SPIXIANA	8	3	231–240	München, 30. Dezember 1985	ISSN 0341-8391

Archolaemus blax Korringa (Pisces, Gymnotiformes, Sternopygidae); a redescription with notes on ecology

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Abstract

Archolaemus blax, previously known only from the Tocantins drainage in Brazil, is reported from many areas of the Brazilian and Guyana pre-Cambrian shields. Populations of this species inhabit rock aggregates of rapids. The fish spend the day inside crevices and emerge at night to forage mainly on larvae of Diptera. Spawning activity was noted during the transition from dry to rainy seasons (October–November) in the Serra Carajás. Like other gymnotiforms, *Archolaemus* is a partial spawner. It is closely related to *Eigenmannia* anatomically as well as in its electric organ discharge frequency and pulse shape. The presence of extra-oral dentary teeth, stated as diagnostic in the original description by KORRINGA (1970), could not be verified in any of the 66 specimens available for the purpose of this redescription.

Introduction

Archolaemus blax was originally described by KORRINGA (1970) on the basis of three specimens from the upper Tocantins River in the Brazilian State of Goias. Close affinities with *Eigenmannia* and *Sternopygus* place the new genus in the family Sternopygidae, as recently delimited by MAGO-LECCIA (1978).

New material from different localities has been collected since, greatly extending the geographic range. In addition, a study of a population in the field has provided information about ecological aspects.

Material and Methods

The specimens utilized for this study are on deposit at the Museu Paraense E. Goeldi, Belém, Pará, Brasil (MPEG), the Museu de Zoologia, Universidade de São Paulo, São Paulo, Brasil (MZUSP), the Instituto Nacional de Pesquisas da Amazonia, Manaus, Amazonas, Brasil (INPA), and the California Academy of Sciences, San Francisco, California, U.S.A. (CAS).

The systematic part is based on 70 specimens, 66 of which were closely examined and measured while 27 were used in the analysis of morphometric and meristic data. Radiographs were obtained from three specimens (MPEG 1369), and of the type and one paratype (CAS 24743, 24744). Measurements were made by ruler for total and standard lengths (TL and SL) to the nearest millimeter, and by calipers for the other dimensions to the nearest tenth of a millimeter.

A population of 19 recognized *Archolaemus* was monitored over 24 hours and was revisited on several other occasions. Specimens were located in their day-time hiding places by a device consisting of a pair of metal electrodes

connected to an audio-amplifier and speaker. Electric organ discharges were recorded on magnetic tape and displayed for evaluation on an oscilloscope (Tektronix 564).

Analysis of stomach contents was performed on 20 individuals (60–154 mm SL) of the Itacaiunas sample. A binocular dissection microscope was employed for identification of food items, and counts and measurements of ova in females.

A large population sample could be captured by Dr. Goulding of the Goeldi Museum with the aid of rotenone (timbo). Captured specimens were initially fixed in formalin and later transferred to 70% ethanol.

Taxonomic Considerations

Archolaemus Korringa

Type species by monotypy: *Archolaemus blax* Korringa, 1970, pp. 267–269, figs. 1, 2.

Korringa placed this genus in the Sternopyginae (REGAN, 1911), but restricted its relationship to what is now the family Sternopygidae (MAGO-LECCIA, 1978). *Archolaemus* and *Sternopygus* share a free orbital margin, but *Archolaemus* differs from *Sternopygus* by having a longer conical snout, a much larger eye, a straight rather than curved maxillary, and a scapular foramen, in addition to having 14–15 versus 24–26 abdominal vertebrae. We were unable to verify the presence of extra-oral teeth in the lower jaw, used by KORRINGA (1970) as a diagnostic feature. Microscopic inspection of the 66 specimens, plus radiographs of the three individuals, show all buccal teeth confined to their normal locations on the premaxillary and dentary inside the mouth. Dr. Stewart G. Poss of the California Academy of Sciences provided radiographs of the holotype and one paratype (CAS 24743, 24744). Both radiographs show evidence of physical damage to the snout region. The mesethmoid and maxillaries of the holotype are fractured, while the maxillary of the paratype is broken anteriorly and soft tissue damage to the upper jaw is evident, exposing the premaxillary tooth pad. Upper and lower jaw dentitions are inside the buccal cavity in the paratype, as is the case with all our material. In the holotype, the two anteriormost rows of dentary teeth are seen pointing forward, some of them apparently penetrating the lower lip. In all specimens with intact heads the teeth on upper and lower jaws are found to be in parallel orientation pointing backwards and it seems to us that the few anterior forward-pointing teeth of the dentary pad in the holotype are most likely to have been dislodged mechanically. We consider the stated presence of extra-oral dentary teeth (KORRINGA, 1970) an artifact not characteristic of the species.

Archolaemus shows affinities with *Eigenmannia,* but it differs by possessing a longer snout, a free orbital margin, a straight maxillary, and by having 14–15 rather than 12–14 abdominal vertebrae. Vent and genital papilla are at eye level in specimens in spawning condition, but are more posterior, between the eye and pectoral fin origin, in immature specimens. The latter also lack the genital papilla. Additional diagnostic features listed by Korringa are shared by other genera of the Sternopygidae.

Archolaemus blax Korringa

Archolaemus blax Korringa, 1970, pp. 267–269, figs. 1, 2. Holotype CAS 24743, two paratypes CAS 24744, 24745. Type locality Porto Nacional, Estado Goias, Brazil, Rio Tocantins, paratypes collected with holotype, coll. Ternetz, 1924; NIJSSEN and ISBRÜCKER, 1972, pp. 173–174 (reference); MAGO-LECCIA, 1978, pp. 16–17, 40, 45 (reference).

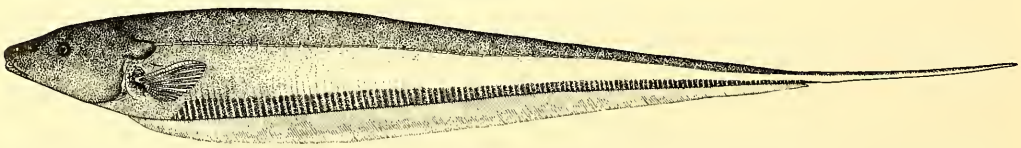

Fig. 1: *Archolaemus blax,* drawing of the larger of the two Xingu River specimens MPEG 1370 (167 mm SL).

Material examined:

Tocantins River system: MZUSP 4991, 1: 191 mm SL, Estreito, Maranhao, coll. D.Z. 2.6.1966; MZUSP 24129, 19: 90–297 mm SL, Jatobal, Pará, coll. E.P.A. 16.9.1970; MZUSP 24158, 2: 92–109 mm SL, Jatobal, Pará, coll. E.P.A. 17.9.1970; INPA TOC 961, 1:285 mm SL, Capuerana, Pará, coll. 10.11.1981; MPEG 1369, 41: 63–187 mm SL, Serra Carajás, Rio Itacaiunas, Pará, coll. M. Goulding 14.10.1983.

Xingu River: MPEG 1370, 2: 118–167 mm SL, Belo Monte, Pará, coll. M. Goulding 29.10.1983 (Fig. 1).

Tapajos River: MZUSP 24268, 1: 345 mm SL, São Luis, Pará, coll. E.P.A. 4.8.11.1970; MPEG 1371, 1: 73 mm SL, Itaituba, São Luis, Pará, coll. M. Goulding 22.11.1983.

Rio Branco (Roraima): MPEG 1641, 1: 101 mm SL, Cachoeira de Bem Querer, Rio Branco, Roraima, coll. M. Goulding 8.1.1984.

Amapá: MPEG 1643, 1: 248 mm SL (incomplete), bridge across Rio Cupixi of road to Serra do Navio, Amapá, coll. M. Goulding, January 1984.

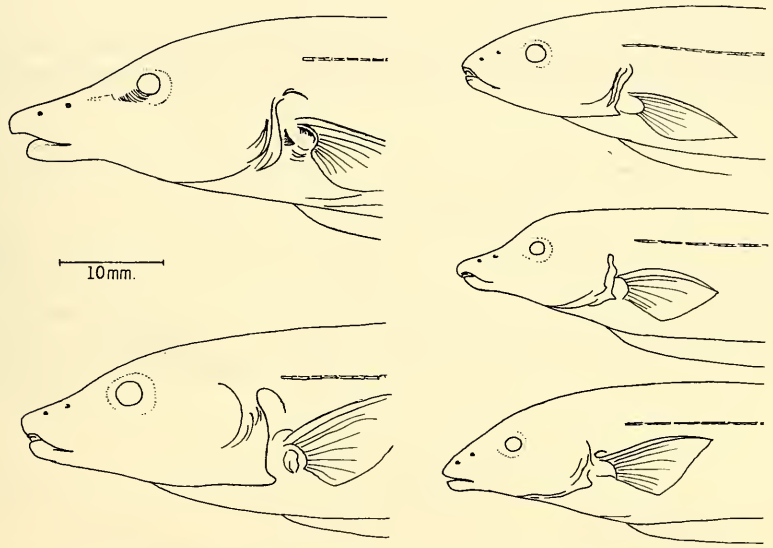

Fig. 2: Head profiles of five specimens of *Archolaemus blax* to show the variation existing in the shape of the snout.

Description:

Standard length of 66 measured specimens ranged from 63 to 345 mm. A summary of morphometric data and counts is contained in Table 1; most data sets are also presented graphically in Figures 3 and 4.

Snout elongated, varying from conical to duck-bill shape (Fig. 2); mandible enclosed, gape relatively long, about one third of length of snout; body laterally compressed, more so posteriorly, and completely scaled; head naked; a great number of tiny protuberances visible on snout, especially upper and lower lips, giving skin a somewhat prickly appearance.

Caudal peduncle 4.65 (3.92–5.0) times in total length; head contained 6.43 (5.79–8.49), snout 16.09 (13.4–21.5), and greatest body depth at level of anal fin origin 7.34 (6.40–8.79) times in standard length; snout contained 2.51 (1.76–3.41), and distance from tip-of-snout to vent, or genital papilla, 1.67 (1.24–2.08) times in head length; anal fin rays 180 to 225; 14 to 15 precaudal vertebrae and seven to nine pairs of pleural ribs.

The color pattern of live and of preserved but yet unbleached specimens is a background of cream-yellow which runs along the flanks as a gradually narrowing streak, reaching almost the tip of the caudal peduncle. Its width extends from the lateral line to slightly above the anal fin base. Head and body above the lateral line are chestnut-brown due to many dark-brown pigment cells. These cells also form a streak of variable width along the anal fin base. Pigment spots are found in low densities on the sides of the abdomen where they tend to obscure to varying degrees the anterior origin of the yellow streak. Fins are hyaline and sprinkled with pigment spots. The conspicuous two-tone pigment pattern is easily lost in older preserved material, probably due to the bleaching action of light. KORRINGA (1970) listed the color of his specimens as "an even tan", which is also the color of the pre-1971 specimens in the São Paulo collection.

There is considerable variation in the width and the intensity of pigment in the longitudinal yellow and brown stripes. A double yellow stripe is present in the one specimen from Amapá. There is usually a high concentration of melanophores over the lateral line which appears as a thin dark streak.

Discussion of Morphometrics:

Conventional scattergrams (Fig. 3) demonstrate certain differences in head morphometrics between *Archolaemus* and related species of *Sternopygus* and *Eigenmannia*. It is predominantly the length of the snout which grows longer in *Archolaemus* than in the two *Sternopygus* species and *Eigenmannia*

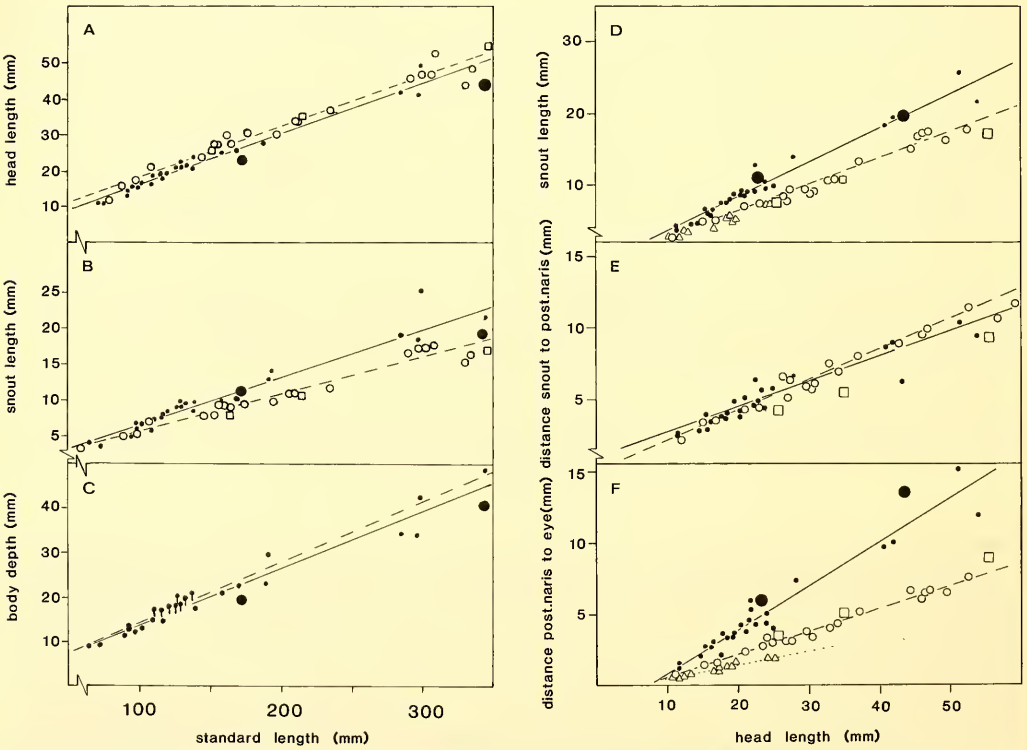

Fig. 3: Scatter diagrams of morphometric variables plotted against standard length (A, B, C) and against head length (D, E, F). Drawn lines and solid circles represent *Archolaemus* (two large circles are CAS 24743 and 24745 of KORRINGA, 1870); interrupted lines and open circles represent *Sternopygus macrurus* and *S. dariensis* (open squares), while the dotted line and the open triangles in D and F are for *Eigenmannia virescens*. *Sternopygus* and *Eigenmannia* measurements are from MAGO-LECCIA (1978).

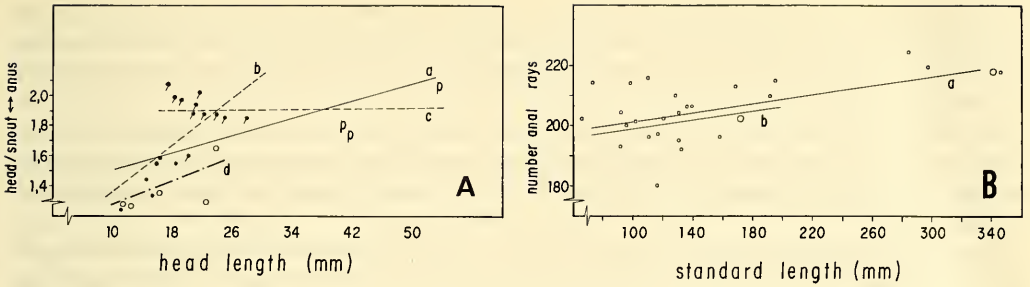

Fig. 4: Left diagram (A) shows the head-to-anus distance in head proportion plotted against head length. Small filled symbols are the Itacaiunas specimens, dashes represent those with developed anal papilla. Open circles are MPEG 1370 (2), MZUSP 4991 (1), and 24158 (2) without papilla. Letters "p" are MZUSP 24129 (1), and 24268 (1), and INPA-Toc 961; all three with developed papillae. For explanation of regression lines see text. Right diagram (B) shows the number of rays in the anal fin plotted against standard length. Regression line "a" is derived from all specimens, line "b" from the Itacaiunas sample only.

virescens (diagrams B, D). The distance from the posterior nostril to the orbit is the dimension which causes the increase in snout length in *Archolaemus* (diagram F) rather than the anterior part of the snout (diagram E).

The body shape is more compact in small individuals than in larger fish; however, the relation is distorted by females in spawning condition with greatly distended bellies (symbols above regression line in diagram C). A more complex situation is found when evaluating the location of the vent, or anal opening. Contrary to the stated familial characteristic of a poorly developed genital (urogenital) papilla (Mago-Leccia, 1978), *Archolaemus* in spawning condition, like the other members of the family, presents a very conspicuous yellow papilla of two to four millimeters in length. This papilla is located at the eye level and is quite comparable to the genital papilla which develops suddenly in sexually mature *Gymnorhamphichthys* (Schwassmann, 1976). In very small *Archolaemus* of the Itacaiunas sample the

Table 1: Morphometric (proportional) data and anal fin ray numbers.

summary of proportions

	proportion	mean	s	range	n
1.	head in SL	6.43	0.57	5.79-8.49	25
2.	snout in SL	16.09	2.16	13.4-21.5	25
3.	body depth in SL	7.34	0.58	6.40-8.79	25
4.	snout in head	2.51	0.35	1.76-3.41	25
5.	snout in head	2.51	0.35	1.76-3.41	25
6.	snout-ant.naris in head	8.82	1.32	7.0-12.9	18
7.	post.naris-eye in head	5.34	1.34	3.39-9.70	23
8.	snout-anus in head (all)	1.668	0.273	1.24-2.08	25
9.	same (Itacaiunas only)	1.73	0.26	1.24-2.07	16
10.	same (with papilla only)	1.88	0.13	1.60-2.08	14
11.	same (without papilla)	1.402	0.16	1.24-1.67	11
12.	number of anal rays (all)	205.5	10.2	180-225	27
13.	same (Itacaiunas only)	200.5	8.6	180-215	17

vent is located near the end of the head, close to the level of the pectoral fin base. It grows forward very slowly (Fig. 4A, line d) when a sudden step-wise decrease of the snout-to-anus distance to about one half the head length is caused by the sudden development and anterior displacement of the genital papilla (Fig. 4A, line c).

It is remarkable that several of the small individuals of less than 100 mm SL in the sample are females with mature ova in their distended abdominal cavities. Of a total of 19 females, 14 have well developed genital papillae, their tips reaching the eye level, while five smaller females already have small eggs but lack papillae.

Finally, analysis of the number of rays in the anal fin, usually considered to be independent of age or size in the gymnotiforms (SCHWASSMANN, 1976), would suggest a slight increase with larger individuals (line 12, Table 1; Fig. 4B). This increase, however, is due to only four large fish from different populations (Fig. 4B, a). If the sample from the Itacaiunas River is used alone in linear regression, the increase is not significant (Fig. 4B, b). It was shown for *Gymnorhamphichthys* that geographically isolated populations can have significantly different anal fin ray counts (SCHWASSMANN, 1976).

Ecology and Behavior:

Archolaemus blax is a lotic species. Single specimens and small groups of these fish could be detected in their day-time hiding places inside crevices and between rocks at places of high current velocities, for example in the Xingu River near Altamira and Belo Monte, and in the Itacaiunas, a major tributary of

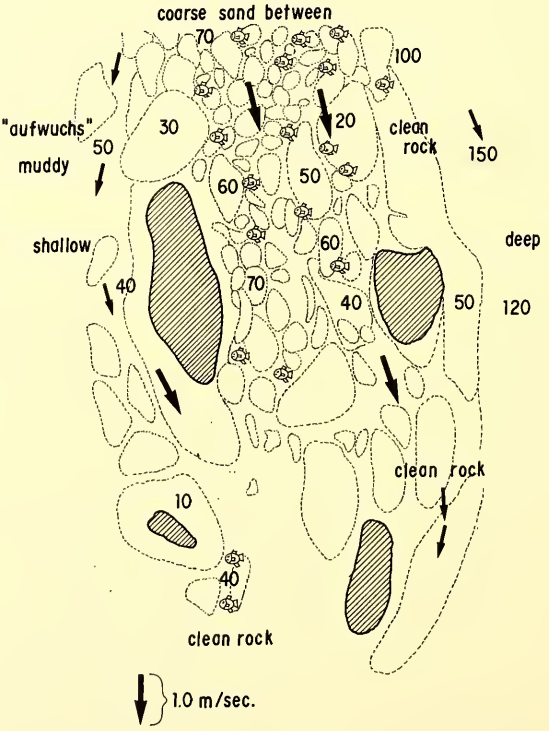

Fig. 5: Sketch of the field study site in the Itacaiunas River showing the locations of 19 *Archolaemus* in their day-time shelters. Current directions and approximate velocities are indicated by arrows; numbers show water depth in centimeter; exposed rocks are cross-hatched.

the Tocantins River. A preferred location is the shallow and fast-flowing water of rapids where the fish find an abundance of hiding places. A typical distribution during the day of part of a larger population in the Itacaiunas River is shown in Figure 5; 19 specimens could be located within the area by means of the electronic detecting device. The population was studied during 24 hours and was revisited twice, all in early November of 1983, which was the beginning of the rainy season in that area. The site was located on the southern bank of the then 80 meters wide river, about 300 meters upstream of the ferry on the road from Docegeo of the Serra Norte, Carajás. There were several huge rocks, the tips of some of which were exposed. Many smaller rocks of not less than 0.3 meter diameter were filling the spaces between the larger ones, and small pebbles, intermixed with coarse sand, made up the deep parts of the site where current velocities were reduced.

Although turbulent water made observation difficult, some fish were seen darting away to other hiding places when their shelter was removed. The first individuals left their hiding places at 18:35, and all appeared to be moving by 18:50. Several could be seen in the light from an electric torch for brief moments, darting between pebbles in deep water or moving into shallower areas. They quickly moved away whenever the light beam or the metal electrodes approached too closely. This behavior led to the impression that this species is well oriented visually as well as electrically. Because of the rough water surface, no details in their behavior could be observed.

The density of these fish within the observation area seemed to be less at night than what it had been during the day. Because of restricted visibility, the exact time of return to the day shelters could not be determined. In a survey over the entire area at 05:00 the following morning, before the first light of dawn could be seen, no specimens were moving about; however, only about ten fish were found inside the observation site. This was possibly due to the nightly activity of the observer.

Syntopic fishes included small characins in the rocky area and a few very large *Cichla ocellaris* (Tucunaré) jumping nearby in deeper water. In sand deposits several *Gymnorhamphichthys* were detected of which one was captured, while several *Sternarchorhynchus* sp. of about 1 kHz frequency were recorded within the site; four of these latter fish were captured together with the Itacaiunas sample of *Archolaemus*.

The water at the observation site was clear with a slight yellow tinge. The first heavy rains in the mountains had caused the water level to rise; an increase in level of 20 cm was noted between November 10 and 11. Results of a limited water analysis are shown in Table 2.

Table 2: Partial water analysis, Itacaiunas River, Serra Carajás, near DOCEGEO, 10-11-1983, 18:00 hrs.

Temperature	:	24.0° C
pH	:	6.38 - 6.58
conductivity	:	51.2 mhos/cm
turbidity	:	2.8 NTU
SiO_2	:	15.2 mg/l
Fe (dissolved)	:	no indication
SO_4	:	no indication
N (NO_2)	:	0.015 mg/l
N (NH_3)	:	0.94 mg/l

The electric organ pulses emitted by *Archolaemus* appear very much like those recorded from several species of *Eigenmannia* and are distinctly different from those of *Sternopygus*. Records from eight specimens were of sufficient quality and isolation to permit frequency determinations. These ranged from 390 to 523 Hz with a mean of 460. Individual specimens maintained the same frequency over se-

veral hours. Fish in close proximity to each other always had different rates of discharge. We have noted such frequency partitioning in the field on many occasions and in many species of the Sternopygidae and Apteronotidae. At night, only a few recordings of poor quality were obtained, but it appeared that frequencies were about the same as those taped during the day.

Actual feeding was not observed, but stomach analysis shows that insect larvae, mostly Chironomidae, constitute the principal diet of *Archolaemus* (Table 3). The presence of sand and filamentous algae suggests these insect larvae are probably picked up from a sandy substrate and from "Aufwuchs" on rocks in less turbulent areas.

The Itacaiunas sample was obtained in mid-October, apparently a time of beginning reproductive activity. Nineteen females and 13 males had mature or maturing gonads and anteriorly located, well developed papillae. Those females with papillae contained 50 to 70 ripe ova of 2.0 mm diameter, in addition to at least three classes of smaller eggs while the males showed enlarged testes. Only nine of the smallest specimens of this sample of 41 fish were immature and could not be sexed; all of these lacked a genital papilla.

Little size difference seems to exist between males and females, although the largest specimens on record happen to be males. Of ten males that are sufficiently complete to permit length measurements, six show a well developed papilla, two have none, while the remaining two possess a small protuberance with a genital pore. Of ten intact females, eight have a well-formed papilla located under the eye, whereas the two smallest have no papilla and only tiny ova in their abdominal cavities. Mean standard length of the ten males is 128 mm (range 93–187). Mean standard length of the ten females is 119 mm (95–138). Comparing only those with developed genital papillae, the mean standard length of six males is 143 mm (100–187); that of eight females is 126 mm (110–138).

Table 3: Results of stomach content analysis of 20 specimens of the Itacaiunas sample. – Three basic parameters evaluated the relative importance of various food items: "Occurance" records number of stomachs containing a particular food. "Dominance" is calculated as number of times a certain item formed the largest part of total content. "Volume" is an estimation of percentage of each item on the basis of total volume of an undistended stomach when the latter was less than full, or as percent of total content when the stomach was distended. In addition, the percentage of the total of each item was calculated.

item	occurance	dominance	volume	% of total
Diptera pupae	1	-	15	1.1
Diptera larvae (mainly Chironomidae)	18	16	940	68.4
Trichoptera cases	2	-	20	1.5
Trichoptera larvae	1	-	10	0.7
Odonata nymphs	3	-	60	4.4
insect remains	6	1	80	5.8
Ostracoda	6	-	20	1.4
Chydoridae	3	-	11	0.8
Porifera spicules	8	-	37	2.7
Nematoda	2	-	10	0.7
filamentous algae	4	1	45	3.3
sand	13	-	107	7.8
unidentified remains	1	1	20	1.4
empty		1		
mean fullness: 69%				

The geographic distribution of *Archolaemus blax,* as it is known at present, is shown in Figure 6. All collecting sites are located either on or at the edges of the two pre-Cambrian shields, the Guyana and the Brazilian plateau. These are areas of swift-flowing waters where many rapids are found.

General Discussion

The case of *Archolaemus blax* illustrates our precariously slow progress in gaining knowledge of the systematics and ecology of Amazonian fishes during a period of increasingly rapid habitat alteration and destruction. The species was described only in 1970 from three specimens that had been on the shelves of the California collections for nearly 50 years. A few additional specimens at the São Paulo Museum, collected in 1966 and 1970, have been identified only recently by F. Mago-Leccia in 1982 and D. G. Steward in 1983. Known until then only from the upper Tocantins and the Tapajos River, recent collecting efforts by M. Goulding have now extended the range into the Guyana shield. *Archolaemus* occurs in clear water rivers which drain crystalline rock of pre-Cambrian formations.

What initially seemed to be an endemic species of very restricted occurrence has now turned out to be of wide geographic distribution; its apparent rarity probably reflects the difficulty in capturing specimens. A few of the larger collection specimens carry marks from having been caught in gillnets, but the only effective capturing method seems to be the use of ichthyocides.

Hidden during the day inside deep crevices and in between larger rocks, *Archolaemus* is well protected from diurnal predators. The high water velocities in the rapids provide sufficient oxygen to these hiding places. This diurnal resting behavior is similar to that of *Gymnorhamphichthys* which spends the day buried in the sandy bottom of small streams (Schwassmann, 1976).

In its dietary habits, *Archolaemus* resembles many other species of gymnotiforms which are reported to feed on insect larvae (Ellis, 1913; Knöppel, 1970). The predominance of diptera probably reflects their relative abundance in this stream.

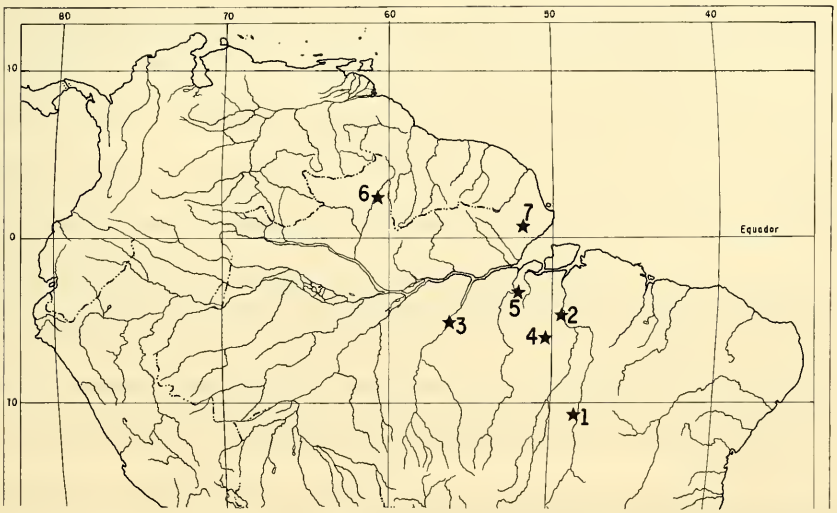

Fig. 6: Map of northern South America showing the geographic range of *Archolaemus blax* based on known localities. 1: Holotype and paratypes, Porto Nacional-Tocantins (10°40′ S – 48°30′ W); 2: Jatobal-Tocantins (4°30′ S – 49°30′ W); 3: São Luis-Tapajos (4°30′ S – 56°20′ W); 4: Itacaiunas, Carajás-Tocantins (5°30′ S – 50°30′ W); 5: Belo Monte-Xingu (3°10′ S – 51°50′ W); 6: Rio Branco, Roraima (2°40′ N – 60°40′ W); 7: Rio Cupixi, Amapá (0°45′ N – 51°45′ W).

Reproductive activity appears to coincide with the onset of the rainy season. As was reported for *Gymnorhamphichthys* (Schwassmann, 1976), *Archolaemus* females carry several size classes of ova, implying many successive spawning bouts. Most or all gymnotiforms are partial spawners and begin their reproductive activity early in the rainy season. However, different mechanisms seem to affect the timing of gonadal recrudescence and spawning in different species. Kirschbaum (1979) reports up to 58 successive spawning bouts during six months in one *Eigenmannia virescens* female under optimal conditions in a breeding tank. This species and several other Sternopygidae respond with gonadal recrudescence only after the onset of heavy rains and considerable flooding (Kirschbaum, 1979; and personal observations on Marajó Island). Other species, especially *Electrophorus electricus* on Marajó, show fully developed gonads several months prior to the first heavy rains and remain in spawning readiness for a long time. Partial spawners are common in small streams where a limited but steady supply of food organisms exists. Total spawners inhabit floodplain lakes that go through pronounced annual cyclic changes, providing a once-a-year vastly extended area with an abundance of food for a more limited period (Schwassmann, 1978b).

Acknowledgements

For assistance in the field we thank our colleagues of the Goeldi Museum, Belém, Pará. For making available specimens of their collections we are obliged to Drs. W. M. Goulding (MPEG) and H. A. Britski (MZUSP). For providing radiographs of type and one paratype we express our appreciation to Dr. S. G.Poss (CAS), and to W. J. B. Miller (Florida State Museum) for taking radiographs of three Itacaiunas specimens. We thank A. C. S. Martins for making the illustrations and G. H. Burgess, Jr. for critically reading a draft of the manuscript. Financial and logistic assistance was provided through the Museu Paraense E. Goeldi/CNPq, and a grant and fellowships from the Brazilian Research Council (CNPq). The Companhia Vale do Rio Doce supported the field work at the Itacaiunas River.

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