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Metazoan and protozoan parasites of freshwater ornamental fish from Brazil

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Resumo

Anualmente, 27 milhões de peixes ornamentais de água doce são exportados do Brasil para o comércio internacional, principalmente para os Estados Unidos e Europa. A maioria destes peixes é proveniente da bacia amazônica, principalmente dos estados do Amazonas (25 milhões/ano) e Pará (1 milhão/ano) e somente uma pequena parte destes peixes é originária de cultivo. Dezenas de espécies são exportadas do Brasil, sendo Paracheirodon axelrodi (18 milhões/ano) a principal espécie, seguido por Otocinclus affinis (1,4 milhões/ano), Hemigrammus bleheri (1,1 milhões/ano) e Paracheirodon simulans (0,88 milhões/ano). Peixes ornamentais exportados do Brasil apresentam parasitos normalmente também encontrados em hospedeiros de outros países. Infecções parasitárias representam importante desafio para produtores de peixes ornamentais. Neste sentido, baixo número de parasitos pode evoluir para número indesejável e perigoso comprometendo a saúde do peixe.

Abstract

Annually, 27 million of freshwater ornamental fish have been exported from Brazil for international trade, mainly to the United States and Europe. Most of these fish are originated from Amazonian basin, especially from the states of Amazonas (25.0 million/year) and Pará (1.0 million/year). Small quantity of these fish is from culture. Paracheirodon axelrodi (18 million/year) is the main fish exported, followed by Otocinclus affinis (1.4 million/year), Hemigrammus bleheri (1.1 million/year) and Paracheirodon simulans (0.88 million/year). Ornamental fish exported from Brazil have parasites that are also reported in hosts from the other countries. Parasitic infections represent an important challenge for commercial suppliers of ornamental fish. On this view, low number of parasites may evolve to undesirable and dangerous number compromising the fish health.

Introduction

The ornamental fish hobbyist has experienced an increase in world popularity since the 1990s. This hobby is a multi-million dollar industry, and the United States of America is considered the largest market for ornamental organisms. Hence, increased demand for ornamental fish by the aquarists from the United States of America, United Kingdom, Japan, Germany, Italy and Belgium has been responsible for development of the activity. Over the last ten years the value of global exports of ornamental fish has averaged over US$ 183 million/year (Prang, 2007). Nowadays, most of the ornamental fish are produced in captivity (90%), and only 10% is wild fish. The world's ornamental fish is growing due to the production and importation of several species from different continents especially from Asia and South America.

Singapore is the principal ornamental fish exporter over the world (Prang, 2007; Ribeiro, 2008). However, a great number of aquarium fish are from the Amazonian Basin (Brazil, Colombia and Peru) in which is an important source of economic resources. Colombia is the largest exporter of South America, with exportation of 25 million of ornamental fish/year, generating an income of US$ 7 million (Ribeiro, 2008). Since 2006, Brazil has exported about 28 million of freshwater ornamental fish/year, which generated an income of about US$ 6 million/year (Figure 1). Ornamental fish are collected in eight Brazilian States. However, only the Amazonas State contributes with 64.0% of export production and Pará State with 26.0% (Figure 2). Part of freshwater ornamental fish exported from Pará State is collected in Amapá State. Nevertheless, the quantity of fish species collected in Amapá is still ignored by the Brazilian government that controls the exploration of ornamental fish.

Ornamental fish from Amazonas State are exported to Germany, Netherlands, France, Belgium, UK and USA (Prang, 2007). Since 2006, Amazonas has exported 25.2 million fish/year with an income of US$ 3.7 million/year (Figure 2). However, the potential of exportation of freshwater ornamental fish is probably much higher than that currently practiced in the Brazilian Amazonia (Prang, 2007).

Selection of fish species is a result of demand for fish highly colorful must be maintained when fed in aquarium. The last point is the choice of imported fish species. Ornamental fish exported from Amazonas State belong to 25 families with 130-140 fish species highly colorful (Table 1). The main fish species are shown in Table 1. There are 800 species documented for Rio Negro basin (Chao et al., 2001), but only 70 fish species from the basin are currently permitted for exportation (Prang, 2007). Barcelos Municipality is responsible for 67.8% ornamental fish exported from the Amazonas State (Chao et al., 2001). This basin is the largest area of ornamental fish capture and *Paracheirodon axelrodi* represents 70.0% of the total exported fish (Table 1). Other important species include the marbled hatchetfish *Carnigiella strigata*, blackwing hatchetfish *C. martae*, brown pencilfish *Nannostomus eques*, oneline pencilfish *Nannostomus unifasciatus*, Loricariid *Ancistrus hoplogenys*, rosy tetra *Hyphessobrycon copelandi*, catfish *Dianema urostriatum*, dwarf sucker *Otocinclus* sp., *Apistogramma* sp., angelfish *Pterophyllum scalare*, discus *Symphysodon* sp., *Hemigrammus microstomus* and catfishes *Corydoras* sp.

Water level oscillations in the Amazonia can affect the habitat and ecological aspects such as food supply and reproduction of ornamental fish population. In the Amazonas State, capture of ornamental fish in flooded forest ("igapós") and water small streams ("igarapés") is strongly influenced by seasonality that occurs from August through February (Figure 1). After capture, fish are transported to Manaus (AM) where they are kept in fattening/quarantine tanks of exporter's holding facilities until their exportation in which depending on the species, can take from 60 days to one year. Prophylaxis and management control must be considered during this time in order to avoid economical losses due to pathogens action.

The monitoring of fish health status must be one of the most important activities in culture and exportation's holding facilities of fish. Studies are carried out after exportation of catfishes *Corydoras* sp. and *Brochis splendens* from Brazil to England. Dinoflagellate *Piscinoodinium pilullare* was detected before exportation (Ferraz & Sommerville, 1998). Procedures to avoid risks of infection or transfer of disease and parasites must be carried out. Ornamental fish exportation has been responsible for introduction of parasites (Sterud & Jorgensen, 2006) that can endanger native population and culture (Mouton et al., 2001; Kim et al., 2002), specially when the prophylactic management and quarantine are ignored. When parasites are introduced into the environment they can persist due to favorable physical and chemical water conditions.

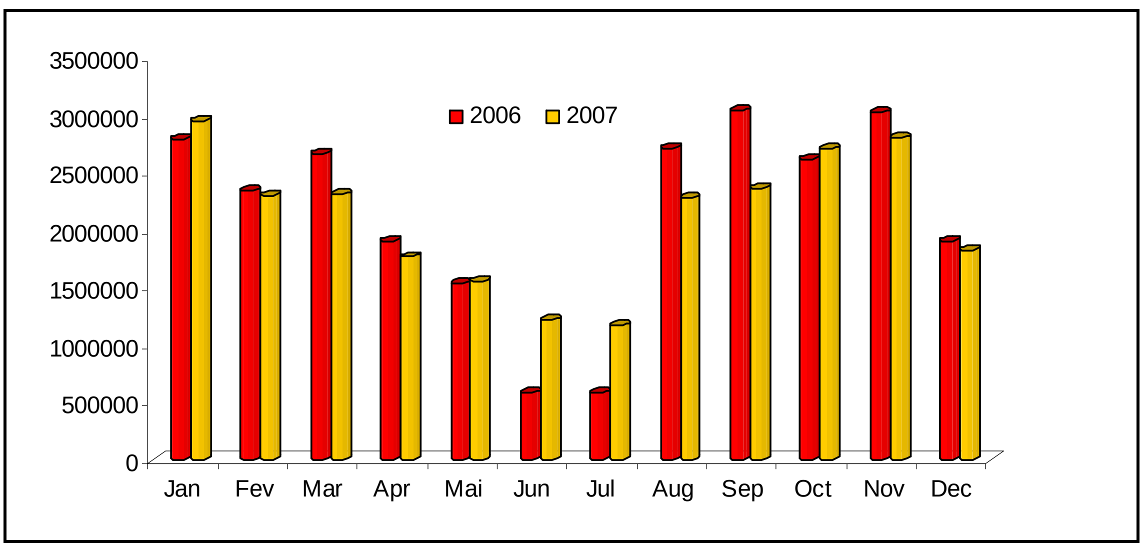

Figure 1. Number of freshwater ornamental fish exported from Brazil during the period of 2006 and 2007 (Ibama, 2008).

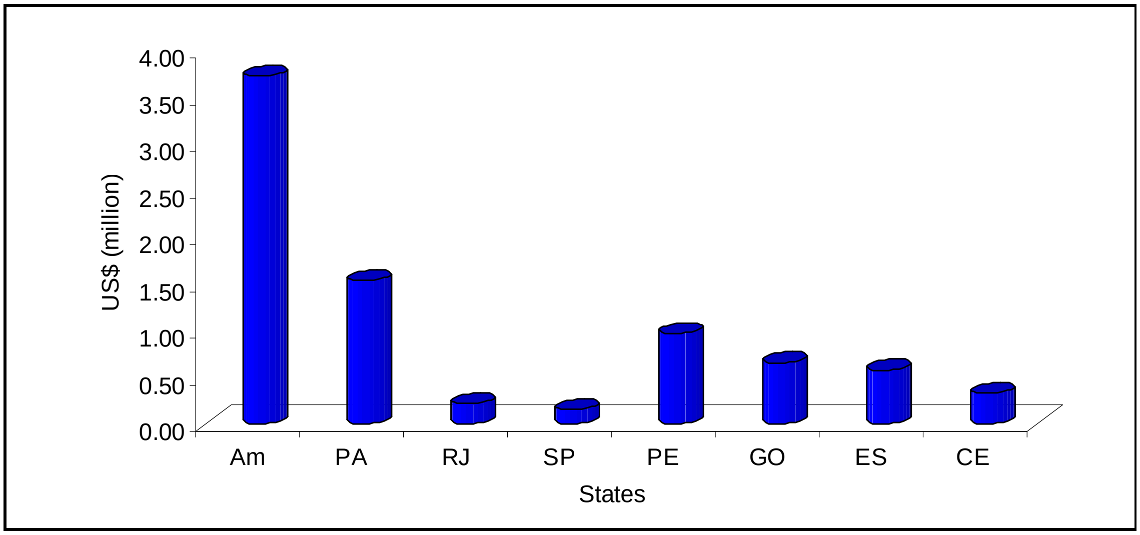

Figure 2. Exportation values of freshwater ornamental fish from the Brazilian States in the year 2007 (Ibama, 2008). Am: Amazonas, PA: Pará, RJ: Rio de Janeiro, SP: São Paulo, PE: Pernambuco, GO: Goiás, ES: Espírito Santo, CE: Ceará.

Table 1. Principal freshwater ornamental fish species exported from the Amazonas State, Brazil in 2007 (Ibama, 2008).

Fish species	Common name	Number of fish exported
Paracheirodon axelrodi	Cardinal tetra	17.783.580
Otocinclus affinis	Golden otocinclus	1.437.978
Hemigrammus bleheri	Firehead tetra	1.180.312
Paracheirodon simulans	Green neon	844.160
Otocinclus vittatus	Dwarf sucker	682.192
Corydoras schwartzi	Schwartz's catfish	525.938
Hyphessobrycon sp.	Rosy tetra	437.500
Carnegiella strigata	Marbled hatchetfish	360.184
Corydoras julii	Leopard corydoras	162.035
Corydoras hastatus	Dwarf corydoras	152.300
Corydoras punctatus	Spotfin corydoras	151.778
Corydoras agassizii	Catfish corydoras	138.283
Nannostomus marginatus	Dwarf pencilfish	134.071
Dicrossus maculatus	Dwarf cichlid	101.180
Corydoras elegans	Elegant corydoras	81.136
Corydoras adolfoi	Adolf's catfish	81.069
Nannostomus trifasciatus	Threestripe pencilfish	75.388
Baryancistrus sp.	Loricariid catfish	74.098
Ancistrus spp.	Loricariid catfish	64.452

Ornamental fish parasites from rivers at the Brazilian Amazonia

A great quantity of good quality fish exported is the challenge to aquarium industry. Higher mortality has been registered from capture and transport of ornamental fish induced by stress (Waichman et al., 2001). Not only good water quality but also adequate handlings are practices that must be adapted for the activity.

Water quality monitoring to reduce stress and fish mortality is the main factor to be thought. Low water quality observed during transport and the lack of basic care result in reduced fish health status (Waichman et al., 2001). The introduction of ornamental fish without quarantine can cause trouble for importation country with consequent economic losses (Kim et al., 2002).

Parasitism in fish occurs normally in the native environment in a great diversity of parasites comparing to cultured fish (Moraes & Martins, 2004). Fish in the nature inhabit with parasites successfully (Roberts, 1981) by the fact that nutritional and physiological aspects are maintained (Andrade et al., 2001). When fish are exposed to different conditions the relation host/parasite/environment is broken especially due to water quality, stocking density and other stressor effects (Molnár, 1994; Moraes & Martins, 2004). Thus, it is important to study the causative agents of disease in ornamental fish (Martins et al., 2001). To success of fish transport the environment must be free of noxious factors that may cause a decrease in fish resistance. It is necessary to evaluate the main factors responsible for compromise the activity.

Up to now, in Brazilian Amazonia, only 54 parasite species of seven zoological groups are known (Figure 3). These parasites have been reported, mainly, in fish species of the genera *Ancistrus* (Matos et al., 1998; Thatcher, 2006), *Carnegiella*, *Corydoras, Hemigrammus*, *Hyphessobrycon*, *Poecilia*, *Xiphophorus*, *Carassis auratus, Astronotus ocellatus* (Thatcher, 2006) and *Gasteropelecus sternicla* (São Clemente et al., 2000). However, as has a great number of Amazon ornamental fish species known and only some few fish were studied, hence many parasites species must be described yet.

Studies on *P. axelrodi*, *S. discus*, *H. erythrostigma*, *Ancistrus* sp., *Corydoras robinae*, *C. burguessi* and *C. adolfoi* from the Barcelos area, Negro River basin before they were sent to the exporters in Manaus (Amazonas State, Brazil), have registered the occurrence of protozoans *Chilodonella* sp., *Trichodina* sp. and *Piscinoodinium pilullare,* Monogenoidea and bacteria (Ferraz, 1999). In general, these occurrences of multiple parasitic infections are associated to inadequate handling, poor water quality, and high stocking density during the transport, as well as long periods of time without feeding. This knowledge is important to avoid alterations on fishe's health status, since a diagnosis of an epidemiological and sanitary situations are necessary to avoid the dissemination of parasites to other municipalities.

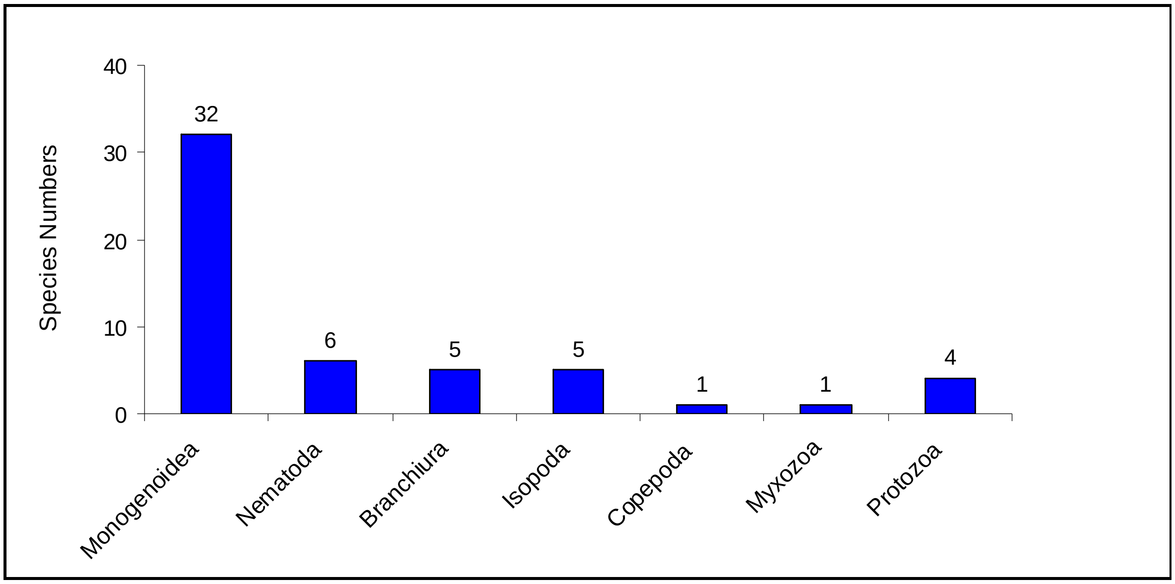

Figure 3. Number of parasite species described in ornamental fish species from Brazilian Amazonia

Parasites in five ornamental fish species kept in exporter's holding facilities from Amazonas State

Specimens of *Dianema urostriatum* (6.5 ± 1.3 cm and 6.0 ± 2.0 g), *Hyphessobrycon copelandi* (3.0 ± 0.7 cm and 0.7 ± 0.5 g), *Otocinclus* sp. (3.3 ± 0.5 cm and 0.9 ± 0.6 g), *Apistogramma* sp. (3.4 ± 0.5 cm and 0.9 ± 0.4 g) and *Paracheirodon axelrodi* (2.5 ± 0.2 cm and 0.3 ± 0.1 g) were collected from tanks of an exporter from Manaus municipality, Amazonas State, Brazil.

In this chapter, we assumed that mean relative dominance is the total number of parasites of each species divided by total number of parasites of all parasite species found (Rhode et al., 1995), prevalence is the number of parasitized fish divided by examined fish.100, and the mean intensity of infection is the total number of each parasite divided by parasitized fish (Bush et al., 1997).

These fish were kept in a density of 3,500 fish/m^3 and feed twice a day with an ornamental fish prepared ration containing 36.0% of crude protein. Upon their arrival at the exporter, the fish were submitted to treatments prophylactic with formalin and tetracycline. Moreover, fish were fed with a ration containing ivermectin. Every seven days a prophylaxis with these chemotherapeutants was carried out in the tanks. Fish that had arrived at the exporter and fish that maintained in tanks for seven days up to one year were treated.

Physical-chemistry parameters of water quality from the exporter's holding facilities tanks from Manaus (AM) are shown on Figure 4. The reported values are within the acceptable range for tropical fish health maintenance and production.

From a total of 218 fish submitted to necropsy, parasites were found in 132 (60.5%). In *D. urostriatum*, *P. axelrodi*, *H. copelandi*, *Otocinclus* sp. and *Apistogramma* sp., parasite prevalence was 60.5%, with the of *Ichthyophthirius multifiliis* Fouquet 1876, *Trichodina* Ehrenberg, 1838, *Henneguya* Thelohan, 1892, *Piscinoodinium pilullare* (Shäperclaus, 1954) Lom, 1981, Monogenoidea, Nematoda adult, Nematoda larvae, Digenea adult, Digenea metacercariae and Hirudinea *Placobdella* Blanchard 1893 (Table 2).

Prevalence and intensity of *I. multifiliis* on the gills of *P. axelrodi*, *H. copelandi* and *D. urostriatum* were similar, but was not found in *Otocinclus* sp. and *Apistogramma* sp. (Table 3). Dinoflagellate *P. pilullare* (called as velvet disease) was only observed on the gills of *P. axelrodi* and *H. copelandi* (Table 4), whereas *Trichodina* sp. varied from 2 to 30 parasites per host in *Otocinclus* sp (Table 5).

Monogenoidea parasites were present in all species with the lowest prevalence in *Apistogramma* sp. and the highest in *P. axelrodi* and *D. urostriatum*. However, *H. copelandi* and *Apistogramma* sp showed the lowest mean intensity of gill parasites (Table 6). The mean intensity of Monogenoidea was higher in *D. urostriatum* (8.2) and *Otocinclus* sp. (11.5) than that related in the other fish species (Table 6).

The lowest prevalence and intensity of adults Nematoda were observed in the intestines of *D. urostriatum* and the highest in *P. axelrodi* and *Apistogramma* sp. (Table 7). In addition, nematode larvae were also found in the intestines of *H. copelandi* (23.6%), *D. urostriatum* (3.3%) and *P. axelrodi* (10%), but in a few number varying from 1 to 6 helminths per host.

Similar prevalence and intensity of Digenea adults were observed in the intestines of *H. copelandi* and *Otocinclus* sp., whereas the lowest prevalence was found in *P. axelrodi.* These parasites were not found in *D. urostriatum* and *Apistogramma* sp. (Table 8). Metacercariae of Digenea was also observed in the gills of 8.0% of *H. copelandi* and 3.0% of *Apistogramma* sp. Twenty cysts of *Henneguya* sp. were found in the gills of a single specimen of *D. urostriatum*. Leeches of the genus *Placobdella* was found at 3.3% prevalence and one parasite per host on the body surface.

Relative condition factor of parasitized and non-parasitized fish did not show significant difference ($p>0.05$). There was also no significant correlation ($p>0.05$) between parasites intensity and Kn. Hence, these rates of parasites infections load did not compromise the fish health.

In summary, the most dominant parasite taxon was Monogenoidea followed by Nematoda. *Hyphessobrycon copelandi* was the host with the greatest parasite diversity while *Apistogramma* sp. was host with the smallest parasite diversity. Three days after the arrival of fish at the exporter they are weekly submitted to treatment with formalin and tetracycline. This procedure is done specially with *P. axeroldi*, the most exported species, which sometimes is kept in tanks up to one year in order to acquire a bigger corporal size and consequently, a better price in external markets. High prevalence of parasitism was found in fish species of exporter's holding facilities. However, the low mean intensity of parasites was influenced by chemotherapeutants and prophylactic management. Therefore, the concern with treatment and prophylaxis are of extreme importance for ornamental fish aquaculture.

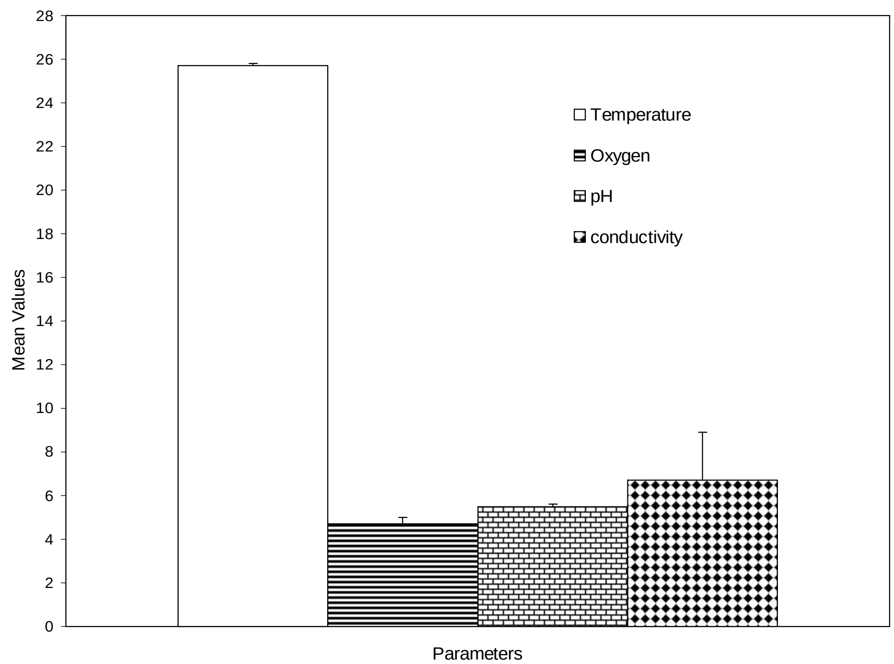

Figure 4. Mean values ± standard deviation of temperature (°C), pH, electric conductivity (µS/cm) and dissolved oxygen concentration (mg/L) of water in tanks of ornamental fish exporter in Manaus, Amazonas State.

Table 2. Parasitological indexes in five ornamental freshwater fishes from an exporter's holding facility in Amazonas state, Brazil.

Parasites	PF/EF	Prevalence (%)	TNP	Mean Intensity	Mean relative dominance
Monogenoidea	70/218	32.1	338	4.8	0.668
Nematoda adult	46/218	21.1	99	2.1	0.196
Nematoda larvae	18/218	8.2	131	7.3	0.259
I. multifiliis	12/218	5.5	50	4.2	0.098
Trichodina sp.	6/218	2.7	57	9.5	0.113
P. pilullare	5/218	2.3	18	3.6	0.035
Henneguya sp.	1/218	0.4	20	20.0	0.039
Digenea adult	10/218	4.6	16	1.6	0.027
Digenea metacercariae	3/218	1.4	77	25.7	0.152
Placobdella sp.	1/218	0.4	1	1.0	0.002
Total	132/218	60.5	807	-	-

PF/EF: Parasitized fish/examined fish; TNP: total number of parasites.

Table 3. Parasitological indexes of *Ichthyophthirius multifiliis* in the gills of five ornamental freshwater fishes from an exporter's holding facility in the Amazonas State, Brazil.

Parameters/Hosts	*P. axelrodi*	*H. copelandi*	*D. urostriatum*	*Otocinclus* sp.	*Apistogramma* sp.
Examined fish	89	34	30	32	33
Parasitized fish	7	3	2	0	0
Prevalence (%)	7.9	8.8	6.7	0	0
Total number of parasites	6	8	8	0	0
Mean intensity (MI)	4.9	2.7	4.0	0	0
Range of MI	1–9	2-3	4	0	0

Table 4. Parasitological indexes of *Piscinoodinium pilullare* in the gills of five ornamental freshwater fishes from an exporter's holding facility in the Amazonas State, Brazil.

Parameters/Hosts	*P. axelrodi*	*H. copelandi*	*D. urostriatum*	*Otocinclus* sp.	*Apistogramma* sp.
Examined fish	89	34	30	32	33
Parasitized fish	3	2	0	0	0
Prevalence (%)	3.4	5.9	0	0	0
Total number of parasites	6	12	0	0	0
Mean intensity	2.0	6.0	0	0	0
Range of MI	1–3	5-7	0	0	0

Table 5. Parasitological indexes of *Trichodina* sp. in the gills of five ornamental freshwater fishes from an exporter's holding facility in the Amazonas State, Brazil.

Parameters/Hosts	*P. axelrodi*	*H. copelandi*	*D. urostriatum*	*Otocinclus* sp.	*Apistogramma* sp.
Examined fish	89	0	30	32	33
Parasitized fish	3	0	0	6	0
Prevalence (%)	3.4	0	0	18.7	0
Total number of parasites	6	0	0	57	0
Mean intensity	2.0	0	0	9.5	0
Range of MI	1–3	0	0	2-30	0

Table 6. Parasitological indexes of Monogenoidea in the gills of five ornamental freshwater fishes from an exporter's holding facility in the Amazonas State, Brazil.

Parameters/Hosts	*P. axelrodi*	*H. copelandi*	*D. urostriatum*	*Otocinclus* sp.	*Apistogramma* sp.
Examined fish	89	34	30	32	33
Parasitized fish	38	8	12	11	1
Prevalence (%)	42.7	23.5	40.0	34.4	3.0
Total number of parasites	100	11	99	127	1
Mean intensity	2.6	1.4	8.2	11.5	1.0
Range of MI	1–6	1-2	1-21	5-17	1

Table 7. Parasitological indexes of Nematoda in the intestines of five ornamental freshwater fishes from an exporter's holding facility in the Amazonas State, Brazil.

Parameters/Hosts	*P. axelrodi*	*H. copelandi*	*D. urostriatum*	*Otocinclus* sp.	*Apistogramma* sp.
Examined fish	89	34	30	32	33
Parasitized fish	21	6	1	5	13
Prevalence (%)	23.6	17.6	3.3	15.6	39.4
Total number of parasites	50	7	1	10	31
Mean intensity	2.4	1.2	1.0	2.0	2.4
Range of parasites	1–14	1-2	1	1-6	1-3

Table 8. Parasitological indexes of Digenea in the intestines of five ornamental freshwater fishes from an exporter's holding facility in the Amazonas State, Brazil.

Parameters/Hosts	*P. axelrodi*	*H. copelandi*	*D. urostriatum*	*Otocinclus* sp.	*Apistogramma* sp.
Examined fish	89	34	30	32	33
Parasitized fish	1	4	0	5	0
Prevalence (%)	1.1	11.8	0	15.6	0
Total number of parasites	1	8	0	7	0
Mean intensity	1.0	2.0	0	1.4	0
Range of MI	1	1-4	0	1-3	0

Parasites of freshwater ornamental fishes from Southern Brazil

A survey of parasitic fauna on freshwater ornamental fishes from commercial supplier at the Florianópolis city, Santa Catarina State, Southern Brazil was performed by Piazza et al. (2006). A total of 18 fish species were examined for a period o one year. From a total of 189 fish examined, 75 (40.5%) were parasitized (Table 9). The highest prevalence rate (100%) was found in *Gymnocorymbus ternetzi*, *Paracheirodon innesi*, *Colisa lalia*, *Noemacheitus barbatulus*, *Pteprophyllum scalare*, *Helostoma temmincki* and *Mikrogeophagus ramirezi*. Intermediate values of prevalence were registered in *Xiphophorus helleri* (71%), *Poecilia sphenops* (40%), *Beta splendens* (50%), *Carassius auratus* (67%) and *Cyprinus carpio* (50%). *Trichogaster trichopterus*, *Poecilia reticulata*, *Macropodus opercularis* and *Pseudotropheus socolofi* were not parasitized. Parasites showed the following prevalences: Monogenoidea (15.7%), metacercariae of heterophyid digenean *Ascocotyle* sp. Looss, 1899 (15.3%), dinoflagellate *Piscinoodinium pillulare* (Schäperclaus, 1954) Lom, 1981 (7.0%), ciliate protozoans *Trichodina acuta* Lom, 1961 (4.9%) and *Ichthyophthirius multifiliis* Fouquet, 1876 (3.8%), cestodes (2.7%), camallanid nematode *Camallanus maculatus* Martins, Garcia, Piazza and Ghiraldelli, 2007 (2.7%); copepod crustacean *Lernaea cyprinacea* Linnaeus, 1758 (2.2%) and *Chilodonella* sp. Strand, 1928 (0.5%).

The majority of fish examined was parasitized by one parasite species, followed by two and three parasites. From four parasites per host species the occurrence was lower (Figure 5). The most dominant taxon of parasite was Digenea in metacercarial stage named *Ascocotyle* sp. followed by Monogenoidea (Table 10)

Digenean are endoparasites with complex life cycle generally found encysted in the muscle, nervous system, gonads, other internal organs or free in eyes (Pavanelli et al., 2002; Santos et al., 2002). Its main pathogenic action is when the fish act as intermediate host in which encysts causing tissue damage (Takemoto et al., 2004). Thus the metacercarial form is more aggressive than the adult worms. Metacercariae of *Neascus* sp. and *Clinostomum* sp., cause respectively black spot and yellow grub diseases and are important parasites to the ornamental fish industry by its location on the body surface or fins. According to Carvalho et al. (2008) 90% of *Geophagus brasiliensis* examined from the Peixe River, Juiz de Fora, MG, were parasitized with *Neascus* sp. At a mean intensity varying from 1 to 75 parasites. Kuo et al. (1994) registered prevalences of 0.9% *Clinostomum* sp. and 4% *Centrocestus* sp. in a survey realized in imported fish from China. Metacercariae of *Ascocotyle tenuicollis*, *A. nunezae* and *A. nana* were described from the heart, gills and viscera of *Poecilia petenensis*, *Cichlasoma meeki* and *C. octofasciatum* (Scholz et al., 1997). On the other hand, *Centrocestus* sp. was found encysted in the gill filaments of *Carassius auratus*, *Poecilia reticulata*, *Beta splendens*, *Xiphophorus variatus* and *Poecilia latipinna* (Tampieri et al., 1999) at 100% prevalence. It is important to emphasize that birds act as definitive hosts and snails as the first intermediate host (Scholz et al., 1997). In ornamental farms from Sri Lanka, Thilakaratne et al. (2003) observed low (0.8%) prevalence of *Centrocestus* sp. in *C. auratus*. In Brazil, Piazza et al. (2006), have reported infection rates of *Ascocotyle* sp. reaching 7,844 specimens in 29 infected fish with mean intensity varying from 1 to 1,070 parasites per host (Tables 10-11).

In comparison, the data here reported as prevalence and mean intensity are higher than that related in the literature. This is, in fact due to commercial supplier located in Southern Brazil that presents the appropriate condition for intermediate and definitive hosts to close the life cycle successfully.

On the other hand, Monogenoidea was found in 11 out of 18 analyzed fish species at a mean intensity varying from 2 to 60 parasites. They are among one the most important fish parasites causing economic losses in fish culture for consumption or ornamentals (Thoney & Hargis Junior, 1991). Their life cycle is direct or monoxenic without the involvement of intermediate host, and its pathogenicity is related to mechanical damage produced by attachment on the body surface or gills (Noga, 1995). Moreover, the water quality may present correlation with parasite number in which is characterized by a decrease in Monogenoidea number in elevated pH and electric conductivity conditions (Garcia et al., 2003). This is reinforced by the prophylactic method of salt addition (60 $g.m^{-3}$) in fish ponds as efficient practice to avoid parasitosis (Martins, 2004). Water temperature can constitute an important factor to control Monogenoidea reproduction. In *Gyrodactylus bullatarudis*, common parasite of *P. reticulata* the highest average fecundity was obtained at 25.5 °C while the highest birth rate of Monogenoidea was related at 27,5^{o}C (Scott & Nokes, 1984). In the Brazilian ornamental fish this effect has not yet been studied. From these data we can handle the water temperature to an increase or a decrease in the fecundity of Monogenoidea without affect the host health. In the studies of Piazza et al. (2006), the commercial suppliers where the fish was collected the water temperature was maintained at 28^{o}C favoring parasite's reproduction. The maximum Monogenoidea population increasing in guppies was reported at 27.5^{o}C (Scott & Nokes, 1984).

Prevalence of 15.3% Monogenoidea in *X. helleri* (Table 9) was higher than that related in *P. reticulata* (Dove & Ernst, 1998). Similar results were found by Garcia et al. (2003) in *X. maculatus* in the Northeast of the São Paulo State. These authors have registered 20 to 100% prevalence of *Urocleidoides* sp. (Monogenoidea) in fish at a mean intensity of infection varying from 1.7 to 16.8. This is the contrary to that observed by Piazza et al. (2006) with mean intensities from 27 to 60 parasites per host.

In the majority of examined fish the number of Monogenoidea was considered high in relation to body size. According to Thoney & Hargis (1991) 30 to 40 dactylogyrids may cause die in fish 3 to 4 cm length. After that, it can be concluded that the number of Monogenoidea between 27 and 60 parasites per host observed in the studies of Piazza et al. (2006) suggests fish health compromising and consequently economic losses.

Trichodinids are ciliated protozoan that might be opportunist ectoparasite with low host specificity, found on the body surface, fins and gills (Ghiraldelli et al., 2006). Its reproduction by binary fission allows the rapid reproduction (Mancini et al., 2000) and is directly related to high contents of organic matter in water (Moraes & Martins, 2004). They are among one of main etiological agents causing disease in cultured fish (Vargas et al., 2000; Martins et al., 2002). It must be commented on their host specificity. The capacity of trichodinids occurs or not in an especial host might be discussed and contested. For example, *T. heterodentata* is found in cichlid, cyprinid, gobiid and poecilid fishes as registered by Duncan (1977), Al-Rasheid (2000), Basson & Van As (1992, 1994) and Dove & O´Donoghue (2005). On the other hand, *T. sylhetensis*, *T. aplocheilusi*, *T. chittagongensis* was found respectively in *Nandus nandus*, *Aplocheilus panchax* and *Labeo bata* by Asmat et al. (2003) e Asmat (2005). On this way, the low host specificity of trichodinids can be contested according to published data. We can assume that exist variability in trichodinid host-specificity according to the environment quality in a fish farm and fish species.

Little information on trichodinid infestation in the Brazilian ornamental fish is found (Garcia et al., 2009). These authors related 54% *Trichodina* sp. in *Xiphophorus* spp. from ornamental fish farm in the State of São Paulo. Nevertheless, they argued that reduction in dissolved oxygen concentration and the addition of organic fertilizer favored the parasite reproduction. In fish commercialized in Florianópolis, SC, *Trichodina acuta* was found in *X. maculatus*, *X. helleri*, *P. sphenops*, *B. splendens*, *C. auratus* and *N. barbatulus* at a mean intensity of 1 to 31 parasites varying from 1 to 35 parasites per host (Piazza et al., 2006). According to Madsen et al. (2000) trichodinid infestation was divided in three categories: category 1 comprehending 1 to 10 parasites per host, category 3 comprehending 100 to 1,000 trichodinids per host. On the other hand, in the majority of analyzed fish the infestation was in category 2 (11 to 100 parasites per host). Trichodinid parasitism is directly related to water quality, high stocking density, temperature and organic pollution (Moraes & Martins, 2004; Ogut & Palm, 2005). These studies suggested high stocking density in aquaria as the most important source of infestation (Piazza et al., 2006). Consequently, its presence in a fish farm at a category 2 must be constantly monitored.

Dinoflagellate *P. pillulare* was found in five fish species (Table 8). Obligatory parasites that attach host cells provided by rizocysts (prolongation like roots), may cause petechial hemorrhages, integument hemorrhages, gill hyperplasia, lamellar fusion, and necrosis that frequently comes to severe mortality (Martins et al., 2001). First report in Brazil was in the State of São Paulo (Martins et al., 2001) in which caused mortality of 3,000 fish in 15 days of infection. The appearance of disease in ornamental fish is more evident than in cultured fish for consumption. Fish can show white spots on the body surface and fins compromising the commercialization.

The *I. multifiliis* (called as Ich), ciliate protozoan cause significant losses in ornamental fish culture (Thilakaratne et al., 2003). Ectoparasite of low host-especificity parasitizes the body surface or gills reaching 1 mm diameter. After definitive host a fish, comes down to substrate or aquarium botton in which develops in tomont and posteriorly in infective theront (Buchmann et al., 2001). In cultivated fish for human consumption they are found in a great number and/or prevalence because their reproduction is favored by climatic or water changes especially in temperate region (Garcia et al., 2009).

In studies with the hybrid *X. maculatus* x *X. variatus*, Clayton & Price (1988) did not observe nor influence of the host genus neither water temperature on the Ich parasitism. But, they argued that a genetic factor can be responsible for resistance.

Piazza et al. (2006) have reported *I. multifiliis* infestation in *X. maculatus*, *X. helleri* and *P. shenops* at a prevalence of 3.8%, different to that registered in *X. maculatus* and *X. helleri* (13%) in the State of São Paulo by Garcia et al. (2009). These authors commented that high electric conductivity of water reduced *I. multifiliis* infestation and the sodium chloride (salt) additioned to ponds water consists in efficient method for parasite control. Nevertheless, pH handling might be an efficient strategy for parasite control. Garcia et al. (2009) observed negative correlation between Ich and elevated pH of water in ornamental fish farm.

The nematode *Camallanus cotti* Fujita, 1927 was firstly related in freshwater fish from Japan (Fujita, 1927). Common parasite found in the intestines feeds of blood, tissue liquids or cells host. Heavy infection with a great number of nematode causes inflammatory reaction, anemia, sexual behavior changes and mortality, especially in shorter fish (Wu et al., 2007). This nematode is worldwide distributed allied to introduction of poecilid fish as ornamental fish or to control fly (Kim et al., 2002). In Brazil, *Camallanus acaudatus* and *Camallanus tridentatus* were described in *Osteoglossum bicirrhosum* and *Arapaima gigas* by Ferraz & Thatcher (1990). On the other hand, Martins et al. (2007) described *C. maculatus* in *X. maculatus* from a fish farm in the São Paulo State with a prevalence of 82.0%. In Florianópolis, Southern Brazil, Piazza et al. (2006), the nematode showed low prevalence (2.7%) in *X. maculatus* and *P. sphenops*. In experimental infection with camallanid larvae (*C. maculatus*) in copepod crustacean (*Notodiaptomus* sp.), Martins et al. (2007) found that 24 h after infection the larvae were located successfully in the hemocele of crustacean. This study showed the importance and feasibility of the uses of crustacean as a disease vector.

Xiphophorus maculatus was the unique fish parasitized by all parasites taxa (Tables 10-11) reaching 41% from the total examined fish. It is suggested that high number of *X. maculatus* analyzed provoked the difference in relation to other fish species. *Xiphophorus* species are, in fact, the most common and commercialized fish among the aquarists. Seven fish species were parasitized by one parasite taxon, followed by two and three parasite taxa. Multiple occurrences of parasite taxa (five or six parasites) were registered only in one host species. Prevalence rate of *I. multifiliis*, *T. acuta,* Monogenoidea and nematodes here observed was lower than those observed by Conroy et al. (1981). On the other hand, *Trichodina* sp., *P. pillulare*, *I. multifiliis*, Monogenoidea and digenean showed higher prevalence in comparison to findings of Kuo et al. (1994). The protozoans *I. multifiliis* and *P. pillulare* can proliferate if the water conditions are adequate. In this study, mean intensity of parasites it depended on the fish health status. Although *I. multifilis* is the most common parasite in ornamental fish culture but no case of severe infection was observed. Low prevalence (3.7%) of *I. multifiliis* was noted, being *X. maculatus*, *X, helleri*, *P. sphenops* affected fish. Contrarily to mean intensity of 98 parasites observed in *P. sphenops*, greater mean intensity (442.100 parasites) was reported in *Leporinus macrocephalus* (Tavares-Dias et al., 2001). Important factors can favor its reproduction as low water temperature, high stocking density and nutritional deficiency.

Lernaea cyprinacea is actually dispersed worldwide and in severe cases if infestation causes fish mortality and refuse of consumers (Martins et al., 2002). Gabrielli & Orsi (2000) registered the presence of *L. cyprinacea* in fish farms and Tibagi river, Paraná State. According their results, not only cultivated fish but also native fish from river are infested. This copepod has low host-specificity. In the studies of Piazza et al. (2006) lerneosis was related in 2.1% prevalence in *X. maculatus* and *P. sphenops* one parasite per host (Table 10). In molly (*Poecilia latipinna*) from India, Kumaraguru et al. (2006)

related for the first time in that country *L. cyprinacea*. Contrarily to that found in this study by Piazza et al. (2006), Kumaraguru et al. (2006) reported high infestation with 38 parasites in one female fish of 78 mm length. Fish susceptibility it depends on fish species and environment. In a survey of *L. cyprinacea* from aquarium fish, Shariff et al. (1986), observed higher susceptibility of *Helostoma temmincki*, an introduced fish, in which was infested for the first time. Santos & Brasil-Sato (2006) analyzing *Franciscodoras marmoratus* from the Upper São Francisco river observed copepodids of *L. cyprinacea* when fish were stocked before necropsy. They affirmed that parasitosis was dependent on the body size. On this view, greater fish was more parasitized than smallest. The importance of introduction and dissemination of lerneosis in varied aquatic systems especially in aquarium must be thought.

In summary, the most dominant parasite taxon in the studies of Piazza et al. (2006) was Digenea (larval stage) followed by Monogenoidea. The mean intensity of metacercariae and Monogenoidea was sufficient to cause prejudice to fish health. *Xiphophorus maculatus* was the unique fish species parasitized by 9 types of parasites. It can be concluded that inadequate prophylactic methods in fish farm favored the reproduction and dissemination of parasites in ornamental fish. In this study, the highest parasite prevalence was found by Monogenoidea in fish from the Amazonian region followed by nematodes. *Ichthyophthirius multifillis* and *Piscinoodinium pillulare* showed low prevalence rates in the analyzed fish. Sanitary handling must be considered to avoid diseased or asymptomatic fish introduction. This is, in fact, proved when analyzing *X. maculatus* and *X. helleri* as the most parasitized fish. For freshwater fish, Thoney & Hargis Junior (1991) suggested salt bath at 35 $g.L^{-1}$ for 10 minutes. It must be considered the fish tolerance to salt that vary depending on fish species and age. Ornamental and cultured fish maintained in ponds or tanks the addition of 60 $mg.L^{-1}$ sodium chloride for 8 to 12 hours with water circulation is recommended. This practice reduces the stress and avoids the parasite dissemination (Martins, 2004). Kumaraguru et al. (2006) found successfully control *Lernaea cyprinacea* infestation with 10 $g.L^{-1}$ in poecilid fish. Other practices must be commented as the constant water quality and fish health monitoring to verify changes responsible for parasite reproduction. Moreover, earth ponds for ornamental culture must be disinfected with lime to avoid reinfection as well as quarantine practice, certified fish by qualified professionals before and after transport. If these practices allied to technician, farmers and researchers integration the productivity and expansion of ornamental fish industry it reachs the best performance.

Table 9. Prevalence and mean relative dominance of parasites in freshwater ornamental fishes from Southern Brazil (Piazza et al., 2006).

Parasites	Parasitized fish /examined fish	Prevalence (%)	Mean relative dominance
Monogenoidea	29/189	15.3	0.052
Ascocotyle sp	29/189	15.3	0.907
Piscinoodinium pillulare	13/189	6.9	0.012
Trichodina acuta	9/189	4.7	0.012
Ichthyophthirius multifiliis	7/189	3.7	0.012
Cestoidea	5/189	2.6	0.002
Camallanus maculatus	5/189	2.6	0.001
Lernaea cyprinacea	4/189	2.1	0.000
Chilodonella sp	1/189	0.5	0.000

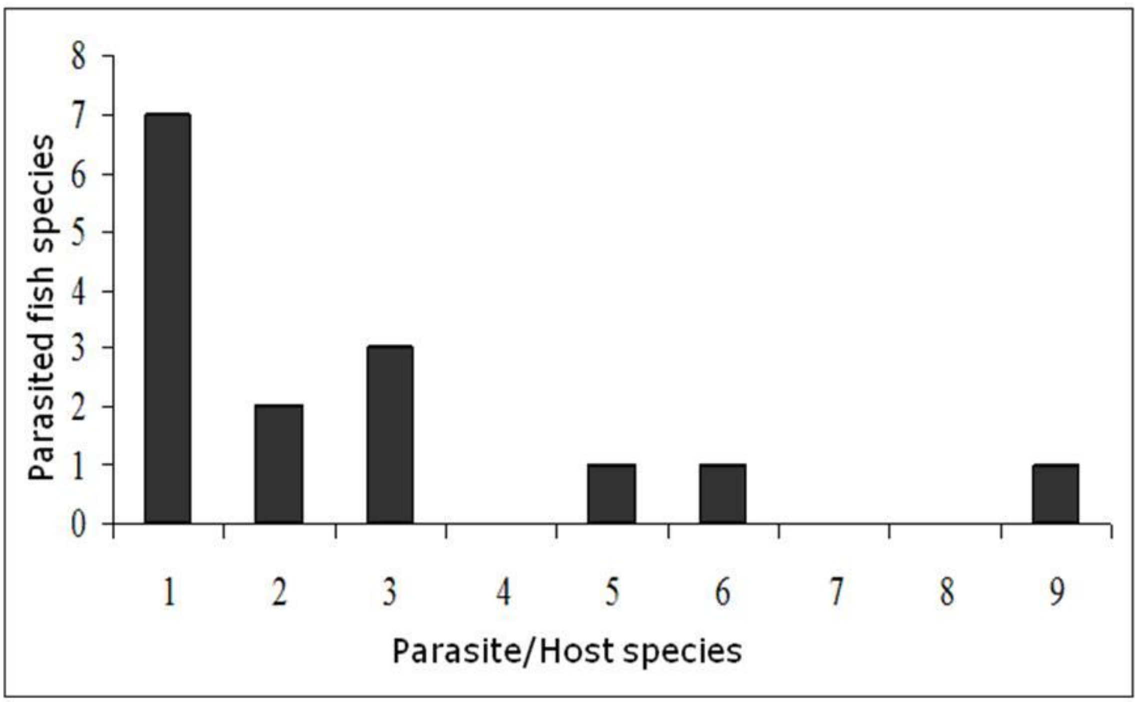

Figure 5. Relationship between freshwater ornamental fish species parasitized from Florianópolis, SC, Brazil, and number of parasite species.

Table 10. Distribution frequency of parasites in freshwater ornamental fishes from Florianópolis, Santa Catarina, Southern Brazil (Piazza et al., 2006).

Fish host	*T. acuta*	*I. multifiliis*	*Chilodonella*	*P. pillulare*	Monogenoidea	*Ascocotyle*	Cestoidea	*C. maculatus*	*L. cyprinacea*
X. maculatus	3	5	1	3	3	19	2	2	3
X. helleri	1	1	0	0	8	7	1	0	
P. sphenops	1	1	0	3	4	0	0	3	1
T. tricopterus	0	0	0	0	0	0	0	0	
B. splendens	2	0	0	0	2	1	0	0	
P. conchonius	0	0	0	0	0	0	1	0	
C. auratus	1	0	0	1	3	0	0	0	
G. ternetzi	0	0	0	0	4	1	0	0	
P. reticulata	0	0	0	0	0	0	0	0	
P. innesi	0	0	0	2	0	0	0	0	
M. opercularis	0	0	0	0	0	0	0	0	
C. carpio	0	0	0	0	1	0	1	0	
C. lalia	0	0	0	1	1	1	0	0	
N. barbatulus	1	0	0	0	0	0	0	0	
P. scalare	0	0	0	0	1	0	0	0	
P. socolofi	0	0	0	0	0	0	0	0	
H. temmincki	0	0	0	0	1	0	0	0	
M. ramirezi	0	0	0	0	1	0	0	0	
Total	9	7	1	10	29	29	5	5	4

Table 11. Mean intensity and range between parentheses in ornamental freshwater fish from Florianópolis, SC, Brazil, June 2004 through July 2005 (Piazza et al., 2006).

Fish host	*T. acuta*	*I. multifiliis*	*Chilodonella*	*P. pillulare*	Monogenoidea	*Ascocotyle*	Cestoidea	*C. maculatus*	*L. cyprinacea*
X. maculatus	10.3±12.7 (2-25)	2.0±1.73 (1-5)	3.0	7.0±9.5 (1-18)	2.0±1.0 (1-3)	335.0±365.3 (1-1070)	4.5±3.5 (2-7)	4.5±0.7 (3-4)	1.0
X. helleri	5.0	20,0	-	-	5.7±3.2 (1-10)	205.4±181.8 (80-313)	3.0	-	
P. sphenops	1.0	98,0	-	13.0±14.2 (2-29)	4,7±3,0 (1-8)	-	-	2.0±1.0 (1-3)	1.0
M. opercularis	-	-	-	-	-	-	-	-	
T. trichopterus	-	-	-	-	-	-	-	-	
B. splendens	31.0±5.7 (27-35)	-	-	-	31.5±16.3 (20-43)	2.0	-	-	
P. conchonius	-	-	-	-	-	-	4.0	-	
C. auratus	7.0	-	-	3.0	31.7±26.7 (1-50)	-	-	-	
G. ternetzi	-	-	-	-	27.7±28.1 (5-68)	1	-	-	

Parasites of cultured ornamental fish from the Brazilian Southeast region

Nowadays, most of Brazilian producers of ornamental fish have the aquaculture as the principal activity, in contrast of last decades (Fujimoto et al., 2006). Hence, ornamental fish export has emerged as an important activity generating foreign exchange for the three states of Southeast region (Figure 6), Rio of Janeiro (RJ), São Paulo (SP) and Espírito Santo (ES). From 2006 to 2007, these states exported US$ 418.572 in freshwater ornamental fish. In 2007, this production has increased 100%.

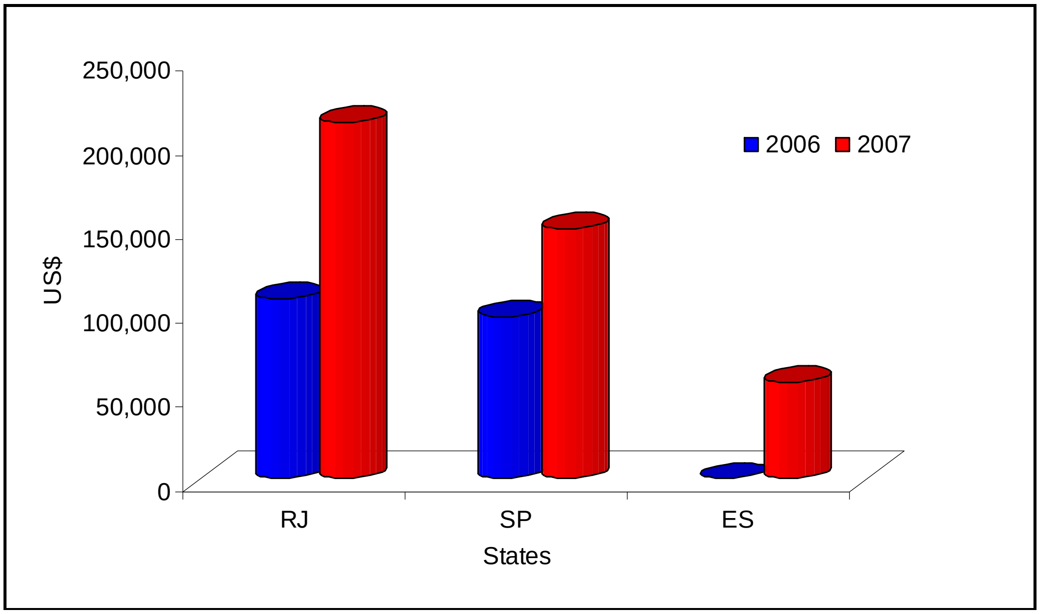

Figure 6.Production of freshwater ornamental fish in Rio of Janeiro (RJ), São Paulo (SP) and Espírito Santo (ES) States, in 2006 and 2007. Ibama (2008).

As the demand for cultured ornamental fish is increasing, consequently the parasitic infections can be one of the most impacting problems for cultured fish in Southeast region. In Brazil, few studies regarding parasitic infections of cultured ornamental fish exist (Piazza et al., 2006; Tavares-Dias et al., 2009). High Prevalence rates of metazoan parasites such as nematodes and Monogenoidea have been reported from cultured ornamental fish in fish farms or pet shop from Rio of Janeiro and São Paulo states (Table 12). However, in fish farms of other Brazilian states the infections rates are still unknown.

Ornamental fish in intensive culture are continuously affected by management practices such as handling, crowding, transport, poor water quality, and frequently provokes stress to fish, rendering them susceptibility to a variety of other parasites and pathogens. Infections by nematodes *Camallanus cotti* have been responsible for high mortality rate of *Poecilia reticulata*, in Rio of Janeiro fish farm (Alves et al., 2000). This mortality was due to the pathology caused by *C. cotti*, which includes microscopic lesions with hemorrhage, congestion, edema, extensive areas of erosion on the mucosa and rectum, with an enlargement of the intestinal walls, without the presence of inflammatory cells (Menezes et al., 2006). Moreover, metacercariae of *Clinostomum marginatum* (yellow-spot disease) have been found causing lesions on the fin of *P. scalare* (Alves et al., 2001).

Table 12. Ornamental fish parasites of intensive culture in Southeast region from Brazil.

Host fish	Parasites	P (%)	MI	Reference
Xiphophorus sp.	*Urocleidoides* sp.	100	6.6	Garcia et al.(2003)
Xiphophorus sp.	*I. mutifiliis*	22.2	1.5	Garcia et al.(2009)
Xiphophorus sp.	*Trrichodina* sp.	54.2	1.4	Garcia et al.(2009)
P. scalare	Monogenea	100	50	Fujimoto et al. (2006)
S. discus	*Dactylogyrus* sp.	-	-	Dambros (2007)
P. reticulata	*C. cotti*	93,4	4.0	Alves et al.(2000)
P. scalare	*Capillaria sp.*	100	~14	Fujimoto et al.(2006)
X. maculatus	*C. maculatus*	82	2.8	Martins et al.(2005)
P. reticulata	*C. cotti*	-	-	Menezes et al.(2006)
B. splendens	*C. cotti*	-	-	Menezes et al.(2006)
P. scalare	*C. marginatum*	-	1-93	Alves et al.(2001)

P= prevalence; MI= mean intensity.

Concluding Remarks

Parasitic infections represent an important challenge for ornamental fish, and that is undesirable in culture, same when in low intensity. High stocking density can also facilitate the rapid propagation of parasites, leading to the occurrence of severe diseases in the culture. Therefore, quarantine and prophylaxis are extremely important in the ornamental aquaculture, as well as in the exportation stage and hence must not be neglected (Tavares-Dias et al., 2009). Furthermore, if the tanks and nets are not properly disinfected, parasitic infections may easily spread to other fish species kept in tanks of the fish farm or handled with the same nets. Hence, any ornamental fish trade operated without appropriate practices causes significant economic losses for the exporter, as well as negative influence to exportation. As a result, the introduction of transmissible parasites may cause serious disease outbreaks.

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