EFFICIENCY OF BRAZILIAN NATIVE ORNAMENTAL FISHES AS MOSQUITO LARVAE PREDATORS

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ABSTRACT

Fish are an alternative in mosquito biological control. Some species are proven to be effective in many countries, but are Brazilian native. Brazilian species may be larvivorous but this lacks information. Therefore, the widely used exotic species, Poecilia reticulata and Betta splendens, were compared with the Brazilian species Hyphessobrycon eques and Pterophyllum scalare for their efficiency as Aedes aegypti mosquito larvae feeders. Fifty mosquito larvae were offered to the fishes (n = 20) and after five minutes the remaining larvae were counted. Betta splendens ingested the largest larval amount but when this value was divided by fish weights, P. reticulata was the species with the highest intake per gram. Brazilian native species did not differ from B. splendens in the ingestion per weight rate. Thus, it is concluded that the most efficient larvivorous fish was P. reticulata, but the Brazilian species showed a larvivorous potential, with fewer impacts on biodiversity.

Keywords: Aedes aegypti; angelfish; jewel tetra; larvivorous fish; mosquito control

EFICIÊNCIA DE PEIXES NATIVOS BRASILEIROS COMO PREDADORES DE LARVAS DE MOSQUITOS

RESUMO

Peixes são uma alternativa no controle biológico de mosquitos. Algumas espécies são comprovadamente eficientes em muitos países, porém não são nativas brasileiras. Espécies brasileiras podem ser larvófagas, porém há carência de informações. Portanto, foram comparadas as espécies exóticas geralmente utilizadas, Poecilia reticulata e Betta splendens, com as espécies brasileiras, Hyphessobrycon eques e Pterophyllum scalare, por sua eficiência como predadoras de larvas do mosquito Aedes aegypti. Foram oferecidas 50 larvas do mosquito para os peixes (n = 20) e, após cinco minutos, as larvas restantes foram contabilizadas. Betta splendens ingeriu a maior quantidade de larvas, mas quando esse valor foi dividido pelo peso dos peixes, P. reticulata foi a espécie com maior ingestão por grama. As espécies nativas não diferiram de B. splendens na taxa de ingestão por peso. Conclui-se que o peixe mais eficiente foi P. reticulata, mas as espécies brasileiras apresentaram potencial como larvófagas, com menores impactos na biodiversidade.

Palavras-chave: Aedes aegypti; acará-bandeira; mato-grosso; peixes larvófagos; controle de mosquitos

Scientific Note/Notas Científica: Recebida em 11/11/2016 – Aprovada em 10/03/2017

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INTRODUCTION

An efficient and responsible method to control Aedes aegypti is needed. The mosquito transmits zika, chikungunya and dengue, and its distribution is alarmingly increasing throughout the urbanized areas in the world (BHATT et al., 2013; MESSINA et al., 2015; AI et al., 2016; NDEFFO-MBAH et al., 2016). This is happening as a consequence of the increase of suitable places for laying their eggs (BENTLEY and DAY, 1989), its rapid growth and higher population densities (EISENSTEIN, 2016). The chemical control, despite being efficient (VAN DEN BERG et al., 2012), is a weapon against the environment, because it pollutes the air and the water while suppressing non-target species and causing diseases in humans (HEMINGWAY and RANSON, 2000). This requires the search for alternative and efficient control means which has fewer impacts on the environment.

Biological control by fishes is not a new proposal, however it was forgotten during time even though its efficiency has been proven in other opportunities in several places (WU et al., 1987; FLETCHER et al., 1993; NAM et al., 2000; LARDEUX et al., 2002; MARTÍNEZ-IBARRA et al., 2002). For the success of the mosquito control, the fishes used must be larvivorous, which are defined as small fish capable to easily move between thick weeds to reach the suitable places where mosquitoes lay their eggs (JOB, 1940). Other characteristics are defined, such as toleration to rough handling and transportation, short and prolific life cycle, surface carnivorous feeding habits with preference for mosquito larvae and non-impactant for the local fish community (CHANDRA et al., 2008).

Some ornamental fish species are used as larvivorous species (CHAPMAN, 1974; KUMAR and HWANG, 2006; CHANDRA et al., 2008). Despite their efficiency, in Brazil they are not native species, and this is considered a misguided strategy because it negatively affects native populations (AZEVEDO-SANTOS et al., 2016). Thus, the main objective was to evaluate the efficiency of Brazilian native ornamental fishes as predators of A. aegypti larvae, comparing with two of the most used species for mosquito control.

MATERIAL AND METHODS

Animals and stock conditions

The species tested were guppy (Poecilia reticulata), betta (Betta splendens), jewel tetra (Hypheossobrycon eques) and angelfish (Pterophyllum scalare). All the species, except for the guppies, were obtained in a commercial establishment. In pilot surveys conducted in a coastal city of the State of São Paulo, in Brazil, was verified that the wild guppies had a larger size than the fish bred in captivity, which is why the wild animals were chosen for this study. They were collected in a water channel of São Vicente, São Paulo, Brazil, using baited traps to avoid physical injury to the animals. The A. aegypti larvae were achieved through partnership with the São Vicente Regional Service of the Endemics Control Superintendence (SUCEN SR-2). The larvae were born in laboratory conditions from an A. aegypti population with no contact with the natural environment. The adults laid their eggs in traps placed inside the cages, and these eggs were hatched until the larvae reached the IV instar.

The animals were stocked in three 45 L tanks (one for each species) with controlled temperature (25.0 ± 1.0 °C), pH (6.8 ± 0.3) and dissolved oxygen (>5.00 mg L⁻¹) and fed ad libitum with commercial feed. The bettas, due to their aggressiveness with conspecifics (JOHNSON and JOHNSON, 1973), were stocked in individual 6 L aquaria under the same conditions as the others. All animals remained at least two weeks in stock conditions prior to the tests to exclude effects of capture or transport. The larvae were collected and immediately used in tests.

This study was approved by the UNESP IB/CLP Animal Use Ethics Committee (CEUA-UNESP/CLP) under the protocol number 24/2016.

Experimental design and procedures

Were used 20 fish of each species, randomly chosen from the stock populations, weighed them and placed individually in 6 L aquaria without visual contact with the outside, totaling 20 samples per species. The temperature was maintained constant at 25.0 ± 1.0 °C. The acclimation period occurred during 24 hours in which individuals were not fed, so that when
testing started, the animals were in fasting conditions.

The test consisted in offering the animals, at once, 50 stage IV larvae of *A. aegypti* and, five minutes later, the fish were removed from the aquaria and all the remaining larvae were accounted. This period was chosen based on a pilot experiment in which the predation occurred mostly during the first five minutes after the food presentation.

**Statistical analysis**

After testing normality with Shapiro-Wilk test and homoscedasticity with Levene’s test and having both confirmed, the amount of ingested larvae by each fish species was compared using analysis of variance (ANOVA), followed by Tukey’s HSD, as well as the number of ingested larvae per gram of fish. Statistical differences were set at \( p<0.05 \).

**RESULTS AND DISCUSSION**

Siamese fighting fish ate more larvae (29.50 ± 11.24; number of larvae ± standard deviation) than all other species (Figure 1; \( p<0.05 \)). Angelfish ingested 13.84 ± 13.02 larvae; guppies ate 5.78 ± 4.63 larvae and jewel tetras consumed 2.39 ± 3.18 larvae.

However, when the values are considered proportionally to the fish weights, the most efficient species in larval ingestion was the guppy (Figure 2; \( p<0.05 \)), ingesting 2.05 ± 1.10 larvae per gram. The other species did not show statistical differences; betta ingested 1.94 ± 0.53 larvae per gram; angelfish, 1.25 ± 0.86; and jewel tetra, 0.85 ± 0.95 larvae per gram.

![Figure 1. Number of Aedes aegypti larvae ingested by Brazilian native (jewel tetra – *Hyphessobrycon eques* and angelfish – *Pterophyllum scalare*) and non-native (*Guppy – Poecilia reticulata* and Betta – *Betta splendens*) ornamental fish species. Different letters indicate statistical differences between species \( (p<0.05) \).](image1)

![Figure 2. Amount of Aedes aegypti larvae ingested by the weights of Brazilian native (jewel tetra – *Hyphessobrycon eques* and angelfish – *Pterophyllum scalare*) and non-native (*Guppy – Poecilia reticulata* and Betta – *Betta splendens*) ornamental fish species \( (N \ g^{-1}) \). Different letters indicate statistical differences \( (p<0.05) \).](image2)

The Brazilian native ornamental fish species are suited to be used in mosquito control programs. Both *H. eques* and *P. scalare* were efficient, and their use would not cause great damages to local fish populations. Even though they do not consume the highest amounts (Figure 1), the proportions of larvae ingested by their weights are similar of *B. splendens* (Figure 2). In this case, the native species have an advantage over the Siamese fighting fish, because they group in shoals (CARVALHO and DEL-CLARO, 2004; GÓMEZ-LAPLAZA and GERLAI, 2011) while *B. splendens* tends to be aggressive with other fishes (BRADDOCK and BRADDOCK, 1955; JOHNSON and JOHNSON, 1973). Consequently, a large group can eat a higher amount of larvae compared with a single individual.

The species with the greatest efficiency to capture mosquito larvae is *P. reticulata* because it showed the highest larvae ingestion relatively to
the body weight and also groups in shoals (SEGHERS, 1974). The guppy is less effective than the most widely used species for mosquito control, Gambusia affinis (CHANDRA et al., 2008; SARWAR, 2015), but the latter does not breed well in tropical environments (SARWAR, 2015). Nevertheless, individual guppies are able to consume up to 102 larvae per day, and females are more efficient than males (SENG et al., 2008). The use of non-native species to control another invasive species such as A. aegypti is not recommended by the World Health Organization (WORLD HEALTH ORGANIZATION, 2003). This is considered to be a threat to native biodiversity by reducing or negatively affecting local populations (AZEVEDO-SANTOS et al., 2016), even when they are efficient mosquito larval predators (EL-SABAAWI et al., 2016). In some places native fishes are already proven to be more effective than introduced species, as in Australia (RUSSELL et al., 2001; LAWRENCE et al., 2016), India (RAO et al., 2015), Iran (SHAHI et al., 2015) and Mexico (MARTÍNEZ-IBARRA et al., 2002).

Therefore, although the use of non-native fishes in mosquito control programs in Brazil is succeeded (LIMA et al., 2010), the use of jewel tetra and angelfish as mosquito larvae controllers should and must be encouraged, since they can be effective mosquito larval predators and are Brazilian native species. Another alternative to reduce the number of introduced fishes into the environment is the integrated use of different methods along with the fishes (ARAUJO et al., 2015; SARWAR, 2015; CAIXETA et al., 2016). Some chemicals already used for controlling A. aegypti in low and environmentally safe concentrations tend to reduce the mosquito infestation, such as pyriproxyfen (CAIXETA et al., 2016) and spinosad (PEREIRA et al., 2016). Moreover, reduced doses of silver nanoparticles synthesized with Someratia alba extracts can boost the larval predation by P. reticulata (MURUGAN et al., 2017). Future studies are needed to assess the Brazilian native species sensitivity to chemical larvicides and support their use in integrated programs.

ACKNOWLEDGEMENTS

Authors thank Lumi Peixes and SUCEN for the fish and larvae used in this work. Also Dr. Alessandra Pereira Majer for statistical advising.

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