Lat. Am. J. Aquat. Res., 45(2): 496-500, 2017
DOI: 10.3856/vol45-issue2-fulltext-25

Short Communication

The impact of *Neoechinorhynchus buttnerae* (Golvan, 1956) (Eoacanthocephala: Neochinorhynchidae*) outbreaks* on productive and economic performance of the tambaqui *Colossoma macropomum* (Cuvier, 1818), reared in ponds

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ABSTRACT. This study evaluates the impact of *Neoechinorhynchus buttnerae* on the productive and economic performance of "tambaqui" reared in ponds. Two fish farms were selected, one with infected fish (IF) and the other with non-infected fish (NIF). Biometry, age, initial weight and handling data were collected from each studied specimen. Our results show that IF presented lower weight, evident loss of body mass and body deformities, reflecting on a condition factor 300% smaller than NIF. Infection by acanthocephalans caused an impact bigger than 200% on growth and affected the gross income directly, resulting in a difference higher than 1000% between IF and NIF farms. We conclude that this impact could be even greater if we consider both income decrease and raising production costs due to the parasite infection.

Keywords: *Colossoma macropomum*, *Neoechinorhynchus buttnerae*, endoparasites, fish farm, gross revenue.

The Amazon fish "tambaqui" (*Colossoma macropomum*) is the principal native species reared in Brazil reaching a production increase of 90.3% with 139.21 ton in 2014 (IBGE, 2014). The success in the aquiculture of tambaqui is due to its high commercial value, great acceptance by consumers (Garcez, 2009), rapid growth especially during fingerling life stage (Villacorta-Correa, 1997), omnivorous feeding behavior (Claro *et al.*, 2004), physiological and anatomical adaptations to low oxygen environments and good growth when reared in high densities (Melo *et al.*, 2001).

The intensification of the pond production system of tambaqui allows the emergence of diseases in this species (Skinner, 1982; Lizama *et al.*, 2007) such as *Neoechinorhynchus buttnerae*, an obligate endoparasite found in the intestines of the fish (Santos *et al.*, 2013). *N. buttnerae* can cause intestinal obstruction and intestinal wall lesions that lead to the fish death (Martins *et al.*, 2001; Santos *et al.*, 2013). Although several studies have reported the occurrence of this parasite in *C. macropomum*, its impact on production systems was not quantified. Thus, this study aimed to evaluate the impact of *N. buttnerae* infection on the productive and economic performance of tambaqui farmed in lakes.

Two fish farms located in the metropolitan region of Manaus-AM, Brazil: farm 1 (2°42' 36,66"S, 59°52'08, 78"W) and farm 2 (2°36'19,27"S, 59°55'28,37"W), were selected for the present study containing non-infected (NIF) and infected (IF) *C. macropomum* with *N. buttnerae* of 210 and 240 days of age. Both farms had similar structures, management systems, and same fish origin and age. From each farm, two ponds were sampled totaling eight sampled points.

Farm 1 (with NIF) is located in a flat area on a side road with easy access but low traffic intensity; enabling the ponds to be more protected. The water supply for the ponds comes from a dammed area inside the property through water pump distribution to the nurseries. The water flow is controlled and independent between ponds. The water supply is only accessed to maintain an adequate water level; sporadic drainage and low water flow.

Corresponding editor: Andrés Abitia

Farm 2 (with IF) is also located on a side road with the nurseries in a flat area. The water supply for the ponds comes from a stream located inside the property also through water pump distribution. The ponds do not have drainage system. The replacement of the water occurs only for the maintenance of water level, consisting of a low-flow water system. Biometric data (weight in g and standard length in cm) were taken from 331 specimens (312 IF and 19 NIF). Moreover, additional data related to the age, initial weight and husbandry methods were obtained from the owners of the farm.

The biometric data was used to determined: average weight gain (g) = mean initial weight - mean final weight, and productivity = quantity of kilograms produced per square meter. Total weight and standard length data from the specimens were used to determine the length-weight relationship through the equation $P = a\ Cp^b$ (LeCren, 1951), where: P = total weight (g), Cp = standard length (cm), and a and b = the estimates of the regression parameters. In order to verify if weight increase was isometric or alometric, the slope values "b" from the regression were tested through the equation $t = (b\text{-}3)\ Sb^{-1}$ on a 5% level. The relative condition factor (K) was determined using the observed weight (Wo) and expected weight (We) ratio to a given length ($Kn = Wo\ We^{-1}$).

The collected fish were irreversibly anesthetized with eugenol diluted in water (80 mg L^{-1}) and killed by cerebral concussion. The intestinal tract was removed and opened lengthwise to quantify the parasites. The parasite load was determined by the parasite index: Prevalence (number of infected fish / total number of fish examined × 100) and mean intensity (total number of parasites /number of infected hosts) (Bush *et al.*, 1997).

T-Student test was applied to analyze the difference between the values of the zootechnical parameters and condition factor in the groups NIF and NI ($\alpha = 0.05$). To estimate the impact of the parasite on the company revenue, we first determined the tambaqui production for one hectare of water, considering the obtained biomass (g m^{-2}) on both properties and calculating the gross revenue (US\$ ha^{-1}), multiplying the production by the sales price (in April of 2017, 1US\$ = US\$ 3,133) in each fish farm, considering the impact of the parasite as the difference between: NIF-210 and IF-210 for 210 days of production, and NIF-240 and FI-240 for 240 days of production.

IF had the following clinical signs: cachexia, growth retardation, decrease of mucus production, dryness on the body surface and the skin became dull. Macroscopically, head and body size were disproportional and it was observed a considerable loss of muscle mass from the dorsal region. There was no mortality.

Figure 1. Intestine of *Colossoma macropomum* highly infected with Acanthocephalans.

The presence of *N. buttnerae* in the fish caused impacts on the growth, health, productive performance and revenue. *N. buttnerae* was present in all the IF (prevalence of 100%) with an intensity variation of 15 to 720 parasites per fish (mean = 152). *N. buttnerae* was present along the entire intestine (Fig. 1), occasionally forming nodules and luminal obstruction. NIF and IF had a b value of 2.52 and 2.19 respectively. It shows that NIF presented greater growth in weight than IF. IF health was widely affected, as these fish were thinner and with evident loss of body mass. In addition, IF presented deformed bodies (Fig. 2), reflecting on a condition factor 300% smaller than NIF (Table 1).

IF production was 592.89% and 293.52% smaller than NIF for 210 and 240 rearing days respectively. IF of 210 days of age did not reach the minimum commercial weight, therefore its revenue was considered zero. In order to IF possibly reach the minimum commercial weight of 400g (regionally called "curumim") and generate a higher production cost, a longer rearing time would be required. The price paid for the 400 g product does not exceed US\$ 0.96 kg^{-1} representing a decreased value of 66.7% compared to same aged fish. We observed a receipt of US\$ 1,286.82×ha^{-1} in IF at 240 days.

If we consider that these IF at 210 days reached the commercial value of US\$ 0.96 kg^{-1}, the producer would have a revenue of US\$ 613.66×ha^{-1}. Thus, the differences between IF and NIF would be US\$ 6,473.71×ha^{-1} and US\$ 7.100,05×ha^{-1} at 210 and 240 days, respectively. This result could represent an impact of 1,054.93% at 210 and 5,558.89% at 240 days.

Although eating normally, IF showed typical clinical signs of starvation. Most of the parasites were found adhered to the intestinal mucus and distributed throughout the entire tract. Several hosts had partial and

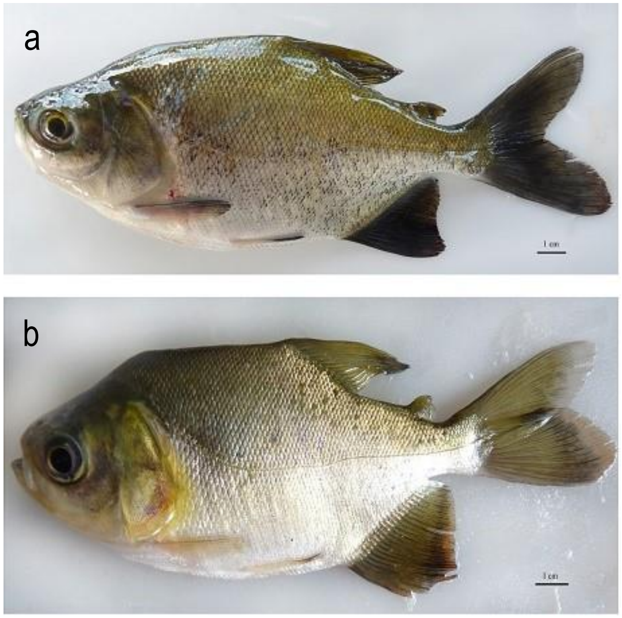

Figure 2. a) Infected and b) non-infected (below) *Colossoma macropomum* with Acanthocephala.

sometimes total luminal occlusion. Malta *et al.* (2001) described the first outbreak of massive *N. buttnerae* infection that resulted in economic loss of reared tambaqui in the state of Amazonas. After intensive reports in 2010 from Darpa/FINEP Project, acanto-cephalosis was considered the main sanitation problem affecting tambaqui in the northern region of Brazil. Jerônimo *et al*. (2016) also reported low growth performance of highly infected cachamas in aquiculture farms of Amazonas and Rondônia, Brazil.

In this study, we present the highest record of parasite intensity of *N. buttnerae* in tambaqui raised in intensive nursery system: 720 parasites in a single host (mean = 152). This infection rate was bigger than the values recorded by Malta *et al*. (2001) with 30 to 406 parasites per fish (mean = 125.6) and Jerônimo *et al*. (2016) with even higher values for the state of Amazonas (IM = 476) and with additional data from Rondônia (IM = 262) (Table 1).

According to Taraschewski (2000), representatives of the Phylum Acanthocephala do not present intestinal tract and this characteristic led them to develop a highly specialized syncytial epidermis for nutrients absorption. This epidermis is effectively permeable to sugars, amino acids, organic acids, ethanol, lipids, fats and soluble pigments interfering with the absorptive capacity of the host, and causing both functional and morphological changes in it (Crompton, 1970; Cheng 1974; Romer & Parsons, 1985).

Many studies have shown that acanthocephalans usually do not cause serious effects on the fish development in natural environments (Hine & Kennedy, 1974; Mayian, 1990; Williams & Jones, 1994; Ontaka, 2002). However, the tambaqui fish raised in an intensive production system in the State of Amazonas presented massive infections by acanthocephalan parasites. This parasitism caused great impact on the growth, productive performance and production cycle income. On the contrary to other parasitic diseases that cause loss of appetite and high mortality rates (Kabata, 1985), acantocephalosis had a larger impact because the fish survive, continue eating, but do not develop. We believe that the absorption efficiency of these parasites allow them to compete with the host for nutrients affecting the hygiene and consequently the development of the host. Our data reinforce this hypothesis by showing a large difference in mean weight between IF and NIF for 210 days (1150 g) and 240 days (1099 g). Cavero *et al*. (2009) reported that tambaqui in the same rearing conditions and time interval (210 and 240 days) presented, respectively, average weights of 1,350 g and 1,581 g. These values were higher than those from this present study. However, evaluating the tambaqui farming

Table 1. Productive, sanitation and economic indicators of infected (IF) and non-infected (NIF) tambaqui of fish farms in Amazonas-Brazil, January 2014 (1US$= US$ 3,133). *Significant difference between FI and FNI ($P < 0.05$)

Indicators	NIF - 210	IF - 210	NIF - 240	IF - 240
Condition factor	7.94 ± 0.26	2.43 ± 0.09*	7.85 ± 0.12	2.64 ± 0.21*
Parasitic intensity	-	103.25 ± 105.55	-	152.5 ± 69.99
Average standard length (cm)	36.90 ± 2.11	16.65 ± 1.88*	37.17 ± 1.60	24.46 ± 2.37*
Average final weight (g)	1,285.44 ± 277.49	134.57 ± 42.19*	1,499.67 ± 213.39	400.30 ± 109.34*
Average weight gain (g)	1,284.94 ± 277.49	133.97 ± 42.25*	1,499.17 ± 213.40	399.40 ± 109.35*
Average density (fish m^{-2})	0.35	0.48	0.35	0.33
Biomass (g m^{-2})	444.06	64.08*	524.88	133.38*
Production (kg ha^{-1})	4,440.63	640.82*	5,248.83	1,333.77*
Retail price (US$ kg^{-1})	1.60	0.00	1.60	1.12
Revenue (US$ ha^{-1})	7,087.37	0.00	8,337.30	1,490.11

farming with aerators, Castro *et al*. (2002) showed that the average weight of the fish was 543.25 g at 210 days and 727.87 g at 240 days. Our study shows that due to the lack of knowledge on sanitation conditions in tambaqui populations infected with acantocephalosis, the farm producer continues to feed the fish regularly leading to reduction of feed conversion efficiency and raising production costs. In addition, cost increase, especially input costs, related to the income decrease suggests that the parasite impact might be even greater than what was evidenced in this research.

The fish were subjected to similar husbandry conditions such as handling and environmental conditions. The difference in growth performance and revenue activity can be attributed to the high level of parasitic infection. The massive infection by acanthocephalans presented an impact larger than 200% on fish growth reflecting directly on the gross revenue activity and presenting a difference >1000% between FI and NIF. The way that the parasite acts suggests that its impact on the decreased revenue and increased production costs can be even greater. However, more studies will be necessary to show the real impact of this parasite in the revenue and costs of fish production.

ACKNOWLEDGMENTS

The authors are grateful for the financial support from DARPA/FINEP-Desenvolvimento da Aquicultura e dos Recursos Pesqueiros na Amazônia and Programa de Inovação Tecnologica-UFAM/FAPEAM.

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Received: 8 September 2016; Accepted: 8 February 2017