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Ectoparasites of Nile tilapia (*Oreochromis niloticus*) in cage farming in a hydroelectric reservoir in Brazil

Ectoparasitas de tilápias-do-Nilo (*Oreochromis niloticus*) criadas em tanques-rede em um reservatório de usina hidrelétrica no Brasil

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Abstract

For this study, we performed a parasitological analysis of cage-cultured Nile tilapia (*Oreochromis niloticus*) from the Água Vermelha Reservoir, Southeastern Brazil, and verified relationships with limnological data, seasonality, and fish growth phase. From March 2010 to March 2011, sixty-three specimens of *O. niloticus* in three growth phases (i.e., initial, intermediate, and final) were collected. All fish specimens were infested with at least one ectoparasite species (prevalence = 100%). Five species of protozoans (*Trichodina compacta*, *Trichodina magna*, *Ichthyophthirius multifiliis*, *Piscinoodinium pillulare*, and *Epistylis* sp.) and five species of monogenoids (*Cichlidogyrus halli*, *Cichlidogyrus thurstonae*, *Cichlidogyrus* sp. 1, *Scutogyrus longicornis*, and *Gyrodactylus* sp.) were observed. The abundance of *Trichodina* spp. and the prevalence of *Epistylis* sp. were higher in the dry season, and the prevalence of *C. halli* was higher in the rainy season. For the majority of ectoparasites found in this study, fish in the intermediate and final phases had higher parasitism rates than those in the initial phase. The data presented may help fish farmers to understand the parasite dynamics of the fish species studied in cage-farming systems.

Keywords: Fish farming, health, water quality, monogenoid, *Trichodina* spp., *Ichthyophthirius multifiliis.*

Resumo

O presente estudo teve como objetivo realizar análise parasitológica de tilápias-do-Nilo, (*Oreochromis niloticus*) criadas em tanques-rede no Reservatório de Água Vermelha, Sudeste do Brasil, bem como verificar suas inter-relações com as características limnológicas, sazonalidade e fase de criação. Durante o período de março de 2010 a março de 2011, espécimes de *O. niloticus,* pertencentes a três fases de criação (inicial, intermediária e final), foram colhidos, totalizando 63 indivíduos. Todos os peixes estavam infestados por pelo menos uma espécie de ectoparasita (prevalência = 100%). Foi observada a ocorrência de cinco espécies de protozoários (*Trichodina compacta*, *Trichodina magna*, *Ichthyophthirius multifiliis*, *Piscinoodinium pillulare* e *Epistylis* sp.), assim como cinco espécies de monogenóides (*Cichlidogyrus halli*, *Cichlidogyrus thurstonae*, *Cichlidogyrus* sp. 1, *Scutogyrus longicornis* e *Gyrodactylus* sp.). A abundância de *Trichodina* spp. e prevalência de *Epistylis* sp. foram maiores no período seco, e a prevalência de *C. halli* foi maior no período chuvoso. Para a maioria dos ectoparasitas encontrados neste estudo, os peixes pertencentes às fases intermediária e final apresentaram maiores taxas de parasitismo do que aqueles pertencentes à fase inicial. Os dados apresentados neste estudo podem ser de grande importância para piscicultores, de forma a auxiliá-los no conhecimento da dinâmica dos parasitas da espécie de peixe estudada em sistemas de tanques-rede.

Palavras-chave: Piscicultura, sanidade, qualidade da água, monogenóide, *Trichodina* spp., *Ichthyophthirius multifiliis*.

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Introduction

Fish farming is an important activity for the production of protein for human consumption. Brazil is ranked internationally as a country with high potential for fish farming because of its extensive territory and climatic conditions that favor the implementation of freshwater fish culture (PAVANELLI et al., 2008). Fish cage technology is widespread in Brazil, since a production system employing it can use already-existing water resources and requires less investment than traditional aquaculture in fish ponds (ONO; KUBITZA, 1999).

In intensive fish farms, such as cage-culture systems, problems associated with nutritional deficiency, inadequate handling, and poor water quality are common. The stressful conditions caused by these factors can foster infectious and parasitic diseases (CAVICHIOLO et al., 2002; MARTINS et al., 2002). Thus, studies on parasites and other pathogens of aquatic organisms are extremely important for the creation of the species with potential for aquaculture.

The Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758), is a widely farmed fish species that is used as an economic source in Brazil (LIZAMA et al., 2007). Several diseases and parasites can affect *O. niloticus* production; however, certain parasites frequently parasitize this fish species, including the protozoan ciliates *Trichodina* spp. Ehrenberg, 1830, *Ichthyophthirius multifiliis* (Fouquet, 1876), and monogenoids (MARTINS et al., 2011).

Monogenoids are considered to be responsible for the most important parasitic disease in Brazilian fish farming because they can cause high mortality rates. The presence of these parasites in fish gills can cause hypersecretion of mucus, cell hyperplasia, and even fusion of the filaments of gill lamellae, reducing the host's respiratory capacity (THATCHER; BRITES-NETO, 1994; PAVANELLI et al., 2008).

In severe infestations, ciliate protozoans can damage fish health and consequently cause economic losses in fish farming systems. *Trichodina* spp. and *I. multifiliis* occur in the gills and on the body surface of fish and may cause mucus hypersecretion and lesions in the integument and gills (PAVANELLI et al., 2008). Several studies have reported the occurrence of these parasites in *O. niloticus* and their associations with limnological data or seasonality (TAVARES-DIAS et al., 2001a, b; RANZANI-PAIVA et al., 2005; LEMOS et al., 2006; LIZAMA et al., 2007; BRACCINI et al., 2008; BUCUR et al., 2011; JERÔNIMO et al., 2011). However, there has been a lack of studies on the association between disease occurrence and parasitism rates in *O. niloticus* during the different growth phases.

Thus, for this study, we aimed to perform a parasitological analysis of cage-cultured *O. niloticus* of the Água Vermelha Reservoir, Southeastern Brazil, and to verify any associations with limnological data, seasonality, and fish growth phase.

Table 1. Dominance frequency and mean relative dominance of the ectoparasites found in Nile tilapia (*Oreochromis niloticus*) reared in fish cages in the Grande River Basin, Água Vermelha Reservoir, Southeastern Brazil, March 2010–March 2011.

Ectoparasites	Dominance frequency	Mean relative dominance*
Trichodina spp.	45	0.6 ± 0.3
Ichthyophthirius multifiliis	0	0.01 ± 0.02
Cichlidogyrus halli	14	0.2 ± 0.3
Cichlidogyrus thurstonae	4	0.1 ± 0.2
Cichlidogyrus sp. 1	0	0.001 ± 0.1
Scutogyrus longicornis	0	0.03 ± 0.1
Gyrodactylus sp.	0	0.04 ± 0.1

*Values presented as mean ± standard error (range).

Materials and Methods

Characterization of fish farming

This study was carried out in an *O. niloticus* cage farm located in the Grande River Basin, Água Vermelha Reservoir (Figure 1), municipality of Mira Estrela, São Paulo State, Brazil (19° 55' 47.52" S, 50° 08' 36.56" W). The fish cages, sized 6 m^3, were positioned in parallel lines. Fish were stocked at a density of 80 kg/m^3 and were fed twice daily (at 8:00 AM and 4:00 PM), in accordance with the recommendations of the feed manufacturer, considering fish size and water temperature. The fish were harvested when their average weight reached 800 g, and they were sold to cold storage plants to be processed and filleted or to fee-fishing farms. The fish production cycle took approximately 4 months.

Parasitological procedures

From March 2010 to March 2011, nine specimens of *O. niloticus* across the three growth phases (three each from the initial, intermediate, and final phases) were collected bimonthly, totaling 63 individuals. Fish growth phase was determined according to fish weight (initial, intermediate, and final phases: ≤150 g, 151-400 g, and 401-800 g, respectively). The fish were caught with nets and transported to the laboratory, where they were measured (cm) and weighed (g) (Table 1). *Oreochromis niloticus* specimens were necropsied according to Eiras et al. (2006). Qualitative and quantitative analyses of protozoan parasites were performed on mucus scrapings from the entire body surface on microscope slides after fixation in 70% alcohol. Subsequently, all this content was analyzed with an optical microscope by compressing them between a microscope slide and a cover slip; excess liquid was removed using filter paper (adapted from EIRAS et al., 2006).

All organs were analyzed with a stereo microscope. The gills were collected and fixed in 70% alcohol for later identification and the counting of monogenoids. To study sclerotized structures (hooks, anchors and bars of haptor, and copulatory complex), the monogenoids were clarified with Hoyer's medium or Grey and Wess (EIRAS et al., 2006). The following references were used for parasite identification and diagnosis: Douëllou (1993) and Pariselle and Euzet (2009) for monogenoids and Van As and Basson (1989), Martins and Ghiraldelli (2008), and Pavanelli et al. (2008) for protozoans.

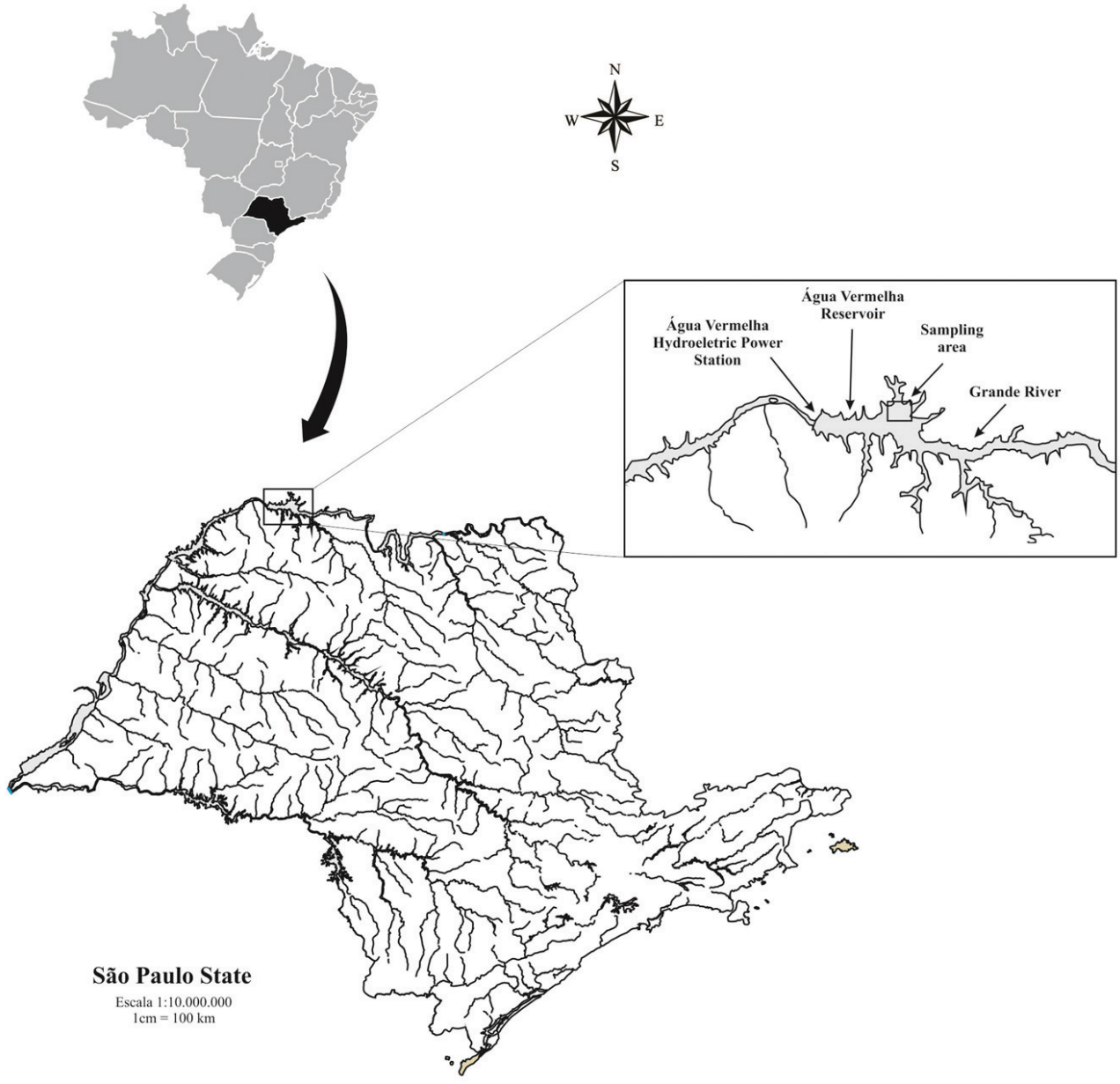

Figure 1. Map of Brazil highlighting São Paulo State and the sampling area of the Água Vermelha reservoir (19° 55' 47.52" S, 50° 08' 36.56" W).

For species identification, parasites were analyzed using a computerized image analysis system with differential interference contrast (DIC) - LAS V3 (Leica Application Suite). Voucher specimens were deposited at the Coleção Helmintológica of the Departamento de Parasitologia, Instituto de Biociências, Universidade Estadual Paulista - UNESP, municipality of Botucatu, São Paulo State, Brazil (CHIBB: 055L-067L).

Water quality

Water samples were obtained bimonthly from the investigated fish farm. The water's physical and chemical parameters, such as dissolved oxygen and temperature, were evaluated in situ using a YSY - Mod. 50 multisensor, and its transparency was measured with a Secchi Disk. Nitrite concentration (mg/L), total ammonia nitrogen concentration (mg/L), and pH were measured using a commercial kit (AlfaKit; Alfa Techno Chemistry Company, Florianópolis, SC, Brazil).

Data analysis

Parasite prevalence, mean intensity of infection, and mean abundance data were obtained according to Bush et al. (1997), and the frequency of dominance and mean relative dominance were determined according to Rohde et al. (1995).

Comparisons of the prevalence of each species of parasite in relation to seasonality were performed using *Z*-tests, and comparisons in relation to fish growth phase were performed

using chi-square (χ^2) tests of independence and a posteriori tests of adjusted residuals.

The variation of intensity of infection and abundance in relation to seasonality were compared by Student's *t*- or Mann–Whitney *U*-tests, according to data distribution. Variation in the intensity of infection and abundance of parasites among the fish growth phases were compared by one-way analyses of variance (ANOVAs) or Kruskal–Wallis (*H*) tests, according to data distribution.

The condition factor (*K*) was calculated using the curve of the relationship between the total weight (Wt) and standard length (L_s) of *O. niloticus* specimens; a scatter plot of the variables (Wt and L_s) was used (LE CREN, 1951). The ratio Wt / L_s was adjusted by an exponential equation of the type $Wt = a \times L_s^b$, where the *a* constant (linear coefficient) indicates fish health and the *b* parameter (angular coefficient) expresses the fish species' type of growth (SANTOS, 1978; BENEDITO-CECÍLIO; AGOSTINHO, 1997; ORSI et al., 2004). The individual condition factor ($K = Wt / Lt^b$) for each fish specimen was calculated using the angular coefficient. Spearman's rank correlation (r_s) analysis was used to study any possible correlation between the condition factor (*K*) and abundance according to seasonality and fish growth phase.

Tricodinids were quantified only at the genus level, and because of this they were not quantified separately for statistical analysis.

The calculations of the mean intensity of infection and mean abundance were not performed for *Epistylis* sp., because it is a colonial protozoan.

Statistical tests were performed using SigmaStat 3.1 (Systat Software Inc., California, USA) and XLStat 7.5.2 (Addinsoft, New York, USA), adopting a significance level of 5%.

Results

Ectoparasites

All fish specimens were infested with at least one species of ectoparasite (prevalence = 100%), and the presence of the following taxa was observed: *Trichodina compacta* Van As & Basson, 1989, *Trichodina magna* Van As & Basson, 1989, *I. multifiliis* and *Epistylis* sp. Ehrenberg, 1830 parasitizing the body surface and gills; *Piscinoodinium pillulare* (Schäperclaus, 1954) Lom, 1981, *Cichlidogyrus halli* (Price & Kirk, 1967), *Cichlidogyrus thurstonae* Ergens, 1981, *Cichlidogyrus* sp.1 Paperna, 1960 and *Scutogyrus longicornis* (Paperna & Thurston, 1969) parasitizing only the gills; and *Gyrodactylus* sp. Nordmann, 1832, parasitizing only the body surface. *Trichodina* spp. showed a higher frequency of dominance and mean relative dominance among the parasites found in this study (Table 1).

Fish growth phase

Fish specimens from the intermediate and final phases presented higher mean intensity of infection and mean abundance than those from the initial phase ($H = 10.7$, $p = 0.005$; Table 2). *Trichodina* spp. had the highest mean abundance values of any parasites in all fish growth phases ($p < 0.05$). In relation to mean intensity of infection, this protozoan also showed the highest parasitism rates ($p < 0.05$), with the exception of *I. multifiliis* in the intermediate phase.

Analysing in which fish growth phase determined ectoparasite species presented the higher parasitism rates, Nile tilapia in the intermediate and final phases presented the highest intensity of infection and abundance of *Trichodina* spp. ($H = 6.9$, $p = 0.03$ and $H = 11.5$, $p = 0.003$, respectively) and *S. longicornis* ($H = 12.9$, $p = 0.002$ and $H = 18.8$, $p < 0.001$, respectively). Fish specimens from the final phase had the highest prevalence of *Cichlidogyrus* sp.1 ($p < 0.05$) and *I. multifiliis* ($p < 0.05$), and the highest abundance of *C. halli* ($H = 7.1$, $p = 0.03$; Table 3).

No correlation was observed in the fish growth phases in relation to *K* or parasite abundance ($p > 0.05$).

Water quality and seasonality

The water parameters of the studied fish farm are presented in Table 4. In the dry season, *Trichodina* spp. ($U = 1010.5$, $p = 0.043$) was the most abundant parasite, and *Epistylis* sp. ($Z = 2.739$, $p = 0.006$) was the most prevalent. In the rainy season, there was a higher prevalence ($Z = 2.239$, $p = 0.025$) of *C. halli* (Table 5).

No correlation was observed in the dry or rainy seasons in relation to *K* or parasite abundance ($p > 0.05$).

Table 2. Prevalence (P), mean intensity of infection (MII), and mean abundance (MA) of the ectoparasites and biometric data observed in each fish growth phase of Nile tilapia (*Oreochromis niloticus*) reared in fish cages in the Grande River Basin, Água Vermelha Reservoir, Southeastern Brazil, March 2010–March 2011.

Fish growth phase	Weight (g)	Standard length (cm)	P (%)	MII*	MA*
Initial	56.4 ± 13.7	10.06 ± 0.9	100[a]	25 ± 5.9	25 ± 5.9
	(1.4-214.3)	(4.2-17.2)		(2-108)[a]	(2-108)[a]
Intermediate	228.4 ± 27.4	18 ± 0.8	100[a]	181 ± 94.3	181 ± 94.3
	(59.8-444.6)	(13-23.5)		(10-2030)[b]	(10-2030)[b]
Final	590.6 ± 59.6	24.2 ± 0.8	100[a]	581.2 ± 387.6	581.2 ± 387.6
	(205.4-1481.1)	(17-32)		(4-8199)[b]	(4-8199)[b]

*Values presented as mean ± standard error (range). g: gram; cm: centimeter. Prevalence, mean intensity of infection and mean abundance followed by the same letter in the column: no significant difference ($p > 0.05$). *Epistylis* sp. was not included in the calculations of mean intensity of infection and mean abundance because it is a colonial protozoan.

Table 3. Prevalence, mean intensity of infection, and mean abundance of the ectoparasites found in each fish growth phase (IN: initial - *n* = 21, IT: intermediate - *n* = 21, and FN: final - *n* = 21) of Nile tilapia (*Oreochromis niloticus*) reared in fish cages from the Grande River Basin, Água Vermelha Reservoir, Southeastern Brazil, March 2010–March 2011.

Ectoparasites	Prevalence (%)			Mean intensity of infection*			Mean abundance*		
	IN	IT	FN	IN	IT	FN	IN	IT	FN
Trichodina spp.	76.2[a]	100[a]	90.5[a]	23.9 ± 7.1 (2-96)[a]	159.3 ± 83 (2-1778)[b]	603 ± 405.3 (2-7768)[b]	18.2 ± 5.8 (0-96)[a]	159.3 ± 83 (2-1778)[b]	545.5 ± 367.9 (0-7768)[b]
Ichthyophthirius multifiliis	0[a]	9.5[a]	38.1[b]	0[a]	100 ± 98 (2-198)[a]	51.1 ± 1 (2-10)[a]	0[a]	9.5 ± 9.4 (0-198)[a]	1.9 ± 0.7 (0-10)[a]
Epistylis sp.†	19.1[a]	52.4[a]	57.14[a]	-	-	-	-	-	-
Piscinoodinium pillulare	4.8[a]	0[a]	0[a]	1[a]	0[a]	0[a]	0.1 ± 0.1 (0-1)[a]	0[a]	0[a]
Cichlidogyrus halli	61.9[a]	100[a]	90.5[a]	5.3 ± 1.8 (0.7-23.5)[a]	4.5 ± 0.7 (0.9-13.5)[a]	7.2 ± 2.6 (0.6-45.5)[a]	3.3 ± 1.2 (0-23.5)[a]	4.5 ± 0.7 (0.9-13.5)[a]	8 ± 2.4 (0-45.5)[b]
Cichlidogyrus thurstonae	57.1[a]	95.2[a]	85.7[a]	2.4 ± 0.9 (0.3-9.7)[a]	4.7 ± 1.6 (0.3-25.5)[a]	4.2 ± 0.7 (0.8-12.2)[a]	1.4 ± 2.5 (0-9.7)[a]	4.5 ± 1.4 (0-25.5)[a]	4 ± 0.7 (0-12.2)[a]
Cichlidogyrus sp. 1	0[a]	0[a]	61.9[b]	0[a]	0[a]	0.2 ± 0.1 (0.01-1)[a]	0[a]	0[a]	0.1 ± 0.1 (0-1)[a]
Scutogyrus longicornis	42.9[a]	85.7[a]	76.2[a]	0.3 ± 0.1 (0.1-1)[a]	1.6 ± 0.4 (0.3-6)[b]	1.7 ± 0.5 (0.1-8.2)[b]	0.1 ± 0.1 (0-1)[a]	1.4 ± 0.3 (0-6)[b]	1.3 ± 0.4 (0-8.2)[b]
Gyrodactylus sp.	33.3[a]	33.3[a]	47.6[a]	5.7 ± 1.5 (2-12)[a]	7 ± 3 (1-24)[a]	44.2 ± 38.3 (1-388)[a]	1.9 ± 0.8 (0-12)[a]	2.3 ± 1.2 (0-24)[a]	21.1 ± 18.4 (0-388)[a]

*Values presented as mean ± standard error (range). †The calculations of mean intensity of infection and mean abundance were not performed as this is a colonial protozoan. Prevalence, mean intensity of infection and mean abundance followed by the same letter in the row: no significant difference ($p > 0.05$).

Table 4. Water quality measured in the Grande River Basin, Água Vermelha Reservoir, Southeastern Brazil close to the fish farming cage culture of *Oreochromis niloticus*, March 2010–March 2011.

Parameters	Sampling months						
	Mar/10*	May/10†	Jul/10†	Sept/10†	Nov/10*	Jan/11*	Mar/11*
Dissolved oxygen ($mg.L^{-1}$)	6.6	6.7	6.3	7.6	3.9	6.2	5.2
Transparency (m)	2	> 2	> 1.5	1.5	0.98	>1.5	> 1.5
pH	7	7	7	6.8	6.5	7.5	7
Temperature (°C)	29.3	24.5	22.9	23.6	28.6	30.8	28.6
Ammonia ($mg.L^{-1}$)	0.1	0	0	0.1	0.1	0.1	0.1
Toxic ammonia ($mg.L^{-1}$)	9×10^{-4}	0	0	6×10^{-4}	2.3×10^{-4}	2.3×10^{-4}	9×10^{-4}
Nitrite ($mg.L^{-1}$)	0.1	0.03	0	0	0.03	0.1	0.03
Rainfall (mm)‡	147.3	58.9	14.1	64.5	124	271.6	147.3

*Months belonging to the rainy season (Mar: March, Nov: November, Jan: January); †Months belonging to the dry season (May, Jul: July, Sept: September); ‡Rainfall data were obtained by consulting the database CIIAGRO - Centro Integrado de Informações Agrometeorológicas of the São Paulo State, Brazil.

Discussion

The ectoparasites found in this study are commonly observed in *O. niloticus* and have been described in several previous reports under various culture systems (VARGAS et al., 2000; MARTINS et al., 2001; TAVARES-DIAS et al., 2001a, b; RANZANI-PAIVA et al., 2005; GHIRALDELLI et al., 2006; LEMOS et al., 2006; BRACCINI et al., 2008; BUCUR et al., 2011; JERÔNIMO et al., 2011).

The majority of the values observed in the water analysis were appropriate for farming of *O. niloticus*, with the exception of temperature, which in dry season months was lower (< 26 °C) than that recommended for this fish species (KUBITZA, 2000; ZANIBONI-FILHO, 2004). In the dry season, there was a higher abundance of *Trichodina* spp. and prevalence of *Epistylis* sp.

According to Pavanelli et al. (2008), the susceptibility of fish to parasites and diseases depends on several factors related to stress caused by nutritional status, handling or transport and, particularly, water quality and organic load of the production units. Low temperature can reduce appetite and growth and suppress the immune system, predisposing the fish to attack by pathogens (KUBITZA, 2000).

During the rainy season, only the prevalence of *C. halli* was higher than that observed during the dry season. However, the mean intensity of infection and mean abundance of *C. halli* and the other monogenoids observed in this study were low in both of the studied periods. A similar result was observed by

Table 5. Prevalence (P), mean intensity of infection (MII), and mean abundance (MA) of the ectoparasites found in Nile tilapia (*Oreochromis niloticus*) reared in fish cages in the Grande River Basin, Água Vermelha Reservoir, Southeastern Brazil, according to seasonality, March 2010–March 2011.

Ectoparasites	P (%)		MII*		MA*	
	DS[ɣ]	RS[ʒ]	DS[ɣ]	RS[ʒ]	DS[ɣ]	RS[ʒ]
Trichodina spp.	96.3[a]	83.3[a]	472.8 ± 302.5 (4-7768)[a]	96.4 ± 33.8 (2-926)[a]	455.3 ± 291.6 (4-7768)[a]	80.3 ± 28.8 (0-926)[b]
Ichthyophthirius multifiliis	28.6[a]	11.1[a]	37.7 ± 32.1 (2-198)[a]	3.8 ± 1.2 (2-7)[a]	8.4 ± 7.3 (0-198)[a]	0.4 ± 0.2 (0-7)[a]
Epistylis sp.[†]	71.4[a]	33.3[b]	-	-	-	-
Piscinoodinium pillulare	11.1[a]	0[a]	1[a]	0[a]	0.1 ± 0.1 (0-1)[a]	0[a]
Cichlidogyrus halli	70.4[a]	94.4[b]	5.1 ± 1.2 (0.7-18.8)[a]	6.4 ± 1.6 (0.6-45.5)[a]	3.6 ± 0.9 (0-18.8)[a]	6.1 ± 1.5 (0-45.5)[a]
Cichlidogyrus thurstonae	90.5[a]	86.1[a]	3.7 ± 0.8 (0.3-12.2)[a]	4.1 ± 1 (0.3-24.5)[a]	2.6 ± 0.7 (0-12.2)[a]	3.5 ± 0.9 (0-24.5)[a]
Cichlidogyrus sp. 1	18.5[a]	22.2[a]	0.4 ± 0.2 (0.03-1)[a]	0.2 ± 0.1 (0.01-0.9)[a]	0.1 ± 0.04 (0-1)[a]	0.04 ± 0.03 (0-0.9)[a]
Scutogyrus longicornis	59.3[a]	75[a]	1.7 ± 0.4 (0.02-6)[a]	1.2 ± 1.6 (0.05-8.2)[a]	1 ± 0.3 (0-6)[a]	0.9 ± 0.3 (0-8.2)[a]
Gyrodactylus sp.	48.2[a]	30.6[a]	36.3 ± 29.4 (2-388)[a]	5.4 ± 1.6 (1-18)[a]	17.5 ± 14.3 (0-388)[a]	1.6 ± 0.6 (0-18)[a]
Total	100[a]	100[a]	506.1 ± 322.4 (0-8166)[a]	94. 2 ± 30.1 (2-943)[a]	506.1 ± 322.4 (0-8166)[a]	94.2 ± 30.1 (2-943)[a]

*Values presented as mean ± standard error (range). [ɣ]DS: dry season (April to September) - n = 36; [ʒ]RS: Rainy season (October to March) - n = 27. [†]The calculations of mean intensity of infection and mean abundance were not performed as this is a colonial protozoan. Prevalence, mean intensity of infection and mean abundance followed by the same letter in the row: no significant difference ($p > 0.05$).

Ranzani-Paiva et al. (2005) when studying *O. niloticus* from Guarapiranga Reservoir, São Paulo State, Brazil. In that study, Ranzani-Paiva et al. (2005) observed a low mean intensity of infection of *Cichlidogyrus* sp., with a higher prevalence in the Brazilian rainy season (i.e., October, November, and December). Likewise, Zica (2008) studied *O. niloticus* reared in fish cages in the Chavantes Reservoir, São Paulo State, Brazil, observed a high prevalence of monogenoids, especially during the rainy season; however, the intensity of infection and abundance were low in both of the evaluated periods (rainy and dry seasons).

According to Eiras (1994), the majority of monogenoid species had well-defined annual patterns of infection, with an increased number of parasites at higher temperatures (i.e., the rainy season) and a decrease at lower temperatures (i.e., the dry season).

The seasonality results observed in this study corroborate the findings of Jerônimo et al. (2011), who observed higher rates of infestation by protozoans in *O. niloticus* reared in three regions of Santa Catarina State, Brazil during lower-temperature months (i.e., the autumn and winter) and an increase in monogenoid parasitism rates in higher-temperature months (i.e., the spring and summer).

Trichodinid parasites have great significance in the commercial production of tilapia and occur in a wide quantity of fish-farming systems (GHIRALDELLI et al., 2006). In the present study, *Trichodina* spp. presented with the highest frequency of dominance and mean relative dominance, and the highest parasitism rates during all fish growth phases and periods of the year. Ghiraldelli et al. (2006) studied ectoparasites in *O. niloticus* reared in three regions of Santa Catarina State, Brazil and found similar results: trichodinids were the most numerous parasites and served as the dominant parasite group. Similarly, Ranzani-Paiva et al. (2005) observed that *Trichodina* spp. had the highest infection rates in *O. niloticus* from the Guarapiranga Reservoir, São Paulo State, Brazil.

Fish in the intermediate and final phases had higher parasitism rates than those in the initial phase. As reported by Zuben (1997), host body size is the factor most strongly correlated with the number of parasite species present. Larger hosts may offer more space to parasites and harbor more species. Consequently, a greater variety of niches is available for occupation, allowing the simultaneous occurrence of more parasite species (POULIN, 1995). In addition, major hosts release large amounts of nitrogen compounds, which accumulate in the fish cages and may increase the parasitism rates of some parasite species, such as *Trichodina* spp. Studies comparing parasitism rates across growth phases in *O. niloticus* are scarce, and they usually investigate the occurrence of parasitism in only one fish growth phase; an especially common choice is the fingerling phase.

The only report in the literature that compares fish growth phases was performed by Vargas et al. (2000), who studied *O. niloticus* reared in ponds from the municipality of Umuarama, Paraná State, Brazil. Those authors compared parasitism rates in the fingerling and reproductive phases. The total prevalence of ectoparasites in fingerlings was 87%, with a higher occurrence of *Trichodina* sp. than monogenoids (36% and 15%, respectively). A total prevalence of 31% was observed in the reproductive phase, with a higher incidence of monogenoids than *Trichodina* sp. (14% and 12%, respectively).

In the present study, no correlations of K or parasite abundance were observed with respect to either fish growth phase or seasonality. This result suggests that, although the fish were more parasitized in the intermediate and final phases and the dry season, these parasitism rates were not enough to affect the physiological state, health, or welfare of the fish. Furthermore, the adequate aspects of handling used in the fish farm studied, such as the reduced fish stocking densities (80 kg/m^3) and the adequate water quality of the Água Vermelha reservoir, could have contributed to the observed result.

This study reports on the main parasites that affect the cultivation of *O. niloticus*, and the data obtained indicate that seasonality and fish growth phase can influence the occurrence of these organisms. Moreover, the presented data may be of great importance to fish farmers to help them to understand the parasite dynamics of the studied fish species in cage farming systems.

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