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Summer Food of Juvenile American Shad in Virginia Waters[1]

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ABSTRACT

This study was made to determine the feeding habits of juvenile shad during late summer in the Pamunkey and Mattaponi Rivers and to discover, if possible, reasons for an apparent upriver migration. The stomachs of 1949 shad captured in 1953, 1954, and 1955 were examined. Insects were the most important food item; those of terrestrial origin made up a larger volume of food than did aquatic insects. Shad captured upriver from major spawning areas contained more food than those taken in the vicinity of spawning grounds.

Insects of terrestrial origin made up a larger proportion of food of shad from upriver, while aquatic insects made up a larger proportion of food from downriver. The feeding of young shad in the Pamunkey River differed in both quantity and quality from those in the nearby Mattaponi River. Feeding began to increase in late afternoon, was most active at dusk, continued to a lesser extent during night and almost ceased by midday.

Introduction

Surface trawl surveys conducted in fresh waters of Virginia tidal estuaries have shown juvenile American shad, *Alosa sapidissima*, to be most numerous upriver from the major shad spawning grounds (Massmann, 1954). This was unexpected because sampling for both benthos and plankton has shown that small aquatic organisms, potential food for young shad, were more abundant in the vicinity of shad spawning grounds than they were upriver from these grounds (Massmann et al. 1952a).

Since cruises were made to obtain information on the relative abundance of young shad (Massmann, 1953), it was not difficult to obtain samples for stomach analyses. It was believed that a study of feeding habits might suggest an explanation for the abundance of young shad in apparently unproductive river areas.

Previous studies in other regions have shown the most important foods of young shad to be planktonic crustacea and chironomid larvae (Leim, 1924); adult insects and ostracods (Hildebrand and Schroeder, 1928); insect larvae and copepods (Maxfield, 1952, Mitchill, 1925). Walburg (1957), in a study of the food of juvenile shad in six rivers along the Atlantic coast, found insects and crustaceans to be the most important foods. In none of these studies, however, were shad sampled throughout their range in a river system.

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Methods

Juvenile shad were captured at night by surface trawl (Massmann et al., 1952b) except when studies of diurnal feeding were conducted through 24 hours. Stations in the Pamunkey and Mattaponi Rivers were located at 5-mile intervals from the vicinity of salt water to the upper limit of tidal influence (Fig. 1). This encompassed the habitat of most juvenile shad in the York River system. Pamunkey River stations 30 to 55 and Mattaponi River stations 30 to 45 are arbitrarily designated as down-river stations while Pamunkey River stations 60 to 70 and Mattaponi River stations 50 to 55 are designated as upriver stations. Sampling was done during August and September in 1953, 1954, and 1955.

Shad were preserved in 10 percent for-

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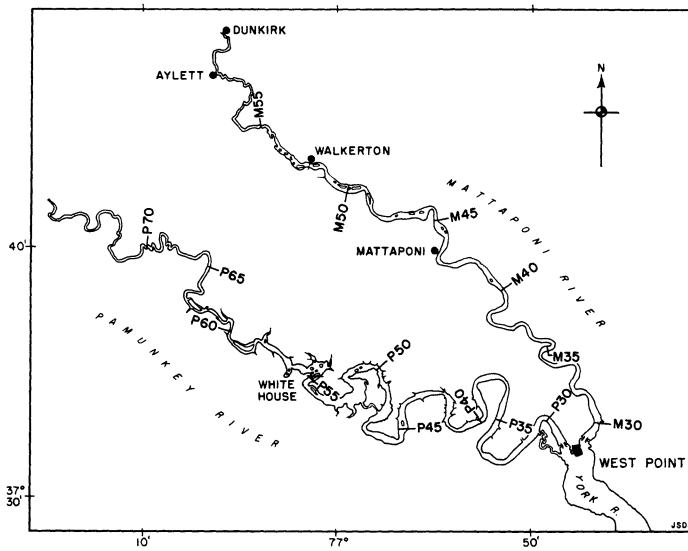

Fig. 1.—The Pamunkey and Mattaponi Rivers showing stations sampled.

TABLE 1.—Length frequencies of juvenile shad captured in the Pamunkey and Mattaponi Rivers by surface trawl during August and September 1953–1955.

Fork length (mm)	Stations			
	Pamunkey River		Mattaponi River	
	30–55	60–70	30–45	50–55
45	1	13	4	2
50	5	15	18	10
55	26	37	60	58
60	62	46	188	110
65	100	75	198	104
70	112	127	204	62
75	116	153	118	30
80	60	102	62	12
85	20	29	16	2
90	4	6	14	
95	1		2	
Total	507	603	884	390
Mean	69.9	70.5	67.2	63.7

malin immediately after capture. The stomachs from 1,519 shad were examined from fish collected August 10 to 27, 1953, August 23 to September 17, 1954, and September 8 to 10, 1955. All were collected between 1830 and 0300 hours.

Length measurements (fork length to nearest mm) were obtained from shad captured at all stations (Table 1). In most instances the same individuals saved for stomach examination were measured for length but this was not always the case.

For each pooled sample, the food from individual stomachs was preserved collectively and measured volumetrically by water displacement to the nearest cc, in a graduated cylinder. After separating and identifying food items present in each sample the most important components were measured to the nearest 0.1 of a cc. The volumes of food organisms are expressed as percentages of the total sample. Identifications and nomenclature are based on Pennak (1953).

To learn if feeding was more pronounced at certain hours of the day and night, additional samples were collected at 3-hour intervals during two different 24-hour periods: at Pamunkey River station 50 on August 5–6, 1953, and at Mattaponi River station 45 on September 22–34, 1954.

Results

Thirty-seven samples of shad stomach contents from 2,049 shad were examined. Twenty-one of the samples were utilized for the general food habits study in both rivers and 16 for the special problem concerning the time of feeding. Food items identified from samples in the general study, and the number of samples in which they occurred

include: Ephemeroptera—18, Hymenoptera —11, Diptera—9, Amphipods—9, Coleoptera—6, Hemiptera—5, Nematoda—3, Hydracarina—2, Trichoptera—2, Odonata—2, Lepidoptera—2, Insecta eggs—2, Pisces—1, Neuroptera—1, Protozoa—1, Rotatoria—1, Cladocera—1, Arachnida —1, and Homoptera—1. In addition vegetation fragments occurred in 2 samples and gravel and seeds each occurred once. Ninety-nine percent of the food was insect, 71 percent of which was of terrestrial origin and 28 percent of aquatic origin; one percent of the food consisted of amphipods. Although ants and wasps were the most important insects in terms of total volume, mayfly nymphs, sub-adults, and adults (most of which were probably *Hexagenia*) occurred most frequently in the samples. Water boatmen (principally corixids), most of which were young stages, were found in 4 percent of the samples and a variety of flies, gnats, and mosquitoes contributed 1 percent of the volume. With the exception of postlarval anchovies, the remaining items were present in quantities too small for volumetric measurement. In addition to food items, fragments of vegetation, plant seeds, and gravel (probably swallowed accidently) were also present. Twenty-five cc of food material present in the samples was so completely digested that identification was not possible. It is assumed that this material consisted primarily of foods listed above.

The mean volume of food per individual from upriver stations was seven times greater than the mean volume of food from shad taken from downriver stations (Table 2). Insects of terrestrial origin, principally the flying stage of ants, predominated in fish from upriver while aquatic insects including mayfly larvae and adult and young water boatmen were most prevalent in samples from downriver stations.

A comparison of the food of shad in each river (Table 3) showed the mean volume of food per individual to be four times greater in samples from the Pamunkey than from the Mattaponi. Ants were the principal food item for Pamunkey River shad while mayfly larvae and adults were the main food of shad from the Mattaponi River. Samples from the Mattaponi River contained a wider variety of food organisms than did those from the Pamunkey River.

TABLE 2.—The amounts and kinds of food from samples of young shad stomachs captured in the vicinity of and upriver from major shad spawning areas in the Pamunkey and Mattaponi Rivers.

	Downriver samples	Upriver samples
Number of stomachs	782	737
Total food volume cc.	24	163
Mean volume cc.	0.03	0.22
Food item (percent of volume)		
Ephemeroptera	36	21
Hemiptera	26	1
Hymenoptera	23	77
Amphipoda	11	0
Pisces	3	0
Diptera	1	1

TABLE 3.—Comparison of the amount and kinds of food obtained from the stomachs of juvenile shad captured in the Pamunkey and Mattaponi Rivers.

	Pamunkey River	Mattaponi River
Number of stomachs	1,005	514
Total food volume cc.	169	18
Mean volume cc.	0.17	0.04
Food item (percent of volume)		
Hymenoptera	77	7
Ephemeroptera	18	73
Hemiptera	4	0
Amphipoda	1	2
Diptera	0	13
Pisces	0	5

From samples of shad captured at different times during the day and night (Table 4) the mean food volumes per individual show that at noon most stomachs were empty. Food volume increased in late afternoon, reached a maximum in early evening, and decreased from midnight to midday.

Discussion

Shad stomach analyses showed rather conclusively that previous information on potential fish food production in Virginia tidal rivers, based on benthos and plankton sampling, was not correct. The most im-

TABLE 4.—Amount of food obtained from the stomachs of juvenile shad captured at different times of day. Collections include 207 fish sampled from Pamunkey River station 50 on August 5–6, 1953, and 346 fish from Mattaponi River station 45 on September 22–23, 1954.

Time	Number examined	Volumed food cc.[1]	
		total	mean
0300	53	9	0.17
0600	143	8	0.06
0900	50	3	0.06
1200	29	X	X
1500	58	1	0.02
1800	43	2	0.05
2100	89	18	0.20
2400	65	8	0.12
Total	530	49	0.09

[1] The presence of food in quantity too small to measure is shown by X.

portant food source did not originate in the rivers, but rather in the wooded areas bordering them. It is of interest to note that the shores of the Pamunkey River are more heavily wooded than the shores of the Mattaponi River. The ratio of open water to shore line is much greater downriver where the rivers are wider, than it is upriver.

Although much time was spent on the rivers in making these collections, at no time were large numbers of insects observed floating on the surface. Presumably most insects which fell or landed on the water were immediately devoured.

The time of most active feeding, as indicated from this study, was indeed the most active period suggested by direct observations. Although young shad and river herrings, also present in large numbers, were often observed to feed by jumping from the water after insects during the day, this activity greatly increased at dusk.

In this connection, the ability of young shad to capture insects flying over the water was demonstrated one evening when a housefly was dangled over the water alongside the boat at the end of a fine thread. When the fly was jiggled within 2 or 3 inches of the water surface, a young shad leaped from the water and caught it. Sometimes several fish would jump at the same instant. This experiment was repeated several times with the same results. Shad seldom attempted to capture the bait when it was suspended 6-inches above the water.

A shortcoming of this study was the relatively short period during which shad were collected. Collections spread over a longer period of time would have resulted in data more representative of feeding during the season. It also appears that sampling done only at dusk would be more productive than sampling done over a longer period of time.

It is interesting to note that young shad apparently fed least at midday. Young pickerel, on the other hand, appeared to feed most heavily at this time (Meyers and Muncy, 1962). Estimating periods of feeding based on stomach analyses alone has limitations, as pointed out by Darnell and Meierotto (1962). Concurrent collecting for potential food organisms at the time the fish were collected would have added to the value of the present study.

The amounts of food that these small shad could hold was rather surprising. At times stomachs contained several hundred ants. The walls of these stomachs were stretched tissue-paper thin. It was noted that fishes from the same samples usually contained similar food organisms, although the success of individual fish in feeding appeared to differ markedly.

Tusks of larval mayflies remained in shad stomachs long after the rest of the larvae had been digested. Many times these tusks were the only evidence that mayfly nymphs had been consumed. Pooling of stomachs was helpful in bringing the occurrence of these remains into proper perspective, however remains of mayfly were found in most of the samples.

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