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The Food and Feeding Habits of the Common Bay Anchovy, *Anchoa Mitchilli* (Valenciennes)

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ABSTRAK

*Makanan dan tabiat pemakanan **Anchoa mitchilli** telah dikaji bagi tiga stesen di kawasan Teluk Biloxi, Mississippi. Kajian tentang aspek lakuan pemakanan telah direkabentuk supaya melibatkan suatu pemerhatian 24 jam ritma pemakanannya. Keputusan daripada kajian ini menyarankan bahawa ikan bilis teluk yang terdapat di kawasan ini mencari makanan terutamanya di awal pagi dan terdapat puncak kedua yang kecil, beberapa ketika sebelum tengah malam. Ikan bilis ini nampaknya bergantung kepada plankton dan organisma bentos sebagai makanan. Krustasea merupakan bahan makanan paling utama dan kopepod kalanoid merupakan kumpulan yang terpenting, dari segi jumlah yang dimakan. Lakuan kanibalisme juga dikenalpasti dan ini dilakukan apabila makanan yang lain kurang didapati. Berbagai kaedah pemakanan digunakan oleh ikan ini bagi keadaan yang berlainan. Plankton halus dituras dari turus air, manakala organisma yang lebih besar dipungut satu demi satu. Jika keadaan memerlukan, ikan bilis ini akan memangsa makanannya secara aktif.*

ABSTRACT

*The food and feeding habits of **Anchoa mitchilli** studied at three stations in the Biloxi Bay area, Mississippi. Studies on the behavioural aspects of feeding were designed to include a 24-hour observation of a feeding rhythm. Results of the study indicated that the bay anchovy in this area fed mainly during early morning with a second, minor peak, just before midnight. The anchovy appeared to be dependent on both plankton and benthic organisms for food. Crustaceans were the main food items consumed, with calanoid copepods being the most prominent, numerically. Cannibalistic behaviour was identified, and this coincided with periods of low abundance of other food items. Different feeding methods were employed by the fish for various feeding situations. Small plankton were filtered through the water column, while larger organisms were picked individually. When the situation demands, the anchovy will also prey actively on its food.*

INTRODUCTION

The common bay anchovy *Anchoa mitchilli* (Valenciennes) is one of the most abundant species of fish in coastal waters of the northern Gulf of Mexico. Studies on its abundance and distribution in this area include those of Gunter (1941, 1945) who ranked it first in "species mass" among the fish in shallow waters. The importance of the common bay anchovy in Texas waters was also emphasized by Reid (1955 a, b).

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Owing to its great numbers, the influence of this anchovy on the ecology of its surroundings is highly significant, not only because of its effect on plankton populations through its feeding activities, but also because it serves as forage species for many commercial and recreational fish and is included in the diet of many other animals, including man.

Specific studies dealing with the life-history and feeding habits of this ecologically important species of fish are limited. This is probably because a commercial fishery for this anchovy does not exist or is very limited in western countries, such as the United States or Great Britain. Although the bay anchovy is one of the most abundant species of fish in the Gulf of Mexico waters, it is still not regarded as commercially important. However, in other parts of the world, the economic importance of this fish is well documented (Perry and Boyes, 1978). In Asian countries such as Malaysia, Indonesia, and the Philippines, anchovies (though not of the same species) are eaten as one of the major sources of protein.

The prime objective of this investigation was to determine the kind of organisms that were preyed upon by adult bay anchovies in the study area. Studies on the behavioural aspects of feeding were designed to include a 24-hour observation of a feeding rhythm, observations on selectivity of food organisms and to see how the feeding habits depended on the food available. Only numerical abundance was considered in this study.

MATERIALS AND METHODS

Field Methods

Three stations were identified in Biloxi Bay, Mississippi. These were Davis Bayou (Station 1), Back Bay (Station 2) and Deer Island (Station 3) *(Fig. 1)*. Davis Bayou has a mean depth of about 1.8 m and salinity ranging between $3.0 - 22.0\%_{o}$, while Back Bay has an average depth of about 5.2 m and salinity in the range of $0 - 18.0\%_{o}$. Station 3, which is in the vicinity of Deer Island has a depth of around 1.7 m and salinity of between $5.5 - 24.0\%_{o}$.

Collections of fish were made using a 12-foot otter trawl with a cod-end mesh size of 7 mm. Trawling was conducted for 15 minutes with the boat moving at a speed of about 3.5

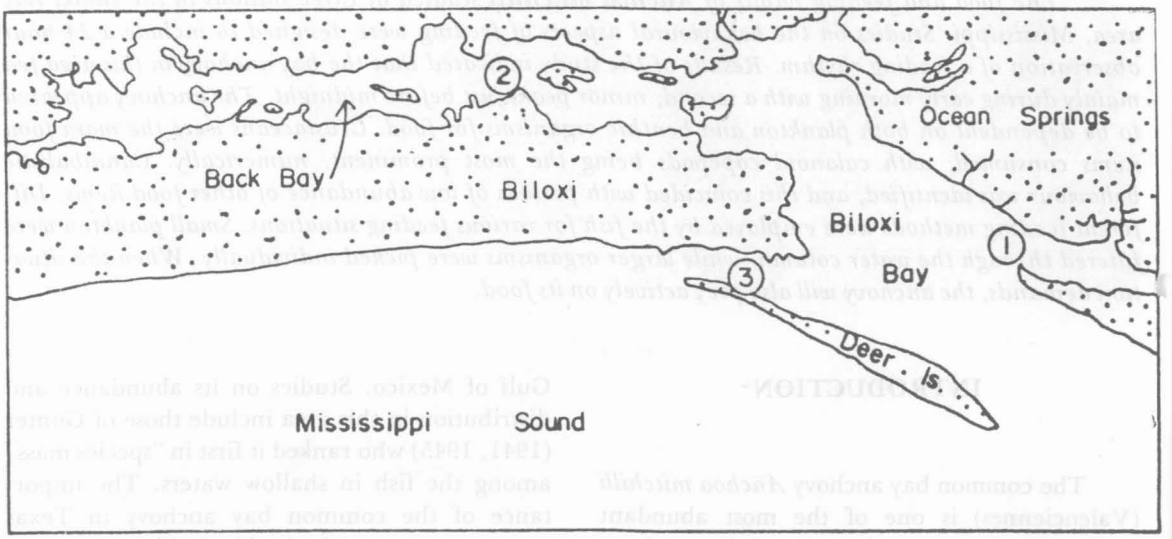

Fig. 1: Locations of sampling stations:
(1) Station 1 — the mouth of Davis Bayou at Biloxi Bay
(2) Station 2 — in Back Bay (3) Station 3 — proximity of North-west Section of Deer Island.

knots. Immediately after collection, the fish were preserved in 5% formalin buffered with borax.

Sampling was initiated at Station 2 in Davis Bayou to establish a feeding rhythm and a feeding peak or peaks. Samples were collected at different times of the day for a period of 24 hours. Based on these results, regular monthly collections were made during the time when the feeding activities of the fish were detected to be at their highest.

A total of 16 samples were collected from the three stations for the period from April through October. Seven of these collections were conducted in Davis Bayou, five taken in Back Bay and four around Deer Island.

Laboratory Methods

In the laboratory, seven fish with visible food contents in their stomach, were dissected and their food material, identified and counted. For a 24-hour study of feeding rhythm, the stomachs were separated from the rest of the alimentary system and weighed with the contents in them. Following removal of the food materials, the stomachs were again weighed. The wet weight of the stomach contents was then computed. The ratios of the weight of the contents to the weight of empty stomachs were calculated as a measure of their fullness.

RESULTS

Feeding Rhythm of Anchoa mitchilli

Fig. 2 shows the plot of a 24-hour feeding rhythm of *A. mitchilli* collected in Davis Bayou. The figure indicates two feeding peaks (significant at $\alpha = 0.05$). A major peak occurred at around 0800 hours and a minor peak just prior to midnight. There was very little feeding activity for the period from noon until about 2200 hours. Since a feeding rhythm was calculated through measurements of weight of the stomach contents and not by actual observations of feeding, it can be safely assumed that the actual feeding took place a little earlier than the quoted times. However, the actual feeding times could not have been much earlier since most of the food contents removed from the stomach were still intact.

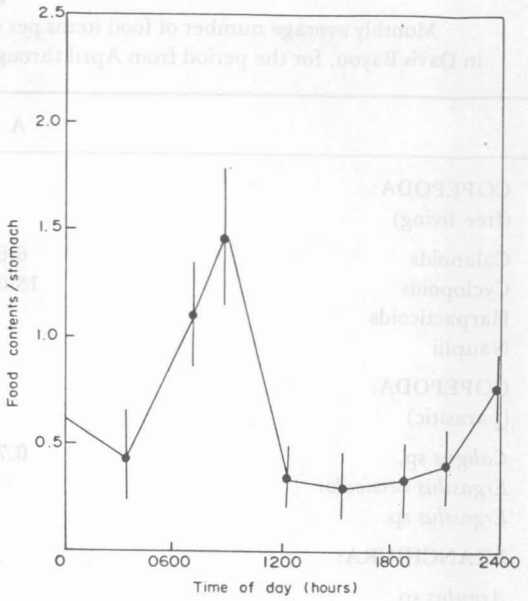

Fig. 2: Feeding rhythm of ***Anchoa mitchilli:*** *Diurnal variations in weight of food material per stomach.*

Food of Anchoa mitchilli

Station 1: Davis Bayou. The numerical abundance of food items identified in the stomach of fish caught in Davis Bayou are presented in Table 1. The major components of the diet were calanoid copepods; zoeae of the crab, *Sesarma* sp.; the mysid shrimp; *Mysidopsis almyra;* the amphipods, *Ampelisca* sp.; juvenile *A. mitchilli;* and bivalve larvae. The cypris larvae of barnacles, though not consumed in large quantities, were always present in the stomach.

One interesting feature in the diet of the bay anchovy at this first station was the presence of parasitic copepods; but as parasitis but as part of the food collections. Their presence in the stomach did not appear to have been accidental since they occurred in more than one sample.

TABLE 1

Monthly average number of food items per stomach of *Anchoa mitchilli*, recorded for Station 1 in Davis Bayou, for the period from April through October. Seven stomachs were examined each month

	A	M	J	J	A	S	O
COPEPODA: (free living)							
Calanoids	6.6	20.4	17.7	2.0	5.0	0.4	79.3
Cyclopoids	13.0	0.3	1.0	0.2			1.9
Harpacticoids		1.6	0.5				0.4
Nauplii							0.1
COPEPODA: (parasitic)							
Caligus sp.	0.7			0.1			
Ergasilus versicolor				0.2			
Ergasilus sp.				0.1			
BRANCHIURA:							
Argulus sp.			1.8				
BRACHYURA: Zoeae							
Rhithropanopeus harrisii	0.1	0.3			0.1		
Sesarma sp.	2.0				122.7	1.0	
BRACHYURA: Megalopae							
Callinectes sapidus	0.1	0.2	0.2	2.1			
Rhithropanopeus harrisii				0.1			
MACRURA: Megalopae							
Callianassa sp.			0.2				
CARIDEA: Zoeae							
Palaemonetes sp.	0.1	0.1		0.2	0.6	0.1	
Ogyrides sp.			0.2		0.1		
Unidentified		0.1	0.5				
MYSIDACEA:							
Mysidopsis almyra	0.3	9.2	1.0				2.1
Unidentified			0.3				
AMPHIPODA:							
Ampelisca sp.	6.9	12.8	2.7		1.4		2.7
Cerapus sp.	0.1		0.8				0.1
Corophium louisianum	0.3	0.1					3.1
ISOPODA:							
Aegathoa sp.	0.1						
CUMACEA:							
Cyclapsis sp.			0.2				
CIRRIPEDIA:							
Cypris larvae	0.7	1.2	0.5	0.2	0.4	0.3	0.3
Nauplii			0.2				

TABLE 1 (cont.)
Monthly average number of food items per stomach of *Anchoa mitchilli,* recorded for Station 1 in Davis Bayou, for the period from April through October. Seven stomachs were examined each month

	A	M	J	J	A	S	O
OSTEICHTHYES:							
Anchoa mitchilli	0.1				0.1	1.3	
Unidentified						0.1	
OSTROCODA:		0.2					
TANAIDACEA:		0.1	0.5				
BIVALVIA:							
Larvae				16.6	3.5	0.1	
Juveniles		0.1		2.0	0.3		

Three species of parasitic copepods were encountered. They were *Caligus* sp., *Ergasilus versicolor* (Wilson) and an unidentified species of *Ergasilus*. Although these parasitic copepods were not eaten in very large quantities, they were obviously important components of the diet of the fish due to their large size.

Two species each of crab zoeae and crab megalops were found in the stomachs. Zoeae of *Rhithropanopeus harrisii* (Gould) and *Sesarma* sp. and the megalops of *Callinectes sapidus* (Rathbun) and *R. harrisii* were identified. Based on the numbers consumed, zoeae of *Sesarma* sp. were the most important of these organisms. In August, they ranked first in numerical abundance in the diet of the fish, with a value of 122.7 zoeae per stomach.

Zoeae of shrimp made up an important component of the diet of the anchovy collected at this station, not in terms of quantities but rather in terms of their frequency of presence. They were included in the diet of the fish in all but one month of the sampling period. The larval shrimps identified were *Palaemonetes* sp. and *Ogyrides* sp.

Two groups of bottom dwellers were also major components of the food items collected in the stomach of the anchovy. Two species of mysids, including *Mysidopsis almyra* Bowman, and three species of amphipods, namely *Ampelisca* sp., *Cerapus* sp. and *Corophium louisianum* Shoemaker, were identified. The occurrence of these benthic organisms in the stomach of the fish suggested that some selective feeding may have occurred at or near the bottom, especially when some of these organism are known to be burrowers.

Juvenile fish were occasionally found in the stomach of the bay anchovies at this station, but in September they were the most prominent food item, primarily due to their large size. Most of the juvenile fish collected were *A. mitchilli.*

Station 2: Back Bay. Numerical abundance of food items identified in the stomach of the anchovies collected in Back Bay are tabulated in Table 2.

Copepods, especially the calanoids, were the most important food item. In terms of numerical abundance, they ranked first in four of the five months of collections for this station, especially in June and November. The three species of parasitic copepods included in the diet of the anchovies in Davis Bayou, also constituted components of the stomach contents of the fish collected at this station.

The zoeae of the crabs *Sesarma* sp. and *R. harrisii* were also identified among the food items of the anchovies collected here. However, no crab megalops were found.

TABLE 2

Monthly average number of food items per stomach of *Anchoa mitchilli*, recorded for Station 2 in Davis Bayou, for the period from June through October. Seven stomachs were examined each month

	J	J	A	S	O
COPEPODA: (free living)					
Calanoids	24.2	3.6	3.5	1.0	49.3
Cyclopoids	0.6	1.8			0.1
Harpacticoids	0.9	0.2	0.8	1.0	0.4
COPEPODA: (parasitic)					
Caligus sp.		0.2	0.8		
Ergasilus versicolor		2.8			
Ergasilus sp.		0.2			
BRANCHIURA:					
Argulus sp.			0.2		
BRACHYURA: Zoeae					
Rhithropanopeus harrisii	0.1		0.5		
Sesarma sp.	0.2				
CARIDEA: Zoeae					
Palaemonetes sp.		0.2		0.5	
Ogyrides sp.			0.8		
Unidentified		0.2			
MYSIDACEA:					
Mysidopsis almyra	0.6		4.3		1.3
Unidentified					0.1
AMPHIPODA:					
Ampelisca sp.			0.2		
Cerapus sp.	0.1				
Corophium louisianum					0.1
CIRRIPEDIA:					
Cypris larvae	0.8	0.2	0.2		0.7
Nauplii	0.7				
OSTEICHTHYES:					
Juveniles				1.0	
TANAIDACEA:		0.6			
CLADOCERA					0.1
GASTROPODA		0.1			
BIVALVIA:					
Larvae	0.2	4.9			
Juveniles		1.3			

Though similar species of shrimp zoeae were consumed by the fish here, they were never as important as at Station 1. Benthic organisms, especially mysids, were also important constituents of the stomach contents of the fish. Based on total volume and total weight (estimated only), mysids were found to be the main food component for the fish in August and major food items in three other month's samples.

Juvenile fish were found in the stomach of the anchovy only in one month's food samples. Although the number averaged one fish per stomach, their relatively large size made them the main food item in terms of biomass.

Station 3: Deer Island. Food items from the stomachs of bay anchovies at Deer Island are shown in Table 3. The major food components for this station were calanoid copepods, the parasitic copepod *Caligus* sp., megalops of the blue crab *Callinectes sapidus,* the mysid *Mysidopsis almyra,* and bivalve larvae. Barnacle larvae were present in each month's sample but in nominal quantities. Juvenile *A. mitchilli* were only occasionally found in the diet.

In terms of numbers, the calanoid copepods were the most frequently occurring food items in the stomachs of the bay anchovies at this station although the number consumed varied with each sample.

Similar species of parasitic copepods as in Station 1 and 2 were also identified.

One interesting feature in the diet of the fish collected at this station was the near absence of crab zoeae. This is quite surprising since the abundance of crab zoeae (especially *Rhithropanopeus harrisii*) in the plankton collections during the same period for the three stations, were quite similar (Din, unpublished data). Crab megalops on the contrary, were frequently included.

Mysids were again identified as one of the major components in the food items of the bay anchovies collected at this station, further indicating bottom feeding by the fish.

DISCUSSION

The adult *A. mitchilli* collected in this study area appear to feed twice in a 24-hour period; a major feeding peak at around 0800 hours and a minor one just before midnight. These results seem to agree partially with other studies on feeding habits of various species of anchovies which indicated that feeding was done mainly in the day time (Darnell, 1958; Muzinic, 1960; and Laukashkin, 1965), suggesting that vision was involved in finding food. Therefore, it was rather surprising to observe a night-time minor feeding peak in this particular study. Darnell (1958) commented that the daily feeding activity of the bay anchovy is not very clear. He suggested that the adult fish feed early in the morning, while the juveniles start their feeding activities in the middle portion of the day.

Based on numerical abundance, calanoid copepods were particularly important in the diet of *A. mitchilli* collected in this study. These plankton were believed to be copiously consumed because of the nominal presence of other alternatives during most of the time. When other food items such as mysids and amphipods were available, the numbers of calanoid copepods consumed was much reduced. The high dependence of bay anchovies on copepods as food has been emphasized by such workers as Hildebrand and Schroeder (1938) in Chesapeake Bay, Darnell (1958) in Lake Pontchartrain, Louisiana, and Springer and Woodburn (1960) in Tampa Bay, Florida.

Data collected in this study suggest that three kinds of feeding techniques may be employed by *A. mitchilli.*

Plankters which are relatively small, including copepods and crab zoeae, are probably filter-fed by the fish. This inference is based on the variations in abundance of these food items in the stomach of the anchovy. As an illustration, at Station 3, the abundance of calanoid copepods consumed by the anchovy varied from a high 151.5 per stomach in September to a low 1.9 per stomach in August. Similar variations were also observed for the crab zoeae *Sesarma*

TABLE 3

Monthly average number of food items per stomach of *Anchoa mitchilli,* recorded for Station 3 in Davis Bayou, for the period from July through October. Seven stomachs were examined each month

	J	A	S	O
COPEPODA: (free living)				
Calanoids	17.0	1.9	151.5	26.7
Cyclopoids				0.3
Harpacticoids			0.1	0.1
Nauplii				0.1
COPEPODA: (parasitic)				
Caligus sp.	2.0	0.3	0.8	0.1
Ergasilus versicolor	0.5			0.1
Ergasilus sp.	0.1			
BRACHYURA: Zoeae				
Sesarma sp.			0.1	
BRACHYURA: Megalopae				
Callinectes sapidus	6.0	1.0	0.3	
Rhithropanopeus harrisii		0.1		
Paguridae		0.1		
CARIDEA: Zoeae				
Palaemonetes sp.	0.3		0.1	
Unidentified		3.4	0.1	
MYSIDACEA:				
Mysidopsis almyra	4.5			1.1
Unidentified			0.4	0.1
CIRRIPEDIA:				
Cypris larvae	0.3	0.7	3.1	1.3
Nauplii				0.3
OSTEICHTHYES:				
Anchoa mitchilli		0.1	0.4	
Unidentified			0.3	
BIVALVIA:				
Larvae	2.9	141.8	0.1	0.3
Juveniles	0.1	0.1		0.1

sp. at Station 1. It is felt that such large variations in numbers could not have occurred if the organisms were individually selected. In addition, it is also believed that the rate of feeding of these organisms by the anchovies is quite dependent on the density of the food material. No work on *A. mitchilli* has been reported with regard to this aspect of its feeding behaviour. However, Leong and O'Connell (1965), working on the northern anchovy, *Engraulis mordax* Girard, demonstrated that within certain limits, variations in abundance of food organism did

not affect the feeding behavior of the fish very much, until when a certain threshold density was reached. At this point, the fish exhibited a feeding frenzy, consuming the organisms in very large amounts.

Bottom feeding seems to be an important aspect of the feeding habits of *A. mitchilli*. The consistent presence of such benthic organisms as mysids and amphipods, as well as detritus (though it was not measured quantitatively) are all indicative of this feeding behaviour.

The amphipods, particularly *Ampelisca* sp., were the most important of the bottom food items in Station 2, especially for the months of April and May. They were hardly consumed at Station 2 and were never identified in the food items of the anchovies collected at Station 3. It is felt that these differences were merely a consequence of the availability of the amphipods themselves. Farrel (1970) indicated a seasonal variation in the abundance of this crustacean in Mississippi Sound, with peak densities in the months of May and June.

The amounts of mysids consumed by the anchovies also varied with time and sampling site. This is believed to be due to the seasonal changes in the abundance of the crustacea as indicated by Price (1976), who suggested that the major factors involved are temperate and photoperiod. Conte and Parker (1971), however, added that salinity variations can also influence the abundance of the mysids; greater numbers of the crustaceans were collected at the station with a mean salinity of 12.6‰ when compared to the station with a mean salinity of 17.0‰.

The third feeding habit practiced by the bay anchovy is cannibalism. This cannibalistic behavior has been accounted for by Hildebrand and Schroeder (1928) and Verheijen (1960), but neither emphasized its importance. Juvenile *A. mitchilli* were especially important in the diet of the adults in September. During this month, juvenile bay anchovies were one of the more important food items at Station 3 and certainly the most prominent for Stations 1 and 2. It is interesting to note that in September, very few other food items were found in the stomach of the anchovies. This perhaps may indicate that cannibalistic feeding behavior is practiced only when other food organisms are limited.

Since the juvenile anchovies eaten were relatively large, they were already able to swim freely in the water. This fact suggests that feeding among *A. mitchilli* is not a matter of merely "picking" and straining food organisms from the water but there are times when the fish have to actually hunt for their prey. The only drawback to the assumption here is the possibility that the juveniles eaten were already injured.

Some results of this study point to the fact that *A. mitchilli* is selective in terms of relative size of its food items. This factor might not be evident if only the numerical abundance presented in Tables 1, 2 and 3 were considered. One should also be aware of the relative sizes of the organisms eaten. It appeared that the larger food items, which include amphipods, mysids, zoeae of caridean shrimp and megalops of the crab *Callinectes sapidus* were more prominent in the diet of the fish than their smaller counterparts. No literature on *A. mitchilli* is available to support this statement, but works on related species of fish have demonstrated selectivity of food organisms based on size differences. These include the study on *E. mordax* by Leong and O'Connell (1965), and on two species of sardine by Okera (1973).

In summary, the anchovy population of the Biloxi Bay area appeared to be dependent on both plankton and bottom dwelling organisms for their daily diet. Crustaceans were the main food items consumed, with calanoid copepods being the most prominent in terms of numbers. Cannibalistic behaviour was identified, and this paralleled periods of low abundance of other food items. Undetermined organic materials and detritus were occasionally found in the stomach of the fish but were never measured quantitatively. The importance of the detritus food chain among bay anchovies had been stressed by Darnell (1958).

Different feeding methods were employed for the various feeding situations. Small plankters were thought to be filtered from the water column while larger organisms were picked individually. When the situations demanded, *A. mitchilli* also preyed actively on juvenile fish including its own species.

Several factors may determine the number of a particular organism eaten by the fish. Availability of the food item and the presence or absence of other food alternatives were considered the most important.

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