FEEDING ECOLOGY OF THE BANDED KILLIFISH (FUNDULUS DIAPHANUS) AT TIVOLI NORTH BAY, HUDSON RIVER, NEW YORK

by

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Abstract

The feeding habits of banded killifish were determined from a tidal freshwater marsh in Tivoli North Bay, Hudson River National Estuarine Research Reserve during July and August, 1986. The most significant foods were Cladocera, Copepoda, Ostacoda, and Chironomidae larvae with a variety of invertebrates of lesser importance. Significance of food items changed with size. Smaller killifish depended more on Cladocera and Copepoda while in larger individuals, Ostracoda and Chironomidae were more significant.

Banded killifish appear to feed on the flooded marsh surface at high tide. Their behavior and selection of food items is very similar to that of the mummichog (Fundulus heteroclitus), a killifish known to have a significant role in saltmarsh food webs. We conclude that banded killifish are the ecological equivalent of mummichogs in Hudson River fresh tidal marshes.

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Introduction

Observations on the fish fauna of Tivoli Bay (Kiviat, In press; Schmidt, 1986) have indicated that banded killifish are common in certain areas of the marsh and are probably a significant component of the ecosystem. Fundulids are found in marsh environments on both the East and Gulf coasts of North America and considerable literature exists on Fundulus heteroclitus (e.g., Valiela, et al., 1977). In the Hudson River, the low salinity marshes are inhabited by F. diaphanus instead of F. heteroclitus (which is found at the seaward end of the estuary). In comparison, literature on the biology of the banded killifish is scarce. Lazara (1984) compiled an exhaustive list of killifish literature and only two papers address the basic ecology of this species other than anecdotal information (Griffith, 1974; Keast and Webb, 1966). Food habits of banded killifish have been compared to sympatric mummichogs (Fritz, 1974; Baker-Dittus, 1978).

The purposes of this study were to gather data on the food habits of banded killifish in a Hudson River fresh tidal marsh and to begin to define the ecological role of banded killifish in this habitat. Our hypothesis is that banded killifish are as important to freshwater tidal marshes as its congenor (F. heteroclitus) is to saltmarshes.

Methods

Study Area

This study was done in Tivoli North Bay, a tidal freshwater marsh on the Hudson River Estuary (river mile 99), New York. Tivoli North Bay is part of the Hudson River National Estuarine Research Reserve and has been designated as an Experimental Ecological Reserve.

Tivoli North Bay is a high marsh dominated by narrowleaf cattail (Typha angustifolia). Stable winding channels are found throughout the marsh that, with a tidal range of about 1.2 m (4 fee)t, vary in depth from about 1.6-2 m (5-6 feet) at low tide to 3.1 m (10 feet). Substrates ranged from scoured clay in the main channels to deep silt in backwaters.

The site chosen for this study was a shallow channel located at the entrance of a large pool in the middle of the marsh (Figure 1). The pool is virtually dry and the channel has approximately 6-10 inches of water at low tide. At high tide the channel is 1-1.3 m (3.5-4 feet) deep which is enough to allow water to spread through the cattail stands. The substrate is moderately deep silt with dense growths of water celery (Vallisneria americana) and filamentous green algae.

Procedure

Sampling was done at or near low tide during the day. Fishes were collected with a 3/16-inch Ace knotless nylon

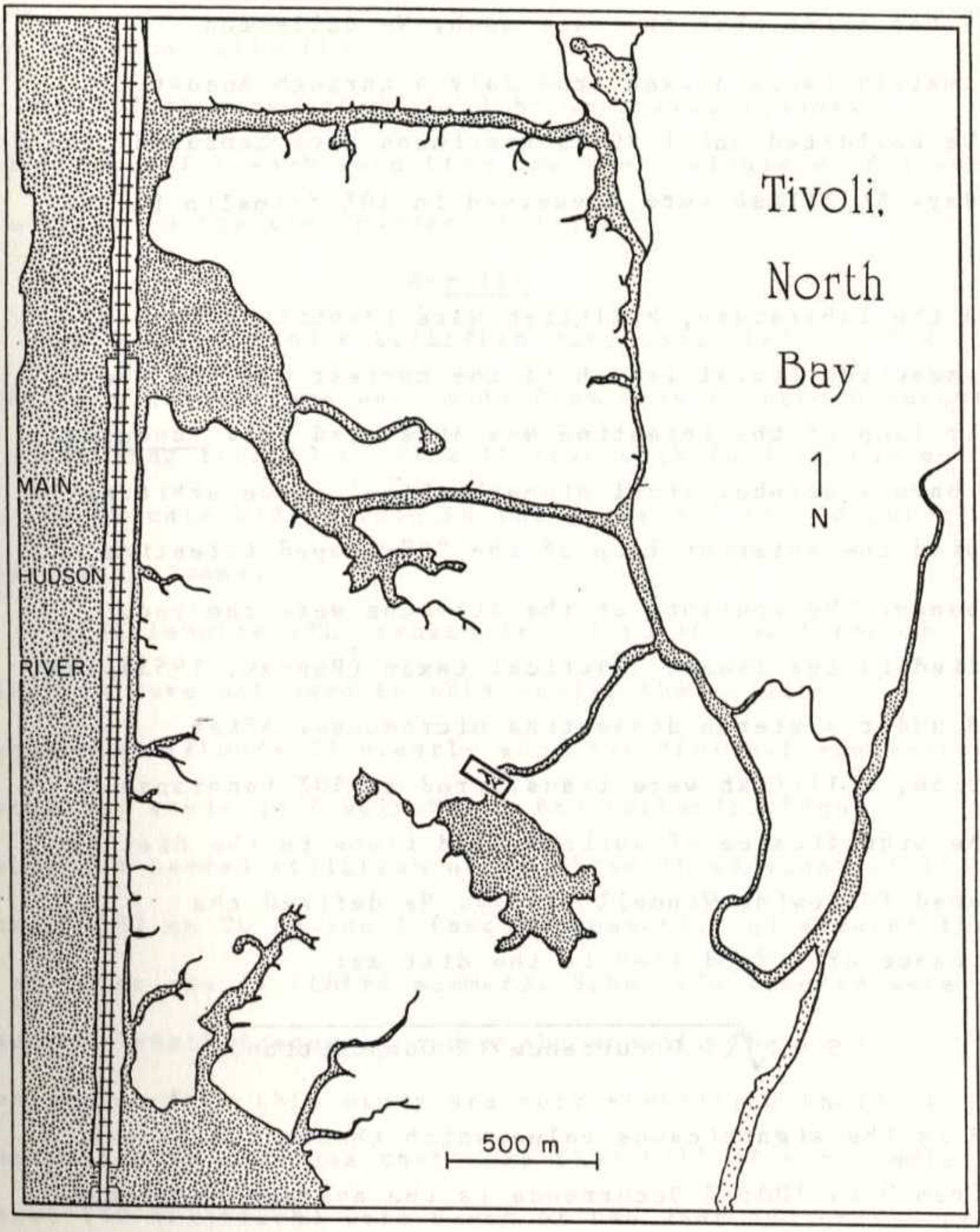

Figure 1. Sample area (outlined) in Tivoli North Bay, Hudson River, NY.

mesh 3 m (10-ft) seine. Occasionally, when water levels were exceptionally high (after heavy rains), we used a 15.5 m (50-ft) bag seine with the same mesh. We collected approximately twice a week from July 6 through August 23, 1986. We collected until 20-25 specimens were captured on a given day. Killifish were preserved in 10% formalin in the field.

In the laboratory, killifish were identified (Smith, 1986), measured (total length to the nearest mm) and the anterior loop of the intestine was dissected out. <u>Fundulus</u> do not have a morphological stomach therefore we arbitrarily designated the anterior loop of the "S"-shaped intestine as the stomach. The contents of the stomachs were removed, identified to the lowest practical taxon (Pennak, 1953) and counted under a stereo dissecting microscope. After dissection, killifish were transferred to 50% isopropanol.

The significance of various food items in the diet was calculated following Windell (1971). He defined the significance of a food item in the diet as:

$$S = \sqrt{(\%\ \text{Occurrence})(\%\ \text{Composition})}$$

where S is the significance value which theoretically can range from 0 to 100; % Occurrence is the average percentage that a particular food item contributes to the total number of items in a sample; and % Composition is the percentage of fish that contain that item out of the total number of fish examined. All calculations were based only on killifish containing food. Significances were calculated for each food item for each collection.

Killifish were categorized by 1-cm size groups. Significance for each food item was then calculated for each size group in the same manner as above.

Results

Two hundred banded killifish were collected in this study. Ten collections were made from July 8 through August 22 containing from 12 to 22 killifish with food in the gut. Six individuals had no food in their gut and were eliminated from the analyses.

Total lengths (TL) ranged from 2 to 10 cm. Although killifish were not aged in this study, the length frequencies (Figure 2) clearly show two distinct age groups. A previous study on Tivoli North Bay (Schmidt, 1986) designated banded killifish up to 51 mm TL as young of the year, 53-82 mm TL as age I (second summer), and greater than 86 mm TL as age II (third summer). Schmidt's results were based on length frequency and scale annuli. The length frequencies from this study are very similar to those of Schmidt and we conclude that more than half of our sample (about 130 killifish) were young of the year and only 2 or 3 individuals were age II.

Four food items had consistently high significance

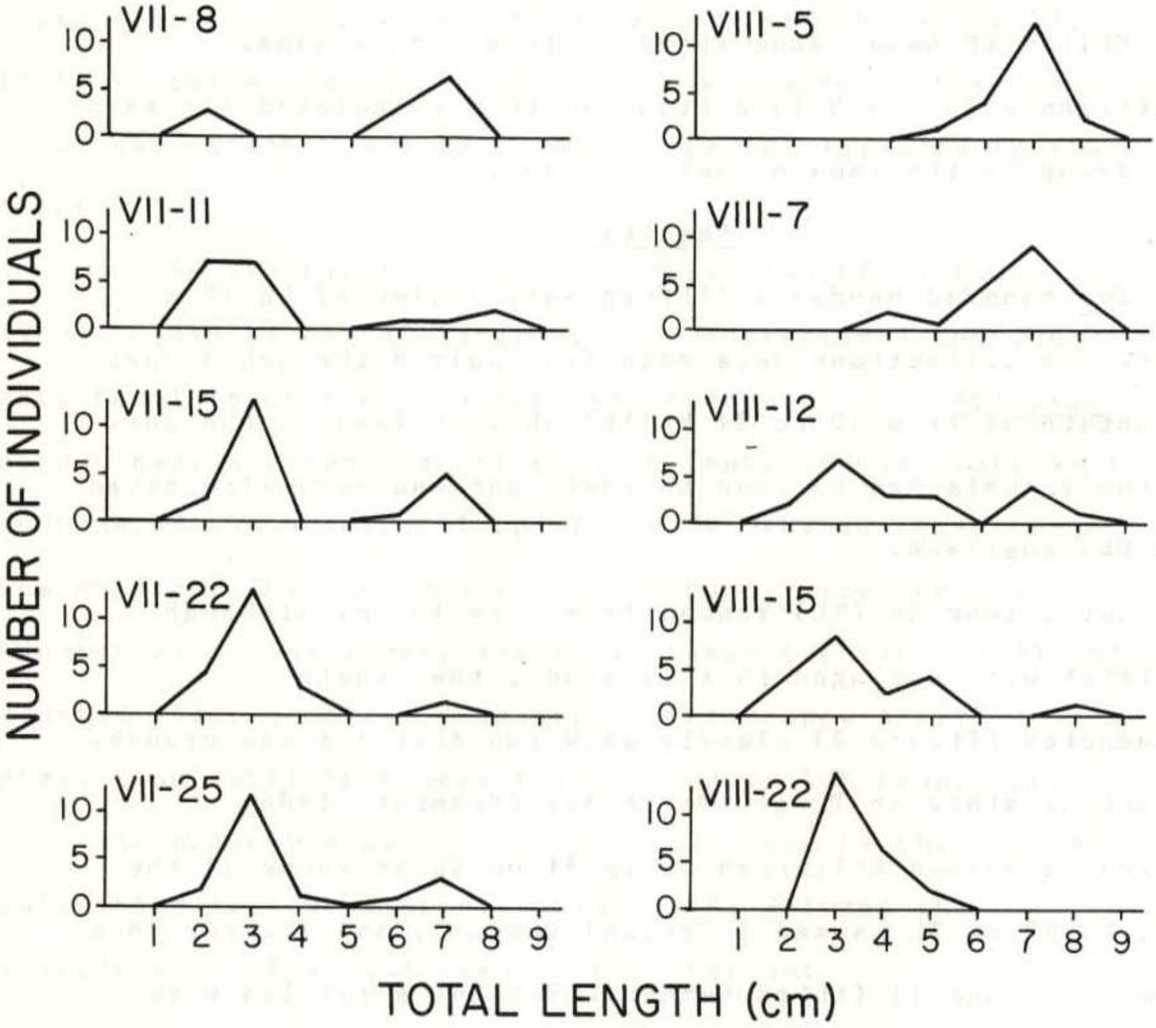

Figure 2. Length frequency of banded killifish from Tivoli North Bay, NY.

values: Cladocera, Chironomidae, Copepoda, and Ostracoda (Table 1). We had 12 other categories of food items which rarely had high significance values. The significance values of the four most important food items do not show any clear patterns when compared over time, but there are striking disparaties in fishes collected on August 5 and 7 (Table 1). The significance values for Cladocera are very low compared to the other collections and the opposite is true of Ostracoda. Looking at Copepoda and Chironomidae, this pattern seems to repeat but is less obvious. On these two dates, virtually all of the sample consisted of large killifish (Figure 2). If you examine the significance values calculated for 1-cm size groups, significance of Cladocera and Copepoda are lower for larger fish and vice versa for Chironomidae and Ostracoda (Table 2). These data indicate to us that larger killifish are feeding on food organisms different from those of smaller (younger) individuals. The Chironomidae are larger in general than cladocerans and copepods and it makes sense that larger killifish are better able to handle the larger prey. The Ostracoda, however, appeared roughly the same size as cladocerans and copepods. Therefore the high significance of Ostracoda in larger killifish may indicate different foraging patterns as well as the increased ability to handle larger prey. A similar increased utilization of ostracods was reported for large mummichogs (Kneib, 1986).

Table 1. Significance values of food items in the diet of <u>Fundulus</u> <u>diaphanus</u> relative to collection date, 1986. Food items are: A= Cladocera, B= Chironomidae larvae, C= Copepoda, D= Ostracoda, E= Amphipoda, F= Oligochaeta, G= Anodontidae, H= predaceous Cladocera, I= fish eggs, J= fish larvae, K= Odonata, L= Chironomidae pupae, M= Trichoptera, N= Gastropoda, O= Coleoptera, P= miscellaneous.

	Food Items															
Date	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
7/8	55	35	3	16	14											5
7/11	78	21	2	17	10	2			2	2			2			2
7/15	80	8	16	14	11		1					1				1
7/22	48	8	75	1	9		2	5								1
7/25	47	10	80	4			1		2							1
8/5	10	57		70	6				1			1	1	1		
8/7	9	34	16	69	6					6	1	3	1		1	1
8/12	58	28	34	25	3		1		1	4	1	2				1
8/15	46	5	67	3	1		2		2	5						4
8/22	46	10	78	3	1		2	2			2					1

Table 2. Significance of food items in the diet of *Fundulus diaphanus* relative to the size of the fish from Tivoli North Bay, Hudson River, NY.

	Total Length (cm)						
Food Item	2	3	4	5	6	7	8+
Cladocera	81	53	50	30	38	46	32
Chironomidae larvae	16	8	10	31	33	27	39
Copepoda	41	67	67	72	16	12	5
Ostracoda	5	1	2	29	51	43	55
Amphipoda	16	4	1	3	1	6	4
Oligochaeta	1						
Anodontidae		2	4				
Predacious Cladocera		2	3				
Fish eggs		1		2		1	
Fish larvae		<1	2	2	1	1	8
Odonata		1				1	
Chironomidae pupae				2		2	3
Trichoptera					3		
Gastropoda						<1	
Coleoptera							2
Miscellaneous	1	1		2	4	7	2
Total fish	25	74	18	11	15	42	9

Thirty-five of the fish examined (12.9%) contained filamentous green algae. We agree with Weisberg (1986) that the algae is incidental in the diet of killifish and does not contribute to the nutrition of the fish. Filamentous algae was very abundant in the study area and could easily be entangled with prey items and swallowed.

Killifish were abundant in the study area at low tide. However, when we tried sampling at higher tides, few if any killifish were caught. It appears that banded killifish follow the rise of the tide and spread out among the roots of the emergent cattail community when they are flooded. This phenomenon has been incidently observed on the marsh (Kiviat, pers. comm.). This behavior has also been observed in the mummichog in saltmarshes (Weisberg and Lotrich, 1982).

We collected too few mummichogs in this study to make meaningful comparisons of the feeding habits of the two congenors. Schmidt (1986) also found that mummichogs were comparatively rare in Tivoli North Bay. The marshes in the southern Hudson estuary are dominated by _F. heteroclitus_ (due to high salinity- Weisberg, 1986) and it would be interesting to compare the ecology of the two species.

We found large red parasitic nematodes (larval forms of _Eustronglides_ sp.) in the body cavity of 10 banded killifish. The adults of these worms are found in endothermic animals.

Discussion

In saltmarshes, the mummichog has been considered an important energy link between the intertidal marsh invertebrates and surface and subtidal food webs (Valiela et al., 1977). Our observations indicate that the banded killifish are functioning in the same ecological role in Hudson River freshwater tidal marshes. Fish-eating birds take a substantial number of mummichogs from the saltmarsh surface (Peterson and Peterson, 1979) and we have observed great blue herons, little green herons, and least bitterns feeding (apparently) on banded killifish in Tivoli North Bay. Other piscivorous birds are present, such as belted kingfishers and American bitterns. Banded killifish may be affecting the local bird population by harboring larval Eustronglides sp., a nematode that has caused mortality in heron and egret nestlings (Wiese, et al., 1977).

In the subtidal environment, larger fishes feed on Fundulus which are often used as bait for larger carnivorous game fishes. There are no data available on the occurrence of banded killifish in predatory fish stomachs, but we hypothesize that they are used as prey.

Conclusions

In studies that compared the sympatric feeding habits of mummichogs and banded killifish (Fritz, 1974; Baker-Dittus, 1978), overlap between the two species was large (Weisburg, 1986). These data suggest that feeding biology of these two Hudson River killifish species is very similar and that our assumption that banded killifish are ecologically similar to mummichogs in tidal marshes is reasonable.

Recommendations

This study indicated that banded killifish may be an important component of the Hudson River freshwater tidal marsh ecosystem. More detailed information should be gathered on feeding habits of this species, especially regarding the significance of the flooded marsh surface to this species. Productivity estimates for banded killifish in comparison to mummichog productivity in the more saline Hudson River marshes would be a very interesting study.

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