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On line version of this paper is available from:

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Received/ Recebido em 18/07/2011 - 
Revised/ Versão reformulada recebida em 03/12/2011 - Accepted/ Publicado em 14/12/2011

ISSN 1676-0603 (on-line)
Fruit-eating fishes of *Banara arguta* (Salicaceae) in the Miranda River floodplain, Pantanal wetland

**Raul Costa-Pereira**¹,³, Francisco Severo-Neto¹,
Tamires Soares Yule² & Ana Paula Tinti Pereira²

¹Programa de Pós-graduação em Ecologia e Conservação, Universidade Federal de Mato Grosso do Sul – UFMS, Cidade Universitária, CEP 79070-900, Campo Grande, MS, Brazil
²Programa de Pós-graduação em Biologia Vegetal, Universidade Federal de Mato Grosso do Sul – UFMS, Cidade Universitária, CEP 79070-900, Campo Grande, MS, Brazil
³Corresponding author: Raul Costa-Pereira, e-mail: brycon@ymail.com

Abstract: The role of fish as frugivorous and its ecological consequences are often neglected in ecological studies. However, the importance of the interaction between fish and plants is gaining force in scientific literature, and fish has been considered effective seed dispersers. The fruit-eating fish assemblage of *Banara arguta* (Salicaceae) was evaluated in Southern Pantanal wetlands. Nine species were reported consuming fruits, with different strategies to capture them. The distribution of *B. arguta* associated with the Pantanal floodplain and the presence of several species of fruit-eating fish, suggest that ichthyochory can be an important seed dispersal strategy to *B. arguta*.

Keywords: Brycon, diet, foraging behavior, frugivory, ichthyochory, Triportheus.


...Continued in Brazilian Portuguese...


...Continued in English...

Resumo: O papel de peixes como frugívoros e suas consequências ecológicas são frequentemente negligenciados em estudos ecológicos. Entretanto, a importância da interação entre peixes e plantas vem ganhando força na literatura científica, e peixes têm sido considerados como efetivos dispersores de sementes. A comunidade de peixes frugívoros de *Banara arguta* (Salicaceae) foi avaliada no Pantanal Sul. Nove espécies foram reportadas consumindo os frutos, com diferentes estratégias para capturá-los. A distribuição de *B. arguta* associada à planície de inundação no Pantanal, além da presença de várias espécies de peixes frugívoros, sugere que a ictiocoria pode ser uma importante estratégia de dispersão de sementes para *B. arguta*.

Palavras-chave: Brycon, dieta, comportamento de forrageamento, frugívoria, ictiocoria, Triportheus.
Introduction

Approximately 275 species of fish belonging to 39 families are potentially fruit-eating (Horn et al. 2011). Most of them are Neotropical Characiformes, representing 70% of fish biomass in South America (Harvey & Carolifield 2003). However, the role of fish as frugivorous and its ecological consequences, including seed dispersion, are often neglected in studies about plant-vertebrates interaction (Correa et al. 2007).

A growing number of studies are beginning to consider the interaction between fishes and plants as an interesting link in the dynamics of Neotropical communities (Horn et al. 2011, Pollux et al. 2011). Indeed, fishes are able to consume large quantity and variety of fruits and seeds (Goulding 1980, Reys et al. 2008, Anderson et al. 2009), keeping viable or increase the germination efficiency of seeds (Kubitzki & Ziburski 1994, Horn 1997, Anderson et al. 2009) and disperse seeds for long distances and in suitable sites (e.g. upstream and floodplains) (Horn 1997, Anderson et al. 2011).

The role of fish as frugivorous is more noticeable in wetlands, mainly floodplains (Goulding 1980, Parolin et al. 2011). Several fish species invade floodplains to feed and breed (Lowe-McConnell 1999). Considering the plants, some species synchronize their fructification with the flood season, which increases the probability of its fruits being consumed by fishes (Goulding 1980, Kubitzki & Ziburski 1994, Anderson et al. 2009). One of the largest wetlands in the world, the Pantanal, still has gaps in knowledge of its fruit-eating fishes, with few studies realized until now (e.g. Galetti et al. 2008, Reys et al. 2008).

Studies on frugivory and seed dispersion by fishes highlights fish-plant species interactions by single fish species (Horn 1997, Banack et al. 2002, Galetti et al. 2008), or more (Kubitzki & Ziburski 1994, Lucas 2008, Anderson et al. 2009). Our aim is to evaluate the fruit-eating fish assemblage of *Banara arguta* Briq. (Salicaceae) in Pantanal wetland. Furthermore, we discuss the ichthyofauna potential role in the seed dispersion of *B. arguta* based on fish foraging behavior.

Material and Methods

The Pantanal is one of the largest continuous floodplain in the world, located in the upper Paraguai River basin (Junk et al. 2006). Its flood pulse follows a uni-modal annual cycle whose amplitude varies between two and five meters and last three to six months, (Lorenzi 2002). Primates, birds and bats were already registered in literature consuming *B. arguta* fruits (Bravo & Sallennave 2003, Ragusa-Netto & Facchio 2006, Gonçalves et al. 2007, Teixeira et al. 2009).

We collected 50 mature fruits of *Banara arguta* to quantify the number of seeds and the fruit’s size with a precision caliper. To capture the fishes, we used four fishing rods/tree with barbelless hooks baited with fruits of *B. arguta* around the four selected trees (sampling effort of 16 hours). Captured individuals were quantified and mostly returned to the water. Fishes were identified according to Bertski et al. (2007). For taxonomic identification of species of the genus *Triportheus* (Malabarba 2004) is necessary to count Gill rakers, so we captured three individuals and deposited in the zoological collection of the Federal University of Mato Grosso do Sul (ZUFMS-accession number: 3089). Additionally, we offered ripe fruits of *B. arguta* to fishes and observed the feeding behavior with a snorkel and a dive mask. All species which consumed fruits were recorded. Feeding behavior was recorded in situ following Sazima (1986).

Table 1. Fish species that consumed *Banara arguta* in the Miranda River floodplain.

<table>
<thead>
<tr>
<th>Species</th>
<th>Position</th>
<th>n</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astyanax asuncionensis</td>
<td>S,C</td>
<td>1</td>
<td>Plucks fruit fragments or take advantage of fragments left by the larger species</td>
</tr>
<tr>
<td>Brycon hilarii</td>
<td>S,C</td>
<td>15</td>
<td>Captures the entire fruit or large pieces</td>
</tr>
<tr>
<td>Triportheus pantanensis</td>
<td></td>
<td>74</td>
<td>Nibbles fruit on the bottom, ingesting small pieces</td>
</tr>
<tr>
<td>Leporinus striatus*</td>
<td>B</td>
<td>-</td>
<td>Adults manipulate the fruit in the mouth and ingest the entire fruit, while young individuals manipulate the fruit tearing small fragments</td>
</tr>
<tr>
<td>Leporinus friderici</td>
<td>B</td>
<td>1</td>
<td>Tears fruit fragments or take advantage of fragments left by the larger species, nibbling on those pieces while it fall into the water column</td>
</tr>
<tr>
<td>Tetrangopterus argenteus</td>
<td>C</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Markiana nigripinnis</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Brachychalcinus retrospina*</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mylossoma dairvente</td>
<td>B</td>
<td>-</td>
<td>Swallows the entire fruit that was being contested by smaller fish</td>
</tr>
</tbody>
</table>

Position on water column: S = surface, C = water column and B = bottom; number of individuals captured (n) and strategy to capture the fruits. *Species that were recorded consuming fruits of *B. arguta* only during the subaquatic observation sessions.
the fruit in the mouth before eating it entirely, while young nibble fruit tearing small pieces, but both capture fruits deposited on the floodplain bottom. Leporinus striatus (Kner, 1858) nibble fruits in the bottom of the floodplain, eating small pieces.

The smaller species Markiana nigripinnis (Perugia, 1891), Tetragonopterus argenteus Curvier, 1916 and Brachychalcinus retrospinus Boulenger, 1892 (Figure 1b), take advantage of fruit fragments left by larger species, nibbling on those pieces while they fall into the water column. Moreover, when the entire fruit that fell in the water are not attacked by the larger species, smaller species also nibble on the fruit into the water column or bottom. Mylossoma orbignyanum (Valenciennes, 1849) was seen moving from bottom to the fruit, and swallowing whole the fruit that was being contested by smaller fish.

**Discussion**

No other study reported the occurrence of B. arguta fruits in the stomach contents of fish as food item, so far. The feeding of fish is strongly dependent on the availability of food resources and, considering that fruits are available seasonally due to plant phenology, frugivory is also seasonal (Correa et al. 2007). Except in studies that capture fish in floodplains or monitor the diet of the species throughout the year in flooded areas (Mérona & Rankin-de-Mérona 2004, Lucas 2008), frugivory by fish is underestimated (Correa et al. 2007). Another source of underestimation is the aggregation of fruits, seeds, flowers, leaves and macrophytes in major food categories, such as plant material. This partly explains the only recent consideration of ichthyochory as an important part of life history for many species of plants and fish (Anderson et al. 2009, 2011, Horn et al. 2011).

The frugivory of B. arguta by Triportheus spp. is well known in riverine communities (Morais & Silva 2010). In literature, Goulding (1980) points out that the Triportheus genus possesses behavioral and morphological adaptations for the consumption of fruits. By testing the germination of seeds recovered from the digestive tract of T. angulatus in a lake in the Amazon, Maia et al. (2007) found that the species is one of the dispersal agents of the Rubiaceae Bothriospora corymbosa. The high abundance of T. pantanensis in floodplains of the Miranda River, and the high number of individuals caught by baits of B. arguta, suggests this species as a major consumer of fruits of B. arguta.

The genus Brycon comprises omnivorous – frugivorous species (Goulding 1980, Kubitzi & Ziburski 1994, Horn 1997, Gomiero et al. 2008), with morphological and biochemical evidence of specialization to herbivory and frugivory as adults (Drewe et al. 2004). Reys et al. (2008) observed 12 fruit species in the diet of B. hiliarii and discussed that half of all plant species of riparian vegetation in Formoso River, Central Brazil, can be dispersed by this species. Horn (1997) showed that the seeds of Ficus glabrata remained viable for germination after their passage through the tract of B. guatemalensis, and that the species dispersed seeds upstream. The larger body size and high mobility of B. hiliarii suggests this species as potential seed disperser of B. arguta in the Pantanal floodplains.

We found some evidences of B. arguta dispersal by fish, related to its fruits and seeds characteristics, and also its phenology and distribution in the floodplain. Their small size and conspicuous color of the fruit, numerous and small seeds, the distribution along floodplains and the fruitting during the rainy season of B. arguta are characteristics that allows the dispersal by ichthyofauna. Moreover, the fruits of B. arguta do not float which is a disadvantage to hydrochory, especially in lentic environments such as floodplains, and highlights the potential role of ichthyochory as a dispersal strategy of the B. arguta.

As for the ichthyofauna foraging behavior, the ingestion of whole fruit or large pieces by some of the species, such as B. hiliarii, and adults of T. pantanensis, A. asuncionensis and L. friderici, decreases the probability of seed predation by the bite of the Characidae (Correa et al. 2007). On the other hand, the small seeds of B. arguta can be ingested even by small fish species that nibble the fruits, such as B. retrospinus. In this context, we suggest future studies to evaluate the seed dispersal potential of the fruit-eating fish assemblages, mainly T. pantanensis and B. hiliarii. Aspects such as dispersal distance, seed viability and the efficiency of seed germination involving experimental analysis are important to defining the real role of fish in the recruitment of B. arguta.
Acknowledgements

IBAMA for permitting us to conduct this study, Universidade Federal de Mato Grosso do Sul for field support and CNPq and CAPES for financial support. We are grateful to Julie Lepine, Sharyn Burgess and Rudi Laps for helping in review of the English. We thank the anonymous referee for his constructive comments and suggestions.

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Received 18/07/2011 Revised 03/12/2011 Accepted 14/12/2011