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ON THE FEEDING ECOLOGY OF THE CATFISH *HYPOPHTHALMUS FIMBRIATUS* IN THE BLACKWATER RIO NEGRO OF THE AMAZON BASIN

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The catfish family Hypophthalmidae, with at least three species, is widely distributed in South America, to which it is confined. The Amazon Basin is the only hydrographical system to contain all three of the currently recognized species (Oliveira, 1981). *Hypophthalmus edentatus* (Spix, 1929) is known from the Orinoco, Amazon and La Plata drainages, and *H. marginatus* (Valenciennes, 1840) only from the Amazon. Both of these species are food fishes but not very important in total catches in the Amazon Basin, the area where they are most exploited (Petrere, 1978; Goulding, 1979, 1981; Smith, 1979, 1981). In the large mouth-lakes of eastern Amazon affluents, such as the Rio Tocantins, however, *H. marginatus* is the most important species captured (J. L. Carvalho, 1978) *.

Hypophthalmus fimbriatus (Kner, 1857) appears to inhabit mostly blackwater rivers (see below), and the majority of the known specimens are from the Rio Negro (Oliveira, 1981 and pers. obser.). *Hypophthalmus fimbriatus* is quite distinct from its congeners because of its smaller adult size (seldom reaching over 30 cm standard length) and its greatly elongate, flat and thick mental barbels (Fig. 1). No other known catfish species, anywhere in the world, has as large of mental barbels, relative to body length, as does *H. fimbriatus*. Like other hypophthalmids, *H. fimbriatus* has a ventrally keeled body with an extremely long anal fin that runs from near the pectoral fins to the anterior edge of the caudal peduncle. The eyes are low on the head and laterally displaced; the lateral line is well developed with ventral and dorsal ramifications from the main axis. The gillrakers are characterized by numerous, elongate filaments.

In this paper we offer the first observations on the ecology of *H. fimbriatus* and its interactions with zooplankton in the Rio Negro.

STUDY AREA

The Rio Negro, so-named because of its blackwaters, is the largest affluent, in terms of discharge, of the Rio Solimões-Amazonas (Fig. 2). Rio Negro waters are stained by organic compounds derived from low-lying forest growing on podzolic soils in some of the tributary catchments basins (Klinge, 1967; Leenheer, 1980). These organic compounds, in conjunction with Guiana Shield headwaters draining granitic and gneissic formations, render the Rio Negro highly acidic, with pH values usually bellow 4.8. The humic acids that stain the Rio Negro reduce it water transparency to about 1.0-1.5 m. Despite its organic compounds, the Rio Negro is still analogous to slightly contaminated distilled water, owing to its basic nutrient poverty (Sioli, 1968a). In situ primary production is very low (Schmidt, 1973).

River level fluctuation of the lower Rio Negro is largely controlled by the oscillation of the Rio Solimões-Amazonas because of the differential rise and fall of the main trunk and its large tributary. Average annual fluctuation of the lower Rio Negro at the port of Manaus has been about 12.5 m since 1902 (PORTOBRAS, 1977). The damming influence of the Rio Solimões-Ama-

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* Ironically, three of the people who have worked on *Hypophthalmus*, including the first author of this paper, have the surname Carvalho. To avoid confusion, innitials are also used when the name Carvalho appears.

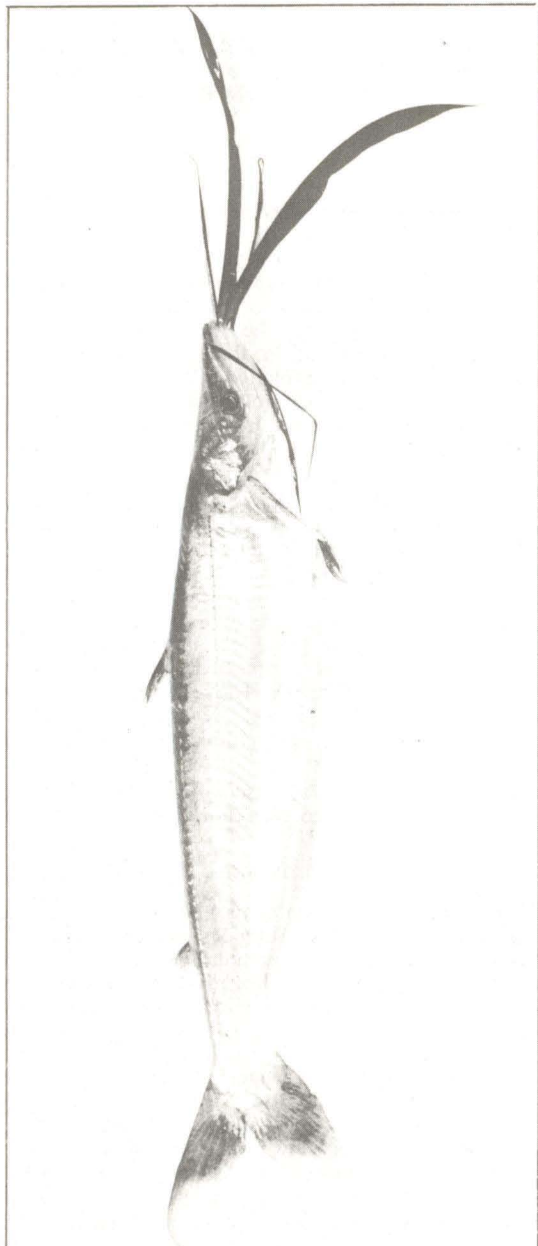

Fig. 1. *Hypophthalmus fimbriatus.* 28 cm Standard Length.

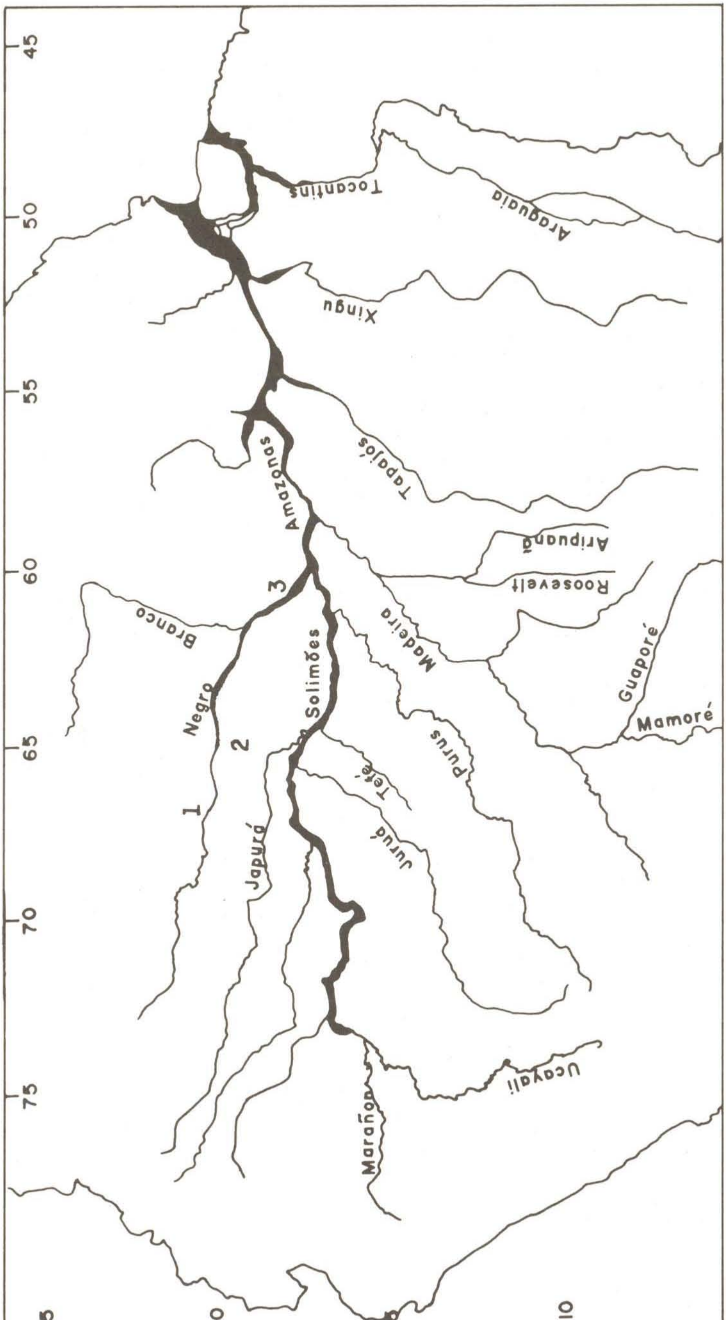

Fig. 2. The sites where *Hypophthalmus fimbriatus* specimens were collected in the Rio Negro. 1. São Gabriel da Cachoeira. 2. Ilha de Tamaquaré. 3. Ilhas das Anavilhanas.

zonas is not felt above about the mouth of the Rio Branco, the Rio Negro's largest affluent, and which lies about 250 km upstream. The main flooding season of the lower Rio Negro is between about February and the end of July. The high water period of the upper Rio Negro is between about April and July with a small rise as well in November or early December. The low water period is much more pronounced in the upper than in the lower Rio Negro, again because the former is not influenced by the Rio Solimões-Amazonas.

METHODS

Twenty-five specimens, or about three-fourths of all those captured in the upper and lower Rio Negro by the second author in 1979 and 1980, during both the low and high water periods, were analyzed for food contents in the stomachs and intestines. Three basic methods — occurrence, dominance and total volume — were employed to analyze the food items encountered. Occurrence is defined as the number of times that a particular food item was present and dominance as the number of specimens in which a food item accounted for the greatest part of the bulk. Total volume was determined by first estimating fullness on the basis of 5 percent, 25 percent, 50 percent, 75 percent or 100 percent. The entire bulk of the food items in the stomach and intestines was then assigned a value of 100, and subsequently, the relative percentages of zooplankton and all other food items (the latter considered as a group) were estimated at the same intervals used to calculate total volume. For each specimen the fullness value was multiplied by the relative abundance values for each of the two main food groups (i.e. zooplankton and other food items), and then each of these values was divided by 100.

The specimens were captured at three sites, namely São Gabriel da Cachoeira (May 1979), the Ilha de Tamaquaré of the middle Rio Negro (October 1979) and the Ilhas das Anavilhanas (March/April and August 1980) in the lower course of the river (see Fig. 2). The analyses were separated into the high and low water periods based on the presence of inundated floodplain forest to separate the first season from the second. Thus the specimens from São Gabriel da Cachoeira and the March/April collection from the Ilhas das Anavilhanas were taken in floodplain forest, and the individuals from the Ilha de Tamaquaré and the August collection at the Ilhas das Anavilhanas were captured in island lakes during the low water season. All of the specimens were captured with gillnets.

Cladoceran zooplankton were identified, whenever possible, to the level of species, rotifers to genera, copepods to Cyclopoida or Calanoida and ostracods only to the order. Insects were identified mostly to orders. All arachnids found were of the class Acarina. No attempt was made to identify the small amounts of phytoplankton and bryozoans found.

RESULTS

Of the 25 specimens of *H. fimbriatus*, ranging between 24 and 30 cm standard length, analyzed for food contents, only three individuals had completely empty stomachs and intestines (Tab. 1). The mean fullness at both lake sites was 62 percent, compared to only 35 and 34 percent for the two flooded forest areas where *H. fimbriatus* was captured. Zooplankton was the major food item eaten at all sites, and accounted for about 89 percent of the total food consumed.

Cladocerans were the principal zooplankton eaten at all sites, followed by copepods and ostracods in much lesser quantities (because the zooplankton taxa eaten were nearly the same at all sites, we have combined the results to show the occurrence and dominance of each — Tab. 2). *Bosminopsis deitersi* (Cladocera) showed the highest occurrence and dominance, hence volume, of all zooplankton taxa eaten, followed by *Bosmina* sp. (Cladocera). Together these two zooplankton taxa were the dominant food in 18 (72 percent) of the specimens. Rotifers were represented by the genera *Kratella* and *Leca-*

FOOD ITEMS	OCCURRENCE	DOMINANCE
ZOOPLANKTON		
Bosminopsis deitersi (Cladocera)	19	11
Bosminopsis negrensis (Cladocera)	1	--
Bosminopsis sp. (Cladocera)	1	1
Bosmina hagmani (Cladocera)	2	--
Bosmina sp. (Cladocera)	21	6
Ceriodaphnia cornuta (Cladocera)	3	1
Moina rostrata (Cladocera)	4	1
Moina minuta (Cladocera)	6	--
Ilyocriptus sp. (Cladocera)	3	--
Chydoridae (Cladocera)	3	--
Unidentified Cladocera	1	--
Ephippial eggs (Cladocera)	4	--
Cyclopoida (Copepoda)	13	1
Calanoida (Copepoda)	6	--
Ostracoda	14	--
Keratella sp. (Rotifera)	1	--
Lecane sp. (Rotifera)	1	--
Total for all Zooplankton	22	21
OTHER FOOD ITEMS		
Diptera larvae	17	--
Diptera pupae	3	--
Diptera winged forms	1	--
Ephemeroptera larvae	2	--
Coleoptera larvae	1	--
Coleoptera adults	2	--
Dytiscidae (Coleoptera)	1	--
Hemiptera	2	--
Trichoptera	4	--
Unidentified insects	2	--
Acarinae (Hydracarina)	16	--
Bryozoa	4	--
Phytoplankton	1	--
Filamentous algae	5	--
Detritus	1	1
Total for other food items	20	1

Tab. 1. The occurrence and dominance of the food items eaten by 25 specimens, ranging between 23 and 30 cm standard length, of *Hypophthalmus fimbriatus* captured in the Rio Negro.

SITE	RELATIVE ABUNDANCE (o/o)		RELATIVE VOLUME			MEAN FULLNESS (o/o)
	Zooplankton	Other Food Items	Zooplankton	Other Food Items	Total	
Flooded Forest A	89	11	244	231	475	34.0
Flooded Forest B	98	2	103	2	105	35.0
Floodplain Lake A	95	5	355	20	375	62.0
Floodplain Lake B	93	7	465	35	500	62.0

Tab. 2. The relative abundance and volume of the zooplankton and 'other food items' eaten by *Hypophthalmus fimbriatus* at two flooded forest and two lake sites in the Rio Negro study area.

ne, but these were found in only one specimen. Aquatic insect larvae (especially Diptera) and water mites (Hydracarina, Acarina) showed a high occurrence, but they were never the dominant food items in any of the specimens examined.

DISCUSSION

The data presented abcve clearly show that *H. fimbriatus* in the Rio Negro is mostly zooplanktivorous, and that cladocerans are the principal zooplankton eaten. F. M. Carvalho (1980), studying a Rio Solimões floodplain lake, showed that *H. edentatus* is also zooplanktivorous, and that cladocerans were the most important taxa eaten. Contrary to the feeding behavior of *H. fimbriatus* and *H. edentatus, H. marginatus* appears to be phytoplanktivorous, or at least in the Rio Tocantins mouth-lake where it has been studied (F. M. Carvalho, Coelho & Toda, 1978).

Both tropical and temperature studies have shown that cladocerans are the preferred choice of zooplankton-feeding fishes (e.g. Galbraith, 1967; Brooks, 1969; Goulding & M. L. Carvalho, 1982). Cladocerans, however, constitute only a small part of the total zooplankton found in most tropical inland waters investigated (e.g. Burgis, 1969 for Africa), and this is also true of the Rio Negro (Brandorff, 1977; Hardy, 1980). Monthly samples from a lateral lake of the lower Rio Negro taken by the first author showed that about 90 percent of the zooplankton consisted of copepod nauplius larvae and rotifers (M. L. Carvalho, unpublished). Rotifers and copepod nauplii are very small compared to the cladocerans eaten by *H. fimbriatus,* and the first two taxa probably pass through the gillrakers. We believe that *H. fimbriatus* is a filter feeder vis-à-vis a zooplanktivore pecker, and selects cladocerans, through the sieving action of gillrakers, because of the larger size of these crustaceans.

Although no zooplankton collections were made at the sites where *H. fimbriatus* specimens were collected, studies by Brandorff (1978), Hardy (1980) and M. L. Carvalho (unpublished) indicate that Bosminidae is the most abundant cladoceran family, in terms of individuals, in the Rio Negro. *Bosminopsis deitersi* and *Bosmina* spp. are usually the dominant cladoceran taxa in the Rio Negro, and occasionally *Ceriodaphnia cornuta.* Other cladocerans, such as *Bosminopsis negrensis, Moina minuta* and *rostrata, Diaphanosoma* spp. and *Holopedium amazonicum,* are rarely found in large quantities. The cladoceran taxa found in *H. fimbriatus* stomach and intestine contents, then, are similar to those that are dominant in the Rio Negro water column.

The food chain leading to Rio Negro zooplankton communities has not been investigated. Sioli (1968b), however, made the observation that, though zooplankton communities could be found in the Rio Negro, no corresponding phytoplankton counterpart was observed. We believe that it is safe to assume that most of the photosynthetic energy supporting zooplankton communities in the Rio Negro is derived from floodplain or adjacent terra firme forests and not from phytoplankton. Because of annual inundation, floodplain forests probably contribute a much larger quantity of organic material to the Rio Negro than adjacent terra firme plant communities.

Our data suggest that *H. fimbriatus* feeds heaviest during the low water period when it inhabits floodplain lakes. During the high water season it moves into flooded forest but, in this habitat, captures only about one-half of the quantity of zooplankton that it does during the low water period when it is found in open waterbodies, or at least along their shores. No quantitative samples of zooplankton or perizoan from Rio Negro flooded forests have been reported, though the data from *H. fimbriatus* suggest that densities — at least of cladocerans on which it feeds — are lower than those found in the lakes during the drawdown period. On the other hand, zooplankton densities in flooded forests may be higher than those found in the open waterbodies during the flooding season. The movement of *H. fimbriatus* into flooded forests suggests this, though the habitat might also be used for spawning as well.

The last point to be addressed here is the function of the large mental barbels of *H. fimbriatus,* as we believe that they may be useful for locating zooplankton in extremely poor waters, such as the Rio Negro, where the species appears to be most common. We hypothesize that the large barbels are sensory organs that, projected forward, as in Fig. 1, allow the fish to 'feel' about olfactorily, and perhaps electrically, for zooplankton concentrations. Once zooplankton concentrations are found, they are sucked in and the larger cladocerans are sieved out by the gillrakers.

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