Dynamics Of Monogenean Gill Parasites Of *Synodontis rebeli* (Siluriformes, Mochokidae) From River Sanaga Reveals Unusual Switching Status

Jonathan Armel Mbondo [1], Etienne Didier Bassock Bayiha [2], Bahanak Dieu Ne Dort [3], Nack Jacques [4,5], Kingsley Etchu [6], Charles Félix Bilong Bilong [2]

[1]Institute of Agricultural Research for Development (IRAD), Experimental Research Station in Marine Ecosystems, PO Box 219, Kribi, Cameroon
[2] Laboratory of Parasitology and Ecology, University of Yaoundé I, PO Box 812, Yaoundé, Cameroon
[3]Institute of Agricultural Research for Development (IRAD), Station of Batoke, BO box 77 Limbe, Cameroon
[4]University of Douala, Laboratory of Parasitology and Ecology, PO Box 24157, Douala, Cameroon
[5]Institute of Fisheries and Aquatic Sciences of Yabassi (ISH), University of Douala, Cameroon
[6]Institute of Agricultural Research for Development (IRAD), Yaoundé, PO Box 2123, Yaoundé

DOI: 10.29322/IJSRP.12.09.2022.p12908
http://dx.doi.org/10.29322/IJSRP.12.09.2022.p12908

Paper Received Date: 19th July 2022
Paper Acceptance Date: 29th August 2022
Paper Publication Date: 6th September 2022

Abstract- The present survey on population's dynamics of gill monogeneans aimed to contribute in minimizing catastrophic losses in potential fish ponds. Monogeneans were dislodged from the gill filaments, with the aid of a dissecting needle and mounted between slide and cover slip in a drop of water. They were identified and counted using a microscope. The present study revealed three monogenean species gill parasites of *Synodontis rebeli*: *Synodontella melanoptera*, *Synodontella sanagaensis* and *Synodontella* sp. These parasite species are aggregated among the host population. The significant increase of the parasite loads as a function of the host size (standard length) is explained by the fact that, larger fish offer larger bodies and gill surfaces potentially colonizable by the parasites. Significant variations of parasitological indexes as function of both season and fishing campaign period were revealed. Water temperature and the levels of others environmental parameters appear as an important factor associated with the variation in monogenean infections; it might explain changes in the status of *Synodontella* sp.

Index Terms- Monogenean, dynamics, *Synodontis rebeli*, switching status, River Sanaga, Cameroon, Catfish

I. Introduction

Members of the catfish family Mochokidae are amongst the most important teleosts suitable for aquaculture with species of the genus *Synodontis* Cuvier, 1817 of great commercial value and larger ones are important food fishes in many parts of Africa [1]. In the Sanaga River basin, individuals of *Synodontis rebeli* Holly, 1926 are highly consumed by local populations, and potential candidates for aquaculture [2]. Ectoparasites such as monogeneans may cause localized hyperplasia, disturbance of osmoregulation and mortality of their hosts [3], [4]. Secondary infections in hosts due to viruses, bacteria and fungi are also observed [5]. In addition, environmental pollution of the aquatic ecosystem may either increase or decrease the worm (parasite) burden in aquatic organisms such as fish [6], [7]. Fish parasite diseases reduce the amount of food available to people [8] and remain a constraint for a successful fish farming [9]. Thus, fishery development programs also depend on the intensification of parasitological researches so that improved fish yield can be achieved from healthy fish stocks [10]. It is known that, parasites usually affect the marketability of fish and raise economic losses in aquaculture industry [11], [12]. The present study aimed at assessing the population dynamics of gill monogeneans of *Synodontis rebeli* in view to contribute to minimizing catastrophic losses which could be observed in potential fish ponds.

II. Materials and Methods

A. Study Area

This study was conducted in the Sanaga downstream, at Edéa (3°48'00''N; 10°7'60''E) in Cameroon (Central Africa). This locality is subject to an oceanic variant of the equatorial climate of the Guinean type, characterized by two seasons: the dry season (from December to February with less than 50 mm rainfall) and the rainy season (from March to November) with the monthly average temperature of 25.5°C and the annual average humidity of 28.4 mb [13].

B. Host Fish Sampling and Parasitological Examination

A total of 257 specimens of *Synodontis rebeli*, at least 30 fish per campaign, were bought from fish landing site bimonthly immediately after fishing by nets from January 2018 to March 2019 and constituted the overall sample. After capture, fish were immediately fixed and kept in 10% formalin then transferred to the laboratory. In the laboratory, specimens standard length [SL =

horizontal distance from front tip of snout to base (articulation) of caudal fin [14] was measured to the nearest millimeter (mm) using a Carbon fiber Caliper. Fish were sexed (as male, female or undetermined) then gills were dissected. Monogeneans were dislodged from the gill filaments, with the aid of a dissecting needle, and mounted between slide and cover slip in a drop of water. They were identified to species level by the morphological characters of sclerotized parts of the haptor as well as of the copulatory organs after Mbondo *et al*. [2], using a Leica DM2500 microscope equipped with a Leica DFC425 camera. They were then counted.

C. TERMINOLOGY

The terms prevalence (Pr), intensity (I), mean intensity (MI) and abundance (A) are defined after Bush *et al*. [15]. Based on the prevalence, parasite species were termed common (Pr > 50%), intermediate (10%< Pr ≤ 50%) and rare (Pr ≤ 10%) after Valtonen *et al.* [16]. The mean intensity (even the intensity) is categorized very low (MI ≤ 10), low (10 < MI ≤ 50), average (50 < MI ≤ 100) and high (MI > 100) after Bilong Bilong & Njiné [17].

D. DATA ANALYSIS

The Chi-square (χ^2) test made it possible to compare prevalence. The Kruskal-Wallis (K) test allowed comparing several (more than 2) mean values, while Mann-Whitney test was used for pairwise comparisons. The Sperman's coefficient "r_s" permitted to investigate the potential relationship between the parasite load of a given species and the host standard length. These analyses were performed using STATISTICA 6.0 software and Quantitative Parasitology 3.0. All values of P <5% were considered significant.

III. RESULTS

A. DISTRIBUTION AND STATUS OF *SYNODONTELLA* SPP.

A total of 3683 Monogeneans (*Synodontella melanoptera* Dossou & Euzet, 1993, *S. sanagaensis* Mbondo, Nack & Pariselle, 2017 and *Synodontella* sp. (undescribed species)) were collected from the gills of the 257 specimens of *Synodontis rebeli*. Among these fish, 237 specimens harbored at least one parasite species (overall infection rate of 92.2% ± 0.02) and the mean intensity was 15.54 monogeneans per individual host. The three monogenean taxa aggregated in the host population (s^2/Im > 1). Out of the 257 *Synodontis rebeli* examined, 220 were parasitized by *S. melanoptera* (prevalence: 85.6% ± 0.02), 214 by *S. sanagaensis* (prevalence: 83.3% ± 0.02), and 55 by *Synodontella* sp. (prevalence: 21, 4% ± 0.02). Therefore, based on the overall sample, *S. melanoptera* and *S. sanagaensis* were common species while *Synodontella* sp. was rare or satellite. The mean intensities of the three above parasite species varied from very low to low (Table I).

Table I: epidemiological indexes and status of *Synodontella* spp.

Parameters	Parasites species		
	S. melanoptera	*S. sanagaensis*	*Synodontella* sp.
Hosts examined	257		
Infected	220	214	55
Pr (%)±S.E	85.6 ± 0.02	83.3 ± 0.02	21.4 ± 0.02
MI ± S.E	7.6 ± 0.92	6.65 ± 0.54	10.67 ± 3.8
Overall Status	Common		Satellite

S.E: Standard Error

A total of 119 males and 113 females *Synodontis rebeli* were examined (sex ratio females to males = 0.9). The sex of the other 25 fish specimens was undetermined. The overall infestation rate was 90.75% ± 0.02 in males and 92.92% ± 0.02 in females respectively and did not vary between host sexes (P = 0.16).

B. RELATIONSHIP BETWEEN STANDARD LENGTH AND DEGREE OF INFECTION

Generally, the number of monogenean individuals increased with the size (Standard length) of host. The equation of regression line obtained (Fig. 1) is *ln (A + 1) = 2.28 ln (LS +1) – 1.78*.

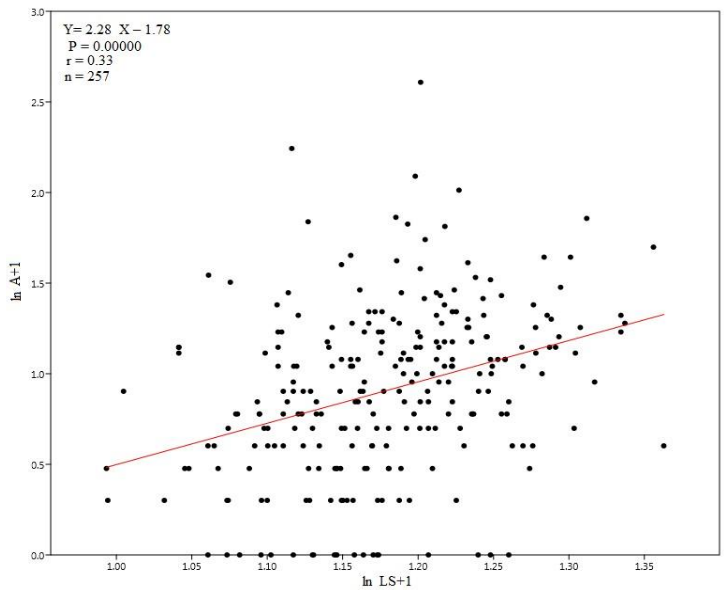

Figure 1: regression line of parasite load (ln A+1) as a function of host length (ln SL+ 1).

The prevalence as well as the mean intensity of *Synodontella* sp. were similar (P = 0.31 and P = 0.78 respectively) between host size classes. However, fish of the class size]148-163] were often relatively more parasitized (MI = 23.7 ± 15.6). For the other monogeneans species, difference of prevalence amongst host size classes was significant for *S. melanoptera* (P = 0.0001) and for *S. sanagaensis* (P = 0.004). For these two monogenean species, the pairwise comparisons for prevalences and mean intensities revealed that fish of SL <118 mm were less infected while those of SL > 148 mm precisely of the size classes]148-163] and > 178 mm were always more infected (Table II).

Table II: prevalence and mean intensity in relation to host size

Size classes	*S. melanoptera*		*S. sanagaensis*		*Synodontella* sp.	
	Pr (%)±SE	MI±SE	Pr(%)±SE	MI±SE	Pr(%)±SE	MI±SE
≤ 118	64 ± 0.07^{b}	4.81 ± 0.8^{b}	69 ± 0.07^{d}	3.72 ± 0.6^{d}	14.2 ± 0.05^{a}	3 ± 1.2^{a}
] 118-133]	84 ± 0.05^{ab}	6.5 ± 0.61^{ab}	82 ± 0.05^{c}	6.46 ± 1.7^{bc}	24 ± 0.06^{a}	7 ± 3.5^{a}
] 113-148]	87.3 ± 0.14^{a}	6.67 ± 1.35^{ab}	77.7 ± 0.05^{c}	5.81 ± 0.8^{c}	25.3 ± 0.05^{a}	8.25 ± 4^{a}
] 148-163]	98.1 ± 0.01^{a}	11.25 ± 3.2^{a}	94.3 ± 0.03^{b}	7.84 ± 1.2^{b}	22.6 ± 0.05^{a}	23.7 ± 15.6^{a}
] 163-178]	92 ± 0.05^{a}	5.17 ± 0.72^{b}	92 ± 0.05^{b}	6.86 ± 1^{b}	20 ± 0.08^{a}	1.2 ± 0.2^{a}
> 178	87.5 ± 0.06^{a}	9.52 ± 1.17^{a}	95.8 ± 0.04^{a}	9.34 ± 1.6^{a}	16.6 ± 0.07^{a}	15.5 ± 12.2^{a}
Stat.	χ^2=8.71 P = 0.0003	K=19.54 P = 0.0015	χ^2=7.1 P = 0.004	K=21.06 P = 0.0007	χ^2 = 5.3 P = 0.31	K = 2.45 P = 0.78

Stat: Statistics; S.E: Standard Error. ^{a,b,c}: different letters in the same column indicate significant statistical differences.

C. SEASONAL VARIATION OF EPIDEMIOLOGICAL INDEXES OF *SYNODONTELLA* SPP.

The seasonal variations of the prevalence only differed for *S. sanagaensis* (P = 0.007) while those of the mean intensity were not-significant (P = 0.21). The prevalence did not vary during the different seasons for *S. melanoptera* and *Synodontella* sp., while their mean intensities fluctuated (P = 0.001and P = 0.0001 respectively) and were always higher during the rainy season (Table III).

Table III: prevalence (%) and mean intensity in relation

Seasons	Parasites species					
	S. melanoptera		*S. sanagaensis*		*Synodontella* sp.	
	Pr (%)±SE	MI±SE	Pr (%)±SE	MI±SE	Pr (%)±SE	MI±SE
DS2018	93.54±0.03^{a}	5.7± 0.5^{b}	93.54±0.03^{a}	6.37±0.5^{a}	29.03±0.15^{a}	1.77±0.4^{b}
RS2018	83.33± 0.03^{a}	10.3±1.7^{a}	76.51±0.03^{b}	7.1±0.9^{a}	21± 0.03^{a}	18.55±6.9^{a}
DS2019	82.53±0.04^{a}	4.01± 0.4^{b}	87.30±0.04^{ab}	6.05±0.9^{a}	12.6±0.04^{a}	2.12±0.6^{b}
Stat.	χ^2= 1.5; P = 0.12	K=12.72; P = 0.001	χ^2=4.06; P = 0.007	K=3.05 P = 0.21	χ^2=2.67 P = 0.07	K=15.58; P = 0.0001

Stat: Statistics; S.E: Standard Error; DS2018: Dry season 2018; RS2018: Rainy season 2018; DS2019: Dry season 2019; ^{a,b,c}: different letters in the same column indicate significant statistical differences.

D. PARASITISM IN *SYNODONTIS REBELI* AS A FUNCTION OF FISHING CAMPAIGN

The overall mean parasite load of infected *Synodontis rebeli* increased sharply during the rainy season, in September 2018 (K=56.11, P = 0.0001). At the species level it was the case in September 2018 for *S. melanoptera* and *S. sanagaensis*, and in September 2018 and November 2018 for *Synodontella* sp. The prevalence also increased in September 2018 so that the status of *Synodontella* sp. reversed from satellite in July 2018 to common. In November 2018 it changed again to satellite (Table IV). Concerning the mean intensity, it varied significantly between campaigns and was very low to low for all parasite species.

Table IV: Epidemiological indexes of *Synodontella* spp. during the fishing campaigns

Fishing campaign	*S. melanoptera*		*S. sanagaensis*		*Synodontella* sp	
	Pr(%)±SE	MI± SE	Pr(%)±SE	MI± SE	Pr(%)±SE	MI± SE
Jan 2018	93.7±0.04^{b}	6.3±0.8^{ab}	93.7±0.04^{a}	7.9±0.8^{ab}	21.8±0.07^{bc}	2.4±1.1^{b}
Mar 2018	93.3±0.04^{b}	5.1±0.6^{b}	93.3±0.04^{ab}	4.6±0.6^{c}	36.6±0.08^{b}	1.3±0.2^{c}
May 2018	70.9±0.08^{d}	8.3±3^{ab}	64.5±0.08^{c}	2.9±0.7^{d}	3.22±0.03^{c}	1±0^{c}
Jul2018	81.8±0.06^{c}	5.3±0.9^{b}	63.6±0.08^{d}	2.2±0.2^{d}	6.06±0.04^{c}	1.5±0.5^{c}
Sep 2018	100±0^{a}	18±4.9^{a}	94.2±0^{a}	13.4±2.4^{a}	65.7±0.08^{a}	20±8.4^{a}
Nov 2018	78.7±0.07^{c}	6.7±1.3^{ab}	84.84±0.06^{b}	6.03±1.2^{b}	9.09±0.05^{bc}	24.3±17.8^{a}
Jan 2019	83.3±0.07^{c}	4.9±0.7^{b}	93.3±0.04^{ab}	7.4±1.6^{b}	16.6±0.06^{bc}	2.6±0.9^{b}
Mar 2019	81.8±0.07^{c}	3.1±0.5^{c}	81.8±0.06^{b}	4.5±0.7^{cd}	9.09±0.05^{bc}	1.3±0.3^{c}
Stat.	χ^2=6.1 P=0.02	K=28.27 P=0.0001	χ^2=14.12 P=0.00001	K=50.3 P=1.2^{E-08}	χ^2=32.2 P=6.5^{E-11}	K=22.23 P=0.002

Stat: Statistics; S.E: Standard Error. ^{a,b,c}: different letters in the same column indicate significant statistical differences.

The distribution of *Synodontella* spp. revealed that these monogenean species aggregate among *S. rebeli* individuals. Similar observations have been made by several authors around the world [16], [9], [18]. This model of parasite distribution among their hosts was proposed as a general feature of metazoan parasites and possibly the only universal law in parasite ecology [19], [20]. According to Combes [21], aggregated distribution may indicate heterogeneity in the relationship between the hosts even parasite populations. It also increases the probability for the parasite to meet its host in the one hand and its chance of surviving in the latter in the other hand; it may vary from one host to another. The overall prevalence of *S. melanoptera* and that of *S. sanagaensis* were above 50% during all campaigns while that of *Synodontella* sp. was below 25%. *Synodontella melanoptera* and *S. sanagaensis* where therefore common species while *Synodontella sp*. was rare or satellite [16]. The infestation of *Synodontis rebeli* (prevalence and the mean intensity) was similar for both males and females specimens. It is known that, *Synodontis* spp. live at the bottom of rivers, near shores and banks; these habitats offer them food security, protect them from predation and are favorable to their reproduction [22]. Therefore, *Synodontis* spp. being distributed irrespective of the host sex, it was not surprising that males and females individuals were equally parasitized because equally exposed and probably susceptible to oncomiracidia. The overall parasite load increased with the size of the host. This result is linked to the fact that, as they grow fish offer larger bodies and gill surfaces potentially colonizable by the parasites [23], [9]; it is also due to the strongest water current passing through the gills of larger hosts, thus creating convenient conditions for parasites settlement [24]. The mean intensities of *Synodontella* spp. increased significantly during the rainy season; therefore, fish suffered more from these parasitic agents during this period. In a pound, Bilong Bilong & Njiné [17] found that the rise in water temperature up to 25 °C or 26 °C in the long dry season was responsible for the mortality of the adult monogeneans, and justifying the low parasite loads and limited the recruitment of infective stages. In addition, temperature is generally considered the most important factor associated with seasonal variation in monogenean infections [25]. In the downstream of Sanaga River, Nzieuleu Tchapgnouo *et al*. [26] stated that, temperatures generally decrease during the rainy season (from September to November), increase during the dry season (from December to January), and can reaching up to 30 °C. On the other hand, the physicochemical characteristics of the water in lower Sanaga fluctuate with the seasons. During the rainy season, water in the Sanaga downstream attains the highest values of solid particle levels, conductivity, depth, salinity, dissolved oxygen, sodium, nitrate, phosphate, and is characterized by low levels of transparency, temperature, pH, magnesium, ammonium and calcium. All these observations show poor quality of water in Sanaga River downstream during this period [27]. According to El-Naggar *et al.* [28] poor quality of water likely creates a stressful circumstance that weakens the immune system and alters the defense tactics of aquatic organisms, leading to poor fish heath. Stressed fish become susceptible to a variety of health problems such as helminth invasions. This situation might also explain the findings in this study. Infection rate and parasite load increased during the rainy season. Moreover, a numerical dominance of *Synodontella* sp. was observed in September and November (rainy season). This parasite species seems to better withstand the water conditions during this period; this result obtained in a natural environment gives rise to some fear for the breeding of *S. rebeli*. In the fish farming, *Synodontella* sp. could provoke epizootics in *S. rebeli* during rainy season. Such fish mortality may be reinforced by secondary infections favored by lesions caused by parasite hooks/anchors and the spoiling action of these ectoparasites [17]. The variation of the status of *Synodontella* sp.

as a function of the host capture period poses the problem of monogeneans response to environmental conditions which remains to specify. This observation demonstrates that the status of a parasite depends on the period of sampling. Therefore, its meaning should not only be searched on the overall host sampling basis, as it is currently found in literature [18].

V. CONCLUSION

The present study provides additional information to the ecology of monogeneans in general and of *Synodontella* spp. in particular, in order to avoid catastrophic losses due to parasite epizootic outbreaks in the case of intensive fish farming. These findings reinforce our previous work [29] recommending quarantining native large fish specimens captured in the nature and used as sires in ponds and/or captures during the dry season when parasitic loads are low.

DISCLOSURE OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

Thanks to Dr. Geneva Ojong Nkongho for technical advice assistance.

REFERENCES

[1] [1] J. P. Friel, T. R. Vigliotta, "Synodontis acanthoperca, a new species from the Ogôoué River system, Gabon with comments on spiny ornamentation and sexual dimorphism in mochokid catfishes (Siluriformes: Mochokidae)," Zootaxa 1125, 45-56, 2006.

[2] [2] J.A. Mbondo, J. Nack, A.R. Bitja Nyom, A. Pariselle, C.F. Bilong Bilong, "New species of Synodontella (Monogenea, Ancyrocephalidae) gill parasites of two Synodontis spp. (Pisces, Mochokidae) from the Boumba River (Congo Basin, East Cameroon)", Parasite, 26, 37, 2019.

[3] [3] W. Piasecki, A. E. Goodwin, J. C. Eiras, B .F. Nowak, "Importance of copepoda in freshwater aquaculture", Zoological Studies 43(2), 193-205, 2004.

[4] [4] M. Bednarska, M. Bednarski, Z. Soltysiak, R. Polechonski, "Invasion of Lernaea cyprinacea in rainbow trout (Oncorynchus mykiss)," ACTA Scientarum Polonurum Medicina Veterinaria 8(4), 27-32, 2009.

[5] [5] D. H. Xu, C. A. Shoemaker, P. H. Klesius, "Evaluation of the link between gyrodactylosis and streptococcosis of Nile tilapia, Oreochromis niloticus (L.)", Journal of Fish Disease, 30, 233-238, 2007.

[6] [6] B. Sures, Host-parasite interactions in polluted environment, Journal of Fish Biology 73, 2133-2142, 2008.

[7] [7] C. A. Blanar K. R. Munkittricka, J. Houlahana, D. L. MacLatchy, D. J. Margogliese, "Pollution and parasitism in aquatic animals: A meta-analysis of effect size," Aquatic Toxicology, 93, 18-28, 2009.

[8] [8] A. H. Bichi, A. A. Ibrahim, "A survey of ecto and intestinal parasites of Tilapia zillii (Gervais) in Tiga Lake, Kano, Northern Nigeria," Bayero Journal of Pure and Applied Sciences 2(1), 79-82, 2009.

[9] [9] J. Tombi, C. F. Bilong Bilong, "Distribution of gill parasites of the freshwater fish Barbus martorelli Roman, 1971 (Teleostei: Cyprinidae) and tendency to inverse intensity evolution between Myxosporidia and Monogenea as a function of the host age", Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, 57, 71-76, 2004.

[10] [10] A. Karvonen, A. M. Bagge, E. T. Valtonen, "Interspecific and intraspecific interactions in the monogenean communities of fish: a question of study scale?" Parasitology, 134, 1237-1242, 2007.

[11] [11] M. Barson, "The occurrence of Contracaecum sp. larvae (Nematoda: Anisakidae) in the catfish Clarias gariepinus (Burchell) from Lake Chivero, Zimbabwe," Onderstepoort Journal of Veterinary Research 71: 35-39, 2004.

[12] [12] A. L. Velloso, P. J. Joaber, "Influence of ectoparasitism on the welfare of Micropogonias furnieri", Aquaculture, 310, 43-46, 2010.

[13] [13] D. Wirrmann, "Le lac Ossa: une monographie préliminaire", Revue de Géographie du Cameroun, XI, 27-38,1992.

[14] [14] M. L. J. Stiassny, G. G. Teugels, C. D. Hopkins, " Poissons d'eaux douces et saumâtres de basse Guinée ouest de l'Afrique Centrale, " Paris, France, MNHN-MRAC-IRD 1, 789 pp, 2007.

[15] [15] A. O. Bush, K. D. Lafferty, J. M. Lotz, A. W. Shostak, "Parasitology meets ecology on its own terms: Margolis et al., revisited," Journal of Parasitology, 89, 575-583, 1997.

[16] [16] E. T. Valtonen, M. Prost, R. Rahkonen, "Seasonality of two gill Monogeneans from two freshwater fish from an oligotrophic Lake in Northeast Finland", International Journal for Parasitology, 20 (1), 101-107, 1990.

[17] [17] C. F. Bilong Bilong, T. Njiné, "Dynamique de populations de trois Monogènes parasites d'Hemichromis fasciatus (Peters) dans le lac Municipal de Yaoundé et intérêt possible en pisciculture intensive," Sciences Naturelles et Vie 34 (2), 295-303, 1998.

[18] [18] J. Nack, J. Massende, D.F. Messu Mandeng, "Distribution spatiale de deux monogènes du genre Protoancylodiscoides Paperna. 1969 (Dactylogyridea. Ancyrocephalidae) parasites branchiaux de Chrysichthys auratus (Geoffroy Saint-Hilaire. 1808) (Siluriformes, Claroteidae) dans le Lac Ossa (Littoral -Cameroun)", Journal of Applied Biosciences, 121, 12157-12167, 2018.

[19] [19] H. D. Crofton, "A model of host-parasite relationship," Parasitology 63, 791 – 833, 1971.

[20] [20] B. R. Krasnov, R. Poulin, "Ecological properties of a parasite: species-specific stability and geographical variation. In: Morand S and Kasnov BR (eds.). The biogeography of host-parasite interactions," Oxford University Press, Oxford, 99-114, 2010.

[21] [21] C. Combes, "Parasitism: The ecology and evolution of intimate interactions," University of Chicago Press, Chicago, Illinois, 728 p, 2001.

[22] [22] M. C. Danadu, "Problématique de Synodontis Cuvier, 1816 (Siluriformes, Mochokidae) dans le bassin du fleuve Congo: systématique et écologie (R.D.C.)," Thèse, Université de Kisangani, 230 p, 2014.

[23] [23] J. Cable, R. C. Tinsley, P. D. Harris, "Survival and embryo development of Gyrodactylus gasterostei (Monogenea : Gyrodactylidae)," Parasitology 124 (1): 53-68. 2002.

[24] [24] E. Turgut, A. Shinn, R. Wootten, "Spatial distribution of Dactylogyrus (Monogenean) on the gills of the host fish", Turkish Journal of Fisheries and Aquatic Sciences, 6, 93-98, 2006.

[25] [25] N. Hirazawa, R. Takano, H. Hagiwara, M. Noguchi, M. Narita, "The influence of different water temperatures on Neobenedenia girellae (Monogenea) infection, parasite and emerging second generation on amberjack Seriola dumerili (Carangidae) and the histopathological effect of this parasite on fish skin," Aquaculture, 299, 2-7, 2010.

[26] [26] J. G. Nziéleu Tchapgnouo, T. Njiné, S. H. Zébazé Togouet, S.C. Djutso Segnou, T. S. Mahamat Tahir, S. Tchakonté, B. Pinel-Alloul, "Diversité spécifique et abondances des communautés de copépodes, cladocères et rotifers des lacs du complexe Ossa (Dizangué. Cameroun) ", Physio-Géo-Géographie physique et environnement, 6 ,71-93, 2012.

[27] [27] Guegang Tekou, J. G. Makombu, C. T. Tiogue, P. C. M. Tchiegang, C. F. Nguedia, A. Kenfack, "Caractéristiques physico-chimiques de l'eau et du substrat des palourdes Egeria (Roissy, 1805) dans le fleuve Sanaga, Cameroun," Afrique Science 17 (1), 47-58, 2020.

[28] [28] A. M. El-Naggar, M. I. Mashaly, A. M. Hagras, H. A. Alshafei, "Monogenean Microfauna of the Nile Catfish, Clarias gariepinus as Biomonitors of Environment Degradation in Aquatic Ecosystems at the Nile Delta, Egypt," Journal of Environment Science, Toxicology and Food Technology (IOSR-JESTFT), 11 (8), 45-62, 2017.

[29] [29] E. D. Bassock Bayiha, J. A. Mbondo, and C. F. Bilong Bilong, "Epidemiological study of Acanthogyrus tilapiae, gut parasitic helminth of Hemichromis elongatus in the Mefou hydrographic system (South-Cameroon): Effect of the environment," International Journal of Fisheries and Aquatic Studies 8(3), 400-404, 2020.

AUTHORS

First Author – Jonathan Armel Mbondo, Institute of Agricultural Research for Development (IRAD), Experimental Research Station in Marine Ecosystems, PO Box 219, Kribi, Cameroon
Second Author – Etienne Didier Bassock Bayiha, Laboratory of Parasitology and Ecology, University of Yaoundé I, PO Box 812, Yaoundé, Cameroon
Third Author – Bahanak Dieu Ne Dort, Institute of Agricultural Research for Development (IRAD), Station of Batoke, BO box 77 Limbe, Cameroon
Fourth Author – Nack Jacques, Institute of Fisheries and Aquatic Sciences of Yabassi (ISH), University of Douala, Cameroon
,
Fifth Author – Kingsley Etchu, Institute of Agricultural Research for Development (IRAD), Yaoundé, PO Box 2123, Yaoundé
Sixth Author – Charles Félix Bilong Bilong, Laboratory of Parasitology and Ecology, University of Yaoundé I, PO Box 812, Yaoundé, Cameroon

Corresponding Author – Jonathan Armel Mbondo, Institute of Agricultural Research for Development (IRAD), Experimental Research Station in Marine Ecosystems, PO Box 219, Kribi, Cameroon, jonathan.mbondo@yahoo.com , 00237656930098.