

## Abundance, feeding and reproduction of *Salminus* sp. (Pisces: Characidae) from mountain streams of the Andean piedmont in Venezuela

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To obtain basic information for management, aspects of the ecology of *Salminus* sp. (Pisces: Characidae), were studied in piedmont rivers of the southwestern flank of the Andes in Venezuela. Collections were made with seines of various lengths and mesh sizes, and both underwater and terrestrial observations were recorded to estimate abundance and feeding events. Interviews with local fishermen and inhabitants were made to obtain data on use. The species is present along the entire length of the Andean piedmont in Venezuela, although in some rivers it is now scarce. Small individuals form mixed schools with *Brycon whitei*, but larger *Salminus* sp. usually only school with others of the same species. Average abundance was greater in larger rivers, and didn't vary appreciably with season for any of the rivers studied. Size and weight ranged from 15.1 to 40.5 cm SL and 47.7 to 1,210 g, respectively. Females had maximum ovary maturity at the beginning of the rainy season, with an average fecundity of 35,834 eggs, and spawning occurred during spates of high water. Feeding was crepuscular, with most events recorded during the first and last hours of sunlight. In smaller fish up to 20 cm SL, the diet was varied, but above that size fish were the principal food item. *Salminus* sp. has little commercial importance in this region but forms an important part of the local subsistence fishery, and occasionally it is targeted for sport fishing. The minimum legal size of capture for the species should be raised, since the current limit permits the capture of many sexually immature individuals.

Para obter informações básicas para o manejo de *Salminus* sp. no sopé andino ocidental da Venezuela, se estudaram aspectos sobre sua ecologia e aproveitamento. Nos rios do sopé da montanha efetuaram-se capturas de peixes com variados tamanhos de malha, assim como observações subaquáticas e terrestres para estimar abundâncias e eventos de alimentação. Aplicaram-se entrevistas para recolher dados sobre seu aproveitamento. A espécie é representada em toda a região, seus indivíduos são pouco frequentes e formam cardumes, sendo mixtos com exemplares de *Brycon whitei* quando os primeiros são de tamanho pequeno. A abundância média foi maior nos rios de tamanho grande e não variou de maneira importante no tempo para todos os rios. Os tamanhos e pesos estiveram entre 15,1 e 40,5 cm de comprimento padrão (CP) e entre 47,7 e 1.210 g, respectivamente. As fêmeas tiveram máxima maturação gonadal no começo do período de chuvas, com fecundidade média de 35.834 ovos e eventos reprodutivos em momentos de subida dos rios. Os eventos de alimentação foram mais frequentes nas primeiras e últimas horas de luz solar. Em peixes menores de 20 cm de CP, a dieta da espécie foi variada, mas acima deste tamanho os peixes foram o item principal na dieta. *Salminus* sp. tem pouca importância comercial mas forma parte da pesca de subsistência e eventualmente é objeto da pesca esportiva. O tamanho legal mínimo de captura para a espécie deve ser revisado, visto que permite o aproveitamento de indivíduos imaturos sexualmente.

**Key Words:** Food, Sexual Maturity, Andes Mountains, Subsistence fishery, Ecology, Management.

### Introduction

Fishes of the genus *Salminus* Agassiz in Spix & Agassiz 1829 (Pisces: Ostariophysi: Characidae) represent a small lineage of fishes present in most major Atlantic drainages to the Ocean in tropical and subtropical South America. Currently

only three species are recognized by Reis *et al.* (2003): *Salminus affinis* from northern Colombia and part of Ecuador; *S. brasiliensis* (including the synonyms *S. brevidens* and *S. maxillosus* which are often used in biological and fishery literature) from southern South America; and third, *S. hilarii*, originally described from the São Francisco river of Brazil, and now

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reportedly present in that river, the upper Paraná, the Tocantins and upper Amazon (plus the Orinoco River, but see below).

In high and low plains (savannah) regions as well as the lower Portuguesa River, the presence of this species is sporadic. The only species recorded from Venezuela was reported, until recently, to be *Salminus hilarii* Valenciennes 1849. Ongoing research by Flavio C. T. Lima at São Paulo University confirms our suspicion that populations from southern Brazil and those present in the Orinoco Basin are distinct species. In Venezuela this species (hereafter referred to as *Salminus* sp.) is found only in the Orinoco Basin, both from the Andean piedmont and the upper plains as well as the Guyana Shield. The species undoubtedly occupies similar habitat in the Orinoco Basin of Colombia. Its absence from the Maracaibo Basin is puzzling, since it occurs on the southern flank of the Andes that separate that drainage from the Orinoco, and a similar species, *S. affinis*, is present in the Magdalena River drainage of northern Colombia, with which the Maracaibo fish fauna has great affinity.

Aspects of the biology and ecology of *Salminus* have been studied by several scientists in southern South America (Fuster de Plaza, 1950; Cordiviola, 1966; De Godoy, 1975; COMIP, 1994; Britski *et al.*, 1999; Agostinho *et al.*, 2003) who reported on diet, growth, age and migrations, as well as their potential for fish culture. These rheophilic fishes are mostly piscivorous as adults, but juveniles have a more varied diet. When mature they make annual migrations for reproduction. In Brazil, the smaller of the two species, *S. hilarii*, is not very important in the commercial catch, but the larger *S. brasiliensis* (= *S. maxillosus*), is taken in considerable volume (Ferreira *et al.*, 1997) and has sufficient economic value to make it a species of national concern in Argentina (Governmental resolution S.R.N. y D.S. Decreto 29/97, Buenos Aires). In Venezuela, *Salminus* sp. is sought by sport fishermen, but large trophy-sized fish are now extremely rare. Barbarino & Taphorn (1995) recognized the importance of this species in sport and subsistence fisheries but also noted that basic biological information was scant.

Along the southern flank of the Andean piedmont of Western Venezuela, traditional conditions of lotic ecosystems have been modified by intense human activities such as dams, agriculture and urbanization, causing severe impacts to entire drainage systems and their fishes (Winemiller *et al.*, 1996). An apparent reduction in the frequency of capture and maximum size of *Salminus* sp. suggests that this species has suffered population reductions throughout the region; the same trend has been reported for other commercial species such as the coporo, *Prochilodus mariae*, and tiger catfish, *Pseudoplatystoma fasciatum* (Barbarino *et al.*, 1998).

In light of the fact that existing government fishery databases lack information for *Salminus* sp., along with the lack of basic biological studies for this large predator, we initiated research to provide basic information needed to guide management. Our objectives were to 1) determine the current distribution for this species along the southern flank of the Western Andes in Venezuela; 2) document local population

abundance; 3) record basic morphometric and life history information; 4) study diet and feeding habits, and 5) determine the importance of this species in local fisheries.

## Materials and Methods

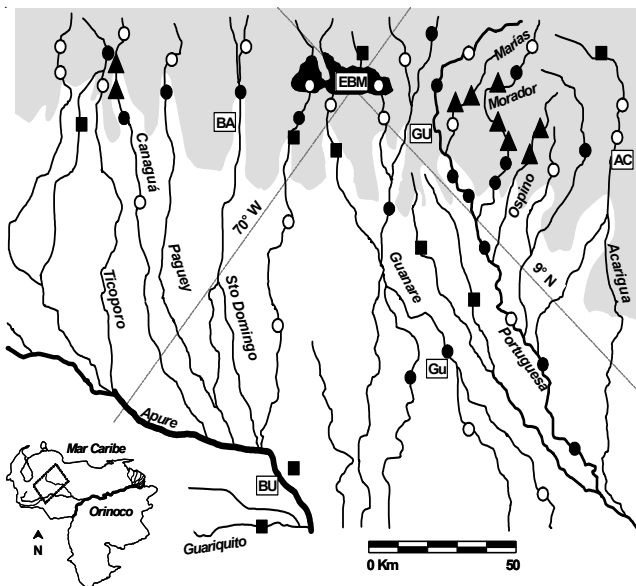
**Study Area.** The Andean piedmont of Western Venezuela stretches about 400 km between altitudes of 200 to 700 m and is characterized by dissected hills, ridges and alluvial cones (Schubert & Vivas, 1993). Vegetation in this band consists of a mosaic of semi-deciduous forests, gallery forests, savannahs and chaparrals (Ortega, 1991) located in dendritic watersheds that eventually drain into the Apure River. According to Vásquez (2000), in the middle Morador River drainage the annual mean temperature and rainfall are 25 °C and 1,800 mm, respectively. Nearly all annual precipitation occurs during the wet season, from May to November.

In the upper piedmont, where slopes are greater, most rivers have high transparency during the dry season, but visibility diminishes considerably in the plains (called llanos in Venezuela). During the wet season, most rivers carry heavy sediment loads and transparency rarely exceeds 10 cm. Above 250 m (above level sea), the substrate is usually rock or gravel, but in the llanos (120 m) sand and silt dominate. A major highway links important cities located on the southern flanks of the Andes, permitting easy access to the area and the accompanying negative impacts in aquatic ecosystems. Extensive deforestation is associated with conversion to for cattle ranches, sugar cane plantations, and corn, rice and sorghum fields (Winemiller *et al.*, 1996).

**Sampling.** The Morador River (Fig. 1) was visited about every three months from 1999 to 2001. During the first field season, sampling effort was concentrated from December to June, but later observations were made during the rest of the year (August to October). Observations (counts) were recorded from shore and underwater with mask and snorkel. During the dry season fish were collected with gill nets (30 m length, 3 m deep, and 3 - 6 cm mesh between knots) and also with fine-meshed seines (10 m length, 2 m depth, 0.5 cm mesh). Specimens, included intact gonads and stomachs, were preserved in 10% formalin. Total (TL) and standard (SL) lengths were measured and weight was recorded in grams.

During 2000, three Rio Morador pools were observed from shore to record feeding behavior and frequency. From 05:00 to 20:00 h, 10 min. of each hour were spent recording individual feeding events. Live fish were also captured and maintained at the UCLA Fish Culture Station where reproduction was induced by hormone injection. Substrate size and composition was estimated using a 1 m<sup>2</sup> quadrant system, the percentage of the bottom covered by each category (sand, gravel, stones and rocks) was visually estimated. Transparency was measured with a Secchi disk, and pH was measured with a portable meter (Corning® Check Mate 90).

Underwater surveys were made in the Morador, Ospino, Las Marias and Canaguá Rivers (Fig. 1) to estimate fish abun-



**Fig. 1.** A section of the Andean Piedmont in western Venezuela. Black circles indicate capture sites for *Salminus* sp. during this study; white circles indicate observations or literature references; triangles indicate sites where abundance was measured; black squares indicate museum records from MCNG and MHNLS. The shaded gray area roughly delimits the transition from piedmont to high llanos (plains) approximately 200 meters above sea level. Cities are abbreviated as follows: Barinas (BA), Guanare (GU), Acarigua (AC), Guanarito (Gu) and Bruzual (BU). The Boconó-Masparro Reservoirs are indicated as EBM.

dance during the two dry seasons occurring in 1999–2001, using the criteria for such estimates proposed by Uieda & Uieda (2001). After scouting the river for the presence of *Salminus* sp, transects in appropriate habitat were established. In pools transects were established for counts taken while snorkeling at the surface. Along each transect, five repetitions were made, swimming against the current. The average length of transects was 30 meters, and width varied with the size of the rivers. At these sites, a visual inventory of other species of fishes schooling with *Salminus* sp. was also made, along with observations of potential prey species.

In other rivers and reservoirs in the piedmont and upper llanos, additional observations were made from shore and informal interviews were held with local fishermen and inhabitants to determine the presence of *Salminus* sp. Temporary fish camps were visited, and local fishermen were accompanied with the purpose of observing fishing methods, gear, and capture frequency.

**Data Analysis.** To examine the relationship between length and weight, linear regression was performed following procedures outlined by Anderson & Neumann (1996). Ovarian maturity stages were recorded qualitatively as initial, medium, maximum and post reproductive condition (Nikolsky, 1963), and fecundity was calculated by counting mature oocytes in

a weighed subsample of the ovary and then extrapolating based on total ovarian weight (Snyder, 1983). The frequency of occurrence method was used to quantify stomach contents (Marrero, 1994), grouping individuals of *Salminus* sp. into two size classes, (< 20 cm SL, > 20 cm SL). *Salminus* sp. smaller than 20 cm TL form mixed schools with the omnivorous *Brycon whitei*. To estimate correlations between variables (e.g. fecundity, SL, abundance, pool size) Spearman tests were used.

**Voucher Specimens.** The following specimens (listed by state) were examined for this study and are deposited in the Museo de Ciencias Naturales de la UNELLEZ en Guanare, estado Portuguesa, Venezuela (MCNG): Amazonas: MCNG 25809 (1 individual) río Putaco, raudal Chicrita-Pora Cucurital; 45873(1) campamento indígena Piaroa. Apure: 1231 (1) Puente Bruzual; 43810 (12) Hato el Frío; 43840 (1) caño Guaritico, entre los fundos Cornelio Herrera y Las Ventanas. Barinas: 766 (1) río Caparo, entrando a Santa Bárbara; 829 (1) río Apure, Puerto Nutrias; 5389 (1) río Masparro; 8872 (1) río Boconó en sitio de la presa. Bolívar: 12555 (1) río Cataniapo, caño Carinagua; 23678 (1) río Zariapo al norte de Serranía de Maigualida. Guárico: 48859 (1) carretera Calabozo a San Fernando, a 4,5 km de Camaguán y 4,5 km de la torre de CANTV. Lara: 34962 (1) río Guaical, Parque Nacional Yacambú. Portuguesa: 242 (1) préstamo al norte de las Moritas; 243 (9) caños Agropecuaria San Isidro, 1723 (2) caño El Diablo, río arriba confluencia de ríos Guanarito y Guanare, 3514 (1) río Portuguesa en el Rincón; 5541 (1) río Boconó en La Veguita; 5645 (2) río Tucupido en Las Canoas, 300 msnm; 5823 (1) río Tucupido en la presa; 8618 (2) caño Maraca, en el puente; 10882 (1) zanja a 74,8 km al norte de Guanarito; 16413 (1) río Boconó debajo de la presa; 25128 (2) río Las Marías, a 5 km NE de El Potrero; 34155 (1) sabana inundable del caño Igüez; 35450 (1) caño Volcán, vía entre Tucupido y la represa.

## Results

### Distribution and Habitat of *Salminus* sp.

*Salminus* sp. were observed in all rivers and reservoirs visited throughout the piedmont region (Fig. 1). Most observations and captures were obtained during the dry season, since they are rare (or more probably, very difficult to observe) during periods of high water.

Fish were found in permanent water courses from 90 a 720 m above sea level, but were more common between 250 and 450 m. Dry season temperature and pH in these piedmont rivers was 24.5°C and 7.4, respectively. Transparency was high during the dry season (visibility extended to the bottom of the river) but diminished to about 5 cm for short periods following rain storms. In rivers of the high llanos (over 50 meters above sea level), transparency was only 20 cm and was reduced to 5 cm during and shortly after rainstorms. In the Morador River during the dry season and at about 300 m above sea level, substrate composition was rocks and stones 52% (std. dev. = 12.2, max = 67%), 34% course gravel (std. dev. = 8.4, max = 44%) and 12% sand (std. dev. = 8, max = 22%). At lower elevations larger substrate categories were uncommon, and below about 100 m, sand was the dominant substrate (~90%).

### Underwater Observations.

Underwater observations revealed that *Salminus* sp. form small schools (mean school size = 4.2 individuals, max = 12, n = 45). Fish smaller than about 20 cm TL were usually observed in mixed schools with *Brycon whitei* (Characidae), with the latter species usually being more abundant.

The largest numbers of fish were observed in the largest rivers, and those that were the least altered by human impacts such as the Canaguá; in these sites, we were able to capture very few fish with nets. In the underwater counts, average abundance did not vary significantly among rivers (Fig. 2), and remained more or less constant throughout the study period. The largest values were obtained for the Canaguá River (mean = 4.26, std. dev. = 0.21) and the lowest for the

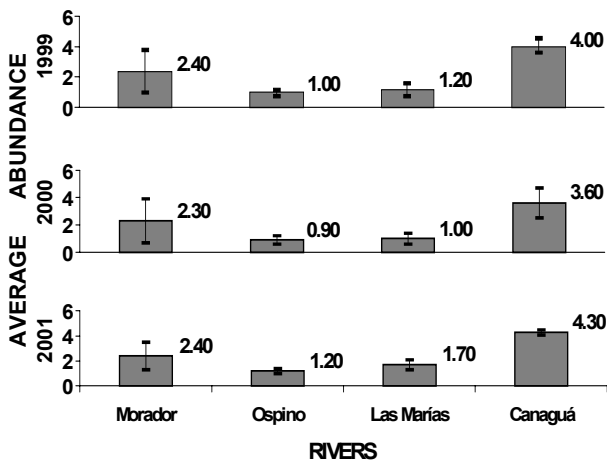


Fig. 2. Annual average estimated abundance (means of individuals for transect) based on underwater surveys in four piedmont rivers. Error bars indicate one standard deviation.

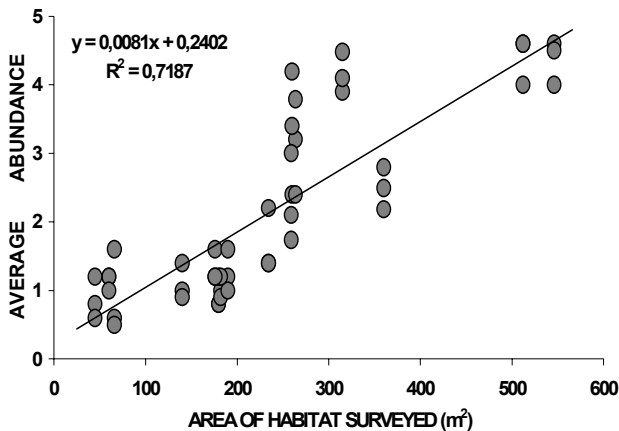


Fig. 3. Relation between estimated areas in river sections where *Salminus* sp. were counted and average abundance (means of individuals for transect). Larger areas correspond to larger rivers.

Ospino River (mean = 0.90, std. dev. = 0.30). We found a positive relationship ( $r^2 = 0.72$ ,  $p < 0.001$ ) between abundance and channel width (Fig. 3).

### Biometric Relationships, Sex Ratios and Fecundity.

Fish caught from the Morador River ranged from 15.1 - 40.5 cm SL in length and weighed between 47.7 - 1210 g, with average size being 23.5 cm SL (std. dev. = 6.9, n = 47). Males (mean = 21.3 cm SL, mean = 181.3 g, n = 19) were smaller in both size and weight than females (mean = 26.4 cm SL, mean = 1,424.1 g, n = 22). The model  $\text{Weight} = 0.073 * \text{SL}^{3.26}$  ( $r^2 = 0.98$ ,  $F = 509.3$ ,  $p < 0.0001$ ) showed nearly isometric growth (Fig. 4).

The sex ratio was 1:1.2 (males:females), for 12.8% of the individuals, sex could not be determined. Minimum size with mature gonads was 19.5 cm SL for females. Ovaries at the maximum maturation stage averaged 38,834 eggs (min = 17,528, max = 57,834, n = 14). Oocytes were 1.4 - 1.5 mm in diameter and light green in color. There was a positive correlation between standard length and fecundity ( $r^2 = 0.66$ ,  $p < 0.01$ ).

Females were found with ovaries in the initial stage of maturity in December, and reached maximum ripeness in June, at which time males were found with small hooks on their anal fin rays. Fish kept in captivity also showed maximum gonad development in June, at which time artificial reproduction was induced by hormone injection. Larvae were collected from the Portuguesa River during discharge peaks. In July and August, individuals of both sexes usually were found in post reproductive condition.

### Diet and Feeding Frequency.

More feeding events were observed between 05:30 a 09:00 h (mean = 4.38 events, std. dev. = 3.2, maximum = 16, n = 92) and 15:30 a 19:00 h (mean = 2.7 events, std. dev. = 2.4, max = 11, n = 64). During these two peaks, 87% of all observed

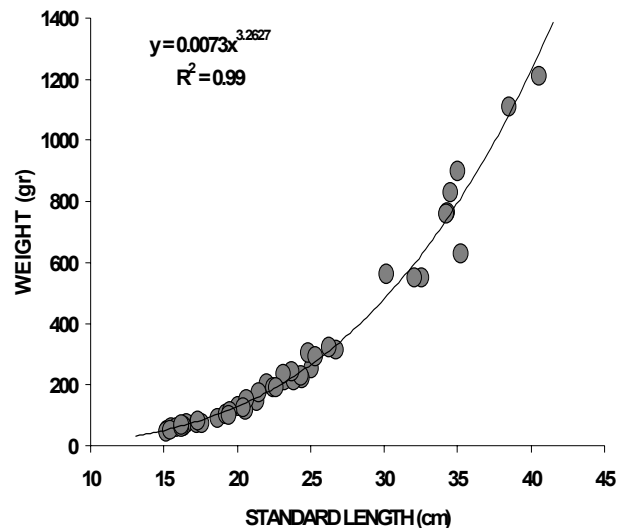


Fig. 4. Length-Weight relationship for *Salminus* sp. in the Morador River.

feeding took place. Between 10:00 and 14:30 hours the average frequency was low (mean = 0.3 events, std. dev. = 0.47, n = 9). Events were rapid attacks involving pursuit in open areas near the center of the channel (52%), near shore (36%) and rarely near the bottom. Smaller individuals schooling with *Brycon whitei* behaved similarly to larger adults, but attacked arthropods drifting downstream in mid channel.

Stomach content analysis showed that individuals of size class I (15.1 - 20 cm SL, n= 18, empty= 4) had a varied carnivorous diet (Table 1). We identified 20 principal diet components, but fishes were most often consumed (40%), usually small characids such as *Bryconamericus* spp. and *Gephyrocharax valencia*. Among the invertebrates found in stomachs (30% of the total diet), we identified ants of the genus *Atta* sp., bees (Hymenoptera, 20%) and Coleoptera (7%). Vegetation was scant (15%) and consisted mostly of seeds (Amaranthaceae y Mimosaceae). In larger individuals of size class II (> 20 cm SL, n = 24, empty = 7) the number of food items was smaller (12), with fishes representing 67% of the diet and invertebrates 25%. Among the fishes consumed by larger *Salminus*, we found larger species such as *Astyanax* spp., *Prochilodus mariae*, and *Brycon whitei* (Table 2), but correlation was low between predator size and size of prey consumed ( $r^2 = 0.53$ ,  $p < 0.001$ ).

**Table 1.** Absolute (AF) and relative (RF) frequencies by item and component (animal, vegetation and inorganic) for small (< 20 cm SL) individuals of *Salminus* sp. from Morador River. n = 18 stomachs.

COMPONENTS	AF	RF (%)		TOTAL
		ITEMS	COMPONENT	
ANIMAL COMPONENT				
1. Fishes				
<i>Astyanax integer</i>	2	25.0	13.3	10.0
<i>Bryconamericus</i> sp.	2	25.0	13.3	10.0
<i>Gephyrocharax valencia</i>	3	37.5	20.0	15.0
<i>Ancistrus</i> sp.	1	12.5	6.7	5.0
Subtotal	8	100	53.33	40.00
2. Crustacea				
Decapoda <i>Macrobrachium</i> sp.	2	100.0	13.3	10.0
Subtotal	2	100	13.33	10.00
3. Invertebrates				
Hymenoptera Formicidae ( <i>Atta</i> )	2	50.0	13.3	10.0
Hymenoptera Vespidae ( <i>Apis</i> )	1	25.0	6.7	5.0
Coleoptera (Carabidae)	1	25.0	6.7	5.0
Subtotal	4	100	26.67	20.00
4. Others animal components				
Dove feathers (Columbidae)	1	6.7	6.7	5.0
Animal component:	15	100	100	75.00
VEGETATION COMPONENT				
Seeds (Amaranthaceae)	1	33.3	33.3	5.0
Seeds (Mimosaceae)	1	33.3	33.3	5.0
Flowers (Amaranthaceae)	2	66.7	66.7	10.0
Vegetation component:	3	100	100	15.00
INORGANIC COMPONENT				
Sand	1	100.0	100.0	5.0
Inorganic component:	1	100	100	5.00
<b>TOTAL COMPONENTS</b>	<b>20</b>			<b>100</b>

## Fishery Exploitation.

In the piedmont the species of most importance for the commercial fishery for human consumption is the coporo, *Prochilodus mariae*. In the high plains, tiger catfish (*Pseudoplatystoma fasciatum*) and pacu (*Colossoma brachypomus*) also were important commercial species. Fishing effort directed at *P. mariae*, also harvest *Salminus* sp. Cast nets and seines, with mesh sizes of about 2 cm are used by fishermen seeking coporo. Fishermen also use hook and line and pneumatic spear guns. Fishing occurred year round.

Subsistence fishers target more species than commercial fishers, including *Brycon whitei*, *Salminus* sp., *Schizodon* sp., *Curimata cerasina*, several types of small catfishes (*Sorubim*, *Rhamdia*) and armored catfishes (*Chaetostoma*, *Ancistrus*). Pressure is most intense during the dry season, when fishing is more efficient.

In the piedmont, our interviews show that fishing was usually undertaken by local residents or sometimes by regional tourists. Sport fishing was only observed occasionally, with more activity observed in sites with tourist facilities, such as the reservoirs, or tourist camps along the Canaguá River near major highways. *Salminus* was occasionally found in fish markets in the llanos but was sold with fish of low market value such as *Schizodon* or *Leporinus*, probably because of their small size and large number of bones.

## Discussion

The saltador lives in rivers of the southern flank of the Andean piedmont during the dry season, and spawning migrations to the llanos are synchronized with the period of high rains and river flood stages. The strategy of timing reproduction to coincide with the annual floods is common to many other fishes of the Apure drainage such as the coporo, pacu, and tiger catfish (Reid, 1983; Winemiller & Taphorn, 1989; Barbarino *et al.*, 1998). Populations in local reservoirs are isolated from those remaining in unimpounded rivers nearby. Reports of saltadors from the lower llanos are scarce. Small *Brycon whitei* and *Salminus* sp. are similar in shape and coloration. Larger saltadors formed monospecific schools, and were seldom seen in association with smaller fish of their own species. Fish larger than 20 cm TL include *Brycon whitei* in their diet.

Mixed schools of *Salminus* sp. and *Brycon whitei* observed here (with *Brycon* being more abundant) were also reported by Taphorn (1992) who suggested aggressive mimicry. He also noted that they apparently compete for drifting food. The two species may school together at smaller sizes to lower juvenile mortality, as has been suggested for other characids (Machado-Allison, 1987). This would be consistent with our observation that larger individuals do not occur in mixed species schools. Dietary differences between the two sizes classes of *Salminus* sp. could indicate differences in feeding strategy because of their participation in mixed or monospecific schools at different sizes. *Salminus* sp. were more abundant in larger rivers such as the Canaguá. This is

**Table 2.** Absolute (AF) and relative (RF) frequencies by item and component (animal and inorganic) for large individuals (> 20 cm SL) of *Salminus* sp. from the Morador River. n = 24 stomachs.

COMPONENTS	AF	RF (%)		TOTAL
		ITEMS	COMPONENT	
<b>ANIMAL COMPONENT</b>				
1. Fishes				
<i>Astyanax integer</i>	2	25.0	18.2	16.7
<i>Astyanax</i> sp.	1	12.5	9.1	8.3
<i>Brycon whitei</i>	1	12.5	9.1	8.3
<i>Gephyrocharax valencia</i>	2	25.0	18.2	16.7
<i>Hemibrycon metae</i>	1	12.5	9.1	8.3
<i>Prochilodus mariae</i>	2	25.0	18.2	16.7
<i>Ancistrus</i> sp.	1	12.5	9.1	8.3
Subtotal	8	100	72.73	66.67
2. Crustacea				
Decapoda <i>Macrobrachium</i> sp.	1	100.0	9.1	8.3
Subtotal	1	100	9.09	8.33
3. Invertebrates				
Coleoptera (Scarabeidae)	2	100.0	18.2	16.7
Subtotal	2	100	18.18	16.67
Animal component:	11		100	91.67
<b>INORGANIC COMPONENT</b>				
Sand	1	100.0	100.0	8.3
Inorganic component:	1	100	100	8.33
<b>TOTAL COMPONENTS</b>	<b>12</b>			<b>100.00</b>

probably related to the fact that there are more habitats and more food available in larger rivers.

Female *Salminus* are longer and heavier than males, as reported by Barbieri *et al.* (2001) for *S. brasiliensis*. Average lengths and weights reported here are similar to those found by De Godoy (1975) for *S. hilarii* from the Mogi Guassu River, where size classes of 15 to 28 cm TL for males and from 27 to 32 cm TL for females were reported. The maximum length (the author does not specify whether SL or TL) of *S. hilarii* reported for the Paraná River was 42 cm (Agostinho *et al.*, 2003). The largest female measured during our study was 50 cm TL, and even larger individuals were observed during the underwater census.

Sato *et al.* (1997) reported an average of 49,200 eggs per kilogram of *S. brasiliensis*, but Agostinho *et al.* (2003) reported a maximum of 2,600,000 eggs. In the smaller *S. hilarii*, males reproduce for the first time in their second year of life, but females wait until their third year according to De Godoy (1975), who estimated fecundity at between 25,000 and 30,000 oocytes. Agostinho *et al.* (2003) reported a maximum fecundity of 100,000 eggs for *S. hilarii*. These values are generally higher than those we observed from the Morador River. Taphorn (1992) reported that the reproductive strategy employed by this species is "r2" (long life, high fecundity, reproduction once per year) and that reproduction follows the annual climatic cycle. During the dry season, the gonads mature and at the beginning of the rainy season, adults apparently descend from the piedmont to spawn in flooded regions of the upper llanos.

*Salminus* sp. is the largest piscivorous fish to inhabit the Andean piedmont year round, although large catfishes are

known to move through the area. Deforestation of the headwaters and extirpation of the Orinoco Crocodile caused river channels and pools to become sedimented. Prior to these impacts, other larger predators also may have been permanent residents. *Salminus* have been characterized as active midstream predators (Almeida *et al.*, 1997). Other visually oriented piscivores, such as the peacock cichlids (*Cichla* spp.: Cichlidae), have been shown to be mostly crepuscular in feeding activity (Rodríguez-Olarte & Taphorn, 1997). Crepuscular feeding could be related to behavioral changes in prey, favorable lighting conditions for the predator, or to emergence or drift patterns known to occur in many aquatic invertebrates.

Diets of species within the genus *Salminus* seem to follow a general pattern. De Godoy (1975) found that *S. brasiliensis* between 5 and 14 cm TL, feed on copepods, odonates, chironomids and small fishes such as *Astyanax*. Above 8 cm TL, the diet was mostly fish, such as *Prochilodus*, *Brycon* and *Leporinus*. Similar results were reported by Bistoni & Gutiérrez (1996) for *S. brasiliensis* from rivers in Argentina. Adult size classes of *Salminus* sp. from the Morador River fed mostly on fish.

*Salminus* are only incidentally caught by commercial fishermen, but are regularly found in the subsistence fisher's catch, and are sought out only occasionally by sport fishermen in this region, corroborating information given by Barbarino & Taphorn (1995). According to those authors, the minimum size for legal capture of this species is 20 cm TL (~ 16.5 cm SL). Our preliminary results from this study indicate that this species does not mature until it reaches at least 23 cm TL or 19.5 cm SL. Thus, the legal size limit should be raised to 23 cm TL to protect the species until it has had the opportunity to reproduce.

Many piedmont rivers have now been dammed or have dikes used to divert their water into irrigation projects (Santo Domingo, Masparro, Boconó, Tucupido, and Guanare). To date, the Portuguesa River has escaped this fate, and thus is one of the few remaining rivers in the region where migratory fishes can make their biannual journeys, and complete their life cycles. Dams have negatively effected *Salminus* populations in other parts of South America, for example *Salminus brasiliensis* populations suffered marked reductions after the construction of the Salto Grande, Itaipú and other reservoirs on the Paraná River (COMIP, 1994; Agostinho *et al.*, 2003). Barbarino *et al.* (1998), showed how Coporo (*Prochilodus mariae*) populations were impacted by the construction of the dams on the Boconó, Masparro and Tucupido rivers.

According to Rodríguez (2000), fishery harvest has grown more quickly than human populations in Venezuela, reflecting a decline in capture per unit of effort, and predicting that current practices are not sustainable in the long term. Commercial fishing, deforestation of headwaters, effluents from urban and agricultural runoff, and dams are posing growing threats to fishery resources in the Andean piedmont of western Venezuela. Sustainable exploitation of *Salminus* sp. will require more research on ecological requirements, better monitoring of fish harvest levels and better consensus among local people and their government.

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