Food Habits of Five Fish Species from a Blackwater Creek in the Colombian Amazon

Aspectos tróficos de cinco especies ícticas de una quebrada de aguas negras (Amazonas, Colombia)

Ecologia Trófica de Cinco Especies de Peixes de Riachos de Aguas Pretas (Amazonas, Colombia)

Edgar Francisco Prieto-Piraquive †
Donald Taphorn
Alexander Sabogal
Santiago R. Duque
Jesús Damaso Yoni

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Abstract

To provide baseline life history information for some of the many small fishes found in blackwater forest streams in the Colombian Amazon near the town of Leticia, we describe trophic aspects of five species of fishes. Collections were made in April (high water), July (falling water) and November (rising water) of 1999. Diverse fishing gear was used, and sampling occurred in the afternoon and night, and usually lasted an average of five hours. We studied stomach contents of four characids: *Ctenobrycon hauxwellianus* (Cope 1870), *Moenkhausia melogramma* Eigenmann 1908, *Tetragonopterus argenteus* Cuvier 1816, *Hemigrammus bellottii* (Steindachner 1882) and one cichlid: *Bujurquina* cf. *peregrinabunda* (Eigenmann 1922). Most are feeding generalists but *M. melogramma* had a great preference for aquatic invertebrates, and *B.* cf. *peregrinabunda* ate both aquatic invertebrates and fishes.

Keywords: diet, food, Characidae, stream, Amazonia

Edgar Francisco Prieto-Piraquive. r.i.p. Universidad Pedagógica Nacional. Bogotá, Colombia. https://orcid.org/0000-0002-6606-8396
Donald Taphorn. Royal Ontario Museum. Toronto, Canada. E-mail: taphorn@gmail.com
Alexander Sabogal. Centro de Investigaciones en Acarología. Bogotá, Colombia. E-mail: asabogalg@yahoo.com
Santiago R. Duque. Coordinador del Grupo de Investigación "Limnología Amazónica" y del Laboratorio de Manejo y Gestión de Humedales Instituto Amazónico de Investigaciones (Imani) Universidad Nacional de Colombia, Sede Amazonia. E-mail: srduquee@unal.edu.co
Jesús Damaso Yoni. Resguardo Ticuna-Cocama de La Playa. E-mail: jesdamayoni2016@gmail.com

Resumen

Para proporcionar información básica sobre la historia de vida de algunos de los muchos peces pequeños que se encuentran en los arroyos de los bosques de aguas negras en la Amazonía colombiana cerca de la ciudad de Leticia, este trabajo describe los aspectos tróficos de cinco especies de peces. Se utilizaron diversos artes de pesca para las capturas de los ejemplares, los muestreos se realizaron en la tarde y en la noche, con un promedio de duración de cinco horas. Estudiamos los contenidos estomacales de cuatro carácidos*: Ctenobrycon hauxwellianus* (Cope 1870), *Moenkhausia melogramma* Eigenmann 1908, *Tetragonopterus argenteus* (Cuvier 1816), *Hemigrammus bellottii* (Steindachner 1882) y del cíclido *Bujurquina cf. peregrinabunda* (Eigenmann 1922). La mayoría de las especies fueron generalistas en su estrategia alimenticia, pero *M. melogramma* tuvo una gran preferencia por los invertebrados acuáticos, y *Bujurquina cf. peregrinabunda* comió invertebrados acuáticos y peces.

Palabras clave: dieta, comida, characidae, quebrada, Amazonia

Resumo

Para fornecer informações básicas sobre a história da vida de alguns dos muitos peixes pequenos que se encontram nos arroios dos bosques de águas negras na Amazônia colombiana perto da cidade de Leticia, este trabalho descreve os aspectos tróficos de cinco espécies de peixes. Para a captura dos espécimes foram utilizados vários métodos de pesca, as coletas foram realizadas no período da tarde e à noite, com duração média de cinco horas. Estudamos o conteúdo estomacal de quatro peixes da familia Characidae: *Ctenobrycon hauxwellianus* (Cope 1870), *Moenkhausia melogramma* Eigenmann 1908, *Tetragonopterus argenteus* (Cuvier 1816), *Hemigrammus bellottii* (Steindachner 1882) e ó ciclido *Bujurquina cf. peregrinabunda* (Eigenmann 1922). A maioria das espécies foram generalistas em sua estratégia alimentar, mais *M. melogramma* tinha grande preferência por invertebrados aquáticos, e *Bujurquina cf. peregrinabunda* comeu peixes e invertebrados aquáticos.

Palabras-chaves: dieta, comida, Characidae, igarapé, Amazônia

Introduction

Diet studies of freshwater fishes have generated basic information required to understand the ecological relationships among fishes and the other organisms found in aquatic communities (Abelha *et al.* 2001; Novakowski y Fugi. 2008). In the tropics, although some fishes have specialized to consume certain food types, most of the species exhibit a great plasticity in their diets, which can hinder the delimitation of the trophic patterns (Abelha *et al.*, 2001; Lowe-McConnell, 1999).

In the Colombian Amazon region some research has been done on fish diets (Barón-Mendoza, 2006; Blanco-Parra, and Bejarano-Rodriguez, 2006; Correa and Winemiller, 2014; Galvis *et al.*, 2006, 2007; Prada, 1987; Prieto-Piraquive, 2018, 2012b, 2012a; Prieto-Piraquive, *et al.*, 2015; Ramírez, *et al.*, 2015; Ramírez, 1986), but studies of most species, even those of commercial importance are still lacking.

Here we present information on the diet of five species found in a blackwater stream near Leticia, in the Colombian Amazon River Basin.

Study Area

This study was done in Yahuarcaca Creek located at 4º 08' 30" S and 69º 56' 25" W near the town of Leticia in the Colombian Amazon. The creek has an elevation between 84 and 89 masl, and is located on an alluvial plain of the Amazon River deposited in the Tertiary (Duque, *et al.*, 1995). The site includes soils of old terraces that are better drained than those of younger soils. The creek's differences in depth range from 0.07 to 2.35m, and flow is less than 0.5 m^3/sec (Prieto-Piraquive, 2012b). Average air temperature is 25.8° C, with a minimum of 24° C and maximum of 27.9° C (Galvis *et al.*, 2006), with lowest temperatures from June to August, caused by the cool winds from the southern hemisphere, this condition is known locally as "Friage" (Damaso, 2004).

During the study period (1999) the total precipitation was 3028 mm, rainfall was atypical and unusually high when compared to statistics available from 1984 - 1998, with an atypical maximum in May of 512 mm and a minimum in September of 153 mm, and the Amazon River rose higher than in most years (Prieto-Piraquive, 2012b). The Amazon River in Leticia usually starts to slowly rise in November, by February the river water is high enough to invade the low-lying varzea areas, and then peaks in April to May. High water flooding continues until July when the water begins to rapidly descend. In Leticia the vertical difference in water level from lowest to highest can reach 18 meters (Prieto-Piraquive, 2012).

The study area is forested with varying degrees of human alteration. Most places have a two strata forest structure composed of older dominant species and younger emergent trees of medium height, with abundant vines. The herbaceous ground cover is sparse. The dominant trees include: Capinuri (*Pseudolmedia laevigata*), Quinilla (*Manillkara bidentata*), Matamata (*Lecythis* sp.), Amacizo (*Erytrina g!auca*), Arenillo (*Qualea paraensis*), and the emergents include: Yarumo (*Cecropia* sp.), Bamboo (*Bambusa* sp.), Juan soco (*Couma macrocarpa*) and Urucana (*Jacaranda copaia*) (Prieto-Piraquive, 2012b).

Methodology

Collections were made in April (high water), July (falling water) and November (rising water) of 1999. Diverse fishing gear was used (seine nets 3 to 12 m long and 1 to 2.5 m deep, cast nets with diameters of 2 to 4 m and mesh size (between knots) from 0.5 to 2 cm, a gill net 15m long and 2m high, and nylon manual traps known locally as "jamas"). Sampling occurred in the afternoon and night, and usually lasted an average of five hours. The collected fish were fixed with 10% formalin, labeled and packed in plastic bags. Taxonomic keys were used for identification including those of (Galvis *et al.*, 2006, 2007; Gery, 1977; Taphorn, 1992; Van der Sleen y Albert, 2018).

The name in Ticuna language for some species was obtained from different sources (Damaso, *et al.*, 2009; Gómez, 2019; Prada, 1987).

In the laboratory, the fish were washed, and on average 30 individuals of the same species and similar size and weight were selected per season to limit the influence of life history stage or size on diet per sampling season.

The digestive apparatus of each selected specimen was removed to allow observation of their stomach contents. Contents were quantified using a volume chamber technique modified from that proposed by Marrero (1994). Volumetric methods give a representative measure of the quantity of foods consumed and they can be applied to all the food item categories (Hyslop, 1980), however it is necessary to take into account that in spite of the possible advantages for its use, there can be up to 3.5% error (Hellawell and Abel, 1971 in Prieto-Piraquive 2012a). The classification of the different food items was based on Goulding, *et al* (1988). To classify the feeding strategy used by each species, we used the analysis proposed by (Amundsen, *et al.*, (1996). The figure (6) of Detrended correspondence analysis (DCA), used to graphically demonstrate diet overlap (or lack thereof), was made with PAST 3.16 (Hammer, Harper, and Ryan, 2001) .

Results

Diet analysis was done for four species of the family Characidae, *Ctenobrycon hauxwellianus* (91 stomachs examined), *Moenkhausia melogramma* (118), *Tetragonopterus argenteus* (88), *Hemigrammus bellottii* (145) and one species of Cichlidae, *Bujurquina* cf. *peregrinabunda* (84).

Ctenobrycon hauxwellianus

This is an important ornamental fish species in Colombia (Ajiaco-Martínez, *et al.*, 2012). The length of specimens studied ranged from 5.7 to 7.8 cm, with an average of 6.8 cm and weight ranged from 4.5 to 16.1g, with an average of 10.3 g. The most prevalent diet item of this species in April was seeds, followed by terrestrial vegetation. During this same month, we found the largest amount of food in their stomachs. In the falling water season (July), we found fishes and seeds and in the rising water season (November), the most common item was terrestrial vegetation but they had also eaten fish and aquatic vegetation (especially the filamentous algae *Oedogonium* sp. and *Oscillatoria* sp) (Fig.1).

Thus, in our study area this fish is an omnivore. It is worth noting that this species has previously been considered mainly vegetarian but we found the whole body of a 1.3 cm characin in one stomach. Tiny fishes are abundant during falling water phase (July), and this species takes advantage of abundant food items. Marlier (1968) categorized this species as a vegetarian, but our

results agree more with Galvis *et al.* (2006), Galvis *et al.* (2007) Ramírez *et al.* (2015), Suçuarana *et al.* (2016) and Prieto-Piraquive (2018), who reported both vegetal and animal elements in diet of *C. hauxwellianus*.

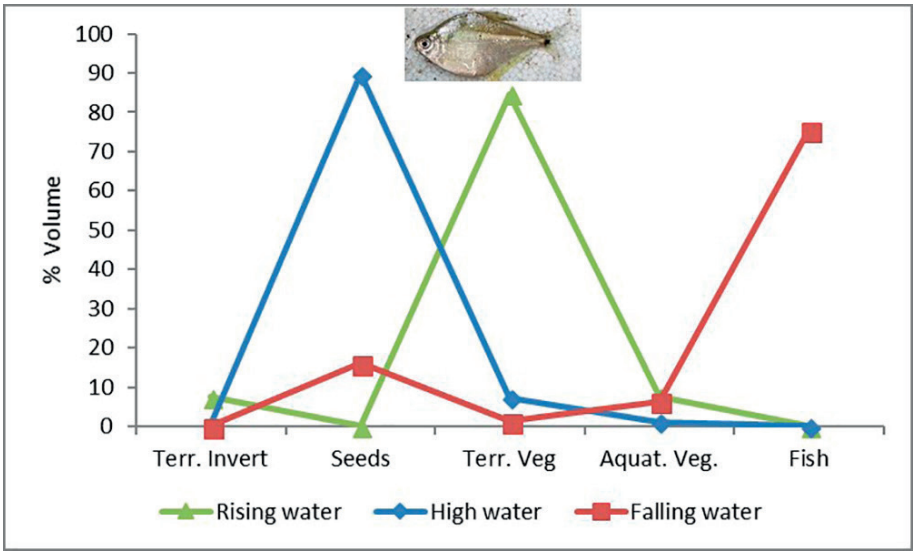

Figure 1. Feeding categories consumed by *Ctenobrycon hauxwellianus*

This fish has a generalist feeding strategy, although seeds and fish were consumed in great quantity by a few individuals, most specimens examined contained small amounts of terrestrial vegetable remains, and just a few individuals consumed aquatic invertebrates or aquatic vegetation. This species shows trophic flexibility and adapts seasonally to consume available food resources.

Moenkhausia melogramma,* Ticuna name: *nitchira

Specimens ranged in length from 2.2 to 3.6 cm, average 2.9 cm, and weight ranged from 0.2 to 0.9, with an average of 0.6 g. In the high-water season (April), the most commonly consumed item was aquatic invertebrates (especially chironomids and microcrustaceans) followed by aquatic vegetation (filamentous algae and diatoms) and in lesser amounts seeds and terrestrial invertebrates (ants and spiders). In the second sample (July), aquatic invertebrates were again the most important food item, but, in the third sample (November), aquatic vegetation predominated (Fig. 2).

This species is an omnivore with preference for allochthonous food items (Castellanos 2002, Galvis *et al* 2006, Prieto-Piraquive 2012a), that feeds mainly on insects and aquatic vegetation.

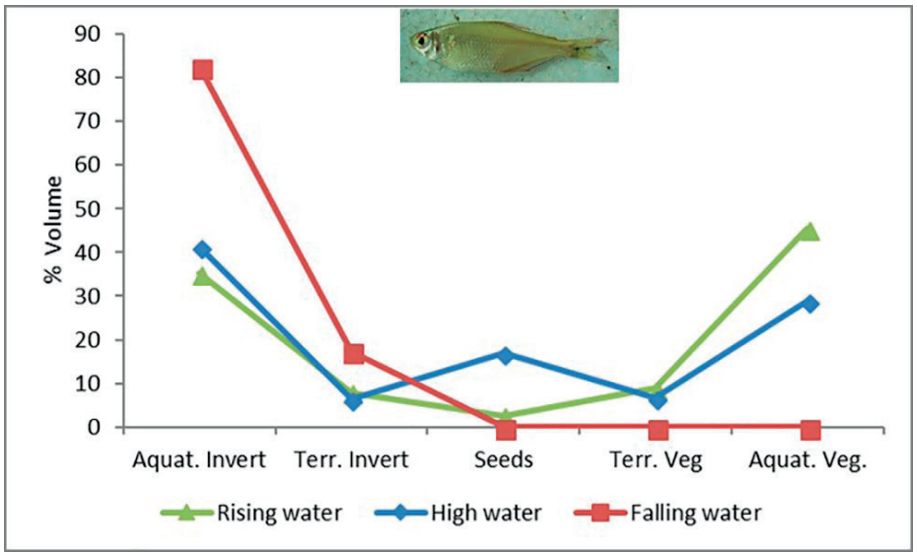

Figure 2. Feeding categories consumed by *Moenkhausia melogramma*

Although we classify this species as a generalist, most of the specimens examined were consuming aquatic invertebrates, which would indicate a somewhat narrow feeding niche. However, a few individuals consumed other types of food, such as aquatic vegetation and in the graph no clear pattern emerges.

Tetragonopterus argenteus,* Ticuna name: *u-penü

This is another important ornamental fish species in Colombia (Ajiaco-Martínez *et al.*, 2012), the size range for this species was 6.1 to 7.8 cm, with an average of 6.9 cm, and the weight was from 14.1 to 21.4 g, with an average of 17.8 g. Of the five species studied, this one consumed the largest volume of food (Fig. 3). In the high-water season, seeds were the dominant food item followed by terrestrial invertebrates and in lesser proportion aquatic invertebrates (especially Diptera and microcrustaceans), and terrestrial vegetation. In this high-water season, the largest amount of food volume was found. In the falling water, the main item was fish but also terrestrial invertebrates and seed. In the rising water, less food was found in the stomachs and terrestrial invertebrates and seeds were the dominant items. The diverse food categories consumed by this species show that it is an omnivore, which agrees with the observations of Taphorn (1992), Galvis *et al.* (2006), Pereira *et al.* (2007), Prieto-Piraquive, (2012), Prieto Piraquive *et al.* (2015) and Ramírez *et al.* (2015).

This species is a generalist, most specimens examined had eaten small amounts of terrestrial invertebrates and terrestrial vegetation while only a few individuals consumed large amounts of seeds and fish. This shows how

the diet of some atypical individuals affects the calculated width of the feeding niche of a species.

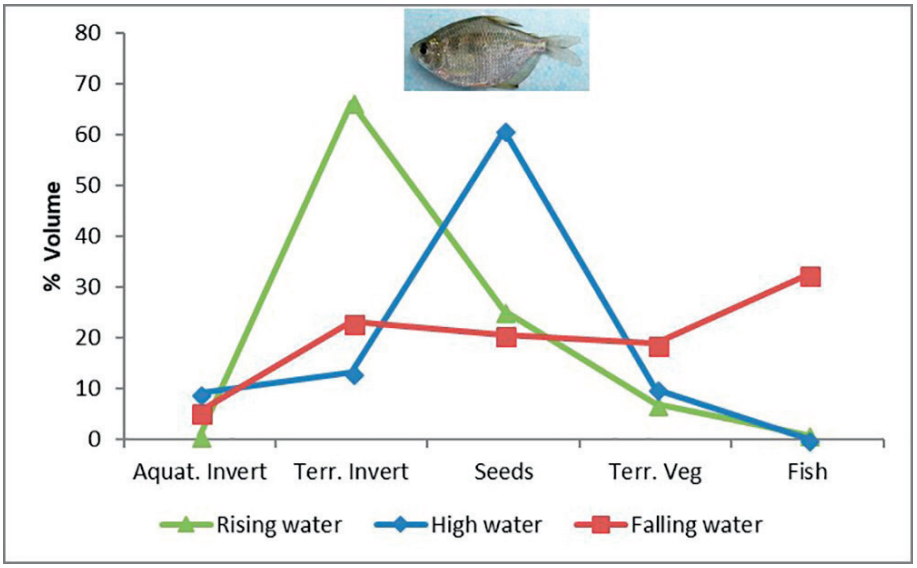

Figure 3. Feeding categories consumed by *Tetragonopterus argenteus*

Only very small amounts of food in the other categories reported were consumed, and by very few individuals. Although this species ate various items of both animal and vegetal origin, according to volume percentages they showed a preference for seeds. As observed for *Ctenobrycon hauxwellianus*, this species ate small fishes in July, when they were particularly abundant in Yahuarcaca stream.

Hemigrammus bellottii,* Ticuna name: *iré

Length ranged from 1.9 to 2.9 cm, with an average of 2.4 cm, and weight was 0.2 to 0.4 g, with an average of 0.3 g.

In the high water season, aquatic invertebrates were the item most consumed, followed by terrestrial invertebrates (ants and spiders) and in smaller proportion terrestrial vegetable remains. For the falling water season, terrestrial vegetation was in first place followed by a small amount of aquatic invertebrates. In the rising water season, terrestrial invertebrates (ants and beetles) were the item most consumed, but seeds were also important (Fig. 4).

Taphorn (1992); Planquette *et al.* (1996); Cabalzar (2005) and Gonçalves *et al.* (2013) reported a preference for arthropods among which aquatic insect larvae and ants were the most important. That agrees with the results of this work. In July, we observed the greatest consumption of terrestrial vegetation.

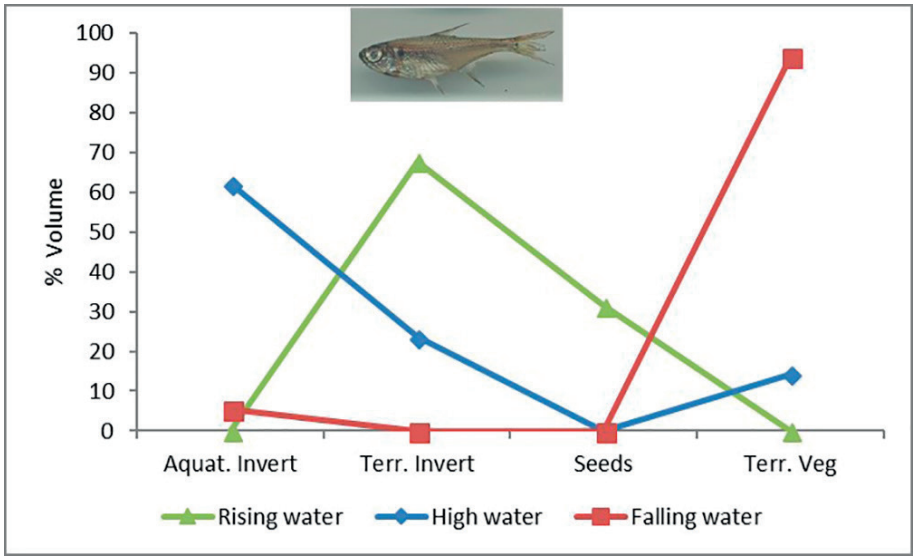

Figure 4. Feeding categories consumed by *Hemigrammus bellottii*

This species is also best categorized as a generalist, many specimens consumed terrestrial invertebrates, but terrestrial vegetation, aquatic invertebrates and seeds were also eaten by a few individuals and in large amounts. This species was often observed swimming near the surface in calm, open water in small groups (Castellanos, 2002).

***Bujurquina cf peregrinabunda,* Ticuna name: Chuná amatükü**

Size range for this species was 4.8 to 7.6cm, and weight 4.6 to 21.7g, with an average of 13.1 g. In the high water season, the most important food item was fish, followed by aquatic invertebrates, terrestrial vegetation and terrestrial invertebrates. In the falling water season, fish remained dominant, but for the rising water season aquatic invertebrates dominated, followed by terrestrial invertebrates (Fig 5). Since the diet is mainly carnivorous, the ingestion of vegetation could be incidental (Galvis *et al.* 2006).

This last species was the one that presented the clearest tendency towards specialization, the food preferred by this species was fish, with many individuals having eaten considerable amounts of fish. Aquatic invertebrates were the second most consumed food item. These prey items correlate well with the type of teeth (conical) and gillrakers (hard and short) of this species, which are adapted for taking prey similar with other trophic investigation with this genus (Ramírez *et al.*, 2015).

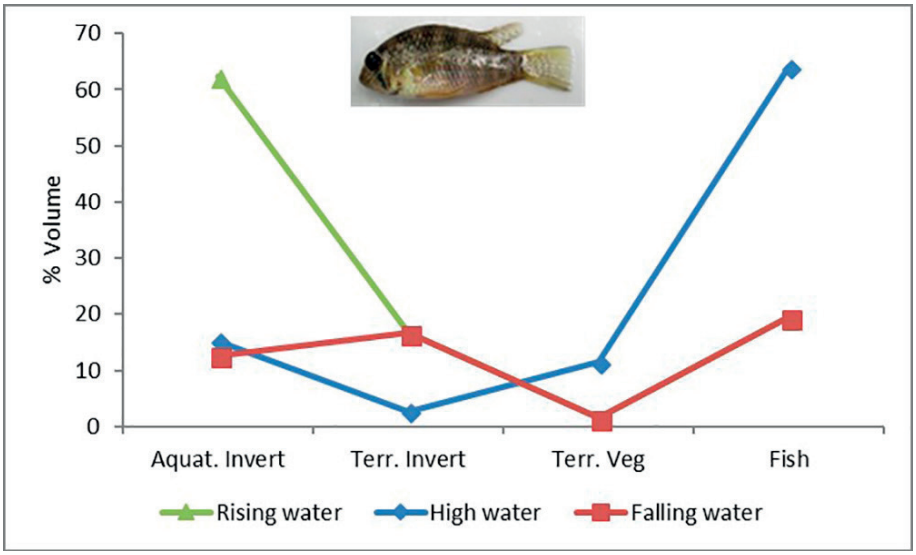

Figure 5. Feeding categories consumed by *Bujurquina* cf. *peregrinabunda*

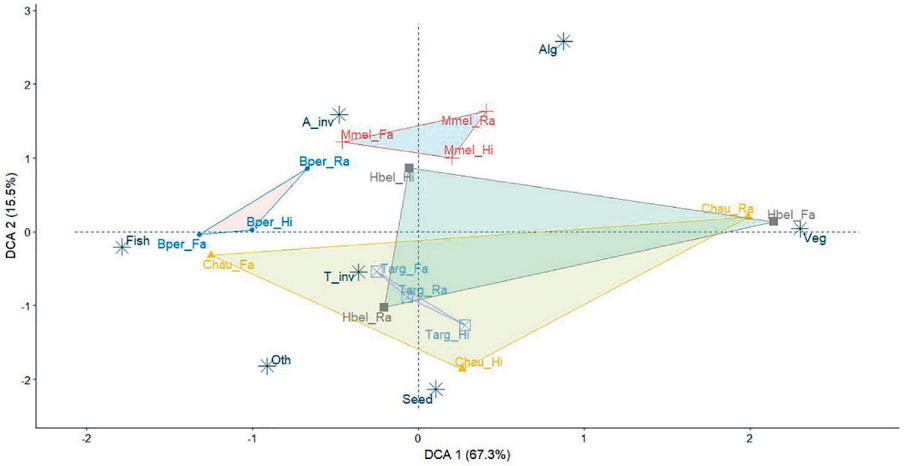

Figure 6. Detrended correspondence analysis of the diets the five species studied. Mmel: *Moenkhausia melogramma,* Bper: *Bujurquina* cf.*peregrinabunda,* Chau: *Ctenobrycon hauxwellianus, Targ: Tegtragonopterus argenteus, Hbel: Hemigrammus bellotti.* Seasons: Fa:Falling water, Hi: High water, Ra: Rising water. Food items: Seed, Fish, Veg: Vegetables, Alg: Algae, A. Inv: Aquatic invertebrates, T.Inv: Terrestrial invertebrates, Oth:Others.

We used detrended correspondence analysis of the diets of the five fishes studied to indicate overlap in their diets. In Figure 6 the horizontal axis (DCA1) extends from a mostly fish diet (negative values) as for *Bujurquina cf peregrinabunda*, to a vegetarian diet (positive values above 2), for example

Ctenobrycon hauxwellianus. The second axis graphed (vertical) shows a spread between seeds at the negative extreme, and a mix of algae and invertebrates at the higher positive values. The colored triangular shapes connect data points for each species during different river stages, showing seasonal variability of diet.

Discussion

Results showed that during the three hydrological seasons studied there was a wider food spectrum (consumption of both plant and animal foods) in the resources used by *C. hauxwellianus* and *H. bellottii*, confirming the general trophic plasticity among the Characiformes found in this study. *Moenkhausia melogramma* mostly ate algae. *Bujurquina cf. peregrinabunda* was mainly carnivorous with about equal amounts of autochthonous and autochthonous prey.

Our field observations revealed habitat preferences and behaviors. *H. bellottii* was observed in large groups (more than 10 individuals) close to the water's surface near shore vegetation where it could easily access allochthonous foods such as invertebrates and plant remains, upon which it mainly fed. Medium-sized species such as *M. melogramma* and larger ones (among those studied), such as *T. argenteus* and *C. hauxwellianus*, used stretches of the creek's main channel. These species moved in groups of a few individuals (less than 10) swimming in the middle and upper part of the water column to wait to catch food near the surface of the water. Finally, *B. cf. peregrinabunda* was found in sectors near the bottoms of the creek capturing prey such as aquatic invertebrates and small fish.

This study confirms the importance of allochthonous food sources (seeds and terrestrial insects for example) for these blackwater Amazon streams and contributes baseline biological data about the trophic habits of five small species from a blackwater creek, in the Colombian Amazon River Basin. All four species of Characidae studied are feeding generalists that consume aquatic invertebrates, seeds and vegetation, a good strategy to survive in the seasonally changing habitats of small streams near the main channel of the Amazon River. The cichlid was found to be more specialized and predatory, mainly feeding on small fish and aquatic invertebrates. All species studied clearly show seasonal differences in the composition of their diets and the amount of food consumed. In this blackwater creek during the rainy season the food resources are abundant and varied (Arbelaez, *et al.*, 2004; Prieto-Piraquive, 2012b), but in the dry season, food is scarce and fishes need to employ survival strategies that often include the consumption of less nutritious food.

Conclusions

During falling water phase, the greatest amount of food was found in stomachs of *T. argenteus, C. hauxwellianus, H. bellottii and B.* cf. *peregrinabunda*. The characids studied ate mainly allochthonous resources. *Bujurquina peregrinabunda* ate mostly autochthonous resources. The characids studied had a generalist feeding strategy. *B.* cf. *peregrinabunda* is a specialized carnivore.

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