Food Habits of the Rough Shiner, Notropis baileyi Suttkus and Raney, in Halawakee Creek, Alabama

DILIP MATHUR[1] and JOHN S. RAMSEY
Department of Fisheries and Allied Aquacultures, Agricultural Experiment Station, Auburn University, Auburn, Alabama 36830

ABSTRACT: In Halawakee Creek, the rough shiner, *Notropis baileyi,* showed two distinct feeding peaks, one during the daylight and the other during the hours of darkness. Immature forms of Diptera, Ephemeroptera, and terrestrial insects were dominant in the diet during the 24-hr period. These organisms were also common in the drift samples taken concurrently with the fish. Daily ration varied from 5.9 to 6.5% of the body weight. Feeding intensity was lowest in winter, highest in spring and summer and moderate in autumn. Fish less than 35 mm fork length fed on dipteran larvae, terrestrial insects and detritus throughout the year. The diet of the larger fish (> 35 mm) was dominated by terrestrial insects, ephemeropteran nymphs, trichopteran larvae and detritus. The diet of the larger fish was more diverse than that of the smaller individuals. The opportunistic feeding habits are in part responsible for the success of this introduced species in Halawakee Creek.

INTRODUCTION

Because of the recent introduction and subsequent establishment of the rough shiner, *Notropis baileyi* Suttkus and Raney, in Halawakee Creek, Alabama, the factors responsible for its unprecedented success have been under investigation since 1968. Mathur and Ramsey (1974) reported on the reproductive biology of the rough shiner and concluded that a long, successful spawning season, a short maturation period and high fecundity were, in part, responsible for its establishment in Halawakee Creek. Since then, we have completed other studies which provide further information relevant to the ecological success of this species. In the present paper we examine the food and feeding habits and define the role of the rough shiner in the trophic dynamics of the fish community in Halawakee Creek.

Halawakee Creek rises in Chambers Co., Ala., flows SE through Lee Co. and enters Lake Harding (Chattahoochee River), Alabama-Georgia. The creek is about 29 km long and is located in the Piedmont region of E-central Alabama. The physical and chemical characteristics of the creek have been described by Hurst (1969) and Mathur (1973a).

METHODS

The method of determination of daily feeding periodicity was similar to that described by Mathur (1973b). It comprised the findings during two 24-hr periods of seining (17-18 April and 2-3 September 1970). The seining was carried out at 3-hr intervals over a 24-hr

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[1] Present address: Ichthyological Associates, P. O. Box 12, Drumore, Pennsylvania 17518.

period on both dates. Immediately upon capture the fish were preserved in 10% formalin and later transferred to 40% isopropyl alcohol. No measurable amount of regurgitation was observed during the preservation of the specimens. Drift samples, each of 20-min duration, were taken concurrently with the fish samples for the 24-hr feeding study. Drift samples were preserved in 5% formalin, later sorted in the laboratory and compared with the stomach contents. A feeding periodicity curve was determined on the basis of mean weight of stomach contents per gram of fish body weight (Keast and Welsh, 1968; Mathur, 1973b). These findings were used to develop a mean quantitative figure for the amount of food eaten in a day (daily ration). Fish for the seasonal study were collected by seine once a month from February 1970 to March 1971.

Fork length to the nearest mm, weight to the nearest 0.1 g and sex of each fish were recorded. The stomach was removed and its per cent fullness was visually estimated (Darnell, 1958). The visual method of estimating relative fullness of stomachs has been found to be satisfactory (Noble, 1972). We also tested the validity of this method from comparisons of the wet weights of stomach contents and the estimated per cent fullness and the results were found to be comparable. The seasonal feeding intensity was determined on the basis of mean per cent fullness of the stomachs and percentage of empty stomachs.

The contents of the stomach were removed and identified under a binocular microscope. Then the proportional volume of each food category was visually estimated (Larimore, 1957). In calculating the proportional volume, each fish was given equal weight independent of its size or actual biomass of food items in its stomach. A total of 1333 stomachs were examined for the seasonal study.

Data for the whole year were initially analyzed for intraspecific differences in diet, since it was suspected that the prey taken by large individuals differed from that taken by small individuals. The objective of the analysis was to divide the species into length strata that would best show up any size-related feeding heterogeneity. Seasonal food habits are described only for those length groups that showed differences. For the sake of convenience and clarity the data were arranged according to the following seasons: spring (March, April, May), summer (June, July, August), autumn (September, October, November) and winter (December, January, February). The monthly food data from which the above figures were derived are available elsewhere (Mathur, 1972b).

RESULTS AND DISCUSSION

The daily feeding cycle.—Feeding activity over the 24-hr period was reflected by changes in the ratio of the weight of the stomach contents to fish body weight (Fig. 1). Two feeding peaks were discernible on both dates. However, the feeding cycles differed slightly. In April a higher feeding peak occurred at 0600 hr and a lower one at 2000 hr. Little feeding occurred from 0600 hr till about 1100 hr. Feeding commenced after 1100 hr reaching a peak at 2000 hr. After this there was a decrease in feeding activity for a short time, followed by increased feeding till 0600 hr. In September a higher feeding peak occurred at 1400 hr and a lower one at 2000 hr. Feeding commenced around midnight and continued until 0600 hr, declined slightly, increased between 0800 and 1100 hr reaching a peak at 1400 hr, followed by a decrease; feeding recommenced around 1700 hr, again reaching a peak at 2000 hr. There was no indication that the feeding activity ceased completely at any one time period. The feeding peaks, one during the daylight hours and the other during the darkness, suggest that stimuli other than visual cues may be involved in capturing the food particles, particularly at night.

Daily ration.—The cyclical nature of the feeding in fishes provides a basis for calculating the daily ration (Keast and Welsh, 1968; Mathur, 1973b). This involves determining the differences between the mean weights of stomach contents per gram of fish weight at the peaks and for the succeeding low points. The resultant values are: April, 0.065 (6.5%) g per g of body weight, and September, 0.059 (5.9%) (Fig. 1). These slight differences in food intake between the two dates are probably due to high temperature in September. The water temperature ranged from 21.1 to 22.8 C in September and 15 to

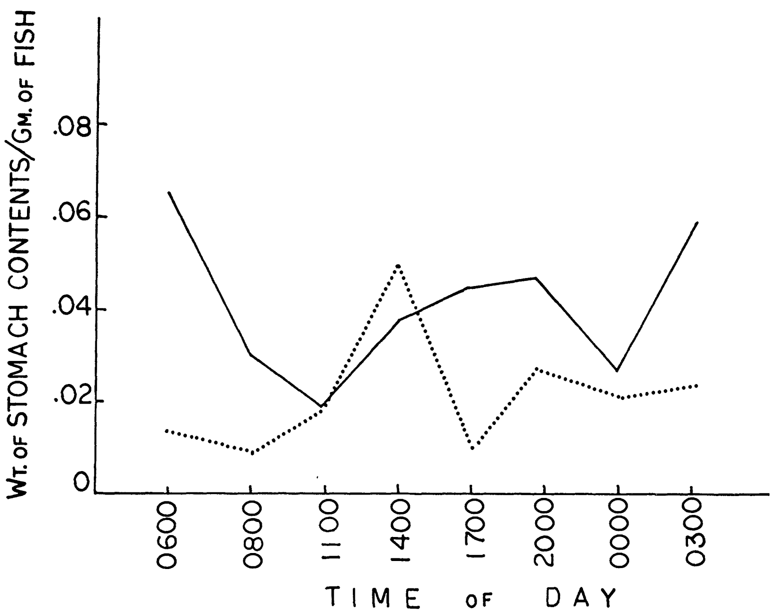

Fig. 1.—Feeding periodicity of *N. baileyi* expressed as the weight of stomach contents per gram of fish on 17-18 April (solid line) and 2-3 September 1970 (dotted line)

17.2 C in April. The high temperature in September could have either increased the digestive rates, resulting in less food contents at each time period, or caused a reduction in food intake, as has been noted in several other species (Braasch and Smith, 1967; Barber and Minckley, 1971; Mathur, 1972b, 1973b). However, our findings on the daily food consumption of this shiner agree well with data for other species (Keast and Welsh, 1968; Mathur, 1972b, 1973b).

Food composition during the 24-hr period.—The relative importance of various food items in the diet differed during the 24-hr period (Table 1). Dipteran larvae were important in the diet only at 0800 hr, and at other times they formed a minor portion of the total food. Ephemeropteran nymphs comprised an important segment of the diet at midnight, 0800 and 1100 hr. Trichopteran larvae were important in the diet at 0300 and 0600 hr. Coleopteran larvae formed the bulk of the diet only at 0300 hr. Terrestrial insects formed the bulk of the food at 1700, 2000 and 0600 hr. Other items which comprised only a minor portion of the diet included: odonate nymphs, oligochaetes, amphipods, fish eggs, amphibians (salamander larvae), diatoms, filamentous algae and detritus.

The differential consumption of various items over the 24-hr period was probably related to the availability of the prey organisms. A comparison of feeding data in Table 1 and drift data in Table 2 indicates

TABLE 1.—Food composition of *N. baileyi*, expressed as per cent volume over the 24-hr period

	Time of day							
Item	0800	1100	1400	1700	2000	2400	0300	0600
Diptera	21	7	4	2	6	4	10	1
Ephemeroptera	20	26	6	6	1	43	14	2
Trichoptera	4	15	3	10	....	3	24	26
Coleoptera	9	....	13	10	16	....	40	....
Odonata	....	....	....	4	....	....	....	....
Oligochaeta	4	7	11	....	....	....	....	7
Terrestrial insects	24	18	36	61	61	37	10	56
Amphipoda	....	....	1	....	....	....	....	....
Diatoms	12	19	10	6	2	2	....	1
Algae	4	5	16	1	4	1	....	....
Amphibia	....	2	....	....	....	....	....	....
Eggs	....	....	....	....	3	8	....	....
Detritus	....	1	tr	....	6	4	1	6

tr = less than 0.5%

TABLE 2.—Numerical analysis by taxonomic group of drift organisms over the 24-hr period

	Time of day							
Item	0800	1100	1400	1700	2000	2400	0300	0600
Diptera	18	77	17	15	62	32	26	17
Ephemeroptera	3	10	1	1	5	8	12	4
Trichoptera	1	3	2	1	4	3	2	....
Plecoptera	....	....	1	1	1	....	3	....
Terrestrial insects	1	5	3	5	7	10	9	6
Others[1]	2	13	3	3	4	1	4	2

[1] Includes molluscs, worms and fish larvae

that peaks in consumption of each food item coincided with their peaks in the drift samples. Thus, terrestrial insects were dominant in the diet between 1700 and 2400 hr, and at 0600 hr, when they were also common in the drift. Likewise, ephemeropteran nymphs were common both in the diet and drift samples at 1100 and 0300 hr. However a similar correlation was not evident for dipteran and trichopteran larvae. A heavy reliance on both the subsurface and surface drifting organisms, as in the case of rough shiner, has also been noted for other shiners (Davis and Louder, 1971; Reisen, 1972).

Presence of terrestrial insects, immature forms of insects, oligochaetes, detritus, diatoms and filamentous algae suggests versatile feeding habits of the rough shiner. Since each of these items is characteristic of a particular habitat it is clear that the rough shiner obtains its nutrition from all the available resources, *i.e.*, surface, subsurface and bottom depths in the stream.

SEASONAL TRENDS

Feeding intensity.—Seasonal feeding intensity was measured by the per cent fullness of stomachs and percentage of empty stomachs. Since the preliminary analysis (Mathur, 1972b) revealed that no significant differences in the proportion of empty stomachs occurred among the various length groups, the data were combined to depict the pattern of feeding for the whole population (Table 3). Most stomachs were empty or contained little food during the winter months. In contrast, during spring and summer the stomachs contained relatively more food and the proportion of empty stomachs was considerably lower. Feeding was moderate in autumn months. These data also bring out clearly that the mean value is considerably lower than that for the individual with the fullest stomach. This indicated that the "average" stomach in the population was far from filled to its capacity during a feeding period. There may be several reasons for this. An individual that "overeats" during one feeding period may consume correspondingly less at the next one. Alternatively, metabolic needs may be met adequately by less than the maximum intake of food, feeding may be rhythmic, or the amount of food available in given time may be limited (Keast and Welsh, 1968). Since this species showed a feeding peak during the hours of darkness, it is possible that the daytime collections used for this seasonal study were also in part responsible for the lower mean values. The lower rate of feeding at low temperatures in winter,

TABLE 3.—Seasonal feeding intensity of *N. baileyi,* expressed as mean per cent fullness and percentage of empty stomachs

Season	No. of stomachs examined	Stomachs empty (%)	Per cent fullness	
			Range	Mean
Spring	313	9	10-100	32
Summer	362	8	10-100	36
Autumn	291	31	10-100	27
Winter	367	48	10-100	19

as observed in this study, has also been noted in many species in natural habitats (Keast and Welsh, 1968; Mathur, 1971, 1972a,b, 1973b; Mathur and Robbins, 1971). However, it is not clear whether the low level of feeding is due to paucity of available food organisms or to the inability of the fish, because of their reduced metabolism at low temperatures, to forage effectively.

Change in food with fish size.—Analysis of the food data for the entire year indicated that both qualitative and quantitative differences existed among the various length classes (Table 4). These differences were most prominent between specimens less than 35 mm and those greater than 35 mm. Quantitatively, the diet of the smaller group was dominated by dipteran larvae, oligochaetes, Collembola, detritus and some unidentified insect matter. Terrestrial insects, and immature forms of Ephemeroptera, Trichoptera and Coleoptera also were eaten in small quantities. In contrast, the diet of the larger fish (> 35 mm) was dominated by terrestrial insects, detritus, immature forms of Ephemeroptera and Trichoptera and filamentous algae. Consumption of dipteran larvae and oligochaetes by larger fish decreased considerably. Qualitatively, the diet of the larger fish was found to be more diverse than that of the smaller ones (Table 4). Some 21 different food categories were utilized by the larger fish; only 14 were consumed

TABLE 4.—Food composition of various sizes of *N. baileyi*, expressed as per cent volume. N represents the number of fish with food in each length group

	Length group (mm)					
	16-25	26-35	36-45	46-55	56-65	66-75
N=	14	115	198	417	251	11
Item						
Diptera	49	45	20	12	13	5
Ephemeroptera	....	9	13	16	17	16
Trichoptera	1	3	6	8	5	2
Coleoptera	....	3	4	3	4	....
Plecoptera	....	....	....	....	tr	....
Collembola	8	9	2	1	....	....
Odonata	....	....	1	tr	tr	....
Terrestrial	4	3	21	23	26	38
Unidentified	19	7	7	9	10	9
Hydracarina	....	1	tr	tr	tr	....
Copepoda	....	....	tr	....	....	....
Cladocera	....	tr	tr	....	....	....
Isopoda	....	....	....	tr	....	....
Amphipoda	....	....	....	tr	tr	....
Oligochaeta	9	4	1	3	3	4
Detritus	9	12	18	14	11	9
Algae	....	tr	3	4	3	9
Diatoms	1	4	2	2	2	5
Aquatic vegetation	....	....	....	tr	tr	....
Plant seeds	....	tr	2	3	4	3
Eggs	....	....	tr	tr	tr	....
Fish	....	....	....	....	tr	....
Amphibia	....	....	....	tr	....	....

tr = less than 0.5 %

by the smaller fish. These qualitative differences in the diets suggest that the species becomes more opportunistic in its feeding habits with increase in size.

Seasonal food composition of 16-35 mm fish.—The principal foods were dipteran larvae, terrestrial insects and detritus throughout the year (Fig. 2). However, the relative proportions of the food items varied seasonally. Dipteran larvae formed the dominant portion of the diet during spring, autumn and winter. Terrestrial insects formed an important segment of the diet in spring and summer. Detritus was an important constituent in spring and winter. Ephemeropteran nymphs were eaten mostly in winter. Collembolans were eaten only in winter. Trichopteran larvae formed a significant portion of the diet only in summer. Coleopteran larvae, Hydracarina, cladocerans, oligochaetes, filamentous algae, diatoms and plant seeds formed a negligible portion of the diet in seasons when they were eaten.

Qualitatively, the diet of these small fish was least diverse in autumn when only three food categories were utilized. In other seasons, the diet was quite diverse as 8-9 types of foods items were consumed.

Seasonal food composition of 36-75 mm fish.—Quantitatively, the diet of these fish was dominated by terrestrial insects, ephemeropteran nymphs, dipteran larvae and detritus (Fig. 3). As in the case of small fish, the dipteran larvae were important constituents of the diet in spring, autumn and winter. Terrestrial insects formed the bulk of the total food in autumn and, to a lesser extent, in other seasons. Detritus was taken in large quantities in winter and was eaten in low quantities in other seasons. Ephemeropteran nymphs were eaten in moderate

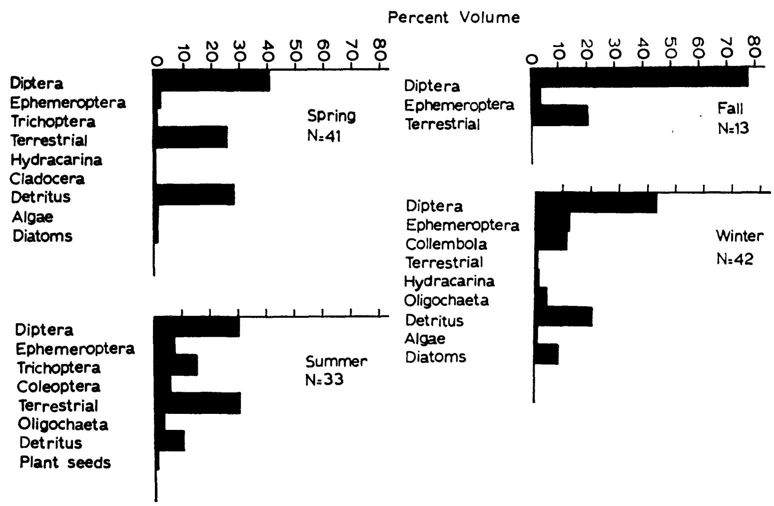

Fig. 2.—Seasonal food composition of *N. baileyi* (< 35 mm), expressed as per cent volume. N represents the number of fish with food

quantities throughout the year. Collectively, other items which were eaten in low quantities and only during certain seasons included coleopteran larvae, trichopteran larvae, plecopteran nymphs, odonate nymphs, Collembola, Hydracarina, amphipods, cladocerans, filamentous algae, diatoms, plant seeds, fish eggs, fish and amphibians.

Qualitatively, the diet was most diverse in spring and summer when 13-17 kinds of food categories were consumed. The diet was moderately diverse in the autumn and winter months. These minor differences presumably reflect the relative accessibility of certain items in the environment.

Seasonal food habits data indicate clearly that this shiner does not strictly conform to a specific trophic level. Specimens of a given size consumed significant amounts of material from several different sources. Thus, the diet of small and large specimens included detritus, filamentous algae, diatoms, dipteran larvae, trichopteran larvae, emphemeropteran nymphs, terrestrial insects, etc. Data also indicate that alternative foods may be utilized from time to time depending upon the availability and abundance of food items. Thus, in some seasons, the species consumed large quantities of fish eggs, collembolans and plant seeds. Obviously, these food substitutions do not take place within the confines of a given trophic level. They indicate a great amount of opportunism and versatility in feeding habits. No known

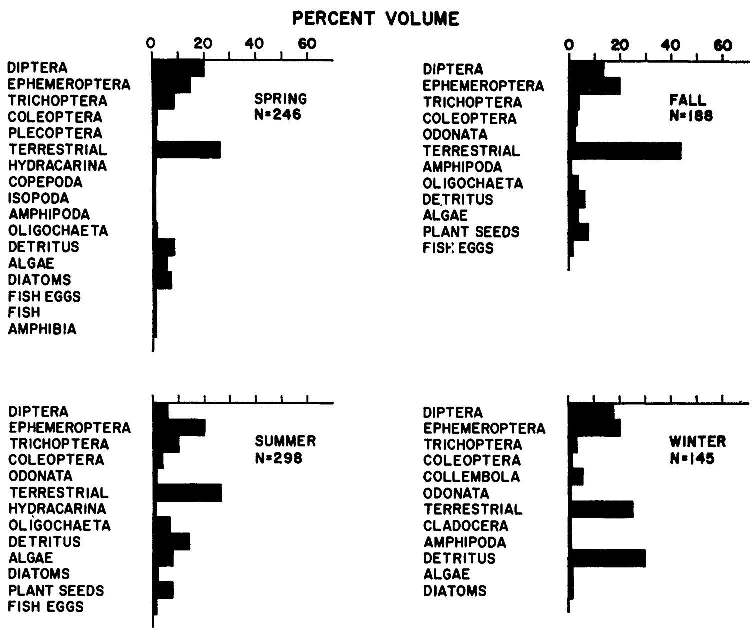

Fig. 3.—Seasonal food composition of *N. baileyi* (> 35 mm), expressed as per cent volume. N represents the number of fish with food

work has been reported on the food habits of the rough shiner, so no comparisons can be made.

Based on data on its reproductive biology (Mathur and Ramsey, 1974) and food habits from this study, we conclude that the key to the success and establishment of *N. baileyi* in Halawakee Creek lies, at least in part, in its opportunistic feeding habits, prolonged successful spawning season and high reproductive potential. We do not have enough abundance and distributional data on other native species prior to the introduction of *N. baileyi* to evaluate the effects its establishment has had on the native fauna.

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