



The monogenean community on the gills of *Oreochromis niloticus* from Melen fish station in Yaounde, Cameroon

TOMBI Jeannette*, AKOUMBA John Francis and BILONG BILONG Charles Félix

Laboratory of Parasitology and Ecology, Faculty of Science, University of Yaounde I,
P. O. BOX 812, Yaounde, Cameroon.

Article History

Received 07 May, 2014
Received in revised form 26
May, 2014
Accepted 02 June, 2014

Key words:

Oreochromis niloticus,
Monogenea,
Gill parasites,
Distribution.

Article Type:

Full Length Research Article

ABSTRACT

The distribution of monogenean gill parasites of 191 specimens of *Oreochromis niloticus* caught at Melen fish station in Yaounde, Cameroon; between February and July 2012 was investigated. Standard methods of parasitological examination were used for identification of monogenean species. Four parasite species were found, of which, three (*Cichlidogyrus thurstonae*, *C. halli* and *C. tilapiae*) were classified as core species and one (*Scutogyrus longicornis*) was classified as secondary. All parasites found aggregated within the host population, although one individual fish was without any parasite. Generally, the mean intensities of the different parasite species were very low, except for *C. thurstonae*, with low mean intensity. From the results obtained, it was observed that parasitism increased with increase in host size but appeared to be sex dependent for *S. longicornis* only; which was significantly more concentrated in males than in females. The distribution of the parasites in the right side was similar to that of the left side and the colonization of the four pairs of gill arches was done in an antero-posterior direction.

©2014 BluePen Journals Ltd. All rights reserved

INTRODUCTION

Monogeneans are essentially fish parasites, most of which infest the skin, gill arches and/or fins. They may also be found in some cavities such as the stomach, intestine, bladder and nostril (Rohde et al., 1992; Pariselle and Euzet, 1998; Whittington et al., 2000). These organisms are often in equilibrium with their hosts in the natural environment, though, they could be responsible for many cases of serious morbidity and even mortality during fish breeding (Post, 1987; Obiekezie and Taeye, 1991; Aloo, 2002; Buchmann and Lindenstrom, 2002). In fact, the attachment of monogeneans and their foraging activities can provoke skin and gill lesions which are frequently precursors of secondary infections (Ogawa, 2002; Kirk, 2003). Overloading of parasites can

damage both the gill system and the skin; and provoke anemia. In some cases, infested fish becomes lethargic or die (Obiekezie, 1991).

The Food and Agricultural Organization of the United Nations (FAO, 2009) reported that, to satisfy an increasing demand in freshwater fish, extensive research must include studies of their parasites for optimal production levels. For Sures (2001) and Dudgeon et al. (2006), knowledge of fish parasites is of particular interest in relation not only to fish health but also to understanding ecological problems. The main goal of this research was to study some bio-ecological aspects of monogeneans' gill parasites of *Oreochromis niloticus* in lentic situation.

MATERIALS AND METHODS

The present study was conducted between February and

*Corresponding author. E-mail: tombijeannette2007@yahoo.fr.
Tel: +237 75 85 43 20.

Table 1. Prevalence and mean intensity $\pm \sigma$ of parasite infracommunities of *Oreochromis niloticus* collected from Melen fish station, Yaounde.

Parasite species	Prevalence (%)	Mean intensity $\pm \sigma$	Variance
<i>C. thurstonae</i>	92.67	10.67 \pm 8.74	76.40
<i>C. halli</i>	96.34	9.34 \pm 7.69	59.14
<i>C. tilapiae</i>	57.07	1.85 \pm 1.18	1.40
<i>S. longicornis</i>	48.69	3.15 \pm 2.74	7.51

σ , Standard deviation.

July 2012 at the Melen fish breeding station (3° 52' N, 11° 31' E) in Yaounde, Cameroon. The fish station is composed of a series of 17 basins of which, one with an area of approximately 120 m² by 0.80 m deep was used for the present study. The basins are interconnected to the same source of water supply. Of the several species of tilapia bred in this station, *O. niloticus* appears to be the most abundant. Fish samples were captured using a net with mesh size 0.5 cm \times 0.5 cm. Once out of the water, the fish was fixed in a solution of 10% formalin. At the laboratory, the standard length (SL) - distance from the anterior end of the snout to the last vertebra - of the each specimen was measured and its sex determined. Gill arches on each side were detached and examined, using a stereoscopic microscope (Wild Heerbrugg M 50). Monogeneans were collected and mounted on a slide in a drop of hematoxylin (eosin). 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 haptor and copulatory complex as described by Pariselle and Euzet (2003, 2009).

The fish samples were divided into five different length classes of 15 mm amplitude (class 1: SL less than 35 mm; class 2: SL ranged between 35-50 mm; class 3: SL ranged between 50-65 mm; class 4: SL ranged between 65-80 mm and class 5: SL is greater than 80 mm).

The terms "prevalence" and "mean intensity" were defined according to Bush et al. (1997). Based on the prevalence, species was considered as common (core) if the prevalence is greater than 50%, intermediate (secondary) if prevalence is between 10 and 50% and rare (satellite) if prevalence is less than 10% (Koskivaara and Valtonen, 1992; Valtonen et al., 1997).

The mean intensity (MI) was high if MI is greater than 100, medium if MI ranged between 50 and 100, low if MI ranged between 10 and 50; and very low if MI is less than 10 as described by Bilong Bilong and Njine (1998).

Statistical analyses

The Chi-square (χ^2) test was used to compare two or more proportions and the Kruskal Wallis (K) test was

used to compare the mean intensities of more than two samples. Student *t*-test was used to compare the mean intensities of two different samples. The difference was statistically significant if $P < 0.05$.

RESULTS

The sex ratio of the host population was 0.97 (that is, 97 males and 94 females). The SL of the sampled fish varied from 11.8 to 112 mm.

Four monogenean species were found to have infested the gills of *O. niloticus* collected at Melen fish station (Table 1). The four monogeneans species infested individuals of any length class. *C. thurstonae*, *C. halli* and *C. tilapiae* were classified as core species whereas *S. longicornis* was classified as secondary species. The mean intensity of all species was very low, that is less than 10, except for *C. thurstonae* with a low mean intensity. All the parasites species adopted an aggregative distribution (S^2 greater MI), with the exception of *C. tilapiae*. Among the 191 fish examined, only one was un-infested. As regards the various species, the parasitic load obtained was 4101 ranging from 1 to 57 specimens per parasitized host.

For each parasite, the prevalence was lowest in the smallest length class (SL less than 35 mm) (Figure 1). For *C. thurstonae* and *C. halli*, the highest prevalence (100%) was observed in the fish of the classes with SL range 50-65 mm and SL range greater than 80 mm. χ^2 value indicated that the prevalence of these two species depends on the size of *O. niloticus* and these values are statistically significant ($\chi^2=56.27$ and 11.27, $df=4$ respectively, $P < 0.05$). The prevalence of *S. longicornis* increased progressively with host size and reached the highest value (90.63%) in the largest individuals ($\chi^2=51.92$, $df=4$, $P < 0.05$). The prevalence of *C. tilapiae* was lowest in the smallest class size, low in two intermediate classes (SL ranges 35-50 and 65-80 mm) and lower in the two other classes (SL range greater than 80 mm and SL range 50-65 mm). Globally, the difference was statistically significant ($\chi^2=9.87$, $df=4$, $P < 0.05$). For *C. thurstonae* and *C. halli*, the values of mean intensity were

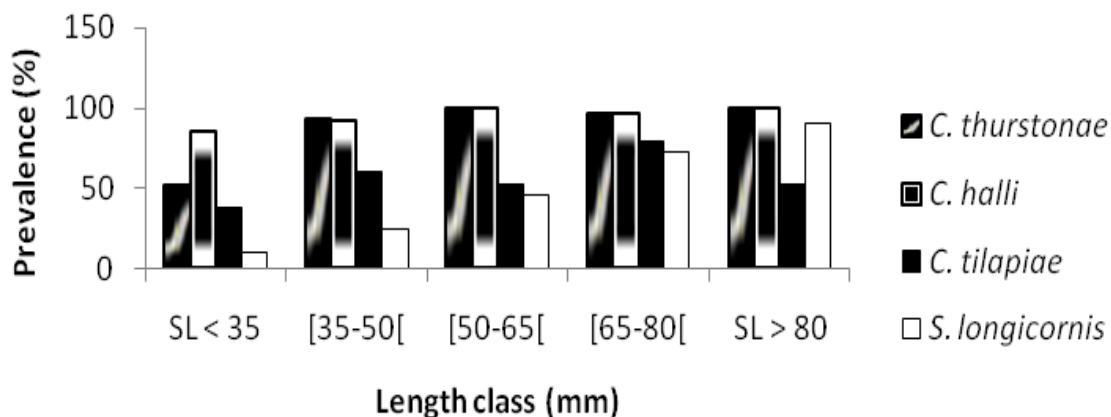


Figure 1. Prevalence as a function of the length class.

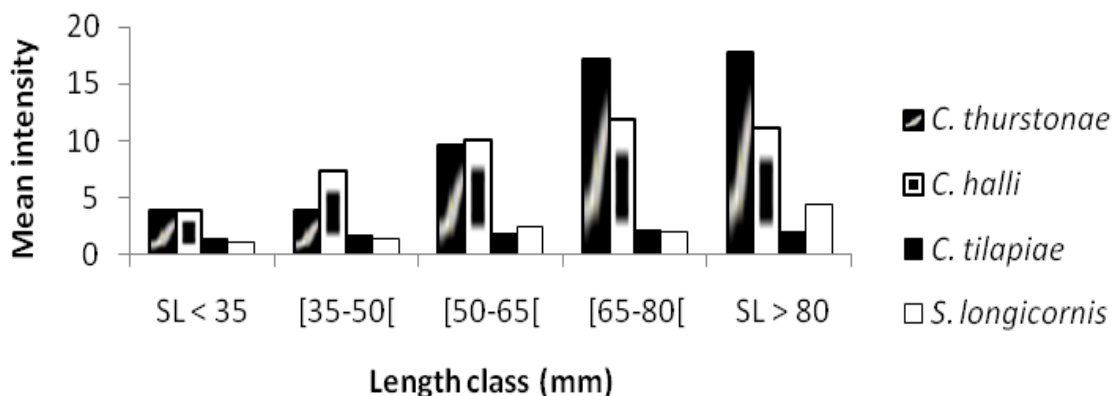


Figure 2. Mean intensity as a function of the length class.

Table 2. Prevalence (%) and mean intensity in relation to host sex.

Parasite species	Prevalence (%)			Mean intensity ± σ		
	Male	Female	χ^2	Male	Female	t
<i>C. thurstonae</i>	91.75	93.62	0.17	11.48± 9.97	9.84± 7.40	1.30
<i>C. halli</i>	95.88	96.83	0.17	9.58± 9.00	9.09± 6.11	0.44
<i>C. tilapiae</i>	53.61	60.64	2.11	1.98± 1.31	1.74± 1.04	1.40
<i>S. longicornis</i>	48.45	48.94	0.19	3.91± 3.20	2.37± 1.91	4.05

σ, Standard deviation.

very low (MI less than or equal to 10) in the first three classes and low (MI ranged between 11 and 50) in the latter two classes, that is 65-80 mm and SL greater than 80 mm (Figure 2). Globally, the difference was statistically significant (K=178.62 and 158.60 respectively, df=4, P<0.05). Also, the mean intensity of *C. tilapiae* and *S. longicornis* remained very low (MI less than or equal to 10) but increased with the host size (K=

21.23 and 19.22, respectively, df=4).

Elsewhere, *Cichlidogyrus* spp. were partitioned equally between males and females while *S. longicornis* was statistically more concentrated in males than in females (Table 2). Apart from *C. tilapiae* which was statistically more frequent on the left side of the fish, the prevalence and mean intensity of parasites did not differ between right and left sides (Table 3).

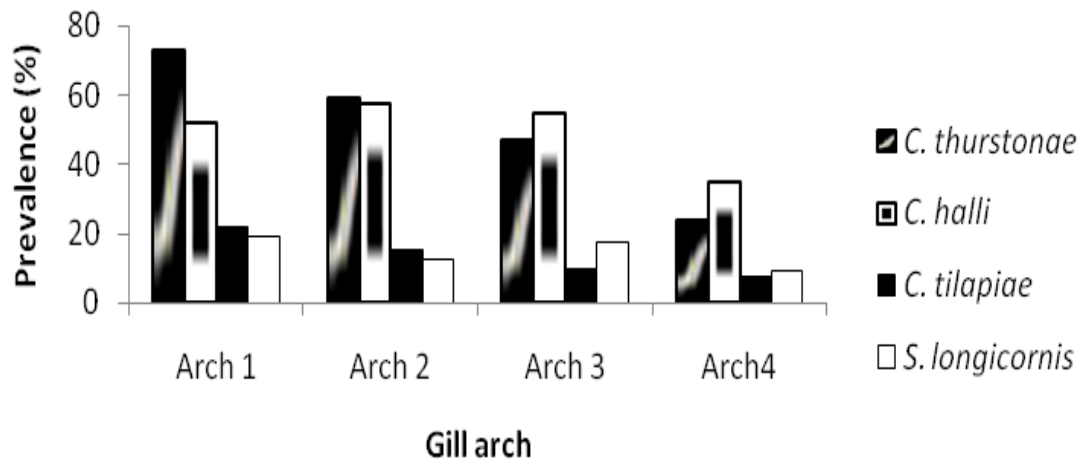


Figure 3. Prevalence as a function of the gill arch.

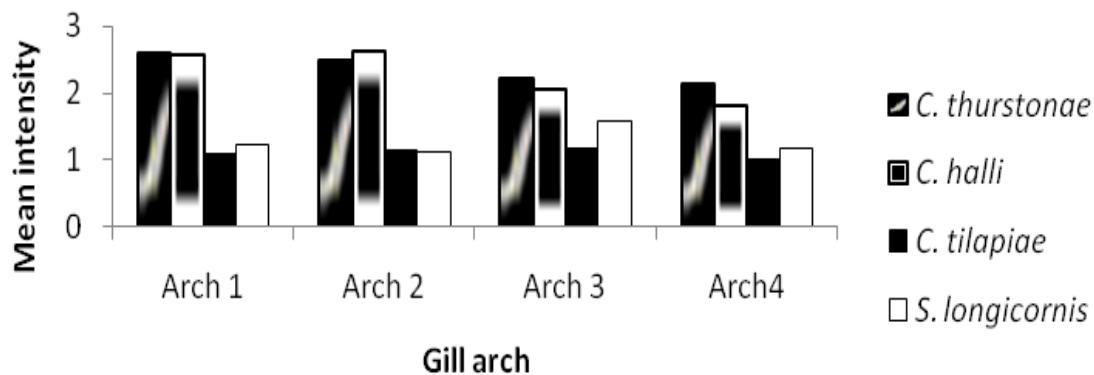


Figure 4. Mean intensity as a function of the gill arch.

Table 3. Prevalence (%) and mean intensity in relation to host side.

Parasite species	Prevalence (%)			Mean intensity (min V- max V)		
	Left side	Right side	χ^2	Left side	Right side	t
<i>C. thurstonae</i>	83.25	84.82	0.18	6.03 (1-22)	5.8 (1-29)	0.44
<i>C. halli</i>	89.01	89.01	0.00	4.94 (1-27)	5.17 (1-30)	0.52
<i>C. tilapiae</i>	44.50	32.38	5.34	1.38 (1-4)	1.35 (1-5)	0.26
<i>S. longicornis</i>	40.84	36.13	0.90	1.91 (1-14)	2.09 (1-7)	0.67

Min V, Minimum value; Max V, maximum value.

The various species parasitized the four pairs of *O. niloticus* gill arches (Figures 3 and 4), however the prevalence of *C. thurstonae* and *C. tilapiae* decreased significantly in the antero-posterior direction ($\chi^2 = 97.83$ and 19.20 respectively, $df=3$, $P<0.05$). *Cichlidogyrus halli* was more frequently found on the median arches while

the arch IV was the least infected ($\chi^2=24.33$, $df=3$, $P<0.05$). The prevalence of *S. longicornis* was significantly the highest in the first gill arch and lowest on the fourth one ($\chi^2=9.87$, $df=3$, $P<0.05$). The mean intensity decreased in the antero-posterior direction for *C. thurstonae* and *C. tilapiae*. In these two cases the

differences were not statistically significant (respectively $K=5.19$ and 2.76 , $df=3$ $P>0.05$). *C. halli* and *S. longicornis* were respectively more concentrated on arches II and III (respectively $K=14.93$ and 8.77 , $df=3$, $P<0.05$). In almost all cases, arch IV has always been the least infected.

DISCUSSION

In several studies, there has been a growing interest on monogenean species-richness of cichlid host. Pariselle (1996) reported that in Africa, six monogenean species infested *O. niloticus* gill system namely: *Cichlidogyrus cirratus*, *C. halli*, *C. thurstonae*, *C. tilapiae*, *C. rognoni* and *S. longicornis*. The gill parasite community of *O. niloticus* collected at Melen fish station consisted of four of the six monogeneans species described in Africa and also presents a low species-richness compared to *O. niloticus* from the dam of Loumbila (Burkina Faso) in which a total of five species have been recorded (Boungou et al., 2008). Usually, the number of monogenean species per fish host varied (Pariselle, 1996); this variability of parasite richness has been associated to various factors related to: experimentation (Walter et al., 1995); the phylogeny of hosts and parasites (Bush et al., 1997; Sasal et al., 1997); host (Morand et al., 1999); ecology (Zharikova, 2000) and water quality (Galli et al., 2001; Mahmoud et al., 2011). The absence of *C. cirratus* and *C. rognoni* in Melen fish station permits the establishment of two hypotheses:

On one hand, the Melen fish station was not supplied with fish infected by the two parasites species thus there were no lateral transfers of parasites which were usually observed after the introduction of new hosts in new environment. Confirming this hypothesis Lambert (1997) stated that, the introduction of an animal species in a new environment means in fact, the introduction of a host-parasite system. On the other hand, this result could suggest the difficulty for these two parasites species to survive in the water of Melen fish station. It is known that, the ecological conditions of water might lead, not only to an increase in the number of parasites but also to a decrease in parasite diversity (Cone et al., 1993; Kaouachi et al., 2010).

Moreover, the polyparasitism observed in this study has also been reported by various authors in mouthbreeder tilapias. For example, Ibrahim (2012) mentioned the presence of eight monogenean species on the gills of *Tilapia zillii*, while Blahoua et al. (2009) showed that, the gill system of *Sarotherodon melanotheron* is parasitized by three monogenean species. Also, it appears from the work of Boungou et al. (2008) that five monogenean species colonized the gills of *O. niloticus* of Loumbila dam. The great diversity of monogenean gill parasites in African cichlids mentioned by Pariselle (1996) was hereby confirmed.

It has been observed that all representatives of the studied component community adopted an aggregative distribution. Tombi and Bilong Bilong (2004) reported an aggregative distribution of *Dactylogyrus bopeleti*, *D. insolitus*, *D. simplex* and *D. maillardi* monogenean gill parasites of *Barbus martorelli*. Similar observations were made by other researchers such as Lo and Morand (2000) and Öztürk and Altunel (2006). According to Combes (1995), an aggregative distribution may indicate heterogeneity in the relationship between the host and the parasite populations. The probability for the parasite to meet its host and its chances of surviving in the latter, may vary from one host to another. In addition, Kennedy (1977) stated that aggregative distribution increases the opportunities for parasites to meet a partner in order to reproduce.

The studied helminthofauna was composed by three core species (*C. thurstonae*, *C. halli*, *C. tilapiae*) and one secondary species (*S. longicornis*), with very low mean intensities except for *C. thurstonae* that was low. Similarly, all the monogenean species constituting the predictable part of *B. martorelli* gill parasitofauna presented very low mean intensities (Tombi and Bilong Bilong, 2004). Koyun (2011) also reported very low mean intensities of *Dactylogyrus minutus* and *D. anchoratus*, gill parasites of *Carassius carassius*. In breeding, the parasite loads are often high because of the confinement of the host (Ergens, 1983; Obiekezie, 1991). The low mean intensities recorded in this work could have a double explanation. On the one hand, in Melen fish station, basins are regularly emptied and cleaned; while on the other hand, during this, drainage large fish are usually caught for commercial purposes. As Combes (1995) declared, this work indicates that the low inflow of parasites associated with natural mortality of individuals provide an explanation to the results.

Monogeneans parasitized individuals of all length classes and in almost all cases, the prevalence and mean intensity increased with the SL of the fish. Blahoua et al. (2009) showed that specimens of *S. melanotheron* whose standard length varied between 100 and 250 mm harbored more monogeneans than those whose SL was between 50 and 100 mm. Ibrahim (2012) reported the positive significant correlation of prevalence and mean intensity of monogenean infracommunities with the total length of *T. zillii*. In contrast to these results, Boungou et al. (2008) showed that the size of *O. niloticus* in the dam of Loumbila (Ouagadougou) had no influence on the prevalence of its monogenean gill parasites. The increase of parasitism with the size of *O. niloticus* from Melen can be attributed to the fact that, larger fish had more time to accumulate parasites than younger ones (Ibrahim, 2012; Sasal et al., 1999). According to Cable et al. (2002) and Bilong Bilong and Tombi (2004), larger (older) fish offer large colonized surfaces area to parasites. This study also agrees with Simkova et al.

(2006), that the volume of water that passes through the gills of larger fish is more important and thus conveys more oncomiracidium.

During this study, members of *Cichlidogyrus* spp. showed no preference for host sex, concurring with Tombi and Bilong Bilong (2004) who found no difference in infection of *Dactylogyrus simplex* and *D. maillardi* based on the sex of *B. martorelli*. Moreover, in the Padda Dam (South Africa), Le Roux et al. (2011) observed no sex influence on the infestation of *Pseudocrenilabrus philander philander* gill filaments by *Cichlidogyrus philander*. These observations corroborate with the idea that very few parasites species have a preference in relation to the sex of the host (Rohde, 1993). Conversely *Scutogyrus longicornis* was observed to be more concentrated in males than in females. Some studies have revealed that monogenean infection sometimes correlate with sex of fish host (Blahoua et al., 2009; Ibrahim, 2012).

In general, the distribution of gill parasites of *O. niloticus* from Melen does not differ between the left and the right sides of the host. Similarly, there were no significant differences between the number of *Pseudodactylogyrus anguillae* on the left and right gill arches of *Anguilla anguilla* (Soylu et al., 2013). In *Clarias camerunensis*, *Birgiellus kellensis* and *Quadriacanthus* sp. colonized the two parts of the gill system of the host in the same way (Nack et al., 2010). Authors such as Gutiérrez and Martorelli (1994); Dzika (1999); Turgut et al. (2006); Tombi et al. (2010) have made similar observation. Bilong Bilong (1995) mentioned that the morphology of the fish body can influence the distribution of monogeneans in the two host sides. Rohde (1993) associated a preference for one side of the host body to body asymmetry of some parasites. It therefore appears logical that the bilateral symmetry of the body of *O. niloticus* associated with that of its gill monogeneans allow for an equitable distribution of parasites on both sides of the fish.

The study of the occupation of the four pairs of gill arches revealed that prevalence rate of each parasite decreases in the antero-posterior direction. These results are similar to those of Rubio-Godoy (2008), who showed that the prevalence of *Discocotyle sagittata* on the four gill arches of *Oncorhynchus mykiss* decreased from arch I to arch IV. On the basis of parasite loads, this study reveals that *C. halli* and *S. longicornis*, respectively showed a preference for arches II and III. Several cases of monogenean arch preferences have been presented: In *Cyprinus carpio*, *Dactylogyrus auriculatus* was preferentially attached to the arches II and III. Similarly, Dzika (1999) had reported that *Pseudodactylogyrus anguillae* mostly colonized the median arches of *Anguilla Anguilla*; Stavrescu-Bedivan et al. (2008) had indicated that arch I was more infested by *Paradiplozoon tisiae* gill monogenean of *Barbus meridionalis*. Jerônimo et al.

(2013) also noted that the monogenean *Mymarothecium boegeri* and *Anacanthorus penilabiatus* from the hybrid patinga showed the greatest mean intensities on the gill arch I when compared to gill arch IV. Several hypotheses are often made to explain gill selection by parasites. Some authors have agreed that the median gill arches II and III are more infected not only because of the large volume of water flowing through them, but also due to the high respiratory water current which is naturally rich at those sites, with a high number of parasites (Gutiérrez and martorelli, 1994; Lo and Morand, 2001). For Buchmann (1989) and Koskivaara and Valtonen (1991), the median preference arches may also be related to the large colonized surfaces they offer to parasites. Other authors have mentioned factors such as parasite load (Lo and Morand, 2000) and the host immunity that may also influence microhabitat selection (Koskivaara and Valtonen, 1992; Gutiérrez and Martorelli, 1994).

REFERENCES

- Aloo P. A. (2002). A comparative study of helminth parasites from the fish *Tilapia zillii* and *Oreochromis leucostictus* in Lake Naivasha and Oloidien Bay, Kenya. *J. Helminthol.* 76:95-102.
- Bilong Bilong C. F. & 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. *Ann. Fac. Sci. Univ. Ydé I., Série Sci. Nat. et Vie.* 34(2):295-303.
- Bilong Bilong C. F. & Tombi J. (2004). Hétérogénéité du système branchial de *Barbus martorelli* (Poisson Cyprinidae) et modèle de croissance. *J.C.A.S.* 4(3):211-218.
- Bilong Bilong C. F. (1995). Les monogènes parasites des poissons d'eau douce du Cameroun: Biodiversité et spécificité; biologie des populations inféodées à *Hemichromis fasciatus*. Thèse de Doctorat d'Etat, Université de Yaoundé I, 341pp.
- Blahoua K. G., N'Douba V., Tidiani K. & N'Guessan K. J. (2009). Variations saisonnières des indices épidémiologiques de trois monogènes parasites de *Sarotherodon melanotheron* (Pisces: Cichlidae) dans le lac d'Ayamé (Côte d'Ivoire). *Sci. Nat.* 6(1):39-47.
- Boungou M., Kabre G. B., Marques A. & Sawadogo L. (2008). Dynamics of population of Five Parasitic Monogeneans of *Oreochromis niloticus* Linné, 1757 in the Dam of Loumbila and possible interest in intensive pisciculture. *Pak. J. Biol. Sci.* 11(10):1317-1323.
- Buchmann K. & Lindenstom T. (2002). Interactions between monogenean parasites and their fish hosts. *Int. J. Parasitol.* 32:309-319.
- Buchmann K. (1989). Microhabitat of monogenean gill parasites on European eel (*Anguilla anguilla*). *Folia Parasitol.* 36:321-329.
- Bush A. O., Lafferty K. K., Lotz J. M. & Shostak A. W. (1997). Parasitology meets ecology on its own terms: Margolis et al. revisited. *J. Parasitol.* 83:575-583.
- Cable J., Tinsley R. C. & Harris P. D. (2002). Survival and embryo development of *Gyrodactylus gasterostei* (Monogenea: Gyrodactylidae). *Parasitology.* 124:53-68.
- Combes C. (1995). Interactions durables. Ecologie et évolution du parasitisme. Masson.
- Cone D. K., Marcogliese D. J. & Watt W. D. (1993). Metazoan parasite communities of yellow eels (*Anguilla rostrata*) in acid and limed rivers of Nova Scotia. *Can. J. Zool.* 71:177-184.
- Dudgeon D., Arthington A. H., Gessner M. O., Kawabata Z., Knowlter D. J., Lévêque C. & Naimon J. R. (2006). Freshwater biodiversity: important, threats, status and conservation challenge. *Biol. Rev.* 81:

- 163-182.
- Dzika E. (1999). Microhabitats of *Pseudodactylogyrus anguillae* and *P. bini* (Monogenea: Dactylogyridae) on the gills of large-size European eel *Anguilla anguilla* from Lake Gaj, Poland. *Folia Parasitol.* 46:33-36.
- Ergens R. (1983). A survey of the results of studies on *Gyrodactylus katharineri* Malmberg, 1964 (Gyrodactylidae: Monogenea). *Folia Parasitol.* 30:319-327.
- FAO, Fisheries and Aquaculture Department (2009). The state of world fisheries and aquaculture 2008. Food and agriculture organization of the United Nations, Rome.
- Galli P., Crosa G., Mariniello L., Ortis M. & D'Amelio S. (2001). Water quality as a determinant of the composition of fish parasite communities. *Hydrobiologia.* 452:173-179.
- Gutiérrez P. A. & Martorelli S. R. (1994). Seasonality, distribution, and preference sites of *Demidosperrus valenciennesi* Gutiérrez et Suriano, 1992 (Monogenea: Ancyrocephalidae) in catfish. *Res. Rev. Parasitol.* 54(4):259-261.
- Ibrahim M. M. (2012). Variation in parasite infracommunities of *Tilapia zillii* in relation to some biotic and abiotic factors. *Int. J. Zool. Res.* 8(2):59-70.
- Jerônimo G. T., Gonçalves E. L. T., Bampi D., Paseto A., De Pádua S. B., Ishikawa M. M. & Martins M. L. (2013). Microhabitat of monogenea and copepodids of *Lernaea cyprinacea* on the gills of four Brazilian freshwater fish. *Neotrop. Helminthol.* 7(1):65-74.
- Kaouachi N., Boualleg C., Bensouilah M. & Marchand B. (2010). Monogenean parasites in Sparid fish (*Pagellus* genus) in eastern Algeria coastline. *Afr. J. Microbiol. Res.* 4:989-993.
- Kennedy C. R. (1977). The regulation of fish parasite populations. In: G.W. Esh (Ed). *Regulation of parasite populations*. New York: Academic Press. 253p.
- Kirk R. S. (2003). The impact of *Anguillicola crassus* on European eels. *Fish. Manag. Ecol.* 10:385-394.
- Koskivaara M. & Valtonen E. T. (1991). *Paradiplozoon homoion* (Monogenea) and some other gill parasites on roach *Rutilus rutilus* in Central Finland. *Aqua. Fennica.* 21(2):137-143.
- Koskivaara M. & Valtonen E. T. (1992). *Dactylogyrus* (Monogenea) communities on the gill of roach in three lakes in Central Finland. *Parasitology.* 104:263-272.
- Koyun M. (2011). Seasonal distribution and ecology of some *Dactylogyrus* species infecting *Alburnus alburnus* and *Carassius carassius* (Osteichthyes: Cyprinidae) from Porsuk river, Turkey. *Afr. J. Biotechnol.* 10(7):1154-1159.
- Lambert A. (1997). Introduction de poissons dans les milieux aquatiques continentaux : Quid de leurs parasites? *Bull. Fr. Pêche Piscic.* 344/345:323-333.
- Le Roux L. E., Avenant-Oldewage A. & Walt van der F. C. (2011). Aspects of the ecology of *Cichlidogyrus philander* collected from *Pseudocrenilabrus Philander philander* from the Padda Dam, Gauteng, South Africa. *Afr. Zool.* 46:103-116.
- Lo C. M. & Morand S. (2000). Spatial distribution and coexistence of monogenean gill parasites inhabiting two damselfishes from Moorea Island in French Polynesia. *J. Helminthol.* 74(4):329-36.
- Lo C. M. & Morand S. (2001). Gill parasites of *Cephalopholis argus* (Teleostei: Serranidae) from Moorea (french polynesia): site selection and coexistence. *Folia Parasitol.* 48:30-36.
- Morand S., Poulin R. & Hayward C. (1999). Aggregative and species co-existence of ectoparasites of marine fishes. *Int. J. Parasitol.* 29:663-672.
- Nack J., Tombi J., Bitya Nyom A. & Bilong Bilong C. F. (2010). Sites de fixation de deux monogènes Dactylogyridae parasites branchiaux de *Clarias camerunensis* : évidence sur le mode d'infestation par les Monopisthocotylea. *J. Appl. Biosci.* 33:2076-2083.
- Obiekezie A. I. & Taege M. (1991). Mortalities in hatchery-reared fry of the African catfish, *Clarias gariepinus* (Burchell) caused by *Gyrodactylus groschafti* Ergens, 1973. *Bull. Eur. Fish Pathol.* 11(2):82-85.
- Obiekezie A. I. (1991). The principal pathogens and diseases of cultured fishes in Nigeria. In : IFS (Eds). *Aquaculture in Africa*. Pp. 197-207.
- Ogawa K. (2002). Impacts of diclidophorid monogenean infections on fishes in Japan. *Int. J. Parasitol.* 32(3):373-380.
- Öztürk M. O. & Altunel F. N. (2006). Occurrence of *Dactylogyrus* infection linked to seasonal changes and host fish size on four cyprinid fishes in lake Manyas, Turkey. *Acta zoo. Hung.* 52(4):407-415.
- Pariselle A. & Euzet L. (1998). Five new species of *Cichlidogyrus* (Monogenea: Ancyrocephalidae) from *Tilapia brevimanus*, *T. buttikoferi* and *T. cessiiana* from Guinea, Ivory Coast and Sierra Leone (West Africa). *Folia Parasitol.* 45:275-282.
- Pariselle A. & Euzet L. (2009). Systematic revision of dactylogyridean parasites (Monogenea) from cichlid fishes in Africa, the Levant and Madagascar. *Zoosystema* 31(4):849-898.
- Pariselle A. (1996). Diversité, spéciation et évolution des monogènes branchiaux de Cichlidae en Afrique de l'ouest. PhD Thesis: University of Montpellier II, France. 199p.
- Pariselle A., Bilong Bilong C. F. & Euzet L. (2003). Four new species of *Cichlidogyrus* Paperna, 1960 (Monogenea, Ancyrocephalidae), all gill parasites from African mouthbreeder tilapias of the genera *Sarotherodon* and *Oreochromis* (Pisces, Cichlidae), with a redescription of *C. thurstonae* Ergens, 1981. *Syst. Parasitol.* 56:201-201.
- Post G. (1987). Animal parasite of fishes. In: T.F.H. (2nd Ed). *Neptune City. Textbook of Fish Health*. Pp. 159-214.
- Rohde K. (1993). *Ecology of marine parasites. An introduction to marine parasitology*, 2nd Ed. Cab International, Wallingford, Oxon.
- Rohde K., Heap M., Hayward C. J. & Graham K. J. (1992). *Calitotyle australiensis* n.sp. and *Calitotyle* sp. (Monogenea, Monopisthocotylea) from the rectum and rectal glands and *Rugogaster hycholagi* Shell, 1973 (Trematoda, Apisidogastrea from the rectal glands of holocephalans off the coast of southeastern Australia. *Syst. Parasitol.* 21:69-79.
- Rubio-Godoy M. (2008). Microhabitat selection of *Discocotyle sagittata* (Monogenea: Polyopisthocotylea) in farmed rainbow trout. *Folia Parasitol.* 55:270-276.
- Sasal P., Morand S. & Guegan J. F. (1997). Parasite species richness for fish of Mediterranean Sea. *Mar. Ecol. Progr. Ser.* 149:61-71.
- Sasal P., Trouvé S., Müller-Graf C. & Morand S. (1999). Specificity and host predictability: a comparative analysis among monogenean parasites of fish. *J. Anim. Ecol.* 68:437-444.
- Simkova A., Verneau O., Gelnar M. & Morand S. (2006). Specificity and specialisation of congeneric Monogeneans parasitizing Cyprinid fish. *Evolution.* 60:1023-1037.
- Soylu E., Çolak S. O., Erdogan F., Erdogan M. & Tektas N. (2013). Microhabitat distribution of *Pseudodactylogyrus anguillae* (Monogenea), *Ergasilus gibbus* and *Ergasilus lizae* (Copepoda) on the gills of European Eels (*Anguilla anguilla*, L.) *Acta zool. Bulg.* 65(2):251-257.
- Stavrescu-Bedivan M. M. & Aioanei F. T. (2008). Aspects of branchial parasitism in *Barbus meridionalis* Petenyi Heckel, 1847 (Teleostei: Cyprinidae). *Bull. Vet. Med.* 65(2):57-90.
- Sures B. (2001). The use of fish parasites as bioindicators of heavy metals in aquatic ecosystems; A Review. *Aquat. Ecol.* 35:245-255.
- Tombi J. & Bilong Bilong C. F. (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. *Rev. Elev. Méd. Vet. Pays Trop.* 57(1-2):71-76.
- Tombi J., Nack J. & Bilong Bilong C. F. (2010). Spatial distribution of Monogenean and Myxosporidian gill parasites of *Barbus martorelli* Roman, 1971 (Teleostei: Cyprinid): The role of intrinsic factors. *Afr. J. Agric. Res.* 5(13):1662-1669.
- Turgut E., Shinn A. & Wootten R. (2006). Spatial distribution of *Dactylogyrus* (Monogenean) on the gills of the host fish. *Turk. J. Fish. Aquat. Sci.* 6:93-98.
- Valtonen E. T., Holmes J. C. & 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. *Can. J. Fish. Aquat. Sci.* (54):572-585.
- Walter B. A., Clayton D. H., Cotgreave P. C., Gregory R. D. & Price R. D. (1995). Sampling effort and parasite species richness.

- Parasitol. Today. 11:306-310.
- Whittington I. D., Cribb B. W., Hamwood T. E. & Halliday J. A. (2000). Host-specificity of monogenean (platyhelminth) parasites: a role for anterior adhesive areas. Int. J. Parasitol. 30: 305-320.
- Zharikova T. I. (2000). The adaptative 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. 34(1): 50-55.