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Influence of aquatic plants on the predation of *Piaractus mesopotamicus* larvae by *Pantala flavescens*

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ABSTRACT. The experiment aimed to study the influence of the aquatic plants *E. najas*, *P. stratiotes* and *S. auriculata* on the predation of *P. mesopotamicus* larvae by *P. flavescens*. One hundred and twenty larvae of *P. mesopotamicus* and 24 larvae of *P. flavescens* were placed in 24 aquariums with capacity of 12 L, with one Odonate per aquarium. Treatments were different regarding the species of aquatic plants *E. najas*, *S. auriculata* and *P. stratiotes*, with one control treatment without aquatic plants. One aquarium (12 L) containing one Odonate and 30 *P. mesopotamicus* larvae was considered one experimental unit. After 18 hours, the Odonates were removed from the aquariums and fish larvae left (alive) were counted in each experimental unit. The survival rate of *P. mesopotamicus* larvae in the treatment without aquatic plants (control) was significantly lower than in the treatment with *E. najas*. However, the survival rates in the aquariums with floating aquatic plants did not differ from the control. The morphological characteristics of *E. najas* promoted higher structural complexity in the environment, offering more protection to the fish larvae, and increasing their survival. We concluded that the presence of the submerged aquatic plant *E. najas* promoted the reduction of predation of *P. mesopotamicus* larvae by *Pantala flavescens*.

Key words: larvae, *Piaractus mesopotamicus*, *Pantala flavescens*, predation, aquatic plants.

RESUMO. Influência de macrófitas aquáticas na predação de larvas de *Piaractus mesopotamicus* por *Pantala flavescens*. O experimento teve como objetivo estudar a influência de macrófitas aquáticas na predação de larvas de peixe *P. mesopotamicus* por larvas de *P.* flavescens Foram utilizadas 720 larvas de *P. mesopotamicus* e 24 larvas de *P.* flavescens, distribuídas em 24 aquários com volume útil para 12 L, sendo colocada uma larva de Odonata por aquário. Os tratamentos diferiram quanto à espécie de macrófita *E. najas* (E), *S. auriculata* (S) e *P. stratiotes* (P) sendo mantido um tratamento controle (C) sem macrófitas. Um aquário contendo uma larva de Odonata e 30 larvas de *P. mesopotamicus* foi considerado uma unidade experimental. Após 18 horas do início do experimento, as Odonatas foram retiradas dos aquários e foi realizada a contagem das larvas de peixe remanescentes (vivas) em cada unidade experimental. A taxa de sobrevivência das larvas de *P. mesopotamicus* no tratamento sem macrófita (controle) foi significativamente menor quando comparada ao tratamento contendo a macrófita submersa *E. najas.* Entretanto o valor de sobrevivência nos aquários com macrófitas flutuantes não diferiu do controle. As características morfológicas da *E. najas* promoveram uma maior complexidade estrutural no ambiente, gerando um maior numero de abrigos para as larvas de peixe, aumentando assim a sobrevivência das mesmas. Conclui-se que a presença da macrófita aquática *E. najas* promove redução na predação das larvas de *P. mesopotamicus* por larvas de *P. flavescens*.

Palavras-chave: larvas, *Piaractus mesopotamicus*, *Pantala flavescens*, predação, macrófitas aquáticas.

Introduction

Aquatic plants play an important role in the structure and functioning of aquatic ecosystems (THOMAZ et al., 2005). Recent studies in Brazilian reservoirs showed a positive relationship between the diversity of fish species (AGOSTINHO et al., 2003; PELICICE et al., 2005) and the richness of aquatic macro- and microinvertebrates (LANSAC-TÔHA et al., 2003; TAKEDA et al., 2003), and biomass, cover or diversity of aquatic plants.

Aquatic insects have been considered important predators of fish larvae in natural environments (McCORMICK; POLIS, 1982; LOUARN; CLOAREC, 1997). Young Odonates have an important role in the dynamics of aquatic ecosystems and are considered one of the main predators of the littoral zone of lakes (SOTO; FERNÁNDES-BADILLO, 1994; LOUARN; CLOAREC, 1997; MARCO JR. et al., 1999), acting as predators of other invertebrates and fish larvae (SOARES et al., 2001).

According to McGrinty (1980), Odonate larvae of *Pantala* sp. were responsible for the consumption of all catfish larvae (*Ictalurus punctatus*), when stored in tanks without chemical control. However, in tanks with chemical treatment, the survival of *Ictalurus punctatus* larvae was around 85%.

Few studies assessed the influence of Odonates in fish larvae survival, especially with Brazilian species. Since predation and starvation are considered the main agents of larval mortality, predation can act as a determinant mechanism on the recruitment of many fish species (GERKING, 1994; PARADIS et al., 1996).

There are many variables that can influence the predation of fish larvae by predators. Turbidity, food availability, eyes and swimming capacity, nutritional condition of larvae, water flow and growth rate of the larvae are among the factors considered important to ensure high survival rates (NORCROSS; BECK, 1984; NAKATANI et al., 2005). The habitat complexity, often related to increasing diversity, may influence the survival of some species of fish in the early stages of development, during which many species use the coastal region as the main area of residence.

Van De Meutter et al. (2004) called attention to the areas occupied by aquatic plants where, according to the authors, the density of Odonate larvae and the total predation rates per unit area can be higher than in open water. Therefore, greater understanding of the various biotic and abiotic factors is necessary.

Fish larvae represent the most critical phase to the success of the species, and are different from the adults in regards to their ecological requirements. Thus, knowledge of this phase is essential to understanding self-ecology and population dynamics (NAKATANI et al., 2001), which can assist in the implementation of measures for management and conservation of the fauna under anthropological impacts.

The objective of this study was to evaluate the influence of aquatic plants *Egeria najas*, *Pistia stratiotes* and *Salvinia auriculata* on the predation of *Piaractus mesopotamicus* larvae by *Pantala flavescens*.

Material and methods

The experiment was conducted at the Aquaculture Laboratory of the Biology Department at State University of Maringá (UEM), from December 2005 to February 2006.

We used 720 larvae of pacu (*P. mesopotamicus*) obtained from regional fingerling producers by artificial fertilization, in the pre-flexion phase. Twenty-four larvae of Odonate (*P. flavescens*) were also used.

To obtain the Odonate larvae, we used seven fiberglass pools (six with 120 L volume and one with a 1,000 L volume) installed outside for adults of Odonate to lay eggs. The pools were washed, supplied with water and fertilized with chemical fertilizer (NPK-7:14:8), and were also inoculated with plankton to promote the availability of food for the developing larvae. Forty days after fertilization, Odonate larvae were collected with the help of a net with 1 x 1 mm mesh size and a hand net with a diameter of 25 cm and 1 mm mesh. The Odonates were selected according to size and separated into homogeneous lots to be used in the experiment.

We used 24 larvae of Odonates, measures of ocular lens, and selected individuals with sizes between 12.83 and 14.33 mm. The size of Odonates used was based on the results found by Soares et al. (2001) and their availability. Larvae were distributed in 24 aquariums with 12 L water volume, one Odonate per aquarium. The experiment was conducted in a randomized design with four treatments and six replications. The treatments differed in species of aquatic plants (*E. najas*, *P. stratiotes* and *S. auriculata*) and their presence or absence. The aquariums were installed in two iron shelves, supplied with water from an artesian well and under constant lighting with fluorescent lamps of 25 watts at 45 cm from the bottom of the aquarium. An aquarium containing one Odonate and 30 fish larvae (*P. mesopotamicus*) was considered an experimental unit.

The pH, electrical conductivity and dissolved oxygen were measured at the beginning and end of the experiment by means of Bernauer digital devices. A mercury thermometer was used to measure temperature.

The Odonates were placed in aquariums one hour before the pacu larvae; this moment was considered the beginning of the experiment. After 18h, the Odonates were removed from the aquariums and fish larvae remaining (alive) in each sampling unit were counted. As control, we used four aquariums, each representing a treatment, but without the presence of Odonates.

The aquatic plants used in the experiments were obtained from the floodplain of Parana river and kept in water tanks, with a volume of 1000 L, in the Laboratory. To be used in treatments, the aquatic plants was selected by size, washed in running water and weighed, to ensure each replication produced similar biomass of aquatic plants species. In each experimental unit, the area occupied by aquatic plants for each treatment was approximately 50% of the aquarium, and was defined by visual criterion. The analyzed variable was the number of prey consumed.

Data of fish larvae consumption by larvae of Odonates and the physical and chemical parameters of water were tested by statistical analysis using Multivariate analysis of variance (MANOVA) and analysis of variance (ANOVA) by protected ANOVA protocol. In cases of statistical difference, the Tukey test was used at 5% probability.

Results and discussion

The average values of physical and chemical variables of water showed no statistical difference ($p > 0.05$) between them, and remained in an appropriate range for the development and metabolism of organisms used in this experiment (EGNA; BOYD, 1997) (Table 1).

Table 1. Mean values of physical and chemical variables of water in the aquariums with different aquatic plants and control.

Treatment		Dissolved Oxygen ($g L^{-1}$)	Electrical condutivity ($\mu S mS^{-1}$)	pH	Temperature (°C)
Control	beginning	5.44	0.15	7.24	24.00
	end	5.14	0.14	7.32	23.75
E. najas	beginning	5.36	0.15	7.23	24.00
	end	4.02	0.14	7.29	23.75
S. auriculata	beginning	4.18	0.14	7.25	24.00
	end	4.15	0.14	7.28	24.00
P. stratiotes	beginning	4.16	0.14	7.24	24.00
	end	3.83	0.15	7.21	24.00

The survival rate of *P. mesopotamicus* larvae in the control treatment (without aquatic plants) was significantly lower ($p < 0.05$), compared to the treatment containing the submerged species *E. najas* (Figure 1). However, the value of survival in aquariums with floating species (*P. stratiotes* and *S. auriculata*) did not differ ($p > 0.05$) from the control. No significant differences ($p > 0.05$) were observed between the values of survival in the treatments with submersed and floating species.

Being submerged, *E. najas* has differentiated morphology in relation to other species (*S. auriculata* and *P. stratiotes*), classified as floating. While the floating species present only the root system submerged, submerged species grow fully into water, often occupying the entire water column and thus may have more structural complexity in the environment they are found.

The lower survival rate of *P. mesopotamicus* larvae in the absence of aquatic plants (control), when compared to the values found with the presence of *E. najas*, is probably related to the fact that this species occupy the water column and provides more shelters for the fish larvae, hindering the visualization of *P. mesopotamicus* larvae by Odonates, reducing the frequency of occurrence of encounters between predator and prey.

According to Boyd (1971) and Barko et al. (1986), aquatic plants act as important components of lakes, rivers and other water bodies, providing shelter for spawning and protection of young stages of aquatic organisms. Van De Meutter et al. (2004) remember that the density of Odonate larvae can be greater in environments with aquatic plants, making the total predation rates per unit area larger than in open water. In this study, under experimental conditions, with the same space and density of prey and predators, the presence of aquatic plants had a positive impact on the survival of prey.

Pacu larvae consumed by Odonates in the control treatment (mean = 16.4 ind) was higher than that found by Soares et al. (2001) studying the predation of *Simocephalus serrulatus* larvae by *Pantala* sp., even with the use of a density five times higher, but with two predators per experimental unit. According to Houde (2002), predation is the main factor controlling the population growth rate of most species of fish that have high fertility. This author argues further that even small changes in mortality in the larval stage can cause changes of great magnitude in the recruitment of populations. Thus, according to data obtained in the experiment, aquatic environments with the presence of *E. najas* can influence positively the survival of fish larvae, reducing predation by Odonate larvae and encouraging the recruitment of the fish species.

Although *P. mesopotamicus* larvae of treatments with *E. najas* and *P. stratiotes* had survival values 15.8 and 8.0% respectively (Figure 1), higher than those found in the control treatment, no statistically significant difference ($p > 0.05$) between the results was found. A possible explanation for the lack of significantly different results between the treatments is the high variance found in the data, which must be related to the biology of the Odonate larvae, with changes in food consumption during development, as reported by Soares et al. (2001). Thus, individuals with the same size can have a wide variation in consumption rates by the proximity of the exchange of the exoskeleton (molt).

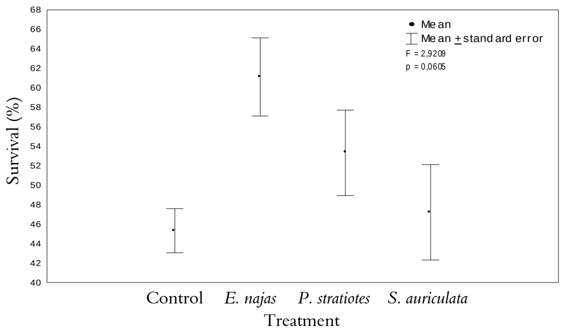

Figure 1. Survival rates of *P. mesopotamicus* larvae in aquariums with larvae of *P. flavescens* and different aquatic plants.

Many studies have shown the importance of environmental heterogeneity in the trophic dynamics of communities. Pioneering studies such as Smith (1972) and Crowley (1978) show that increasing the structural complexity of habitat leads to reduced predatory efficiency, generating stability to predator-prey interactions. This stability contributes to another characteristic attributed to increased heterogeneity, the high diversity. The importance of spatial heterogeneity on the coexistence of predators and prey has been demonstrated mathematically (HASSELL; MAY, 1974) and experimentally (HUFFAKER, 1958; PIMENTEL et al., 1963; HARDMAN; TURNBULL, 1974).

Data found in this study showed that the predatory efficiency of *P. flavescens* was reduced with the increasing structural complexity of the environment. These results contribute to the trophic current theories and studies for greater understanding of behavioral mechanisms of predation and population dynamics. The results also draw attention to the important role of aquatic plants in their natural habitat, which, among other desirable characteristics, showed under experimental conditions great potential for favoring juvenile fish, thus contributing to the maintenance of diversity in aquatic communities.

Conclusion

We concluded that the presence of *Egeria najas* promoted the reduction of predation of *P. mesopotamicus* larvae by *Pantala flavescens*.

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