans (to be confirmed) due to the lethal effect of pollutants via agricultural activities which use pesticides.

The *Hemichromis* are carnivorous; their preys vary with the length/age of the predator and are made up of insect larvae, shrimps and young fish. The larger fish individuals are only ichtyophagous [26]. It follows from this statement that *H. elongatus* is mainly infested when younger and during foraging activities; then worms accumulate over time in the hosts. Therefore during breeding conditions, young fish should be separated from old ones; the latter can facilitate the infestation of the former via the intermediate hosts which serve as a food resource. The situation observed in this study may also be the response of *A. tilapiae* to the health of the different ecosystems considered; thus it holds up or supports the argument of [15] that in free-living species, parasites respond to ecosystem disturbances and can provide valuable information about a system's quality, integrity and health in response to pollutants and other stressors. According to [27] most of the Acanthocephalan species found in African fish are not highly host specific, as they parasitize more than one fish species and frequently many families. *Acanthogyrus tilapiae* is largely distributed in all the African watersheds studied [27]. It has been found in Cichlidae (genera: *Tilapia*, *Oreochromis*, *Sarotherodon*, *Hemichromis*, *Haplochromis…*), and Tetraodontidae (see the literature review by [10]. With such a large host spectrum, *A. tilapiae* is euryxenous [28]. Therefore in Tilapia ponds, many Cichlid species can serve, one another, as parasite reservoirs resulting in high prevalence and intensity of infestation which may cause obvious harm to their hosts. In this case more than a quarantining, we recommend, for a sustainable production of good healthy fish, more domestication and rearing efforts.

The size (SL) of the host was positively correlated with the *A. tilapiae* load in the PO (r^2=16%) and in the FD (r^2=18%). According to many authors, the larger hosts are generally older and usually more heavily parasitized due to their higher nutritional needs [29, 30]. Like [31] we also suggest that, the higher values of the intensity of infection in larger specimens may be related to the accumulation of larvae (cysticanthes) in the host by a repeated process of infection. The prevalence and the mean intensity of *A. tilapiae* were not host sex dependent (see Table 2). Different observations were made in Nigeria on the prevalence of this species in *T. zilli* and *T. dageti*; [32] found a significant difference in the infestation of both sexes, males being more infested than females due to the fact that males have more exposure to increased turbulence and increased productivity, which witness increased worm burden infestation. During the current study, we noticed significant differences (for both the prevalence and intensity) between the seasons. Temperature is the most important environmental factor influencing population dynamics of the parasites [33], it varies with the rainfall [18]. But no clear seasonal profile pattern emerged from our data. We noticed an aggregative distribution of *A. tilapiae* among host individuals in SDS2019 (Figure 2) which explains its low prevalence during that season. In such analysis, it seems important to have information on the dynamics of intermediate hosts and their seasonal infection rate by acanthella/cystacanthes, the reproduction cycle of the host and its feeding habit.

5. Conclusion

It emerges from this study that both parasitological indexes were highest in the forest ecosystem probably due to the abundance of intermediate hosts in the wild. Their lowest values in the Mefou dam are suggested to be linked to the low abundance of intermediate hosts of acanthocephalans due to lethal effect of pollutants via agricultural activities which use pesticides. The variations of the water temperature as a function of the rainfall regime explain the population dynamics of *Acanthogyrus tilapiae* although no clear seasonal profile emerged from the data. This work highlights the necessity to consider the environment when comparing the parasitism of different populations of the same host species. These findings reinforce the practice recommending quarantining native large fish specimens captured in the wild and used as sires in ponds, and separating them from young fish in order to avoid epizootic outbreaks.

6. Conflict of interest

The authors declare no conflicts of interest.

7. Acknowledgements

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