

FEEDING ECOLOGY OF CURVINA *Plagioscion squamosissimus* (HECHEL, 1840) (OSTEICHTHYES, PERCIFORMES) IN THE ITAIPU RESERVOIR AND PORTO RICO FLOODPLAIN

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RESUMO: **Ecologia alimentar da curvina *Plagioscion squamosissimus* (Hechel, 1840) (Osteichthyes, Perciformes) no Reservatório de Itaipu e planície de inundação de Porto Rico.** Capturas realizadas durante o período de novembro de 1983 a setembro de 1988, em diversos pontos da bacia do rio Paraná, no trecho compreendido entre os rios Paranapanema e Iguçu, permitiram avaliar a dieta da curvina, *Plagioscion squamosissimus* e suas variações de acordo com o tamanho dos indivíduos e locais de coleta. Neste estudo a curvina foi considerada essencialmente piscívora, em função do notável predomínio de peixes em sua dieta, embora insetos (por vezes dominantes) e crustáceos tenham sido registrados. Os itens frequentemente encontrados, caracterizados como preferenciais na dieta global foram, *Hypophthalmus edentatus*, *Roeboides paranensis* e *Loricariichthys platymelapon*. Variações espaciais na dieta pareciam estar associadas à disponibilidade de presas no ambiente. O incremento em comprimento foi acompanhado por um aumento na piscivoria, bem como no tamanho médio da presa ingerida.

Palavras-chave: Alimentação de peixe, Piscivoria, *Plagioscion squamosissimus*, Rio Paraná.

ABSTRACT: **Feeding ecology of curvina *Plagioscion squamosissimus* (Hechel, 1840) (Osteichthyes, Perciformes) in the Itaipu Reservoir and Porto Rico floodplain.** Fish samplings were carried out from November 1983 to September 1988, at different sites of the Paraná River basin, comprising the section between the Paranapanema and Iguçu Rivers, with the purpose of analysing the diet diversity of curvina, *Plagioscion squamosissimus*, according to the spatial distribution and size of the individuals. The curvina was considered piscivorous, due to the predominance of fish in its diet, although insects (dominant in some occasions) and crustaceans have been registered. The most frequently

items were *Hypophthalmus edentatus*, *Roeboides paranensis* and *Loricariichthys platymetopon*. Spatial changes in the diet seem associated with the availability of prey in the environment. Piscivory increased with the curvina length, as well as the average size of the ingested prey.

Key-words: Fish feeding, Piscivory, *Plagioscion squamosissimus*, River Paraná.

INTRODUCTION

The curvina, *Plagioscion squamosissimus* (Heckel, 1840) is native of the Parnaíba, Trombetas, Negro and Amazonas rivers (Nomura, 1984) and has been introduced in dams of Northeastern of Brazil in 1940. In 1966 and 1967, it was also introduced in Pardo River, (State of São Paulo). Nowadays it is widely distributed throughout in South America (Goulding & Ferreira, 1984).

The curvina is an important species in the Brazilian freshwater fisheries (Petrere Jr. 1978; Worthmann 1983 and Annibal 1983) whose highest production has been recorded in Northeastern Brazil (Dnocs, 1986). In the Itaipu reservoir it attains second place in fisheries since the river damming (Agostinho et al, 1989). Here in 1990 the curvina yielded 243 tons (Agostinho et al, 1994).

The aim of this study was to investigate the feeding habits of the curvina in a man-made reservoir (Itaipu Reservoir) and in the, River Paraná floodplain (Porto Rico region, Paraná, Brazil).

STUDY AREA, MATERIAL AND METHODS

Samples were taken in Paraná River basin between the mouths of the Paranapanema and Iguaçu Rivers (Fig. 1). The Itaipu Reservoir (built in November 1982) weresampled in three stations with distinct characteristics, they are: Guaira (riverine area) Santa Helena (transitional area) and Foz (lacustrine area).

In Porto Rico fish were caught done at different sites, grouped according to their water dynamics as: lagoons lentic sites (Fechada, Guarana, Pousada das Garças and Patos); channels semi-lotic sites (Baía I and II, and Corutuba); and rivers predominantly lotic sites (Paraná, Ipoitã and Pedreira). Sampling frequencies are shown in table I.

Table I. Sampling frequency in the Itaipu Reservoir and Porto Rico area.

Place / Period	Frequency	
	1 st semester	2 nd semester
Itaipu Reservoir		
Nov/83 - Feb/85	monthly	monthly
Mar/85 - Feb/86	bimonthly	monthly
Mar/86 - Feb/87	bimonthly	monthly
Mar/87 - Feb/88	bimonthly	monthly
Porto Rico		
Oct/86 - Sept/87	monthly	monthly
Oct/87 - Sept/88	monthly	monthly

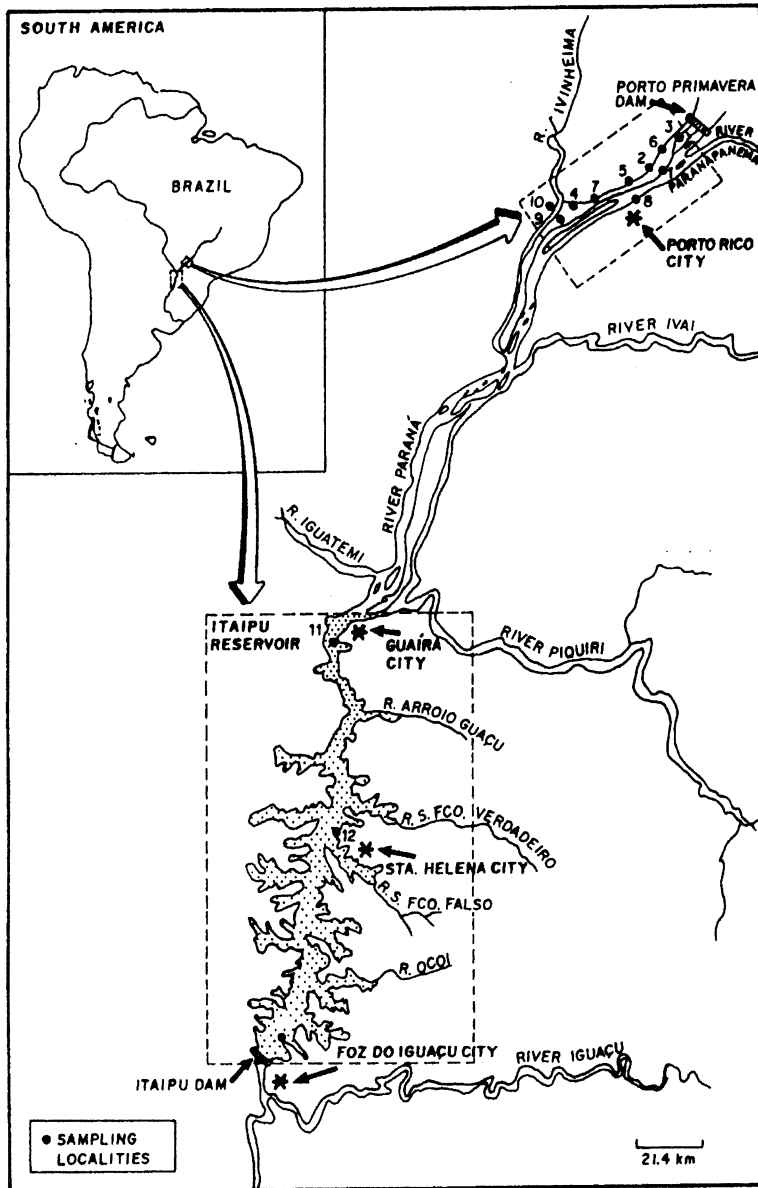


Figure 1. Geographic localization of sampling sites and reservoir stations. 1- Fechada, 2- Guarana, 3- Pousada das Garças, 4- Patos, 5- Baia I, 6- Baia II, 7- Corutuba, 8- Parana, 9- Ipoitã, 10- Pedreira.

Fishes were captured with gillnets of different mesh sizes, which were set for 24 hours. Gillnets were examined in three separate turns: night-morning; daylight and; afternoon-night.

Fish standard length (Ls) and total weight (Wt) were measured and individual stomachs were extracted and fixed in 4% formaldehyde solution. Prey were identified, counted, weighed and, when they were fish they were measured.

Occurrence and gravimetric methods (Hynes, 1950; Hyslop, 1980) were used for the diet analysis. Results were expressed by Food Index (Kawakami & Vazzoler, 1980) modified as:

$$IA_i = \frac{Fi \times Vi}{\sum Fi \times Vi} \times 100$$

where:

IA_i = Food Index

Fi = occurrence frequency (%)

i = 1, 2, ..., n, food items

Wi = wet weight (%)

Prey were defined as preferential, secondary and accessory (Rosecchi & Nouaze, 1987).

Diet variations were analysed by sampling station localities: Guaira, Santa Helena and Foz (**Itaipu Reservoir**), rivers, channels and lagoons (**Porto Rico**), length and reproductive classes (young: 4.5-14.4 cm, subadults: 14.5-22.4 cm; adults: 22.5-41.3 cm). The reproduction size were determined using a published gonadal maturation curve (Fuem/Nupelia/Surehna/Itaipu Binacional, 1987).

The percentage of similarity were calculated (Shorygin apud Clark, 1985) to express the prey importance in relation to the capture areas and size classes. It was calculated from:

$$SP = 100 - 0,5 \sum |a - b|$$

where:

a = the i prey importance value for site a (or size class)

b = the i prey importance value for site b (or size class)

The calculation of "a" and "b" was based on the food index, which ranges from 0 (absence of similarity) to 100 (similar diets).

For evaluation of size relationship between curvina and their preys (SL prey/SL predator x 100), 395 preys were measured and their standard lengths measured. Data were grouped in 13 predator length groups.

RESULTS

The stomach contents analysis of all individuals of Itaipu Reservoir and Porto Rico area showed that curvina feeds basically on fish (> 80%) and insects (> 18%) (Tab. 2). Thirty-seven prey fishes were identified. This number could be higher since 12 species could only be identified to genera level. The Food Index has shown that, at the reservoir the selected prey was *Hypophthalmus edentatus* (46.5%) and *Roeboides paranensis* (26.6%). Among the insects, Odonata (18.5%) was the most important item. At Porto Rico *Lorycariichthys platymetopon* (25.5%) and *Roeboides paranensis* (21.1%) were the main prey, and *Astyanax bimaculatus* (8.5%), *Synbranchus marmoratus* (6.23%) and *Hoplosternum littorale* (6.21%), and also Odonata (6.23%) were the secondary prey.

The curvina diet in Itaipu was more diversified in Guaira station, decreasing towards the Foz station (Fig. 2). In Guaira station the main prey were Odonata, *Trachydoras paraguayensis* and *Steindachnerina insculpta*. *R. paranensis* and *H. edentatus*, were the most abundant prey in Santa Helena and Foz station, respectively (Fig. 2).

In Porto Rico area a great variety of items were found in fish recorded in river sites.

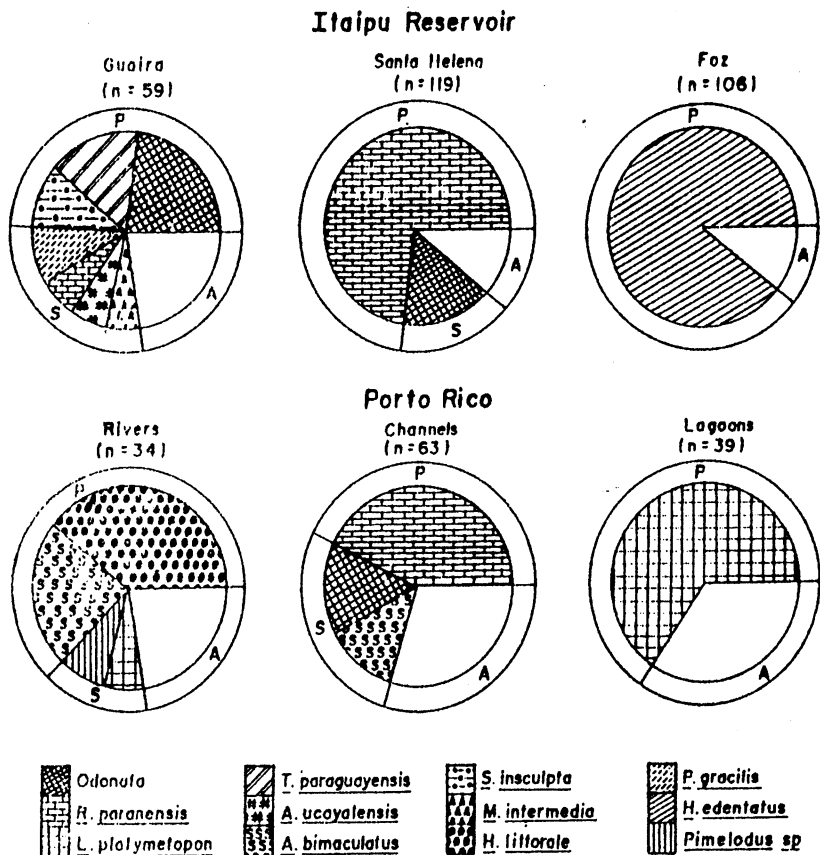


Figure 2. Relative contribution of food items in the diet of the curvina, (*Plagioscion squamosissimus*) at different localities in Itaipu Reservoir and Porto Rico floodplain. P= preferential, S= secondary, A= accessory prey.

However, diet diversity decreased in those fish collected in lagoons (Fig. 2). In rivers the most important items were *H. littorale* and *A. bimaculatus*. In channels *R. paranensis* was the main prey, differently of lagoons where *L. platymetopon* index value exceeded 65%.

Similarities between all sampled areas were low (Tab. 3), even those of the same environment. The highest similarity (61.32%) was observed between individuals from Santa Helena (Reservoir) and those from the channels (Porto Rico).

In both environments, considerable variations occurred among different life history stages (Fig. 3).

Young curvinas of the reservoir fed mainly on Odonata (86.0%), whereas those from Porto Rico has shown a diversified diet, including *Odontostilbe microcephala* and *Cheirodon notomelas* (small size fish) as the preferential prey, and immature piranhas (*Serrasalmus marginatus*) and ephemeropterans as the secondary ones.

Table II. Relative occurrence (O), food weight (G), Feeding Index (IAi) and each prey size item in stomach contents of curvina, *Plagioscion squamosissimus* of Itaipu Reservoir and Porto Rico.

Prey/Places	Prey Sl (cm)	Itaipu Reservoir (n=283)					Porto Rico (n=136)				
		Occurrence		Food weight		IAi	Occurrence		Food weight		IAi
		n	%	g	%	%	n	%	g	%	%
PISCES											
<i>Acestrorhynchus lacustris</i>	11.9	1	0.35	20.89	1.70	0.06					
<i>Aequidens</i> sp	3.9										
<i>Ageneiosus ucayalensis</i>	6.8-11.3	3	1.06	24.59	2.00	0.22			1.23	0.40	0.06
<i>Ageneiosus</i> sp	9.4-9.9	2	0.71	14.74	1.20	0.09					
<i>Apareiodon affinis</i>	4.9-8.3	3	1.06	12.45	1.01	0.11					
<i>Aphyocharax</i> sp	2.4-3.5						2	1.47	0.36	0.12	0.04
<i>Apteronotus</i> sp	11.6-14	1	0.35	6.97	0.57	0.02	1	0.73	4.33	1.40	0.20
<i>Astyanax bimaculatus</i>	2.5-6.9	6	2.12	26.69	2.17	0.49	10	7.35	17.76	5.75	8.49
<i>Astyanax fasciatus</i>	4.8						1	0.73	1.83	0.59	0.09
<i>Astyanax</i> sp	1.6-17	4	1.41	17.06	1.39	0.21					
<i>Auchenipterus nuchalis</i>	7.5-16.5	4	1.41	21.46	1.75	0.26	1	0.73	37.56	12.17	1.78
<i>Bryconamericus stramineus</i>	1.9-4.6	8	2.83	4.23	0.34	0.10					
<i>Callichthys callichthys</i>	-						1	0.73	2.80	0.91	0.13
<i>Cheirodon notomelas</i>	1.7-3.7	3	1.06	1.76	0.14	0.01	11	8.09	7.22	2.34	3.80
<i>Crenicichla lepidota</i>	3.7-6.7	5	1.77	18.34	1.49	0.28					
<i>Crenicichla nierdeleimii</i>	9.5	3	1.06	14.81	1.20	0.13					
<i>Cyphocharax modesta</i>	4.5-6.9	2	0.71	13.33	1.08	0.08	2	1.47	11.69	3.79	1.12
<i>Cyprinus carpio</i>	7.0	1	0.35	7.09	0.58	0.02					
<i>Eigenmannia virescens</i>	10.0	1	0.35	3.78	0.31	0.01					
<i>Galeocharax kneri</i>	-	1	0.35	12.39	1.01	0.04					
<i>Geophagus pappaterra</i>	2.9-3.0	2	0.71	1.52	0.12	0.01					
<i>Gymnotus carapo</i>	6.0-11.0						4	2.94	25.7	8.32	4.92
<i>Hemisorubim platyrhynchos</i>	-						1	0.73	0.35	0.11	0.02
<i>Holoshestes</i> sp	3.6	1	0.35	0.81	0.06	0.01					
<i>Hoplias malabaricus</i>	2.4-7.4	5	1.77	12.65	1.03	0.19					
<i>Hoplosternum littorale</i>	-						5	3.68	25.95	8.40	6.21
<i>Hyphessobrycon</i> sp	1.9-2.6						4	2.94	4.94	1.60	0.94
<i>Hypophthalmus edentatus</i>	2.9-20.6	34	12.01	451.91	36.79	46.49	2	1.47	13.03	4.22	1.25
<i>Hypostomus</i> sp	3.9-4.5	1	0.35	1.79	0.14	0.01					
<i>Iheringichthys labrosus</i>	4.5-10.9	4	1.41	32.00	2.60	0.39					
<i>Leporinus</i> sp	1.9-3.0						2	1.47	0.60	0.19	0.06
<i>Loricariichthys platymetopon</i>	5.5-13.7	1	0.35	9.63	0.78	0.03	12	8.82	44.33	14.36	25.46
<i>Moenkhausia intermedia</i>	4.0-6.0	3	1.06	9.11	0.74	0.08	3	2.20	10.13	3.28	1.45
<i>Odontostilbe microcephala</i>	2.3-2.5						7	5.15	2.13	0.69	0.71
<i>Parauchenipterus galeatus</i>	8.0	1	0.35	12.79	1.04	0.04					
<i>Pimelodella gracilis</i>	6.4-10.7	8	2.83	50.31	4.10	1.23					
<i>Pimelodus</i> sp	1.9-6.2						3	2.20	6.29	2.04	0.90
<i>Plagioscion squamosissimus</i>	1.9-10.7	12	4.24	20.95	1.70	0.77	1	0.73	0.19	0.06	0.01
<i>Pseudocetopsis gobioides</i>	-	1	0.35	11.30	0.92	0.03					
<i>Pterodoras granulatus</i>	3.6						1	0.73	0.94	0.30	0.04
<i>Raphiodon vulpinus</i>	7.1	3	1.06	7.50	0.61	0.07					
<i>Roeboides paranensis</i>	3.0-7.7	48	16.96	181.04	14.74	26.59	13	9.56	35.20	11.40	21.91
<i>Schizodon borelli</i>	8.5						1	0.73	9.50	3.08	0.45
<i>Serrasalmus marginatus</i>	3.9-4.4						3	2.20	6.65	2.15	0.95
<i>Serrasalmus</i> sp	2.3-4.8	1	0.35	2.02	0.16	0.01	2	1.47	0.89	0.29	0.09
<i>Steindachnerina insculpta</i>	3.0-7.0	9	3.18	50.57	4.12	1.39	2	1.47	2.31	0.75	0.22
<i>Sternarchorhynchus</i> sp	17.8	1	0.35	16.06	1.31	0.05					
<i>Synbranchus marmoratus</i>	6.0-23.0	6	2.12	5.11	0.42	0.09	7	5.15	18.59	6.02	6.23
<i>Trachydoras paraguayensis</i>	5.0-7.5	9	3.18	40.05	3.26	1.10					
INSECTA											
Chironomidae		18	6.36	2.15	0.17	0.11					
Ephemeroptera		3	1.06	0.46	0.04	0.01	17	12.5	6.53	2.11	5.30
Odonata		83	29.33	72.82	5.93	18.50	25	18.38	5.66	1.83	6.76
CRUSTACEA											
Decapoda		3	1.06	15.03	1.22	0.14	2	1.47	4.03	1.30	0.38

Table III. Similarity (SP) between the feeding patterns of curvina, *Plagioscion squamosissimus*, at different collecting localities (Itaipu reservoir and Porto Rico).

	Guaíra	S. Helena	Foz	Rivers	Channels	Lagoons
Guaíra	-	29.35	10.53	8.0	27.46	9.93
S. Helena		-	10.37	5.46	61.32	9.88
Foz			-	3.94	9.02	7.42
Rivers				-	20.91	15.54
Channels					-	19.06
Lagoons						-

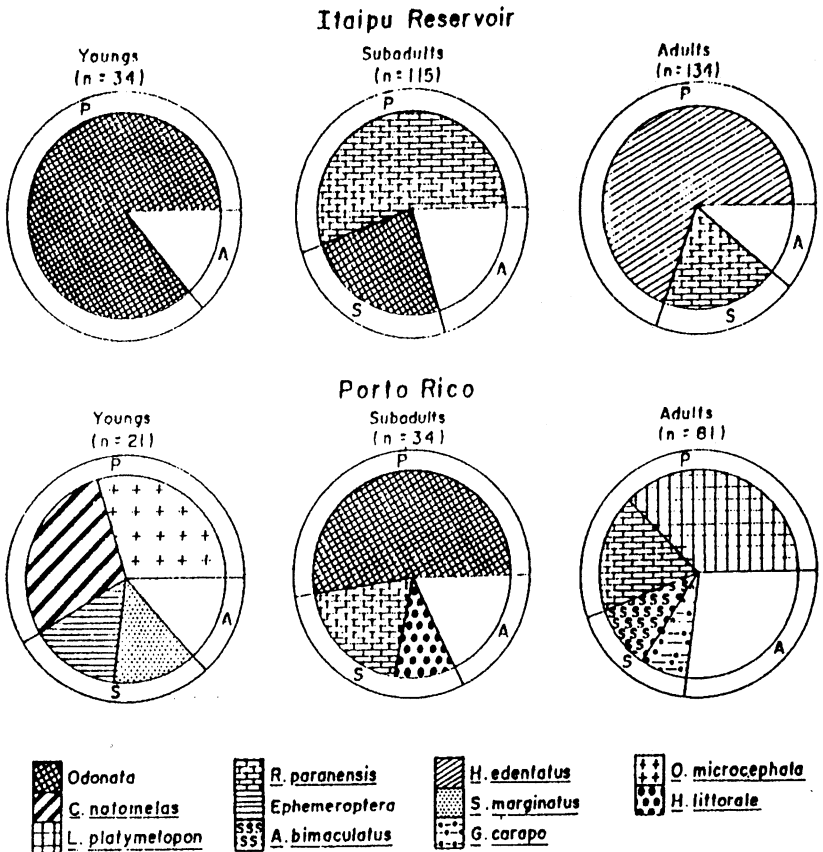


Figure 3. Relative contribution of food items in the diet of the curvina, (*Plagioscion squamosissimus*) at several development stages, for individuals of Itaipu Reservoir and Porto Rico floodplain. P= preferential, S= secondary, A= accessory prey.

Subadults in Itaipu, replaced Odonata by *R. paranensis*, which became the secondary prey, contrasting with Porto Rico curvinas, whose stomach contents showed a dominance of this insect complemented by *R. paranensis* and *H. littorale*.

Adult curvinas started to feed on *H. edentatus* and *R. paranensis* became a secondary prey in Itaipu. Odonata practically disappeared from the diet. In Porto Rico, *R. paranensis* increased in the diet composition and turned up as a preferential item, but *L. platymetopon* was the dominant fish in stomach contents.

A certain degree of similarity among individuals at different developmental stages for both environments was observed (Tab 4). The highest similarity were detected between young individuals of the reservoir and Porto Rico subadults.

The relationships between predator and prey lengths are shown in figure 4. This plot indicates that as the curvina grows, it feeds on larger prey. Minimum, maximum and relative prey lengths show a similar trend. The minimum length of prey remain constant for curvinas attaining 33.0 cm, following a similar trend of the prey relative length.

The same analysis was made for the two most frequent prey, of which a representative number of individuals could be measured. Results are shown in figure 5. For *H. edentatus* a sharp increment related to the curvinas' size was observed. Minimum, maximum and relative prey lengths showed similar variations. Curvinas between 15.0 and 30.0 cm preyed upon *R. paranensis*, of similar size. This can be observed in the decreasing of the prey's relative length as curvina length increased.

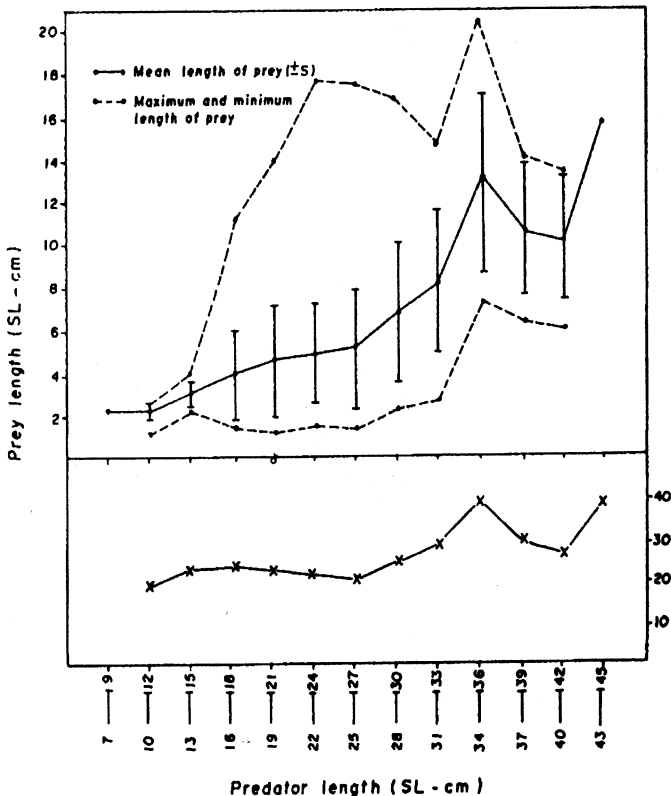


Figure 4- Relationships between the length of *Plagioscion squamosissimus*, its prey length. Vertical bar = standard deviation.

Table IV- Similarity (SP) between the feeding patterns of curvina, *Plagioscion squamosissimus*, at different development stages.

	Youngs1	Subadults1	Adults1	Youngs2	Subadults2	Adults2
Youngs1	-	31.27	1.85	4.38	52.86	1.77
Subadults1		-	31.44	6.07	44.72	22.7
Adults1			-	0.9	12.91	20.4
Youngs2				-	12.18	18.48
Subadults2					-	34.09
Adults2						-

1 =Reservoir; 2 = Porto Rico

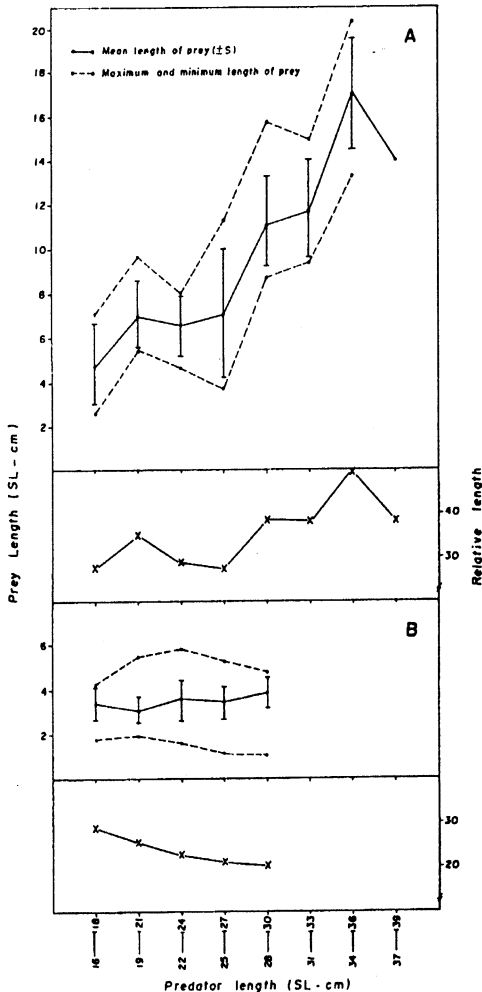


Figure 5- Relationship between the length of *Plagioscion squamosissimus*, and the prey.: A=*Hypophthalmus edentatus* and B=*Roeboides paranensis*. Vertical bar = standard deviation.

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