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Trophic and reproductive ecology of a species of *Hemibrycon* (Pisces: Characidae) in Tinajas creek, Quindío River drainage, upper Cauca basin, Colombia

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Abstract: We studied trophic and reproductive ecology of a new endemic species of characid fish *Hemibrycon sp.*, from Tinajas Creek, Quindío River drainage, upper Cauca basin, Colombia. The diet consisted primarily of Diptera (Tipulidae and Chironomidae), Hymenoptera (Formicidae) and Coleoptera (Dytiscidae), but it also eats algae (Clorophyta) and seeds. Alochtonous food items are important factor for this species. The species reproduces in both the wet and dry seasons. During September-October they store lipids in their celomic cavity. Fecundity is low (405 oocytes) and the sex ratio is 1:2.28, with a predominance of males. *Hemibrycon sp.* is syntopic with: *Cetopsorhandia boquillae, Astyanax aurocaudatus, Trichomycterus caliense, and Poecilia caucae*. Physical and chemical of data of their habitat are included.

Key words: *Hemibrycon sp.*, Characid fish, ecology, reproduction, diet.

The Characidae are distributed from the Rio Grande, in the southern part of Texas, through Central America, down to 41° south latitude in Chile and Argentina (Cala, 1990). This family is of the most important of the Neotropical icthyofauna in terms of biomass and species number (Kramer, 1978). Characids are dominant fishes in density and species quantity from the entire Colombian basin (Cala, 1990), are small-sized, silvered, laterally compressed, diurnal in habitats and usually non-specific in their trophic behavior (Machado-Allison, 1987).

The approximately 18 species of the genus *Hemibrycon* are distributed in Peru, Ecuador, Colombia, Panama, Venezuela, Trinidad and Surinam (Roman-Valencia, 2001). The species we studied, can be considered as endemic of this drainage and has been reported as a novelty within genus (Roman-Valencia *et al*., *in press*). Since little information is available about the ecology of this *Hemibrycon* species (Roman-Valencia *et al* ., *in press*). We decided to study the trophic and reproductive ecology to provide knowledge crucial to promote the conservation of its habitat, which is now a tourist attraction, and as a result, is undergoing many change to the natural ecosystem.

MATERIALS AND METHODS

Fish were collected monthly between February 2003 and January 2004 at Quebrada Tinajas, Rio Quindio Tributary, upper Rio Cauca, 4° 36’ 57" N & 75° 36’ 35" W, 1712 m a.s.l. Collecting took place during both the dry (February-March, July-August) and wet seasons (April-June, September-December).

Fish were captured using a drag net, a seine and preserved in ice, *in situ*; then were carried to the Laboratory of Ichthyology, Department de Biology, Universidad del Quin-dio, Armenia, Colombia (IUQ), where they are now deposited.

120 specimens were examined, 51.5 mm of mean standard length (25.5-75.5 mm SL). Fish were measured, weighed and cut along their major axis to remode their digestive tracts and gonads. 116 stomach contents were analyzed, using occurrence index, numeric index (Hynes, 1950; Hyslop, 1980), volumetric analysis (Pedley & Jones, 1978; Capitoli, 1992), and an importance index (Oda & Parrish, 1981), were I= (Occurrence % * Volume %)/100.

Then Principal Components statistical analysis was applied, considering volume, quantity and frequency as variables and different items found on the stomachs of the individuals. To standardizer frequency, volume and quantity values this procedure was followed: for each variable its mean value and its standard deviation were calculated, then mean value was taken from each individual value and the result was divided by the standard deviation, all of this was done to make it possible to compare between different sized fishes.

The analysis of feeding activity (R) was based on the quotient of stomach content (Ghazai *et al*, 1991), where R= We/Wt * 100 (We: Stomach weight (g) and Wt: Individual weight (g). Using field information about diet from earlier work, Roman-Valencia (*pers. com.*), Román-Valencia & Ruiz (2005), Román-Valencia *et al*. (2003) and of course those from present work, trophic diversity was calculated, by Shannon-Winner index cited in Ferris & Salas (1994), between *Hemibrycon sp.*, *Bryconamericus caucanus, Cetopsorhamdia boquillae, Hyphessobrycon poecilioides, Roeboides dayi* and *Astyanax aurocaudatus*. The units with the diversity is measured come from the infor-mation theory and its depend on the type of used logarithms, in our case bits for logarithm base 2 (Magurran, 1989).

Morisita overlapping diet index was applied (CH) cited by Granado (1996) and Spearman Correlation Range (Rs) (Fritz 1974) to compare between the diet *Hemibrycon sp.*, *Astyanax aurocaudatus* (Roman-Valencia & Ruiz, 2005) and the one of the *Cetopsorhandia boquillae* (Román-Valencia & Giraldo *pers. com.*), to calculate previous indexes those items that could not be quantified as discrete units were not used.

To calculate the Gonadosomatic Index (RGS) (Vazzoler, 1996) the following equation was used: RGS= Wo/Wc*100, where, Wc=Wt-Wo, and Wo=gonad weigh (g), Wt=Individual weigh with internal organs (g) and Wc=body weigh (g) without internal organs. Size at maturity was determined using a graphic statistical method and the sex ratio was tested by Chi-Cuadrado (Sokal & Rohlf, 1995) and the Spearman Correlation Range was used to determine diet season and variation as it was proposed by Ortaz (2001). Statisgraphics plus 5.0, Statistix 7.0 and Krebs 0.1 (Windows) were used for statistical processing.

Physical and chemical variables were recorde thus: Water color and substrate by direct observation, dissolved oxygen, and saturation of oxygen by electrode method, pH with electrometric method (pH meter), width and depth of the creek with measuring tape (decameter), to establish the variation along time of these variables a Variation Coefficient (% CV) was applied.

Finally, two water samples were taken, during dry season (March) and the other in wet season (May). To be analyzed for Biochemical Oxygen Demand (DBO), Dissolved Oxygen using Winkler Method, Alkalinity, hardness, dissolved and Chlorates by APHA Standard Methods (1992).

RESULTS

Habitat

Hemibrycon sp. inhabit Tinajas Creek, which has an average width of -1.50 m, and 0.4 m average depth. its riversides are usually covered by a secondary forest layer composed of Caña Brava (Poaceae) and Heliconias (*Heliconia* sp), *Guadua angustifolia* and agricultural systems like: coffee (*Coffea arabiga*) and plantain (*Musa paradisiaca*). The substrate texture of the river basin is a mixture of sand, stones and decomposed organic matter**.** Water is crystalline but in the wet season it turns brown, superficial temperature is 18.2 °C, with low variation coefficient (17.9-19.7 °C, %CV de 7.17), and atmospheric temperature is 18.52 °C (17.5-18.5 °C; %CV 2.57). The latter presented almost no change during the study. Dissolved oxygen presented a high and stable value during the observation period, 7,18 mg/l medium value (6.13-8.2 mg/l %CV 2.57), and the mean oxygen saturation percentage was 90.71 % (77.8- 107.5 %). pH values near 7 (6.7-7.85 %CV 7.2) were found (Table 1). DBO and DQO presented almost no variation between wet and dry seasons (Table 2). But other items did change alkalinity (24 mg/ l CaCO3 in dry and 42 mg/l CaCO3 in wet), total solids (71 mg/l in ray, and 98 mg/l in wet), dissolved solids (67 mg/l in dry, 94 mg/l in wet); and chlorides (37 mg/l Cl in dry 200 mg/l Cl in wet) (Table 2). Augmentation during wet season on past items could be related with erosion and anthropic processes occurring at this basin; it can be said that valves presented are characteristically for this kind of habitat of Neotropical highlands.

Hemibrycon sp. Is syntopic with: *Cetopsorhamdia boquillae, Astyanax aurocaudatus, Trichomycterus caliense,* and *Poecilia caucana.*

Trophic ecology

Hemibrycon sp. possess a stomach that is longer (mean 10.3 mm) than wide (mean 5.34 mm), located in the anterior part of the celomic cavity surrounded by other organs. Four to nine (mean 5) pyloric cecae are located at the front part of the stomach.

Hemibrycon sp. stomach contents showed a wide diet spectrum of 52 items (Table 3). The most consumed items were: diptera (Chironomidae, Branchycera, Ceratopogonidae, Nematocera), insect pieces, seeds, plant material and Hymenoptera of family Formicidae. The numeric analysis (Table 3) which indicates the importance of each item selected, gave these results: diptera (Tipulidae, Chironomidae y Branchycera), insects

Table 1. Physical and chemical data of *Hemibrycon sp.* from Tinajas creek.

Month/variable	Atmosphere temperature °C	water temperature °C	Disolved oxygen mg/l	Saturation of oxigen %	pH	Color of water
Mar.	18.9	18.8	8.2	107.5	7.75	gray
Apr.	18	18.1	7.5	96.61	7.85	
Jun.	18.3	18	6.13	78.2	7.78	
Jul.	18.2	17.5	7.85	77.8	6.76	Transparent
Ago.	17.9	17.8	7.53	98.9	7.06	Coffee
Sep.	17.8	17.3	7	87.8	6.56	Transparent
Oct.	18.8	18.1	6.96	89.3	6.88	Transparent
Nov.	19.7				6.72	Transparent
Dec.	18.4	17.7	6.9	89	7.31	Transparent
Jan.	18.4	18.5	7.1	94	6.94	Transparent
Averange	18.52	18.2	7.18	90.71	7.09	
Coefficient of variation (%CV)	7.17	2.57	8.32	9.98	7.2	

Table 2. Physical and chemical data of *Hemibrycon sp.* from Tinajas creek, Quindio River, upper Cauca River, Colombia.

Variable/season	Summer march de 2003	Wet May of 2003
water temperature (°C)	16	17.6
Atmosphere temperature (°C)	15.2	19.6
Saturation of oxigen	91	97
Disolved oxygen (ml/l)	7.4	8
pH	7.36	7.7
Relative humidity (%)	92	93
Sustrate	Mud and detritus	Sand and detritus
Color	Transparent	Coffee
Velocity of the running (m/s)	0.21	0.033
Wide (m)	2.95	3.06
Profundity (m)	0.6	0.3
D.B.O (mg/l)	1.1	3.8
D.Q.O (mg/l)	28	17.2
Total Hardness (mg/l CaCO3)	20	26
Calcium Hardness (mg/l CaCO3)	17	10
Magnesium Hardness (mg/l CaCO3)	3	16
Alkalinity (mg/l CaCO3)	24	42
Acidity (mg/l)	2	10
Total solid (mg/l)	71	98
Disolved solids (mg/l)	67	94
Suspended solids (mg/l)	4	4
Chlorine (mg/l Cl)	37	200

parts, and seeds. Volumetric analysis (Table 3) shows a tendency for: diptera (Branchycera and Tipulidae), insects parts, chlorophytas algae, seed, pant material and orthoptera: tetrigidae. The importance index showed that dominant items were again diptera of the family Tipulidae and Branchycera, but also insects parts and seed (Table 3).

Principal component analysis gave a first axis with values of that the main proper values were of 2.50 which accounted for over 83. 65 % of the variation (Table 4). This data was used as criteria

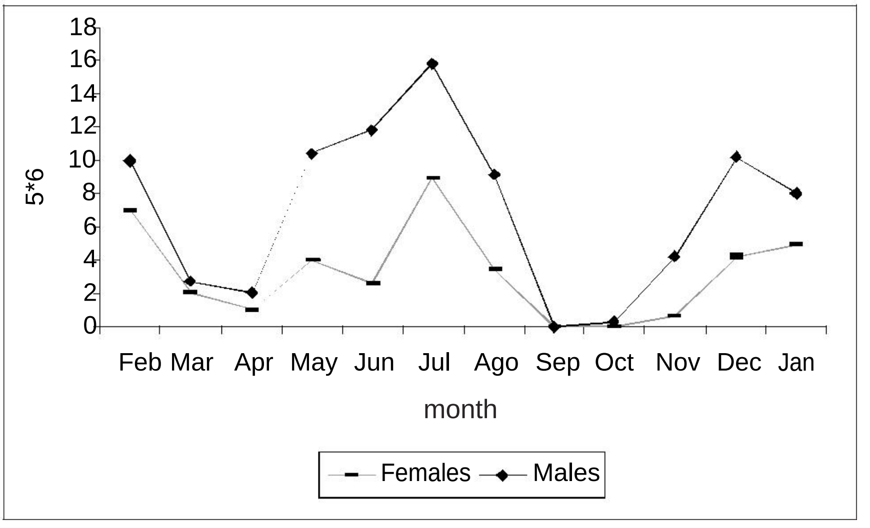

Fig. 1 Gonosomatic Index (RGS) mean of females and males in *Hemibrycon sp.*, in the Tinajas creek, Feb. 2003 - Jan. 2004.

for only considering the first main component where its alimentary tendency index was: 0.520122* standard number + 0.603168* standard volume + 0.604699* standard frequency. Thus essential items of the diet of *Hemibrycon sp.* were insects fragments, clorophyceas algae, and larva of diptera: muscidae, empididae, tipulidae, nematocera.

Feeding activity is diurnal asinferred from the digestion condition of the food items examined. *Hemibrycon sp.* Feeds on organisms that are found at the bottom of the water column, as well as adult insects of alochtonous origin that fall inside this environment. Important differences were not observed between the wet and dry seasons changes diet (Rs=0.8 p=0.0001), which suggests that resources remain mostly unchanged in the environment.

The alimentary spectrum of fish that share the same habitat with the studied species and other characids, presented a high trophic diver-sity with tendency to euophagy: *Hemibrycon sp.* 4.31 bits, *Hemibrycon boquiae* 3.56 bits, *Bryconamericus caucanus* 3.24 bits, *Hyphessobrycon poecilioides* 2.84 bits, *Roeboides dayi* 3.51 bits and *Astyanax aurocaudatus* 3.1 bits. The data by the Morisita index (CH) when comparing the ali-mentary preferences of the species with the ones of sintopic species, the data were low as well as the Sperman quotient of correlation, which also were low (Rs) and it registered a non significative correlation of the variables: between *Hemi-brycon sp. -Astyanax aurocaudatus* (CH=0.0006 y Rs 0.54 p=0.01) and *Hemibrycon sp. -Cetopsor-hamdia boquillae* (CH=0.005 y Rs 0.03 p=0.1).

A significative and positive correlation was found between the standard length and the intestine length (r= 0.69, li = 5.35392 + 0.629008*ls, n=75). A non-significant and positive correlation between the weight of the stomach and the standard length (r= 0.48, n=80); and the relationship between standard length and the total weight was (r= 0.67, wt = - 4.38232 + 0.137985*ls n=75).

Reproductive characteristics

Previous analysis of the reproductive aspects of the *Hemibrycon sp.* indicate that the Gonodosomatic index (RGS) obtained its maximum values with females in June-July and December-February, with spawning occurring in March and August (Fig. 1). Males the maximum valvues of RGS were collected during Mayo-Julio and November-January. The minimums occurred in February-April and the July-August (Fig. 1). In September and October specimens were found with empty gonads and high amounts of lipids inside the body cavity.

The minimum size of maturity was 40 mm SL for females and 30 mm SL for males, 50 % of the population reaches full gonad deve-lopment for females when they are 53 mm standard length and for males 50 mm (Fig. 1). The mean oocyte count was 445 (range 168-741) with a mean diameter 0.74 mm (0.85-0.5 mm). During this study females were more numerous, and comprised 68.8% of the samples, significantly greater with a 1:2.28 (X2 =O.0098, GL 1 á 0.005). No sexual dimorphism was observed.

Table 3. Stomach contents of *Hemibrycon sp.*, in Tinajas creek, Quindio River. Upper Cauca River, Colombia. N: % Numerical; F: % frequency; V:% volume; I: importance índex. pc: principal component. A: adult; L:Larva

Contents	I	%N	%V	%F	pc
Diptera (A)	0.0026	0.312	0.820	1.420	-0.275
Diptera part (L)	0.0112	1.363	0.820	1.136	-0.273
Diptera part (A)	0.0001	0.195	0.075	0.568	-0.485
Diptera (L)	0.0003	0.195	0.149	0.852	-0.432
Diptera Orthorrapha (L)	0.0003	0.195	0.168	0.568	-0.476
Diptera orthorrapha nematocera (L)	0.0024	0.545	0.438	1.705	-0.253
Diptera Psychodoidea (L)	0.0003	0.156	0.205	0.568	-0.475
Diptera Psychodoidea (A)	0.0001	0.039	0.186	0.284	-0.528
Diptera ceratopogonidae (L)	0.0018	0.351	0.507	1.989	-0.21
Diptera simulidae (L)	0.0015	0.584	0.261	1.136	-0.359
Diptera tipulidae (L)	0.0185	1.948	0.950	3.125	0.086
Diptera culicidae (L)	0.0000	0.039	0.056	0.284	-0.540
Diptera chironomidae (L)	0.0073	1.130	0.646	6.534	0.571
Diptera orthorrapha brachycera (L)	0.0231	1.675	1.379	4.545	0.341
Diptera Empididae (L)	0.0050	0.662	0.755	1.989	-0.174
Diptera stratiomydae (L)	0.0000	0.039	0.075	0.568	-0.492
Diptera tabanidae (L)	0.0010	0.234	0.447	1.420	-0.312
Diptera cyclorrapha (L)	0.0052	0.779	0.671	2.841	-0.038
Diptera cyclorrapha (A)	0.0001	0.078	0.093	0.568	-0.488
Diptera muscidae (L)	0.0034	0.506	0.663	3.125	-0.005
Hymenoptera A	0.0006	0.156	0.354	1.136	-0.369
Hymenoptera formicidae A	0.0027	0.312	0.857	1.705	-0.226
Hymenoptera parts (A)	0.0079	0.935	0.848	1.136	-0.290
Himenóptera vespidae (A)	0.0002	0.039	0.466	0.284	-0.503
Hemiptera mesoveliidae (A)	0.0004	0.039	0.969	0.284	-0.458
Orthoptera (A)	0.0002	0.039	0.466	0.284	-0.503
Orthoptera tetrigidae (A)	0.0020	0.117	1.751	0.568	-0.339
Coleotera (L)	0.0002	0.078	0.242	0.568	-0.475
Coleotera dytiscidae (A)	0.0016	0.195	0.820	1.136	-0.326
Coleoptera psephenidae (L)	0.0043	0.857	0.503	0.852	-0.370
Coleoptera parts	0.0046	0.623	0.736	1.420	-0.269
Ephemeroptera (nymph)	0.0000	0.039	0.093	0.284	-0.536
Ephemeroptera part (nymph)	0.0002	0.273	0.056	1.420	-0.345
Trichoptera (L)	0.0000	0.039	0.009	0.284	-0.543
Trichoptera Hydropsichidae (larva)	0.0003	0.156	0.205	0.852	-0.429
Collembola Sminthuridae	0.0001	0.039	0.242	0.284	-0.523
Annelida	0.0003	0.078	0.335	0.284	-0.512
Aracnea (At)	0.0000	0.039	0.112	0.284	-0.534
Neuroptera	0.0005	0.078	0.652	0.284	-0.484
Odonata (nymph)	0.0004	0.039	0.112	0.284	-0.534
Insect part	26.3582	81.262	32.436	18.750	9.0154
Algas: clorophyceas	0.0000	0.000	8.160	4.830	0.915
Fish scale	0.0000	0.039	0.024	0.284	-0.542
Epithelium tissue of fish	0.0000	0.039	0.093	0.284	-0.536
Stones	0.0003	0.234	0.116	0.852	-0.433
Plant material	0.0000	0.000	1.025	1.136	-0.317
Fruits	0.0004	0.117	0.354	0.852	-0.417
Oocyte	0.0000	0.039	0.019	0.284	-0.543
Seed	0.0768	3.078	2.497	4.830	0.549
Digested material	0.0000	0.000	36.088	19.034	5.696
Total		100	100	100	

Table 4. Variation percentage and mean values of the main component analysis of the alimentary items of *Hemibrycon sp.* from Tinajas creek, Quindio River. upper Cauca River. Colombia.

Component number	Eigenvalue	Porcent of Variance	Cumulative percentage
1	2.5	83.6	83.6
2	0.44	14.7	98.3
3	0.05	1.68	100

DISCUSSION

Species are not pieces of a machine with fixed properties, nor constants populations rather, the same species responds differently in different places or moments to the challenges of survival (Margalef, 2002). Most tropical fish do not usually show trophic specializations and often change their diet as their biotype changes or according with the fluctuation of the seasons (Lowe-McConnell, 1987). This is the case for *Hemibrycon sp.*, given that it does not only feed on aquatic insects but also on alochtonous material (Ara-nnea, Himenoptera, vegetal part and beetles Coleoptera) that fall occasionally into the water, during the dry and wet seasons. This response is similar to that found by Román-Valencia *et al*., (*pers. com.*) for *Bryconamericus caucanus* and

Hemibrycon boquiae, where the only differences in the food was the presence of alochtonous material (such as Hymenoptera (Formicidae), terrestrial beatles, Annelida and Hemiptera. It is accurate to say that *Hemibrycon sp.* then, is a generalist species.

The presence of bushy remnants along the shores of Tinajas creek provides more oppor-tunity for vegetal components and forest related arthropofauna which *Hemibrycon sp.* Exploits. This can be noticed by the presence of terrestrial insects, vegetal material, seeds and fruits which are not part of the aquatic environment. Lowe-McConnell (1987) noted the great importance of alloctonous material for the fish that dwell in fast flowing rivers lined with a flora and fauna foreign to the aquatic medium.

Intestinal length relative to body length is yet another indication of diet: herbivores tend to have a relative longer intestine, than carnivores (Kramer & Bryant, 1995). With the ratio in carnivores less than one (Bussing, 1993). This is confirmed for *Hemibrycon sp.*, and allows us to classify it as a carnivore and insectivore, taking into account that its diet contains mainly insects and algae, the vegetable material (plants, fruits and seeds) fruits are only 4 of the 52 items (Table 3), compared to 45 insect items. This feature has been reported for other characids like *Creagrutus brevipinnis* (Román-Valencia, 1998), *Roeboides dayi* (Román-Valencia *et al*., 2003), *Argopleura magdalenensis* (Román-Valencia & Perdomo, 2004), *Bryconamericus caucanus* and *Hemibrycon boquiae* (Giraldo & Román-Valencia *pers. com.*), all from upper Cauca river.

Unidentified nematodes were found in the stomachs of *Hemibrycon sp.*; as well as *Bryco-namericus caucanus* (Román-Valencia & Muñoz, 2001), *Argopleura magdalenensis* (Román-Valencia & Perdomo, 2004) and *Hemibrycon boquiae* (Roman-Valencia *et al*., *per. com.*), the presence of apparently undigested nematodes inside the fishe's gut means that these nematodes were endoparasites of the *Hemibrycon sp.*, these endoparasites are of indirect cycle in adult fishes (Granado, 1996), that can affect or regulate the *Hemibrycon sp.* populations.

Hemibrycon sp. has lower fecundity (445 oocytes) than other characids with wider geo-graphical range like: *Bryconamericus caucanus* with 3759 oocytes (Román-Valencia & Muñoz, 2001; Giraldo & Román-Valencia, *per. com.*), *Bryconamericus galvisi* 1391 oocytes (Román-Valencia & Muñoz, 2001) and *Creagrutus bre-vipinnis* 613 oocytes (Román-Valencia, 1998). But similar or fewer results were found in other cha-racids who have same geographical range, like: *Hemibrycon boquiae* 376 oocytes (Román-Va-lencia *et al*., *pers. com.*), *Roeboides dayi* 305 oo-cytes (Román -Valencia *et al*., 2003), *Astyanax aurocaudatus* 181 oocytes (Román-Valencia & Ruiz, 2004).

Progressive increases of Gonosomatic Index (RGS) shows the maturity level of the species which suddenly drops marking egg-laying time (Kaiser, 1973; Htun -Kan, 1978). *Hemibrycon sp.* reproduce when the dry season is ending (August) and again when the wet season is beginning (February-April). Similar results were found on other upper Cauca characids as: *Roeboides dayi* (Román-Valencia *et al*., 2003), *Creagrutus brevipinnis* (Román-Valencia, 1998) and *Bry-conamericus caucanus* (Román-Valencia & Muñoz, 2001). Confirm what was said by Lowe-

McConnell (1987), these features support that the few estimations of reproductive cycles at small basins show that there different reproductive strategies coexist, that includes spawns at dry season or at wet season or throughout the year. September-October individuals presented fat-tissue and not gonads, so they when preparing themselves for the next reproductive event.

The Shannon-Wiener diversity index gives an approximation of trophic specialization values reflect europhagic behaviour of predators (Ferriz & Salas, 1994), it works for *Hemibrycon sp.*, *Hemibrycon boquiae*, *Bryconamericus caucanus,* and *Astyanax aurocaudatus*; similar results were obtained for *Argopleura magdalenensis* (Román-Valencia & Perdomo, 2004). This trophic diver-sification let species be not -specialized and opportunistic and this behavior reduced inter and intraspecific competition, and favors differential usage of resources (Ferriz & Salas, 1994). For the sake of last considerations is why it can be said that *Hemibrycon sp.* is an opportunistic and eu-rophagic species.

Hemibrycon sp. present little or no compe-tition with *Astyanax aurocaudatus* or *Cetop-sorhamdia boquillae* as concerns feeding resour-ces, because the Morisita index (CH), resulted in a non- significant, less than 0.6 (sensus Zaret & Rand, 1971, in Herrera & López, 1997); the same was shown by Correlation Spearman range (Rs); to conclude that food is a mechanism of ecological segregation for syntopic species that could compete for resources inside the environment (*Hemibrycon sp., A. aurocaudatus* and *C. boqui-llae),* even though their diets are composed of high numbers of macroinvertebrates, differences in the exploitation method because *A. auro-caudatus* eats more alternative items like alochtonous seeds and fruits (Román-Valencia & Ruiz, 2004), *C. boquillae,* feeds at late afternoon until night and prefers Trichoptera, Ephe-meroptera, and Odonata (Román-Valencia & Giraldo, *pers. com.*), and *Hemibrycon sp.* prefers diptera and insect of alochtonous origin such as Hymenoptera and they search and catch their prey during daylight also, they have a wider alimentary spectrum.

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