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FOOD AND FEEDING HABITS OF KING WEAKFISH, *Macrodon ancylodon* (BLOCH & SCHNEIDER, 1801) CAUGHT IN THE SOUTHERN COAST OF BRAZIL (LAT. 29° TO 32°S)*

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Synopsis

Macrodon ancylodon was obtained from landings in Santos Port (São Paulo State) of fish caught monthly by commercial vessels, on the southern coast of Brazil during September 1976 to August 1977. The measurements of total lenght, total weight determination of sex and maturity stages were made. The food items found in stomach contents were: shrimp (Artemesia longinaris), fishes (Paralonchurus brasiliensis, Macrodon ancylodon, Trichiurus lepturus, Gadidae, Engraulidae), molluscs (Loliginidae, Bivalvia) and Stomatopoda. Widening of food spectrum was observed in winter. The index of preponderance showed that immature females, immature and mature males fed predominantly on shrimp, while mature females fed mainly on fishes. During spring and summer (spawning season) M. ancylodon exhibited relatively low percentage of full stomachs. Cannibalism was encountered more intensively for mature fish.

Descriptors: Feeding, Feeding behaviour, Stomach content, Food organisms, *Macrodon ancylodon*, Southern coast: Brazil
Descritores: Alimentação, Hábitos alimentares, Conteúdo estomacal, Itens alimentares, *Macrodon ancylodon*, Costa sul: Brasil

Introduction

Macrodon ancylodon (Bloch & Schneider, 1801), is an appreciated sciaenid fish among the most important bottom fishery resources of the southern and southeastern coast of Brazil, and comprised about 16.2% (1976) and 18.7% (1977) by weight of all wet fish landed (PDP-SUDEPE, 1981).

M.*ancylodon* has demersal habits whose range extends from Occidental Atlantic (Venezuela) to Argentina (Cervigón, 1966); it has a wide distribution along the Brazilian coast with a large concentration in the southern coast (Rio Grande do Sul State) (Richardson & Moraes, 1960; Lopez, 1963; Yamaguti & Moraes, 1965; Vazzoler & Iwai, 1971), where it constitutes a distinct subpopulation from others at regions north of 28°S latitude (Yamaguti, 1979).

In the literature there is a number of publications on aspects of the biology of the king weakfish (Lara, 1951; Vazzoler 1963, 1965; Vazzoler *et al.*, 1973; Yamaguti, 1967; Yamaguti & Santos, 1966; Santos & Yamaguti, 1965; Vazzoler, 1975; Yamaguti, 1979; Martins-Juras, 1980). However, information on its diet is limited (Vannucci, 1963; Tanji 1966, 1974).

The work described here is intended to contribute to the knowledge on the diet of M. *ancylodon*, particularly on the food of this fish at different sizes (immature and mature) and in different seasons.

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Material and methods

Field work began in September 1976 and finished in August 1977. The king weakfish were caught by trawl nets in the coast of Rio Grande do Sul State (Brazil) by commercial vessels operating in this area. The total number of fish examined monthly and their length range are given in Table 1. After landing the length and total weight were measured and the stomachs were removed and fixed in formalin 4% solution. Each stomach was separated from the rest of the gut, opened and the fullness was estimated. The contents were then placed in water on a Petri dish and the organisms were identified to the lowest taxon under a binocular dissecting microscope.

Hynes (1950) in evaluating several methods of stomach contents analysis concluded that volumetric and gravimetric methods are less satisfactory than numerical ones, and that combinations of two or more methods may be more advantageous than a single one. In this work we applied the numeric, occurrence and volumetric methods.

The number of individuals of each food items were counted, or estimated when necessary on the basis of characteristics of indigested fragments.

The frequency of occurrence of each food item is given as the percentage of stomachs in which it was found in relation to the total number of stomachs examined. The number of specimens of each food item is given as the percentage in relation of the total number of specimens of all food species.

The volumetric method is based on the displacement that each food item causes when immersed in a liquid (alcohol) into a graduate cylinder. The values are given as a percentage in relation to the total volume of all food items examined.

Table 1. Number of king weakfish, *Macrodon andylodon*, examined, range of total lenght (mm) and sex

Months	Number of fishes collected	Range of total lenght (mm)	Males	Females
September/76	349	130 - 373	163	186
October	195	185 - 420	86	109
November	216	185 - 375	89	127
December	216	145 - 401	113	103
January/77	196	170 - 370	56	140
February	165	215 - 376	51	114
March	213	178 - 408	55	158
April	193	153 - 383	52	141
May	229	160 - 382	62	167
June	225	135 - 422	61	164
July	202	123 - 354	79	123
August	257	133 - 384	117	140
Total	2656	123 - 422	984	1672

To understand the food preference of king weakfish both volume (Vi) and occurrence (Oi) values were used to calculate the index of preponderance (IP) (Natarajan & Jhingran, 1961, *cit. in*: Ramakrishnaiah, 1972) by season, for immature and mature females and males:

$$IP = \frac{Vi\ Oi}{\Sigma Vi\ Oi}\ 100$$

For separating immature from mature fish we applied the criterion of the length at first maturity, i.e., 21.5 cm for males and 27.4 cm for females (Juras, 1979).

The relative frequency of full stomachs by season for immature and mature males and females was calculated to estimate feeding intensity.

Results

a) *Diet composition*

The values obtained by the use of index of preponderance of the food items found in stomachs of M. *ancylodon* (Table 2; Fig. 1), showed that during the year, Crustacea (*Artemesia longinaris*) was the main food of immature females (81.8%) and males (83.5%); the mature males fed predominantly on A. *longinaris* (52.0%), *Paralonchurus brasiliensis* (26.4%) and Engraulidae (11.1%); in mature females the main dietary items were P. *brasiliensis* (37.0%), A. *longinaris* (32.8%) and *Macrodon ancylodon* (23.7%).

The importance of A. *longinaris* as food item decreased for mature king weakfish and that of fish increased.

Loliginidae, Stomatopoda, Gadidae, Bivalvia, *Trichiurus lepturus* were of minor importance in M. *ancylodon* diet.

b) *Seasonal variations in food composition*

The consumed food items were found to vary seasonally. Figure 1 depicts the trends observed throughout the year by sex and for immature and mature fish.

In spring immature and mature females fed mainly on A. *longinaris*, *Paralonchurus brasiliensis* and *Macrodon ancylodon*; this dietary spectrum is the same for mature and immature males; except for the item M. *ancylodon* not consumed by immature males (Table 3).

In summer all females and males fed on A. *longinaris*, P. *brasiliensis* and M. *ancylodon*.

The species most frequently eaten in

Table 2. Annual values of prepoderance index of dietary items of *Macrodon ancylodon*

Dietary items	Females		Males	
	Immature	Mature	Immature	Mature
Artemesia longinaris	81.8	32.8	83.5	52.6
Paralonchurus brasiliensis	8.2	37.0	6.1	26.4
Macrodon ancylodon	8.1	23.7	1.4	7.2
Loliginidae	1.3	0.08	8.2	0.1
Engraulidae		3.5		11.1
Gadidae		2.0		1.1
Trichiurus lepturus		0.9		1.2
Stomatopoda	0.3		0.7	
Bivalvia	0.02	0.1		
Mud	0.08			

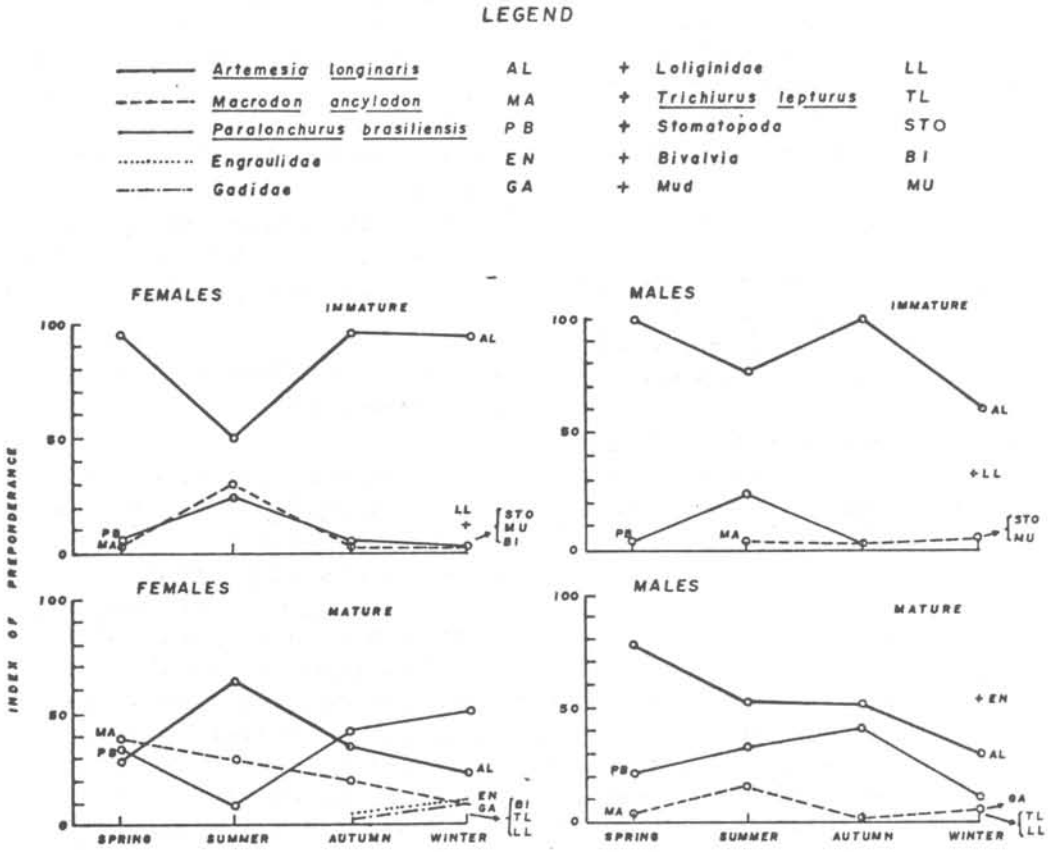

Fig. 1. Index of preponderance of different food items for immature and mature females and males of *Macrodon ancylodon*.

autumn by immature females were the same found in stomachs in summer, but the mature females added Engraulidae and Gadidae to their dietary spectrum. Only A. *longinaris* and P. *brasiliensis* were found in the stomachs of immature males. The mature males fed on A. *longinaris*, P. *brasiliensis*, M. *ancylodon* and Loliginidae (Table 3).

In winter the stomach contents showed more variety of food organisms. In immature females the following components were found: A. *longinaris*, P. *brasiliensis*, M. *ancylodon*, Loliginidae, Stomatopoda and Bivalvia. Mature females ate A. *longinaris*, P. *brasiliensis*, M. *ancylodon*, Loliginidae, Engraulidae, Gadidae, *Trichiurus lepturus* and Bivalvia. For immature males four food items occurred in the stomachs (A. *longinaris*, M. *ancylodon*, Loliginidae, and Stomatopoda); the diversity was higher in mature males that fed on A. *longinaris*, P. *brasiliensis*, M. *ancylodon*, Loliginidae, Engraulidae, Gadidae and *Trichiurus lepturus* (Table 3).

c) *Seasonal feeding intensity*

Higher percentages of full stomachs in mature females and males of *Macrodon ancylodon* occurred during the autumn and winter months, while the lower percentages were found in spring and summer months (Fig. 2); the immature king weakfish presented smaller variations in intake of food, and general observations showed an annual average of 31% for males and 43% for females of full stomachs.

Discussion

The food habits of *Macrodon ancylodon* can be best categorized as those of carnivore. This type of food habit is substantiated by data of Tanji (1974) who examined the stomachs of king weakfish from the southeastern coast of Brazil.

Crustacea (A. *longinaris*) was the most important food group in the diet of king weakfish, and fish was the secondary prey (P. *brasiliensis*, M. an-

Table 3. Seasonal composition of food itens by sex and for immature and mature fish

				Artemesia longinaris	*Paratanakutus brasiliensis*	*Macrodon ancylodon*	Loliginidae	Engraulidae	Gadidae	*Trichiurus lepturus*	Stomatopoda	Bivalvia	Mud
SPRING	FEMALES	IMMATURE	Nº	78.0	12.0	10.0							
			Oc	58.0	21.0	21.0							
			Vol	85.0	11.0	4.0							
			IP	94.0	4.4	1.6							
		MATURE	Nº	49.0	22.0	29.0							
			Oc	37.0	29.0	34.0							
			Vol	30.0	32.0	38.0							
			IP	33.3	27.8	38.8							
	MALES	IMMATURE	Nº	98.0	2.0								
			Oc	98.0	2.0								
			Vol	91.0	9.0								
			IP	99.8	0.2								
		MATURE	Nº	70.0	24.0	6.0							
			Oc	67.0	27.0	6.0							
			Vol	49.0	32.0	19.0							
			IP	77.0	20.3	2.7							
SUMMER	FEMALES	IMMATURE	Nº	58.0	22.0	20.0							
			Oc	38.0	39.0	31.0							
			Vol	51.0	19.0	30.0							
			IP	47.0	23.0	29.0							
		MATURE	Nº	24.0	46.0	30.0							
			Oc	23.0	46.0	31.0							
			Vol	13.0	52.0	35.0							
			IP	7.9	63.4	28.7							
	MALES	IMMATURE	Nº	82.0	9.0	9.0							
			Oc	82.0	9.0	9.0							
			Vol	25.0	69.0	6.0							
			IP	75.2	22.8	1.9							
		MATURE	Nº	62.0	25.0	13.0							
			Oc	53.0	33.0	14.0							
			Vol	32.0	32.0	36.0							
			IP	52.0	32.4	15.5							
AUTUMN	FEMALES	IMMATURE	Nº	81.0	13.0	6.0							
			Oc	74.0	16.0	10.0							
			Vol	77.0	13.0	10.0							
			IP	95.8	3.5	1.7							
		MATURE	Nº	36.0	31.0	18.0		12.0	3.0				
			Oc	38.0	30.0	22.0		6.0	4.0				
			Vol	25.0	27.0	21.0		17.0	10.0				
			IP	40.2	34.3	19.5		4.3	1.7				
	MALES	IMMATURE	Nº	94.0	6.0								
			Oc	93.0	7.0								
			Vol	92.0	8.0								
			IP	99.3	0.7								
		MATURE	Nº	56.0	33.0	7.0	4.0						
			Oc	54.0	40.0	4.5	1.5						
			Vol	27.0	29.0	35.0	9.0						
			IP	52.0	41.6	5.6	0.8						
WINTER	FEMALES	IMMATURE	Nº	71.0	6.0	3.0	13.0				4.0	3.0	
			Oc	58.8	7.6	2.5	15.2				7.0	1.9	7.0
			Vol	63.0	9.0	4.0	14.0				7.0	1.0	2.0
			IP	91.2	1.7	0.2	5.3				1.2	0.1	0.3
		MATURE	Nº	32.0	24.0	13.0	2.0	16.0	5.0	5.0		3.0	
			Oc	36.0	21.0	14.0	2.0	10.0	7.0	7.0		3.0	
			Vol	24.0	19.0	10.0	3.0	17.0	16.0	10.0		1.0	
			IP	49.0	22.6	7.9	0.3	9.6	6.4	3.9		0.2	
	MALES	IMMATURE	Nº	64.0		5.0	24.0				7.0		
			Oc	52.0		7.0	32.0				9.0		9.0
			Vol	37.0		16.0	33.0				10.0		4.0
			IP	59.8		3.5	32.8				2.8		1.1
		MATURE	Nº	23.0	17.0	7.0	5.0	36.0	7.0	5.0			
			Oc	32.7	13.5	7.7	1.9	26.9	7.7	9.6			
			Vol	17.0	16.0	12.0	4.0	31.0	11.0	9.0			
			IP	29.6	11.5	4.9	0.4	44.5	4.5	4.6			

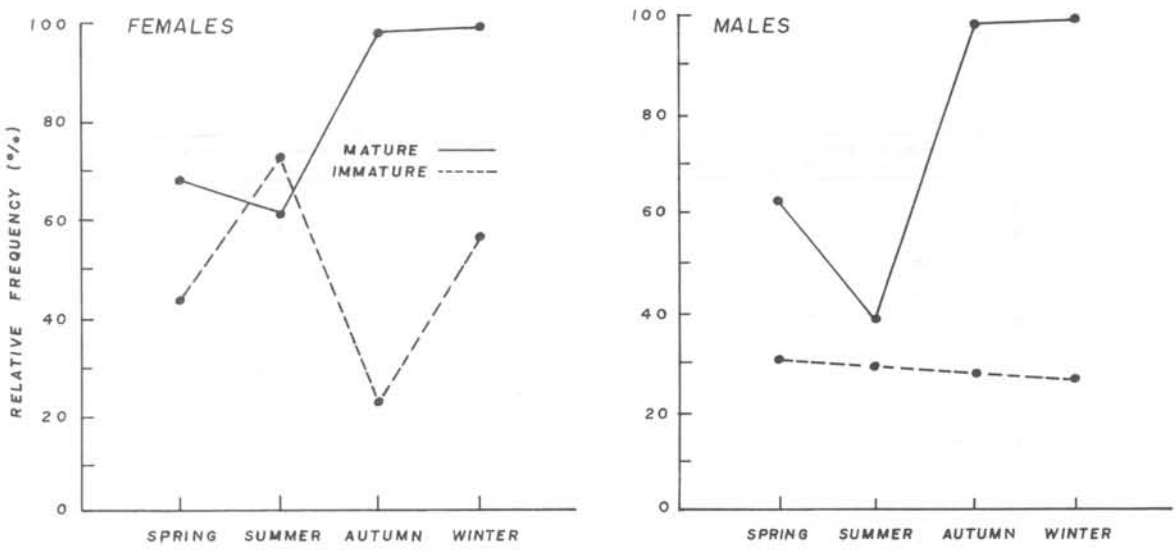

Fig. 2. Relative frequency of fullness of stomachs for immature and mature of *Macrodon ancylodon*, by sex and season.

cylodon, *T. lepturus*, Gadidae and Engraulidae). Vannucci (1963) and Tanji (1974) found a very similar food composition in *M. ancylodon* caught off the southeastern coast of Brazil. The remaining of the food items were of minor importance, e. g. the Loliginidae, Stomatopoda and Bivalvia that were mainly eaten in winter. Lowe-McConnell (1962) found also shrimp and fish as the dominant food for *M. ancylodon* of Guiana. Basically, Crustacea and fishes provided most of the reported food items for the king weakfish.

The shift of food habits with size of fish is well known (Lowe-McConnell, *op. cit.*; Nikolsky, 1963; Chao & Musick, 1977; Keast, 1977; Poltz & Norden, 1977; Geistdoerfer, 1979; Sheridan, 1979; Villiers, 1980; Gabriel & Pearcy, 1981; Love & Westphal, 1981; Targett, 1981; Daniels, 1982). Generally, larger fish eat larger sized and greater variety of food organisms, while smaller fish consume less diverse and smaller sized food items. The food habits of king weakfish seemed to follow these trends. Immature fish exhibited a restricted diet, feeding predominantly on *A. longinaris*, while mature fish progressively ate a greater variety of larger food organisms. Thus, fish became a progressively more important food item in the diet of elder king weakfish. This change could be attributed to the size of the prey organism in relation to the size of the predador and to the facility of obtaining larger preys.

The food items selected at any time of the year seem to depend on abundance of prey and to their availability to the predators.

The king weakfish spawns in the early summer extending to autumn, with two peaks, one in December and other in February (Yamaguti, 1967; Juras, 1979). This seems to affect the feeding activity of the fish because relatively higher percentages of empty stomachs were observed during that season. Subdued feeding intensity in fishes during breeding season has been observed by several workers in other species. Southwell & Prosard (1918) *cited in*: Ramakrishnaiah (1972), reported that *Hilsa ilisha* do not feed in spawning time.

The feeding intensity peak was observed during autumn and winter, predominantly in mature fishes which coincide with the post-spawning period of the fish; the poor feeding verified during the spawning period may be attributed to the fact that the gonads enlarge greatly and occupy most of the space in the body cavity during the spawning season, virtually squeezing on the stomach. Hynes (1950) has suggested that the higher percentage of empty stomachs is due to less frequent feeding activity among larger fish. We noted a similar trend in the feeding behaviour of *Macrodon ancylodon*.

Our results showed that females and males of M. *ancylodon* presented higher diversification in the composition of the diet in winter, and this fact may be due to seasonal migration of the king weakfish (Santos & Yamaguti, 1965). This variation in diet could be related to the availability by migration.

Nikolsky (1969) noted that cannibalism can occur when there is a reduction in food supply, or in the case of a particular year class be very abundant, there may be a shortage of food for other year classes and this may lead to the eating of eggs and young. This fact could have occurred with *Macrodon ancylodon* which presented a great portion of M. *ancylodon* item in the stomachs mainly for mature specimens.

Summary

From September, 1976 through August 1977, *Macrodon ancylodon* from southeastern coast of Brazil (29°S to 32°S) were examined for food and the feeding habits and the results obtained are summarized below:

1. nine different food items were found in the stomachs. These included invertebrates (*Artemesia longinaris*, Loliginidae, Stomatopoda and Bivalvia) and fish (*Paralonchurus brasiliensis*, *Macrodon ancylodon*, Engraulidae, Gadidae and *Trichiurus lepturus*);
2. crustacea (A. *longinaris* only) was the dominant food occurring in the stomachs of females (81.9% immature and 32.8% mature) and males (83,5% immature and 52.6% mature); other invertebrates found were of minor importance (Loliginidae, Stomatopoda and Bivalvia);
3. various species of fish constituted a significant part of the diet of females (16.3% immature and 67.1% mature) and males (7.5% immature and 47.0% mature);
4. food habits of king weakfish can be best categorized as those of carnivore;
5. species composition of food organisms varied with size of king weakfish; immature specimens ate heavily on A. *longinaris* (81.8% of females and 83.5 of males), while only mature female fed predominantly on fish (67.1%);
6. significant seasonal variations in food habits were observed: fish collected in spring and summer months fed almost exclusively on A. *longinaris*, P. *brasiliensis* and M. *ancylodon*; specimens collected in autumn and winter months revealed higher diversification of diet, feeding further six food organisms in winter;
7. cannibalism was encountered; there were king weakfish found in stomachs of immatures and matures of *Macrodon ancylodon*. This fact is due probably to a particular year class very abundant, determining a lack of food organisms to the fish.

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