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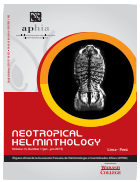

ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

EFFECTS OF WATER PARAMETERS IN MONOGENEANS OF *MYLEUS SCHOMBURGKII* (PISCES: SERRASALMIDAE) FARMED IN THE PERUVIAN AMAZON

EFECTOS DE LOS PARÁMETROS DEL AGUA EN MONOGENEOS DE *MYLEUS SCHOMBURGKII* (PISCES: SERRASALMIDAE) CULTIVADO EN LA AMAZONÍA PERUANA

Anai P.P. Flores Gonzales[1,2*]; Gloria Pizango[3]; Christian Fernández-Méndez[2]; Patrick Mathews[4] & Marcos Tavares-Dias[5]

[1]Universidade Federal do Amapá (UNIFAP), Programa de Pós-Graduação em Biodiversidade Tropical (PPGBio), Rodovia Juscelino Kubitschek, s/n, Universidade, CEP 68903-419, Macapá, AP, Brazil.
[2]Instituto de Investigaciones de la Amazonía Peruana, Programa para el Uso y Conservación del Agua y sus Recursos-AQUAREC, Carretera Iquitos Nauta km 4,5, apartado 784, Iquitos, Loreto, Perú.
[3]Universidad Nacional de la Amazonía Peruana (UNAP), Facultad de Ciencias Biológicas-Acuicultura, Laboratorio de Hidrobiología, Sargento Lores 385, Iquitos, Perú.
[4]Universidade Estadual de Campinas-UNICAMP, Departamento de Biologia Animal, Instituto de Biologia, Avenida Bertrand-Rusel, s/n, 13083-865 Campinas, SP, Brazil.
[5]Embrapa Amapá, Rodovia Juscelino Kubitschek, km 5, 2600, CEP 68903-419, Macapá, AP, Brazil.
Corresponding author: E-mail: anaigonzalesf@gmail.com (+5596-991325890)

ABSTRACT

Myleus schomburgkii Jandine & Schomburgk, 1841 is a fish species distributed in regions of South America. It has great economic importance for the exports generated as ornamental fish. However, little is known about the presence of monogeneans in this fish. The aim of this study was to investigate the monogenean parasites in farmed *M. schomburgkii* and the correlation with the physical and chemical parameters of water. A total of 30 fish cultured in an earthen pond were examined and the main physical and chemical parameters of the water, such as temperature, oxygen and pH were measured. The prevalence of monogeneans was 100%, with presence of *Notozothecium bethae* Kritsky, Boeguer & Jégu, 1996 and *Anacanthorus* sp. and 7,312 parasites were collected. However, *N. bethae* was the most prevalent and abundant parasite. Positive correlation was found between the temperature, dissolved oxygen of the water and the abundance of monogeneans, while no correlation was detected between the abundance of monogeneans and pH of the water. Therefore, the infection by monogeneans was influenced by physical and chemical parameters of cultivation water. This was the first study on parasites in farmed *M. schomburgkii* in relation to the physical and chemical parameters of water in the Peruvian Amazon

Keywords: Correlation - fish farm - infection - parasites - temperature

RESUMEN

Myleus schomburgkii Jandine & Schomburgk, 1841 es un pez con distribución en regiones de América del Sur. Presenta gran importancia económica por las exportaciones generadas como pez ornamental; sin embargo, poco se conoce sobre la presencia de monogeneos en este pez. El objetivo del presente estudio fue investigar los parásitos monogeneos en *M. schomburgkii* cultivados y la correlación con los parámetros físicos y químicos del agua. Se examinó un total de 30 peces cultivados en estanque de tierra donde se midieron los principales parámetros físicos y químicos del agua, como temperatura, oxígeno y pH. La prevalencia de monogeneos fue 100%, con la presencia de *Notozothecium bethae* Kritsky, Boeguer y Jégu, 1996 y *Anacanthorus* sp. un total de 7312 parásitos fueron colectados. Todavía, *N. bethae* fue el parásito más prevalente y abundante. Se observó correlación positiva entre la temperatura, oxígeno disuelto del agua y la abundancia de monogeneos, no encontrándose correlación significativa entre la abundancia de monogeneos con niveles de pH del agua. Por tanto, la ocurrencia y abundancia de monogeneos fue influenciada por los parámetros físicos y químicos del agua. Este es el primer estudio sobre parásitos en *M. schomburgkii* con relación a los parámetros físicos y químicos del agua en la Amazonía peruana.

Palabras clave: Correlación - piscicultura - infección - parásitos - temperatura

INTRODUCTION

Myleus schomburgkii Jardine & Schomburgk, 1841, is a freshwater fish of the family Serrasalmidae, and distributed in the Amazon of Brazil, Venezuela, Colombia and Perú (Lasso *et al.*, 2004; Camargo & Giarrizzo, 2007; Ortega *et al*., 2010). It is an omnivorous fish and has migratory habits related to the availability of food such as zooplankton, seeds, and fruits, and has a dark transversal band that makes it striking as an ornamental fish (Santos *et al*., 2006). It is marketed internationally by the extractive fishing from the Amazon. For this reason, it has been cultivated under an experimental system with the purpose of developing technological packages that help in its development and production under controlled conditions (García-Ayala *et al*., 2012).

Farmed fish are more susceptible to invasion by parasitic agents due to unfavorable environmental conditions that can reduce fish defenses, altering the homeostasis, making fish more sensitive and less resistant to pathogens (Luque, 2004; Delgado *et al*., 2014). One of these agents that could damage the farmed fish are the monogeneans, and studies have shown the effect of water parameters, mainly the temperature on infection levels of parasitized fish (Crespo *et al*., 1992; Koskivaara, 1992; Bagge & Valtonen, 1996; Poulin, 2006; Martins *et al*., 2014). However, there are little studies on parasites in farmed *M. schomburgkii*. Gonzales *et al.* (2016) reported that 100% infection by *Notozothecium bethae* caused 37.5% mortality in farmed *M. schomburgkii*, while 100% prevalence of *N. bethae* did not cause any mortality of this host (Fernandez-Mendez *et al*., 2015), but no study has investigated the effects of water parameters on parasitic infection. Thus, the present study aimed to investigate the effects of water parameters on the presence of monogeneans in farmed *M. schomburgkii* in the Peruvian Amazon.

MATERIAL AND METHODS

Fish and culture conditions

A total of 30 juveniles of *M. schomburgkii* were examined with an average weight of 115.0 ± 20.8 g, total length of 17.1 ± 1.3 cm, cultured for 90 days in an earthen pond (9 m^2 and 1 m depth), in a fish farm of the Instituto de Investigaciones de la Amazonía Peruana (IIAP). Fish were fed an extruded commercial diet with 22% crude protein; often twice a day (08:00 and 16:00 h). The measurements of the physical and chemical parameters of the water (temperature, oxygen and pH) were made

three times a day (07:00, 12:00 and 16:00 h) using an oximeter (YSI, Model 55) and a pH meter (Oakton, Model 110).

Procedures for collecting and analyzing parasites

Fish skin samples were obtained by scraping the body with a spatula and were placed on glass-slides. Samples of fins (caudal, anal, dorsal and ventral) and gills were obtained and mounted on glass-slides with a drop of water to maintain the viability of the monogeneans (Jerônimo *et al*., 2011). The samples obtained were observed under a microscope (Leica Microsystems model DM750, IL, USA). Parasites were collected, counted and prepared for identification according to Eiras *et al.* (2006). Taxonomic identification was performed using keys of Scholz & Kuchta (2005) and Thatcher (2006).

Analysis and interpretation of data

The ecological terms (prevalence, mean intensity and mean abundance) used were those recommended by Bush *et al.* (1997). The Pearson correlation coefficient (r) was applied to check for possible correlations between the abundance of monogeneans and the physical and chemical parameters of the water, with the statistical software "Sigma Plot 11"

Ethic aspects

This is study was approved by the Ethics Committee on the use Animals of Embrapa Amapá (CEUA/CPAFAP N° 014).

RESULTS

In a total of 30 *M. schomburgkii* examined, 100% had the gills infected with Dactylogyridae) *Anacanthorus* sp. (Fig. 1) and *Notozothecium bethae* Boeger & Kritsky, 1988 (Fig. 2), and 7,312 parasites were collected. *Notozothecium bethae* had higher prevalence and abundance compared to *Anacanthorus* sp. (Table 1).

The values of the physical and chemical parameters of water are listed in Table 2. Also, when performing correlations between the abundance and water parameters, a significant positive correlation ($p<0.05$) of temperature and oxygen with the abundance of monogeneans was found, indicating that the water temperature and oxygen increase the abundance of monogeneans in *M. schomburgkii*. However, no significant correlation ($p>0.05$) was detected between the pH of the water and the abundance of monogeneans (Fig. 3).

Table 1. Parasitic indexes in farmed *Myleus schomburgkii* in the Peruvian Amazon. EF: Examined fish, PF= Parasitized fish, P: Prevalence, MA: Mean Abundance, MI= Mean Intensity, TNP: Total Number of Parasites, SD= Standard Deviation.

Monogenean species	EF/PF	P (%)	MA ± SD	MI	TNP
Anacanthorus sp.	30/10	33.3	19.9 ± 115	59.9	599
Notozothecium bethae	30/30	100	223.8 ± 33	223.8	6713

Table 2. Physical and chemical water parameters monitored during 90 days of culture of *Myleus schomburgkii* in the Peruvian Amazon.

Parameters	Mean ± SD	Minimum - Maximum
Temperature (°C)	29.3 ± 0.8	27.5 – 30.8
Oxygen (mg/L)	3.5 ± 1.1	1.4 – 5.5
pH	6.7 ± 0.1	6.3 – 7.0

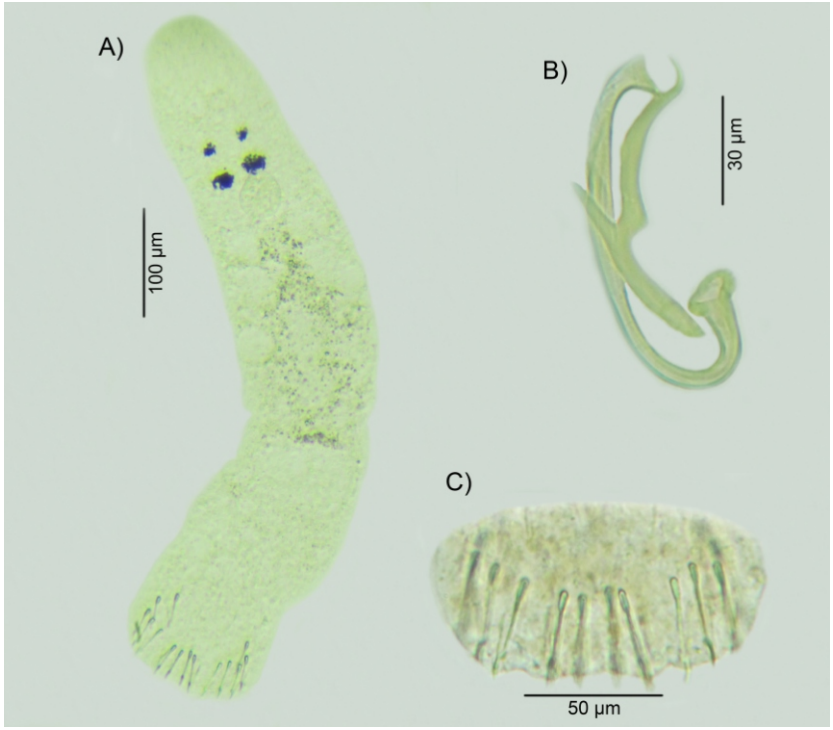

Figure 1. Specimens of *Anacanthorus* sp. (A) in *Myleus schomburgkii* from Peruvian Amazon. Male copulatory organ (B). Haptor (C).

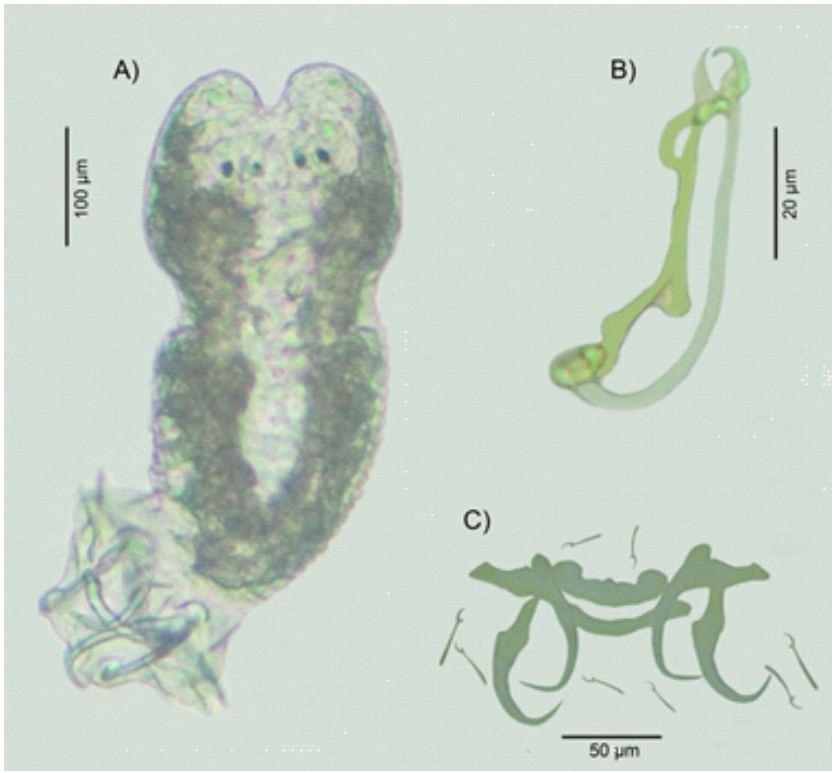

Figure 2. Specimens *Notozothecium bethae* (A) in *Myleus schomburgkii* from Peruvian Amazon. Male copulatory organ (B). Haptor (C).

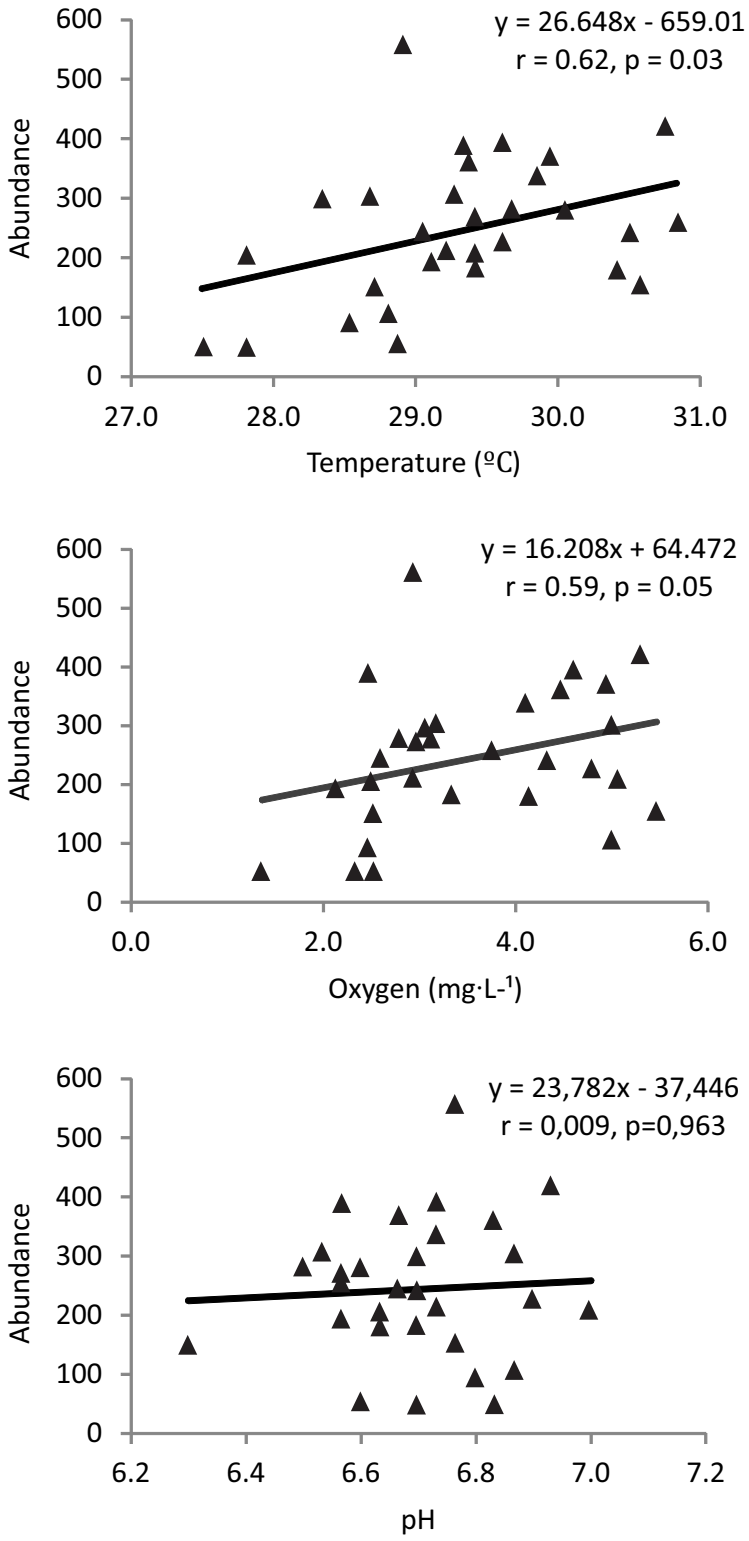

Figure 3. Relationship between the physical and chemical parameters of the water and the abundance of monogeneans in *Myleus schomburgkii* from Peruvian Amazon.

DISCUSSION

In *M. schomburgkii*, the absence of monogeneans in the skin and fins is possibly due to the specificity of the parasites by infection site. Often, Gyrodactylidae species prefer the skin and fins of hosts, while Dactylogyridae species prefer the gills of hosts (Thatcher, 2006). Monogeneans through receptors select their habitat (skin or gills) in hosts, and this selection of infection sites may be influenced by amino acids, fatty acids, carbohydrates, vitamins and minerals, which are used by these parasites to continue their life cycle (Buchmann *et al*., 2002). In addition, both *N. bethae* and *Anacanthorus* sp. show differences ability to infest hosts closely related, such as the same order, family, genus and species. There are reports of these monogeneans parasitizing *Myleus rubripinnus* Müller & Troschel, 1844; *Myleus pacu* Jardine, 1841; *Myleus rhomboidalis* Cuvier, 1818; *Mylesinus paraschomburgkii* Jégu, Santos & Ferreira, 1989; *Mylesinus paucisquamatus* Jégu & Santos, 1988 and *Colossoma macropomum* Cuvier, 1816 (Fischer *et al*., 2003; Scholz & Kuchta, 2005; Thatcher, 2006).

Mortality of 37.5% of *M. schomburgkii* with 100% of prevalence and high mean intensity of *N. bethae* was reported (Gonzales *et al*., 2016). However, infection in 100% of *M. schomburgkii* in the present study, caused by *N. bethae* and *Anacanthorus* sp., did not compromise the survival of hosts. Similar results were reported by Fernández-Méndez *et al.* (2015) for 100% of *M. schomburgkii* infected with *N. bethae*. Possibly, this survival of fish hosts is associated directly with the host-parasite-environment interaction; often these three factors interact with each other, in order to remain stable in the environment (Crespo *et al*., 1992). According to studies (Thatcher, 2006; Santos *et al*., 2013), unlike *N. bethae*, the species of *Anacanthorus* have greater pathogenicity in the host, causing serious injuries and depending on the level of infestation, can cause reduced respiratory capacity of hosts. Nevertheless, Centeno *et al*. (2004) observed high prevalence and abundance of *Anacanthorus spathulatus* Kritsky, Boeger & Van Every, 1992 in *Colossoma macropomum*; however, the fish showed no apparent signs of disease or mortality.

The physical and chemical parameters of water play an important role in the physiological development of fish, and high variations can cause stress (Verján *et al*., 2001; Pulido & Iregui, 2008). In this study, values of the physical and chemical parameters of the water were similar to those reported for another study with farmed *M. schomburgkii* (García-Ayala *et al*., 2012), which showed parameters within the optimum ranges for fish farming. Some parameters of water quality can also influence the reproduction of monogenean species in fish (Mooney *et al*., 2008). Studies show that the temperature directly influences infection levels of monogeneans, since the increase in abundance occur when the temperature increases (Crespo *et al*., 1992; Koskivaara, 1992; Martins *et al*., 2014).

In *M. schomburgkii* of the present study, the increase in temperature and oxygen levels favored the *N. bethae* and *Anacanthorus* burden, without the fish manifesting any sign of apparent disease, that is, there was a balanced relationship between the host, parasite and environment (Crespo *et al*., 1992; Verján *et al*., 2001). The temperature of the water directly affected *Dactylogyrus* spp., by stimulating its development and reproduction, and indirectly, by changing the host immune resistance and leading to an increase in parasitic abundance at higher temperatures (Koskivaara, 1992). Marchiori *et al.* (2015) studied the effect of temperature of water on oviposition, hatching and infestation of *Aphanoblastella mastigatus* (Suriano, 1986) Kritsky, Mendoza-Franco & Scholz, 2000 and concluded that the number of adult monogeneans was greater at 24°C than at 28°C. In addition, they showed that there was no difference in oviposition rate and the total number of eggs between these temperatures. In *Anguilla rostrate* Lesueur, 1817 the abundance and prevalence of *Pseudodactylogyrus anguillae* (Yin & Sproston, 1948) Gusev, 1965 was also positively correlated with temperature and pH of the water (Barker & Cone, 2000). In *Carassius carassius* Linnaeus, 1758, infection by *Dactylogyrus anchoratus* (Dujardin, 1845) Wagener, 1857 varied according to season, and reached its highest values when the water temperature increased (Aydogdu, 2006). Crespo *et al*. (1992) reported significant relationship between water dissolved oxygen levels and monogenean abundance, the same behavior observed in the present study. *Cyprinus*

carpio Linnaeus, 1758 farmed with lower oxygen content in water had the highest infection by *Dactylogyrus vastator* Nybelin, 1924 and died first when compared to non-parasitized fish that survived the longest, what would reflect that certain factors impair the natural resistance of fish (Molnár, 1994).

In our study with *M. schomburgkii*, there was no correlation between the pH of the water and the abundance of *N. bethae* and *Anacanthorus* sp., because the values of this parameter were stable throughout the fish culture. Studies have investigated the variation in water temperature and pH in controlling parasite species such as *Ergasilus celestis* Kabata, 1988 (Barker & Cone, 2000). However, to control these environmental parameters in fish farming, the tolerance of the fish species must be considered; and so far, these studies are scarce in fish of the Amazon region (Mathews *et al*., 2018). Future studies need to be developed in the use of environmental parameters for parasite control as an ideal alternative to using chemicals.

To conclude, moderate infection with *N. bethae* and *Anacanthorus* sp. was observed on the gills of *M. schomburgkii*. Therefore, as the temperature and dissolved oxygen levels of water tends to increase the abundance of monogeneans in hosts, it is important to control these parameters in fish farming.

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