

Ecology of three monogenean ectoparasites of *Barbus camptacanthus* (Teleostei: Cyprinid) from the Koukoum River, Cameroon

Tombi Jeannette*¹, Sandje Bwame Agnès Solange¹, Akoumba John Francis¹ and Bilong Bilong Charles Félix¹

¹ University of Yaoundé I, Laboratory of Parasitology and Ecology, Faculty of Science, PO. Box 812 Yaoundé, Cameroon.

*Corresponding author e-mail: tombijeannette2007@yahoo.fr

Original submitted in on 18th March 2016. Published online at www.m.elewa.org on 31st May 2016
<http://dx.doi.org/10.4314/jab.v101i1.6>

ABSTRACT

Objective: In September 2014, 56 specimens of *Barbus camptacanthus* were captured in the Koukoum River at Makak (Cameroon) in order to study some ecological aspects of their monogenean gill parasites.

Methodology and Results: After host sampling and parasites mounting, determination of various monogenean species was carried out in the laboratory by classical methods. Gill helminthofauna of this fish consisted of *Dactylogyrus amieti*, *D. valeti* and *Dogielius njinei*. The parasite load of core species increased progressively with the size of the fish. The impact of host sex was observed for *D. amieti* and *Dogielius njinei* parasite load. The infestation rate and the parasite load did not statistically vary with the side of the host. The colonization profile of different gradients varied depending on the parasite species.

Conclusion and Application: The study of the distribution of these organisms has identified the most vulnerable hosts. Such information allows envisaging some protocols for monitoring parasitic infection in intensive fish farming. In hatcheries, much care should be given to fry and young fish since they have not yet developed robust immunological processes that enable them to effectively fight against polyparasitism.

Key words: *Barbus camptacanthus*, gills, monogeneans, distribution, Koukoum River.

INTRODUCTION

The ecology of fish parasites provides important information not only regarding their host, but also on the aquatic environment through patterns of parasite species occurrence, and the prevalence and intensity of parasitism (Ferrari-Hoeinghaus *et al.*, 2006). Such studies allow the understanding of parasite communities' structure and the processes involved in the maintenance of this structure. The fish gill monogenean parasites represent an interesting tool for ecological analyses (Bagge & Valtonen, 1999). Their short growth cycle associated with their easy contamination increase the number of

monogeneans per host, particularly among the monopisthocotylea (Silan & Maillard, 1990). The consequence of this characteristic is the presence of several specimens on a restricted surface. In addition to being sensitive to the sex and size of the fish, their study permits to know which category of hosts is more exposed to parasitism (Tombi & Bilong Bilong, 2004). Besides, due to their location, monogenean ectoparasites are subject to changes in the environment in which lives their host and their vulnerability to changes in physico-chemical parameters makes them excellent bio-indicators

(Chubb, 1977). Moreover, good knowledge of the ecology of the monogeneans enables the use of appropriate methods to fight against these pathogens, especially in fish farming. Birgi & Lambert (1987) have described *Dactylogyrus amieti*, *D. valeti* and *Dogielius njinei* on the gills of *Barbus*

camptacanthus Bleeker, 1863 collected in South-Cameroon. No ecological data were included in these species descriptions. The main goal of the present work is to study some ecological aspects of the monogenean gill parasites of this Cyprinid in Koukoum River.

MATERIALS AND METHODS

Barbus camptacanthus Bleeker, 1863 is a non-migratory fish that is abundant in the small forest rivers with maximum length of 16 mm (Vivien, 2012). The representatives of this species were the most numerous in the study site during the sampling period. Moreover, meals obtained base on its flesh are very much appreciated in South-Cameroon. The specimens examined were captured in September 2014 in the Koukoum River (03° 30' 915" North and 11° 00 ' 117 East). This stream located at the heart of the Beng-Nyong village has a sandy bottom and its maximum width was 5m during the study period. The study area is swept by one equato-guinean type of climate (Moby Etia, 1979). Fish were collected fishing rod and fixed in 10% formalin solution. In the laboratory, the standard length of each host was measured and its sex determined. The four gill arches of the left and right sides were removed using dissecting scissors and tweezers, and examined separately under a stereo- microscope. The exact position of each parasite on the gill filaments was determined according to Tombi *et al.* (2010) and the monogeneans obtained were removed and mounted in a

drop of water. The specific determination of the parasites was carried out using the optical microscope. Both prevalence and mean intensity were defined according to Bush *et al.* (1997) and the classification of the species based on prevalence (P) was made according to Valtonen *et al.* (1997). Thus, parasite species were considered as frequent if P > 50%, as less frequent if 10≤P≤50% and rare if P<10%. These categories may correspond to what other authors such as Koskivaara & Valtonen (1992) termed respectively as core, secondary or satellite species. The mean intensity (MI) was considered as high if MI>100, average if 50<MI≤100, low if 10<MI≤50, and very low if MI<10 (Bilong Bilong & Njiné, 1998). The χ^2 (Chi square) test was applied to compare two or more proportions. The Mann Whitney (U) and Kruskal-Wallis (K) tests were respectively used to compare two and several averages. The degree of security for statistical analyses was 95%. The various statistical analyses were performed using the Statistix software version 2.0.

RESULTS AND DISCUSSION

A total of 56 specimens of *Barbus camptacanthus* were analyzed during this work, 25 were males and 31 were females. Only one fish was not parasitized. The maximum number of parasites collected from a single fish host was 153. The 2869 collected monogeneans comprised 2352 *Dactylogyrus amieti* Birgi & Lambert, 1987; 24 *D. valeti* Birgi & Lambert, 1987 and 493 *Dogielius njinei* Birgi &

Lambert, 1987. The core species of this component community were *Dogielius njinei* and their mean intensities were low. These two species adopted an aggregate distribution. *D. valeti* was the only secondary species; its mean intensity was very low and this monogenean adopted a regular distribution (Table1).

Table1: Prevalence and mean intensity of various parasite species

Parasite species	Prevalence (%)	MI(σ)	Variance
<i>D. amieti</i>	98.21	42.76 (31.69)	1004.25
<i>D. valeti</i>	23.21	1.84 (0.89)	0.79
<i>Dogielius njinei</i>	85.71	10.06 (11)	121

Legend: MI = mean intensity, σ = standard deviation

Larger fish statistically exhibited a higher intensity of core species while *D. valeti*, the secondary species showed no preference to host's size (Table 2).

Table 2: Mean intensity as a function of the host length

Parasite species	Length class		U Test
	SL < 7.5 cm	SL > 7.5 cm	
<i>D. amieti</i>	30.28 (20.40)	53.17 (35.39)	P < 0.05
<i>D. valeti</i>	2.00 (1.00)	1.86 (0.90)	P > 0.05
<i>Dogielius njinei</i>	6.36 (5.15)	13.07 (12.10)	P < 0.05

Legend: SL = standard length

Prevalence values for males and females were not significantly different (Table 3). Nevertheless, the mean intensity of *D. amieti* and *Dogielius njinei* was statistically higher in females (U test).

Table 3: Prevalence and mean intensity as a function of the host sex

	<i>D. amieti</i>		<i>D. valeti</i>		<i>Dogielius njinei</i>	
	P (%)	MI (σ)	P (%)	MI (σ)	P (%)	MI (σ)
Male	96	27.5 (14.64)	16	1.8(0.83)	84	5.38(4.42)
Female	100	54.58(35.88)	29.03	1.88(0.92)	90	13.57(11.73)
	P > 0.05	P < 0.05	P > 0.05	P > 0.05	P > 0.05	P < 0.05

Legend: P = prevalence, MI = mean intensity, σ = standard deviation

The prevalence value of each parasite species was not statistically different between the left and the right sides of the host (Table 4, P > 0.05). However, the mean intensity of these two parts was only significantly different in the case of *D. valeti* (P < 0.05). The prevalence of *D. amieti* regarding the gill arch statistically decreased in the antero-posterior direction (Table 4, P < 0.05), arch I being as much parasitized by this species as arch II. That of *D. valeti* declined but not significantly in the same

direction (P > 0.05). For *Dogielius njinei*, the prevalence did not statistically change between gill arches (P > 0.05). The highest mean intensity of *D. amieti* was observed on arch II (P < 0.05). That of *D. valeti* and *Dogielius njinei* did not statistically change between the various gill arches (P > 0.05). Generally, regardless of the parasite species, arch IV statistically accumulated few monogeneans (P < 0.05).

Table 4: Prevalence and mean intensity as a function of the host side and gill arch

Localization	<i>D. amieti</i>		<i>D. valeti</i>		<i>Dogielius njinei</i>	
	P (%)	MI (σ)	P (%)	MI (σ)	P (%)	MI (σ)
Right side	98.21	22.45 (16.85)	10.71	2.16 (0.71)	80.35	5.66 (5.76)
Left side	96.42	20.68 (18.50)	17.85	1.1 (0.44)	69.64	6.10 (5.17)
Arch I	98.21	11.78 (9.42)	12.5	1.43 (0.78)	58.93	3.12 (2.15)
Arch II	98.21	13.64 (10.37)	10.71	1.17 (0.41)	67.86	3.94 (3.11)
Arch III	89.28	11.64 (8.17)	8.92	1.20 (0.45)	67.86	3.55 (3.54)
Arch IV	87.50	7.83 (6.66)	0	0	53.57	3.47 (3.63)

Legend: P = prevalence, MI = mean intensity, σ = standard deviation

The prevalences and mean intensities of each species were identical on the two hemibranches of each gill arch (Table 5, P > 0.05). The occupation models of the five sectors (S) by *D. amieti* are as follows: S₃ > S₄ = S₂ = S₁ = S₅, P < 0.05 (arch I); S₃ = S₄ = S₂ = S₁ > S₅, P < 0.05 (arch

II); S₄ > S₃ > S₂ = S₁ = S₅, P < 0.05 (arch III) and S₄ = S₃ = S₂ > S₁ = S₅, P < 0.05 (arch IV). These models show that, *D. amieti* accumulated preferentially at the median (S₃) and medio-ventral (S₄) sectors. The ventral sector (S₅) has been the least affected.

Table 5: Prevalence and mean intensity as a function of the hemibranch of each arch

Parasite species	Arch	AH		PH	
		P (%)	MI (σ)	P (%)	MI (σ)
<i>D. amieti</i>	I	91.07	5.73 (4.92)	92.85	6.25 (5.17)
	II	98.2	7.31 (5.76)	96.49	5.94 (5.06)
	III	87.5	6.55 (5.14)	83.92	4.96 (3.79)
	IV	76.79	4.88 (3.95)	78.57	3.45 (2.77)
<i>D. valeti</i>	I	8.92	1(0.28)	8.92	1.2 (0.37)
	II	8.92	1(0.28)	3.57	1 (0.19)
	III	7.14	1(0.26)	3.57	1 (0.19)
	IV	0	0	0	0
<i>Dogielius njinei</i>	I	42.85	2.16 (1.39)	39.28	2.04 (1.20)
	II	58.92	2.18 (1.50)	53.57	2.46 (2.00)
	III	50	2.40 (1.92)	48.21	2.41 (1.75)
	IV	42.86	2.41 (1.76)	33.93	2.42 (1054)

Legend: P = prevalence, MI = mean intensity, σ = standard deviation, AH = anterior hemibranch; PH = posterior hemibranch

D. valeti occupied the longitudinal gradient in the following manner $S_2 > S_3 = S_4$, $P > 0.05$ (arch I); $S_3 = S_2 = S_5$, $P > 0.05$ (arch II) and $S_3 = S_4 = S_1 = S_5$, $P > 0.05$ (arch III). This species has not parasitized arch IV and presented a great variability in the colonization of the longitudinal gradient. The occupation models of the various sectors by *Dogielius njinei* are as follows: $S_1 = S_3 = S_2 = S_4 > S_5$, $P < 0.05$ (arch I); $S_2 = S_1 = S_3 = S_4 > S_5$, $P < 0.05$ (arch II); $S_3 = S_2 = S_1 = S_4 > S_5$, $P < 0.05$ (arch III); S_4

$= S_3 = S_2 > S_1 = S_5$; $P < 0.05$ (arch IV). This species showed no sectoral preference, but the sector 5 was statistically the least occupied in most cases. *D. amieti* and *Dogielius njinei* (Figure 1) were more concentrated on the middle zone ($K = 28.79$ and $27.15 > 5.99$ respectively; $df = 2$). For each of them, the parasite loads of the distal and median zones remained statistically equal ($P > 0.05$). *D. valeti* accumulated similarly on all the three filamentous zones ($P > 0.05$).

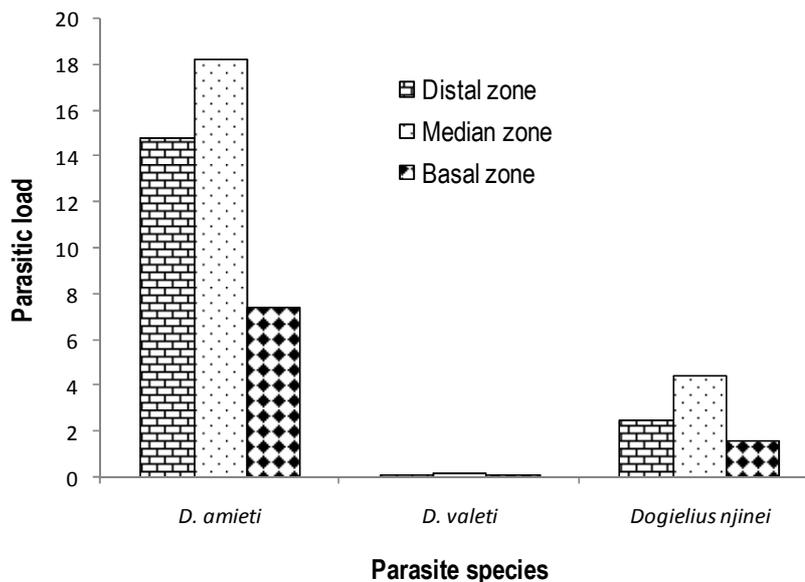


Figure 1 : Parasitic load of various species as a function of a filamentous zone

This study has underlined a polyparasitism with predominance of *Dactylogyrus* species on the gills of *B. camptacanthus* collected at Beng-Nyong. Some cases in which more than one *Dactylogyrus* species are present on a single host fish species have also been reported in Cameroon. Tombi & Bilong Bilong (2004) collected *Dactylogyrus bopeleti*, *D. insolitus*, *D. simplex*, *D. maillardi*, *Dogielius martorelli* and *Dogielius* sp. from *B. martorelli* gill system. The gills of *B. jae* harboured *Dactylogyrus kii*, *D. biradius* and *D. jaei*; those of *B. aspilus* are colonized by *D. aspili*, *D. mendehei* and *D. nyongensis* while those of *B. guiralli* are parasitized by *D. jaei* and *D. nyongensis* (Birgi & Lambert, 1987). In Cameroon, polyparasitism is frequently observed among *Barbus* species. This multi-specific parasitism of *B. camptacanthus* could be explained by the permanent presence of vacant niches on its gill biotope. The mean intensities' values were low in the cases of *D. amieti* and *Dogielius njinei* and very low for *D. valeti*. These results corroborate the observation that in the natural environment, the parasitic load is generally limited due to the low density of hosts (Obiekezie & Taege, 1991). They could also show the low inflow of infective larvae. Indeed, under such conditions, the infra-population cannot easily reach a high level due to its own natural mortality (Combes, 1995). According to Holmes (1990), two or more species that are taxonomically similar or ecologically equivalent and coexist in the same habitat and at the same time as those of the studied component community, should inevitably engage in a competition. In this study despite polyparasitism, the hypothesis of an inter- or intraspecific competition as a factor governing the structuring of *B. camptacanthus* gill infra-communities may not be retained because of the low parasitic loads obtained. In fact, according to Ramasami et al. (1985), inter- or intraspecific competition for space can only occur during massive infestation. Specific parasitic load increased with the standard length of the fish. Various authors have found positive correlations between parasitic load and host size. This is the case of Koskivaara et al. (1991) with *Rutilus rutilus*; Tombi et al. (2014) with *Oreochromis niloticus*; Blahoua et al. (2009) with *Sarotherodon melanotheron* and Ibrahim (2012) with *Tilapia zillii*. The gill filaments are the supporting organs on which monogeneans are attached, their growth with the size of *B. camptacanthus* would increase the colonizing gill surface, which would justify the growth of parasitism with the size of this host. Furthermore, the large volume of water flows over the gills of large fish would increase the possibility of their invasion by

oncomiracidiums (Simkova et al., 2006). *D. valeti* showed no preference for host sex concurring with Tombi et al. (2014) who found no difference in infection of *Cichlidogyrus thurstonae*, *C. halli* and *C. tilapiae* attributable to the sex of *Oreochromis niloticus*. However, female *B. camptacanthus* were more heavily infested by *D. amieti* and *Dogielius njinei*. Tombi & Bilong Bilong (2004); Özer & Öztürk (2005) and Ibrahim (2012) explained this phenomenon based on the females way of life during spawning as well as their large size that would increase their parasitism. Ibrahim & Solima (2011) suggest that the difference in parasitism between the female and male hosts would have an endocrine cause. According to Rohde (1993), few parasite species show a preference for host sex. *D. amieti* and *Dogielius njinei* did not show preference for right or left side of gill. Monogenean gill parasites of *Rutilus rutilus* and that of *Oreochromis niloticus* presented a similar distribution (Soylu et al., 2010; Tombi et al., 2014). This equipartition of monogeneans on both sides of the gills of *B. camptacanthus* could be due to the bilateral symmetry of its body (Tombi et al., 2016). *D. valeti* was more accumulated on the left side of its host. Although this kind of distribution is rare, an asymmetrical distribution of *Gotocotyla acanthura* was also observed on the gills of *Trachinotus ovatus* (El Madhi & Belghyti, 2006a). This phenomenon is often associated with the asymmetry of the parasite body (Rohde, 1993). However, this explanation cannot justify the distribution of *D. valeti* whose body presents a bilateral symmetry (Birgi & Lambert, 1987). In the present study, it has been shown that, *D. amieti* more frequently occurred on the first and second gill arches but was more accumulated on arch II. *D. valeti* and *Dogielius njinei* did not show preference regarding the gill arches. In general, arch IV has been least parasitized. For monogeneans, various patterns of arches exploitation are reported in the literature. An equipartition of *Cichlidogyrus philander* was observed on the four gill arches of *Pseudocrenilabrus philander* (Le Roux et al., 2011). *Silurodiscoides* sp, monogenean gill parasite of *Silurus asotus* adopted a similar distribution (Nie, 2000). Arch IV of the gill systems of *Rutilus rutilus* and *Anguilla anguilla* was the least parasitized by *Dactylogyrus crucifer* and *Pseudodactylogyrus anguilla* respectively (Soylu et al., 2010; 2013). In *Barbus martorelli*, *Dactylogyrus insolitus* showed a preference for arch II (Tombi & Bilong Bilong, 2004). Nack et al. (2010) indicated the preference of arch IV of *Clarias camerunensis* by *Quadriacanthus pariselli* and *Birgiellus kellensis*. In this study, the distribution of *D.*

amieti follows the variation of host filaments number. In fact, according to Tombi et al. (2016), this number decreased significantly from arch I towards arch IV. The high filaments number of arches I and II allows more specimens of *D. amieti* to attach to them. It also appeared that, the posterior arch (arch IV) which harboured the smallest number of filaments was least infected. The two hemibranches of each arch were exploited similarly by the various species. The rate of infestations and the parasite loads of *D. crucifer* were equally distributed between the two hemibranches of *Rutilus rutilus* (Soylu et al., 2010). *Paradiplozoon tisaie* was also equally concentrated on the two hemibranches of *Barbus meridionalis* (Stavrescu-Bedivan & Aioanei, 2008). In the case of *B. camptacanthus*, the distribution of various parasite species cannot be explained by their filaments number. In fact, irrespective of the *B. camptacanthus* gill arch, the anterior hemibranch statistically carried more filaments than the posterior one (Tombi et al., 2016). *D. amieti* mostly parasitized both the median and medio-ventral sectors; *D. valeti* showed a great variability in the exploitation of this gradient while *Dogielius njinei* was statistically less accumulated on sector 5. In their investigations, Tombi et al. (2010) observed no sectoral preference by the gill monogeneans of *B. martorelli*. In *Rutilus rutilus*, sectors 2 and 5 were more colonized by *D. crucifer* (Soylu et al. 2010), while in *Trachinotus ovatus* sector 5 of arch I was more parasitized by *Gotocotyla acanthura* (El Madhi & Belghyti, 2006b). Specimens of *D.*

amieti and *Dogielius njinei* were more concentrated on the median half (zone) of filament while those of *D. valeti* have presented no zonal preference. Numerous authors have established a marked preference of. On *B. martorelli* gill system, *D. bopeleti* and *D. insolitus* were mostly found on the median zone, but never on the basal one (Tombi et al., 2010). *Paradiplozoon tisaie*, ectoparasite of *Barbus meridionalis* has also shown a preference for the median zone (Stavrescu-Bedivan & Aioanei, 2008). According to Paling (1968), more water passes over the distal halves of the filaments than over the proximal ones. The localization of *D. amieti* and *Dogielius njinei* on the median zone may reflect a preference of these species for a site in which the water flow is not maximal. In fact, these parasite species may have a reduced ability to maintain themselves against the respiratory water current. Intra or inter-specific competition could not explain the preference of *B. camptacanthus* gill monogeneans for particular site. Indeed, 157269 zones (52423 of each type) were examined and only 2661 (935 distal, 1223 median and 503 basal) were occupied. It appears that the component community studied occupied 1.69% of the available space so, 98.31% of the niches were not occupied. Logically, there is no competition for space between *B. camptacanthus* gill monogeneans. According to Koskivaara & Valtonen (1991), a polyparasitism cannot conduct to competition as long as there is still space available.

REFERENCES

- Bagge AM and Valtonen ET, 1999. Development of monogenean communities on the gills of roach fry (*Rutilus rutilus*). *Parasitology*, 118: 479-487.
- Bilong Bilong CF and Njine T, 1998. Dynamique de populations de trois monogènes parasites d'*Hemichromis fasciatus* Peters, 1858 dans le lac municipal de Yaoundé, et intérêt possible en pisciculture intensive. *Annales de la Faculté des Sciences de l'Université de Yaoundé I, Série Sciences Naturelles et Vie*, 34: 295-303.
- Birgi E and Lambert A, 1987. Les Dactylogyridae (Plathelminthes, Monogenea) des Cyprinidae du genre *Barbus* du Sud Cameroun. *Revue d'Hydrobiologie Tropicale*, 20: 37-48
- Blahoua KG, N'douba V, Kone T, Kouassi NJ, 2009. Variations saisonnières des indices épidémiologiques de trois monogènes parasites de *Sarotherodon melanotheron* (Pisces: Cichlidae) dans le lac d'Anyamé I (Côte d'Ivoire). *Sciences et Nature*, 6: 39-47.
- Bush AO, Lafferty DK, Lotz MJ, Shostak WA, 1997. Parasitology meets ecology on its own terms: Margolis et al. Revisited. *Journal of Parasitology*, 83: 575-583.
- Chubb JC, 1977. Seasonal occurrence of helminths in freshwater fishes. Part I. Monogenea. *Advances in Parasitology*, 15: 133-199.
- Combes C, 1995. Interactions durables. Ecologie et évolution du parasitisme. Collection d'écologie, n° 26, Masson, Paris, France, 524 p.
- El Madhi Y and Belghyti D, 2006 a. Distribution de deux monogènes dans les individus hôtes de *Trachinotus ovatus* (L., 1758) de la côte de Mehdi. *Biologie & Santé*, 6:65-76.
- El Madhi Y and Belghyti D, 2006 b. Répartition branchiale des monogènes *Gotocotyla acanthura* et *Pyragraphorus hollisae* parente du Pompano, *Trachinotus ovatus* (Pisces; Carangidae) de la côte de Mehdi (Maroc). *Agronomie Africaine*, 18: 117-124.

- Ferrari-Hoeinghaus AP, Fakemoto RM, Oliveira LC, Makrakis MC, Baumgartner G, 2006. Host-parasite relationships of Monogeneans in gills of *Astyanax altiparanae* and *Rhamdia quelen* of the Sao Francisco Verdadeiro River, Brazil. *Parasite*, 13: 315-320.
- Holmes JC, 1990. Helminth communities in marine fishes. In: Parasite communities: Patterns and Processes. (Eds. G.W Esh, A.O. Bush, Aho J.M.), London, Chapman and Hall, UK, 101 - 130.
- Ibrahim MM, 2012. Variation in parasite infracommunities of *Tilapia zillii* in relation to some biotic and abiotic factors. *International Journal of Zoological Research*, 8: 59-70.
- Ibrahim MM and Solima MF, 2011. Prevalence and site preferences of heterophyid metacercariae in *Tilapia zillii* from Ismalia fresh water canal, Egypt. *Parasite*, 17: 233-239.
- Koskivaara M and Valtonen ET, 1992. *Dactylogyrus* (Monogenea) communities on the gills of roach in three lakes in Central Finland. *Parasitology*, 104: 263-272.
- Koskivaara M, Valtonen ET, Prost M, 1991. Dactylogyrids on the gills of roach in Central Finland: features of infection and species composition. *International Journal for Parasitology*, 21: 565-572.
- Le Roux LE, Avenant-Oldewage A, Van Der Walt FC, 2011. Aspects of the ecology of *Cichlidogyrus philander* collected from *Pseudocrenilabrus philander philander* from the Padda Dam, Gauteng, South Africa. *African Zoology*, 46: 103-116.
- Moby-Etia P, 1979. Climat. In : Atlas de la République Unie du Cameroun. (Laclaver G.). (Ed. J. A.), Paris, 16-19.
- Nack J, Tombi J, Bitja Nyom A, Bilong Bilong CF, 2010. Sites de fixation de deux monogènes Dactylogyridea parasites branchiaux de *Clarias camerunensis*: évidence sur le mode d'infestation par les Monopisthocotylea. *Journal of Applied Biosciences*, 33: 2076-2083.
- Nie P, 2000. Microhabitat distribution of metazoan parasites on gills of *Silurus asotus* in Jiangkou reservoir, Jiangxi province, China. *Chinese Journal of Oceanology and Limnology*, 18: 54-60.
- Obiekezie AI and Taege M, 1991. Mortalities in hatchery-reared fry of the African catfish, *Clarias gariepinus* (Burchell) caused by *Gyrodactylus groschafti* Ergens, 1973. *Bulletin European Association Fish Pathology*, 11: 82-85.
- Özer A and Öztürk T, 2005. *Dactylogyrus cornu* Linstow, 1878 (Monogenea) infestations on *Vimba vimba tenella* (Nordmann, 1840) caught in the Sinop region of Turkey in relation to the host factors. *Turkish Journal of Veterinary and Animal Sciences*, 29:1119-1123.
- Ramasamy P, Ramalingam K, Hanna, REB, Halton DW, 1985. Microhabitat of the gill parasites (Monogenea and Copepoda) of Teleosts (*Scomberoïdes* spp.). *International Journal for Parasitology*, 15: 385-397.
- Rohde, K., 1977. A non-competitive mechanism responsible for restricting niches. *Zoologischer Enzeiger*, 199: 164-172.
- Rohde K, 1993. Ecology of marine parasites. An introduction to marine parasitology. (2^e Ed), CAB International, Wallingford, Oxon. 298 p.
- Silan P and Maillard C, 1990. Comparative structures and dynamics of some populations of helminthes, parasites of fishes: the sea bass- *Diplectanum* model. *Acta oecologica*, 11: 857-874.
- Simkova A, Verneau O, Gelnar, M, Morand S, 2006. Specificity and specialization of congeneric Monogeneans parasiting Cyprinid. *Evolution*, 60: 1023-1037.
- Soylü E, Rüzgar B, Soyü M, 2010. Seasonal dynamics and spatial distribution of *Dactylogyrus crucifer* Wagener, 1857 on the gills of roach (*Rutilus rutilus* L.) from lake Sapana, Turkey. *Turkey Journal Zoology*, 34:393-398.
- Soylü E, Özese SC, Erdogan F, Erdogan M, Tektas N, 2013. Microhabitat Distribution of *Pseudodactylogyrus anguillae* (Monogenea), *Ergasilus gibbus* and *Ergasilus lazae* (Copepoda) on the Gills of European Eels (*Anguilla anguilla*, L.). *Acta Zoologica Bulgaria*, 65 (2): 251-257.
- Stavrescu-Bedivan M-M and Aioanei FT, 2008. Aspects of branchial parasitism in *Barbus meridionalis* Petenyi Heckel, 1847(Teleostei: Cyprinidae). *Bulletin UASVM, Veterinary Medicine*, 65: 57-90.
- Tombi J and Bilong Bilong CF, 2004. 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.

- Tombi J, Nack J, Bilong Bilong CF, 2010. Spatial distribution of Monogenean and Myxosporidian gill parasites of *Barbus martorelli* Roman, 1971 (Teleostei: Cyprinid): The role of intrinsic factors. *African Journal of Agricultural Research*, 5: 1662-1669.
- Tombi J, Akoumba JF, Bilong Bilong CF 2014. The monogenean community on the gills of *Oreochromis niloticus* from Melen fish station in Yaounde, Cameroon. *International Journal of Modern Biological Research* 2, 16-23.
- Tombi J, Sandje Bwame AS, Akoumba JF, Bilong Bilong CF 2016. Variation du nombre de filaments et leur importance dans l'hétérogénéité du système branchial de *Barbus camptacanthus* Bleeker, 1863. *Cameroon Journal of Biological and Biochemical Sciences* 24, 36 - 40.
- Valtonen ET, Holmes JC, Koskivaara M, 1997. Eutrophication, pollution and fragmentation: effects on parasite communities in roach (*Rutilus rutilus*) and perch (*Perca fluviatilis*) in four lakes in Central Finland. *Canadian Journal of Aquatic Science* 54, 572-585.
- Vivien J, 2012. Guide des Mammifères et Poissons du Cameroun. Saint Berthevin, France, 332 P.
- Wootton R. 1874. The spatial distribution of *Dactylogyrus amphibothrium* on the gills ruffe *Gymnocephalus cernua* and its relation to the relative amounts of water passing over the parts of the gills. *Journal of Helminthology* 48, 167-174.
- :