# Seasonal variation on the ectoparasitic communities of Nile tilapia cultured in three regions in southern Brazil

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## Abstract

A total of 240 Nile tilapia were examined between April 2007 and March 2008, gathered from three different fish farms, 20 fish in each fish farm, in the four seasons of the year. Fish ponds were located in Joinville, Blumenau and Ituporanga, Santa Catarina state, Brazil and each pond had a different culture system. Prevalence, mean intensity, mean abundance and mean relative dominance were compared among fish ponds and seasons. During this period, the water quality was kept in normal values. *Piscinoodinium pillulare* (Dinoflagellida) was the most dominant parasite followed by *Trichodina magna* e *T. compacta* (Ciliophora), *Cichlydogyrus sclerosus*, *C halli*, *C. thurstonae*, *Scutogyrus longicornis* (Monogenoidea), copepodids Lernaeidae gen. sp. The highest prevalence, mean intensity and mean abundance of ectoparasites were found on the body surface in fish from Joinville followed by Blumenau and Ituporanga. In the gills, the highest mean intensity and mean abundance were found in fish from Blumenau and Ituporanga in the winter. *Piscinoodinium pillulare* showed prevalence 100% during autumn in Blumenau and Ituporanga. In winter *P. pillulare* occurred in all study facilities. Fish from Joinville showed 100% prevalence of Monogenoidea during all seasons, as well as the highest mean intensity and abundance. The results showed that the majority of examined fish had higher infestations by protozoan during autumn and winter and higher infestations by metazoan have occurred in spring and summer.

*Keywords: Oreochromis niloticus*, ectoparasites, seasonality, Brazil.

## Variação sazonal na comunidade de ectoparasitos de tilápia do Nilo cultivada em três regiões no sul do Brasil

## Resumo

Um total de 240 tilápias-do-nilo foi examinado entre abril de 2007 e março de 2008, a partir de três diferentes localidades em quatro estações, 20 de cada piscicultura. As pisciculturas estavam localizadas em Joinville, Blumenau e Ituporanga, Estado de Santa Catarina, Brasil. Taxa de prevalência, intensidade média, abundância média e dominância média relativa foram comparadas entre as pisciculturas e entre as estações. Durante esse período, a qualidade da água se manteve em valores normais para tilápia. *Piscinoodinium pillulare* (Dinoflagellida) foi o mais dominante seguido por *Trichodina magna* e *Trichodina compacta* (Ciliophora), *Cichlydogyrus sclerosus*, *Cichlydogyrus halli*, *Cichlydogyrus thurstonae*, *Scutogyrus longicornis* (Monogenoidea), copepoditos Lernaeidae gen. sp. Os maiores valores de taxa de prevalência, intensidade média e abundância média de ectoparasitos foram encontrados na superfície do corpo de peixes de Joinville, seguidos pelos de Blumenau e Ituporanga. Nas brânquias, as maiores intensidades e abundâncias médias foram encontradas em peixes de Blumenau e Ituporanga examinados no inverno. *Piscinoodinium pillulare* apresentou prevalência de 100% no outono em Blumenau e Ituporanga. No inverno, a prevalência de *P. pillulare* ocorreu também em todas as pisciculturas. Peixes de Joinville apresentaram prevalência de 100% de Monogenoidea em todas as estações, assim como as maiores intensidades e abundâncias médias. Os resultados mostraram que a maioria dos peixes examinados apresentaram maiores infestações por protozoários no outono e inverno, e metazoários na primavera e no verão.

*Palavras-chave: Oreochromis niloticus*, ectoparasitos, sazonalidade, Brasil.

## 1. Introduction

Ectoparasites are among the major etiological agents in Brazil and their presence is directly related to water quality and pond management (Moraes and Martins, 2004).

Parasitism occurs as a result of an interaction between host, parasite and environment (Buchmann and Lindestrøm, 2002). Some factors or substances are responsible for lowering the host immune response resulting in unbalanced host/parasite/environment interaction, factors such as water temperature, stress level (Xu et al., 2007), nutritional quality (Cavichiolo et al., 2002), age and natural immunity (Buchmann and Lindestrøm, 2002).

Trichodinids pathogenicity was confirmed by Madsen et al. (2000) and the level of parasitism was related with parasite number and water quality by Afifi et al. (2000). Experimental infestations with *Trichodina jadranica* Raabe, 1958 (Ciliophora) caused mortality in eels (Mellergaard and Dalsgaard, 1987). On the other hand, mixed infestation by *T. murmanica* Polyanski, 1955 and *Gyrodactylus pleuronecti* Cone, 1981 was observed in winter flounder (*Pseudopleuronectes americanus*) by Barker et al. (2002).

Studying the seasonal dynamics of carp infestation by *T. nobilis* Chen, 1963 in Yugoslavia, Nikolic and Simonovic (1998) observed higher infestation percentages in autumn and spring. On the other hand, Özer (2003) observed higher mean intensities of round goby (*Neogobius melanostomus*) infestations by *T. domerguei* Wallengren 1897 during spring and summer in Sirakirkagadar River, Sinop coast. In Brazil, Ranzani-Paiva et al. (2005) related high infestations of tilapia (*Oreochromis niloticus*) to the lowest temperature and water quality in Guarapiranga reservoir, São Paulo. Consequently, Schalch and Moraes (2005), observed a constant presence of this parasite during summer, autumn and winter, not exceeding 50% prevalence in fee fishing ponds.

High infestations by Monogenoidea were related to high ammonia levels in the water (Skinner, 1982) and high prevalence rates were related to water temperature in fish from India (Singhal et al., 1986) and from Finland lakes (Halmetoja et al., 1992). Koskivaara et al. (1991) observed higher mean intensity of *Gyrodactylus* von Nordmann, 1832 infestation on fish from eutrophic and polluted lakes. In intensive cultures, high fish density, low water flow and high organic matter concentration favors the growth and reproduction of parasites (Moraes and Martins, 2004).

In Mexico, Flores-Crespo et al. (1992), studying the seasonal variation of tilapia parasitised by *Dactylogyrus* Diesing, 1850, observed lower infestation intensity during autumn and winter and related the parasite presence to water temperature increase. In turn, Rawson and Rogers (1973) observed high infestation levels by *Gyrodactylus macrochiri* Hoffman and Putz, 1964 on *Lepomis macrochirus* and *Micropterus salmoides* during winter in Walter F. George Reservoir, Georgia.

In southern Brazil, the first fish parasitological study was performed by Azevedo et al. (2006) in tilapia from Nova Trento, Santa Catarina state, whom related higher ectoparasite infestation intensity with low water quality. Ghiraldelli et al. (2006), studying the parasitic fauna of tilapia cultured in three different production systems, demonstrated that the most abundant ectoparasites were *T. magna* Van As and Basson, 1989, *T. compacta* Van As and Basson, 1989 and *Cichlydogyrus sclerosus* Price and Kirk, 1967.

The hypothesis of this study was to verify whether parasitological indexes in Nile tilapia may vary according to the season of the year in different production systems in the state of Santa Catarina, Southern Brazil.

## 2. Material and Methods

A total of 240 fish were collected during the four seasons of the year, between April 2007 and March 2008, 20 animals from each fish farm in each season. The fish farms were located in three different cities, Joinville (26° 24' 52'' S and 48° 50' 44'' W), Blumenau (26° 55' 10'' S and 49° 03' 58'' W) and Ituporanga (27° 24' 52'' S and 49° 36' 09'' W), all of them in the state of Santa Catarina, Southern Brazil.

Every time the fishes were collected, water parameters such as pH, temperature, oxygen and transparency were availed and a 500 mL water sample was frozen for further ammonia analysis, according to Grasshoff (1976). After biometry, the fish were sacrificed (Ethics Commission n° 23080055748/2006-04/CEUA/UFSC) for parasitological analysis according to Ghiraldelli et al. (2006) methodology. The collection and parasites fixation followed Kritsky et al. (1995) and Eiras et al. (2006) methods.

The quantification of protozoan was done by sampling five aliquot of 0.3 mL from a tissue (skin or gills) homogenate, counting the number of protozoan on the aliquot using a McMaster chamber and estimating the number of possible protozoan by the total homogenate volume. Monogenoidea and crustacean were counted under a stereomicroscope using marked Petri dish (Ghiraldelli et al., 2006). In tables, the species identified are referred as Monogenoidea. Trichodinids were identified according to Lom (1958), Van As and Basson (1989) and Ghiraldelli et al. (2006), Monogenoidea were identified according to Paperna and Thurston (1969), Ergens (1981), Douëllou (1993) and Pariselle and Euzet (1995).

Prevalence, mean intensity and abundance data were obtained according to Bush et al. (1997) and the mean relative dominance according to Rohde et al. (1995). The results were submitted to ANOVA and, upon significance, to Tukey test for comparison among arithmetic means. Significance level adopted was of 5% (Zar, 1999). The data were compared between seasons for each fish farm and between farms for each season.

## 3. Results

Table 1 shows that Joinville was characterised by its traditional method of fish culture with stocking density of 0.75 fish/m$^2$, using 10% daily water renewal, sometimes using aeration and fish fed once a day. On the other hand,

Blumenau was a fee fishing facility in which the introduction of fish from other fish farms once a week was a common practice, fish stocking density 2.0 fish/m$^2$, and fish fed once a day. Due to the fact that the fish stocking density in Blumenau was frequently uncontrolled, they used aeration three times a day. Consequently, Ituporanga practiced the consorted system between fish and pig manure, fish fed only at the finish of cycle and kept 3.5 to 4.0 fish/m$^2$ without water renewal. Only Joinville and Ituporanga assessed the water quality regularly. Water pH was stable in all fish ponds during the whole study period. In Joinville, dissolved oxygen was higher in autumn, while the lowest dissolved oxygen levels were found during summer and winter, respectively in Blumenau and Ituporanga. The highest water temperatures were observed in Blumenau (Table 2). Table 3 shows the biometrical data from the availed fish for each season.

Parasitological analysis revealed the presence of *T. magna*, *T. compacta* (Protozoa: Ciliophora) on the skin mucus; *Piscinoodinium pillulare* (Schäperclaus, 1954) Lom, 1981 (Protozoa: Dinoflagellida), *Cichlidogyrus sclerosus*, *C. halli* Price and Kirk, 1967, *C. thurstonae* Ergens, 1981 and *Scutogyrus longicornis* Paperna and Thurston, 1969 (Monogenoidea: Dactylogyridae), as well as Lernaeidae gen. sp. Cobbold, 1879 (Crustacea: Copepoda) on the gills of the examined tilapia.

There was a higher prevalence rate, mean intensity and mean abundance ($p < 0.05$) of ectoparasites in the

**Table 1.** Handling management in the studied facilities in southern Brazil.

| Characteristics | Localities | | |
|---|---|---|---|
| | Joinville | Blumenau | Ituporanga |
| Culture system | Fry and juvenile production | Fee fishing | Consorted with pig |
| Total pond size (ha) | 2.35 | 0.8 | 8.0 |
| Fish stocking density/m$^2$ | 0.75 | 2.0 | 3.5-4.0 |
| Feeding | 1 time a day | 1 time a day | 2 times a day at the end of growth cycle |
| Ration | Extruded comercial diet 28% crude protein | Extruded comercial diet 32% crude protein | Extruded comercial diet 32% crude protein |
| Aeration use | In emergency cases | 3 times a day | No |
| Fish entrance | No | Yes | No |
| Water renewal | 10% a day | Little | No renewal |
| Water quality monitoring | Yes | No | Yes |

**Table 2.** Water quality of ponds measured at the sampling day in each season in the state of Santa Catarina, southern Brazil.

| Parameters | Autumn | Winter | Spring | Summer |
|---|---|---|---|---|
| | | Joinville | | |
| Dissolved oxygen (mg/L) | 8.94 | 6.2 | 5.33 | 5.86 |
| Transparency | 38 | 77 | 31 | 48 |
| pH | 7.7 | 7.5 | 6.5 | 6 |
| Ammonia (mg/L) | 0.5 | 0.3 | 0.5 | 0.15 |
| Temperature (°C) | 20.3 | 18.1 | 22.5 | 22.9 |
| | | Blumenau | | |
| Dissolved oxygen (mg/L) | 5.77 | 4.1 | 4.46 | 4.44 |
| Transparency | 11 | 15 | 15 | 8 |
| pH | 7.02 | 7.2 | 7.4 | 7.32 |
| Ammonia (mg/L) | 0.26 | 0.19 | 0.68 | 1.9 |
| Temperature (°C) | 16.8 | 19 | 24.8 | 26.5 |
| | | Ituporanga | | |
| Dissolved oxygen (mg/L) | 7.95 | 2.34 | 6.12 | 2.75 |
| Transparency | 15 | 22 | 10 | 10 |
| pH | 7.07 | 7.01 | 7.22 | 6.85 |
| Ammonia (mg/L) | 0.39 | 1.2 | 0.89 | 0.79 |
| Temperatur3 (°C) | 15.8 | 23.4 | 23.7 | 22.4 |

**Table 3.** Mean values of prevalence (P), mean intensity (MI), range of mean intensity (AV) and mean abundance (MA) of parasites on the body surface of Nile tilapia in each season and facilities from the state of Santa Catarina, southern Brazil. Capital letters indicate significant difference among facilities in each season and lowercase letters indicate the difference at the same facility ($p < 0.05$).

| | Monogenoidea | | | | | Trichodinids | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Joinville | | | | | | | | | |
| | PF/PE | P (%) | MI | AV | AM | PF/EF | P (%) | MI | AV | MA |
| **Autumn** | 5/20 | 25 | 2 Aab | (2-2) | 0.5 Aab | 19/20 | 95 | 350.5 Aab | (162-672) | 333.0 Aab |
| **Winter** | 0/20 | 0 | 0 Ab | (0-0) | 0 Ab | 16/20 | 80 | 72.3 Ab | (2-616) | 57.8 Ab |
| **Spring** | 2/20 | 10 | 2 Aab | (2-2) | 0.2 Aab | 11/20 | 55 | 540.9 Aa | (2-189) | 357.5 Aba |
| **Summer** | 6/20 | 30 | 2.7 Aa | (2-4) | 0.8 Aa | 17/20 | 85 | 174.9 Ab | (88-364) | 148.7 Ab |
| | Blumenau | | | | | | | | | |
| | PF/PE | P (%) | MI | AV | AM | PF/EF | P (%) | MI | AV | MA |
| **Autumn** | 0/20 | 0 | 0 Bb | (0-0) | 0 Ba | 8/20 | 40 | 3.8 Bb | (2-10) | 1.5 Bb |
| **Winter** | 2/20 | 10 | 2 Aa | (2-2) | 0.2 Aa | 17/20 | 85 | 37.2 Bb | (2-112) | 31.7 Ab |
| **Spring** | 0/20 | 0 | 0 Bb | (0-0) | 0 Aa | 17/20 | 85 | 168.0 Aa | (6-502) | 142.8 ABa |
| **Summer** | 3/20 | 15 | 2.7 Aa | (2-4) | 0.4 Aba | 17/20 | 85 | 99.6 Bab | (2-338) | 84.7 Bab |
| | Ituporanga | | | | | | | | | |
| | PF/PE | P (%) | MI | AV | AM | PF/EF | P (%) | MI | AV | MA |
| **Autumn** | 0/20 | 0 | 0 Ba | (0-0) | 0 Ba | 12/20 | 60 | 8.5 Bc | (2-26) | 5.1 Ba |
| **Winter** | 0/20 | 0 | 0 Ba | (0-0) | 0 Aa | 9/20 | 45 | 47.5 Bbc | (2-137) | 21.4 Aa |
| **Spring** | 0/20 | 0 | 0 Ba | (0-0) | 0 Aa | 2/20 | 10 | 147.0 Aa | (147-147) | 14.7 Ba |
| **Summer** | 0/20 | 0 | 0 Ba | (0-0) | 0 Ba | 0/20 | 0 | 0 Cc | 0 | 0 Ca |

skin mucus of fish from Joinville's fish pond. Trichodinids were the most representative parasites in the skin mucus (Table 3).

The highest mean intensities and abundance ($p < 0.05$) for *Trichodina* parasiting gills were found in fish collected in Blumenau and Ituporanga during winter (Table 3).

A prevalence rate of 100% was observed for *P. pillulare* (Table 4) in Blumenau and Ituporanga during autumn. Infestation levels for this parasite were high during winter in all farms.

Regarding infestation by Monogenoidea on the gills, fish from Joinville presented prevalence of 100% during all seasons, as well as higher mean intensity and abundance values when compared to Blumenau and Ituporanga ($p < 0.05$). In Joinville, there was a significant increase on Monogenoidea parasitism during winter and spring. Contrarily, in Blumenau, there was no significant difference ($p < 0.05$) between seasons, whereas Ituporanga presented higher values during winter ($p < 0.05$) (Table 5).

The ectoparasites mean relative dominance values found in this study (Table 4) revealed *Trichodina* as the most dominant genus in fish skin mucus during all seasons, except for Ituporanga during summer. On the other hand, in fish gills, the most dominant parasite was *P. pillulare* during all seasons in Blumenau, during autumn and spring in Ituporanga and during winter in Joinville. Comparatively, *Trichodina* had an intermediate position between Monogenoidea and *P. pillulare* in fish gills.

## 4. Discussion

The water quality was maintained within the acceptable values for tilapia, fish that supports broad variation in water quality (Boyd, 1979; Zaniboni Filho, 2004). The higher dissolved oxygen and water transparency values observed in Joinville were related to a high pond water renewal, a fact that distinguished it from the other fish ponds. In Ituporanga, oxygen levels were low during winter and summer, due to water stratification, and despite the pig manure deposition, ammonia levels were tolerable, as also observed by Azevedo et al. (2006).

Water transparency in Blumenau and Ituporanga was lower due to aspects of pond management, especially lack of fish entrance control and pig manure deposition, respectively. Temperature levels were below those recommended for tilapia culture, whose thermal comfort is between 27 and 32 °C (Kubitza, 2000). As related by Ghiraldelli et al. (2006), water quality assessment must be emphasised throughout the fish culture. The variation in water quality parameters could present severe consequences on fish health in high temperature climate (Tavares-Dias et al., 2008).

With the increase of intensive tilapia culture in Brazil, trichodinids started to play an important role in the list of potential fish pathogens. (Moraes and Martins, 2004; Martins and Ghiraldelli, 2008). Studying eels (*Anguilla anguilla*) in a recirculation system, Madsen et al. (2000) classified infestation by *T. jadranica* in four categories:

**Table 4.** Mean relative dominance of ectoparasites in the gills and body surface of Nile tilapia in each facility in the state of Santa Catarina, southern Brazil.

| | Gills | | | | Body surface | |
|---|---|---|---|---|---|---|
| | Joinville | | | | | |
| | **Monogenoidea** | **Trichodinids** | ***P. pillulare*** | **Copepodids** | **Monogenoidea** | **Trichodinids** |
| **Autumn** | 0.07051 | 0.77780 | 0.15159 | 0.00010 | 0.0015 | 0.9985 |
| **Winter** | 0.02306 | 0 | 0.97694 | 0 | 0 | 1 |
| **Spring** | 0.50664 | 0.38770 | 0.10566 | 0 | 0.0002 | 0.9998 |
| **Summer** | 0.15267 | 0.21830 | 0.62903 | - | 0.0060 | 0.9940 |
| | **Blumenau** | | | | | |
| | **Monogenoidea** | **Trichodinids** | ***P. pillulare*** | **Copepodids** | **Monogenoidea** | **Trichodinids** |
| **Autumn** | 0.00001 | 0.00108 | 0.99889 | 0.00002 | 0 | 1 |
| **Winter** | 0.00005 | 0.04272 | 0.95723 | 0 | 0.0063 | 0.9937 |
| **Spring** | 0.00005 | 0.07330 | 0.92660 | 0 | 0 | 1 |
| **Summer** | 0.00037 | 0.07225 | 0.92738 | 0 | 0.0047 | 0.9953 |
| | **Ituporanga** | | | | | |
| | **Monogenoidea** | **Trichodinids** | ***P. pillulare*** | **Copepodids** | **Monogenoidea** | **Trichodinids** |
| **Autumn** | 0.00001 | 0.00021 | 0.99978 | 0 | 0 | 1 |
| **Winter** | 0 | 0.56376 | 0.43624 | 0 | 0 | 1 |
| **Spring** | 0.00024 | 0.19138 | 0.80838 | 0 | 0 | 1 |
| **Summer** | 0.00146 | 0.31507 | 0.68347 | 0 | 0 | 0 |

0 (no parasites), 1 (from 1 to 10 parasites), 2 (from 11 to 100), 3 (from 100 to 1000).

In the present study the highest mean intensities for trichodinids were found on the skin mucus of fish from Joinville, during autumn and spring, corresponding to category 3 of Madsen et al. (2000). Trichodinids were present in all seasons, but higher infestation levels were seen in spring.

On the gills, trichodinids parasitism was also classified as category 3 during autumn in Joinville, winter in Blumenau, spring and summer in Ituporanga. This study confirms that the high eutrophication caused by the deposition of pig manure in Ituporanga was responsible for keeping high levels of trichodinids, which agrees with the findings of Afifi et al. (2000).

Regarding seasonality, this study corroborates Nikolic and Simonovic (1998) and Özer (2003), who found higher infestation intensities by *T. nobilis* and *T. domerguei* during spring and autumn, and during spring and summer, respectively. Özer (2000) also found high mean intensity of *T. mutabilis* Kazubski and Migala, 1968 during spring. Comparatively, fish in this particular study presented higher infestation intensities than those studied by Özer (2000). Özer and Erdem (1999) verified that trichodinids occurred during all seasons, but with higher infestation levels during spring, which was also verified in the present study.

Prevalence of trichodinids found in this study were higher than those found in tilapia from Guarapiranga reservoir studied by Ranzani-Paiva et al. (2005) and than those found in the same farms by Ghiraldelli et al. (2006) in study carried between October 2004 and June 2005. Furthermore, in the study performed by Ghiraldelli et al. (2006), fish presented lower mean intensities of parasitism. In this study, neither mortality nor clinical signs of disease were observed, probably due to lower temperatures when compared to Southeast Brazil (Tavares-Dias et al., 2001a, 2008).

Massive infestations by the dinoflagellate *P. pillulare* most of the time culminates in high mortality rates in cultured fish (Martins et al., 2001) and its dissemination is related to water quality (Shaharom-Harrison et al., 1990; Moraes and Martins, 2004). Prevalence of *P. pillulare* in tilapia was higher in the present study than those observed by Tavares-Dias et al. (2001a, 2008) in pacu (*Piaractus mesopotamicus*), piauçu (*Leporinus macrocephalus*), matrinxã (*Brycon amazonicus*) and in the hybrid tambacu (*P. mesopotamicus* x *Colossoma macropomum*). Contrary to that related in this study, Tavares-Dias et al. (2001a) did not verify seasonality on the occurrence of *P. pillulare*, when the parasite number was lower in winter.

Great infestation values by *P. pillulare* on gills of tambacu can cause excessive skin mucus production, loss of epithelium, paleness and lamellar hyperplasia on gills, petechiae and congestion, resulting on the death of 4,000 fish in the first 24 hours and 3,000 more in the next 15 days (Martins et al., 2001). With its fixation structures, named rhizocysts, *P. pillulare* causes severe damage to gill tissue in high infestations (Lom and Schubert, 1983). Hundred percent mortalities were also observed in cultured

**Table 5.** Prevalence (%) (P), mean intensity (MI) and mean abundance (MA) of Monogenoidea, *Piscinoodinium pillulare* and trichodinids in the gills of Nile tilapia from the different localities in the state of Santa Catarina, Brazil. Different uppercase letters indicate significant difference between the localities in each season and lowercase letters difference between seasons in the same localities ($p < 0.05$).

| | **Monogenoidea** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Autumn** | | | **Winter** | | | **Spring** | | | **Summer** | | |
| | **P** | **MI** | **MA** | **P** | **MI** | **MA** | **P** | **MI** | **MA** | **P** | **MI** | **MA** |
| **Joinville** | 100 | 36.9 Ab (3-81) | 36.9 Ab | 100 | 216.2 Aa (41-443) | 216.2 Aa | 100 | 179.1 Aa (34-542) | 179.1 Aa | 100 | 90.8 Ab (14-205) | 90.8 Aab |
| **Blumenau** | 15 | 1.3 Ba (1-2) | 0.2 Ab | 5 | 1.0 Ba (1-1) | 0.1 Ba | 20 | 1.5 Ba (1-2) | 0.3 Ba | 30 | 1.5 Ba (1-4) | 0.5 Ba |
| **Ituporanga** | 20 | 1.6 Ba (1-2) | 0.4 Bb | 0 | 0 Cb (0) | 0 Cb | 10 | 2.5 Ba (1-4) | 0.3 Bb | 55 | 3.8 Ba (1-10) | 2.1 Ba |
| | ***Piscinoodinium pillulare*** | | | | | | | | | | | |
| | **Autumn** | | | **Winter** | | | **Spring** | | | **Summer** | | |
| | **P** | **MI** | **MA** | **P** | **MI** | **MA** | **P** | **MI** | **MA** | **P** | **MI** | **MA** |
| **Joinville** | 35 | 226.4 Bc (94-540) | 79.3 Bb | 95 | 9,640.4 ABa (1,680-13,920) | 9,158.4 ABa | 5 | 747 Bb (747-747) | 37.4 Bb | 45 | 830.9 Ab (160-2,027) | 373.9 Ab |
| **Blumenau** | 100 | 33,133.5 Aa (21,547-42,120) | 33,133.5 Aa | 90 | 17,270.6 Ab (347-75,534) | 15,543.5 Ab | 80 | 3,057.3 Ac (214-13,940) | 2,445.8 Ac | 60 | 1,909.3 Ac (100-4,860) | 1,145.6 Ac |
| **Ituporanga** | 100 | 30,918 Aa (22,867-57,200) | 30,918 Aa | 100 | 460.1 Bb (71-1,208) | 460.1 Bb | 70 | 1,195.7 ABb (67-4,080) | 836.6 ABb | 60 | 1,642.7 Ab (130-5,610) | 985.6 Ab |
| | **Trichodinids** | | | | | | | | | | | |
| | **Autumn** | | | **Winter** | | | **Spring** | | | **Summer** | | |
| | **P** | **MI** | **MA** | **P** | **MI** | **MA** | **P** | **MI** | **MA** | **P** | **MI** | **MA** |
| **Joinville** | 90 | 451.8 Aa (90-1,040) | 406.6 Aa | 0 | 0 Bc (0) | 0 Cc | 65 | 210.9 Ab (69-774) | 137.1 Bb | 45 | 288.3 Ab (54-769) | 129.8 Bb |
| **Blumenau** | 20 | 180 Bb (120-240) | 36 Bc | 70 | 901.1 Aa (67-3,468) | 693.8 Aa | 65 | 297.6 Ab (107-499) | 193.5 Ab | 45 | 198.3 Ab (1-1,003) | 89.3 Bc |
| **Ituporanga** | 10 | 64 Bb (56-72) | 6,4 Bc | 90 | 660.1 Aa (89-1,093) | 594.6 Ab | 45 | 440.1 Aa (2-1,334) | 198.1 Ab | 75 | 605.8 Aa (130-1,700) | 454.4 Aa |

*Puntius gonionotus* from Malaysia and were related to high ammonia levels in water by Shaharom-Harrison et al. (1990).

In this study, the highest values of *P. pillulare* infestation on tilapia gills during winter in Joinville, autumn and winter in Blumenau and autumn in Ituporanga were probably related to low water temperature, which is in agreement with the data presented by Martins et al. (2001). These authors registered mortalities in Brazilian fish cultured during winter in southeast Brazil. Dinoflagellate was the most dominant parasite in all three fish farms, with higher mean abundance during autumn and winter, probably due to lower fish resistance in low temperatures. Also, it is worth mentioning that management characteristics do not seem to exert an influence on the infestation levels.

Monogenoidea, parasites with high host specificity, play an important role in intensive fish pond culture of both ornamental and food fish in Brazil (Garcia et al., 2003; Moraes and Martins, 2004; Lizama et al., 2007). *Cichlidogyrus sclerosus* was considered a chemical pollution biomarker for tilapia (Sanchez-Ramirez et al., 2007).

The highest prevalence rates, mean intensities and mean abundance for Monogenoidea, for all study seasons, were observed on fish gills from Joinville. Water quality can influence on Monogenoidea parasitism, as reported by Flores-Crespo et al. (1992), who verified higher intensity of dactylogyrids in tilapia at higher temperatures. Similar results were verified by Cecchini et al. (1998) studying the life cycle of *Diplectanum aequans* Wagener, 1857. Contrarily, Koskivaara et al. (1991) reported that gyrodactylids on *Rutilus rutilus* were more abundant during autumn in Finland. Mortality on carp fry parasitised by *Dactylogyrus vastator* Nybelin, 1924 exposed to low water oxygen concentrations was observed by Molnár (1994). Garcia et al. (2003) reported that parasitism by *Urocleidoides* Mizelle and Price, 1969 was negatively influenced by pH, temperature and electric conductivity of water.

In the present study, though, it was not possible to associate the presence of Monogenoidea, neither on the gills nor on the skin mucus, with water quality. Something worth reporting is the significantly higher mean parasitism intensities on fish gills from Joinville. These values were higher than those reported by Tavares-Dias et al. (2001b) in tilapia from fee-fishing ponds; by Ghiraldelli et al. (2006) in tilapia from the same farms assessed in this study; and by Ranzani-Paiva et al. (2005) in tilapia from Guarapiranga reservoir, southeast Brazil. Lizama et al. (2007), registered occurrence of Monogenoidea during all studied period in a fish pond from Assis city, such as observed in this study. The farm from Joinville monitored water quality regularly in its ponds and kept a high water renewal rate, which contributed to the higher water transparency observed. The only water parameter that distinguished Blumenau from Ituporanga was also water transparency.

These results show that most of the analysed fish had greater infestations by protozoan during autumn and winter and by metazoan during spring and summer seasons. The use of trichodinids infestation as a good water quality biomarker for fish pond cultures can be suggested, since they are directly associated with high organic matter concentration. Contrarily to what was observed in southeastern Brazil, dinoflagellates were not influenced by management characteristics. The highest mean intensities of Monogenoidea in fish from Joinville could not be easily explained since this farm usually controlled the pond water quality in comparison to Blumenau and Ituporanga. But, it must be commented that Joinville's fish pond was rarely dried. This fact could be associated to high stocking density and Monogenoidea proliferation.

It was evident that the parasitological assessment was influenced by seasonality, even though values of water quality analysis were among recommendations for tilapia culture. Contrary to other Brazilian regions, in southern Brazil, the seasons of the year are well defined, fact that have supported these results. Knowledge of seasonal influence over ectoparasite communities is an important tool for applying adequate prophylactic measures. Despite their importance, preventive programmes for fish disease control have not been established yet in Santa Catarina.

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## References

AFIFI, SH., THOBIATI, AL. and HAZAA, MS., 2000. Parasitic lesions in Nile tilapia *Oreochromis niloticus* from fish farms in Saudi Arabia. *Assiut Veterinary Medical Journal*, vol. 42, p. 183-194.

AZEVEDO, TMP., MARTINS, ML., BOZZO, FR. and MORAES, F.R., 2006. Haematological and gill responses in parasitized tilapia from Valley of Tijucas River, SC, Brazil. *Scientia Agricola*, vol. 63, no. 2, p. 115-120.

BARKER, DE., CONE, DK. and BURT, MDB., 2002. *Trichodina murmanica* (Ciliophora) and *Gyrodactylus pleuronecti* (Monogenea) parasitizing hatchery-reared winter flounder, *Pseudopleuronectes americanus* (Walbaum): effects on host growth and assessment of parasite interaction. *Journal of Fish Diseases*, vol. 25, no. 2, p. 81-89. doi:10.1046/j.1365-2761.2002.00341.x

BUCHMANN, K. and LINDESTROM, T., 2002. Interactions between monogenean parasites and their fish hosts. *International Journal for Parasitology*, vol. 32, no. 3, p. 309-319. doi:10.1016/S0020-7519(01)00332-0

BUSH, AO., LAFFERTY, KD., LOTZ, JM. and SHOSTAK, W., 1997. Parasitology meets ecology on its own terms. Margolis et al. Revisited. *Journal of Parasitology*, vol. 83, no. 4, p. 575-583.

BOYD, C., 1979. *Water Quality in Warmwater Fish Ponds. Agricultural Experiment Station.* Alabama, USA: Opelika.

CAVICHIOLO, F., VARGAS, L., RIBEIRO, RP., MOREIRA, HLM. and LEONARDO, JM., 2002. Níveis de suplementação de vitamina C na ração sobre a ocorrência de ectoparasitas, sobrevivência e biomassa em alevinos de tilápia do Nilo (Oreochromis niloticus). *Acta Scientiarum Animal Sciences*, vol. 24, no. 4, p. 957-964.

CECCHINI, S., SAROGLIA, M., BERNI, P. and COGNETTI-VARRIALE, AM., 1998. Influence of temperature on the life cycle of *Diplectanum aequans* (Monogenea, Diplectanidae), parasitic on sea bass, *Dicentrarchus labrax* (L.). *Journal of Fish Diseases*, vol. 21, no. 1, p. 73-75. doi:10.1046/j.1365-2761.1998.00068.x

DOUËLLOU, L., 1993. Monogeneans of the genus *Cichlidogyrus* Paperna, 1960 (Dactylogyridae: Ancyrocephalinae) from cichlid fishes of Lake Kariba (Zimbabwe) with descriptions of five new species. *Systematic Parasitology*, vol. 25, no. 3, p. 159-186. doi:10.1007/BF00007007

EIRAS, JC., TAKEMOTO, RM. and PAVANELLI, GC., 2006. *Métodos de estudo e técnicas laboratoriais em parasitologia de peixes.* 2nd ed. Maringá: Eduem.

ERGENS, R., 1981. Nine species of the genus *Cichlidogyrus* Paperna, 1960 (Monogenea: Ancyrocephalinae) from Egyptian fishes. *Folia Parasitologica*, vol. 28, p. 205-214.

FLORES-CRESPO, J., VELARDE, FI., FLORES-CRESPO, R. and VAZQUEZ-PELAEZ, CG., 1992. Variacion estacional de *Dactylogyrus* sp. em dos unidades productoras de tilapia del Estado de Morelos. *Técnica Pecuaria en México*, vol. 30, no. 2, p. 109-118.

GARCIA, F., FUJIMOTO, RY., MARTINS, ML. and MORAES, FR., 2003. Parasitismo de *Xiphophorus* spp. por *Urecleidoides* sp. e sua relação com os parâmetros hídricos. *Boletim do Instituto de Pesca*, vol. 29, no. 2, p. 123-131.

GHIRALDELLI, L., MARTINS, ML., JERÔNIMO, GT., YAMASHITA, MM. and ADAMANTE, WB., 2006. Ectoparasites communities from *Oreochromis niloticus* cultivated in the State of Santa Catarina, Brazil. *Journal of Fisheries and Aquatic Sciences*, vol. 1, no. 2, p. 181-190. doi:10.3923/jfas.2006.181.190

GRASSHOFF, K., 1976. *Methods of seawater analysis.* Verlag Chemie. New York: Weinheim. p. 117-181.

HALMETOJA, A., VALTONEN, ET. and TASKINEN, J., 1992. Trichodinids (Protozoa) on fish from central finnish lakes of differing water quality. *Aqua Fenica*, vol. 22, p. 59-70.

KOSKIVAARA, M., VALTONEN, ET. and PROST, M., 1991. Seasonal occurrence of gyrodactylid monogeneans on the roach (*Rutilus rutilus*) and variations between four lakes of differing water quality in Finland. *Aqua Fennica*, vol. 21, no. 1, p. 47-54.

KRITSKY, DC., BOEGER, WA. and POPAZOGLO, F., 1995. Neotropical Monogenoidea. 22. Variation in *Scleroductus species* (Gyrodactylidea, Gyrodactylidae) from siluriform fishes of southeastern. *Brazilian Journal of Helminthology*, vol. 62, p. 53-65.

KUBTIZA, F., 2000. *Tilápia: tecnologia e planejamento na produção comercial.* Jundiaí: Ed. Acqua Supre Com. Suprim. Aqüicultura Ltda. 285 p.

LIZAMA, MLP., TAKEMOTO, RM., RANZANI-PAIVA, MJT., AYROZA, LMS. and PAVANELLI, GC., 2007. Relação parasito-hospedeiro em peixes de pisciculturas da região de Assis, Estado de São Paulo, Brasil. 1. *Oreochromis niloticus* (Linnaeus, 1757). *Acta Scientiarum Biological Sciences*, vol. 29, no. 2, p. 223-231.

LOM, J., 1958. A contribution to the systematics and morphology of endoparasitic trichodinids from amphibians, with a proposal of uniform specific characteristics. *Journal of Protozoology*, vol. 5, no. 4, p. 251-263.

LOM, J. and SCHUBERT, G., 1983. Ultrastructural study of *Piscinoodinium pillulare* (Schapercalus, 1954) Lom, 1981 with special emphasis to the fish host. *Journal of Fish Diseases*, vol. 6, no. 5, p. 411-428. doi:10.1111/j.1365-2761.1983.tb00096.x

MADSEN, HCK., BUCHMANN, K., and MELLERGAARD, S., 2000. Association between trichodiniasis in eel (*Anguilla anguilla*) and water quality in recirculation systems. *Aquaculture*, vol. 187, no. 3/4, p. 275-281.

MARTINS, ML., MORAES, JRE., ANDRADE, PM., SCHALCH, SHC. and MORAES, FR., 2001. *Piscinoodinium pillulare* (Schäperclaus 1954) Lom, 1981 (Dinoflagellida) infection in cultivated freshwater fish from Northeast region of São Paulo State, Brazil. Parasitological and pathological aspects. *Brazilian Journal of Biology*, vol. 61, no. 4, p. 639-644.

MARTINS, ML. and GHIRALDELLI, L., 2008. *Trichodina magna* Van As and Basson, 1989 (Ciliophora: Peritrichia) from cultured Nile tilapia in the State of Santa Catarina, Brazil. *Brazilian Journal of Biology*, vol. 68, no. 1, p. 169-172.

MELLERGAARD, S. and DALSGAARD, I., 1987. Disease problems in Danish eel farms. *Aquaculture*, vol. 67, no. 1/2, p. 139-146. doi:10.1016/0044-8486(87)90019-6

MOLNÁR, K., 1994. Effect of decreased water oxygen content on common carp fry with *Dactylogyrus vastator* (Monogenea) infection of varying severity. *Diseases of Aquatic Organisms*, vol. 20, p. 153-157. doi:10.3354/dao020153

MORAES, FR. and MARTINS, ML., 2004. *Predisposing conditions and principal diseases of intensive fish farming teleosts.* In CYRINO, JEP., URBINATTI, EC., FRACALOSSI, DM., CASTAGNOLLI, N. (Eds.). *Especial topics in intensive freshwater fish culture in the Tropics.* São Paulo: TecArt. p. 343-383.

NIKOLIC, VP. and SIMONOVIC, PD., 1998. Seasonal dynamics of carp infestation by *Trichodina nobilis* Chen 1963 (Peritricha, Ciliata) in two fish-ponds in Banat. *Tiscia*, vol. 31, p. 59-61.

ÖZER, A., 2000. The occurrence of three species of *Trichodina* (Ciliophora: Peritrichia) on *Cyprinus carpio* in relation to culture conditions, seasonality and host characteristics. *Acta Protozoologica*, vol. 39, no. 1, p. 61-66. doi:10.1080/002229399300209

-, 2003. *Trichodina domerguei* Wallengren, 1987 (Ciliophora: Peritrichia) infestations on the Round Goby, *Neogobius melanostomus* Pallas, 1811 in relation to seasonality and host factors. *Comparative Parasitology*, vol. 70, no. 2, p. 132-135. doi:10.1654/4073

ÖZER, A. and ERDEM, O., 1999. The relationship between occurrence of ectoparasites, temperature and culture conditions; a comparison of farmed and wild common carp (*Cyprinus carpio* L., 1758) in the Sinop region of northern Turkey. *Journal of Natural History*, vol. 33, no. 4, p. 483-491.

PAPERNA, I. and THURSTON, JP., 1969. Monogenetic trematodes collected from cichlid fish in Uganda; including the description of five new species of *Cichlidogyrus*. *Revue de Zoologie et de Botanique Africaines*, vol. 79, p. 1-2.

PARISELLE, A. and EUZET, L., 1995. Gill parasites of the genus *Cichlidogyrus* Paperna, 1960 (Monogenea, Ancyrocephalidae) from *Tilapia guineensis* (Bleeker, 1862), with descriptions of six new species. *Systematic Parasitology*, vol. 30, no. 3, p. 187-198. doi:10.1007/BF00010469

RANZANI-PAIVA, MJT., FELIZARDO, NN. and LUQUE, JL., 2005. Parasitological and hematological analysis of Nile tilapia *Oreochromis niloticus* Linnaeus, 1757 from Guarapiranga reservoir, São Paulo State, Brazil. *Acta Scientiarum Biological Sciences*, vol. 27, no. 3, p. 231-237.

RAWSON, MV. and ROGERS, WA., 1973. Seasonal abundance of *Gyrodactylus macrochiri* Hoffman and Putz, 1964 on bluegill e largemouth bass. *Journal of Wildlife Diseases*, vol. 9, no. 2, p. 174-177.

ROHDE, K., HAYWARD, C. and HEAP, M., 1995. Aspects of the ecology of metazoan ectoparasites of marine fishes. *International Journal for Parasitology*, vol. 25, no. 8, p. 945-970. doi:10.1016/0020-7519(95)00015-T

SANCHEZ-RAMIREZ, C., VIDAL-MARTINEZ, VM., AGUIRRE-MACEDO, ML., RODRIGUEZ-CAMUL, RP., GOLD-BOUCHOT, G. and SURES, B., 2007. *Cichlidogyrus sclerosus* (Monogenea: Ancyrocephalinae) and its host the Nile tilapia (*Oreochromis niloticus*), as bioindicators of chemical pollution. *Journal of Parasitology*, vol. 93, no. 5, p. 1097-1106. PMid:18163344. doi:10.1645/GE-1162R.1

SCHALCH, SHC. and MORAES, FR., 2005. Distribuição sazonal de parasitos branquiais em diferentes espécies de peixes em pesque-pague no município de Guariba-SP, Brasil. *Brazilian Journal of Veterinary Parasitology*, vol. 14, no. 4, p. 141-146.

SHAHAROM-HARRISON, FM., ANDERSON, IG., SITI, AZ., SHAZILI, NAM., ANG, KJ. and AZMI, TI., 1990. Epizootics of Malaysian cultured freshwater pond fishes by *Piscinoodinium pillulare* Schaperclaus 1954) Lom 1981. *Aquaculture*, vol. 86, no. 2/3, p. 127-138.

SINGHAL, RN., JEET, S. and DAVIES, RW., 1986. The relationships between changes in selected physico-chemical properties of water and the occurrence of fish parasites in Haryana, India. *Tropical Ecology*, vol. 27, no. 1, p. 1-9.

SKINNER, RH., 1982. The interrelation of water quality, gill parasites and gill pathology of some fishes from South Biscayne Bay, Florida. *Fisheries Bulletin*, vol. 80, no. 2, p. 269-280.

TAVARES-DIAS, M., MORAES, FR. and MARTINS, ML., 2008. Hematological assessment in four Brazilian teleost fish with parasitic infections, collected in feefishing from Franca, São Paulo, Brazil. *Boletim do Instituto de Pesca*, vol. 34, no. 2, p. 89-196.

-, 2001a. Fauna parasitária de peixes oriundos de "pesque-pague" do município de Franca, São Paulo, Brasil. I. Protozoários. *Revista Brasileira de Zoologia*, vol. 18, no. 1, p. 67-79.

TAVARES-DIAS, M., MORAES, FR., MARTINS, ML. and KRONKA, SN., 2001b. Fauna parasitária de peixes oriundos de "pesque-pague" do município de Franca, São Paulo, Brasil. II. Metazoários. *Revista Brasileira de Zoologia*, vol. 18, no. 1, p. 81-95.

VAN AS, JG. And BASSON, L., 1989. A further contribution to the taxonomy of the Trichodinidae (Ciliophora: Peritrichia) and a review of the taxonomic status of some fish ectoparasitic trichodinids. *Systematic Parasitology*, vol. 14, no. 3, p. 157-179. doi:10.1007/BF02187051

XU, D-H, SHOEMAKER, CA. and KLESIUS, PH., 2007. Evaluation of the link between gyrodactylosis and streptococcosis of Nile tilapia, *Oreochromis niloticus* (L.). *Journal of Fish Diseases*, vol. 30, no. 4, p. 233-238. PMid:17394525. doi:10.1111/j.1365-2761.2007.00806.x

ZANIBONI FILHO, E., 2004. Piscicultura das espécies exóticas de água doce. In POLI, CR., POLI, ATB., ANDREATTA, ER. and BELTRAME, E. (Eds.). *Aqüicultura:* experiências brasileiras. Florianópolis. p. 309-336.

ZAR, JH., 1999. *Biostatistical Analysis*. 4nd ed. New Jersey: Upper Saddle River.