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Coelho Florindo, Maitê; Tomas Jerônimo, Gabriela; Dordete Steckert, Lilian; Acchile, Monyele; Tavares Gonçalves, Eduardo Luiz; Cardoso, Lucas; Laterça Martins, Maurício
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Research Article

Protozoan parasites of freshwater ornamental fish

Maitê Coelho Florindo[1], Gabriela Tomas Jerônimo[1], Lilian Dordete Steckert[1], Monyele Acchile[1] Eduardo Luiz Tavares Gonçalves[1], Lucas Cardoso[1] & Maurício Laterça Martins[1]
[1]AQUOS - Aquatic Organisms Health Laboratory, Aquaculture Department
Federal University of Santa Catarina Florianópolis, SC, Brazil
Corresponding author: Maurício Laterça Martins (mauricio.martins@ufsc.br)

ABSTRACT. The ornamental fish aquaculture represents a consolidated market worldwide. In Brazil, the major volume of commercialized freshwater ornamental fish is originated from fish farms managed by small and midsized farmers. The aim of this study was to characterize the metazoan parasitic fauna associated with the main freshwater ornamental fish farmed in Southern Brazil. Between July 2014 and January 2015, 423 fishes belonging to nine freshwater species were examined: angelfish *Pterophylum scalare*, siamese fighting fish *Betta splendens*, telescope and comet goldfish *Carassius auratus*, zebrafish *Danio rerio*, blood red swordtail *Xiphophorus helleri*, caramel and wagtail platy fish *Xiphophorus maculatus*, black molly *Poecilia sphenops*, white cloud mountain minnow *Tanichthys albonubes* and goldfinned barb *Puntius sachsii*. Water quality was measured in fishponds from each facility. Specimens were obtained from three ornamental fish farms located in three micro-regions in the State of Santa Catarina (Biguaçu, Camboriú e Joinville). Parasitological indexes were obtained after parasitological analysis of mucus, gills, and eyes. Trichodinids, *Piscinoodinium pillulare*, and *Ichthyophthirius multifiliis* were found in all fish farms analyzed. However, *P. pillulare* showed the greatest prevalence and mean intensity, compared to the other protozoa analyzed. 75% prevalence and mean intensity 57.5 were observed in the gills of *P. scalare* from fish farm Araquari. This study showed that fish farm Biguaçu, was the facility presenting the greatest parasite diversity. *P. scalare* and *C. auratus* were the most parasitized fish species presenting the higher richness when compared to another species. These ornamental species are widely traded and require greater care in cultivation because it is essential to produce healthy fish with attractive features accepted by the market.

Keywords: ornamental fish, parasitology, freshwater environment, diseases, risk factors.

INTRODUCTION

The trade of ornamental fishes represents a competitive and promising sector over the world. In 2006, the statistics on the global volume of export of ornamental fish generated U$277.2 million revenues (FAO, 2006). Actually, Brazil is recognized as an important exporter country of tropical species generating an income of more than US$6 million annually (IBAMA, 2008). The great majority of the exportation is from the Amazon region (Pelicice & Agostinho, 2005) where concentrate a great amount of freshwater fauna (Zuanon *et al.*, 2011).

The greatest volume of freshwater ornamental fishes is from fish farms Junk *et al*. (2007) and their economic value in both national and international market stimulates the appearance of new farmers. Rapid growth, easy to handling, well adapted to captivity conditions and reduced capture from nature are factors important to be considered (Tlusty, 2002; Zuanon *et al.*, 2011).

In Brazil, the exotic goldfish *Carassius auratus*, platy fish *Xiphophorus maculatus*, siamese fighting fish *Betta splendens*, and the native oscar *Astronotus ocellatus*, guppy *Poecilia reticulata*, the cardinal tetra *Paracheirodon axelrodi*, jewel tetra *Hyphessobrycon eques*, angelfish *Pterophylum scalare* and the discus *Symphysodon discus* are the most cultured ornamental fishes (Froese & Pauly, 2010). These species present color and attractiveness making them of great commercial interest. The success of fish farming depends on several factors including the environmental quality, fish health, and welfare. However, physical and chemical alterations, the stress of handling, transport and high stocking density (Lima *et al.*, 2006) are responsible for economic losses (Martins *et al.*, 2002).

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Among fish parasites, the Dinoflagellida protozoan *Piscinoodinium pillulare* (Schäperclaus, 1954) Lom, 1981, was reported as the main parasite with 100% prevalence in *B. splendens* in Turkey (Kayis *et al.*, 2013). In Scotland, seven species of genus *Trichodina* were registered from *Gasterosteus aculeatus* (Hugo & Wootten, 1998). In farmed Brazilian ornamental fish, *Trichodina reticulata* Hirschmann & Partsch, 1955 and *Trichodina nobilis* were found in *C. auratus*, *P. reticulata* and *X. maculatus* (Martins *et al.*, 2012) and *Ichthyophthirius multifiliis* was related in ornamental fish from Negro River, Amazon (Tavares-Dias *et al*., 2010). Additionally, Santos *et al.* (2017) observed that *I. multifiliis*; *Trichodina* sp. were the main protozoan parasites observed in ornamental fish cultivated in Brazil, and were not able to cause pathological damages to fish, being these changes more related to the culture environment.

Parasitological assessment in ornamental fish constitutes an important endpoint to improve the fish productivity and to keep the fish health in ornamental fish farming. This study contributes to the knowledge of the parasite fauna associated with ornamental freshwater fish cultured in the southern Brazil and discusses the handling management adopted in the facilities analyzed.

MATERIALS AND METHODS

From July 2014 to January 2015, a total of 423 ornamental fish species were examined from three facilities situated in the State of Santa Catarina, South of Brazil: fish farm Camboriu (27°01’33”S, 48°39’ 18”W), fish farm Araquari (26°22’13”S, 48°43’24”W), fish farm Biguaçu (27°29’41”S, 48°39’22”W). The fish were transported alive to AQUOS Laboratory for parasitological analysis according to the Ethics Committee on Animal Use (CEUA/UFSC NºPP00928).

The number of examined fish (n) and biometry are shown in (Table 1). Water quality parameters were measured during the fish collection: pH, dissolved oxygen, and temperature with a multiparameter Hanna® HI9146 and ammonia with a colorimetric kit Alfakit®. Simultaneously to the collections, the handling characteristics in each facility were assessed (Table 2).

Parasitological analysis followed the method of Jerônimo *et al.* (2012) and the parasitological indexes were calculated according to Bush *et al.* (1997). Mean relative dominance was also calculated (Rohde *et al.*, 1995).

For quantification of the protozoans *Icthyophthirius multifilis*, *Apiosoma* sp., *Piscinoodinium pilulare*, the samples were counted in triplicate in a Sedgwick Rafter chamber (Santos *et al.*, 2017). Trichodinids were identified from the mucus and gill smears, dried at room temperature, fixed in methylic alcohol to posterior silver nitrate impregnation by the Klein method (Lom, 1958). Measurements from the body and the adoral ciliature were obtained from wet-mounted specimens in 5% formalin solution to be given in micrometers according to Lom (1958).

Results were obtained by Mann-Whitney test, using the software Statistica (StatSoft) for comparison of two independent groups, for bicaudal comparison and the parasitological indexes among the facilities for each fish species ($P < 0.05$). This data does not meet the requirements for a parametric test because it did not show normality and homoscedasticity, therefore a non-parametric test was used.

RESULTS

The great majority of the examined specimens were not parasitized. The protozoans identified in this study were the ciliate trichodinids, *Trichodina heterodentata*, *T. reticulata*, and the dinoflagellate *P. pillulare* in *C. auratus*, *T. reticulata* in *P. sphenops* and *X. maculatus*. Trichodinids, *P. pillulare* and *I. multifiliis* were found in all fish farms analyzed. However, *P. pillulare* showed the greatest prevalence and mean intensity, compared to the other protozoa analyzed.

Trichodina sp. was found on the body and gills in all fish species examined except for *P. scalare* from fish farm Camboriú. The greatest parasitological indexes were found on the body surface of comet *C. auratus* (50%, mean intensity 8.66), followed by the gills of *D. rerio* (33.3%, mean intensity 5.66) from fish farm Biguaçu (Table 3). *I. multifiliis* was found on the body surface and gills of fish from all facilities, but in low prevalence. *P. scalare* from fish farm Araquari, presented (25%, mean intensity 1.00) followed by wagtail platyfish (10%, mean intensity 1.54) from fish farm Biguaçu (Table 3).

Piscinoodinium pillulare was reported in all fish species examined except for comet *C. auratus* from fish farm Biguaçu. 75 percent of prevalence and mean intensity 57.5, were observed in the gills of *P. scalare* from fish farm Araquari, and 33.3% with mean intensity 47.4 in the same species from fish farm Camboriú (Table 4). *Piscinodinium pillulare* was the parasite that obtained the greatest abundance (43.16 ± 48.6) in angelfish from fish farm Araquari, the second greatest abundance (21.32 ± 28.39) was reported the same species from fish farm Camboriú. *Apiosoma* sp. was reported only on the body surface of telescope *C.*

Table 1. Number of examined fish (n) and biometry. Average weight (AW ± standard deviation), Average length (AL ± standard deviation), n: sample size.

Fish farm	Fish species	AW (g)	AL (cm)	n
Fish farm Camboriu	*Carassius auratus* (telescope goldfish)	5.10 ± 2.71	6.09 ± 1.57	29
	C. auratus (comet goldfish)	5.87 ± 2.84	8.57 ± 1.28	30
	Pterophyllum scalare (angelfish)	1.73 ± 0.94	4.61 ± 0.82	30
Fish farm Araquari	*P. scalare* (angelfish)	4.67 ± 1.15	6.42 ± 0.47	4
	Poecilia sphenops (black molly)	2.43 ± 1.71	5.37 ± 1.42	15
	Xiphophorus helleri (blood red swordtail)	4.0 ± 2.86	6.71 ± 1.15	30
	X. maculatus (caramel platyfish)	2.0 ± 0.57	4.62 ± 0.00	30
	X. maculatus (wagtail platyfish)	1.0 ± 0.43	4.0 ± 0.38	30
Fish farm Biguaçu	*B. splendens* (siamese fighting fish)	0.58 ± 0.79	3.64 ± 1.94	19
	C. auratus (comet goldfish)	3.89 ± 0.89	6.95 ± 0.90	29
	Danio rerio (zebrafish)	0.55 ± 0.21	3.87 ± 0.71	30
	P. sphenops (black molly)	0.89 ± 0.47	4.04 ± 0.59	29
	Puntius sachsii (goldfinned barb)	3.22 ± 1.37	6.16 ± 0.96	30
	Tanichthys albonubes (white cloud mountain minnow)	0.48 ± 0.12	3.84 ± 0.33	29
	X. helleri (blood red swordtail)	2.67 ± 1.93	5.89 ± 1.39	29
	X. maculatus (wagtail platyfish)	1.40 ± 0.63	4.32 ± 0.55	29

Table 2. Management characteristics of ornamental fish farms in Brazil. CP: crude protein, DO: dissolved oxygen, TE: temperature, AM: ammonia.

Characteristics	Fish farm Camboriu	Fish farm Araquari	Fish farm Biguaçu
System and site of culture	Semi-intensive system, earthen pond, water recirculation system	Semi-intensive system, geomembrane liner	Semi-intensive system; earthen pond with floating cages
Employee management	Aeration, fertilization and liming with crops	Aeration, fertilization and liming with no periodicity	Aeration, fertilization and liming between each fish culture
Feeding	Extruded diet 50% CP	Extruded diet 55% CP	Extruded diet 50% CP
Stocking fish density	30 m^{-3}	No control	No control
Water source	Waterfall	River	Source with interference from rivers
Water quality monitoring	No	No	No
Type of marketing	Middlemen and retailers	Held only for projects	Middlemen and retailers and wholesale
pH	6.29 ± 1.02	7.10 ± 0.84	5.93 ± 0.39
DO (mg L^{-1})	6.57 ± 1.26	5.78 ± 2.36	4.14 ± 1.77
TE (°C)	20.65 ± 3.10	23.30 ± 6.04	21.15 ± 3.73
AM (mg L^{-1})	0.63 ± 0.35	1.16 ± 0.99	0.69 ± 1.90

auratus from fish farm Camboriu and fish farm Biguaçu (3.3%) (Table 4). *Epistylis* sp. was also registered on the body surface of telescope *C. auratus* (26.6%, mean intensity 0.28) and *X. maculatus* (10%, mean intensity 0.33) from fish farm Biguaçu (Table 5).

DISCUSSION

Some studies have reported the presence of trichodinids in ornamental fishes, as for example, 9.3% of *T. nigra* (Thilakaratne *et al.*, 2003), 16.3% (Kayis *et al.*, 2013) and 57% (Marques *et al.*, 2015), of *Trichodina* spp. on the body surface of *C. auratus*. In contrast to that observed in this study, Marques *et al.* (2015) found more prevalence of trichodinids than monogenean, *Epystylis* sp., *P. pillulare* and larvae of digenea.

T. heterodentata, herein reported, has been observed in cichlids, cyprinids, gobiids, and poecilids (Duncan, 1977; Basson & Van As, 1991; Al-Rasheid *et al.*, 2000; Dove & O'Donoghue, 2005). According to Van As & Basson (1992), *T. heterodentata* presents wide distribution and it is capable to parasitize several fish hosts. In Southern Brazil, it has been registered in channel catfish *Ictalurus puntactus* (Martins *et al.*, 2010). Other trichodinids like *T. reticulata* and *T. nobilis* were observed to be parasitizing several ornamental fish species including *C. auratus* (Martins *et al.*, 2012); Trichodinids such as *T. acuta* in *X. helleri*, *X. maculatus*, *P. sphenops*, *B. splendens* were previously reported (Piazza *et al.*, 2006). The present study showed a higher prevalence of trichodinids than that found by Thilakaratne *et al.* (2003), Piazza *et al.*

Table 3. Parasitological indexes of ornamental fish parasitized by *Trichodina* sp. and *Ichthyophthirius multifiliis*. Prevalence (P%), mean intensity (MI ± SD), mean abundance (MA ± SD), mean relative dominance (RD), parasite richness (U) and infestation/infection site (SI), gills (G), body surface mucus (M). *Different letters represent statistical differences between the properties in relation to the same species of fish analyzed. SD: standard deviation.

Parasites			Trichodinids				*Ichthyophthirius multifiliis*			
Fish farms	Species / Indexes	SI	*P*	MI	MA	RD	*P*	MI	MA	RD
Camboriu	*C. auratus* (comet goldfish)	G	13.30	1.6 ± 2.3[a]	0.2 ± 0.3[a]	0.02	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
		M	30.00	17.3 ± 24.5[b]	10.4 ± 14.7	0.29	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	C. auratus (telescope goldfish)	G	6.60	0.5 ± 0.7	0.06 ± 0.09	0.01	3.3	4.5 ± 6.3	0.3 ± 0.4	0.02
		M	20.00	9.0 ± 12.7	2.4 ± 3.4	0.19	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	P. scalare (angelfish)	G	0.0	0.0 ± 0.0	0.0 ± 0.0	0.00	6.6	3.4 ± 4.9	0.4 ± 0.6	0.02
Araquari	*P. scalare* (angelfish)	M	25.00	1.0 ± 0.0	0.25 ± 0.0	0.50	25.0	1.0 ± 0.0	0.25 ± 0.0	0.50
	P. sphenops (black molly)	M	6.60	2.5 ± 3.5[b]	0.2 ± 0.3[b]	0.00	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	X. maculatus (caramel platyfish)	G	6.60	0.5 ± 0.7	0.03 ± 0.04	0.04	6.6	1.0 ± 1.4	0.06 ± 0.09	0.08
		M	10.00	1.0 ± 0.0	0.1 ± 0.4	1.00	3.3	0.5 ± 0.7	0.3 ± 0.4	0.50
	X. maculatus (wagtail platyfish)	G	10.00	0.5 ± 0.7	0.1 ± 0.1	0.02	0.0	0.00 ± 0.00[a]	0.00 ± 0.00[a]	0.00
		M	3.30	0.5 ± 0.7[b]	0.03 ± 0.04	1.00	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
Biguaçu	*B. splendens* (siamese fighting fish)	M	30.0	4.07 ± 5.75	1.90 ± 2.68	1.00	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	C. auratus (comet goldfish)	G	26.60	4.85 ± 6.86[b]	2.83 ± 2.40[b]	0.26	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
		M	50.00	8.66 ± 4.33[a]	2.31 ± 2.43[a]	0.48	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	D. rerio (zebrafish)	G	33.30	5.66 ± 3.82	2.40 ± 3.39	0.55	3.3	10.5 ± 14.8	0.7 ± 0.98	0.16
		M	30.00	0.21 ± 0.30	2.60 ± 3.39	0.98	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	P. sphenops (black molly)	G	3.30	0.5 ± .7	0.03 ± 0.05	0.02	3.3	7.0 ± 9.8	0.46 ± 0.65	0.34
		M	3.30	0.5 ± 0.7	0.03 ± 0.05[a]	0.04	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	P. sachsii (goldfinned barb)	G	13.30	0.07 ± 0.10	3.10 ± 4.28	1.00	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
		M	10.00	1.0 ± 1.4	0.26 ± 0.37	1.00	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	T. albonubes (white cloud mountain minnow)	M	6.60	0.26 ± 0.40	0.13 ± 1.88	0.22	0.0	0.00 ± 0.00	0.00 ± 0.00	0.00
	X. helleri (blood red swordtail)	G	23.30	2.85 ± 4.04	1.42 ± 2.02	0.71	3.30	0.07 ± 0.10	0.03 ± 0.04	0.01
		M	26.60	1.21 ± 1.71	0.56 ± 0.80	0.80	10.0	0.14 ± 0.20	0.20 ± 0.09	0.19
	X. maculatus (wagtail platyfish)	G	26.60	0.8 ± 1.2	0.46 ± 0.66	0.28	10.0	1.54 ± 2.18[b]	0.72 ± 1.02[b]	0.43
		M	13.30	1.37 ± 1.94	0.36 ± 0.51	0.02	6.60	0.50 ± 0.70	0.03 ± 0.04	0.03

Table 4. Parasitological indexes of ornamental fish parasitized by *Apiosoma* sp. and *Piscinoodinum pillulare*. Prevalence (P%), mean intensity (MI ± SD), mean abundance (MA ± SD), mean relative dominance (RD) and infestation/infection site (SI), gills (G), body surface mucus (M). *Different letters represent statistical differences between the properties in relation to the same species of fish analyzed. SD: standard desviation.

Parasites			*Apiosoma* sp.				*Piscinoodinium pillulare*			
Fish farms	Species \ Indexes	SI	*P*	MI	MA	RD	*P*	MI	MA	RD
Camboriu	*C. auratus* (comet goldfish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	23.3	14.9 ± 7.0	4.3 ± 5.1	0.55
		M	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	10.0	3.8 ± 5.4	0.7 ± 1.0	0.02
	C. auratus (telescope goldfish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	36.6	20.5 ± 14.7	5.5 ± 4.9	0.55
		M	3.30	1.0 ± 1.41	0.06 ± 0.09	0.00	10.0	17.8 ± 25.2	2.3 ± 3.3	0.19
	P. scalare (angelfish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	33.3	47.4 ± 58.3	21.32 ± 28.39	0.96
		M	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	3.3	5.0 ± 7.0	0.3 ± 0.4	1.00
Araquari	*P. scalare* (angelfish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	75.0	57.5 ± 49.0	43.16 ± 48.6	0.01
	X. hellerii (blood red swordtail)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	10.0	3.1 ± 4.3[b]	0.6 ± 0.8[b]	1.00
	X. maculatus (caramel platyfish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	3.3	2.3 ± 3.2	0.1 ± 0.2	0.20
	X. maculatus (wagtail platyfish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	6.6	68.0 ± 76.3	4.5 ± 5.0	0.92
Biguaçu	*B. splendens* (siamese fighting fish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	5.3	12.0 ± 16.9	3.0 ± 4.2	1.00
	C. auratus (comet goldfish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	23.3	8.66 ± 12.25	4.07 ± 5.67	0.45
		M	3.30	0.07 ± 0.10	0.03 ± 0.04	0.00	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00
	D. rerio (zebrafish)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	6.6	2.33 ± 3.29	1.25 ± 1.30	0.28
	P. sphenops (black molly)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	16.6	1.33 ± 1.88	0.74 ± 0.64	0.58
	T. albonubes (white cloud	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	13.3	4.37 ± 6.18	0.03 ± 0.05	1.00
	mountain minnow)	M	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	23.3	1.00 ± 1.41	0.46 ± 0.65	0.77
	X. hellerii (blood red swordtail)	G	0.00	0.00 ± 0.00	0.00 ± 0.00	0.00	6.6	1.00 ± 1.41[a]	0.50 ± 0.61[a]	0.26

Table 5. Parasitological indexes of ornamental fish from fish farm Biguaçu, parasitized by *Epistylis* sp. on the body surface mucus. Prevalence (P%), mean intensity (MI ± SD), mean abundance (MA ± SD), mean relative dominance (RD), infestation/infection site (SI), body surface mucus (M). SD: standard deviation.

Species \ Indexes	SI	*P*	MI	MA	RD
C. auratus (comet goldfish)	M	26.6	0.28 ± 0.57	0.13 ± 0.18	0.16
X. maculatus (wagtail platyfish)	M	10.0	0.33 ± 0.65	0.04 ± 0.03	0.97

(2006), Martins *et al.* (2012), Kayis *et al.* (2013) and Marques *et al.* (2015).

In fish farm Biguaçu, *D. rerio* presented mortality outbreaks caused by trichodinids in pond-reared fish, but the fish farmer did not quantify both the amount of dead fish and financial losses. The emergence of this parasite is strongly associated with water quality (Moraes & Martins, 2004) supplied to fish farm that receives the influence of rivers and fee fishing facilities surrounding the fish farm Biguaçu. Except for telescope *C. auratus* from fish farm Camboriu, trichodinids were present with higher prevalence in all fish examined from fish farm Biguaçu, when than that observed in the other facilities. Trichodinids reproduction increases when increasing the organic matter contents (Moraes & Martins, 2004). It can be inferred that temperature variations and high ammonia contents have also influenced the proliferation of these parasites.

The dinoflagellate *P. pillulare* is highly pathogenic for cultured fish (Pavanelli *et al.*, 2013) responsible for gills hyperplasia and damages to respiratory epithelium causing mortalities (Iqbal & Haroon, 2014). It provoked 100% of mortality in *B. splendens* farmed in Turkey (Kayis *et al.*, 2013). Iqbal & Haroon (2014) have identified the dinoflagellate on the body surface and fins of *X. helleri* with 15% prevalence, which caused fin erosion and petechiae. Similarly, *P. pillulare* were found in 9% of *C. auratus* examined by Thilakaratne *et al.* (2003) and 1 to 3% prevalence in *X. maculatus, P. sphenops* (Piazza *et al.*, 2006). On the other hand, 65.2% prevalence was reported in *P. axelrodi* (Tavares-Dias *et al*., 2009).

In this study, *P. scalare* showed the highest prevalence rates (63.9% from fish farm Camboriu and 57% from fish farm Araquari, compared to previous studies. Similar results have been reported by (Tavares-Dias *et al*., 2009) in *X. maculatus* responsible for gill lesions. In fish farm Araquari, it was observed fish mortality caused by dinoflagellate. Different prevalence values are probably due to the absence of preventive management adopted in fish farms (Carnevia & Speranza, 2003; Piazza *et al.*, 2006). Like trichodinids, *P. pillulare* has a direct life cycle favored by high organic matter contents, reduced dissolved oxygen, and high stocking densities (Portz *et al*., 2013). Epistyliasis is considered an emergent protozoan fish disease in Brazil for cultured fish for consumption. In this study, the prevalence was low and the injury degree was not compared to previously related (Pádua *et al*., 2016).

According to Blas (2008) argued that the ideal sample size for the sampled population is based on the confidence level and size of the population. These factors are especially important for fish that presents great populations. The sizes of samples of 150, 60, and 30 fish are frequently used that correspond respectively to 10, 5, and 2% of minimum prevalence with a confidence interval of 95%. Fish that presented n = 30 corresponded to a minimum prevalence of 2%. According to Blas (2008) epidemiology of the disease control, the sample size is one of the factors needed to characterize the epidemiological fauna of a population. This index is important to calculate the prevalence of the positive results in a sample.

The richness is an important parameter used in the population ecology studies consisting of the number of parasite species that inhabit the host (Poulin, 1995). In this study, *P. scalare* and *C. auratus* were the most parasitized fish species presenting the higher richness when compared to another species (Fig. 1). In fact, this could be explained because the fish farming Camboriu makes a bath of mebendazole in still juvenile fish, it is a medication used to eliminate helminths, and fish farm Araquari does not carry out this practice. Water quality may influence directly the fish physiology predisposing the fish to parasitic infections (Froese & Pauly, 2015). Angelfish a sensitive species to environmental alterations presented mortality in this study, six fish died, but these were not analyzed. *C. auratus* herein examined did not present mortality. It is possible to affirm that *C. auratus* could be more resistant fish than others could because it has a greater capacity to keep the health status without causing serious injury or mortality.

This study showed that fish farm Biguaçu, was the site presenting the greatest parasite diversity. This could be associated with the greatest number of orna-

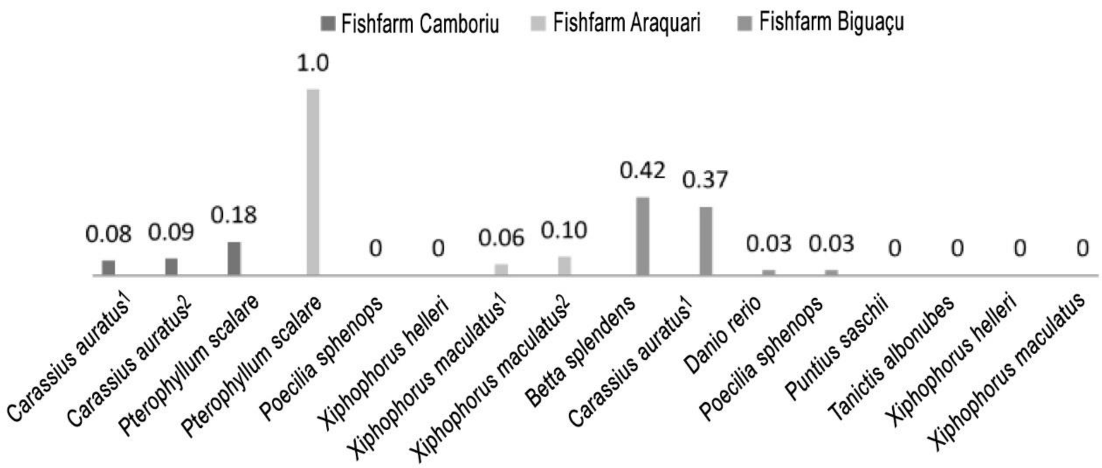

Figure 1. Parasite richness in ornamental fish farming in South Brazil showing the greatest richness in *Pterophyllum scalare* from fish farm Araquari, followed by *Carassius auratus* from fish farm Biguaçu, and *Carassius auratus* from fish farm Camboriu.

mental fish produced when compared to other facilities. Moreover, the management adopted could also interfere once this fish farming did not present control on the fish stocking density in ponds. Additionally, the source of water had the influence of the rivers that take the effluent from other fish farms in the region, and they do not have a screen that prevents or minimizes the entrance of other parasites. These data present allowance for implementation of the Best Management Practices including prophylaxis in fish farming and monitoring of the fish health. It was noted that the fish farmer must be better advised to detect the risk factors associated with ornamental fish production and keep the good water quality and adequate stocking density. This study provides important epidemiological data on the protozoan from ornamental fish. These ornamental species are widely traded, and require greater care in cultivation because it is essential to produce healthy fish with attractive features to be accepted by the market. Histopathological analyses of organs more infected by parasites in ornamental fish are needed to assess the damage on the fish tissues.

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