

LABORATORY INFECTION COMPARISON OF THREE CATFISH SPECIES WITH *Ligictaluridus floridanus* (Monogenoidea: Dactylogyridae)

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ABSTRACT

This study looked at the prevalence, abundance, and mean intensity of the parasite *Ligictaluridus floridanus* (Monogenoidea: Dactylogyridae) in channel catfish (*Ictalurus punctatus*), hybrid catfish (*I. punctatus* x *I. furcatus*), and the striped catfish (*Pangasianodon hypophthalmus*), an exotic, non-local species. The channel catfish was the most susceptible to *L. floridanus* infection, followed by the hybrid catfish with a 100 % prevalence. The striped catfish was the least susceptible, and although the parasite was detected once, this species does not seem susceptible to long-term infection.

Keywords: non local fish, hybrid, infection, striped catfish.

INTRODUCTION

Ligictaluridus floridanus (Monogenoidea: Dactylogyridae) is a monogenean parasite that chronically infects the channel catfish (*Ictalurus punctatus*) (Rábago-Castro *et al.*, 2014), a fish native to North America that is commercially cultured in the United States and Mexico (Lara-Rivera *et al.*, 2015). Catfish crossbreeding is performed to induce hybrid vigor and positive heterosis. The cross of channel catfish x blue catfish (*I. punctatus* x *I. furcatus*) usually outperforms parental species in most environments (Argue *et al.*, 2014).

The striped catfish (*Pangasianodon hypophthalmus*), a fish native to the Mekong River, is now a significant component of the global whitefish supply due to its ease

of production (Griffiths *et al.*, 2010) and increased consumer popularity (Mendoza-Franco *et al.*, 2018); however, it is considered an exotic species, and its introduction into new habitats may endanger local fish populations. Its parasites have also been found in places where it has been introduced, including Poland (Wieczaszek *et al.*, 2009) and India (Chaudhary *et al.*, 2014). Striped catfish were first introduced in Mexico for ornamental aquaria, and their culture is a source of concern for fish farmers because no study has been conducted on the environmental impact of their introduction and that of their parasites into local wild habitats (Mendoza-Franco *et al.*, 2018). Many striped catfish found in the wild are escapees from ornamental ponds, fish farms, or aquarium fish waste dumps (Garcia *et al.*, 2018).

Intensive channel catfish production in Tamaulipas, Mexico, is primarily done in cage culture systems (Lara-Rivera *et al.*, 2015), where *L. floridanus* is prevalent (>85 %). This is problematic (Rábago-Castro *et al.*, 2011), as the chronic parasite's damage to the gill lamellae reduces the mean weight of channel catfish. Many monogeneans have been described for the Pangasiidae family in Southeast Asia (Pariselle *et al.*, 2003) and India (Tripathi *et al.*, 2014), and monogenean transfaunation, i.e., the exchange of fauna from an introduced species to a native one and vice versa, has been reported in Mexico between cichlids (Jiménez-García *et al.*, 2001), and even between different families in Cameroon (Bahanak *et al.*, 2022). However, while *L. floridanus* is common in channel catfish, its infectivity in hybrid or the non-local striped catfish is unknown. Thus, the goal of this study was to compare the susceptibility of two local catfish species (channel catfish, hybrid catfish) and a non-local catfish species (striped catfish) to experimental infection with *L. floridanus* under identical laboratory conditions.

MATERIALS AND METHODS

The experimental animals were cared for and used in accordance with the local Bioethics Committee of the Faculty of Veterinary Medicine of the Autonomous University of Tamaulipas. Seventy-five healthy fingerlings of each catfish species (channel, hybrid, and striped) were obtained and transported to the Aquaculture Laboratory at the Autonomous University of Tamaulipas (Ciudad Victoria, Mexico). Channel catfish were obtained from a local hatchery in Soto La Marina, Mexico; hybrid catfish were produced at the Technological University of the Sea of Tamaulipas Bicentennial (Soto La Marina, Mexico); and striped catfish were obtained from a pet store ("Acuario fish club," Guadalajara, Mexico). Fish were examined for the presence of parasites (Hoffman, 1999) before being randomly assigned to nine 40 L aquaria (n = 25 per aquarium), forming three groups based on the fish species, with three replicates each.

All fish were acclimated for two weeks and grown for 16 additional weeks to increase their size and weight before the experiment. They were fed a commercial 32 % protein feed (Purina®, Mexico) *ad libitum* until satiation without waste twice a day, six days a week. The water temperature was kept constant at 25.17±1.93 °C, the pH was 7.15±0.21, and the dissolved oxygen averaged 4.05±0.38 mg L⁻¹, as measured with a freshwater

kit (La Motte®, Charlestown, MD, USA). Subsequently, all fish were anesthetized, weighed, and measured before the infection trial. The mean \pm standard deviation (SD) weight and fork length of the catfish (CF) were as follows: channel CF (40.97 ± 5.83 g, 15.02 ± 0.55 cm), hybrid CF (8.90 ± 2.79 g, 8.90 ± 0.91 cm), and stripped CF (28.18 ± 4.47 g, 13.32 ± 0.51 cm).

In preparation for the experimental fish infection with *L. floridanus*, each 40 L aquarium was fitted with a mesh (0.5 cm^2) to create two compartments. Channel catfish infected with *L. floridanus* were obtained from a local farm (Abasolo, Tamaulipas, Mexico). Parasites on the infected fish were identified as *L. floridanus*, according to Hoffman (1999). Co-habitation was used to achieve monogenean infection (del Rio-Zaragoza *et al.*, 2011), with four channel catfish naturally infected with *L. floridanus* placed on one side of the mesh-divided aquarium and healthy fish on the other. Infected fish had an initial mean infection of 11.67 ± 8.69 parasites per gill arch and had no direct physical contact with the uninfected fish during the 14-day co-habitation.

The presence of parasites on healthy fish was monitored by sampling three fish from each aquarium every 48 h for a total of nine fish from each group during the 14-day co-habitation period. After euthanasia with an overdose (120 mg L^{-1}) of benzocaine and excision of the four left gill arches from each fish, parasite infection in the three groups was determined. Parasites were counted under a stereomicroscope with the gills placed in Petri dishes containing 0.65 % saline solution, and identification was confirmed. According to Bush *et al.* (1997) and Mladineo (2005), the mean parasite number per gill arch was determined, as well as the prevalence and mean intensity of *L. floridanus* (immature and adults).

Prevalence was assessed with the formula:

$$\text{Prev} = \frac{\text{Number of IF}}{\text{Number of EF}} \times 100$$

where Prev = prevalence; IF = infected fish; and EF = examined fish (infected and uninfected).

Mean abundance was calculated as:

$$\text{MA} = \frac{\text{Number of parasites found in EF}}{\text{Number of EF}} \times 100$$

where MA = Mean abundance; and EF = Examined fish (infected and uninfected).

Mean Intensity was measured with the following formula:

$$\text{MI} = \frac{\text{Number of parasites found in EF}}{\text{Number of EF}}$$

where MI = Mean intensity; EF = Examined fish (infected and uninfected); and IF= Infected fish.

Mean abundance and mean intensity of parasites were standardized per unit of body weight. The commercial software Statistica® was used to statistically process all of the data (StatSoft Inc., Tulsa, OK, USA). To meet ANOVA assumptions, data were transformed to the fourth root function when necessary for the normality test (Kolmogorov-Smirnov) and variance homogeneity test (Bartlett) (Zar, 1999). With the data obtained, a one-way ANOVA was performed, followed by a Tukey honestly significant difference post hoc test. Additionally, to determine if there was an association between the mortality (proportion of live and dead fish) and the host type (i.e., ictalurid species), a chi-square analysis of a 2 x 3 contingency table was carried out. A significance level (α) of 0.05 was utilized in all statistical tests.

RESULTS AND DISCUSSION

Ligistaluridus floridanus was detected in both channel catfish and hybrid catfish from day 2 post-cohabitation. In striped catfish, *L. floridanus* was detected only once in two fish on day 8 post-cohabitation, similar to *Enterogyrus malmbergi*, a parasite of African cichlids reported in a native Mexican cichlid (Jiménez-García *et al.*, 2021). Mortality rates for striped, channel, and hybrid catfish were 1.33, 7.11, and 10.66 %, respectively (Table 1). However, no significant association ($p > 0.05$) was found between fish mortality and the host type (i.e., ictalurid species).

The mean abundance of *L. floridanus* in channel catfish fluctuated throughout the experiment, ranging from 1.4 ± 0.41 to 2.8 ± 0.91 per g of fish body weight (fbw). In hybrid catfish, the abundance started low but increased at each sampling point, peaking at 10.19 ± 7.66 per g fbw on the last day. In striped catfish, mean parasite abundance was zero on all days except day 8, where it was 0.01 ± 0.02 per g fbw (Table 1). The mean abundance of parasites in striped catfish was significantly lower than in channel catfish and hybrid catfish, with no significant differences detected between the latter two species. This outcome was consistently observed throughout the experiment (from days 2 to 14 of the trial).

When analyzing the mean intensity of parasites, the channel catfish showed the highest mean intensity by day 2 (2.8 ± 0.91 per g fbw), while hybrid catfish had similar values to channel catfish during the first four days, increasing to 10.19 ± 7.66 per g fbw by day 14. However, no significant differences were observed throughout the experiment ($p > 0.05$). The striped catfish was excluded from this analysis due to the impossibility of calculating the parasite mean intensity, as the monogenean *L. floridanus* only infected a single fish throughout the experiment (particularly on day 8) (Table 1).

The preference of *L. floridanus* for channel catfish has been observed (Rábago-Castro *et al.*, 2014), as most monogeneans are strict host-specific parasites (Bahanak *et al.*, 2022). The observed infection rate appears to confirm the parasite's preference for channel

Table I. Average number of parasites per gill arch, prevalence, mean abundance, and mean intensity (\pm standard deviation) of *Ligictaluridus floridanus* during the infection trial in channel catfish (*Ictalurus punctatus*), hybrid catfish (*I. punctatus* x *I. furcatus*), and striped catfish (*Pangasianodon hypophthalmus*) at different sampling days.

Parameter	Day 0	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day 14
Channel catfish								
Parasites per gill arch	0	13.89 \pm 2.83	13.64 \pm 2.56	11.69 \pm 5.88	7.49 \pm 0.99	10.61 \pm 6.38	7.17 \pm 2.09	13.47 \pm 9.00
Prevalence	0 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Mean abundance per g fbw	0	2.80 \pm 0.91	2.73 \pm 0.84	2.27 \pm 1.43	1.58 \pm 0.32	2.02 \pm 1.16	1.40 \pm 0.41	2.52 \pm 1.33
Mean intensity per g fbw	N/A	2.80 \pm 0.91	2.73 \pm 0.84	2.27 \pm 1.43	1.58 \pm 0.32	2.02 \pm 1.16	1.40 \pm 0.41	2.52 \pm 1.33
Hybrid catfish								
Parasites per gill arch	0	2.08 \pm 1.42	3.25 \pm 1.24	4.47 \pm 1.25	5.39 \pm 3.86	4.86 \pm 0.74	6.97 \pm 5.29	9.56 \pm 3.88
Prevalence	0 %	89 %	100 %	100 %	100 %	100 %	100 %	100 %
Mean abundance per g fbw	0	2.31 \pm 2.28	2.95 \pm 0.64	4.07 \pm 0.36	6.19 \pm 6.45	4.53 \pm 0.91	8.07 \pm 8.80	10.19 \pm 7.66
Mean intensity per g fbw	N/A	2.40 \pm 2.18	2.95 \pm 0.64	4.07 \pm 0.36	6.19 \pm 6.45	4.53 \pm 0.91	8.07 \pm 8.80	10.19 \pm 7.66
Stripped catfish								
Parasites per gill arch	0	0	0	0	0.06 \pm 0.10	0	0	0
Prevalence	0 %	0 %	0 %	0 %	22 %	0 %	0 %	0 %
Mean abundance per g fbw	0	0	0	0	0.01 \pm 0.02	0	0	0
Mean intensity per g fbw	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A: not available because the denominator in the mean intensity formula (i.e., infected fish) is zero in some cases. The mean abundance and intensity of *L. floridanus* are reported per g of fish body weight (g fbw).

catfish, as well as the fact that hybrid catfish are equally susceptible to infection with this parasite, whereas striped catfish appear to be immune to persistent infection.

Translocation of fish and their parasites from their original biotope may endanger natural fish populations in importing countries, with disastrous consequences for native communities (Tompkins *et al.*, 2011). Transfaunation of parasites can occur from introduced to native species (Jiménez-García *et al.*, 2001). Monogenea are considered least probable species switchers, although some transfers between clariid and non-clariid fish have been reported in Cameroon (Bahanak *et al.*, 2022), while other transfers from African to American cichlids (and viceversa) have been reported in Mexico (Jiménez-García *et al.*, 2001). Although new Monogenea species have been reported from Pangasiidae (Pariselle *et al.*, 2001), as observed in this study, striped catfish does not appear susceptible to a sustained infection by *L. floridanus*, suggesting the non-transfaunation of this parasite from channel catfish to striped catfish. However, further studies are recommended.

CONCLUSIONS

The degree of infection among channel catfish, hybrid catfish, and striped catfish after experimental infection with *Ligictaluridus floridanus* varied greatly. The most susceptible

species is channel catfish, with a prevalence of infection of 100 % with medium to high intensity; in hybrid catfish, *L. floridanus* took slightly longer to reach 100 % prevalence, but once reached, it never decreased, exhibiting the highest abundance and mean intensity of parasites from six days after infection onwards. Striped catfish was the least susceptible to a sustained infection, and although *L. floridanus* was detected one time, had an infection prevalence of zero for the majority of the trial, and does not seem susceptible to long-term infection with *L. floridanus*.

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